FACILITATOR GUIDE

Conservation

Level 3

P.O. Box 461, Hillcrest, 3650
(031) 313-3364

Title:		**Monitor Natural Resource Management Practices**					
Applied Title:		**Monitor Natural Resource Management Practices in Citrus Production**					
Field:		Agriculture and Nature Conservation					
Sub-Field:		Primary Agriculture					
SETA (SGB):		AgriSETA					
Skills Area:		Conservation					
Context:		Citrus Production					
US No:	116263	**Level:**	3	**Credits:**	4	**Notional Hours:**	40
Author:		Cabeton Consulting					

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Unit standard alignment and assessment tool development:
Cabeton Training and Development

Project coordinator:
Jacomien de Klerk

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Directions

1. Learning Material

This guide has developed to assist the facilitator in presenting this unit standard. The guide contains all necessary material to ensure that the facilitator will be able to assist the learner to attain the competencies required by the unit standard.

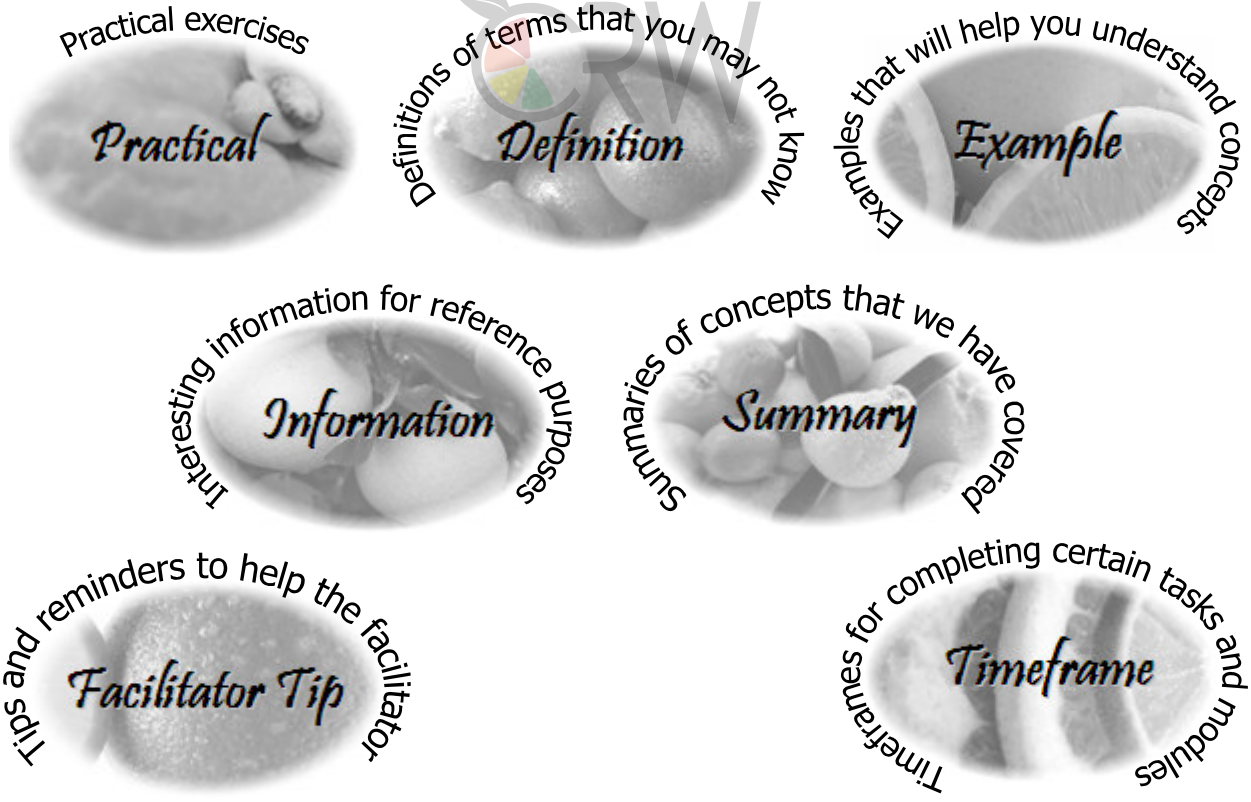
This set of learning material consists of the following guides:

- ***Learner guide*** that contains all the information required by the learner to attain competency in this unit standard
- ***Facilitator guide*** that is a copy of the learner guide but contains additional instructions for the facilitator.
- ***Assessment Guide for Assessors and Facilitators*** that contains all the documentation needed by the assessor and facilitator to assess the competency of the learner against this unit standard.
- ***Assessment Guide for Learner and Learner Workbook*** that contains the documentation required by the learner to complete the assessment, along with the worksheets and practical exercises that the learner needs to complete as part of the formative assessment.

Please ensure that you are familiar with the contents of all of these guides before presenting this unit standard.

Although the learner and facilitator guide contains all the information required for attaining competency in this unit standard, references to additional resources (both printed and electronic) are provided for further study by the learner.

Information in boxes is indicated by tags that show:



2. Learning Program Timeframe

This is a summary of the timeframe for this learning program. You will be reminded of the time allowed for each module as you work through the guide.

Process	*Total Allocated Time*	*Theoretical Learning*	*Practical Learning*	*Activities*
Complete Program (Including summative assessment)	**40h**	**12h 30min**	**27h 30min**	**12**
Learner Orientation and Ice Breaker	30min	15min	15min	
Purpose, Introduction and Learner Directions	30min	15min	15min	
Revision of Level 2	45min	30min	15min	
Session 1 (Chapter 1)	4h	1h 30min	2h 30min activities	1-3
Session 2 (Chapter 2)	3h 30min	1h 30min	2h activities	4-5
Session 3 (Chapter 3)	3h	1h 30min	1h 30min activities	6
Session 4 (Chapter 4)	4h 30min	1h 30min	3h activities	7-9
Session 5 (Chapter 5)	2h 30min	1h 30min	1h activities	10
Session 6 (Chapter 6)	2h 15min	1h 30min	45min activities	11
Session 7 (Chapter 7)	2h 30min	1h 30min	1h activities	12
Practical work on a farm: Participate in, undertake and plan farming activities with knowledge of their environment impact.	14h		14h	
Preparation for Assessment and Revision	2h	1h	1h	

3. Technical Program Specifications

Format	Programmed instruction workshop, combined with structured internship format as prescribed for learnership, skills program or short course.

Target Learner Description	A typical level 3 learner would have been exposed to the working world for some time as a team member, and would now be ready to emerge as a team leader or supervisor. **EE Ratios:** 1 Male:1 Female 8 PDI:2 W 1 Employed:1 Unemployed
Articulation Options	Nil formal in place
Delivery Mode	A combination of small group mode and individual mode
Training Method and Activities	**Program Instruction:** This program forms part of an apprenticeship where coaches provide practical training in the fields requiring functional competency. The theoretical study section of the training is conducted as a 4-day workshop in the Cohort group format. Additional training activities include buzz groups, rotating role-plays, simulations, games and brainstorming sessions, and group discussions.
Learner Support Strategies	Learners are inducted by "explore strategies to learn program". Learners are supplied with all resources and aids as required by the program, including: • Objects and devices such as equipment • Manuals and guides • Visual aids

This unit standard is aimed at level 3 learners.

- A typical level 3 learner would have been exposed to the working world for some time as a team member, and would now be ready to emerge as a team leader or supervisor.
- Explain concepts and define words in a simple, clear and concise method throughout the learning program to help the learner where possible.
- Ensure that you spend extra time on concepts surrounding leadership, presentation skills, responsibility and accountability, as well as critical problem solving skills.
- Take special care to facilitate for ALL learners. Allow them opportunities to share experiences and prior knowledge, to translate into their mother tongue for each other, and to enjoy the learning process.
- The examples given in this resource guide might be for a different geographical area or commodity to what the learner is exposed to. Please adapt your examples according to the learning context.

4. Facilitator's Checklist

This checklist has been designed to assist you in delivering the best possible facilitation to the learners. Please use it and supply whatever resources you might have in short supply at your venue of learning.

Preparation	***Yes***	***No***
Content Knowledge I have sufficient knowledge of the content to enable me to facilitate with ease.		
Application Knowledge I understand the program matrix and have prepared for program delivery accordingly.		
Ability to Respond to Learners Background and Experience I have studied the learner demographics, age group, experience and circumstances, and prepared for program delivery accordingly.		
Enthusiasm and Commitment I am passionate about my subject and have prepared my program delivery to create a motivating environment with real commitment to success.		
Enterprise Knowledge I know and understand the values, ethics, vision and mission of the Citrus Academy and the service provider under whose auspices the program will be conducted, and have prepared my program delivery, reporting and administrative tasks accordingly.		
Equipment Checklist:		
Learner Guides: 1 per learner		
Learner Assessment Guides: 1 per learner		
Writing material and stationery for facilitator and learner		
White board and pens		
Flip chart paper		
Proxima projector and screen		
Notebook computer and program disk		
Documentation Checklist:		
Attendance register		
Course evaluation		
Learner course evaluation		
Portfolios of evidence		

5. Proposed Floor Plan

No floor plan is prescribed for this training module.

Introduction

1. Purpose

A learner achieving this unit standard will be able to explain the importance of maintaining and increasing of natural resources. Furthermore, the learner will be able to incorporate this understanding into existing farming activities by monitoring practices to conserve the environment, including natural resources, thereby ensuring optimal use of natural resources on the farm.

Competent learners will be conversant with agricultural regulations and aspects of conservation so that environmentally sound agricultural practices will be applied. Learners will gain an understanding of sustainable agricultural practices as applied in a citrus production environment. This unit standard focuses on the application of natural resource management in primary agriculture.

Learners will be able to participate in, undertake and plan farming practices with knowledge of their environment. This unit standard will instil a culture of maintenance and care for both the environment as well as towards farming infrastructure and operations.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

NQF Level	*Unit Standard Number*	*Unit Standard Description*
NQF2	Literacy and Numeracy	
2	116121	Apply sustainable farming practices to conserve the ecological environment

It is important to ensure that the learners who are undertaking this learning program has already completed the correct prior learning modules, to ensure that they are not unfairly disadvantaged by the learning process, and can be supported accordingly.

Do not forget to complete the Diagnostic Assessment (Step 3 in the Assessment Guide).

Revision of Level 2

You have to complete this section as follows:

Total time	*Theory*	*Practical*
45min	30min	15min

Spend sufficient time in introducing the learners to each other, their learning environment and the purpose of this program. If time permits, hold a brief class discussion around the concept of conservation to determine what learners already know and to identify areas where you will have to spend extra facilitation time to thoroughly explain information or concepts.

Briefly revise the concepts, definitions, and information below, which serve as a foundation for this programme. Be alert to learners who show uncertainty about the information and determine whether such learners are ready to continue with this programme.

1. Natural Resources and Sustainable Farming Systems

- The environment is made up of various elements, or natural resources, namely ground, water, air, fauna and flora.
- Renewable natural resources are resources that nature reproduces constantly, while non-renewable natural resources are resources that cannot be reproduced, or are reproduced over many years.
- Biotic natural resources are alive, such as plants and animals, while abiotic natural resources are not alive, such as water and air.
- Waste is what is left over once resources have been used to create energy.
- Pollution is the over-production of waste that the environment cannot deal with naturally.
- Acid rain and global warming are deadly consequences of pollution.
- Reusing means using a waste product for another purpose, while recycling means reprocessing waste products to produce other products.
- Energy is the ability to work and is produced from using resources. There are two forms of energy, being working and stored energy.
- Traditional energy sources use stored energy from non-renewable resources, such as the burning of fossil fuels.

- Alternative energy sources aims to use renewable resources and include solar energy, wind energy, water energy, nuclear energy and bio diesel.
- Carbon is the building block of life as most living organisms are made up mostly of carbon atoms.
- Carbon dioxide is produced through amongst others the burning of fuel, and used by plants during photosynthesis.
- Higher production of carbon dioxide and reduction in plants causes an imbalance that causes a greenhouse effect and leads to global warming.
- Carbon sinkholes are where carbon is stored, mostly in organic form in plants and in soil.

2. Beneficial and Non-Beneficial Fauna and Flora

- Fauna means all living organism on earth, while flora means all plants, or vegetation.
- Indigenous flora refers to plants that were originally found in an area or in a country, and that have adapted to the local climatic conditions.
- Fauna and flora are interdependent for life, and live together in ecosystems, such as river catchment area, wetlands, grasslands and estuaries.
- The distinction between beneficial and non-beneficial fauna and flora is in many cases subjective, and depends on the human being making the judgement. Non-beneficial fauna and flora is considered as such because it impacts negatively on the needs of humans.
- Non-beneficial fauna in citrus production includes micro-organisms, such as fungi, viruses and bacteria, and insects that attack citrus trees.
- Non-beneficial flora is commonly referred to as weeds, which can be controlled manually or chemically.
- Beneficial fauna and flora are attracted to a healthy environment, which can be encouraged by limiting the use of chemical control measures, removing alien plant species, and encouraging wildlife activities.
- There are natural alternatives to chemical weed and pest control measures, and natural soil fertilisation can be used in addition to chemical fertilisation.

3. Alien Plant Species and Noxious Weeds

- Alien, or invasive, plants are plant species that are not indigenous, and were brought to South Africa as garden plants, in horse feed or when plantations were established.
- Alien plants proliferate in South Africa because they do not have any natural enemies in their environment.
- Alien plants are categorised as follows: plants that must be removed and destroyed immediately, plants that may be grown under controlled conditions only, and plants that may no longer be planted, but that does not have to be removed.
- Alien plants are controlled by means of sawing, hand-pulling, bio control or herbicides.

4. Erosion

- Soil erosion is caused by water or wind.
- Gullies and dongas are formed as a result of soil erosion.

- Soil erosion can be prevented and controlled by maintaining a grass cover in orchards and controlling irrigation by managing irrigation to prevent excessive runoff.
- Dongas and gullies can be rehabilitated by diverting water ways and by shoring them up.

5. Firebreaks

- Fire poses a great threat to all farming operations.
- A firebreak, or fireguard, is a strip of land that has been cleared of trees, bushes, and any other combustible material in order to prevent a fire from spreading.
- Firebreaks are most commonly made by grading and burning.

Resources A resource is a natural or man-made element. It can be utilised to meet human needs. **Renewable** resources come from sources that are constantly renewed – the wind keeps blowing, the sun keeps shining and the earth keeps heating the ground. **Non-renewable** resources are exhaustible, meaning it cannot be replenished easily, such as fossil fuels, usable water, and soil lost through erosion.
Natural Resources Natural resources are materials that occur in nature and are essential or useful to humans, such as water, air, land, forests, fish and wildlife, topsoil, and minerals. Natural resources that are alive, such as plants, are called **biotic** resources. Natural resources that are not alive are **abiotic**, for example water.
Waste Waste refers to the "leftovers" or unwanted products from industries and other human activities.
Pollution Pollution is the unwelcome concentration of unnatural, harmful or poisonous substances that are beyond the environment's capacity to handle. These substances are detrimental to people and other living things.
Acid Rain When water in the air combines with gasses, most importantly sulphur and nitrogen, rainwater becomes more acid and is referred to as acid rain.
Global Warming Global warming is the increase in the average temperature of the earth's lower atmosphere as a result of an increase in greenhouse gasses since the industrial revolution. Greenhouse gasses are water vapour, carbon dioxide, methane, nitrous oxide and ozone. The sustained increase in temperature causes climatic changes.
Reuse Reusing waste means employing certain waste items for a different purpose, for instance using empty non-chemical plastic containers for storage.

Recycling Recycling means reprocessing waste material and using the material to make new items, such as melting down old plastic containers and using the plastic to make new containers.
Energy Energy is the ability to do work and it comes in various forms of heat and light. There are two main types of energy, being working energy and stored, or latent, energy. Stored energy becomes working energy when it is used.
Carbon Sinkholes Carbon sinkholes are where carbon is stored after being returned to plants and soil through photosynthesis.
Fauna Fauna is the term used for all living organisms on earth, including animals.
Flora Flora refers to all vegetation on earth, including trees, flowers and grass.
Alien Plants Alien or invasive plants refer to plants that do not originate in South Africa. They cause problems by using 10% of South Africa's annual rainfall, killing indigenous plants, causing fires and soil erosion, and endangering many animals.

Chapter 1

After completing this chapter, the learner will be able to:

Know and monitor the occurrence of key types of fauna and flora and their environmental requirements.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
4h	1h 30min	2h 30min activities

Approach the facilitation of this programme practically and through site visits as far as is possible. Conservation is a practice, not an overload of theoretical information. Show learners examples and encourage constant discussions and feedback regarding these discussions. Remember to pay special attention to the geographical area where the learners are and alert learners to possible different methodologies in other areas.

1. Introduction

South Africa has a wealth of natural fauna and flora, with more than 20,000 different plants, or about 10% of all the known species of plants on Earth. This makes South Africa particularly rich in plant biodiversity. To ensure that the fauna and flora that occurs naturally in your environment is protected, it is necessary to be aware of the key types that occur and their environmental requirements.

2. Biomes of South Africa

Spend sufficient time in explaining the concepts of ecosystems and biomes through showing learners how to identify these in their immediate area. Pay specific attention to bringing across the importance of maintaining the delicate balances within ecosystems.

Please note that it is much easier to distinguish biomes on the biome map if the map is in colour. Please make an effort to obtain a colour copy of the map. This map was obtained from www.environment.gov.za/enviro-info/nat/biome.htm.

Definition

Ecosystem

An ecosystem is a community of organisms that inhabit specific a physical environment.

Biomes

Biomes are major ecological communities, and represent a division of the world's vegetation that generally correspond to a particular climate and are characterised by certain types of plants and animals, for example tropical rain forest or desert. Biomes are composed of several ecosystems and represent a regional community of organisms named after the dominant vegetation.

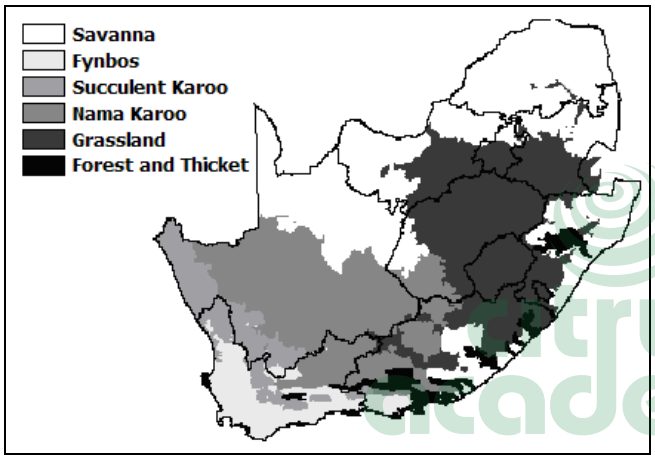


Figure 1.1: Biomes of South Africa

Citrus is produced in seven of the nine provinces of South Africa, and it can be seen from the map above that its production influences a wide variety of biomes.

Information

Biomes of South Africa

For more information on the biomes and vegetation in the production area where your farm is situated, consult the National State of the Environment Report, by searching for it on the Internet or by researching it in your library.

3. The Importance of Biodiversity

Facilitator Tip

Explain the concept of biodiversity to learners by identifying the elements that constitute a bio-diverse environment from a picture (e.g. the information available on the Kleinmond area in the Western Cape and its world wide importance in terms of biodiversity). Alternatively, identify biodiversity elements in a citrus orchard.

Biodiversity

Biodiversity (or biological diversity) is a collective term meaning the totality and variety of life on Earth. Biodiversity includes genetic diversity within species, the variety among different species, and the range of ecosystems within which life exists and interacts.

Biodiversity is necessary for the existence of ecosystems. A variety of organisms must exist in any given ecosystem for the sake of the health of the ecosystem. For example, if there were an ecosystem with only chickens, this would be extremely unhealthy and would not exist for long. There would be nothing for the chickens to eat, and nothing to eat the chickens. In the same way, if there were to be an ecosystem with only one type of plant, it would be extremely unhealthy.

The importance of biodiversity to the functioning of ecosystems is therefore in the variety of fauna and flora that ensures a healthy food chain and competition for food and resources that ensures that natural selection sees to the survival of the fittest. Biodiversity ensures that the natural balance between various species of fauna and flora is maintained.

If only one species becomes extinct in an ecosystem, it can have a knock-on effect on others it interacts with. Some species are by virtue of their interactions with others important to the continued existence of their ecosystems. These are known as **keystone** species. The extinction of a keystone species causes a cascade of further extinctions.

The variety of life on earth forms a huge gene pool which is the material on which natural selection works in the ongoing process of evolution, which generates more biodiversity. This gene pool is also a resource of crucial importance to humanity for food, fuel, clothing, shelter, and to maintain our health. Biodiversity enhances our lives in countless ways, from the development of new and improved food crops and medicines, to the sight of a flight of geese against a sunset. While modern technology has given people greatly increased power over nature, it has done little to reduce our dependence on biodiversity.

Living things do not exist independently of each other or the abiotic environment. They depend on one another in a variety of ways, for example in the food chain. Together with the abiotic parts of the environment, such as soil, water and air, living organisms form essential life-support systems, such as the water cycle, the carbon cycle and several other nutrient cycles. The pool of life is therefore much more than the sum of its parts.

The leading threats to biodiversity are:

- Converting land to agricultural use
- Forest clearing
- Climate change
- Pollution
- Unsustainable harvesting of natural resources
- The introduction of alien species

The importance of each factor varies geographically, but one study of animal extinctions since 1600 found that 39% of extinctions arose mainly from the introduction of alien species, 36% from habitat destruction, and 23% from hunting or deliberate extermination.

Secondary causes of biodiversity loss include human population growth, unsustainable patterns of consumption, increasing production of waste, urban development, and international conflict.

4. Biodiversity and Agriculture

It is important that learners form their own opinions regarding the impact of agriculture on biodiversity and suggest methods in which these impacts can be minimised. Encourage active participation from learners during class discussions.

Agriculture is a major contributor to loss of biodiversity, because agriculture in essence aims at establishing a majority of one species of plant or animal in an ecosystem – in the ecosystem which is a citrus farm, there may be a variety of plants, but there will be more citrus trees than anything else. In fact, other plant species may even be actively put under pressure because of weed control and the need for establishing infrastructure, such as roads.

Establishing a majority of one plant species in an ecosystem also has a knock-on effect on the diversity of fauna found in the ecosystem. Animal species, specifically insect species, for which this specific plant is a food source, will flourish and increase in numbers, while animal species who may have been present in the ecosystem before but that can no longer find food because of the loss of diversity in plant species, will disappear from the ecosystem.

The same situation is found in animal farming. Where a specific animal species, such as cattle, is introduced into an ecosystem where it becomes the major species, other animal species will be put under pressure by farming practices and unfair competition for food. The diversity of plant species will also be affected as the majority animal species will have a preferred food source, which will put specific plant species under pressure.

The rate at which agricultural land is expanding varies from region to region, but much of the biodiversity lost due to agriculture is occurring in Latin America, sub-Saharan Africa and South and South-East Asia.

Agriculture is however essential for human survival because it provides food security. If all agricultural activity were to come to an end, the population of the earth will simply run out of food. It is therefore necessary to find a balance between human survival and environmental survival, of which biodiversity is a central component.

5. Sustainability in Agriculture

Sustainability is quite the buzz-word at the moment, but many learners do not quite understand its true meaning. Utilise examples from the learners' own environment and communities to explain how sustainability is being catered for or ignored. If it is ignored, explore the future consequences to their children and the generations to follow.

To limit the impact of agriculture as far as possible while ensuring that food security is not compromised, the principle of **sustainability** is essential. Sustainability is about ensuring that the practices that are used today will maintain the environment so that farming will still be possible in a hundred years from now. Every person that is involved in agriculture must have an awareness of the impact of agriculture on the environment, and especially of those practices that impact most severely on biodiversity.

The aspects of agricultural that have the biggest impact on biodiversity are:

- Planning and site analysis
- Fertiliser applications
- Chemical plant protection product applications

These aspects need to be managed with extreme care to increase and maintain biodiversity in the agricultural environment.

5.1. Planning and Site Analysis

Steer clear of trying to facilitate site analysis as a theoretical concept. Go to a site and conduct a site analysis with the learners. Always draw conclusions about how site analysis and planning affects sustainability in agriculture.

Proper planning before the establishment of an orchard and effective management for the lifespan of the orchard is the most important aspect of maintaining biodiversity. For the farmer to plan and manage his farm while minimising the environmental impact of his activities, he needs to:

- Know about biodiversity and its importance in terms of conservation
- Know the types of fauna and flora that occur naturally in the environment of his farm
- Know the needs of the fauna and flora
- Know the needs of citrus production
- Strive to balance the needs of his crop with those of naturally-occurring fauna and flora

For example, when a new planting is being planned, the orchards must be laid out in such a way that a balance is achieved between the planted crop and the naturally occurring plants of the area. If the naturally-occurring fauna and flora is maintained, the natural balance of the ecosystem will contribute in such a way that the site will need less fertiliser, water and pesticides. The farmer would determine the sun, wind and drainage requirements of the specific cultivar that has been selected. A cultivar and / or rootstock that has specific needs which are not fulfilled will perform poorly, and be more attractive to pests and diseases. This will in turn mean that more agrochemical control needs to be applied, which will impact negatively on biodiversity.

In terms of ongoing management of activities, the two farming practices that have the greatest direct impact on biodiversity are applications of fertilisers and chemical crop protection products.

5.2. Fertiliser Applications

Many learners will be used to commercial fertilisation practices, which may involve over-fertilisation with artificial fertilisers. Bring the concepts over with sensitivity to how farmers approach this matter and aim for a positive mindset change in the learners towards alternatives.

Fertilisers are applied to improve crop health and yields. Fertilisation introduces some substances into the soil that are not found there naturally, and increases the concentrations of other substances that are in the soil.

If the plants do not absorb all the additional substances that are added during fertilisation, over-fertilisation occurs. The excess substances are then either retained in the soil, which can lead to soil salinisation, or leached from the soil into waterways.

When fertilisers end up in waterways, fertilisation is a source of **diffuse pollution**. Diffuse pollution is caused by lots of smaller pollution sources spread over a wide area. The combined effect of many of these small sources of pollution impacts greatly on the environment. Surplus nutrients washed off farmland can create abnormal nutrient levels in rivers, lakes and the sea, causing a condition known as **eutrophication**.

Eutrophication

Eutrophication is the depletion of oxygen in water, and the process by which a body of water becomes rich in dissolved nutrients, thereby encouraging the growth and decomposition of oxygen-depleting plant life and resulting in harm to other organisms.

Controlling and managing fertiliser applications are essential in limiting the harm that it can cause to the environment. Only the amount of fertiliser that the plants need must be applied at a time that the plants need it. Sandy soil types are more prone to leaching, and fertiliser must then rather be applied in smaller quantities over a number of applications.

5.3. Chemical Plant Protection Product Applications

Learners will again have been exposed to commercial practices. Strive for a positive mindset change by exploring alternatives to traditional use of chemicals. Refer to its affect on biodiversity and the ecosystem, using the tagline "if we keep going this way, the consequences will be…"

The application of plant protection products and herbicides is aimed at suppressing specific plant and animal species that pose a threat to the agricultural crop, such as insect pests, or that compete with the crop, such as weeds. These applications directly impact on biodiversity. Ineffective applications can also impact on other species that were not specifically targeted.

Plant protection products and herbicides must be applied judiciously and care must be taken that only the target pest, disease or weeds are affected. There are also biological control measures that can be used for many pests and diseases that limit the need for chemical plant protection products.

Some plant protection products are also toxic to aquatic life, and can devastate the ecosystems of rivers, dams and groundwater if they are used carelessly or if the waste products are not disposed of properly.

6. Biodiversity and Population Growth

Be sensitive to learners that hail from cultures where wealth is measured in the children one has. Focus on the direct impact on the immediate community if x number of people of a certain age was to move into the community. Encourage learners to discuss the impact on their own sustainability in terms of job security, personal security and the availability of resources.

As the population of the world increases, there is a higher demand for living space. More and more natural ecosystems are being destroyed to provide in the need of living space, and to establish towns and cities. In addition, more and more people stream to cities looking for jobs and economic livelihoods. This is called **urbanisation**. As cities grow as a result of urbanisation, the demand for water, which is a limited resource, increases, while the output of potential emissions and pollution increases.

There is also a higher demand for food, which leads to an increase in agricultural activity. This again leads to a higher demand for water and land, especially fertile soil in areas where ecosystems with a great biodiversity exist. If the farmer also employs environmentally unfriendly farming practices, the impact on the natural environment and biodiversity can be immense.

If population growth continues unchecked, and the cycle that is described above carries on, soil and water resources and natural ecosystems may become so damaged that we will simply run out of viable resources.

7. The Impact of Animals on Vegetation

Learners who are only exposed to plant production might not readily identify with this concept. Use examples such as demonstrating the erosion impact of animals by having a number of learners walk over a piece of polystyrene, which will effectively illustrate compaction and erosion.

In a balanced biome the impact of indigenous and wild animals on the naturally-occurring vegetation is minimal. Where agricultural activity is introduced it impacts on the natural fauna in the area by reducing their natural habitat when the land is used for orchards or field crops, while animal farming introduces domestic animals in large numbers to the area.

There are a few very important considerations when assessing the impact of animals on vegetation and in making decisions about the conservation or eradication of wildlife on a farm, and about the introduction of domestic animals.

7.1. The Introduction of Domestic Animals

Domestic animals such as cattle and sheep can have a significant impact on the ecosystem. If these animals are not managed carefully, they may contribute to soil degradation through overgrazing or overstocking in relation to the carrying capacity of the veldt. Some domestic animals might graze on the indigenous flora, or simply trample it, thereby shrinking the natural resources of the biome further. Domestic animals also often have an impact on water quality.

Even when a small herd of domestic animals is introduced on for instance a citrus farm as a secondary crop, it is important to remember that it must be managed with the same attention to detail as the primary crop, especially with regard to grazing management.

The introduction of domestic animals encroaches on the habitat of naturally-occurring animals. As the area available to natural fauna becomes smaller and smaller, the impact that they have on the environment may also become harmful.

Natural habitats and ecosystems form over thousands of years. The different types of naturally-occurring animals need different types of plants and different sized areas to graze or browse for food. If the area is too small, the animals may develop divergent behaviour or simply become extinct. This causes a further imbalance in the ecosystem and lead to an irreversible loss of biodiversity.

7.2. Utilisation Patterns of Animals

There are about 150 ruminant species of animal, each having evolved distinctive living and feeding strategies to cope with environmental pressures, such as food availability and predators. Although their physiology and eating habits vary widely, these animals can be classified roughly into three groups, being:

- Grazers – 25%, for example cattle, buffalo and sheep
- Intermediates – 35%, for example goats and white-tailed antelope
- Browsers – 40%, for example giraffe and dik-dik

Animals are not classified by size, but by GI tract structure and feeding strategy.

Grazers and browsers have different living and feeding strategies. Grazers eat only three times per day, then hide since grass offers no cover from predators. They eat lots of low nutrition grass, specialising in low digestibility fibres. They do not digest sugars, but are good at digesting starches, which are found in grains such as grass seeds.

Browsers stay in the woods most of the time where they are protected from predators and they eat about eighteen times a day. Except in winter, browsers eat high nutrition sticks, twigs and fatty shrubs. Browsers do not have access to grains in the wild and have trouble digesting them, but they can digest simple sugars. In winter, when good forage is not available, browsers switch to low digestibility fibre. Browsers therefore need either very high or very low digestibility fibres, and are more sensitive to abrupt changes in available food than grazers.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 1

- South Africa is particularly rich in plant biodiversity and the naturally-occurring fauna and flora must be protected.

- Citrus is produced in seven of the nine provinces of South Africa and its production influences a wide variety of biomes.
- The succulent Karoo is restricted to the year-round and winter rainfall areas and has the greatest summer aridity.
- Fynbos occupies 5.3% of South Africa, occurring almost exclusively in the south-western and southern parts of the Western Cape.
- The Nama Karoo covers most of the vast central plateau region of the Western and Northern Cape Provinces.
- Grasslands cover the high central plateau of South Africa, inland areas of Kwazulu-Natal and the mountain areas of the Eastern Cape Province, and occupy 24.1% of the country's surface area.
- Savanna is the wooded grasslands of the tropics and subtropics that account for 46% of the South African landscape.
- The forests of South Africa include the indigenous evergreen and semi-deciduous closed forests of the coastal lowlands and escarpment slopes and cover only about 0.25% of the land area.
- Biodiversity is necessary for the existence of ecosystems, because a variety of organisms must exist in any given ecosystem for the sake of the health of the ecosystem.
- The leading threats to biodiversity are converting land to agricultural use, forest clearing, climate change, pollution, unsustainable harvesting of natural resources, and the introduction of alien species.
- Agriculture is a major contributor to loss of biodiversity, because agriculture in essence aims at establishing a majority of one species of plant or animal in an ecosystem.
- To limit the impact of agriculture as far as possible while ensuring that food security is not compromised, the principle of sustainability is essential.
- Proper planning before the establishment of an orchard and effective management for the lifespan of the orchard is the most important aspect of maintaining biodiversity.
- Controlling and managing fertiliser applications are essential in limiting the harm that it can cause to the environment.
- Plant protection products and herbicides must be applied judiciously and care must be taken that only the target pest, disease or weeds are affected.
- If population growth continues unchecked, soil and water resources and natural ecosystems may become so damaged that we will simply run out of viable resources.
- Where agricultural activity is introduced it impacts on the natural fauna in the area by reducing their natural habitat.

Complete activities 1, 2 and 3 in the **Learner Workbook**.

<u>Activity 1 – Group Discussion</u>

Divide the class into work groups of five to eight members. Allow groups to break away after explaining the requirements of the activity. Remind learners that there are multiple sections to this activity. Encourage all group members to actively participate in discussions. Where time permits, allow for one or two of the groups to give feedback, allowing all learners the opportunity to comment on each group's conclusions.

Timeframe: 30min

Activity 2 – Group Brainstorm

Divide learners into their groups. Revise the concept of brainstorming and allow time for groups to draw their conclusions. Allow time for some of the groups to report back on their conclusions, while encouraging other learners to comment on their conclusions.

Timeframe: 1h

Activity 3 – Group Project

Divide learners into their groups after explaining the requirements of the activity. Remind learners that each group will have a different strategy and that this will be influenced by their own area and frames of reference.

Allow time for some of the groups to report back on their conclusions, while encouraging other learners to comment on their conclusions.

Timeframe: 1h

Chapter 2

After completing this chapter, the learner will be able to:

Identify the key fauna and flora types and their sustainable management.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
3h 30min	1h 30min	2h activities

Spend as much time as possible outside and on the farms, rather than trying to teach the theory of these concepts. A lot more will sink in if learners immediately see or identify what is being referred to.

1. Introduction

As we have already seen, biodiversity describes the variety of life in an area, including the number of different species, and the genetic wealth within each species. An immensely wide diversity of species is found in South Africa. Unfortunately this natural wealth is under extreme pressure as a result of human demands placed on the environment through economic development, agriculture and urbanisation. Invasive alien vegetation and the trade in wildlife also contribute to the problem.

2. The Conservation Status of Species

Ask learners to name examples of species in the different conservation status categories.

The conservation status of species is described as extinct, endangered, vulnerable or rare.

- ***Extinct*** is used to describe a species for which there is a historical record, but which no longer exists in the area under review.
- ***Endangered*** describes a species in danger of extinction, and whose survival is unlikely if the factors causing its decline continue.

- ***Vulnerable*** means a species which it is believed will move into the endangered category if the factors causing its decline continue.

- **Rare** is used to describe a species with small populations that are not yet vulnerable or endangered, but that are at risk.

The term **threatened** is commonly used as a collective description for species which are endangered, vulnerable or rare. Some species are endemic, meaning that they are restricted to one region and occur nowhere else. A threatened, endemic species is a conservation priority.

3. Indigenous and Invasive Fauna and Flora

Take the time to identify examples in the learners' environment of indigenous, invasive and exotic species. Analyse the role that each example plays in the ecosystem. Pay special attention to exotics, whether they are invasive or not, and, if not, whether they have the have the potential to become invasive. The example illustrates the dangers of invasive species. Learners may struggle to identify with rabbits in Australia, and it is preferable to use a local story if you have an example that illustrates the same point.

Indigenous Species Indigenous fauna and flora species originated from and are typical of a region or country.
Alien (Exotic) Species Alien species, also referred to as exotic species, are fauna and flora that did not originate from the region or country, but that was brought to that region or country by humans.
Invasive Species Around 1% of alien species become problematic to the local ecosystems into which they are introduced. These plants are referred to as invasive species.

Not all exotic species become invasive. Many species that are brought into a country naturalise into their new environment and add to its biodiversity. An excellent example of an exotic plant species that is not invasive is the citrus tree.

About 1% of introduced species become problematic. Species are more likely to become invasive if they have the following traits:

- Mature and grow quickly
- Reproduce in great numbers
- Self-pollinate (in the case of plants)
- Seeds disperse easily and by various means (in the case of plants)
- Good competitors
- Thrive in disturbed areas
- Free of natural enemies

Invasive species are the single biggest threat to South Africa's biodiversity. Invasive alien plants (IAPs) pose a direct threat not only to South Africa's biological diversity, but also to water security, the ecological functioning of natural systems, and the productive use of land. They intensify the impact of fires and floods and increase soil erosion. IAPs can divert enormous amounts of water from more productive uses and invasive aquatic plants, such as the water hyacinth, effect agriculture, fisheries, transport, recreation and water supply.

Invasive Species – A Story from Australia

As an example of the type of devastation that invasive species can bring about, let us look at the case of the harmless rabbit in Australia. Australia is one of the countries (and continents) in the world with the greatest biodiversity, and with the strangest creatures. Because it has been isolated from the rest of the world for millions of years, the fauna and flora there have evolved differently from species in the rest of the world. As a result, most of the fauna and flora in Australia are endemic (not found anywhere else in the world).

After Britain colonised Australia, a great number of British people settled there during the 1800s. In 1859 a man called Thomas Austin, a landowner in the state of Victoria, imported twenty-four wild rabbits from England and released them into the bush for sport — he wanted something to hunt. As we well know, rabbits breed very quickly, and within a couple of years they had completely overrun Austin's property and were spreading into the rest of the region. Fifty million years of isolation has left Australia without a single predator or parasite that could even recognise a rabbit, much less see it as a source of food.

By 1880, more than 800,000 hectares of Victoria had been picked clean of all vegetation, with the largest devastation caused to an indigenous species of flora, called the emu bush, a shrub that grew to a height of about two meters and was in flower most of the year. It was by all accounts a lovely plant and its leaves an important source of food to indigenous animals. The rabbits destroyed the emu bush completely, including its leaves, flowers, bark and stem, until there was none of it left. The emu bush is now extinct.

The rabbits ate so much of everything that the sheep and other livestock were forced to extend their range and their diet, causing yet more damage to a larger area. Farmers had to increase stock levels, which only added to the devastation.

The landscape of southern Australia was changed forever and it is believed that it will never recover even if all the rabbits could be removed today (which is impossible, because it is estimated that there are about 300 million rabbits in Australia today, despite control measures that were eventually implemented). And all of this because 24 animals of one invasive species was introduced by one man.

There are many similar stories in South Africa. Examples of the most harmful invasive plant species in South Africa are Port Jackson, lantana, bugweed, and eucalyptus trees. All of these plant species compete unfairly with indigenous species for nutrients and water and do not have natural enemies.

It is very to remember that any species that is introduced into an ecosystem can become invasive, including species that may not be so obvious, such as microbes. For example, biological control measures that are introduced against pest insects in citrus production, in some cases involve the introduction of microbes that attack the pest insect. These microbes may not occur in the area naturally, which means that there is the danger that it can become invasive.

4. Identifying Indigenous and Invasive Species

If you have access to the SANBI website, show learners how to link to and access information on the site.

There are thousands of invasive plant and animal species and before one can implement control measures for those species, it is important that one should be able to recognise them. It is not possible to give comprehensive information for such a great number of species in such a wide variety of production areas in this guide. We recommend that you make use of the resources below to get more localised information for your area.

Information Sources on Indigenous and Invasive Species

Visit the website of the South African Biodiversity Institute at www.sanbi.org.

For a list of the more than 3,000 plant species that are rare and endangered according to the **Red Data List of South African Plans**, visit the ECOPORT website at www.ecoport.org.

The website of the Department of Agriculture, Forestry and Fisheries and the ARC that provides information invasive and alien plants is at www.agis.agric.za/wip.

5. Control Measures for Invasive Flora

It is recommended that you put the following question to the learners and then fit the examples they list around the information below: "How do you deal with weeds on the farm?"; and "How do you think one should get rid of a Black Wattle tree?"

Any control programme for alien vegetation must include the following three phases:

- **Initial control** — Drastic reduction of existing population
- **Follow-up control** — Control of seedlings, root suckers and woody growth
- **Maintenance control** — Sustain low alien plant numbers with annual control

Invasive plant species can be removed or controlled with chemical means. Invasive shrubs and grasses are controlled with herbicides or manually removed with hoes. With manual control, one must ensure that all plant parts are removed, including the root system, and care must be taken that the seeds or other propagating parts of the plant are not left behind.

Invasive tree species presents a greater challenge. Where trees can be felled, the remaining stump must be treated to ensure that it will not start growing again. Trees are removed with chainsaws, bow saws, brush cutters or cane knives. The following stump treatments can be used:

- **Cut Stump Treatment** — The remaining stumps and all exposed roots are either treated with special herbicides according to the instructions on the product label, or with diesel.

- **Stem Injection** — Downward slanting holes, spaced around the entire circumference of the lower stem, are punched into the main stem using a sharpened metal spike. The herbicide is injected directly into the plant according to the recommendations on the label.

Trees that grow on steep slopes cannot be felled and must be controlled by other means, such as:

- **Basal Bark** — A suitable herbicide mixed with diesel is applied to the bottom 250mm of the stem. Applications are done by means of a low pressure, coarse droplet spray.

- **Hand Pull** — For young plants that can still be easily removed, grip the plant low down and pull out by hand. Wear gloves to protect the hands.

- **Ring Barking** — Bark is removed from the bottom of the stem to a height of 0.75m to 1m. All the bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets are used for debarking.

- **Frilling** — Using an axe or bush knife, make angled cuts downward into the cambium layer through the bark in a ring around the entire stem. Herbicide is applied into the cuts.

Figure 2.1: Tree Frilling

6. Responsible Management of Indigenous Species

As discussed in chapter 1, planning is the single most important factor for the sustainable management of natural resources. In the level 2 learner guide we also examined the different sources of pollution on a farm and how this could be managed. Proper planning and pollution management will already go a long way to protecting the indigenous fauna and flora on a farm.

It is however important to also look at what could be done to repair an environment that has been damaged, and how the current biodiversity can be monitored and maintained.

Some degraded ecosystems are able to recover naturally but many do not. For these reasons human intervention may be needed to either initiate the recovery process or to accelerate it. There are different approaches that can be used in this regard.

Spend sufficient time with the learners to strategise on how they would go about the restoration, rehabilitation, and reclamation of ecosystems and indigenous species in their area.

Restoration is used in those situations where the intent is to recreate an ecosystem as close as possible to that which originally existed at the site.

Rehabilitation is aimed at regaining the original productivity or structure and some, but not all, of the original biodiversity. This might be because commercial imperatives demand certain agricultural or timber species be included to justify the rehabilitation effort or because the site is now unsuitable for some of the original species. This is also the option most frequently used by farmers who are living in sensitive biomes where endangered species of fauna and flora is found.

Reclamation is used in situations where productivity or structure is regained but not much biodiversity. This normally means that a species is removed from its original habitat and placed in an alternative environment or a breeding program. An example of such a program is the Cape Quagga Breeding Program.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 2

- The conservation status of species is described as extinct, endangered, vulnerable or rare.
- Some species are endemic, meaning that they are restricted to one region and occur nowhere else.
- Indigenous species are fauna and flora that originated from and that are typical of a region or country.
- Exotic species are fauna and flora that did not originate from the region or country, but that was brought to that region or country by humans.
- A small percentage of exotic species threaten the continued existence of naturally-occurring fauna and flora and is therefore said to be invasive.
- Invasive species can be plants, animals and microbes. Invasive species are the single biggest threat to South Africa's biodiversity.
- There are thousands of invasive plant and animal species and before one can implement control measures for those species, it is important that one should be able to recognise them.
- Any control programme for alien vegetation must include initial, follow-up and maintenance control.
- Restoration is used in those situations where the intent is to recreate an ecosystem as close

as possible to that which originally existed at the site.
- Rehabilitation is aimed at regaining the original productivity or structure and some, but not all, of the original biodiversity.
- Reclamation is used in situations where productivity or structure is regained but not much biodiversity.

Complete activities 4 and 5 in the **Learner Workbook**.

Activity 4 – Research and Discover

Remind learners to complete the activity individually and to use their own area and examples in their answers and conclusions.

Timeframe: 1h

Activity 5 – Research and Discover

Remind learners to complete the activity individually, with reference to their own environment. Encourage them to find help about control methods for invasive species if they do not know themselves.

Timeframe: 1h

Chapter 3

After completing this chapter, the learner will be able to:

Demonstrate an understanding of the elements of an ecosystem and a food chain.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
3h	1h 30min	1h 30min activities

Rather than working through this information in theory, have the learners explain the elements of the ecosystems in their own area. Allow them to draw similar diagrams to figure 3.1 and 3.2 for the ecosystem to which they refer.

1. Introduction

We have already touched on the interactive links between elements in an ecosystem. We have seen that there are many different types of ecosystems that are important to the existence of every creature on earth. The most vulnerable ecosystems are river catchments, wetlands, grasslands, and estuaries.

Healthy ecosystems are the cornerstone of biodiversity. They ensure that natural resources remain in optimum condition so that sustainable farming can continue into the future. It is important that we examine and understand the different elements of ecosystems and understand how they are interrelated.

2. The Elements of Ecosystems

Ecosystems contain a combination of living and nonliving elements. It is impossible to separate an ecosystem into its living and nonliving components, because the whole constitutes a dynamic system in which there is a flow of energy from sunlight, gases from the atmosphere, and minerals and water from the soil.

In citrus farming, the farmer strives to ensure optimum soil conditions and good water quality, and to minimise pests, diseases and microbes that can affect the crop negatively.

Ecosystems require a rich diversity of species in order to remain healthy. This is important for farmers, as this means that the conservation of biodiversity, and in particular the protection of a high number of different species, should be a high priority for maintaining healthy soils, water and crops.

Precisely how much biodiversity is needed to ensure that ecosystems are healthy and life-sustaining, is still the subject of considerable debate in the ecological community. Its outcome has important implications for the policymakers who are seeking to devise and justify policies aimed at preserving the complex web of ecosystems that support life on earth.

2.1. Living Elements

The living elements of ecosystems include flora, fauna, insects, fungi, and bacteria. To illustrate the interaction between the living elements of an ecosystem, let us consider the food chain. In the figure 3.1 is three examples of food chains that you should be familiar with in you immediate environment.

From these examples, we can see that the food chain in most cases begins with plants, or algae in a marine ecosystem, and ends with what is referred to as an **apex predator** (the eagle, hawk and shark). Apex predators are deemed to sit at the top of the food chain – nothing will kill and eat them. When they die their dead organic material is consumed by bacteria, which recycle the organic matter into nutrients that are taken up by the soil, where it is used to support plant growth. This is the cyclical nature of the food chain.

It is also very important to note that no food chain would be possible if it were not for the non-living elements of the ecosystem. Water, air, soil and sunlight are essential for the survival of all of these living elements.

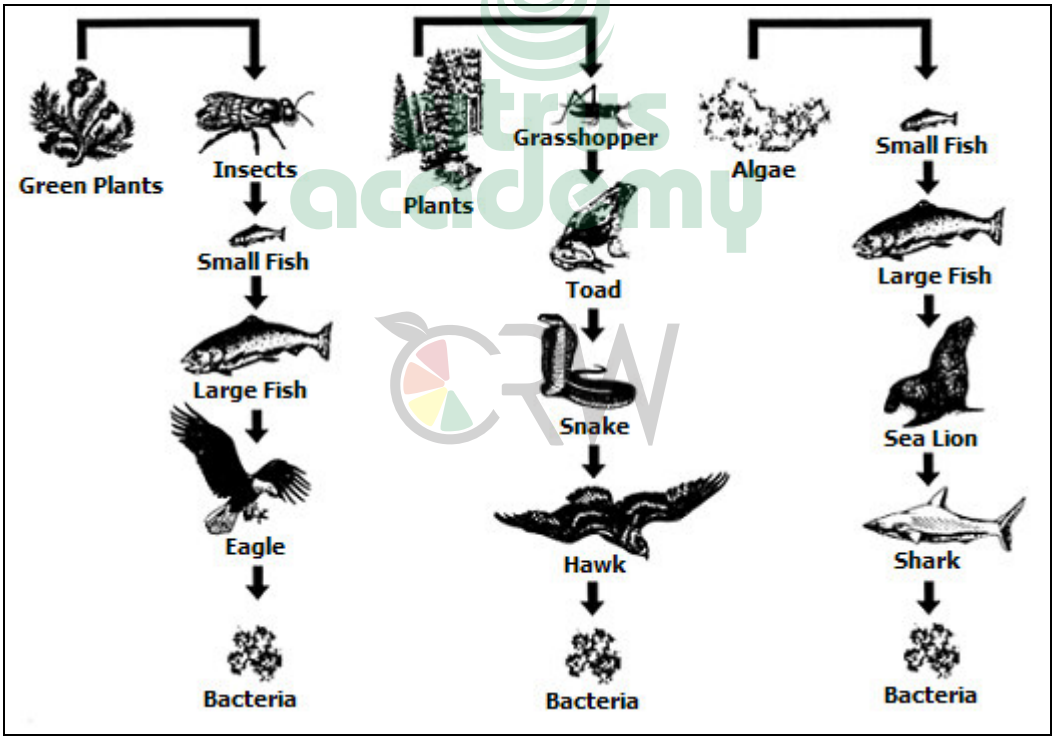


Figure 3.1: Examples of Food Chains
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2.2. Non-Living Elements

The non-living elements of the ecosystem include sunlight, air, water, soil, and rocks. The water cycle is a handy illustration of the relations and interdependence of non-living elements.

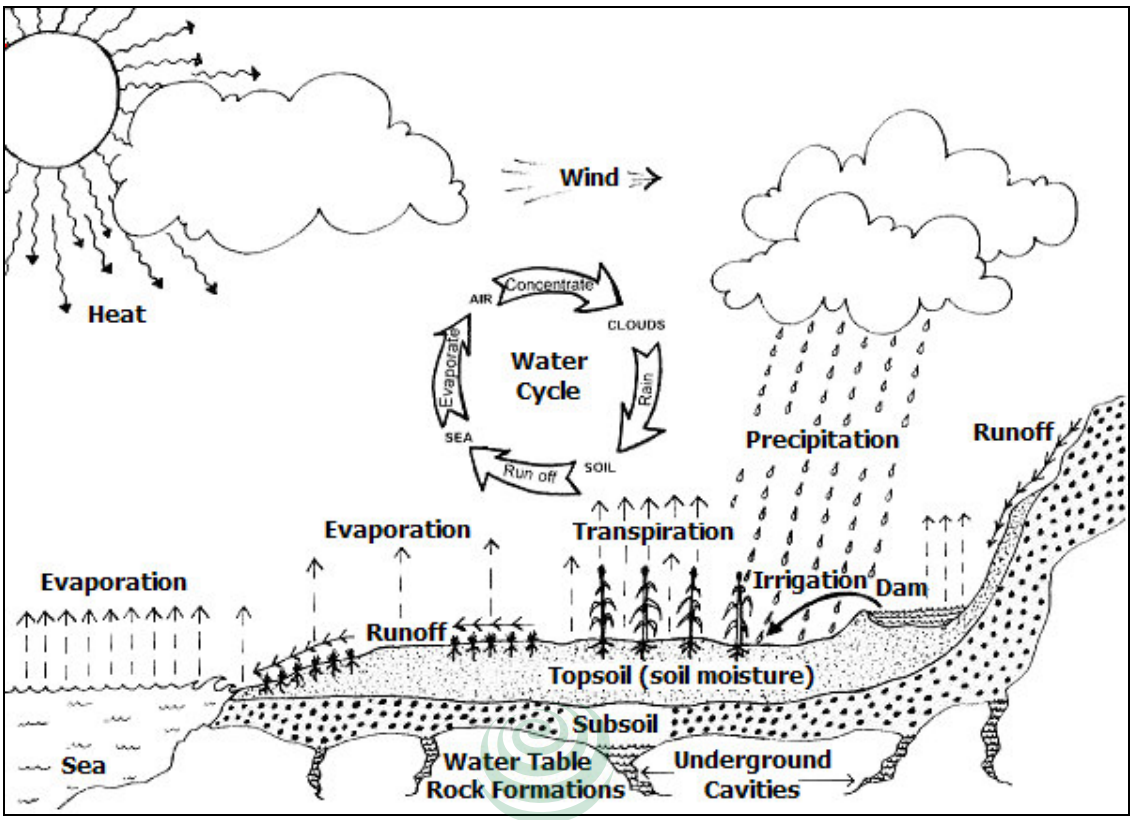

Figure 3.2: The Water Cycle

The water cycle illustrates that all non-living elements of the ecosystem continuously interacts with each other, and with the living elements. If the farmer is not careful about the application of agrochemicals, we can see how these chemicals can contaminate water sources as it is carried by runoff water. Chemicals that are not taken up by the plant can also leach into the underground water, where it will percolate to the deepest levels. This can lead to increased soil and water salinisation.

3. Monitoring the Health of Ecosystems

Facilitator Tip

Pose the example of spiders in citrus orchards to the learners. Be prepared for the initial response of people being rather squeamish about spiders and having a natural instinct to kill them, and then introduce the benefits of the spiders, taking the concept of them being beneficial species as far as the learners' own home gardens and home environment.

Understanding the functioning of each element of an ecosystem and of the ecosystem as a whole, is the first step in being able to monitor the health of the ecosystem on a farm. Take an interest in the ecosystem on your farm and identify each of its elements. Prioritise the importance of the elements for profitability and for sustainability.

Researchers and conservationists can undertake a formal study, called an agro-ecosystem analysis, which is aimed at studying different elements of agricultural ecosystems. In most cases, these studies are conducted for an area or region. A number of farms in the area might be asked to contribute specific information through completing surveys and checklists. In other cases, all the growers of a specific crop may be asked to report information on a regular basis on a specific subject. Below is an example of an ongoing agro-ecosystem analysis from the citrus industry.

Spiders in Citrus Orchards

There are specific species of spiders that are considered as being a very important element of an agricultural ecosystem. Some spiders are natural predators to mites and termites and other pests that cause damage to citrus crops. Some spider species are also suspected of being endangered. Surveys of spiders in citrus orchards have been conducted over the past twenty years in ten citrus producing areas in South Africa. Thirty-five families, represented by 134 genera and 197 species, were recorded. Wandering spiders constituted 61.5% of the spider fauna and web-builders 38.5%. This survey forms part of the South African National Survey of Arachnida (SANSA) in agro-ecosystems.

Every person on the farm, and especially those workers that come into contact with the ecosystems on the farm regularly, must be aware of the impact of their activities at all times and must take responsibility for the conservation of the ecosystem. The most important steps to remember are:

- Observe and monitor the health of all the elements of the ecosystem on the farm, and report unusual situations immediately
- If there is unusual damage to the crop or naturally-occurring flora from animals, pests or disease, or higher than normal numbers of a specific type of insect, bird or animal, report it to a supervisor
- If you encounter dead animals or standing water or water that smells bad, report it
- Water in water sources (dams, boreholes, rivers, and so on) and soil must be monitored through regular testing and sampling

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 3

- Ecosystems contain a combination of living and nonliving elements.
- The living elements of ecosystems include flora, fauna, insects, fungi, and bacteria. The food chain is a good illustration of the interaction of the living elements of the food chain.
- The non-living elements of the ecosystem include sunlight, air, water, soil, and rocks. The water cycle is a handy illustration of the relations and interdependence of non-living elements.
- Understanding the functioning of each element of an ecosystem and of the ecosystem as a whole, is the first step in being able to monitor the health of the ecosystem on a farm.
- It is important to observe and monitor the health of all the elements of the ecosystem on the farm, and report unusual situations immediately.

Complete activity 6 in the **Learner Workbook**.

Activity 6 – Explore and Discover

Remind learners that this activity is aimed at their own work environment and that they have to walk around to answer the activity. Remind learners to communicate with their workplace about what they need to do.

Timeframe: 1h 30min

Chapter 4

After completing this chapter, the learner will be able to:

Identify the different soil categories, the utilisation and maintenance thereof.

You have to complete this section as follows:

Total time	***Theory***	***Practical***
4h 30min	1h 30min	3h activities

Steer clear of theoretical facilitation. The learners need to get their hands dirty and in the soil to really understand the idea, use, value, life and conservation of soil.

1. Introduction

Soil is the result of soil formation processes over thousands of years. Soil types differ from one place on the surface of the earth to the other, as the result of the differences in the formation processes. Soil is a natural resource that is a combination of living and nonliving components, consisting of finely divided mineral substances, atmospheric gases, water, and living and dead organic material. Soil is a product of the interaction between the living and the nonliving environment.

The living components of soil are considered as renewable resources and the mineral components fit the definition of non-renewable resources. As long as the living components of soil remain healthy and continue to function, the mineral components are recycled from the soil through the organic life within it, such as bacteria and other micro-organisms, and back to the soil following the decay and breakdown of dead organic material.

Because most forms of terrestrial life are dependent upon it for their continued existence, soil must be maintained in a renewable state. Mining soil, or using it in such a way that its fertility is exhausted and it is washed or blown away by too-rapid erosion, reduces the likelihood that life can continue to exist in the affected area.

2. Soil Potential

Rather than teaching learners the formal definition of soil potential, ask them to look at a certain soil and judge what one can do with it. You might want to show different types of soil, such as clay, sand, structureless soil, etc., to demonstrate how soil potential is determined. Do mini experiments with the soils, such as judging its fertility by colour, judging its water holding capacity through poring water into a sample of the soil, etc.

Soil Potential

Soil potential refers to the ability of the soil to support plant growth and produce a good quality crop.

Soil potential is an important concept in agriculture. The soil potential determines the type of crop that can be grown in a specific soil, and the volume and quality of crops that can be produced.

Soil potential is judged by the following criteria:

- Soil fertility
- Plant available water
- Soil permeability

These criteria are all influenced by the characteristics of the soil, and especially by the soil texture. Soil fertility and plant available water is especially affected by the texture of the subsoil and topsoil, while soil permeability is affected mostly by the texture of the topsoil.

2.1. Soil Fertility

Soil Fertility

Soil fertility refers to the nutrient content of the soil and its resultant ability of the soil to sustain plant growth.

Plants absorb sunlight, oxygen and carbon dioxide from the air, and water and nutrients from the soil. Soil fertility can simply be referred to as the amount of food that the soil can supply to the plants. Plants need seventeen elements for normal growth. They are:

- ***Carbon***, ***hydrogen*** and ***oxygen***, which come from air and water.
- ***Nitrogen*** is the major essential nutrient element, and also a major plant constituent. Although the atmosphere contains 78% nitrogen, it is not directly available for plant use from the air. In citrus production, nitrogen is taken up from the soil.

- The ***other thirteen essential nutrient elements*** come from the soil and are iron, sodium, calcium, phosphorous, potassium, copper, sulphur, magnesium, manganese, zinc, boron, chloride, and molybdenum.

Under normal circumstances, the nutrients naturally available to plants from the soil vary with clay content: the higher the clay content, the higher the soil fertility. Clay particles tend to however bind nutrients strongly, making fewer nutrients available to the plant.

2.2. Plant Available Water

There is a considerable variation in the capacity of soils to store and release water for plant use. This is referred to as the water holding capacity of the soil. In some clay soils, water holding capacity may be as high as 25mm water per 100mm soil, while it can be as low as 6mm per 100mm soil in sandy soils.

Although clay soils can store more water than sandy soils, the water may not be available to the plants during periods of fast growth. Sandy soils retain less moisture, but the water is more readily available to plants.

2.3. Soil Permeability

The ease with which air, water and roots can penetrate soil is determined by the number and size of the open spaces, or pores, in the soil. Clay soils have a large number of pores, but they are very small. Soil with very high clay content does not allow air, water or roots to move freely through it. Sandy soils on the other hand have less but larger pores, and air and water movement is much quicker.

3. Soil Characteristics

Use mini experiments to demonstrate soil characteristics, using different soil samples or open soil profile pits. Allow the learners to feel the texture, and to look at the structure, layering, and how deep roots can penetrate in a soil profile, etc.

The differences in soils that are found in different areas are associated with suitability for crop production, mainly as result of differences in the following characteristics:

- Texture
- Structure
- Layering, or stratification
- Chemical and mineral composition
- Depth

These factors determine to a large extent the depth of the effective root-zone of the crop, and therefore the production potential of the soil. They also indicate the possible dangers related to crop cultivation and irrigation.

3.1. Texture

Texture relates to the ratio between the different sized particles, being sand, silt and clay, in the soil. Many soil characteristics determining the suitability for specific crops are directly and indirectly related to texture. In general, the finer and more clayey the soil texture:

- The more difficult a soil is to work or till;
- The greater the water holding capacity;
- The slower water will enter and move through the soil profile;
- The more difficult plant root penetration;
- The more readily surface soil will crust; and
- The more nutrient rich the soil

3.2. Structure

Soil structure refers to the manner in which all the soil particles, including organic material, are arranged to form structural units. Good structure of the surface soil is promoted by an adequate supply of organic matter.

Soil structure results from the natural aggregation of all the various particles that can be separated from each other by weakness planes. The primary particles include the amount and type of clay and organic material, and sand, gravel and stones. Factors that determine the soil structure include factors such as absolute amounts and ratios between exchangeable and soluble nutrient elements, wetting and drying cycles, soil depth, tillage practices and a number of other factors.

Structure is a characteristic of soil that can therefore be changed by farming practices. Soil structure has an influence on movement of air, water and roots in the soil, as well as erosion, ease of cultivation and effective soil depth.

Growing plants also change the soil structure as they send their roots into the soil for mechanical support and to gather water and nutrients. Since plant roots move through the same channels in the soil as air and water, good structure allows extensive root development whereas poor structure discourages it.

3.3. Layering or Stratification

It takes about 1,000 years to form a 25mm layer of soil. When soil is being formed, soil particles are separated and accumulate at different depths. Soils are also carried and deposited by water and wind to form layers with different soil properties.

Layers have an influence on the potential of the soil. Roots do not grow and water does not move easily from one layer to another if the properties, especially the texture, differ too much. The sub-surface soil layers must also be such that it does not prevent the flow of sub-surface water.

3.4. Chemical Composition

The chemical composition of soils is mainly determined by the original material from which it developed, its age, its drainage, the climate, micro-organisms that are present in the soil, and the quality of irrigation water.

3.5. Soil Depth

Soil depth refers to the depth to which the roots of plants can easily penetrate. Soil depth influences root growth and the water holding capacity of the soil. Plants that can develop deep root-systems grow better than plants with restricted root systems. Deep soils normally have more available water and nutrients than shallower soils.

4. Soil Degradation

Soil degradation means a decrease in the quality and potential of the soil and can result from a variety of actions or circumstances. Soil degradation decreases the ability of soil to support and sustain life, and therefore negatively impacts agricultural production and other natural resources and thus biodiversity.

In order to measure and monitor soil degradation, it is essential to determine the current soil potential and soil characteristics. This is done through soil analyses and surveys and may include actions such as soil sampling and digging profile pits.

The services of soil scientists are often required to make an initial survey of a new farm and to develop a soil utilisation plan. After this planning process, the status of the soil is monitored on an ongoing basis through sampling and analysis. Soil degradation is normally caused by circumstances such as:

- Over-use of soil without replacement of lost nutrients
- Compaction due to heavy vehicular traffic or repeated movement of animals on the surface
- Erosion of topsoil
- De-structuring of soil due to run-off and particle breakdown
- Salinisation soil due to high carbon and nitrogen deposits from floods, fire, and high volume inorganic fertiliser and crop protection applications
- Depletion of soil nutrients by invasive species
- Pollution of soils by artificial deposits or unbalanced land-use

The nitrogen cycle is a good illustration of the impact that various farming activities have on the nitrogen content of soil. As we have already mentioned, nitrogen is a major plant nutrient and soil component. The manner in which the nature of the nitrogen in the soil changes in the course of the cycle plays a major role in the ability of the soil to support plant growth.

Nitrification Nitrification means the oxidisation of ammonia ions into nitrite or nitrate ions, as nitrobacteria do.
Denitrification Denitrification means the conversion of nitrates into nitrites and ammonia.
Nitrogen Fixation Nitrogen fixation means the natural conversion of atmospheric nitrogen by bacteria found in the nodules of legumes into compounds in the soil that plants and other organisms can use.

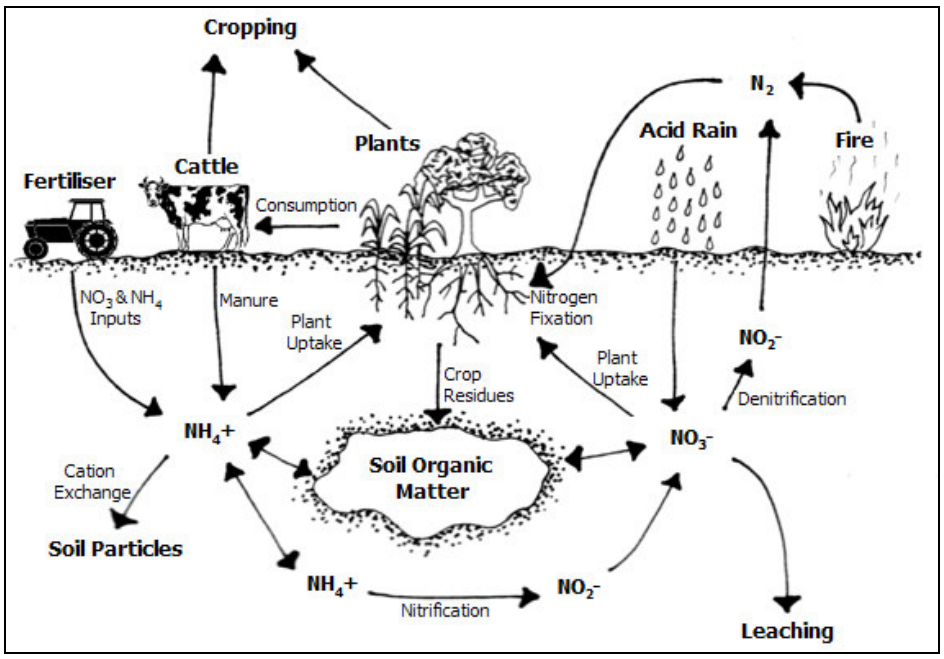

Figure 4.1: The Nitrogen Cycle

5. Soil Erosion

Examples of soil erosion are to be found just about everywhere. Show learners the different types of erosion and have them judge the impact of the erosion on the usability of the soil. It is important that they identify strategies to prevent erosion and to restore eroded soils.

Soil erosion occurs when soil is removed through the action of wind and water at a greater rate than it is formed. When a raindrop hits soil that is not protected by a cover of vegetation and where there are no roots to bind the soil, it has the impact of a bullet. Soil particles are loosened, washed down the slope of the land and either end up in the valley or are washed away out to sea by streams and rivers. The topsoil is removed first. The topsoil is the nutrient-rich layer and when it is gone, the production potential of the soil decreases severely.

Soil covering the surface of the earth has taken millions of years to form and must be protected. Soil is formed at a rate of only 1cm every 100 to 400 years and it takes 3,000 to 12,000 years to build enough soil to form productive land.

In its natural state in any micro-environment, soil is covered and protected by natural vegetation. Removing natural vegetation for the purpose of cultivation, the establishment of infrastructure, or any other use, results in irreversible changes to the soil and increases the risk of soil erosion.

5.1. Forms of Erosion

The most common forms of erosion are water erosion and wind erosion.

5.1.1. Water Erosion

Water erosion causes two types of problems, being on-site loss of agricultural potential, and the off-site effects of downstream sedimentation, causing flooding and the silting up of reservoirs. The main forms of water erosion are:

- Sheet erosion
- Rill erosion (channel erosion)
- Gully erosion

5.1.1.1. Sheet Erosion

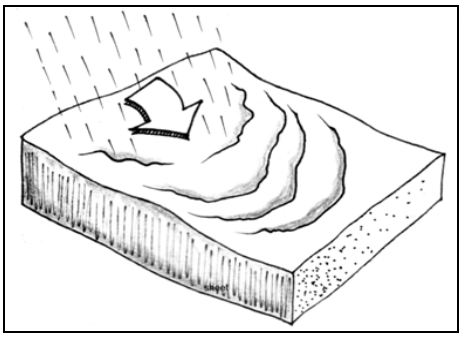

Figure 4.2: Sheet Erosion

Sheet erosion is characterised by the down-slope removal of soil particles by a thin sheet of water. Sheet erosion causes the entire surface of a field to be gradually eroded in a more or less uniform way. It is a gradual process and it is not immediately obvious that soil is being lost.

5.1.1.2. Rill Erosion (Channel Erosion)

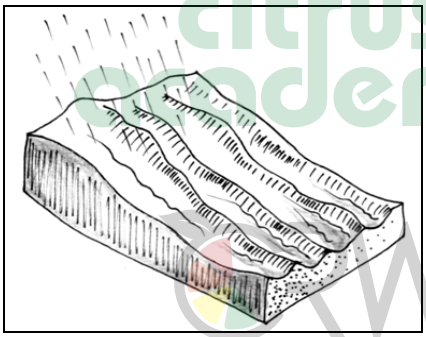

Figure 4.3: Rill Erosion

Channel erosion can occur on steep land or on land that slopes more gently. Because there are always irregularities in a field, water finds hollows in which to settle and low-lying channels through which to run. As the soil from these channels is washed away, the channels become deeper and miniature dongas are formed in the field.

5.1.1.3. Gully Erosion (Dongas)

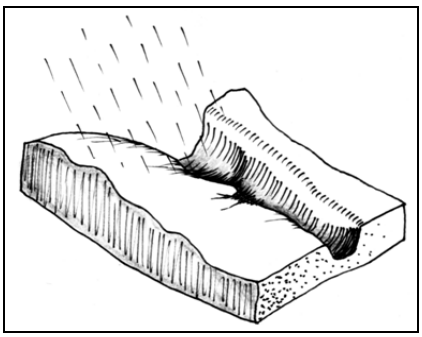

Figure 4.4: Gully Erosion

Dongas usually occur near the bottom of slopes and are caused by the removal of soil and soft rock as a result of concentrated runoff that forms a deep channel or gully.

On steep land, there is often the danger of gullies forming. Water running downhill cuts a channel deep into the soil and where there is a sudden fall, a gully head forms at the lower end of the channel and gradually works its way back uphill. As it does so, it deepens and widens the scar that the gully makes in the hillside.

Gully erosion is related to stream-bank erosion, in which fast-flowing rivers and streams increasingly cut down their own banks.

5.1.2. Wind Erosion

Wind erosion occurs when the land surface is left bare in regions that are arid enough, as a result of low rainfall, to allow the soil to dry out, and flat enough to allow the wind to carry the soil away over an extended period of time.

Land may become susceptible to wind erosion as a result of the grazing of animals that remove the protective plant cover, and whose hooves break up the soil, especially round watering points. Arable land that has been left bare is also a major problem.

5.2. Soil and Land Characteristics that Impact on Soil Erosion

There are various soil and land characteristics that impact on the erodibility of the soil, of which the following are the most important:

- Slope
- Soil texture
- Soil structure
- Terrain unit
- Organic material
- Vegetation cover

5.2.1. Slope

The steeper the slope is, the greater the erosion will be, as a result of the increased speed of water-flow. The length of the slope is also very important, because the greater the size of the sloping area is, the greater the concentration of the flooding water.

5.2.2. Soil Texture

In combination with factors such as the slope of the land, vegetation cover and the intensity of precipitation during rain or irrigation, the soil texture determines the extent of the erosion that will take place. For instance, a heavy rainstorm on a steep slope with sandy soil and no vegetation cover will lead to major erosion. In the same scenario, clay soil will suffer much less erosion.

5.2.3. Soil Structure

A soil with poor structure, meaning high sand fraction, and low clay and organic content, erodes much more readily than a soil with a well-balanced structure. Structure can be altered by cultivation practices. Over-cultivation and compaction cause the soil to lose its structure and cohesion, which is its ability to stick together, causing it to erode more easily.

5.2.4. Terrain Unit

At the crest (top) of the slope the soil is usually well-drained, because soil moisture moves downhill, leaving air in the pore spaces of the soil most of the time. Over time, the fine, clay particles are carried down the slope, leaving the soil at the crest sandy. Plant roots can penetrate easily to deep levels and withdraw enough soil water from there. These soils have a lower erosion potential and are normally more stable.

In the mid-slope area, soil moisture moving from the crest starts to dam up as a result of the clay-rich soil just downhill. The soils are moderately well-drained with a higher erosion potential. In the foot-slope, the soil becomes waterlogged, meaning saturated with water, as a result of the long-term accumulation of clay which does not allow water to infiltrate. Plants that grow on these soils are limited to those that can adapt their root systems to grow laterally above the hard, clayey layer. These imperfectly drained soils have a high erosion potential.

5.2.5. Organic Material

Organic material is the glue that binds soil particles together and plays an important role in preventing soil erosion. Organic matter is the main source of energy for soil organisms, both plant and animal. It also improves the infiltration capacity of the soil, thereby reducing runoff.

5.2.6. Vegetation Cover

The loss of protective vegetation through overgrazing, ploughing and fire makes soil vulnerable to being eroded by wind and water. Plants provide protective cover on the land and prevent soil erosion for the following reasons:

- Plants slow down water as it flows over the soil, allowing much of the water to soak into the ground.
- Plant roots bind the soil and hold it in place, preventing it from being blown or washed away.
- Plants break the speed of water drops or wind before it hits the soil, reducing its impact.

5.3. Other Causes of Soil Erosion

- Poor farming practices, such as ploughing down-slope, instead of along the contours, leads to gullies forming and soil being washed away.
- Overgrazing is when animals are left to graze in the same area for too long. The soil becomes trampled and compacted, and the vegetation cover is reduced and eventually removed.
- Farming in areas that are too dry causes the structure of the soil to be destroyed and desertification to takes place.
- Reducing the natural plant cover through ploughing and cultivation leaves no protective vegetation layer.
- Uncontrolled veldt fires reduce ground cover, and leave the soil without protection.
- Deforestation, meaning cutting down forest to make way for cultivation, leaves the soil unprotected and disturbs the natural ecosystem.
- Incorrect structures, farm layout and spacing between plants increase the risk of gully erosion and increase runoff.

5.4. Prevention of Soil Erosion

The following measures can be implemented to prevent soil erosion:

- Pay special attention to controlling storm water and run-off on and around orchard areas, both while they are being prepared for the establishment of a citrus orchard, and after the orchard has been planted until the plants and a good grass covering has been established.
- Where erosion is already occurring, construct small structures such as gabions, weirs and silt traps to ensure that erosion does not become worse.
- Ensure that the infiltration capacity of the soil is considered in the design of the irrigation system to prevent excess run-off.
- Develop a runoff plan with strategic vegetation beds designed to not only decrease the runoff speed of the water, but to also filter irrigation water before it returns to the groundwater system.
- Use contour ploughing and windbreaks.
- Establish grass strips in the inter-row areas in orchards.
- Make sure that there are always plants growing on the soil, and that the soil is rich in humus.
- Allow indigenous plants to grow along riverbanks.
- Re-establish plants indigenous to the biome and ecosystem or pioneer plant species on eroded areas or degraded soils.
- Conserve wetlands.
- Employ minimum or no tillage.
- Implement veldt reclamation and stock reduction schemes whereby farmers are encouraged to reduce or withdraw production stock so that the land can recover.
- Implement legislation such as the Environmental Conservation Act and a national grazing strategy.
- Employ rotational grazing and crop farming practices.
- Divide farms into camps with sufficient waterholes to prevent trampling.
- Control veldt fires and cut fire breaks or construct fire barriers from stones.

In terms of citrus farms there are a number of additional factors that must be taken into account. Although most citrus farms are not situated in topographical areas where slope is a consideration, it is important to remember that cultivation of crops is not recommended on slopes with an elevation of more than 20 degrees.

Cultivar selection and irrigation should take into account soil type to avoid over-irrigation and runoff. Most citrus rootstocks are not suited to heavy soils, but it should be noted that water usage and runoff on very sandy soils would be equally unproductive.

The recommended row direction for citrus planting is north-south, but elevation may necessitate alteration and possibly contour planting. Citrus trees should be spaced 6m by 3m apart and a turning circle of at least 8m around orchards is recommended to avoid degradation that would cause gulley erosion.

Wind breaks should be planted around orchards in areas where high winds are experienced regularly to control wind erosion.

It should be noted that citrus growers should beware of using organic compost materials directly on the crop, as this has a proven negative affect on colour development. Research on alternative and sustainable citrus production practices of is constantly being done by Citrus Research International and it is recommended that citrus growers consult with them regularly to stay abreast of the latest GAP recommendations.

6. Monitoring and Reporting on Soil Erosion and Soil Degradation

Soil degradation and erosion should be monitored on a continuous basis. On commercial farms there should be standard operating procedures and a recordkeeping system that provides for the monitoring of the status of the soil on the entire farm. The state of natural, indigenous vegetation is a good indicator of the health of the soil.

Every person on the farm, from farm workers to management, must be aware of the procedures that are in place. They should also be trained to recognise the signs of erosion and soil degradation and should be aware of the reporting procedures. Procedures to contain and counter erosion and degradation must be in place to be instituted immediately when a problem is detected. Areas that may be vulnerable to erosion must be identified and special attention must be paid to these areas on an ongoing basis.

7. Reversing Soil Degradation

Before facilitating this section, allow learners the opportunity to suggest methods of reversing soil degradation. Present the strategies that follow, as far as possible using examples or pictures. Help the learners to identify the pioneer, sub-climax and climax species in their area. Lead a class discussion about what it means when one sees, for example, only pioneer species in the area.

We have already discussed a few methods for preventing soil degradation and conserve soil potential. We need to however examine two methods that can be employed to reverse soil degradation, being the re-establishment of vegetative cover and rotational farming.

7.1. Re-Establishing Vegetation on Degraded Soil

We have already discussed the importance of vegetative cover in the soil prevention of soil erosion. Re-establishing vegetative cover on degraded soil is also the best method of reclamation, provided that the factors that have led to the degradation of the soil in the first place have been dealt with. The advantages of the re-establishment of vegetative cover are:

- Improved soil infiltration rate, resulting in less runoff and more moisture available to plants.
- Cooler soil surface, resulting in less evaporation and improved seedling development.
- Protection against wind offers the opportunity to build up a seed bank.
- Root action and return of micro-organisms improve soil structure.
- Build-up of organic material around the plants retains moisture and increases soil fertility.
- Improved nitrogen fixing and increased soil quality over time.

In order to understand how the re-establishment of vegetation is achieved, it is important to understand the basics of veldt composition and plant succession.

Plant succession is an important ecological process and a basic knowledge of this process is essential to understand the dynamics of veldt. Plant succession is the progressive succession of plant communities. When a disturbance takes place in an area, the area is re-colonised by a new, better adapted plant community. This new community improves the growth conditions, and a second plant community that is better adapted to the new, improved growth conditions, replaces the first plant community.

The three stages of plant succession are the establishment of a pioneer species, followed by a sub-climax species, followed by a climax species. The process of plant succession continues until the climax community has been established. If the succession process is disturbed again, the veldt reverts to pioneer stage.

7.1.1. Pioneer Species

Pioneer plants species are hardened, annual plants that can grow in very unfavourable conditions. Examples of pioneer grasses are *Aristida adscensionis* and *Tragus berteronianus*.

Pioneer plants protect the ground against wind and water erosion, and improve the growth conditions. As the growth conditions improve, it becomes more favourable for perennial grasses. These grasses are stronger growers and, in time, will drive out the smaller annual pioneer grasses.

7.1.2. Sub-Climax Species

Sub-climax plant species are denser than pioneer plants and offer more protection to the soil. More moisture now becomes available, which leads to a denser plant stand, which deposits more organic material on the surface.

Examples of sub-climax grasses are *Eragrostis rigidior* and *Bothriochloa insculpta*. These grasses are mainly weak perennials with a lifespan of approximately two to five years. As growth conditions improve even more, climax species replace the sub-climax species.

7.1.3. Climax Species

Climax grasses are strong perennial plants that are adapted to normal, optimal growth conditions and will grow in an area as long as these conditions prevail. Climax grasses offer excellent protection against wind, sun and flooding. Examples of such grasses are *Themeda triandra*, *Digitaria eriantha* and *Anthephora pubescens*, all dense perennial tufted grasses.

There are also some species that is referred to as top climax species. These grasses all occur in areas with a mild to high rainfall and are usually robust tufted grasses. They are particularly prone to increase in climax veldt when conditions become too good, for example when no grazing takes place and a high rainfall is experienced over a few consecutive seasons. Thatching grasses (*Hyparrhenia* species) is examples of top climax species. The climax-stage is the best stage for grazing and soil protection, and is the stage towards which the plant succession process automatically progresses.

In more arid regions, climax plant species cannot be supported by the environment and the succession process often only progresses as far as the sub-climax stage, and may even remain in the pioneer stage. The same situation occurs when the topsoil is removed through erosion. The soil is too weak to support climax grasses and the succession process only progresses up to the pioneer or sub-climax stage, until a new layer of topsoil has developed.

Habitat-specific grasses often represent two or even all three succession stages. A good example of this is *Panicum maximum* which can be a climax, sub-climax or even a pioneer grass underneath trees.

7.2. Rotational Farming

Rotational Farming

Rotational farming means the successive cultivation of different crops in a specified order on the same fields, in contrast to a one-crop system or haphazard crop successions.

Although rotational farming is not practiced in citrus farming due to the nature and lifespan of citrus trees, it is important to take note of this concept. Broadly speaking, rotational crop systems should be planned around the use of deep-rooting legumes and fodder such as grains and lucernes.

The general recommendation is to include legumes on its own or in mixtures with non-legume sod-forming crops as a regular crop in field rotations. In general, rotation should occur once in each four-year period. Short rotations are not likely to provide the best crop balances, and long rotations on a larger number of fields may introduce complications. With a moderate number of fields, additional flexibility can be provided by split cropping on some fields.

The usefulness of individual field crops is affected by regional differences in climate and soil. A major crop in one region may have little or no value in another. In each region, however, there are usually row, grain and sod, also called rest crops, which can be brought together into effective cropping systems.

In addition to the many beneficial effects on soils and crops, well-planned crop rotations provide the business opportunities for the farmer. Labour, power, and equipment can be managed with more efficiency, weather and market risks are reduced, livestock requirements can be met more easily, and the farm can be a more effective year-round enterprise.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 4

- Soil is the result of soil formation processes over thousands of years. Soil types differ from one place on the surface of the earth to the other, as the result of the differences in the formation processes.
- Soil potential determines the type of crop that can be grown in a specific soil, and the volume and quality of crops that can be produced.
- Soil fertility can simply be referred to as the amount of food that the soil can supply to the plants.

- There is a considerable variation in the capacity of soils to store and release water for plant use, referred to as the water holding capacity of the soil.
- The ease with which air, water and roots can penetrate soil is determined by the number and size of the open spaces, or pores, in the soil.
- The differences in soils that are found in different areas are associated with suitability for crop production, mainly as result of differences in the following characteristics texture, structure, layering, or stratification, chemical and mineral composition, and depth.
- Texture relates to the ratio between the different sized particles, being sand, silt and clay, in the soil.
- Soil structure refers to the manner in which all the soil particles, including organic material, are arranged to form structural units.
- Soils form layers with different soil properties.
- Soil depth refers to the depth to which the roots of plants can easily penetrate.
- Soil degradation means a decrease in the quality and potential of the soil and can result from a variety of actions or circumstances.
- The nitrogen cycle is a good illustration of the impact that various farming activities have on the nitrogen content of soil.
- Soil erosion occurs when soil is removed through the action of wind and water at a greater rate than it is formed.
- Water erosion causes two types of problems, being on-site loss of agricultural potential, and the off-site effects of downstream sedimentation, causing flooding and the silting up of reservoirs. The main forms of water erosion are sheet erosion, rill erosion (channel erosion), and gully erosion.
- There are various soil and land characteristics that impact on the erodibility of the soil, of which slope, soil texture, soil structure, terrain unit, organic material, and vegetation cover are the most important.
- There are a number of steps that can be taken to prevent or limit soil erosion.
- Soil degradation and erosion should be monitored on a continuous basis through effective standard operating procedures and recordkeeping.
- Two methods that can be employed to reverse soil degradation are the re-establishment of vegetative cover and rotational farming.
- The re-establishment of vegetation cover involves the identification and establishment of pioneer, sub-climax and climax species.
- Rotational crop systems should be planned around the use of deep-rooting legumes and fodder such as grains and lucernes.

Complete activities 7, 8 and 9 in the **Learner Workbook**.

Activity 7 – Worksheet

Remind learners to complete the activity individually and as per their own understanding.

Timeframe: 1h 30min

Activity 8 – Explore and Discover

Remind learners to complete the activity individually, with application to their own area and to incorporate either dried examples or pictures of the plant species. Caution learners not to damage plants while taking samples for this activities – a single leaf is preferable to a whole plant being ripped up.

Timeframe: 1h

Activity 9 – Research and Advise

Ensure that learners understand that they need to put on a different thinking cap from their usual farm worker approach, and that they have to play the role of the consultant.

Timeframe: 30min

Chapter 5

After completing this chapter, the learner will be able to:

Monitor and implement principles of water management.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
2h 30min	1h 30min	1h activities

Learners will identify better with different water management strategies if they can relate it to their own work experience. Lead group discussions while visiting different water sources, rather than simply relaying the theoretical information to the learners.

1. Introduction

Water management on citrus farms has traditionally been concerned with managing irrigation scheduling and maintaining irrigation systems to conserve water. Citrus farms are often located in areas that suffer from periodic droughts, and the using water conservatively has therefore become a way of life for most farmers and farm workers involved in citrus production.

Citrus trees and citrus crops are not hypersensitive to water quality. It is however worth noting that maintaining of water quality can make the difference between an export quality and a poor crop.

For the purpose of this learning module we will examine water management from a conservation perspective for agriculture and will therefore examine some interesting examples and alternatives to what might be known practices in citrus production at present.

2. Water Management Methods

The most common water management methods include:

- Rainwater harvesting
- Subsurface irrigation
- Protecting water sources
- Maintain irrigation systems

2.1. Rainwater Harvesting

Rainwater harvesting involves collecting rainwater that is used for irrigating crops and for household use. Rainwater can be collected by various means, from simply using open tanks in which water is collected directly or indirectly from a gutter system, to building specially designed structures using shade-netting aimed at collecting mist and rainwater.

Rainwater harvesting can significantly reduce reliance on water sources for irrigation. It is often used on farms to collect water for gardening, human consumption and secondary crop production, such as vegetable gardens.

2.2. Subsurface Irrigation

Subsurface irrigation refers to specialised irrigation systems, where lateral lines are placed permanently below the soil surface. This system delivers irrigation water directly to the subsoil, targeting specific root zones. This method is used in very hot and dry regions with sandy soils. It conserves water because it limits losses due to evaporation.

2.3. Protecting Water Sources

Water sources refer to those sources on the farm from where water for irrigation and other uses are drawn. This includes rivers, boreholes, earth dams and storage dams. Measures to protect water sources are aimed at maintaining good water quality and at avoiding pollution and silting.

Fences are used to control direct access for animals and humans to water sources. This limits the risk of contamination and pollution.

Routine water sampling to monitor water quality is used to ensure that control measures are effective and that farming practices, such as over-fertilisation that may cause the leaching of chemicals to water sources resulting in salinisation of water, are not impacting negatively on water quality.

Silt traps and filters are also placed at strategic points to prevent silt from entering the water source. It will also trap topsoil runoff and filter out materials that may contribute to salinity and pH imbalance.

2.4. Maintain Irrigation Systems

Annual maintenance plans and regular critical control point checklists are used to maintain the components of the irrigation system. This includes ensuring that pumps work correctly, that filters are not clogged and back-flushed regularly, that water pressure is maintained throughout the system, that emitters are working effectively and that there are no leaks in the pipeline.

Proper irrigation system maintenance avoids water wastage, assists with maintaining water quality, and ensures that the correct amount of water is delivered to each tree.

3. Developing a Water Runoff Plan

Water runoff occurs naturally when high rainfall occurs in a short period of time. Regular water runoff occurs mostly as a result of over-irrigation, when water is applied at such a high rate or in such volumes that it does not have sufficient time to infiltrate the soil. A secondary cause of water runoff may be soil crusting, which is caused by increased soil salinity.

As we have already seen, excessive runoff is a major cause of erosion and can cause permanent damage to the soil and topography. A water runoff plan is developed to ensure that water runoff is monitored and controlled.

A good water runoff plan takes the following into consideration:

- Sediment clouds the water and can destroy aquatic habitats.
- Excess nutrients can cause algae blooms. When algae die, they sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other aquatic organisms can not exist in water with low dissolved oxygen levels.
- Bacteria and other pathogens can cause health hazards and affect food safety adversely.
- Debris, such as plastic bags, bottles and cigarette butts, that are washed into water bodies can threaten aquatic life.
- Household hazardous wastes and agrochemical products such as herbicides, pesticides, paint, solvents, used motor oil, and other auto fluids can poison aquatic life.
- Soil erosion must be prevented by planning pre-emptive actions and structures to avoid erosion formation on potentially sensitive terrain.
- Maintenance of irrigation systems and water sources.
- Erecting structures or establishment of indigenous reeds and grasses that will help with filtering of runoff water.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 5

- Water management on citrus farms has traditionally been concerned with managing irrigation scheduling and maintaining irrigation systems to conserve water.
- The most common water management methods include rainwater harvesting, sub-surface irrigation, protecting water sources, and maintain irrigation systems.
- Rainwater harvesting involves collecting rainwater that is used for irrigating crops and for household use.
- Subsurface irrigation refers to specialised irrigation systems, where lateral lines are placed permanently below the soil surface.
- Measures to protect water sources are aimed at maintaining good water quality and at avoiding pollution and silting.
- Proper irrigation system maintenance avoids water wastage, assists with maintaining water quality, and ensures that the correct amount of water is delivered to each tree.
- Regular water runoff occurs mostly as a result of over-irrigation, when water is applied at such a high rate or in such volumes that it does not have sufficient time to infiltrate the soil.
- A water runoff plan is developed to ensure that water runoff is monitored and controlled.

Complete activity 10 in the **Learner Workbook**.

Activity 10 – Worksheet

Remind learners to answer the worksheet individually and as per their understanding, and, where possible, with reference to their experience or examples.

Timeframe: 1h

Chapter 6

After completing this chapter, the learner will be able to:

Demonstrate a basic understanding of the energy cycle.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
2h 15min	1h 30min	45min activities

After holding a discussion around the energy cycle – most learners will already be familiar with it – complete a mock resource utilisation plan with the learners to demonstrate how it can be used to correctly and efficiently utilise resources.

1. The Energy Cycle

In the level 2 guide we spent considerable time discussing different forms of energy. Most energy used in the world comes from the burning of fossil fuels, which is a non-renewable natural resource. There are also alternative sources of energy such as solar energy, wind energy, water energy, nuclear energy, and bio-diesel.

It is important to understand the energy cycle in order to plan and use the right resource of energy correctly and efficiently. Figure 6.1 illustrates the flow of energy through the food chain.

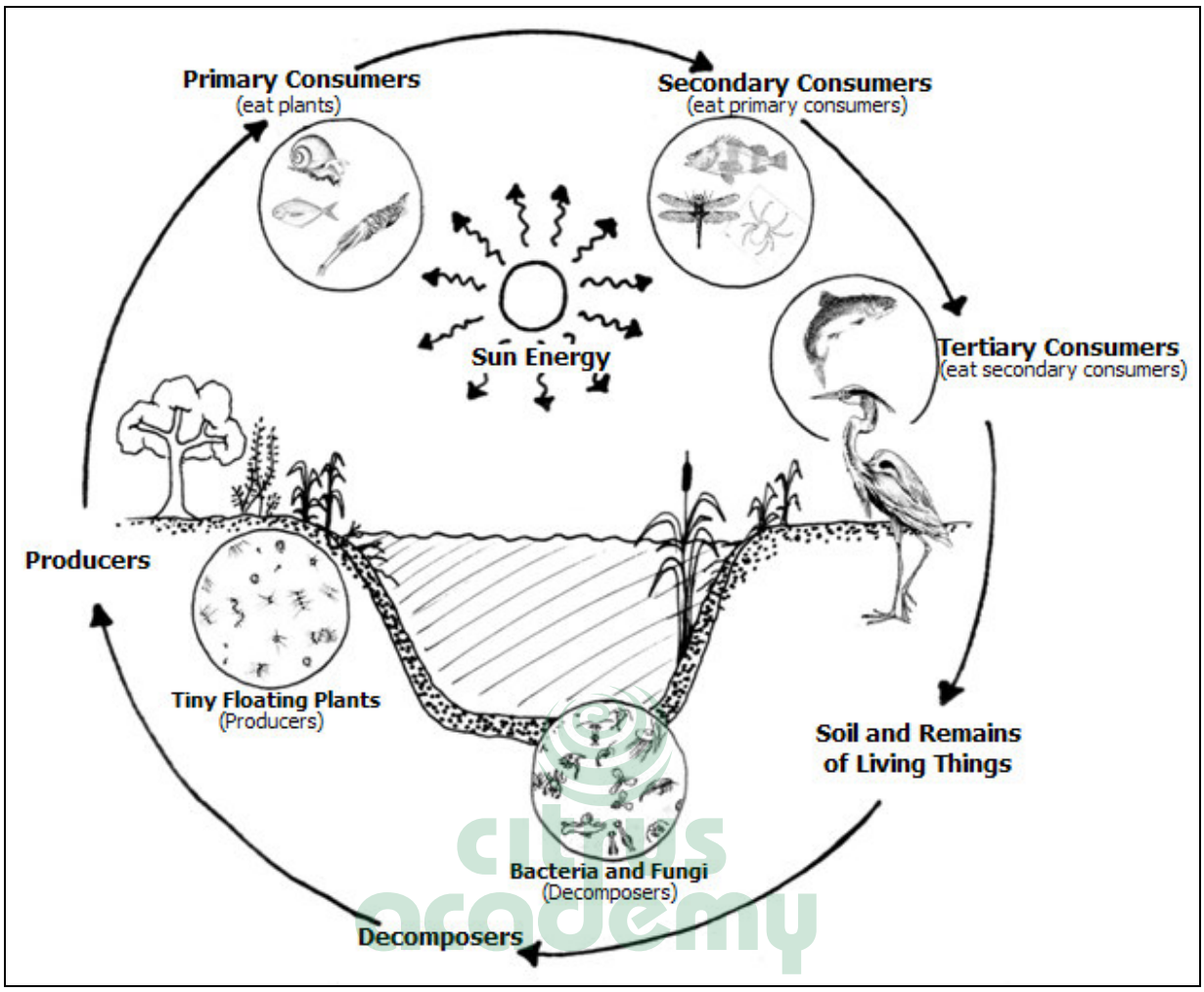

Figure 6.1: The Energy Cycle

2. The Energy Cycle and Citrus Farming

It is important to understand the interaction of different phases of the energy cycle and how the crop that is produced on the farm fits into the cycle. Citrus trees use sun energy during photosynthesis to grow and to produce leaves, pollen, seeds and fruit that is passed on to primary, secondary and tertiary consumers.

In the level 2 guide on plant structures and functions, the process of photosynthesis is discussed in detail. For the purpose of this guide it is important to have a basic understanding of photosynthesis and the fact that photosynthesis is considered a sun interactive cycle which forms part of the energy cycle.

Photosynthesis

Photosynthesis literally means light production, or production by light (photo=light, synthesis=production) and is the metabolic process by which green plants turn carbon dioxide and water into food using energy obtained from sunlight.

The leaf is possibly the most important part of the plant, as it is here that carbohydrates are produced in the process of photosynthesis. This is the energy source for further growth and development, including that of the fruit. Chlorophyll is the main pigment responsible for photosynthesis. Photosynthesis occurs throughout the lifespan of the plant. The formula below summarises the process of photosynthesis:

$$6CO_2 + 12H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Remember That

CO_2 = Carbon dioxide
H_2O = Water
$C_6H_{12}O_6$ = Carbohydrates (sugars)
O_2 = Oxygen

This formula means that, through using light energy, the plant is able to convert six molecules of carbon dioxide and twelve molecules of water to one molecule of carbohydrates. Six molecules of oxygen and six molecules of water come free in the process.

During photosynthesis, the plant absorbs CO_2 through the stomata in the leaves, and water through the roots, which is taken to the leaves by the xylem in the vascular tissue of the roots and stem. The green pigments (chlorophyll) in the chloroplast absorb sunlight and with this energy the plant manufactures sugars (carbohydrates). Oxygen and water molecules come free, and are released through the stomata.

If citrus trees are planted with the correct attitude to the sun it will contribute to a healthy crop from healthy trees without the use of unnaturally high amounts of agrochemical crop protection products. The trees will get the right amount of sun energy to ensure that the canopy develops sufficiently without trapping moisture that causes disease. This in turn will contribute to the maintenance of healthy ecosystems.

Global Warming

Ever heard it said that the destruction of vast tracts of natural forest, especially the rain forests, contributes to there being too much carbon dioxide in the air, leading to the greenhouse effect and global warming? This is because plants are able to absorb carbon dioxide and produce oxygen during the process of photosynthesis.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 6

- Most energy used in the world comes from the burning of fossil fuels, which is a non-renewable natural resource.
- It is important to understand the energy cycle in order to plan and use the right resource of energy correctly and efficiently.
- Citrus trees use sun energy during photosynthesis to grow and to produce leaves, pollen, seeds and fruit that is passed on to primary, secondary and tertiary consumers.
- If citrus trees are planted with the correct attitude to the sun it will contribute to a healthy crop from healthy trees without the use of unnaturally high amounts of agrochemical crop protection products.

Complete activity 11 in the **Learner Workbook**.

Activity 11 – Worksheet

Remind learners to complete the worksheet individually and as per their own understanding of the concepts.

Timeframe: 45min

Chapter 7

After completing this chapter, the learner will be able to:

Read a two dimensional map of the direct vicinity.

You have to complete this section as follows:

Total time	*Theory*	*Practical*
2h 30min	1h 30min	1h activities

Developing map-reading skills requires practice on real maps. Have maps available, preferably of the surrounding area, to allow learners to read and interpret the information and symbols.

1. Introduction

We have discussed topographical features such as slope and elevation and its significance in terms of runoff and erosion control. Topography also influences the climate and soil formation of specific areas. Effective soil conservation and crop establishment planning are essential for conservation, and water sources with good quality water are essential for the production of citrus as well as for maintaining healthy ecosystems and biodiversity.

Topography plays a significant role in the choice of farming activity and that rivers, streams, wetlands and cultivated areas has to be balanced with the choice of farming activity in a sustainable manner.

We have discussed the importance of planning and the contribution that site analysis can make to conservation and healthy ecosystems. The most practical way in which to do site analysis is by reading maps of the area on which the farm is situated and recognising the topographical features, boundaries, and natural resources on the map.

2. Recognising Features on Maps

The three most important features that one needs to be able to identify on a map are topography, water sources and wetland areas, and boundary lines.

2.1. Topography

Topographic maps describe vertical information through the use of contour lines, also called contours. A contour line connects points on a map that have the same elevation. Contour lines provide us with a simple, effective system for describing landscape configuration on a two-

dimensional map. The arrangement, spacing, and shape of the contours provide the user of the map with some idea of what the actual topographic configuration of the land surface looks like.

Contours are often drawn on a map at a uniform vertical distance. This distance is called the contour interval. Contour intervals that are spaced closely together describe a steep slope. Gentle slopes are indicated by widely spaced contours. Contour lines that form an upwards V-shape indicate the presence of a river valley. Ridges are indicated by contours that V downwards.

A **topographic profile** is a two-dimensional diagram that describes the landscape in vertical cross-section. Topographic profiles can be created from the contour information found on topographic maps.

The simplest way to construct a topographic profile is to place a sheet of blank paper along the specific portion of the map. From the map, the elevation of the various contours is transferred on to the edge of the paper from one end of the section to the other. This process is illustrated in figure 7.1.

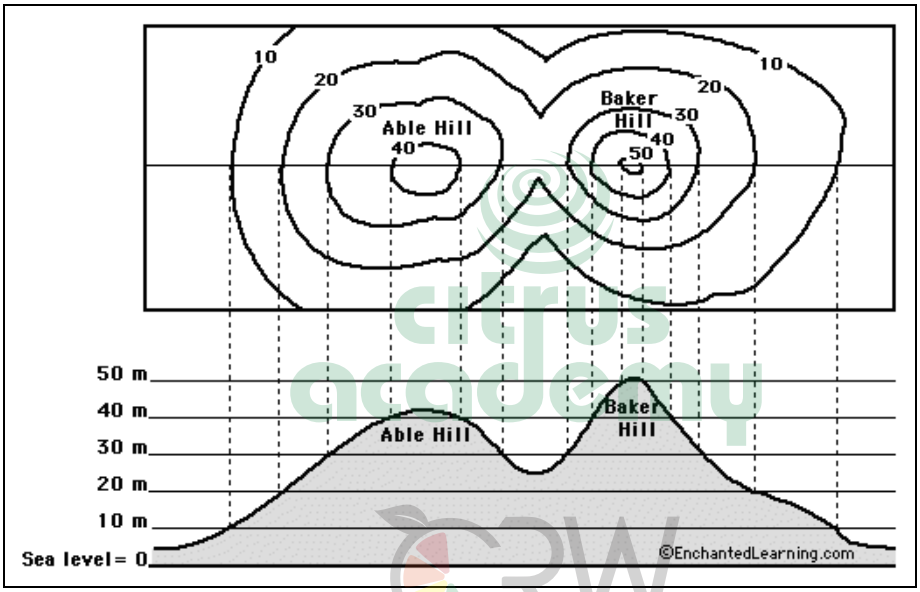

Figure 7.1: Drawing a Topographic Profile from Contour Lines

2.2. Water Sources and Wetland Areas

Water sources and wetlands are indicated with pale blue coloured symbols on maps in the shape of the water source, such as a dam. In figure 7.1 and 7.2 are some examples of such symbols.

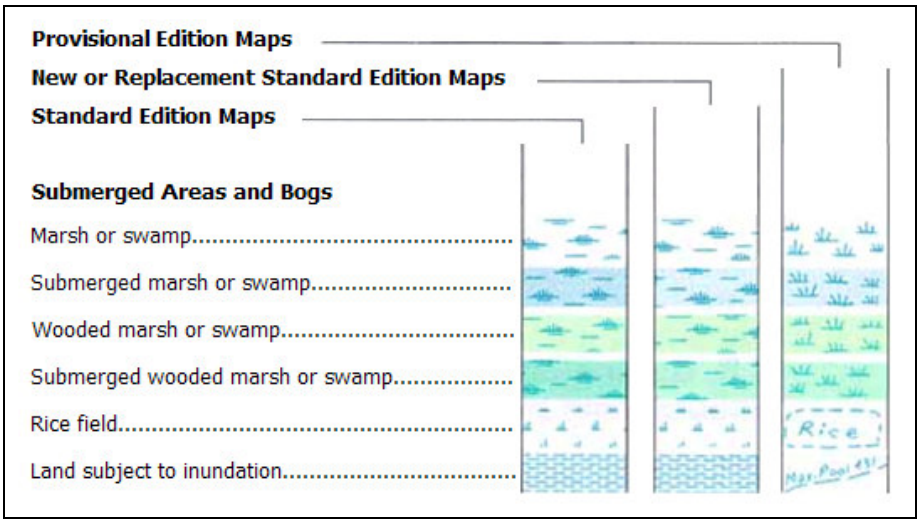

Figure 7.2: Map Symbols for Wetlands, Marshes and Flood Zones

Please Note

If your learner guide is not printed in colour, please note that all the symbols in figure 7.2 and 7.3 are light blue, except for those for **wooded marshes or swamps** and **submerged wooded marshes or swamps**, which are light green in colour.

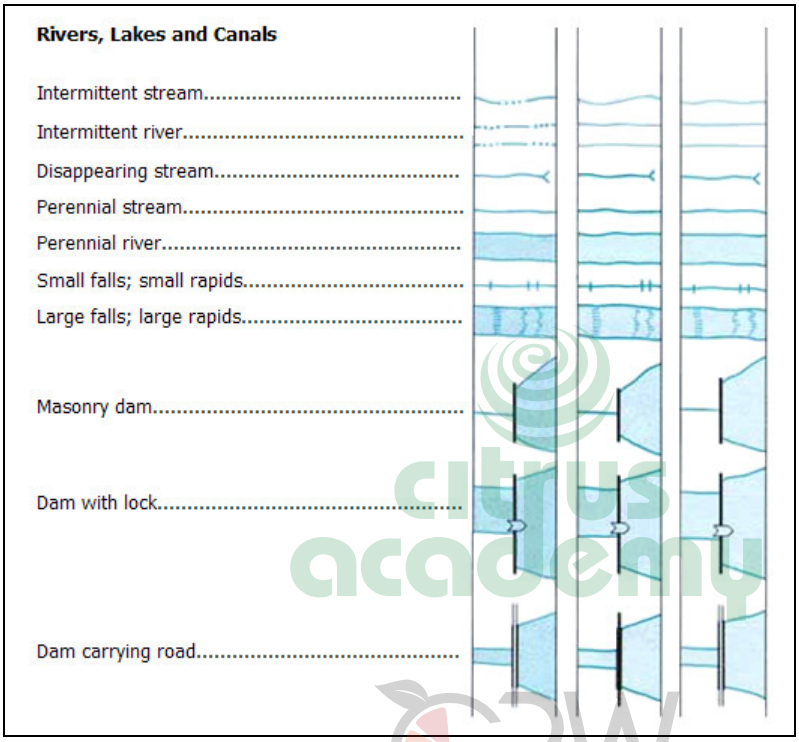

Figure 7.3: Map Symbols for Dams, Streams and Rivers

2.3. Boundaries and Basic Features

Boundaries are depicted by a variety of lines on maps. In figure 7.4 are some examples:

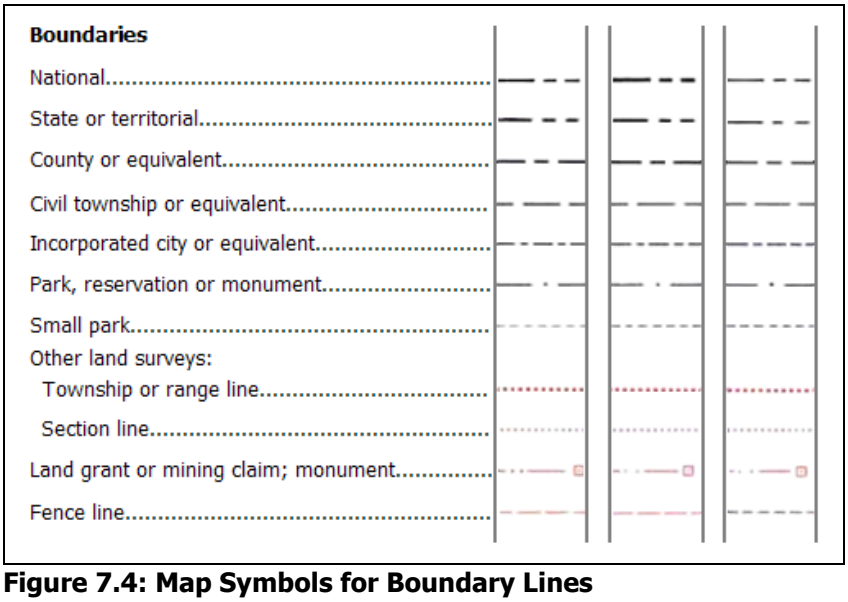

Figure 7.4: Map Symbols for Boundary Lines

3. Agricultural Geo-Referenced Information System (AGIS)

The Agricultural Geo-Referenced Information System (AGIS) offers a one-stop information service for the agricultural sector in South Africa. Using interactive web-based applications, AGIS provides access to maps, industry specific information and decision support tools.

The major role-players responsible for the development of AGIS are the national Department of Agriculture, Forestry and Fisheries (DAFF), the nine provincial Departments of Agriculture and the Agricultural Research Council (ARC). The AGIS Serving Centre is located within DAFF while the Institute for Soil, Climate and Water (ISCW) of the ARC is central to the development and maintenance of AGIS content.

Orientation information including the 1:250,000 and 1:50,000 maps, showing the location of towns, roads, rivers, and administrative areas, as well as farm boundaries. The natural resources atlas includes soils, natural vegetation and climate information, as well as land capability on a national scale.

Agis Information

For maps and other information from AGIS, log onto www.agis.agric.za.

Summary

This is an opportunity to check the progress that learners have made.

Allow time for the learners to read through the summary and to gauge their own progress. Make sure that each and every learner gets and opportunity to ask questions.

Chapter 7

- The most practical way in which to do site analysis is by reading maps of the area on which the farm is situated and recognising the topographical features, boundaries, and natural resources on the map.
- The three most important features that one needs to be able to identify on a map are topography, water sources and wetland areas, and boundary lines.
- Topographic maps describe vertical information through the use of contour lines, also called contours, which connect the points on a map that have the same elevation.
- A topographic profile is a two-dimensional diagram that describes the landscape in vertical cross-section.
- Various symbols are used to indicate water sources, wetland areas and boundary lines on maps.
- The Agricultural Geo-Referenced Information System (AGIS) provides access to maps, industry specific information and decision support tools.

Complete activity 12 in the **Learner Workbook**.

Activity 12 – Worksheet

Remind learners to arrange with their workplace for a copy of the farm map. This copy must be included in the workbook and the information on the map must be interpreted by the learner.

Timeframe: 1h

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Subject Matter Experts:

B. Harington (BSc Agric)
C. Harington (OBET)