fundisa for change

Teaching **Biodiversity**

Life Sciences Grades 10–12

Soul Shava & Ingrid Schudel

This is a teacher education text. Its purpose is to expand educators' knowledge of environmental topics to support the teaching thereof in the curriculum. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as these units are not a textbook, but rather a resource for teacher education.

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Contents

ORIENTATION

Introduction 4
- What is biodiversity? 4
- Why is biodiversity important? 4
- How do these units support teaching and learning about biodiversity? 4

These Biodiversity units and the CAPS 5
- The Biodiversity units and their relationship to teaching the CAPS 5

UNIT 1 – WHAT IS BIODIVERSITY?

Subject Content Knowledge 10
- Defining key concepts 12
- South African Biomes 18
- Taxonomic classification 22
- Identification instruments or tools 26
- Summary: Organising aspects of biodiversity 27

Teaching Practice 29

Assessment Practice 30
- CAPS Life Sciences assessment focus 30
- Summative assessment 33
- Assessment methods and instruments 33

Conclusion 34

UNIT 2 – THE ROLES OF BIODIVERSITY

Subject Content Knowledge 37
- Ethical considerations 40

Teaching Practice 42

Assessment Practice 42

UNIT 3 – CAUSES OF BIODIVERSITY LOSS AND EMERGING HUMAN RESPONSES TO BIODIVERSITY LOSS

Subject Content Knowledge 45
- Human impacts on biodiversity 45
- Responses to biodiversity loss 48

Teaching Practice 55

Assessment Practice 55

Conclusion 56

REFERENCES 57

APPENDICES

1. Biomes of South Africa 60
2. Imifino 64
3. The rape of the Pelargoniums 65
4. Invading ants disrupt ecosystem 67
5. Interdependence of biological and cultural diversity amongst the *amaXhosa* and *Mfengu* of the Eastern Cape, South Africa 68
6. Wetlands 69

Orientation

Introduction

What is biodiversity?

The variety of living things around us is one of the greatest wonders of life on Earth. Biodiversity (biological diversity) is the variety of life in an area, including the number of different species, the genetic wealth within each species, the interrelationships between them, and the natural areas where they occur. Biodiversity refers to the life-support systems and natural resources upon which we depend (Enviro Facts, 1993). Within this topic, we learn about species, energy levels, biomes, hotspots, causes of biodiversity loss and how to protect our precious biodiversity.

Why is biodiversity important?

Living things cannot exist independently of each other. All living things depend on each other and the non-living environment in a number of ways. To look after ourselves we need to look after all the parts that make up the system of which we are part.

Human activity has been changing ecosystems for thousands of years, but the pace and extent of change has increased rapidly with agricultural and industrial development. South Africa ranks as the third most biologically diverse country in the world, and is thus of major global importance for biodiversity conservation. (Enviro Facts, 2001)

How do these units support teaching and learning about biodiversity?

These units attempt to draw together biodiversity aspects in the curriculum in order to develop a progressive understanding of the topic.

The three units focus on the following topics:

- What is biodiversity?
- What roles does biodiversity play?
- What causes biodiversity loss and how do humans respond?

These Biodiversity units and the CAPS

These three Biodiversity units have been developed to expand teachers' knowledge and expertise in ways that also support teaching the CAPS Life Sciences curriculum for Grades 10-12 (details provided in the tables below). The sections do not follow the sequence of the CAPS; instead the progression is from exploring the concept of biodiversity, the roles it plays, the causes of biodiversity loss, and finally human responses to this loss.

In these three units, we support you as a teacher and facilitator or interested reader to:

- Strengthen your subject content knowledge of climate change;
- Enhance your teaching practice; and
- Support your assessment practice.

The units cannot provide all the information or perspectives on biodiversity, so teachers also need to consult other knowledge resources. It is also important to review carefully what is presented in textbooks and other biodiversity information sources. A list of these is provided at the end of this resource. You will find links to key concepts in the side bars.

The same is true for the methods and assessment practices suggested here. A more extensive learning resource *Methods and Processes to support Change-Oriented Learning* is provided as part of the Fundisa for Change materials.

In line with the CAPS, each of the three units relevant to teaching Biodiversity in FET Life Sciences includes sections that cover:

- Subject knowledge,
- Teaching practice, and
- Assessment practice.

The Biodiversity units and their relationship to teaching the CAPS

These biodiversity learning units have been developed to support teaching and learning in the Diversity, Change and Continuity knowledge strand of the Curriculum and Assessment Policy Statement (CAPS) Further Education and Training Phase Life Sciences for Grade 10-12 (Department of Basic Education, 2011). Most of the content on biodiversity in this knowledge strand falls within Grade 10 (Terms 3 and 4) and some falls within Grade 11. For details of the framework see the outlines of each unit below.

The tables in this section summarise the key concepts and processes covered in each unit, and show when and in which grades each of these topics should be taught, according to CAPS.

Unit 1: What is biodiversity?

This learning unit covers a number of areas necessary for exploring biodiversity:

1. Defining key concepts (including biodiversity, species, population, genus, community, habitat, ecological niche, ecosystem, trophic levels and biomes)
2. South African biomes (including Succulent Karoo, Nama Karoo, Savannas, Fynbos, Grasslands, Thicket, Forest, Wetlands, Marine and Coastal Ecosystems)
3. Taxonomic classification (naming and grouping organisms in a hierarchically ordered system that reveals their natural or evolutionary relationships)
4. Identification instruments or tools (for identifying species).

Table 1a: Unit 1 related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	GRADE	TERM
Definitions of key concepts	Biodiversity – Variety of life and life systems Species Population Genus Community Habitat Ecological niche Ecosystem Trophic levels Biomes	10 11	3, 4 3
Levels of biodiversity	Genetic (variation within species) Species (species diversity, indigenous and endemic species) Ecological (diversity of ecosystems)	10	4
Ecosystems	Aquatic (marine & freshwater), Terrestrial (forests, coastal, savanna, grasslands, desert, fynbos, etc.) ◆ Species composition of ecological communities: fauna and flora ◆ Trophic energy levels ◆ South African biomes	10	3
Taxonomy	Basis of classification – homologous (shared) features Hierarchical (graded order) system of increasing complexity: 1) Across levels of biological organisation ◆ Prokaryotes (acellular) > Eukaryotes ◆ Unicellular > Multicellular ◆ Cell>tissue > organ systems 2) Diversity of species Kingdoms of living organisms: ◆ Viruses, bacteria, protists, fungi, plants, animals Binomial classification system: ◆ The species concept ◆ Nomenclature (Latin names) – Carl Von Linne Plant Taxonomy/Classification – The Plant Kingdom: ◆ Hierarchical system of increasing complexity ◆ Levels of organisation (cellular > tissue > organ systems): algae > mosses/liverworts > ferns > gymnosperms > angiosperms ◆ from aquatic > terrestrial habitats ◆ from H_20 dependent reproduction > wind pollination > insect and animal pollination	10 11	4 1

Unit 2: What roles does biodiversity play?

This unit explores the roles of biodiversity, which include ecosystem services and contributing to human well-being.

Table 1b: Unit 2 related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	GRADE	TERM
Ecosystem services and human well-being	Life support systems and processes Biodiversity resources Livelihood sustenance	10	1, 3

Unit 3: What causes biodiversity loss and how do humans respond?

This unit explores the causes of biodiversity loss, and then how humans are responding to this loss.

Table 1c: Unit 3 related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	GRADE	TERM
Impacts of human activities on biodiversity	Biodiversity loss Overexploitation Extinction Invasive aliens Ecosystem change Desertification	11	4
Biodiversity conservation	Environmental Education and Education for Sustainable Development Protected areas, CBNRM, in situ and ex situ conservation Invasive alien control Policy and legislation Multilateral Environmental Agreements/International Conventions (CBD, Ramsar, CITES, World Heritage Convention) Low Carbon and Green Economy		

Each learning unit that follows will cover the three key aspects of teaching, as introduced in the introductory core text:

1. **Subject content knowledge**
2. **Teaching practice**
3. **Assessment practice.**

Activities for developing teaching and assessment practice can be found interspersed in sections of content knowledge.

Unit 1

What is biodiversity?

Subject Content Knowledge

This learning unit covers a number of areas necessary for exploring biodiversity:

1. Defining key concepts (including biodiversity, species, population, genus, community, habitat, ecological niche, ecosystem, trophic levels and biomes)
2. South African biomes (including Succulent Karoo, Nama Karoo, Savannas, Fynbos, Grasslands, Thicket, Forest, Wetlands, Marine and Coastal Ecosystems)
3. Taxonomic classification (naming and grouping organisms in a hierarchically ordered system that reveals their natural or evolutionary relationships)
4. Identification instruments or tools (for identifying species)

Unit 1 Biodiversity related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	BIODIVERSITY RELATED TOPICS IN CAPS – LIFE SCIENCES	GRADE	TERM
Definitions of key concepts	Biodiversity –Variety of life and life systems Species Population Genus Community Habitat Ecological niche Ecosystem Trophic levels Biomes	p.35 – **Biodiversity** ◆ Enormous biodiversity on Earth (large variety of species, different ecosystems and genetic differences) with an emphasis on the extent of biodiversity and endemism in southern Africa: indigenous and endemic species **Topic: Population ecology Population Size** ◆ Immigration, emigration, mortality, births, fluctuations ◆ Limiting factors and carrying capacity ◆ Logistic and geometric growth curves with phases	10	4
		p.33 **– Biomes** ◆ Terrestrial and aquatic biomes of southern Africa and how climate, soils and vegetation influence the organisms found in each ◆ The location of the different biomes in South Africa	10	3
		p. 34 – **Energy flow through ecosystems and relationship to trophic structure** (food pyramids): ◆ Trophic levels: producers, consumers (herbivores and carnivores and omnivores, decomposers *(link with Grade 9 and nutrition in Grade 11)* ◆ Flow charts of the following: nutrients, water, oxygen, carbon and nitrogen cycles	10	3
		p. 49 – **Interactions in the environment** ◆ **predation:** two South African examples of predator-prey relationships: graphs	11	3

<table>
<tr><th>SUB-THEME</th><th>CONTENT</th><th>BIODIVERSITY RELATED TOPICS IN CAPS – LIFE SCIENCES</th><th>GRADE</th><th>TERM</th></tr>
<tr><td>Definitions of key concepts (cont.)</td><td></td><td>◆ competition:
◆ interspecific: for light, space, water, shelter and food
◆ intraspecific: for food, access to mates, water, space, and shelter; survival is determined by access to the above, ecological niches
◆ specialisation: competitive exclusion and resource partitioning; discuss one example of coexistence in animals and one example in plants
◆ parasitism: two examples from South Africa
◆ mutualism (one species benefits): two examples from South Africa
◆ commensalism (both species benefit): two examples from South Africa

CAPS p.49 suggests: “Case study: Rationale for culling, e.g. elephants in the Kruger National Park as an example of an application of estimating population size (link to researched reasons for culling)”</td><td></td><td></td></tr>
<tr><td>Levels of biodiversity</td><td>Genetic (variation within species)
Species (species diversity, indigenous and endemic species)
Ecological (diversity of ecosystems)</td><td>p.35 – Extent of biodiversity and endemism in southern Africa: indigenous and endemic species</td><td>10</td><td>4</td></tr>
<tr><td>Ecosystems</td><td>Aquatic (marine & freshwater), Terrestrial (forests, coastal, savanna, grasslands, desert, fynbos, etc.)
◆ Species composition of ecological communities: fauna and flora
◆ Trophic energy levels
◆ South African biomes</td><td>p.33 – Terrestrial and aquatic biomes of southern Africa and how climate, soils and vegetation influence the organisms found in each
◆ The location of the different biomes in South Africa. Terrestrial and aquatic biomes of southern Africa and how climate, soils and vegetation influence the organisms found in each
◆ The location of the different biomes in South Africa</td><td>10</td><td>3</td></tr>
<tr><td>Taxonomy</td><td>Basis of classification – homologous (shared) features
Hierarchical (graded order) system of increasing complexity:
1) across levels of biological organisation
◆ Prokaryotes (acellular) > Eukaryotes
◆ Unicellular > Multicellular
◆ Cell > tissue > organ systems
2) diversity of species
Kingdoms of living organisms:
◆ viruses, bacteria, protists, fungi, plants, animals</td><td>p.35 – Classification Schemes: Classification schemes are a way of organising biodiversity
◆ Brief history of classification: Scientists attempt to classify organisms based on shared features. As information increases classification changes. One of the currently accepted classification systems is the five-kingdom system: Animalia, Plantae, Fungi, Protista and Monera (Bacteria)
◆ The naming of things in science: species concept and binomial system. Focus on Linnaeus (Carl von Linne) and his role in</td><td>10</td><td>4</td></tr>
</table>

SUB-THEME	CONTENT	BIODIVERSITY RELATED TOPICS IN CAPS – LIFE SCIENCES	GRADE	TERM
Taxonomy (cont.)	Binomial classification system: ◆ The species concept ◆ Nomenclature (Latin names) – Carl Von Linne Plant Taxonomy/Classification – The Plant Kingdom: Hierarchical system of increasing complexity Levels of organisation (cellular > tissue > organ systems): ◆ algae > mosses/liverworts > ferns > gymnosperms > angiosperms ◆ from aquatic > terrestrial habitats ◆ from H_20 dependent reproduction > wind pollination > insect and animal pollination	classification systems: Why do we use Latin? ◆ Differences between prokaryotes and eukaryotes *(link to cell structure)* ◆ The main groupings of living organisms; diagnostic features of each: ◆ Bacteria ◆ Protista ◆ Fungi ◆ Plants ◆ Animals p.40 – **Draw a phylogenetic tree** showing the evolutionary history of the four plant groups and major structural changes in their history of development	11	1

Defining key concepts

> **Key issue:**
>
> It is important to develop a foundation for a progressive understanding of biodiversity. This includes understanding the levels of biodiversity and the associated terminologies. The concept of biodiversity is based upon the principle of hierarchies and the basic building block is the species. Biodiversity refers to life on Earth in all aspects of its varieties. However, biodiversity is a complex concept and one needs to be able to specify what kind of biodiversity is being discussed and how it is being measured.

To teach the topic of biodiversity, it is necessary to define it first and explain key terms associated with it. This enables learners and teachers to develop the necessary vocabulary for understanding the topic.

Biodiversity (Biological diversity)

This is the variety of life and life systems. There is biodiversity at different levels of biological organisation. These levels are:

i) **The variation of life systems or *ecological diversity (ecosystem diversity)*.** The variety of *ecological systems* or *ecosystems* includes a range of aquatic and terrestrial systems. Each ecological system has its own unique environmental conditions that suit certain communities of species.

ii) **The variety of living organisms, that is, the full range of species on Earth or *species diversity*.** These life forms include viruses, bacteria, protists, fungi, plants and animals. It is estimated that there are 14 million species on Earth (Global

Biodiversity Assessment, 1995), of which approximately 1.7 million species (13%) have currently been identified including more than 300 000 plants, a million insects, 25 000 fish, 7 800 reptiles, 4 700 amphibians, 9 700 birds, and 4 600 mammals. The remainder includes molluscs, worms, spiders, fungi, algae and microorganisms.

The variety of living organisms on Earth is yet unknown, with many species still to be discovered. Consider and discuss the implication of this against a background of increasing demand on land and the human impacts on biodiversity.

Species that naturally occur in a particular environment are called *indigenous species* (as opposed to exotic or non-native species). Some species are indigenous (native) to South Africa, but also to the southern Africa region and to the African continent (e.g. the African elephant, lion, eland, kudu, and wildebeest). However, it should be noted that some species are only found in one specific area of the Earth and are adapted only to such an environment. Such species are termed *endemic species*. South Africa has some endemic plant and animal species which are only found in specific sites within South Africa. In terms of the number of endemic species of mammals, birds, reptiles and amphibians, South Africa ranks as the fifth richest country in Africa and the 24th richest in the world (South Africa's National Biodiversity Strategy and Action Plan, 2005).

South Africa has three of the world's major biodiversity hotspots:

1. *the Cape Floral Kingdom (also called the fynbos biome),*
2. *the succulent Karoo (shared with Namibia),*
3. *the Maputaland-Pondoland-Albany centre of endemism (shared with Mozambique and Swaziland).*

Appendix 1 describes these three hotspots in more detail.

The fynbos vegetation only occurs in the Southern Cape and nowhere else in the world as does the succulent Karoo vegetation of the Western Cape Province. These areas have been identified internationally as biodiversity *hotspots* due to their high numbers of endemic species.

In a world where conservation budgets are insufficient given the number of species threatened with extinction, identifying conservation priorities is crucial. British ecologist Norman Myers defined the biodiversity hotspot concept in 1988 to address the dilemma that conservationists face: what areas are the most immediately important for conserving biodiversity? The biodiversity hotspots hold especially high numbers of endemic species, yet their combined area of remaining habitat covers only 2.3 percent of the Earth's land surface. Each hotspot faces extreme threats and has already lost at least 70 percent of its original natural vegetation. Over 50 percent of the world's plant species and 42 percent of all terrestrial vertebrate species are endemic to the 34 biodiversity hotspots (Conservation International, 2007).

Species diversity is important in increasing the capability of an ecosystem to be resilient against a background of changing environmental (e.g. climatic) conditions. Species are an important biological resource in that they provide us with products such as food, medicines and raw materials and have a variety of human uses (both known and with future potential).

An example of genetic diversity within the same species is the variation within human populations.

iii) **The variability within the same species of a living organism or *genetic diversity*.** There are variations in the genetic make-up of each individual organism within each species which are important for the maintenance of reproductive vitality, resistance to disease and the adaptation to changing environmental conditions.

For more on case studies as an educational method see page 26 in the *Methods and Processes* booklet.

ACTIVITY 1

USING CASE STUDIES TO EXPLORE BIODIVERSITY

Read the three case studies below.

- Discuss which of the three 'levels' of biodiversity is significant in each case.
- Explain how the situation might be/have been different given a greater biodiversity.

1. The Irish Potato Famine

During the summer of 1845, an unknown blight (disease) devastated Ireland's potato crop, the basic staple food for Irish peasant farmers. A few days after potatoes were dug from the ground, they began to turn into a slimy, decaying, blackish mass. The cause was a fungus that had travelled from Mexico to Ireland. Due to a lack of genetic variation in the potatoes this fungus spread rapidly throughout the country. The resultant famine was exacerbated by inadequate response from the oppressive British rulers of the time, in a system where Irish Catholics were prohibited from entering the professions or even purchasing land so that their only recourse to sustaining themselves was to rent small plots of land from absentee British Protestant landlords. The blight resulted in the starvation of almost one of every eight people in Ireland during a three-year period.

2. Cultivating coffee

"Brazil's 'typica' coffee originates from the progeny of one tree, introduced from East Africa via the Caribbean. Such uniformity, and the susceptibility to disease which goes with it, means that landraces and the wild relatives of crops are likely to become even more important in the future. In the 1970s Latin American coffee plantations were under threat from rust disease. The plantations were saved because of information gained from a rust-resistant strain of coffee found in Ethiopia. However, despite their continuing importance as a genetic resource, the montane forests of Ethiopia and the Coffea species which grow in the forest under-storey are under serious threat: about four-fifths have already been destroyed." (Stolton, Maxted, Ford-Lloyd, Kell & Dudley, 2006, p. 16)

3. Disease regulation

The disease regulation service of biodiversity is evident in the agricultural sector. The Millennium Ecosystem Assessment reports a concern about externalised costs of irrigation, fertiliser, pesticide, and herbicide inputs associated with monoculture agriculture. Agricultural technologies which have promoted hybridisation and genetic uniformity have made plants vulnerable to pests and diseases, thus requiring more pesticides, which results in the destruction of pest\predator balances. For example, high yielding sorghum introduced in Dharwar, India, in the sixties resulted in the proliferation of a midge, which wiped out the indigenous variety of sorghum (Shiva, 1988). In another case, in 1988, an epidemic of a highly virulent virus of the African cash crop and staple, cassava, began in Uganda and spread throughout East and Central Africa, causing crop losses on a scale that required international intervention to prevent widespread famine.

Species

A species is the basic unit of taxonomic or biological classification. This can be elaborated as follows:

a) A *species* is a group of individual organisms that share common attributes but is morphologically, physiologically and biochemically distinct from other groups.

b) Genetically, this is a group of individual organisms that in nature is actually and potentially capable of interbreeding and producing fertile offspring but does not breed with individuals of other groups (i.e. it is reproductively isolated from other such groups). These individual organisms living together in a particular area (*niche*) comprise a natural *population*.

c) Members of a species have a common name, which is subordinate to (falls under) a *genus* (which groups together species with similar attributes). As a result a species has two names in taxonomic classification: the genus name and species name, giving rise to *binomial nomenclature* (a two-name naming system). The genus (*generic*) name is the first word/name of a scientific name of a species, while the second name is used to differentiate the species (denotes the species).

For example *Acacia sieberiana*: the *Acacia* genus and the *sieberiana* species.

Population

A population comprises interbreeding members of a single species occupying a particular niche within an ecosystem. A species can include one or more separate populations. Populations of the same species can be geographically (ecologically) separated and can be genetically distinguished from other populations of the same species). The members of a population, while belonging to the same species, are often genetically different from one another (genetic variation).

The total array of genes within a population is referred to as the *gene pool*.

Genus

This is an intermediate taxonomic ranking category that falls below the family and above the species. A genus comprises a group of species exhibiting similar characteristics.

Community

A *biological community* is made up of the populations of different species occupying a particular locality (site or place) and the interactions between them. The composition of a particular biological community is strongly affected by competition and predation. The biological community together with its physical environment comprises an *ecosystem*.

Habitat

A habitat is the natural home of a living organism, population or community that is the particular environment in which it is normally found.

Ecological niche

This refers to the role that a particular species plays and the space that the species occupies in an ecosystem. A niche includes the unique set of resources that each particular species requires and utilises.

Ecosystem (ecological system)

The term *ecosystem* derives from the Greek word *oikos*, meaning living, and *system* referring to an integrated functional unit. An ecosystem is therefore a natural system comprising living organisms (biotic communities), their physical environment (abiotic – soil, water, temperature, light, atmospheric gases, etc.) and the dynamic complex interrelations between them that enables them to function together as a unit (*ecological unit*). For example, an ecosystem in particular area can be made up of animals, plants, micro-organisms, soil, rocks, minerals, water and the atmosphere interacting with one another. Components of an ecosystem are linked together through cycles such as the water, carbon and nutrient cycles and energy flows. Ecosystems are influenced by internal dynamics and external factors, such as climate, which determine the types of ecosystems resident in a particular area.

Ecosystem diversity refers to the variety of habitats and their associated biological communities and the complex life processes on Earth. Ecosystem diversity is determined by species composition, physical structure and processes within the different ecosystems. There are three main types of ecosystems: *marine* (oceans, deep sea and sea floor, salt marshes, estuaries and lagoons, mangroves and coral reefs); *freshwater* (lake, river and wetland systems); and *terrestrial* (grasslands, forests, woodlands, savannas, fynbos, bush thicket, Karoo, etc.).

Trophic energy levels

Biological communities are organised into hierarchical feeding levels called trophic levels that represent how energy is acquired from and circulated within the environment. These successive trophic levels are as follows:

i) *Primary producers:* these are photosynthetic species that derive their energy directly from the sun and utilise this energy to make food (organic compounds). Included here are members of the plant kingdom (algae, mosses, ferns, gymnosperms and flowering plants).

ii) *Primary consumers (herbivores):* these are organisms that feed directly on plants to obtain energy. Herbivores include all browsing and grazing animals. The energy transfer at this level is quite low (thus herbivores need to consume large quantities of plant matter).

iii) *Secondary consumers (carnivores or predators):* these derive their energy from consuming other animals. *Primary carnivores* feed directly on herbivores while *secondary carnivores* feed on other carnivores. Energy transfer in carnivores is higher than in herbivores and therefore they require less quantities of their food. Their numbers are also significantly lower than those of their prey. Some carnivores derive a substantial proportion of their energy needs from plants while also feeding on animals. These are referred to as omnivores due to their mixed diets.

iv) *Decomposers (detritivores):* these are species that feed on dead plant and animal tissue and organic waste matter (detritus) for their energy needs, breaking it down into organic nutrients. They include bacteria and fungi. Decomposers release minerals such as nitrogen and phosphorous back into the environment, where it can be taken up by primary producers like plants and converted into organic compounds. Decomposers are at the top of the trophic level hierarchy.

The complex feeding relationships between trophic levels in an ecosystem can be described through *food chains* and *food webs*. Some organisms form *symbiotic relationships* with other different species of living organisms, in which both organisms benefit. These include mutualism, parasitism and commensalism.

Mutualism occurs, for example, between bees and flowering plants where bees are pollinators and benefit from nectar in the flowers. Nitrogen fixing bacteria form mutual symbiotic relationships with legumes such as groundnuts in which they live in the root nodules obtaining food from the plant while at the same time manufacturing nitrates required by the plants. Similarly the colon bacteria, *Escherichia coli* lives in our intestines and obtains the food that we digest, while at the same time its helps break down cellulose and other complex compounds for us that we not be able to digest on our own. *Parasitism* includes disease causing organisms that obtain their food from another species and might eventually kill it. Red spider mites and aphids feeding on plants are examples of parasitism. Tapeworms and roundworms in humankind are also examples of parasitism. *Commensalism* is where species live together and one benefits while the other is neutral (does not benefit but is not compromised): cattle egrets following grazing cape buffaloes do not harm the animal but benefit from insects which spring up as the buffaloes feed. Scavenging hyenas or vultures that feed on remains of a lion's prey are also examples of commensalism.

Biomes

Biomes are a global classification of ecologically similar areas on Earth. These are major biotic communities (ecological communities of plants and animals) of broad regional significance (*ecoregions*), extending over large areas, defined mainly by the dominant forms of vegetation and prevalent climatic conditions. Biomes fall under three categories: terrestrial (including savanna and temperate grasslands, tundra, desert, tropical rainforest, coastal, deciduous and coniferous forests), freshwater and marine.

ACTIVITY 2

EXPLORING BIODIVERSITY
Media analysis and outdoor investigations

Learning focus:

Development of scientific knowledge (information) and understanding of biodiversity and related concepts, critical analysis, visual art, report writing and presentation skills.

Resources:

Selected articles on local biodiversity issues from local newspapers or magazines or from the Internet, dictionaries (scientific dictionaries where possible) and Life Science textbooks. You can task the learners to find these articles where resources are available.

For more on critical media analysis as an educational method see page 32 in the *Methods and Processes* booklet.

i) Media analysis – identifying key words and concepts

Vocabulary development (scientific literacy) (Grade 10, term 3)

Divide the learners into groups and ask them to list the different terms and concepts that they come across in the selected article. Ask them to find and discuss the meanings of these different terms in the group. Ask the learners to summarise the main focus/theme of the article according to their own understanding. The group should then present the topic and explain the terms to the class.

ii) Media analysis – article review, critical analysis

(Grade 10, term 4; Grade 11, term 1)

Using the same article, ask the learners in the group to discuss the main points the article is trying to make. Are these points supported by relevant facts? What are the underlying assumptions? Do they agree with the proposed viewpoint of the author(s)? Ask them to suggest how the message contributes to responses to biodiversity loss. The learners should write down their deliberations as an article review report.

iii) Outdoor investigation – Show and tell (listening with intent - information transfer)

(Grade 10, term 3)

Take learners to a nearby natural area and ask them to take detailed notes of observations and information provided. Explain to them the type of ecosystem that you are investigating (seek the help of an experienced guide/conservationist if necessary). Point out the different species in the environment and their natural habitats. Explain to them the relationships between the different components in the ecosystem and discuss the roles of the different species. Ask them to write an essay describing the ecosystem and the different relationships of the components within it (using their notes). In the essay they should include a drawing representing what they saw during the visit.

South African Biomes

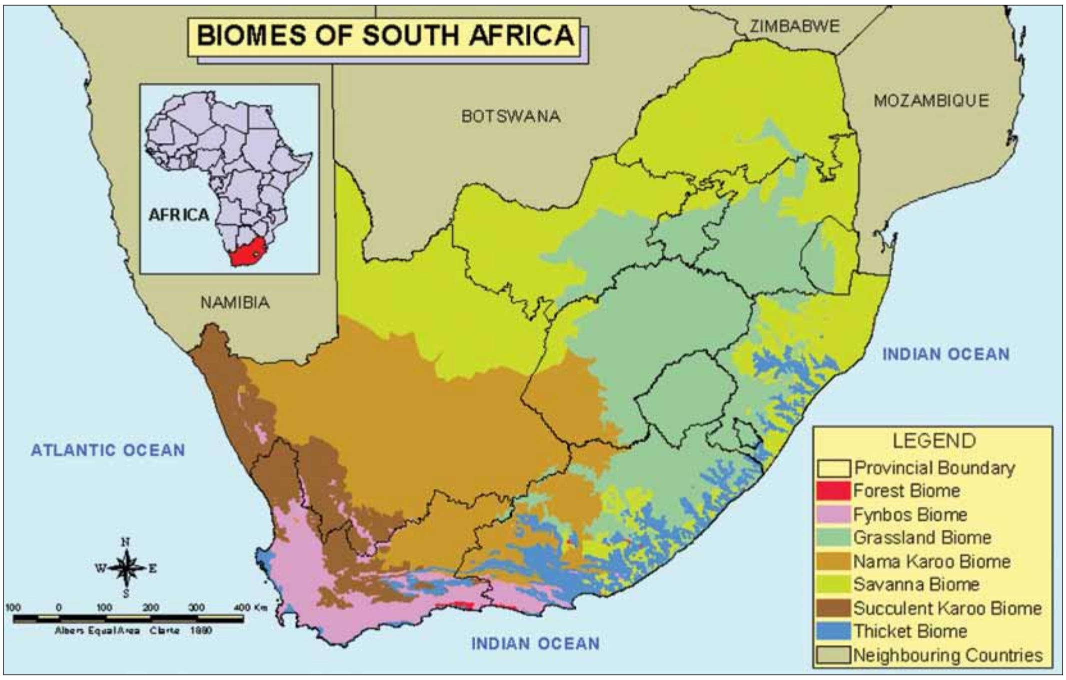
Key Issue:

The understanding of South African biomes, particularly the biome(s) in the immediate vicinity of the learning context, and their composition opens up opportunities for teaching and learning about biodiversity. A starting point could be looking at the diversity at the micro-scale within the school garden or yard in order for learners to appreciate the biodiversity around them. This can then be broadened to a macro-scale looking at the biodiversity of the province, the country, the region, the continent and global biomes.

See Appendix 1 for detailed information on South African biomes. Summaries of each biome can be found below.

South Africa has the following major terrestrial biomes: Succulent Karoo, Nama Karoo, Savannas, Fynbos, Grasslands, Thicket, Forest, Wetlands, Marine and Coastal Ecosystems (Department of Environmental Affairs and Tourism, 2000). Terrestrial biomes are characterised by the soil types and rainfall availability, which in turn influence the type of vegetation that grows in particular area. For example, dry sandy soils in low rainfall areas with short rainy seasons and long dry seasons favour drought tolerant plants as are found in arid desert environments; on the other hand humus rich soils and wet and humid environments with rainfall throughout the year favour evergreen forest vegetation types. The distribution of these biomes is shown in Figure 1.1.

Figure 1.1: Terrestrial biomes of South Africa



Source: Department of Environmental Affairs & Tourism, South Africa, 2000

Thicket

This is shrubland to low forest consisting mainly of spiny succulent trees, shrubs and vines. The vegetation is almost impenetrable and there is little or no herbaceous layer. The thicket biome shares many features with other biomes and is referred to as transitional thicket biome. Thicket biome occurs mainly in the Eastern Cape.

Fynbos

The Fynbos biome (also referred to as the Cape Floristic Region or Cape Floral Kingdom) comprises two main vegetation groups, Fynbos and Renosterveld. This biome is characterised by high plant species richness and a high number of endemic plant and animal (amphibian, bird and mammal) species localised in the Cape area. Fynbos vegetation has seven endemic or near-endemic plant families: Blacktips (*Bruniaceae*), Guyalone (*Geissolomaceae*), Sillyberry (*Grubbiaceae*), Brickleaf (*Penaeaceae*), Buttbush (*Retziaceae*), Dewstick (*Roridulaceae*) and Candlestick (*Stilbaceae*). Dominant plant species in the fynbos vegetation include Ericas, Proteas and Restios. The Renosterveld vegetation is characterised by the dominance of daisy family (*Asteraceae*), specifically the species Renosterbos *Elytropappus rhinocerotis*. Also found in the Renosterveld are other members of the daisy family (*Eriocephalus, Felicia, Helichrysum, Pteronia, Relhania*), legumes, Sterculias, Thymes and geophytes (members of the Iris, Lily and Orchid family).

Forest

Forests occur in frost-free areas of high rainfall (mean annual rainfall of more than 525mm in the winter rainfall region and more than 725 mm rainfall in the summer rainfall region). Forests are characterised by stratified vegetation comprising a canopy of evergreen trees, a mid layer comprising shrubs, lianas or vines and epiphytes, and a herbaceous layer or ground layer. Forest types include afromontane, coastal and riverine.

Succulent Karoo

The succulent Karoo biome occurs in areas characterised by low winter rainfall and extreme summer aridity, with excess temperatures of up to 40^{0}C. The vegetation is dominated by dwarf succulents comprising mainly the desert Vygies (*Mesembryanthemaceae*) and Stonecrops (*Crassulaceae*). Also occurring here are aloes (e.g. *Aloe pearsonii*) and the legendary halfmens *Pachypodium namaquanum.* Mass flower displays by members of the *Asteraceae* (daisy) family occur in spring.

Nama Karoo

This arid biome occurs in lime-rich soils of the central plateau of the Cape Province. The dominant vegetation is open grassy low (dwarf) shrubland (Kapokbush *Eriocephalus ericoides*, Silverkaroo *Plinthus karooicus* and Perdekaroo *Rosenia humilis* are some common shrubs). Very little of this vegetation (less than 1%) is protected and most of the land has been converted into livestock (sheep) farming in South Africa.

Savanna

Savannas are the natural habitat of the Big Five animal species (African elephant, buffalo, lion, leopard and rhino), as well as the cheetah, giraffe, zebra and eland and various other antelopes.

The savanna biome is the largest and most predominant vegetation type of southern Africa, spanning Botswana, Namibia, Mozambique, South Africa, Zimbabwe and Zambia. Savannas are characterised by a grassy ground layer and a woody trees and shrubs upper layer. Savannas are high in plant and animal biodiversity. This rich species diversity makes the savannas the centre of wildlife tourism. Conservation areas in this biome include the Kruger National Park and the Kalahari Gemsbok Park in South Africa.

Grassland

The grassland biome occurs mainly on the high central plateau of South Africa and in the inland areas of KwaZulu-Natal and the Eastern Cape. This biome is dominated by a single continuous layer of grasses with a notable absence of trees and shrubs. Most grassland has been converted into grazing land as well as maize cultivation. The grassland biome is of significant importance in water production in South Africa in that major rivers, the Orange, Tugela, Caledon and Kei rivers, have their headwaters originating in this biome (South Africa Environmental Outlook, 2012).

Inland water ecosystems

South Africa is a very dry country and the management of freshwater ecosystems is of paramount importance.

Inland water ecosystems refer to all inland water bodies, both fresh and saline, including rivers, lakes, wetlands (pools, ponds and pans, marshes, swamps, vleis), dams, subsurface waters and estuaries. Inland water ecosystems are our primary sources of water supply for human needs. They are also habitats to our aquatic biodiversity that includes inland water fishes, amphibian species, aquatic reptiles and birdlife and aquatic plant communities.

Marine ecosystems

With a coastline that stretches over 3000km, from the cool temperate waters of the south-east Atlantic Ocean to the subtropical Indian Ocean bordering Mozambique, South Africa is located at the confluence of two great currents, the cold Benguela Current on the west coast and the warm Agulhas Current on the east coast. This contributes to the high levels of marine biodiversity and species endemicity found within the region. The upwelling of cold, nutrient-rich waters along the west coast contributes to the high marine biodiversity of this area, supporting vast fish and invertebrate species, while the warmer, less productive waters of the east coast still support a range of marine biodiversity. The status of South Africa's marine resources is represented in Table 1.1 below.

Table 1.1: Status of South African marine resources

STATUS	PERCENTAGE	SPECIES
Optimally exploited	48.1%	Shallow-water hake; yellowtail; oysters; anchovy; sardine; squid; South Coast rock lobster; prawns; kelps; South East Atlantic skipjack; Atlantic big eye tuna; Indian Ocean big eye tuna
Uncertain	29.6%	Agulhas sole; Cape horse mackerel; Patagonian toothfish; white mussel; South Atlantic swordfish; Indian Ocean albacore; Indian Ocean skipjack; Atlantic yellowfin tuna
Overexploited	14.8%	Deep-water hake; West Coast rock lobster; Indian Ocean yellowfin tuna; Southern bluefin tuna
Underexploited	7.4%	Round herring; seaweeds

Source: WWF-South Africa: Fisheries Facts and Trends South Africa, 2011.

ACTIVITY 3

WORKING WITH FIELD GUIDES

Work with a variety of field guides from southern Africa.

1) Find one plant and one animal endemic to your province (only found in your province) and one plant and one animal endemic to South Africa. Read about these plants and animals and present what you have learned to the rest of the group.

2) Using the map in Figure 1.1 above, can you find out which biome your chosen provincial plant and animal are endemic to?

For more on fieldwork as an educational method see page 24 in the *Methods and Processes* booklet.

Taxonomic classification

Key issue:

Classification arises out of the need to create order of our lived world through allocating specific names to identify living organisms. The vast diversity of living organisms on Earth has required the development of a systematic process of naming and identifying them. It is impossible to discuss biodiversity if we are unable to identify the different species that make up that diversity.

The naming of living things has been with humankind since our origins. Ever since people have been able to speak they have started to name living organisms around them. The cumulative information derived from interacting with living organisms and their subsequent naming was essential for human survival. For example, the naming of edible and poisonous plants was necessary in order to communicate the acquired experiences to other members of the human community. Folk classification has played a significant role in the ordering of living organisms based on their uses, characters or habits. Folk taxonomies are however shallow in hierarchy, at times combining related species into one name or separating the same species into different names.

Taxonomy derives from the Greek word *taxis*, meaning arrangement.

Living organisms are grouped according to their observed fundamental similarities and separated according to their differences.

Modern *taxonomic classification* or *systematics* refers to the theory and practice or science of naming (*identification*) and grouping or organisation (*classification*) of organisms in a *hierarchically ordered system* that reveals their natural or *evolutionary relationships*. By grouping together similar species, it is easier to identify them. The hierarchical categories are termed *taxa* (singular is *taxon*). In the classification process each species belongs to a genus, each genus belongs to a family, and so on through order, class, phylum, and kingdom. The associations within the hierarchy reflect evolutionary relationships, which are deduced typically from morphological and physiological similarities between species, and more recently from analysis of genetic compositions. The basis of taxonomic classification is therefore shared similarities or *homologous features*.

Each organism falls under the following main taxonomic ranks (categories) given in Table 1.2 below.

Table 1.2: Hierarchy of taxonomic ranks

INCREASING COMPLEXITY OF RELATIONSHIPS (MORE INCLUSIVE)

RANK	EXAMPLE 1: HUMAN BEING	EXAMPLE 2: HONEY BEE
Domain	Eukarya (the eukarytotes)	
Kingdom	Animalia (the animal kingdom)	Animalia
Phylum (in animals) Division (in plants)	Chordata (animals with a backbone)	Arthropoda
Class	Mammalia (mammals)	Insecta
Order	Primates	Hymnoptera
Family	Hominidae (the Hominids)	Apidae
Genus	*Homo*	*Apis*
Species	*Homo sapiens* (H. Sapiens) (the human being)	*Apis mellifera* (honey bee)
Variety	*Homo sapiens sapiens* (modern human being)	*Apis mellifera scutellata* (African honey bee)

INCREASING SPECIFICITY (LESS INCLUSIVE)

ACTIVITY 4

DEVELOPING TAXONOMIC HIERARCHIES

Develop similar examples of taxonomic hierarchies to those provided in Table 1.2 above for two or more species.

Modern taxonomic classification is largely accredited to the work of Carolus Linnaeus (Carl Von Linne), drawing from his main work in the volumes *Species Plantarum* (1753) covering global flora and *Systema Naturae* (1758) covering global fauna. Linnaeus chose Latin and this is still used as the universal language for taxonomic classification. During his time Latin was considered the language of the learned.

Flora = plants; fauna = animals.

The main reason for continuing to use one language in taxonomic classification is to ensure that each species is called by the same name everywhere throughout the world (every language has different names for the same species and this makes it complicated). However, Latin is now considered a 'dead' language (very few people speak or use it), meaning that the name given to an organism will not change over time. Latin also has the advantage that words can be added together to make one-word descriptions, which are shorter and simpler than, for example, the English translation.

Linneaus laid the foundation for binomial nomenclature (binary naming system), based on the use of two Latin names in identifying (naming) species. The Linnaean binomial nomenclature has been adopted in modern taxonomic (scientific classification) systems as the conventional way of naming species. Linnaeus used five taxonomic ranks in naming living organisms: class, order, genus, species and variety. He grouped the living organisms based on shared physical (homologous as opposed to analogous) characteristics. This system has subsequently been revised to include Darwinian evolutionary (*phylogenetic*) relationships.

Currently five main kingdoms of living organisms are recognised. These are:

- Bacteria (Monera)
- Fungi
- Protozoa or Protists (Protista)
- Plants (Plantae) and
- Animals (Animalia).

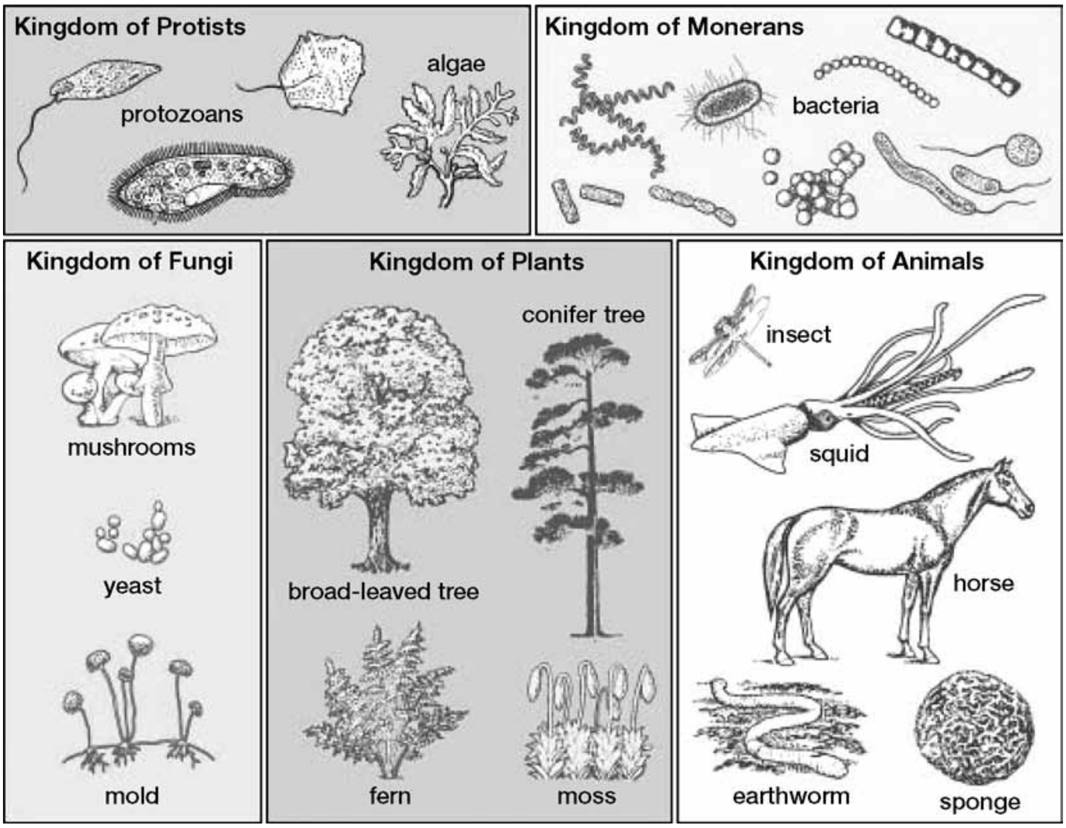
The species remains the basic unit in the biological classification of living organisms. The kingdoms are summarised in Table 1.3 below.

Table 1.3: Kingdoms of living organisms

KINGDOM	KEY FEATURES	LEVEL OF ORGANISATION	EXAMPLES OF SPECIES IN THE KINGDOM
Monera (Bacteria)	Body comprises a protein membrane cell wall and genetic material (no nucleus), microscopic in size and usually parasitic. Distinguished by shape of the cell (circular, rod shaped, etc.)	Prokaryote (before the cell - without nuclei and membrane-bound organelles), unicellular. Individuals reproduce by binary fission and are normally found in groups in the forms of chains or colonies.	True bacteria (eubacteria) and cyanobacteria (blue-green algae).
Protista	Body comprises cell with intracellular organelles including a nucleus. Microscopic in size and water dwelling. Some contain chloroplasts with chlorophyll and are photosynthetic (algae, autotrophs), while others feed by ingesting other organisms (heterotrophs). Mobile.	Eukaryotic, most unicellular, some multicellular. Most have hair like body extensions (cilia or filaments) for movement and feeding.	Unicellular protozoans and unicellular and multicellular (macroscopic) algae with cilia and flagella.
Fungi	Macroscopic. Haploid and dikaryotic (binucleate) cells, multicellular, generally heterotrophic, without cilia and eukaryotic flagella. Multicellular and visible with the naked eye. Mainly saprophytic, i.e. non-photosynthetic, digest and absorb dead organic matter (leaves, bark and wood). Sessile.	Eukaryotic, multicellular, tissue level of organisation. Reproduce through spores.	Mushrooms, toadstools, yeasts, moulds, mildew, rusts, smuts, puffballs.
Plantae	Macroscopic. Haploid-diploid life cycles, mostly autotrophic, retaining embryo within female sex organ on parent plant. Have cellulose cell walls. Range in size from minute plants, to herbs and shrubs, to huge tall tree specimens. Mainly sessile (stagnant) and photosynthetic.	Eukaryotic, multicellular, tissue level of organisation. Some have non-vascular tissue (mosses and liverworts) and the rest have vascular tissue (containing xylem and phloem vessels). Some reproduce through spores and rely on water (mosses, liverworts and ferns), some produce naked seeds (gymnosperms), while some produce flowers (angiosperms).	Mosses, ferns, woody trees, shrubs, bushes, climbers) and non-woody (herbs, reeds, grasses) flowering plants.
Animalia	Macroscopic. Multicellular animals, without cell walls and without photosynthetic pigments, forming diploid blastula. Range from minute animals to giant specimens. Feed on other organisms (heterotrophs), are mobile, communicate through sound. Include animals with backbones or internal skeletons and developed limbs (chordates), animals with external skeletons and six or more legs (arthropods – insects, spiders, crabs), animals with soft body and hard outer shell (molluscs) and long segmented soft bodies (worms).	Eukaryotic, multicellular, tissue and organ level of organisation (reproductive, digestive, gaseous exchange, nervous, blood and circulatory, sight, smell, thought and speech).	Sponges, worms, insects, crustaceans, fish, amphibians, reptiles, birds, and mammals.

The above kingdoms are illustrated diagrammatically in Figure 1.2.

Figure 1.2: Five kingdoms of living organisms



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Plant Taxonomy/Classification: The Plant Kingdom

The taxonomic arrangement of plants follows an *evolutionary pathway* in which plant life derived from water (algae) and then progressively moved to occupy the terrestrial environment through evolution and adaptive radiation. The occupation of the terrestrial environment was associated with increased complexity. This included the shift from unicellular to multicellular organisation; from cellular through tissue level to organ level of organisation; from non-flowering to flowering plants; from water dependent reproduction through wind dependent to complex symbiotic associations with pollinating agents (such as insects and bats); etc.

All plants belong to the Kingdom Plantae (Plant Kingdom). Plants are subdivided into two main taxa: Bryophytes or non-vascular plants (mosses and liverworts) and vascular plants (plants with a vascular system of xylem and phloem vessels). Vascular plants are divided into two sub-groups: seedless (Pteridophyta – the ferns) and seeded plants. Seeded plants are divided into two taxa: Gymnospermae (Gymnosperms – naked seed plants) and Angiospermae (Angiosperms – flowering plants), which comprise the majority of terrestrial plants. Angiosperms are in turn divided into two taxa: Monocotyledon (monocots – with one cotyledon) and Dicotyledon (dicots – with two cotyledons). Additional taxa in descending order are family, genus and species. The main taxonomic ranks in plant classification are listed in Table 1.4 below.

Table 1.4: Main taxonomic ranks in botanical (plant) classification systems

RANK	EXAMPLE (PAPER BARK THORN TREE)
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae (the pea and bean family)
Genus	*Acacia*
Species	*Acacia sieberiana*
Variety	*A. sieberiana* var. *woodii*

Identification instruments or tools

Key issue:

Identification instruments provide a method for easily identifying species. They vary greatly in form. They can be used to identify the biodiversity found in a particular geographical area, or in a related group of organisms (for example, animals, trees, grasses, aquatic plants, fish, birds), or in a particular grouping (for example, Acacia trees in southern Africa).

The quick identification of species in the field requires the use of simple tools or instruments that are easily accessible. These are what one can refer to as the 'quick and dirty' methods of identifying species as they are usually based on an artificial classification system that does not follow the scientific approach to classification. The main aim of tools is to aid the user to quickly arrive at the right name for a plant. Some identification tools are discussed below.

Taxonomic keys

Taxonomic keys are tools used to help with identifying an unknown species. A key provides a structure for sorting through a great deal of information, enabling quicker identification based on fundamental differences. The simplest and most often used key is the *dichotomous key*. Here the keys are structured in a set of couplets, based on two mutually exclusive choices (contrasting or opposing descriptions) of a particular feature, hence the term *dichotomous keys*. The user chooses a description that best fits the unknown specimen. Once the decision is made this then leads to the next couplet and the next, a progression based on accepting a certain feature and rejecting the other until the final identification (conclusion) is reached. During the identification process one moves from large distinguishing features to smaller differences.

Identification guides

Identification guides work in a similar way to taxonomic keys. However, in a guide the key distinguishing features of each species are usually lumped together in a species description, which is often accompanied by an illustration or photograph of the specimen. The user can then compare the description and illustration or photograph with their own specimen. Most guides combine the use of a key and the species description to aid identification. Examples of guides include the *Field Guide to Trees of Southern Africa* (van Wyk & van Wyk, 1997) and other similar guides on trees, grasses, ferns, flowers, fungi, mammals, fish, reptiles, birds, butterflies, insects and other living organisms.

Summary: Organising aspects of biodiversity

Biodiversity is organised both on the basis of scale as well as a taxonomic hierarchy as shown in Table 1.5 below.

Table 1.5: Organising aspects of biodiversity

SCALES OF BIODIVERSITY	TAXONOMIC LEVELS OF BIODIVERSITY	
	ANIMALS	PLANTS
Genes (within populations)	Variety	Variety
↓	↓	↓
Populations (within species)	**Species**	**Species**
↓	↓	↓
Species (within communities)	Genus	Genus
↓	↓	↓
Communities (within ecosystems)	Family	Family
↓	↓	↓
Biomes/Ecosystems (within bioregions)	Order	Order
↓	↓	↓
Bioregions	Class	Class
	↓	↓
	Phylum	Division
	↓	↓
	Kindgom	Kingdom

For more on Investigative methods and Learning by Doing see pages 23-29 in the *Methods and Processes* booklet.

ACTIVITY 4

BIODIVERSITY IS EVERYWHERE
Outdoor practical investigation – learning by doing

Learning focus:

Identifying, grouping/classifying and developing classification tools.

Resources:

School grounds and/or garden.

(Grade 10, term 4)

Task the learners to explore the grounds and/or garden within your school in groups. Each group should attempt to identify (using common or local indigenous names) and make a list of all living organisms that that exist within the garden. They should then attempt to classify these organisms based on their observed similarities. They should represent this in a table and present it before the entire class.

(Grade 11, term 1)

For the higher grades, each group should then attempt to classify the living organisms further by trying to differentiate them more according to their similarities and differences (using distinguishing features such as shape, size or height, mobility, colour, habitat use). They should also represent this as a table. Each group must try to develop a simple key that can be used to identify these different organisms. Ask them to present their findings to the class.

Teaching Practice

Within these biodiversity learning units there are a range of possible **pedagogical approaches** (methods) for the teaching and learning processes for the topic of biodiversity.

Biodiversity is about life forms and life systems and is therefore to a large extent a **practice-oriented** subject. However, this does not imply that **theoretical** as well as other **classroom-based activities** are not possible. A mixture of practical action-oriented aspects in real life contexts as well classroom-based activities can facilitate learning on this topic. These include **investigative, experiential, learning by doing** and **deliberative methods** as discussed in the Introductory Core Text and *Methods and Processes* booklet. Some activities are suitable for groupwork while some are individual activities. Using a diverse range of teaching and learning approaches creates opportunities for learners to actively engage in the learning process.

The Biodiversity topic will require:

i) the development of **language skills**, in this case with regard to scientific literacy on *key terms and concepts* employed in biodiversity;

ii) the development of **analytical skills** as employed in

a. appreciating the enormous variety of life and life systems in the local (and global) context(s) and the need to conserve it;
b. the classification of biodiversity and the theory/theories behind taxonomic classification;
c. the conceptualisation of how different living organisms are interrelated in nature and the natural processes within ecosystems;
d. recognising the different roles of biodiversity and relating this society and to human well-being;
e. understanding the impacts of human activities on biodiversity, their interrelated nature and their implications to human well-being; and
f. appreciating the role of science in the development of the range of responses to biodiversity loss;

iii) the development of **critical decision-making skills** with regard to

a. development of relevant contextualised responses to biodiversity loss;
b. debating and discussing critical issues relating to biodiversity issues;

iv) the development of **mathematical skills** and their application in real life contexts of biodiversity.

Teacher activities have been interspersed into the first section (Subject Content Knowledge); these give suggestions for various methods for teaching biodiversity.

Assessment Practice

Assessment activities will vary according to the content knowledge that is being assessed. The table below illustrates some possible links between the content in this learning unit and assessment activities and skills.

Table 1.6: Linking content knowledge to assessment processes

CONTENT KNOWLEDGE SECTION	SECTION SUMMARY	ASSESSMENT ACTIVITY	KEY ASSESSMENT SKILLS (VERBS)
Definition of key biodiversity concepts	The concept of biodiversity is based upon the principle of hierarchies and the basic building block is the species. Understanding the levels of biodiversity and the associated terminologies. South African biomes.	1. Review of selected texts/ articles on biodiversity to identify key terms and concepts. (Grade 10, 11) 2. Investigation of a local natural ecosystem (Grade 10) [Practical activity]	Define, describe, list, name, observe, recall, illustrate, measure, record (draw)
Taxonomic classification	Taxonomic classification as a systematic process of naming and identifying living organisms following the system developed by Carolus Linneaus. Hierarchical classification/ranking process.	1. Identification and classification of organism with the school yard or garden (Grade 10,11) [Practical activity] 2. Development of a simple taxonomic key (Grade10, 11) [Practical activity]	Identify, name, organise, categorise, list, classify, select, differentiate, design, develop, use/application of knowledge

CAPS Life Sciences assessment focus

Below are the CAPS Life Sciences Grade 10-12 specific aims and their related assessment focus:

1) **Knowing Life Science concepts**

   This refers to knowledge of biodiversity concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etc. This includes the acquisition of knowledge on biodiversity; understanding and making links between ideas and concepts; applying biodiversity knowledge in new and unfamiliar contexts; and analysing, evaluating and synthesising scientific knowledge, concepts and ideas.

2) **Investigating phenomena in Life Sciences**

   This refers to the practical ability to carry out investigations and solve problems about biodiversity. This includes listening to instructions, handling and using equipment and apparatus, making observations, measuring, recording, interpreting data and designing investigations on biodiversity.

3) **Appreciating and understanding the history, importance and application of Life Sciences in society**

   This refers to realising the relevance and application of the science of biodiversity in real life contexts (socio-biology and animal behaviour, plant pathology, game management, environmental impact studies, preservation of biodiversity, palaeontology, palaeoanthropology, agriculture, horticulture, environmental law, science journalism, biotechnology, genetic engineering, etc); understanding the historic development; and appreciating the relationships between indigenous knowledge systems and modern science on biodiversity.

The above aims can be linked to possible assessment activities as shown in Table 1.7 below.

Table 1.7: Linking aims to assessment activities

SPECIFIC AIM	COGNITIVE SKILLS	ASSESSMENT FOCUS	EXAMPLES OF ASSESSMENT ACTIVITIES
Knowing Life Science (Biodiversity) Concepts	*Knowing Biodiversity Science* – knowledge of biodiversity terms, concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etc.	This will involve assessing learners' ability to state, name, label, list, define and describe aspects of biodiversity (e.g. concepts, terms, issues, etc.)	◆ Defining what the term biodiversity means (building a conceptual framework) ◆ Describing the different levels of biodiversity ◆ Defining the terms species, population genus, community, habitat, niche, ecosystem, biome, etc. ◆ Naming and listing the different organisms living in a selected area
	Understanding Biodiversity Science – understanding of the conceptual framework of biodiversity, recognition of the hierarchical organisation of biodiversity, development of taxonomic ranking systems	Learners will be assessed on their ability to explain, compare, rearrange, give an example of, illustrate, calculate, interpret, suggest a reason, make a generalisation, interpret information or data, predict, select, differentiate aspects of biodiversity	◆ Categorising and classifying food items in the kitchen ◆ Categorising, differentiating and classifying living organisms in an area ◆ Develop/create food chains and food webs
	Apply knowledge of biodiversity in new and unfamiliar contexts – use of knowledge in a new way and application of knowledge in new/unfamiliar contexts	Assessing learners' ability to demonstrate, interpret, predict, compare, differentiate, illustrate, and select relevant aspects of (knowledge and information on) biodiversity and use it to design solutions to biodiversity problems	◆ Demonstration of knowledge of biodiversity in an area (types of ecosystems, different species and their habitats) ◆ Design/suggest solutions to local biodiversity problems
	Analyse, evaluate and synthesise biodiversity knowledge, concepts and ideas – analysis, evaluation and synthesis of biodiversity knowledge, concepts and ideas in different contexts	Assessment of learners' ability to appraise, argue, judge, select, evaluate, defend (a point of view), compare, contrast, criticise, differentiate, distinguish and discuss biodiversity issues	◆ Identification/appraisal of the human impacts on biodiversity in specific context ◆ Compare and contrast levels biodiversity in natural and developed areas ◆ Discuss the implications of colonial era conservation practices on local communities ◆ Critically evaluate the effects of elephant culling
Investigating Phenomena in Life Sciences (Biodiversity)	Following instructions on biodiversity investigations	Ability of learners to follow instructions on use of equipment and safety procedures	◆ Identifying dangers of wild animals and plants (dangerous animals and poisonous plants and animals)

SPECIFIC AIM	COGNITIVE SKILLS	ASSESSMENT FOCUS	EXAMPLES OF ASSESSMENT ACTIVITIES
Investigating Phenomena in Life Sciences (Biodiversity) *(cont.)*	Handle equipment or apparatus for biodiversity investigations	Ability of learners to name, know and use equipment appropriately	◆ Naming of equipment and apparatus for biodiversity investigations (rulers, tape measures, binoculars, magnifying glasses, etc.) ◆ Using measuring equipment, using identification guides and keys
	Make observations during biodiversity investigations	Ability of learners to draw, describe, group according to similarities and differences, measure, comparing before and after, observe results, count	◆ Visiting a local conservation area and using identification guides and keys to correctly identify different species in an area ◆ Drawing the different species occurring in the area ◆ Observing the types of ecosystem, their major constituents and interrelationships between the different components ◆ Grouping/classifying organisms into their right taxa according to their similarities and differences ◆ Counting living organisms found in a particular area
	Record information or data from biodiversity investigations	Learners' ability to draw, describe, construct tables, graphs	◆ Compiling a list of living organisms (plants and animals) occurring in a particular area ◆ Describing different types of ecosystems ◆ Recording different weeds occurring in the school garden ◆ List the different taxa for an organism ◆ Draw food chains and food webs
	Measure biodiversity aspects	Learners' ability to know what to measure, how to measure, understand accuracy and estimation	◆ Measuring and comparing species diversity in a natural and a lived area ◆ Make an audit (identify and measure and record the impact) of the school's carbon footprint that negatively impacts on biodiversity
	Interpret biodiversity information	Ability of learners to convert information from one form to another (e.g. table to graph), analyse and extract information, apply knowledge, recognise patterns or trends, understand limitations, make deductions	◆ Develop a simple key for identifying organisms in a particular area ◆ Observe biodiversity in a lived area and describe the impacts of human activities on biodiversity
	Design/plan biodiversity investigations	Learners' ability to identify a problem, investigate a situation, select apparatus or equipment and/or materials, selecting appropriate materials and tools, suggest ways of recording results, write a design brief, identify specifications and constraints, design solutions to problems	◆ Design an instrument (questionnaire) for carrying out a survey of plant use in a local community ◆ Carry out a plant use survey in the area ◆ Investigate threatened and endangered species in your area and explain the causes of these threats ◆ Design a public survey form to test the public opinion about elephant culling. Test this form through a survey of opinions of this within the class. Show results in a pie graph.

Summative assessment

Summative assessment in the Further Education and Training Phase Grade 10-12 for Life Sciences comprises the following components as outlined in Table 1.8 below.

Table 1.8: Formal assessment

GRADES	FORMAL SCHOOL-BASED ASSESSMENTS	END-OF-YEAR EXAMINATIONS
10 and 11	25% including a mid-year examination	75%
12	25% including mid-year and trial examinations	External examination: 75%

The formal (summative) school-based assessment comprises a test and/or exam and practical task in each school term. The end-of-year examinations comprise two written examinations and a practical examination. It is therefore essential to include assessment of practical tasks as well as written tasks or tests when planning for assessment.

Assessment methods and instruments

A variety of assessment instruments/tools can be employed in the assessment process of these Biodiversity learning units. These include those listed in Table 1.9 below.

Table 1.9: A list of some possible assessment methods and instruments/tools

ASSESSMENT METHODS	ASSESSMENT TOOLS/INSTRUMENTS
Case studies and open problems	Checklists, assessment grids and rubrics
Classroom-based discussions	Discussion checklist
Computer-based assessments	Multiple choice questions (MCQs)
Direct observation	Observation sheet
Self-assessment	Self-assessed questions
Peer assessment	Peer-assessed questions
Essays	Essay checklist
Knowledge tests	Short answer questions
Learning logs/diaries	Checklists, assessment grids and rubrics
Mini-practicals	Practical checklist
Orals	Oral assessment checklist
Portfolios	Portfolio of Evidence guideline/checklist
Poster sessions	Poster checklist
Presentations	Presentation checklist
Quizzes	Checklists, assessment grids and rubrics
Problems	Checklists, assessment grids and rubrics
Projects	Project checklist
Interviews	Questionnaires

ASSESSMENT METHODS	ASSESSMENT TOOLS/INSTRUMENTS
Reflective practice assignments	Practical checklist
Practical demonstrations	Practical checklist
Reports (on practicals)	Report forms
Simulated interviews	Interview questionnaire
Written examinations	Multiple question examinations, single essay examinations, modified essay questions (MEQs), multiple choice questions (MCQs)

It should be noted that there is no hard and fast rule as to which type of assessment tools should be used with particular assessment types. Some assessment tools can be used across a range of assessment methods. It is also essential to employ a variety of assessment methods and instruments as well as to provide interesting and challenging tasks that are imaginative and engaging to the learners and yet still meet the required assessment objectives.

Conclusion

In this first biodiversity learning unit the concept of biodiversity and its related terms have been discussed, as well as an overview of levels (organising aspects) of biodiversity. Taxonomy and its role in biodiversity was also discussed. A number of classification tools were also explored.

Unit 2

The roles of biodiversity

This unit explores the roles of biodiversity, which include ecosystem services and contributing to human well-being. Ecosystem services are the various benefits that ecosystems provide. Biodiversity plays an important role in the provision of various *ecosystem services* (provision, regulatory, cultural and supporting services) necessary for sustaining human life on Earth.

Unit 2 Biodiversity related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	BIODIVERSITY RELATED TOPICS IN CAPS – LIFE SCIENCES	GRADE	TERM
Ecosystem services and human well-being	Life support systems and processes Biodiversity resources Livelihood sustenance	Provisioning: ◆ Food: Chemistry of Life (pp.23-24) ◆ Medicine: Applications of Indigenous Knowledge Systems and Biotechnology (p.28)	10	1
		Regulation & Support: ◆ Energy flow through ecosystems – cycles (water, oxygen, carbon dioxide, nitrogen) – flow charts (p.34)	10	3
		Cultural: ◆ Tourism and cultural heritage: ecotourism (p.34)	10	3

Subject Content Knowledge

Key issue:

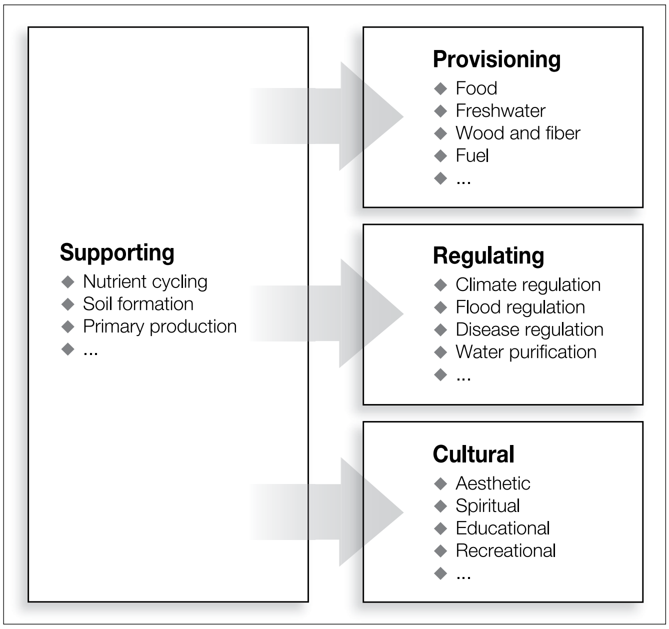
It is important to highlight the diverse range of services provided by biodiversity, both realised and the future potential. Biodiversity does not only provide goods and services to humankind but is important for the sustenance of life systems.

Human beings have always relied on nature for the provision of various services, both directly and indirectly. However the total value of biodiversity is frequently underestimated. Biodiversity plays an important role in the provision of various *ecosystem services* (provision, regulatory, cultural and supporting services) necessary for the sustenance of human life on Earth (see Figure 2.1).

At least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources (UN Convention on Biodiversity, 1992).

Ecosystem services are the various benefits that ecosystems provide. These include:

Figure 2.1: Biodiversity ecosystems services



Source: MA 2005

i. ***Provisioning** (supply) of material goods such as food, water, medicine, fibre and fuel, as well as genetic resources for agriculture from the direct use of fauna and flora for livelihood sustenance (i.e. utilitarian value).*

   The direct reliance on biodiversity for livelihood sustenance is more visibly evident in local rural communities. They rely on their environment for food through hunting, fishing and gathering of edible products. They also use local biodiversity for the provision of various products such as fuel energy, construction materials, utility items, water and medicine. Wild vegetables (both indigenous and naturalised) are an important food source in many rural households. Diets can be significantly improved with traditional wild food harvesting practices to supplement commercially cultivated crops.

   There is a growing worldwide industry in developing new pharmaceuticals drawing on knowledge and resources previously unknown to modern medicine. If not carefully regulated, the economic possibilities of a resource can lead to increased pressure on the resource.

Detail of the nutritional value of wild vegetables extracted from Husselman and Sizane (2006) – see Appendix 2 – illustrates this point.

See Appendix 3 for an article about Pelargonium harvesting in Grahamstown (Limson, 2002).

Some indigenous species have been used by local communities for medicinal and other purposes. However, bio-prospecting by pharmaceutical companies has led to some of them being patented without consent and without benefit sharing with local communities from which this indigenous knowledge is derived. Discuss the case example of Hoodia species which are traditionally used as hunger suppressants by the San communities in semi arid areas of South Africa, Botswana and Namibia. They have now been overexploited for commercial purposes and patented by foreign pharmaceutical companies without their consent.

The following extract is from a book inspired and co-authored by JJ Machobane – the founder of the Machobane farming system. The extract illustrates the importance of biodiversity in an individual diet:

> *"I talked to elderly people about how the Basotho used to live. They said that in one land we used to grow in one season pumpkin, maize and beans so that the children can have a variety of food. My parents used to grow beans in all the fields they had, broadcasting it so when the winter came they would eat it until it is finished, then start again. I began to think, I must rotate in such a way that people can eat fresh food all the time from the land. People around me were only interested in maize. I used to call maize mohlants'a, which means that when one eats maize alone all the time the mouth cracks and becomes red. This is a sign of some deficiency. Eventually one is not very sound in the head and that is why I called it a crop that makes one go mad. I told them that maize had to be accompanied with beans, peas, pumpkin and all sorts of vegetables that one can afford."*
>
> (Machobane, 2003)

For more on investigative methods see page 23 in the *Methods and Processes* booklet.

ACTIVITY 5

LOCAL PLANT USE SURVEY
Investigation

Learning focus:
Species identification, uses of biodiversity, indigenous knowledge, writing skills.

Resources:
Local community members, school yard or garden

(Grade 11, term 1)
Ask learners to identify and list the names of plants growing in the school yard or garden with the help of knowledgeable community members. After listing these plants they should take the list to community members in their area and find out what these different plants commonly used for. The learners should then work in groups to develop a chart on the different uses of these plants based on their investigation. Each learner should then write an essay on the useful roles of biodiversity to humankind.

ii. ***Regulation*** *of climate (influence of vegetation on climate, hydrological cycle and regulation of atmospheric gases, e.g. carbon capture and retention), water (protection of water resources, regulation and stabilisation of water runoff and acting as buffer against extreme weather events) and disease (delimitation of disease vectors) and the breakdown and absorption of pollutants.*

Another important regulatory role played by biodiversity is that of pollination. A healthy ecosystem is one where a multitude of complex mutualistic interrelationships co-exist. Losing species within these systems can have far-reaching and unexpected outcomes and dire consequences for the continuing healthy functioning of an ecosystem. For example, species and groups of species play important roles in pollination and seed distribution.

Appendix 4 describes what happened to plants in the fynbos after an alien invasive ant from Argentina outcompeted the ant with which these plants had had a symbiotic relationship (Invading ants disrupt ecosystem, 1995).

ACTIVITY 6

HOW BIOMES REGULATE CLIMATE
Group poster presentation

Listed below are three ways in which particular biomes regulate climate. Choose one of these to discuss with your group. Illustrate the explanation in the form of a poster and present to the other groups.

- In Western Australia, the replacement of native heath vegetation by wheatlands increased regional albedo (the proportion of incoming radiation from the sun that is reflected by the land surface back to space). As a result, air tended to rise over the dark (more solar-absorptive and therefore warmer) heathland, drawing moist air from the wheatlands to the heathlands. The net effect was a 10% increase in precipitation over heathlands and a 30% decrease in precipitation over croplands.

- Forests have higher evapotranspiration than other ecosystems, such as grasslands, because of their deeper roots and greater leaf area. Thus forests have a net moistening effect on the atmosphere and become a moisture source for downwind ecosystems (Millennium Ecosystem Assessment, 2005, p.29).

- In the oceans there is a "**biological pump**" that moves carbon from the surface ocean and sequesters it in deep waters and sediments (Millennium Ecosystem Assessment, 2005, p.29). This happens when the photosynthesising phytoplankton is consumed by filter feeders and plankton-eating fish which are in turn eaten by predatory sea creatures. The detritus created within these food webs (faeces and dead animals) sinks to the bottom of the ocean and in this way removes some of the carbon from the atmosphere. This pump is dependent on biodiversity for an effectively functioning food web.

For more on information transfer methods see page 11 in the *Methods and Processes* booklet.

iii. ***Cultural services*** *such as recreation and tourism, spiritual, aesthetic, cultural heritage, and research and educational purposes (living laboratories).*

Vistas of diverse plants and landscapes are also important in inspiring religious experiences for some, and knowledge and familiarity of a particular habitat or species can provide an important sense of place for others. Recent research in Peddie, Eastern Cape, has shown that almost half of the total amounts of wild harvested plant resources and a third of the total number of species are used for spiritual and ritual purposes in both rural and urban communities to sustain cultural practices and maintain cultural identity.

ACTIVITY 7

BIOLOGICAL AND CULTURAL DIVERSITY
Indigenous knowledge

Read Appendix 5 (Cocks and Dold, no date) which discusses the interdependence of biological and cultural diversity amongst the AmaXhosa and Mfengu people. The article lists religious, cultural, and medicinal values of plants and specific landscape features. It also describes the link between language and nature. Tell a story to your group about your own culture and a plant or landscape feature that is significant to this culture.

ACTIVITY 8

ECOSYSTEM SERVICES OF A WETLAND

Read the fact sheet: Wetlands – Enviro Fact series (2001) – see Appendix 6. Draw a mind map illustrating the different ecosystem services provided by wetlands. You may also add information that you may know about a specific wetland in your area.

iv. ***Supporting services*** *such as primary production, soil formation and protection (maintenance of soil structure), nutrient cycling and storage, and natural purification of water.*

Biodiversity plays an important role in ensuring regular and sustainable water availability in the river systems and preventing flooding in water catchments. A well-vegetated water catchment with a variety of plants with roots and leaves at different heights breaks the impact of rain and serves as a sponge for the water which is filtered and cleaned and released slowly into the rivers. The water of the Western Cape is known to be of particularly high quality and takes less filtering and cleaning than water in other parts of the country. This is attributed to the fibrous root systems and large biodiversity of the fynbos biome of the Western Cape.

Ethical considerations

Ecosystem services are dependent on living organisms (biotic elements) and their interactions with the physical (abiotic) elements of the environment. Sustaining ecosystem services is therefore only possible if these interactive processes are maintained to provide or produce these services. Continuous provision of these ecosystem services through biodiversity conservation enables sustained human well-being and poverty reduction. The Millennium Assessment places human well-being as the central focus for assessment. At the same time it recognises that "biodiversity and ecosystems also have intrinsic value". This means that biodiversity has a value in and for itself, irrespective of its usefulness for someone else (Millennium Ecosystem Assessment, 2005:1).

One critic argues that ecology's approach of scientific analysis can detract from our experiences of the beauty and intrinsic value of the natural world – which is a learning process in itself. We become conditioned to 'classify', 'evaluate' and 'manage' the diversity of life around us without necessarily listening, appreciating or caring. Consider the following extracts from Evernden's book *The Natural Alien: Humankind and environment* (Evernden, 1993) in which he describes some of the limitations of an ecological lens:

> It is difficult to imagine the world as anything but a collection of objects, each amenable to study and control. A gorilla is, after all, *nothing but* the manifestation of a particular kind of DNA. And cattle are nothing but protein, and a mountain nothing but rocks and minerals. A tree is a cellulose support structure, a river is energy (going to waste unless dammed), and the human body is a collection of a few dollars worth of chemicals. We pride ourselves in being able to get to the bottom of life's mysteries, that is to reduce them to their basic components. The world is made up of parts, just like a car. And knowing the nature of those parts and the way they are put together, man can not only understand but also control nature. The revelation of 'the way the world is' is part of the hidden curriculum of education systems of the industrialized West ... (p.14)
>
> ... the arrival of ecology and of all forms of resource management has made it possible to be that contradictory being, a dispassionate environmentalist. That is, it is now possible to regard the world as a composite of neutral material, and at the same time to frame suggestions for action based upon a mechanistic understanding of natural processes. As noted, this has made the environmental arguments much more presentable to government agencies and to a disinterested public, but it does so at the expense of that central feature of the environmental movement: passionate involvement. (p. 19)

Teaching Practice

Refer to Teaching Practice section in the previous learning unit as many of the general points on teaching practice are relevant for this learning unit too. Teaching activities have been interspersed into the subject knowledge section.

Assessment Practice

Refer back to the Assessment section in Biodiversity learning unit 1, as many of the general ideas are relevant here. The table below gives some assessment activity examples and illustrates some assessment skills relevant to this unit.

CONTENT KNOWLEDGE SECTION	SECTION SUMMARY	ASSESSMENT ACTIVITY EXAMPLES	KEY ASSESSMENT SKILLS (VERBS)
Role of biodiversity	Diverse range of services provided by biodiversity (to human kind and to the environment), both realised and the future potential.	Survey of local plant uses (Grade 11) [Practical activity]	Design/plan an investigation, measuring, recording, illustrate (draw graphs), interpretation

Unit 3

Causes of biodiversity loss and emerging human responses to biodiversity loss

This unit explores the causes of biodiversity loss, specifically the impacts of humans on biodiversity, and then how humans are responding to this loss.

Unit 3 Biodiversity related topics within the CAPS, showing relevant grades and terms

SUB-THEME	CONTENT	BIODIVERSITY RELATED TOPICS IN CAPS – LIFE SCIENCES	GRADE	TERM
Impacts of human activities on biodiversity	Biodiversity loss Overexploitation Extinction Invasive aliens Ecosystem change Desertification	p.51-52 – Causes and consequences of the following (relate to conditions and circumstances in South Africa): **Water** ◆ Destruction of wetlands ◆ Poor farming practices ◆ Exotic plantations and depletion of water table ◆ Alien plants, e.g. Eichornia **Food Security** *(link with population ecology dynamics)* ◆ human exponential population growth; ◆ poor farming practices: monoculture; pest control, loss of topsoil and the need for fertilisers; ◆ alien plants and reduction of agricultural land; ◆ the loss of wild varieties: impact on gene pools; ◆ genetically engineered foods; **Loss of Biodiversity** (the sixth extinction) ◆ habitat destruction: farming methods, e.g. overgrazing and monoculture, golf estates, mining, urbanisation, deforestation; loss of wetlands and grasslands; ◆ poaching, e.g. for rhino horn, ivory and 'bush meat'; ◆ alien plant invasions: control using mechanical, chemical and biological methods; and ◆ indigenous knowledge systems and the sustainable use of the environ-ment e.g. devils' claw, rooibos, fynbos, the African potato *(Hypoxis)* and *Hoodia*.	11	4
Biodiversity conservation	Environmental Education and Education for Sustainable Development Protected areas, CBNRM, *in situ* and *ex situ* conservation Invasive alien control Policy and legislation Multilateral Environmental Agreements/International Conventions (CBD, Ramsar, CITES, World Heritage Convention) Low Carbon and Green Economy			

Subject Content Knowledge

Human impacts on biodiversity

Key issue:

It is important to recognise the diverse drivers of biodiversity change (direct and indirect), mostly human induced, and the complex interrelated nature in which these drivers impact on biodiversity in reality.

Human (development) activities have both direct and indirect effects on biodiversity, leading to changes in the provision of ecosystem services by the environment. Human (anthropogenic) activities that impact on biodiversity include agriculture, industry, urbanisation, transport, excessive extraction of biological resources. These are referred to as the drivers of biodiversity loss (losses of different components of biodiversity) (Millennium Ecosystem Assessment, 2005). Drivers of biodiversity loss are both local and global in nature. It should be noted that changes in biodiversity are usually the result of multiple drivers and the interactions between these.

The main causes (direct drivers) of biodiversity loss are habitat change, climate change, overexploitation, invasive alien species and pollution (Secretariat of the Convention on Biological Diversity, 2010).

The Sixth Extinction?

Discuss the implications of the following passage:

Scientists agree that the Earth is currently undergoing a new wave of mass extinction that rivals the five great mass extinctions of the geological past. While past extinctions have been caused by geophysical events (climate change, plate tectonic movements, collision between the Earth and extra-terrestrial bodies/comets, and volcanic eruptions), the current wave of extinctions is human induced (biotic).

This sixth extinction is believed to have two phases, the first phase being the effect of the dispersal of humans to occupy different parts of the earth (100 000 years ago). The second phase was the effect of the agricultural revolution (10 000 years ago) and the subsequent industrial revolution.

The main factors contributing to the sixth extinction are:

i) transformation of the landscape (habitat change),
ii) over-exploitation of species,
iii) pollution, and
iv) introduction of invasive aliens species.

Habitat change

Land cover change through conversion of habitats into agricultural land for crop and livestock farming as well as housing and industrial developments significantly impacts on natural ecosystems and their biodiversity. Human activities such as mining in the Gauteng Province affect underground water systems (through acid mine drainage) and above ground natural ecosystems (with visible impacts such as mine dumps, open pits and slime dams). Huge expanses of agricultural farmland are used for crop monocultures which are significant contributors to habitat change and biodiversity loss. Crop monocultures result in loss of wild biodiversity and gene pools of wild crop relatives which then affects food security.

Pollution

It should be noted that pollution and greenhouse gases can have far reaching effects. The impacts can be realised in areas across the globe, far removed from their source in space and time.

Linked to agricultural activities is the release of synthetic chemical substances such as inorganic fertilisers (nutrient loading), herbicides and pesticides, which have a cumulative effect in food chains and food webs in the environment and affect natural biodiversity as documented in Rachel Carson's *Silent Spring* (1962). Inorganic (synthetic and non-biodegradable) chemical substances and gaseous pollutants from industrial and other human activities are also significant contributors to environmental change. These include the release of greenhouse gases as well as toxic substances into the environment.

Overexploitation

Natural resources provide many products for use by humankind. However, when resource utilisation goes beyond meeting basic human needs to non-sustainable exploitation for profit where demand exceeds supply, this results in significant biodiversity loss. High demand for timber forest products has resulted in the loss not only of the targeted species but of natural forest ecosystems from which they are derived. Similarly, demand for fish has resulted in the collapse of fish populations and ultimately the extinction of some fish species through overfishing, for example the Peruvian anchovy (Clarke, 1976). Overexploitation includes extinction of animals hunted for meat, for ivory and horns (e.g. elephant and rhino in southern Africa), animals hunted for their skins or fur, rare plants and animals in demand as collection specimens by private collectors, and commercialisation of traditional medicinal plants.

Invasive alien species

The deliberate or accidental introduction of non-native species into ecosystems results in a destabilising change in species composition within an ecosystem and has been a major cause of species extinction. Loss of certain indigenous species occurs, for example through predation or competition for similar habitats, wherein the indigenous species are outcompeted as exotic species normally lack natural predators in the new ecosystem they invade. Examples of invasive plants include the invasive gum, pine, wattle and prickly pear populations in local vegetation in the Eastern Cape and KwaZulu-Natal, as well as the invasive water hyacinth on inland water bodies. Invasive animals include the controversial issue of exploding populations of introduced rabbits on Robben Island in the Western Cape, the invasive bass and carp that have successfully outcompeted native fish in inland riverine ecosystems, and the varroa mite which attacks and is causing the collapse of native bee populations.

Climate change

Human induced (anthropogenic) global climate change has had a significant effect on local ecosystems and their biodiversity (IPCC, 2007). Seasonal changes have resulted in changes in species distribution and population sizes. Included among these are the shifting distribution of vector borne diseases such as malaria and waterborne diseases such as cholera, resulting in increased disease outbreaks, even in new areas. Also related to climate change is encroaching desertification due to increased drought periods as well as unprecedented flooding in some areas.

There are also some indirect drivers to biodiversity loss. These include change in economic activity, population change, socio-political factors, cultural and religious factors, and science and technology.

There is a direct link between the status of biodiversity and human well-being. Loss of biodiversity negatively affects (diminishes) the ability of ecosystems to provide goods and services to humankind. This is more apparent in local communities that rely directly on natural resource goods and services for their daily livelihood sustenance. For example women having to walk longer distance to get firewood due to deforestation or fetch water due to drought and desertification.

ACTIVITY 9

EXPLORING BIODIVERSITY AND HUMAN IMPACTS

Learning focus:

Environmental awareness. Comparison of biodiversity scenarios within a built environment and outside in a natural environment. Use of identification guides to name plants and animals. Species, populations and ecosystems, counting, measurement (data processing).

For more on fieldwork and collaborative research as an educational method see page 24 in the *Methods and Processes* booklet.

Resources:

School classroom, school yard and garden, natural environment, ruler, tape measure, identification guides or charts (for weeds, invasive plants and for local plants and animals).

i) Class discussion

Activity: Compare and contrast (deliberation) (Grade 10, term 4)

Ask students to differentiate between the diversity of living organisms that they observe in the outside environment and within their classroom. Ask them to relate this to the impact that human activities have on biodiversity and to cite other examples of such impacts.

ii) Fieldwork

Activities:

a) *Transect walk (investigation) (Grade 10, term 4; Grade 11, term 1):*

Take the learners to a natural area and to the school yard and ask them to compare the diversity within the school environment and in the natural area. They should look at the diversity within each square metre in the school yard and the diversity within each square metre in the natural environment along a line transect of 10 metres. They should do this by counting and making a list the different living organisms they see in the natural area and comparing this list with that of living organisms within their school. They should count not just the numbers of different species but the population sizes of each species. Ask the learners to identify the different species using identification guides or charts for plants and animals (you can arrange to borrow these from the school or nearby library, obtain them from the local Department of Environmental Affairs or download some from the Internet). Learners should also note and list other differences between the school yard environment and that of the natural area. The learners should record their findings in a table showing the different species and the numbers of each species within each square metre of the line transect for the two different environments. Each learner should then write an essay on the impact of human activities on biodiversity based on their experiences.

b) *Observing and recording (learning by doing) (Grade 10, term 4; Grade 11, term 1):*

Take learners to a school garden and ask them in groups to list and record the different types of weeds that they observe in the garden. They should take a sample of each weed and bring this back to the class and attempt to identify each weed using a guide or chart for garden weeds or for alien invasive plants. Ask them to find out and write an essay on the effects of alien invasive plants on our biodiversity.

Responses to biodiversity loss

Key issue:

Responses to biodiversity loss are quite varied. However, no singular response is effective on its own. Each response is a continuous learning process and in some instances certain responses can have negative implications. An integrated approach to biodiversity conservation is more feasible.

Considering the important role of ecosystems and biodiversity to humankind and to the environment in general, several responses to reduce the human impacts on biodiversity have emerged. These include traditional Western conservation approaches in protected areas, international and national conventions, policies and legislation, gene banks, collaborative management and community based natural resources management (CBNRM). Summarily, at a local level, responses promote the implementation of local biodiversity conservation initiatives, drawing on the synergic link between local biodiversity and human well-being. At the regional and global level, effective responses enable the development of shared goals and programmes such as regional treaties and agreements, establishment of transboundary nature reserves, and international conservation-related conventions. The low carbon and green economy encompasses technological interventions to reduce business impacts on the climate and subsequently on biodiversity. Some examples of emerging responses to biodiversity conservation are given below.

Environmental Education and Education for Sustainable Development

Environmental Education (EE) is an educational response to environmental challenges (most of them resulting from human activities) that draws upon a holistic view of the environment. This holistic view of the environment does not consider humankind as an independent component of the environment but incorporates the biophysical and human dimensions (socio-ecological aspects) of the environment and the integrated relationships between them. It focuses on raising awareness of environmental issues and responding to them through relevant environmental knowledge, skills attitudes, values and practical action. EE is lifelong learning process that seeks solutions to emerging environmental challenges, such as reversing negative environmental trends and adapting to a changing environment.

Education for Sustainable Development (ESD) derives from a realisation of the intertwined nature of environmental issues and human development and the need to balance economic growth, social needs with environmental concerns (see Nhamo, Shava & Togo, 2011). ESD promotes a reorientation (rethinking) of education programmes, systems and processes towards the development of sustainable societies. This includes initiatives such as sustainable agricultural practices and renewable energy.

Indigenous conservation practices

Indigenous communities have employed a variety of methods to conserve biodiversity, showing their relationship with the environment and their concern for its sustainable use and conservation. For example it was taboo to kill, eat or destroy some species as they were considered sacred. These species include the python, the pangolin, the secretary bird, the owl. Certain trees were never cut down, including the rain tree (*Lonchocarpus capassa*) which was believed to bring division and bad luck in the family if it was used for firewood (Shava, 2000). Some trees and plants were protected and traditionally conserved because of their medicinal value (Shava & Mavi, 1999). Indigenous fruit trees were never cut down, even if they occurred in a field, as they were considered sources of food. Similarly some wild leafy vegetables were recognised as food sources and not weeds. Most families would not hunt down and eat a particular animal (or plant) because it was their totem.

Traditional (western) protected areas

These include state nature reserves (national, provincial or local government), national parks, gazetted state forests and botanical reserves for *in situ* conservation of biodiversity. Traditional (western) protected areas rely on the power of the state to define areas in which varying degrees of conservation (from strict preservation to protected multi-use landscapes) are put in place, to set policies for land and resource use, and to enforce those policies through allocation of resources and prosecution of offenders. In South Africa, the South African National Parks (SANParks), the South African National Biodiversity Institute (SANBI) (formerly South African National Botanical Institute) as well as provincial and local park institutions are the main custodians of biological diversity, managing vast areas of parks, game and botanical reserves.

Discuss the implications of the conservation of the African elephant in the Kruger National Park. While conservation has reversed severe losses of the species, the current population sizes are a cause of concern, both to the park vegetation and to the neighbouring communities. Some consider culling a solution while some animal rights activists do not support this practice; some scientists suggest translocation or contraceptives and local communities are caught in dilemma of crop-invading elephant encroachment. (Cummings & Jones 2005)

Some environmental non-governmental organisations (NGOs) have been actively engaged in the conservation and management of natural resources for a long time. These include the Wildlife and Environment Society of South Africa (WESSA) and the Endangered Wildlife Trust (EWT).

Support for biodiversity conservation also comes from the private sector, for example, the Mazda Wildlife Fund and Goldfields.

Collaborative management and community-based natural resource management (CBNRM)

This usually involves multiple stakeholder arrangements – government, community, and private sector – to identify and implement approaches to conservation that may include varying degrees of sustainable natural resource use. CBNRM approaches range from local community traditional approaches such as sacred sites, forests and groves to western style protected areas. They provide community participatory alternatives to traditional western biodiversity conservation approaches.

The Malukuleke Region of the Kruger National Park is an example of a CBNRM initiative involving participation of previously displaced local communities in the management of natural resources under the People and Parks programme initiatives of the South African National Parks (SANParks) (Steenkamp & Uhr, 2000).

Discuss the implications of colonially derived western conservation approaches on indigenous local populations.

Ex situ *conservation*

Ex situ conservation involves the conservation of key species, including in some cases threatened or endangered species outside their natural habitats. Key examples include conservation in botanical gardens and zoos as well as gene banks for agrobiodiversity conservation. A number of endangered species in the wild are revived by *ex situ* conservation initiatives through breeding and re-introduction. These include the cheetah and cycad species in South Africa.

Non-consumptive use of biodiversity

Ecotourism and photographic safaris provide alternative approaches to enjoying biodiversity without destruction as opposed to trophy hunting.

Private game reserves

Private game reserves, a growing sector in South Africa, are a significant emerging approach to biodiversity conservation. These business entities vary in size from small individually owned game farms to huge estates owned by consortiums.

> *Private game reserves are a controversial issue, especially in the Eastern Cape Province where farm workers find themselves without employment after conversion of agricultural farms into private game farms. Discuss this.*

Invasive aliens control

Local programmes to eradicate and control invasive aliens have been implemented in South Africa. These include the national Working for Water programme, targeting the eradication and control of invasive alien plants in water catchment areas and the Working for Wetlands programme aiming at the protection, rehabilitation, and sustainable use of the country's wetlands (Department of Environmental Affairs, 2011). Both programmes fall under the government's Expanded Public Works Programme.

> *Alien plants and animals are considered a nuisance and there is a drive to eradicate them. However alien species are sometimes useful to local communities as timber resources, food and medicine. Debate this issue in the context of the Working for Water and Working for Wetlands projects.*

Policy and legislation

National legislation

There are several laws in South Africa for the protection of the environment in general and for the conservation of species and habitats specifically. These include the following:

- Atmospheric Pollution Prevention Act, Act 45 of 1965
- Bill of Rights – Chapter 2 of the Constitution of the Republic of South Africa, 1996
- Conservation of Agricultural Resources Act, Act 43 of 1983
- Environment Conservation Act (ECA), Act 73 of 1989
- Environmental Laws Rationalisation Act, Act 51 of 1997
- Marine Living Resources Act, Act 18 of 1998
- National Environmental Management Act (NEMA), Act 107 of 1998.
- National Environmental Management: Air Quality Management Act, Act 39 of 2004
- National Environmental Management: Biodiversity Act, Act 10 of 2004
- National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008
- National Environmental Management: Protected Areas Act, Act 57 of 2003
- National Environmental Management: Protected Areas Amendment Act, Act 15 of 2009
- National Environmental Management: Waste Act, Act 59 of 2008
- National Forests Act, Act 84 of 1998
- National Heritage Resources Act, Act 25 of 1999
- National Parks Act, Act 57 of 1976

- National Veld and Forest Fire Act, Act 101 of 1998
- National Water Act, Act 36 of 1998
- Physical Planning Act, Act 125 of 1991
- Water Services Act, Act 108 of 1997
- Water Services Amendment Act, Act 30 of 2004

International environmental agreements/treaties/conventions and related programmes

Species and habitats are not confined to national boundaries but tend to straddle them. Similarly the impacts on biodiversity span political boundaries. The realisation of biodiversity conservation as a global concern has resulted in various international conventions to conserve biodiversity. These include:

- Convention on Biological Diversity (CBD) (1992)
- Convention on International Trade in Endangered Species (CITES) (1973)
- The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat (1982 & 1987)
- United Nations Framework Convention on Climate Change (UNFCCC) (1992)
- United Nations Convention to Combat Desertification (1994)

International conservation organisations play an important role in spearheading global biodiversity conservation through supporting the development of international agreements (conventions), and the implementation of multinational conservation initiatives such as transboundary parks and game reserves, and international initiatives such as Global Strategy for Plant Conservation (GSPC) (The Secretariat of the Convention on Biological Diversity, 2008), Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) (FAO, UNDP & UNEP, 2008) and Payment of Ecosystem Services (PES) (Forest Trends, The Katoomba Group & UNEP 2008). Such international organisations include the United Nations Environmental Programme (UNEP), the International Union for Conservation of Nature (IUCN), World Wildlife Fund for Nature (WWF), Botanical Gardens Conservation International (BGCI), Biodiversity International and Birdlife International.

The low carbon and green economy

The low carbon and green economy hinges on the willingness by the industrial sector to invest in sustainable economic activities through initiatives that enable mitigation of and adaptation to human induced climate change effects. These initiatives include cleaner technologies, renewable energy and energy efficiency and investment in the carbon market (such as the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).

Some science and technology advances are considered to provide solutions to environmental problems. However, they could lead to more environmental problems. Consider this in the light of wind energy as renewable energy resource and the emerging negative effects of wind farms on bird and bat populations. (Jenkins, 2011)

ACTIVITY 10

INVESTIGATING BIODIVERSITY
Projects, surveys and research assignments

For more on these educational methods see the *Methods and Processes* booklet.

Learning focus:

Measurement and recording, monitoring, critical analysis, problem solving, decision making, deliberation, conflict resolution, research and report writing, action learning for transformation, environmental values clarification.

Resources:

School grounds, articles on energy resources.

i) Class or school project (learning to act)

Activity: Reducing our carbon footprint (Grade 10, term 4; Grade 11, term1)

Divide your class into groups. Ask the learners to make an audit (identify and measure and record the impact) of the school's carbon footprint that negatively impacts on biodiversity (energy consumption, water consumption, waste accumulation, etc) over a period of time (e.g. one day). The learners should then discuss different ways in which they can reduce human impact on biodiversity and on the broader environment. Task each learner to write an essay on this. Engage your class in a practical project in which they implement these activities to reduce the human impact on biodiversity in the school (e.g. recycling, tree planting, establishing indigenous gardens (e.g. medical plants gardens or indigenous fruit and vegetable gardens), water harvesting, energy use reduction, adopt a park, etc.).

ii) Public survey

Activity: Opinion poll on elephant culling (Grade 11, term 1)

Ask the learners to draw up a public survey form to test the public opinion about culling. Test this form through a survey of opinions within the class. Show results in a pie graph.

iii) Individual research assignment (investigation and reporting)

Activity: Energy in South Africa (Grade 11, term 1)

South Africa's energy supply company, ESKOM, relies on mainly coal-powered electricity generation as well as nuclear powered stations. Research the environmental impacts of such energy sources and on alternative cleaner energy sources that can also be used to supply electricity. Write an essay on the impact of coal and nuclear powered electricity generation on biodiversity and the environment and discuss the positive effects of alternative electricity sources as a response to this.

ACTIVITY 11

BIODIVERSITY CONSERVATION
Lectures, role play and debate

For more on these educational methods see the *Methods and Processes* booklet.

Learning focus:

Recall (listening with intent), critical analysis, problem solving, decision making, deliberation, conflict resolution, research and report writing, action learning for transformation, environmental values clarification.

Resources:

Guest person (conservation expert); learner groups, elephant article.

i) Lecture/seminar/talk (information transfer)

Activity: Guest presentation (Grade 10, term 3)

Invite a resource person from a local environmental organisation or government institution to give a talk to your class about plant or animal biodiversity and the need for its conservation. Alternatively you can take your learners on a guided tour visit of a natural park, zoo or botanic garden. Ask the learners to take notes on what is said or what they observe. The learners should then write an essay on what was said or on what they saw and were told with regards to biodiversity conservation.

ii) Role play (deliberation)

Activity: Park and community conflict (Grade 11, term 1)

Describe a scenario in which there is heated conflict between park managers and the neighbouring local community because lions from the park are killing livestock of the local community members and elephants are destroying their crops and threatening the lives of the local communities. Local community members are threatening to kill these animals and are demanding compensation for their losses. A meeting is called to resolve this issue involving the park management and the community members and their chief. Ask the members of the class to assume the different roles in this meeting and to act out this meeting. Some members of the class are to play the role of the park management (the park manager and conservation staff), while other will assume the roles of the community members. Each side should argue their points and eventually a consensus should be reached.

iii) Debate

Activity: Elephant Crisis in Kruger National Park (Grade 10, term 4, Grade 11, term 1) (Appendix 1)

Ask your learners to read an article on the elephant crisis in the Kruger National Park in South Africa. Divide the learners into an even number of groups. Ask half of the groups to argue for the culling of elephants and the other half to argue against elephant culling. After they have discussed they should write down their points and present them. A point should be awarded for each well supported fact. The side with the highest number of points wins the argument.

ACTIVITY 12

TEACHER ACTIVITY

1) Work with the Life Sciences curriculum. Look at the three specific aims outlined in the document and map out the skills associated with each of the three specific aims.
2) Choose one of the activities in the text above and list all of the skills that could be developed through the activity.
3) For each skill describe how the activity can develop this skill and consider some of the challenges that you as a teacher might have in supporting the development of this skill (Do you and/or your learners have the necessary prior knowledge? Do you have the relevant knowledge resources to develop the necessary skill? Are there any fundamental skills not yet in place that might hinder the development of this particular skill? Are there any logistical or structural problems associated with developing this skill?).
4) Reflect on the overall strengths and weaknesses of this method (use the *Methods & Processes* booklet to help facilitate this reflection).

Teaching Practice

Refer to this section in the learning unit 1 as many of the general points on teaching practice are relevant here too. Teaching activities have been interspersed into the subject knowledge section.

Assessment Practice

Refer to this section in Biodiversity learning unit 1, as many of the general ideas are relevant here. The table below gives some assessment activity examples and illustrates some assessment skills specifically relevant to this unit.

CONTENT KNOWLEDGE SECTION	SECTION SUMMARY	ASSESSMENT ACTIVITY	KEY ASSESSMENT SKILLS (VERBS)
Responses to Biodiversity issues	Varied emerging responses to biodiversity concerns and their (positive and negative) implications	1. Role play of park-community conflict (Grade 11) 2. Debate on elephant crisis in Kruger (Grade 10, 11) 3. Public survey – opinion poll on elephant culling (Grade 11) [Practical activity] 4. Research on energy sources and their implications (Grade 11)	Recall, debate, discuss, predict, critically analyse, solve problems, use knowledge, write/ synthesis Design/plan an investigation, using equipment properly and safely, measuring, recording, interpretation

Conclusion

These biodiversity learning units attempt to draw together key biodiversity aspects across the Grade 10-12 Life Sciences curriculum as contained in CAPS. This is intended to create/provide a progressive understanding (conceptual and logical coherence) of the topic while covering the required aspects in the curriculum.

It is important to realise that knowledge on biodiversity is continually evolving and that learners should acknowledge that while some knowledge is factual, some of it is contested and uncertain. There is a reality beyond what we actually know and thus even factual knowledge is constantly being challenged and updated.

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This list includes both references cited in these units as well as extra useful resources.

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Appendices

Appendix 1

Biomes of South Africa

Succulent Karoo

VITAL SIGNS	
Hotspot Original Extent (km ^{2})	102,691
Hotspot Vegetation Remaining (km ^{2})	29,780
Endemic Plant Species	2,439
Endemic Threatened Birds	0
Endemic Threatened Mammals	1
Endemic Threatened Amphibians	1
Extinct Species†	1
Human Population Density (people/km ^{2})	4
Area Protected (km ^{2})	2,567
Area Protected (km ^{2}) in Categories I-IV*	1,890

†Recorded extinctions since 1500.
*Categories I-IV afford higher levels of protection.

The Succulent Karoo of South Africa and Namibia boasts the richest succulent flora on earth, as well as remarkable endemism in plants, with 69 percent as endemics. Reptiles also show relatively high levels of endemism in the region. It is also one of only two entirely arid ecosystems to earn hotspot status, and is home to the mysterious tree-like succulent, the halfmens, as well as many unique species of lizards, tortoises and scorpions.

Grazing, agriculture and mining, especially for diamonds and heavy metals, threaten this fragile region. Fortunately, low population levels have allowed for greater preservation in the Succulent Karoo when compared to other more densely populated regions.

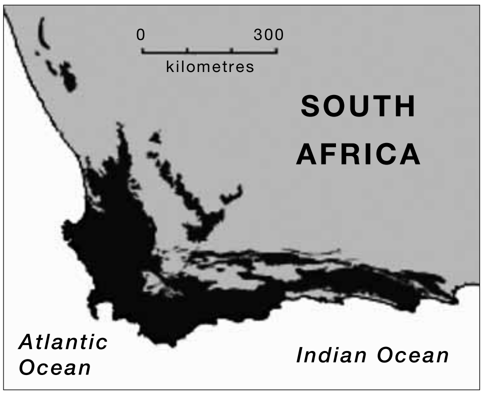
Overview

Stretching along the Atlantic coast of Africa, from southwestern South Africa into southern Namibia, the Succulent Karoo hotspot covers 102,691 square kilometers of desert. Some pockets of this hotspot are scattered within the Cape Floristic Region Hotspot, which borders it to the south. In fact, the Succulent Karoo exhibits a particularly strong floristic affiliation with the Cape Floristic Region, to the point that some have argued convincingly for the region's inclusion as part of a greater Cape Flora.

The Succulent Karoo, which consists primarily of winter rainfall desert, is one of only two hotspots that are entirely arid (the other is the newly recognized Horn of Africa). The region is commonly divided into two zones. The first, Namaqualand, extends along the west coast of South Africa and southern Namibia. It is a winter rainfall desert with a mild climate moderated by cold Atlantic Ocean currents. The mild climate has contributed to the evolution of a rich array of endemic species. The second zone, the Southern Karoo, experiences peaks of rainfall in spring and autumn and has more extreme climate variations than the Namaqualand desert.

Dwarf shrubland dominated by leaf succulents is found throughout the hotspot. These drought-adapted plants have thick, fleshy leaves or stems for water storage. In the Succulent Karoo, there are about 1,700 species of leaf succulents, and this dominance is unique among the world's deserts. The recent and explosive diversification of the Mesembryanthemaceae, the largest group, has been described as an event unrivaled among flowering plants. Stem succulents are also found here (around 140 species), as are seasonal bulbs and annuals that display magnificent spring blooms in the open spaces between the shrubs, particularly during the spring in the Namaqualand. Hilly areas in the southern Karoo are dotted with evergreen shrubs and tall aloes.

Cape Floristic Region



VITAL SIGNS	
Hotspot Original Extent (km ^{2})	78,555
Hotspot Vegetation Remaining (km ^{2})	15,711
Endemic Plant Species	6,210
Endemic Threatened Birds	0
Endemic Threatened Mammals	1
Endemic Threatened Amphibians	7
Extinct Species†	1
Human Population Density (people/km ^{2})	51
Area Protected (km ^{2})	10,859
Area Protected (km ^{2}) in Categories I-IV*	10,154

†Recorded extinctions since 1500.
*Categories I-IV afford higher levels of protection.

Evergreen fire-dependent shrublands characterize the landscape of the Cape Floristic Region, one of the world's five Mediterranean hotspots. Home to the greatest non-tropical concentration of higher plant species in the world, the region is the only hotspot that encompasses an entire floral kingdom, and holds five of South Africa's 12 endemic plant families and 160 endemic genera. The geometric tortoise, the Cape sugar-bird, and a number of antelope species are characteristic of the Cape Floristic hotspot.

Overview

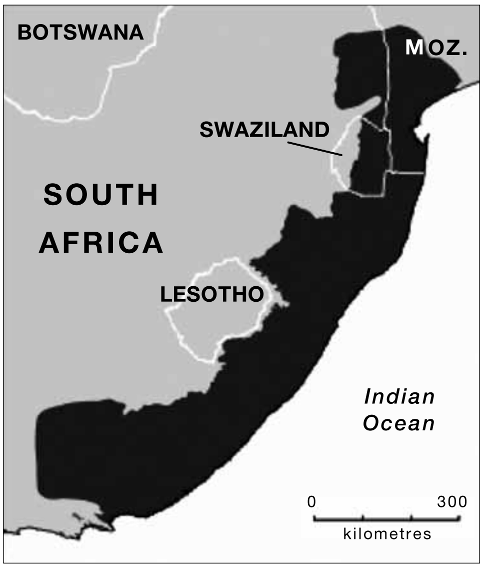
Hugging the coastline along the far southwestern tip of the African continent, the 78,555 km²: Cape Floristic Region hotspot is located entirely within the borders of South Africa. It is one of the five temperate Mediterranean-type systems on the hotspots list, and is one of only two hotspots that encompass an entire floral kingdom (the other being New Caledonia).

The vegetation on the Cape is dominated by fynbos (an Afrikaans word for "fine bush"), a shrubland comprising hard-leafed, evergreen, and fire-prone shrubs that thrives on the region's rocky or sandy nutrient-poor soils. Although the region was once covered by lush rain forest, climate changes around 15 million years ago resulted in the retreat of the forests. Trees were replaced by flammable sclerophyllous plants, and periodic fires became an integral ecosystem process.

The Cape also includes several non-fynbos vegetation types. Of these, Renosterveld (Afrikaans for "rhinoceros veld," referring to the presence of the black rhinoceros (Diceros bicornis), that used to browse there but is now extinct in this region) is the most extensive, covering some 20 000 km². This plant community comprises a low shrub layer, usually dominated by the renosterbos (Elytropappus rhinocerotis), with a ground layer of grasses and seasonally active bulbs.

Today, trees are very rare in pristine Cape landscapes and true forests occupy a mere 3,850 km², mostly in moist, fire-protected sites on the southern coastal forelands and lower mountain slopes. The Cape forests, 10-30 meters tall, are essentially outliers of the Afromontane forests of the high mountains of tropical Africa.

Maputaland–Pondoland–Albany



VITAL SIGNS	
Hotspot Original Extent (km ^{2})	274,136
Hotspot Vegetation Remaining (km ^{2})	67,163
Endemic Plant Species	1,900
Endemic Threatened Birds	0
Endemic Threatened Mammals	2
Endemic Threatened Amphibians	6
Extinct Species†	0
Human Population Density (people/km ^{2})	70
Area Protected (km ^{2})	23,051
Area Protected (km ^{2}) in Categories I-IV*	20,322

†Recorded extinctions since 1500.
*Categories I-IV afford higher levels of protection.

Maputaland-Pondoland-Albany, which stretches along the east coast of southern Africa below the Great Escarpment, is an important center of plant endemism. The region's warm temperate forests are home to nearly 600 tree species, the highest tree richness of any temperate forest on the planet. The celebrated, bird-of-paradise flower is a distinctive hotspot endemic.

The rescue of the southern subspecies of white rhinoceros from extinction, which took place in this hotspot, is one of the best-known success stories in African conservation. Regrettably, much of the once expansive grasslands and forests in which many of the large mammals dwell is facing increased threats from industrial and local farming and also the expansion of grazing lands.

Overview

The Maputaland-Pondoland-Albany Hotspot lies along the east coast of southern Africa, below the Great Escarpment, extending from extreme southern Mozambique (south of the Limpopo River, where it adjuts on the Coastal Forests of Eastern Africa Hotspot) and Mpumalanga province in South Africa (south of the Olifants River) in the north, through eastern Swaziland to the Eastern Cape province of South Africa in the south. The region is floristically, climatologically and geologically complex. There are at least three clear foci of high endemism and high diversity in the area, the names of which have been amalgamated as the name of this hotspot: Maputaland (Tongaland) in the north, Pondoland further south, and Albany in the southwest.

The topography of the region ranges from ancient sand dunes and low-lying plains in the north to a series of rugged terraces deeply incised by river valleys in the central and southern parts. The hotspot also incorporates several mountain ranges, including the Sneeuberg, Winterberg, Amatola Mountains, Ngeli Range, Lebombo Mountains and Ngoye Range. The area is bordered on the west by the Great Escarpment, which separates the elevated interior plateau of southern Africa from the coastal lowlands.

The hotspot's vegetation is comprised mainly of forests, thickets, bushveld and grasslands. About 80 percent of South Africa's remaining forests fall within this hotspot. These warm temperate forests, which are home to nearly 600 tree species, have the highest tree diversity of any of the world's temperate forests. The area also has a remarkable succulent flora, principally in the Albany region; these are mainly stem succulents, as opposed to the dominant leaf succulents found in the Succulent Karoo in the western parts of southern Africa. One type of forest (Licuáti forest), three types of thicket, six types of bushveld, and five types of grassland are restricted to the hotspot.

Appendix 2

Imifino

> *"I grew up eating imifino. The species of imifino I know are:* utyuthu*,* ihlaba*,* umsobo-sobo*. I eat* imifino *because it is healthy. I like the wild* imifino *because it is nutritious. Utyuthu is the tastiest one. I learned how to cook* imifino *from my grandmother."*
>
> – Sisi Andiswa, 15 years, East London.

Since ancient times, humans have supplemented their diet with wild leafy vegetables. Most of the species used nowadays to make imifino in South Africa are originally from countries in the Americas, Europe, Asia or North Africa, but now grow as weeds across the world. Some species are cultivated as vegetables elsewhere, for example imbikicane (in India and Nepal), utyuthu (Kenya, Tanzania and India), umsobo (West and Central Africa) and ihlaba (Indonesia).

How and when these plants were brought to South Africa remains uncertain, but by the nineteenth century most of these exotic species were considered part of the traditional diets of black people. Written records show us that certain species were already eaten here in the late seventeenth century: isiqwashumbe (cultivated by Jan van Riebeeck in 1652) and utyuthu (documented as "very frequently stewed instead of spinach" as early as 1680).

Today many people in the Eastern Cape eat wild leafy vegetables. More than 30 species are eaten in the Transkei region alone! When the wild species are not available, other plants are used to prepare imifino or isigwampa, for example pumpkin leaves, potato leaves, beetroot leaves, turnips and turnip leaves, spinach and cabbage. Imifino plants are full of goodness. Imifino species such as utyuthu, imbikicane and umhlabangulo contain protein. Proteins are needed to build up and repair body tissues and muscle development. This is very important for growing children. Protein helps fight infections. Most importantly, imifino plants contain many vitamins and minerals, which are essential for good mental and physical health. Vitamin C helps the body to use calcium and other nutrients to build bones and blood vessels. It helps the cells heal from damage. Vitamin C is therefore important for healing wounds and fighting infection. Imifino species especially rich in Vitamin C include utyuthu, imbikicane and isiqwashumbe. Vitamin A and carotenoids are needed to help the body resist infections and body cells from damage. They keep our eyes healthy and help children to grow. Umsobo, utyuthu, and umhlabangulo are good sources of vitamin A. Vitamin E protects the body cells from damage and deterioration. It is also good for the skin. Imbikicane and umhlabangulo contain vitamin A. Calcium helps to build strong bones and teeth, so it is especially important for growing children. Yoghurt is a good source of calcium, but so are irhawu, umsobo, utyuthu and ihlaba. Iron is needed for the body to replace and build red cells and to build new tissue. It also assists with mental development of children. Most imifino species contain iron. Zinc and selenium are both important for the immune system. Utyuthu and umhlabangulo are rich in zinc. Imbikicane contains a lot of selenium.

Reference

Husselman, A. and Sizane, N. 2006. I*mifino: A guide to the use of wild leafy vegetables in the Eastern Cape*. Institute of Social and Economic Research, Rhodes University. email: iser-sec@ru.ac.za

Appendix 3

The rape of the Pelargoniums

Article by Dr Janice Limson
www.scienceinafrica.co.za

As the sun beats down on Africa, a woman in a veld in the Eastern Cape of South Africa is hunched over her task – uprooting a species of flowering plant, the Pelargonium reniforme. With a spade she digs right down to the roots, until she has unearthed the whole tuber which she breaks off, dumping the head and adding the tuber to the rest in a bag she carries with her. She and her friends working quietly in a row alongside know that tonight they will be eating – a man will be paying her between ZAR3 and ZAR15 per kilogram for the roots they collect. As the story goes, the local man transports truckloads of the roots to agents in Hermanus in the Western Cape from where they are exported to Europe. According to nature conservation official Quintus Hahndiek a conservative estimate is that at least twenty tons of the root have vanished from the Eastern Cape

The *Pelargonium reniforme* is a medicinal plant known to generations of Khoi/San descendants and Xhosa traditional healers for its health-giving properties in curing stomach ailments, dysentery, blood in stools and the like. This species of pelargonium is indigenous to the Eastern Cape and grows wild, sending out long bulbous roots deep into the ground. The medicinally active ingredients are found in the bitter tasting root of the plant.

There are two issues at stake – the unsustainable and indiscriminate removal of indigenous plants and the export of traditional knowledge. This mass removal of these plants will only enrich a few to the detriment of sustainability for future generations of Africans. Unlike species such as cycads, which are strictly controlled, the pelargoniums are not endangered (yet) and not protected under any regulations. To abuse a pun: nature conservation officials find their hands effectively tied with red tape – hands that should be out there catching plant poachers. According to Eastern Cape Nature Conservation officials legislation to protect a range of species including the pelargoniums have been six years in the pipeline and are still doing time on someone's desk waiting for the promulgation of the new environmental bill. In the meantime, plant poachers and bioprospectors have free reign. In a year or two when strong legislation comes into effect to protect indigenous plants – it may be way too late.

Africa is home to a veritable wealth of plant species, many of which contain active ingredients with as yet untold social and economic benefits for humankind. Traditional knowledge holds the secret and key to many of the potentially economically viable species of health-giving plants. The case with the pelargoniums is a harbinger of things to come. Africa must harness its biodiversity for Africa. We have the scientists, the tools and the know-how. Laws should be in place to protect both indigenous knowledge and indigenous plants – but they are not.

In the case of the pelargoniums, nature conservation officials say they have a good idea as to who may be behind the mass removal of the species, but these individuals are protected by loopholes in the law. According to local botanist Tony Dold people have regularly visited his herbarium over the past three years asking for assistance in identifying several medicinal plants, claiming that they had permits to collect these. Dold says that the visitors admitted then that they were screening plants used in traditional medicines for medicinal properties, enlisting the help of rural people in the former Ciskei. Armed with a book containing Xhosa names of the plants, it was a simple matter for them to enlist someone in the Ciskei to find a plant in question. According to Dold it seems they "obviously had a 'hit' " with the Pelargonium and may be the ones who have organized and conducted the mass removal of pelargoniums from the Eastern Cape and export to Europe. Who pays? At present it is the very poor and ignorant who are paying the price. Several Eastern Cape locals have been arrested for illegal collection of the plant on private property. While this serves merely as a warning – they will most likely not be fined nor found guilty.

According to Hahndiek the pelargoniums are not at any risk now of becoming extinct, but in a worst case scenario if this were to continue, land and insects would be paying the price with loss of ground cover, endangerment of the species and ripple effects to insects, such as pollinators feeding from the plant. But there are many other species out there that have caught the attention of bioprospectors such as the threatened African potato. According to Hahndiek nature conservation faces a similar threat from the over-collection of rare and endangered species by traditional healers. The issue says Hahndiek is that of sustainability. Once it's gone it's gone. "It is not just the Eastern Cape, where problems are being experienced, a conservation official form DR Congo painted a bleak picture with mass removal and decimation of plant species. In the Western Cape you have serious problems with the removal of buchu. In other areas its Dassie urine – urine from dassies is used to make expensive foreign perfumes."

Quintus Hahndiek is a concerned man. Nature conservation is understaffed at only 25% of capacity as posts have been frozen in the past few years and remain so. He shows me a pile of proposals for conservation policy that he and others are impatiently waiting to get passed. He is frustrated at the lack of real power they have to protect the environment. Part of the trouble he says is the lack of a national body overseeing all of the nature conservation regions which he says all work separately, each group having to petition for the same laws to get passed for their regions. He is frustrated that traditional knowledge and potential income is leaving the country when Africa should be its beneficiaries. One very simple way he believes to stem this tide and protect traditional knowledge is to pass regulation forbidding the export of all indigenous plants to foreign climes.

The time has come and gone for us to stop paying lip service to the protection of Africa's biodiversity and its traditional knowledge. But it's not too late for us to pull the wool from our eyes, for the powers that be in South Africa to promulgate and enforce the new environmental bill so that nature conservation can get out there and DO their job. Now.

Dr Janice Limson is Editor-in-Chief of Science in Africa

Appendix 4

Invading ants disrupt ecosystem

The tiny black Argentine ant is well known as a household pest. But by replacing native ants, they could also be disrupting natural ecosystems. A study by a University of California, Davis, graduate student, published this week in the journal Nature, has for the first time shown that when key beneficial species are removed by an invader, the destructive effects can reverberate through the ecosystem.

Caroline Christian, a student at the UC Davis Center for Population Biology, studied the fynbos shrublands of South Africa, an area similar in climate and vegetation to the chaparral of California. The fynbos is renowned worldwide for its high level of biodiversity. Wildfires sweep the fynbos every 15 to 30 years, killing most mature plants. New plants grow from seeds buried in the ground by native ants. Christian found that when Argentine ants displace native ants, plants that depend on those ants to bury their seeds do not regenerate after fire. “There’s been a lot of concern that invasive species may disrupt mutually beneficial interactions between plants and animals,” said Maureen Stanton, a professor of evolution and ecology at UC Davis and Christian’s thesis supervisor. If those interactions are crucial, there might be cascading effects on the whole community, she said.

Seed burial by ants is key to survival for about a third of fynbos plant species, Christian said. When fresh seeds fall, ants are attracted to them and carry them off to bury in their nests. Different ant species specialize in seeds of different sizes: Ants that work cooperatively deal with bigger seeds, while ants that tend to work alone bury smaller ones. If the seeds are not picked up quickly, virtually all are eaten by rodents.

Argentine ants do not bury seeds at all. But they do wipe out two fynbos ant species, Anoplolepis custodiens and Pheidole capensis. Two others, Meranoplus peringuey and Tetramorium quadrispinosum, coexist with the invader. It turns out that Anoplolepis and Pheidole ants prefer large seeds, while the others go for small seeds. Large seeds placed in invaded areas were less likely to be buried by ants and more likely to be eaten by rodents, compared to large seeds in uninvaded areas, Christian said. Small seeds were much less affected.

Christian carried out controlled burns of areas in fynbos to see whether the invading ants had a real effect on the plant community. Seeds of many fynbos plants need fire to germinate, so most new growth happens in the year after a fire. After burning, invaded areas showed a tenfold drop in the number of new plants from large-seeded species, compared to uninvaded areas, Christian said.

“It’s sobering, and a wake-up call,” said Stanton. The study showed the threat from invasive species both to the fynbos and to ecosystems in general, she said. “This is the first work to show not just the immediate effects of an invasive species, but the larger effects on an ecosystem,” Stanton said. Potentially, there could be further effects. For example, animals that eat large-seeded fynbos plants may also decline as a result of the Argentine ant invasion, she said.

The study was funded by the National Science Foundation and conducted in Kogelberg Biosphere Reserve, South Africa, with assistance from the South African Museum and Cape Nature Conservation. It is published in the October 20 11 issue of Nature.

Interdependence of biological and cultural diversity amongst the *amaXhosa* and *Mfengu* of the Eastern Cape, South Africa

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In the current studies of the links between biological and cultural diversity very little acknowledgement has been given to the importance of the environment and its resources to communities whose lifestyles have been affected and transformed by modernization.

To date most of the examples depicting the link between biological and cultural diversity refer to more exotic groups of indigenous people and very little acknowledgement has been given to the importance of communities whose lifestyles have been affected and transformed by modernization. In response, the theory of bio-cultural diversity fails to comprehend the resilience, or rather the persistence, of culture and how the networks of globalisation are often used to maintain aspects of cultural practices amongst communities living in peri-urban and urban conditions.

A primary example of this is reflected within the South African context. South Africa is a country that has witnessed 46 years of turbulent political history during which time the state forcibly moved more then 3.5 million people into "homelands" which were established under the apartheid regime. Consequently local people do not represent people "who have historical continuity with pre-invasion and pre-colonial societies that have developed on their own territories; consider themselves distinct from other sectors of society now prevailing in those territories, or part of them". In contrast they represent communities who are completely integrated into the national economy and as a result draw heavily on livelihoods generated from urban areas and/or State benefits, such as pensions and grants.

Yet, despite these influences, communities in this area continue to make use of biodiversity for cultural purposes and are connected to their surrounding environment. This is reflected in a number of ways.

- Many religious practices rely on the use of plant species. Religious rituals are performed to appease the ancestors, and these invariably involve the sacrifice of an animal in the livestock enclosure (*ubuhlanthi*). *Ubuhlanthi* are constructed out of woody material and only two plant species are considered appropriate for the serving of the sacrificial meat: *Olea europaea* subsp. *africana* (*umnquma*) and *Ptaeroxylon obliquum* (*umthathi*). Religious rituals are regularly engaged in by households in both rural and urban areas.
- Certain cultural rituals rely on the availability of particular plant species. For example, during rites of passage, the initiates (*abakhwetha*) are housed in a temporary hut (*ibhoma*) for a period of seclusion after circumcision. The *ibhoma* is constructed with specific plants such as *Ptaeroxylon obliquum* for the frame.
- Traditional healers make use of specific plant species to perform their healing rites. For example, saponaceous plants such as *Silene undulata* (*unozitholana*) are called *isilawu* which derives from *ukulawula*, meaning to interpret dreams. These plants induce vivid dreams when the foam is ingested and are used by diviners to communicate with the ancestors.
- Not only are specific plant taxa important for local people, but so are aspects of the landscape. For example, deep river pools are revered as sacred places where the ancestors are appeased with gifts of maize and tobacco. The ritual is called *umlambo*.
- The interconnectedness between language and nature is made through local idioms and proverbs, people's names and names given to the months and seasons of the year.

Various strategies are used to raise awareness on the links between biological and cultural diversity, including developing policy briefs for the national government.


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Informal medicinal plant market at a taxi rank, South Africa.

Appendix 6

Wetlands

There is clear water up to your ankles and a dragonfly zips past your head as you watch some ducks fly off the water – welcome to the soggy world of the wetland!

Wetlands are difficult to define because of their great variation in size and location. The most important features of wetlands are: Waterlogged soils or soils covered with a shallow layer of water (permanently or seasonally), unique types of soil, and distinctive plants adapted to water-saturated soils. Marshes, bogs, swamps, vleis and sponges are examples of wetlands.

Why are wetlands important?

Flood busters:

Wetlands associated with streams and rivers slow floodwaters by acting as giant, shallow bowls. Water flowing into these bowls loses speed and spreads out. Plants in the wetland play an important role in holding back the water. The wetland acts as a sponge as much of the flood water is then stored in the wetland and is slowly released to downstream areas, instead of it all rushing to the sea within a few days. This greatly reduces flood damage, particularly erosion, and ensures a more steady supply of water throughout the year.

Filters:

Wetlands improve water quality as they are very good natural filters, trapping sediments, nutrients (e.g. nitrogen and phosphorus), and even pathogenic (disease-causing) bacteria. In addition, pollutants such as heavy metals (e.g. mercury, lead) and pesticides, may be trapped by chemical and biological processes. In other words, the water leaving the wetland is cleaner than the water entering it.

Wetlands and wildlife:

Wetlands are filters where sediments and nutrients accumulate, so many plants grow there, e.g. bulrushes, grasses, reeds, waterlilies, sedges and trees. The plants, in turn, provide food and a place for attachment and shelter for many creatures. There is more life, hectare for hectare, in a healthy wetland than in almost any other habitat. These productive places support huge numbers of insects, fish, birds and other animals. Some animals are completely dependant on wetlands, whilst others use wetlands for only part of their lives. The wattled crane, for example, is dependant on wetlands for breeding. The rich diversity of waterbirds in southern Africa (totalling 130 species) is possible because of the many wetlands spread across the sub-continent. The wetlands of southern Africa are of international importance as they are the southern destination for many migratory wading birds.

People and wetlands:

Wetlands have been used for centuries as grazing for domestic stock, and as a source of reeds used for thatching, hut construction and basket weaving. They are provide fishing, hunting and the opportunity to observe wildlife, especially birds. Wetlands are appreciated for their beauty as open spaces and also for their educational value.

Wetlands in trouble

To most people words such as “marsh, swamp, bog and vlei”, conjure up little more than the “four D’s” – dampness, disease, difficulty and danger. Because of this wetlands have been seen as wastelands to be converted to alternative uses such as cropland, dams, plantations of exotic trees, waste disposal sites and pastures. Many wetlands have been "reclaimed" for industry and the construction of airports, harbours and sewage treatment plants. Historically wetlands have been drained in attempts to control malaria.

Did you know?
In KwaZulu/Natal, 58% of the wetlands associated with the Mfolozi River catchment have disappeared as a result of siltation caused by erosion of overgrazed lands.

All wetlands in southern Africa are threatened. Botswana's magnificent Okavango Delta is threatened by the possible canalization of the Boro river to supply water for both domestic and industrial use. In KwaZulu/Natal, debate rages over the mining of the dunes on the eastern shores of St. Lucia because of the unknown consequences to the water table in the area.

St. Lucia is a Ramsar recognised site. The Ramsar Convention on Wetlands of International Importance recognises such wetlands and works to conserve them. South Africa has 12 sites recognised by the Ramsar Convention, including Langebaan on the west coast, Barberspan in Gauteng and De Hoop vlei in the Cape.

What you can do

- The Department of Environment Affairs and Tourism runs a wetland conservation programme and all interested people are invited to participate.
- Get to know the wetlands in your area and list the plants and animals growing there. Draw a map of the wetland's position, size and usage. Take photographs of the wetlands from fixed vantage points and at different seasons of the year to compare the changes between seasons and from year to year.
- Report the abuse of wetlands to your local nature conservation, agricultural extension officer or Department of Environment Affairs. Always make your report in writing to ensure that the officer concerned has to investigate.
- Read "The Biology and Conservation of South Africa's Vanishing Waters" (see below) which has a very useful chapter titled "What you can do".

Further reading

South African Wetlands. Newsletter on the activities relating to the Ramsar Convention in South Africa. Department of Environment Affairs.

The Wetlands of Natal (Parts 1-4). Natal Town and Regional Planning Commission. Private Bag 9038, Pietermaritzburg, 3200.

Ecology and Conservation of Wetlands In South Africa. CSIR occasional report no.56. CSIR 1982. Waterlogged Wealth. E. Maltby, Earthscan,1986.

Wetlands. C. Gaigher. Dept. Environment and Cultural Affairs (previously Cape Nature Conservation).

The Biology and Conservation of South Africa's Vanishing Waters. B.R. Davies and J.A.Day. CEMS, University of Cape Town and The Wildlife Society of Southern Africa, Cape Town, 1986.

Enviro Facts: River Catchments.

Useful addresses

The Department of Environment Affairs and Tourism. Private Bag X447, Pretoria 0001. Tel. 012-310 3425.

All provincial nature conservation authorities.

Universities of Cape Town, Orange Free State, KwaZulu-Natal, Witwatersrand and Rhodes.

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A partnership programme for environmental learning and teacher education