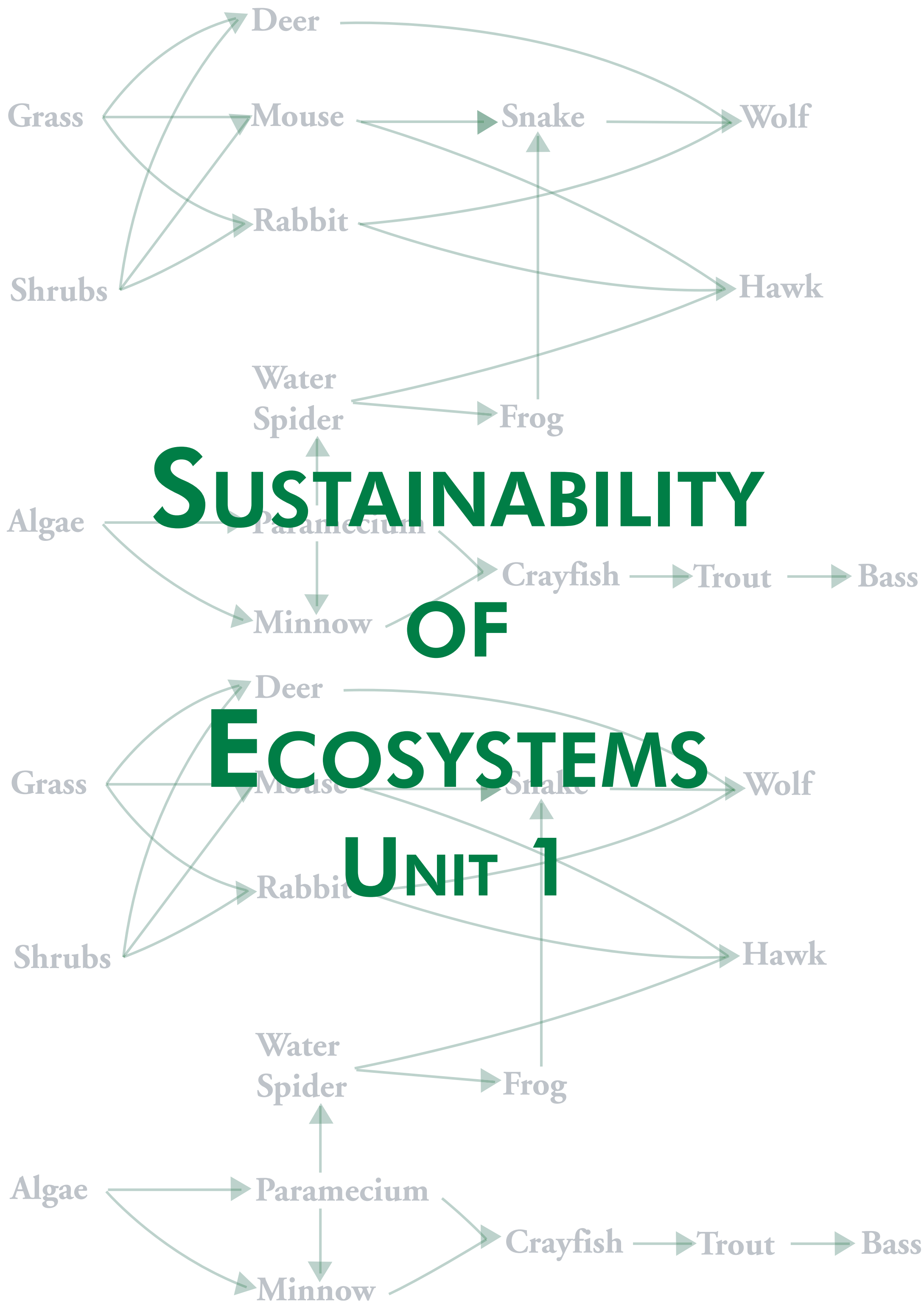
Sustainability of Ecosystems

Unit 1



HOW DOES SUSTAINABILITY FIT INTO YOUR PARADIGM AND SOCIETY'S PARADIGM?

LESSON 1

LEARNING OUTCOMES

Students will be expected to:

- explain how a paradigm shift can change scientific world views in understanding sustainability (114-1)
- communicate questions, ideas, and intentions and receive, interpret, understand, support, and respond to the ideas of others with respect to environmental attitudes (215-1)
- identify multiple perspectives that influence a science-related decision or issue (215-4)
- project the personal, social, and environmental consequences of proposed actions (447)

INTRODUCTION

According to page 116 of ***SciencePower 10***, "a ***paradigm*** is a way of looking at the world that is shared by most people in a community." A paradigm shift is a rare and significant change in the way humans view the world. They are major changes which are controversial when first proposed but eventually come to be accepted as a major advancement in scientific knowledge and understanding. One example of a paradigm (pronounced "pair-a-dime") shift was the change from the belief that the world was flat and the centre of the universe, to the belief that the world is round and rotates around the sun.

ASSIGNMENT 1
DO AND SEND

1. Write an example of a past paradigm. What is the new view most people in the community accept today? Most diseases in the middle ages were treated by bloodletting. A doctor opened a patient's artery or vein to let blood drain. The paradigm, accepted by the medical community and population was founded in the belief that most diseases left the body in the blood. Today it is acknowledged that a bacteria or a virus is the cause of illness. Most illnesses may be treated with a pharmaceutical regime or medical intervention. (6 points)

2. Many people would say that we are in the midst of paradigm shift today with regard to how we think about the environment. What evidence is there to support this belief? What impact would this shift have on the planet in general and Nova Scotians in particular? Why might people not want to make this shift? (14 points)

CAPTURING ENERGY FROM THE SUN
LESSON 2

LEARNING OUTCOMES

Students will be expected to:

- describe and apply classification systems and nomenclature with respect to trophic levels in ecosystems (214-1)

INTRODUCTION

Think about the following questions:

- How is your brain powered by the Sun?
- Why are rabbits more common than foxes?
- Why might overfishing of herring lead to an increase in populations of sea urchins?

The answers to all of these questions have to do with energy and how it is passed from one organism to another.

ACTIVITY - YOU AND FOOD CHAINS

Complete *"You and Food Chains"* from page 3 of ***SciencePower 10***.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 4, 5, and 7, complete *"Check Your Understanding"* questions 1-7 on page 7 of ***SciencePower 10***.

ASSIGNMENT 2
FROM LAND TO MOUTH
DO AND SEND

Complete *"From Land to Mouth"* on page 6 of ***SciencePower 10***. Complete the *"What to Do"* and *"What Did You Discover"* sections. In questions which require calculations you must show your work.

POINT VALUE

What to Do Answers	What did you Discover
1. 4 points	1. 4 points
2. 3 points	2. 3 points
4. 3 points	3. 3 points

FEEDING LEVELS
LESSON 3

LEARNING OUTCOMES
Students will be expected to:

- describe and apply classification systems and nomenclature with respect to trophic levels in ecosystems (214-1)
- classify organisms as producer, consumer, autotroph, heterotroph, decomposer, herbivore, carnivore, omnivore, saprobe
- compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatterplots (214-3)

INTRODUCTION
Before we can look at the effects of various factors on the sustainability of an ecosystem, we must look at the relationships within ecosystems. This lesson will expand the idea of food chains into *trophic levels* or feeding levels.

Begin by reading pages 8 and 9 from ***SciencePower 10***.

ACTIVITY - WHAT EATS WHAT?
Ecosystems are composed of many different food chains. In this activity, from page 10 in the text, you will study some possible pathways of energy flow among organisms in a mixed-forest ecosystem.

WHAT TO DO
1. Photocopy or copy and cut out the following cards:

Grass	**Red Fox**
Grasshopper	**Bacteria/Fungi**
Cottontail Rabbit	**Red Squirrel**
Common Raven	**Willow Tree**
Ruffed Grouse	**Bunch Berries**
Red-tailed Hawk	**Maple Seeds**

2. Sort the cards into three groups: producers, consumers, and detritivores.

3. Arrange the organisms into four food chains. Each food chain should be only three links long.

WHAT DID YOU DISCOVER?
Write responses to questions 1-4 on the *"What Did You Discover"* section of the Student Inquiring Activity.

Environmental Pyramids

While food chains are useful to describe basic feeding relationships among organisms, they tend to oversimplify those relationships. Scientists can also use a variety of pyramids to illustrate different feeding relationships. Pyramids can be used to show visual comparisons among organisms at different trophic levels within the same pyramid and between/among pyramids.

Pyramid of Numbers

A pyramid of numbers shows the numbers of organisms that are required to feed the next trophic level. With a pyramid of numbers, you can show that a large number of producers are required to feed a proportionally smaller number of primary consumers. It is easy to infer which trophic level contains the greatest amount of energy for the ecosystem.

Pyramid of Biomass

A pyramid of biomass shows the energy available in each trophic level of an ecosystem. This is slightly more useful than a pyramid of numbers because it takes into account the size of the organisms.

Pyramid of Energy Flow

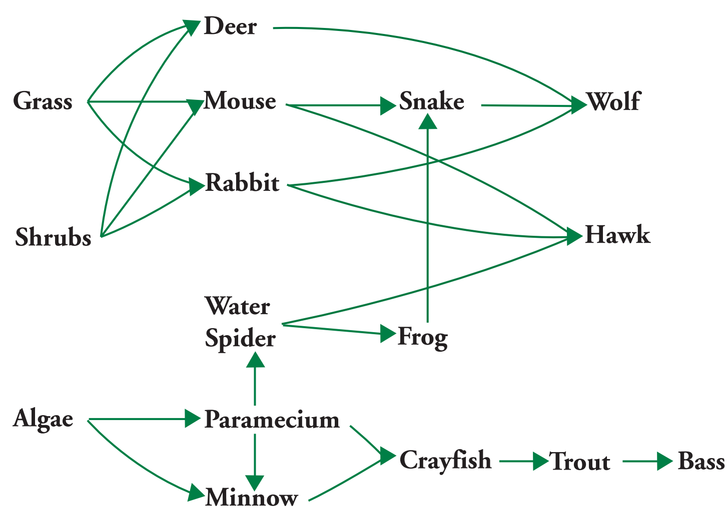
A pyramid of energy flow shows the amount of nutrient energy at each trophic level, which is difficult to measure. A pyramid of energy flow is always upright and cannot be inverted. This is a significant difference between pyramids of energy flow and pyramids of numbers and biomass which can be inverted.

Review Questions - Check Your Understanding

After reading pages 14 - 16, complete questions 1-6 on page 17 of ***SciencePower 10***.

Assignment 3
Food Webs
Do and Send

A food chain is a very simplistic way to look at feeding relationships. A much more realistic picture would include several food chains connected in an illustration called a *food web*.



1. Use words and arrows to identify four possible food chains in this food web. (4 points)

2. Which organisms are the producers? (1 point)

3. Give an example of an aquatic herbivore. (1 point)

4. Give an example of a terrestrial herbivore. (1 point)

5. Name the top carnivore(s). (1 point)

6. To what trophic level does the snake belong? Explain your choice of level. (3 points)

7. Which organism(s) is an omnivore? (1 point)

8. Construct a food web representing organisms which typically inhabit your neighbourhood. Your web must include ***at least*** 10 organisms. (8 points)

POPULATIONS
LESSON 4

LEARNING OUTCOMES

Students will be expected to:

- explain factors that keep populations in equilibrium and within ecosystem limits (318-5)
- explain how biodiversity contributes to an ecosystem's sustainability (318-6)
- analyse the impact of external factors on an ecosystem (331-6)
- identify an example where scientific understanding was enhanced or revised by human invention of a technology (116-1)
- compile and display evidence and information, by hand or computer, in a variety of formats, including diagrams, flow charts, tables, graphs, and scatterplots (214-3)
- state a prediction and a hypothesis based on available evidence and background information (212-4)

INTRODUCTION

A population is a group of organisms of the same species that exists in the same place at the same time. A population changes with time as members of the population leave or join. A natural population will change according to birth rates and death rates, and immigration and emigration. The formula for the *rate of population growth* is:

$$\frac{\text{(Number of births)} - \text{(Number of deaths)} + \text{(Number of immigrants)} - \text{(Number of emigrants)}}{\text{Total population}}$$

Extremely fast growth is called a *population explosion*, which may occur when a new species is introduced into an ecosystem in which there are few, if any, predators, a plentiful food supply, and abundant space. The population of such a species can grow very fast and is sometimes able to take over an ecosystem, changing the nature of interactions among other species. The introduction of Purple Loosestrife into wetlands is an example. While indigenous wetland plants support biodiversity, Purple Loosestrife is not a food source or shelter for any organism. As a result, it can gradually take over and reduce a diverse ecosystem to a single plant species that does not interconnect with other organisms.

A *population extinction* occurs when greater numbers of species leave a population than enter it. A population will steadily decrease if the death rate is higher than the birth rate, or if migration out is higher than migration in. Low population numbers can lead to inappropriate mating practices, during which harmful gene combinations can occur. Such genetic weakness, combined with steady decline in numbers leads to the extinction of the population. There are numerous examples of this process occurring in Canada, especially as a result of human activity.

Overfishing, poaching, reduction of or complete loss of habitat, for example, have resulted in population extinctions.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 18 - 20, complete questions 1-6 on page 24 of ***SciencePower 10***.

ASSIGNMENT 4
POPULATION
DO AND SEND

Time (years)	Population (in millions)
0	0.0
1	3.5
2	4.9
3	6.3
4	7.5
5	8.7
6	16.2
7	33.1
8	40.3
9	43.5
10	45.0
11	46.4
12	46.2
13	46.1
14	46.2

1. The data in the table below, left represents typical population growth. Choose an appropriate scale and construct a line graph of the data. Be sure to label the axis and the graph itself. (4 points)

2. The data in the table below represents a typical population explosion. Choose an appropriate scale and construct a line graph of the data. Be sure to label the axis and the graph itself. (4 points)

Time (years)	Population (in millions)
0	0.0
1	0.5
2	8.0
3	12.2
4	17.5
5	20.3
6	41.6
7	80.0
8	175.0

3. The data in the table at the top of the next page represents a typical population extinction. Choose an appropriate scale and construct a line graph of the data. Be sure to label the axis and the graph itself. (4 points)

Time (years)	Population (in millions)
0	4.5
1	6.3
2	7.2
3	10.0
4	21.7
5	41.6
6	81.9
7	39.8
8	20.5
9	11.4
10	9.6
11	7.2
12	5.5
13	0.0

4. Complete *"Extend Your Knowledge"* question 6, on page 23 of ***SciencePower 10***. (8 points)

FEEDING PEOPLE

LESSON 5

LEARNING OUTCOMES

Students will be expected to:

- describe the mechanisms of bioaccumulation, and explain its potential impact on the viability and diversity of consumers at all trophic levels (318-2)
- explain why ecosystems with similar characteristics can exist in different locations (318-3)
- explain why the ecosystem may respond differently to short-term stresses and long-term changes (318-4)
- analyse the impact of external factors on an ecosystem (331-6)
- appreciate that applications of science and technology can raise ethical dilemmas (437)

INTRODUCTION

There are several different ecosystems around the world - estuaries, swamps, tropical rain forests, agricultural land, grasslands, oceans, and tundra to name a few. Each ecosystem has its *productivity level* (the average amounts of new plant biomass produced each year per unit area). Average productivity is measured in kilojoules per square metre per year, the same measure you used in completing *"From Land to Mouth"* on page 6 of ***SciencePower 10***.

Some quick facts about the major ecosystems:

- Estuary ecosystems are tidal channels at the mouth of rivers, where terrestrial and marine nutrients and organisms mix.
- Swamp and marsh ecosystems are wetlands with great biodiversity and nutrient production.
- Tropical rain forest ecosystems, located on the equator, have great biodiversity.
- Temperate forest ecosystems feature diversity of tree species and populations of organisms inhabiting forest.
- Northern coniferous (or taiga) ecosystems have lower diversity of tree species than boreal or temperate forest, and support fewer organisms.
- Savannah (or tropical grassland) ecosystems, located near the equator, consist of some trees and shrubs and a diversity of natural grasses, which can support very large populations of migrating animals.
- Agricultural land has been converted from a variety of ecosystem types to produce food for human consumption.
- Woodland and scrubland ecosystems may have little diversity of tree and plant species, which support a correspondingly low biodiversity.
- Temperate grassland ecosystems, like the Canadian prairies, have much lower biodiversity than tropical grasslands.

- Lake and stream ecosystems are located inland on continents.
- Continent shelf ecosystems occur where abundant floating plankton can produce nutrients for a diversity of life.
- Open ocean ecosystems are distant from land and have low biodiversity.
- Tundra ecosystems have cold desert conditions, with low biodiversity.
- Desert shrub ecosystems consist of cactus and a few species of plants, which can support small populations of birds and animals.
- Extreme desert ecosystems have the lowest biodiversity of any ecosystem on Earth.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 25, 27-29, 33-34, complete questions 1-4, 6 on page 34 of ***SciencePower 10***.

ASSIGNMENT 5
DDT IN A FOOD CHAIN
DO AND SEND

Complete the Investigation 1-C *"DDT in a Food Chain"* found on pages 30-32 of ***SciencePower 10***. Do questions 1-11 on page 32 in your text. The point values for each question are shown above, right.

POINT VALUES

1. 1 point
2. 1 point
3. 1 point
4. 1 point
5. 1 point
6. 1 point
7. 2 points
8. 2 points
9. 2 points
10. 2 points
11. 2 points

THE CARBON-OXYGEN CYCLE
LESSON 6

LEARNING OUTCOMES

Students will be expected to:

- illustrate the cycling of matter through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen (318-1)
- analyse the impact of external factors on the ecosystem (331-6)

INTRODUCTION

Organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil type, and pH. Physical or non-living factors such as these which influence living things are called *abiotic factors*. Living factors which influence things are called *biotic factors*. Some examples of biotic factors include disease and predation.

The atoms and molecules in the biosphere cycle are among the living and non-living components of the Earth. Carbon dioxide molecules are used in the process of photosynthesis to form energy-rich organic sugar compounds. These carbon dioxide molecules are returned to the environment by the process of cell respiration, when the energy from these compounds is eventually released by cells. Some carbon is also returned to the environment by the decomposition of dead organisms.

Oxygen is required by many living things to release the energy in their food through the process of aerobic cellular respiration. Oxygen is released to the environment as a waste product of the process of photosynthesis.

Other compounds, such as nitrogen, are cycled in the environment when organisms synthesize proteins from simpler compounds. The nitrogen compounds are returned to the environment when they die and decompose.

As mentioned in previous lessons, the number of organisms any environment can support is the carrying capacity of the environment. Carrying capacity is limited by the available energy, water, oxygen, and minerals, and the ability of ecosystems to recycle the remains of dead organisms through the activities of decomposers such as bacteria and fungi.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 40, 42-43, 46-47, 50-51, complete questions 1-6 on page 42 and questions 1-7 on page 51 of ***SciencePower 10***.

ASSIGNMENT 6
THE CHEMISTRY OF PHOTOSYNTHESIS
DO AND SEND

QUESTION

How can you demonstrate that plants absorb carbon dioxide?

BACKGROUND INFORMATION

Carbon dioxide gas dissolves in water to form a weak solution of carbonic acid. Chemists use indicators to test whether a substance is an acid or a base. Indicators work by turning a distinctive colour in the presence of an acid or a base. You can make your own indicator from red cabbage. You can also make indicators from the juice of blackberries or cherries.

Red cabbage juice turns a wide variety of colours depending on the strength of the acid or base which is being added to it. Use the following chart to help you determine the pH of the solutions you will using in this lab.

MATERIALS

- water
- one head of red cabbage (for pH indicator)
- drinking straw
- 2 fresh sprigs of water plant (pick them from a local stream, river, pond, brook, or lake)
- black paper
- masking tape

Approximate pH	2	4	6	8	10	12
Red Cabbage Juice	red	purple	violet	blue	teal	green

APPARATUS

- 250 mL or 1 cup measuring cup
- 2 small jelly or jam bottles with covers, empty and thoroughly cleaned
- 1 large pickle jar which is wide enough to cover both jelly bottles (optional)
- knife and cutting board
- medium sized pot
- bottle with lid, large enough to hold 500 mL (2 cups) of liquid
- sieve or strainer
- large flashlight

PROCEDURE

Part A - Preparing the indicator:

1. Chop red cabbage up finely. Boil 500 mL of water in medium sized pot. Add the red cabbage carefully to the boiling water and take the pot off the heat. Let it stand for 30 minutes (or longer) until it is completely cool.

2. Strain the liquid into a large glass bottle and throw the used cabbage into the compost bin. The liquid should be a dark reddish purple colour. The colour will change when you add acids or bases.

Part B - Testing the plants:

1. Fill the measuring cup with water. Add 1 tablespoon of red cabbage juice. The solution

is any shade between purple and red when the pH is below 7 (acidic) and any shade between green and blue when the pH is above 7 (basic). Store the remaining extract in the refrigerator in a tightly sealed jar. You will need it for the next investigation.

2. Using the drinking straw, gently blow into the solution until the indicator just changes colour.

   Copy the table below and use it to record your observations throughout the investigation. Include this table with your completed assignment. (3 points)

Jar	Original Colour of Solution	Colour of Solution After Blowing Into It	Colour of Solution After 15 to 20 Minutes
Clear			
Black			

3. Pour 125 mL (1/2 cup) of solution into each of the jelly jars.

4. Add a sprig of the plant to each jar. Seal the jar with its cover.

5. Tape a piece of black paper around one jar so that no light can enter.

6. Place both jars in front of the flashlight for 15 to 20 minutes. If possible, place a large glass jar filled with water between the jelly jars and the light to absorb any heat that is given off by the flashlight.

7. Shut off the flashlight and remove the black paper. Record your observations in the table in step 2. If there is no colour change, gently agitate both test tubes for a few seconds.

8. Wash your hands after completing this investigation.

ANALYSE

1. What gas did you add to the solution using the straw? (1 point)

2. Why did the gas produce a colour change in the indicator? (2 points)

3. Describe what colour changes you observed in each test tube. (2 points)

4. Explain your observations, with reference to the equation for photosynthesis on page 43 of ***SciencePower 10***. (5 points)

CONCLUDE AND APPLY

5. Did this investigation have a control? If so, identify it. If not, suggest what control you would set up, and why. (2 points)

6. How does this investigation demonstrate stages of the carbon cycle? To answer, make a simple sketch showing the flow of the carbon that you observed. (5 points)

The Nitrogen Cycle
Lesson 7

Learning Outcomes

Students will be expected to:

- illustrate the cycling of matter through biotic and abiotic components of an ecosystem by tracking carbon, nitrogen, and oxygen (318-1)
- analyse the impact of external factors on the ecosystem (331-6)

Introduction

The nitrogen cycle, part of the nutrient cycle, consists of nitrification and denitrification processes that are interconnected. Through nitrification, nitrogen gas is converted into compounds that can be used by plants and, through denitrification, nitrogen is removed from decaying material and released as gas to complete the cycle.

The availability of nitrates increases when organic or inorganic (artificial) fertilizers are added to soil. Artificial fertilizers usually contain elemental nitrogen, phosphorus, and potassium, each of which is essential for plant and animal productivity. Plants assimilate these elements and convert them into usable products that can pass through the biotic component of an ecosystem. Too much fertilizer has a detrimental effect on plants, as an imbalance in nitrogen is created.

Cycles in nature are often affected in a variety of ways. One cycle can have dramatic effects on other cycles and phases within a cycle can exert impacts on other phases of the same cycle. If nature were left untouched by humans, there would likely be little fluctuation in different parts of the cycle. Ecosystems have in place natural mechanisms that control the balance of elements. Changes in one cycle have little impact on other cycles and, if they do, control mechanisms try to restore the balance.

Humans and natural disasters have great impact on the cycles in nature. Influences from outside an ecosystem alter the balance of different cycles, sometimes permanently. One such case is the disruption of the carbon cycle. Humans have temporarily altered the cycle by releasing vast amounts of carbon into the atmosphere through combustion of fossil fuels. The textbook details the effects of nitrogen on the atmosphere, soil, freshwater ecosystems, and marine ecosystems. It also discusses how humans impact the nitrogen cycle.

Review Questions - Check Your Understanding

After reading pages 52, 54-60, 63, 65 complete questions 1 - 6 on page 65 of ***SciencePower 10***.

Assignment 7
An acid test
Do and Send

Question

How does the pH of rainwater in your community compare with the pH of some other liquids?

Safety

You will be working with hazardous liquids, some of which are irritants or very corrosive. Wear safety glasses. These are available at most dollar stores.

If you get any chemical on your skin or clothes, rinse the area with plenty of water.

APPARATUS

- small glass containers which can hold 250 mL (1 cup) of liquid
- measuring cup
- measuring spoons
- labels or masking tape
- marker
- scissors

MATERIALS

- red cabbage juice extract
- paper coffee filter
- rainwater
- tap water
- distilled water (available at drug stores and supermarkets)

Any 10 of the following:

- household bleach
- vinegar
- lemon juice
- soda water
- window cleaner
- baking soda
- bathroom cleaner
- laundry detergent
- milk
- cream of tartar
- orange juice
- shampoo
- a soft drink
- antacid tablets

PROCEDURE

Part 1 - Making predictions:

Copy the table below onto a piece of paper. Arrange the names of the products you will investigating so they rank from lowest pH to highest. Remember that “0” is the most acidic and “14” is the most basic.

pH Predictions

Lowest *Highest*

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Include this completed table with your assignment. (3 points)

Part 2 - Creating pH papers:

Take a paper coffee filter and soak it in cabbage juice indicator. Allow the paper to dry then cut it into 12 strips long enough to dip into the glass containers.

Part 3 - Testing the household products:

a) For runny liquids: pour 125 mL (1/2 cup) of liquid into a clear glass container then add 5 mL (1 teaspoon) of red cabbage extract and stir the mixture.

b) For viscous (thick) liquids such as shampoo and dish liquid, dilute the liquid with distilled water (75 mL or 3 tablespoons of each) then add 5 mL of red cabbage extract to the solution.

c) For solids, place 5 mL (1 tsp) of the solid in 125 mL of distilled water and stir until the solid dissolves. Then add 5 mL of red cabbage extract to the solution.

Make a copy of the Data Table below to record your results. Include this table with your completed assignment. (6 points)

Material	Colour of pH Paper	pH
Rain water		
Tap water		

Determine the pH values by matching the colours with the table given in the assignment "The Chemistry of Photosynthesis" in Lesson 6 of this guide.

Part 4 - Clean up:

a) When you have finished all the tests, flush the contents of each glass container down the drain with lots of running cold water. Be sure to empty and flush only one container at a time! remember to wash the containers thoroughly with hot soapy water when you are done.

b) Wash your hands well after completing this investigation.

c) Return the unused cabbage extract to the refrigerator for use in the next assignment.

ANALYSE

1. How did your predictions compare with the actual pH of each liquid? (4 points)

2. Unpolluted rainwater has a pH of 5.6. Is your local rainwater more acidic than this? If so, carry out research to find which sources of pollution might be responsible. Give two possibilities. (3 points)

3. Distilled water, which contains no CO_2, has a pH of 7.0. It is neither acidic nor alkaline (basic). Why is unpolluted rainwater slightly acidic? (1 point)

CONCLUDE AND APPLY

4. What does the term "neutralization" mean? Why might acid precipitation be less of a problem in lakes where surrounding rock is made of limestone (calcium carbonate)? (2 points)

5. How might you reduce the effects of acid precipitation in a lake? (1 point)

THE IMPORTANCE OF SOIL
LESSON 8

LEARNING OUTCOMES

Students will be expected to:

- describe how soil composition and fertility can be altered and how these changes could affect an ecosystem (331-7)
- plan changes to, predict the effects of, and analyse the impact of external factors on an ecosystem (331-6, 213-8, 212-4)

INTRODUCTION

Although soil is a renewable natural resource, it is only renewable over long periods of time, measured not in days or years but in decades and even centuries. The livelihood of farmers worldwide is dependant upon their management and nurturing of the soil. In turn, so too is the world's supply of food and fibre, and the well-being of the planet's population. The production of food and fibre for both humans and animals requires an underground plant environment that is favourable for plant growth. Soil affects the growth and development of all plants, whether for human or animal consumption. Soil provides an anchor, or medium, for plant roots to take in oxygen, moisture, and minerals which are all vital to plant life.

Soil is also home to several types of organisms such as bacteria, fungi, algae, microscopic animals, and others.

BACTERIA

As well as plants, other life arose in the soil. In one tablespoonful of soil, there are more bacteria than there are people on the entire planet. A quarter of a million of them could sit on the full stop at the end of this sentence. They can live in air, water, extremes of heat and cold, and are able to function without sunlight. There are bacteria that can take animal excrement and purify it. Others can take nitrogen from the air in the soil and convert it into nitrates that are needed by higher plants for growth. Being contained within a single cell, they cannot eat solids, but feed by secreting enzymes to dissolve their surroundings to a form which they can digest, then re-absorb as lunch.

FUNGI

Essential to the breakdown of woody organic matter, fungi are another mystery in the soil. Some are parasites on live or dead plants, others live in harmony with plant roots, helping to create the ideal conditions for both to flourish (a relationship known as mutualism).

ALGAE

Like plants, but more simple in composition, algae can take up carbon dioxide from the surface air (although a few do it deep in the soil) and convert it to oxygen as part of their food production process. Oxygen is replenished by such means.

MICROSCOPIC ANIMALS

From single celled amoebas and protozoa running their lives in the soil moisture, through nematodes (microscopic worms) that can damage the roots of the plants we want to grow, your soil is teeming with unseen life all of which plays its part in the complex chain of interdependency that is life.

OTHER ORGANISMS

The most obvious are earthworms. They play a huge part in mixing organic matter from the surface into the lower depths of the soil, and in so doing, they provide the source of food for countless numbers of other organisms who feed on the organic matter. Their burrowing also leaves (by comparison) huge aeration channels and fissures in the soil, allowing air to diffuse and water to drain. It is estimated that there are somewhere between 30 and 300 worms in every square metre of your garden. You may notice beetles in the garden. Beetles assist in clearing up the decaying organic matter. In turn, beetles themselves provide food for small animals all the way up the food chain to man.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 74-75, 79-80 and pages 92-95, complete questions 1- 6 on page 80 and questions 1-4, and 6 on page 98 of ***SciencePower 10***.

ASSIGNMENT 8
TESTING YOUR SOIL
DO AND SEND

INTRODUCTION

Scientists typically describe soil according to its:

- colour
- moisture content
- pH
- structure
- texture
- compaction
- organic content
- profile
- temperature

In this assignment you will determine some of these factors for soil in your area.

MATERIALS

- garden spade or small shovel (available at dollar stores if you do not already have one)
- large can (such as coffee) with ends removed, empty and clean
- permanent marker
- hammer
- kitchen scale (available at dollar stores if you do not already have one)
- disposable pie plates (available at dollar stores if you do not already have some)
- small frying pan (purchase one at a dollar store - **do not use** your household ones!)
- red cabbage extract
- white ice cream or margarine container, empty and clean
- large mayonnaise jar with lid, empty and clean
- large resealable plastic bag
- wooden stir stick

PROCEDURE

Part 1 - Colour:

Soil colour can provide information about organic matter in the soil, drainage, biotic activity, and fertility. The chart on the next page can give you some insight into the condition of your soil just from its appearance. To identify the colour of your soil, you should take a garden spade, and dig a shallow hole, at least 6 to 10 cm deep. Place the soil in a large plastic resealable bag as you dig. Gauge the colour as soon as you have the hole dug - this needs to be done quickly before the sun can dry out the soil which will change its colour.

Use the table below to help you determine the organic matter, erosion factor, aeration, available nitrogen, and fertility from the colour of your soil. Record the information in a copy of the data table which you will find at the end of this assignment.

Condition	Colour		
	Dark	Moderately Dark	Light
organic matter	high	medium	low
erosion factor	low	medium	high
aeration	high	medium	low
available nitrogen	high	medium	low
fertility	high	medium	low

Part 2 - Moisture:

The amount of moisture found in soil varies greatly with the type of soil, climate, and the amount of humus (organic material) in that soil. The types of organisms that can survive in your soil is largely determined by the amount of water available to them, since water acts as a means of nutrient transport and is necessary for cell survival. Soil moisture can be estimated visually, although this is quite imprecise. Soil moisture can also be determined by a soils laboratory. Soils laboratories typically dry a sample in an oven or on a hot plate (approximately 225°F for 24 hours) and compare the weight of the soil before drying to the weight after drying. The moisture content is reported as percent moisture on a weight basis.

Empty and spread out half of the soil you collected in the resealable bag onto a disposable aluminium pie plate. Determine the mass of the soil and the plate using a kitchen scale. Record this figure in your observation table. Place the plate and soil on your sunniest, warmest window sill to dry. Leave the soil on the window sill for 48 hours.

Weigh the plate and soil again. Record this mass in the data table. Keep the soil for the next part of the assignment.

Now calculate the percentage of moisture using the formula below:

(Original mass - Dried mass) ÷ Original mass × 100% = % Moisture

Record the result of this calculation in your data table.

Part 3 - Organic Content:

The organic content of soil greatly influences the plant, animal, and microorganism populations in soil. Decomposing organic material provides many necessary nutrients to soil inhabitants. Without fresh additions of organic matter from time to time, the soil becomes deficient in some nutrients and soil populations decrease. The amount of organic material can be determined by ignition. Organic material is made of carbon compounds, which when heated to high temperatures are converted to carbon dioxide and water. In the ignition process, a dry solid sample is heated to a high temperature. The organic matter in the soil is given off as gases. This results in a change in weight which allows for calculation of the organic content of the sample.

Place a disposable pie plate on the kitchen scale. Add soil from Part 2 of the assignment until the scale reads approximately 10 g. Record the exact mass in the data table.

Empty the soil into the new frying pan and place it on the stove. Puncture a second disposable pie plate several times to create air holes. Cover the pan with the punctured pie plate and shape the plate to fit just inside the rim of the pan. Turn the burner onto the highest setting. Allow the fumes to escape (water and carbon dioxide). Continue heating until there are no visible fumes. Cool the container, lid, and sample. Once cooled use the punctured plate to return the soil sample to the pie plate on the kitchen scale. Re-weigh the sample and calculate the per cent of organic material. Record both of these values in the data table.

Part 4 - Soil pH:

To determine the pH of your soil, pour approximately two tablespoons of the soil remaining in the resealable bag into a clean, empty ice cream or margarine container, being careful not to touch the sample. Pour enough red cabbage extract into the container to cover the soil. Stir the soil and extract with a wooden stir stick. Determine the colour of the extract (not the soil) and match this colour with the pH values given in *"The Chemistry of Photosynthesis"* assignment. Record this value in the data table.

Part 5 - Soil Type and Texture:

People describe soil types in many ways such as heavy, light, sandy, clay, loam, poor or good. Soil scientists describe soil types by how much sand, silt and clay are present. This is called ***texture***. It is possible to change the texture by adding different things. Changing texture can help in providing the right conditions needed for plant growth.

Sand is the largest particle in the soil. When you rub it, it feels rough. This is because it has sharp edges. Sand doesn't hold many nutrients.

Silt is a soil particle whose size is between sand and clay. Silt feels smooth and powdery. When wet it feels smooth but not sticky.

Clay is the smallest of particles. Clay is smooth when dry and sticky when wet. Soils high in clay content are called heavy soils. Clay also can hold a lot of nutrients, but doesn't let air and water through it well.

Particle size has a lot to do with a soil's drainage and nutrient holding capacity. To better understand how big these three soil particles are, think of them like this. If a particle of sand were the size of a basketball, then silt would be the size of a baseball, and clay would be the size of a golf ball.

There are three major categories of soil types: sandy, loamy, and clayey. To figure out what type of soil you have, you will complete two different tests.

Test A - The Rope Test:

Using soil left in the bag after Part 4, squeeze a moist, but not muddy, 3 cm ball of soil in your hand. Then rub the soil between your fingers. Sandy soil feels gritty and loose. It will not form a ball and falls apart when rubbed between your fingers. Loamy soil is smooth, slick, partially gritty and sticky and forms a ball that crumbles easily. It is a combination of sand and clay particles. Clayey soil is smooth, sticky, and somewhat plastic feeling. It forms ribbons when pressed between fingers. Clayey soil requires more pressure to form a ball than loamy soil, but does not crumble apart as easily. Record your observations in the data table. State which type of soil you believe exist in your samples.

Test B - The Jar Test:

First, fill a clean, empty mayonnaise jar about 2/3 full with clean water. Next, take some of the remaining soil from the bag and crumble it into the jar until the water level reaches the base of the collar of the jar. Screw on the lid and shake it vigorously for a minute or two, until all the soil particles are broken down into suspension in the water.

Allow the suspended soil to settle for about a minute. Using a permanent marker, place a mark on the side of the jar at the top of the layer that has settled out. This is the sand layer, comprised primarily of sand and larger particles such as rocks. Set the jar aside, being careful not to mix the sand layer that has already settled and wait approximately an hour.

Place a mark on the side of the jar at the top of the next layer to settle out. This is the silt layer. Again, place the jar carefully aside for a full day, being careful not to shake or mix the layers that have settled out.

After 24 hours, or when the water is once again clear (more or less), place a mark on the side of the jar at the top of the final level. This is the clay layer.

The percentages of each layer tell you what kind of soil you have. To determine the percentage, place a ruler beside the jar and measure the following:

- the total depth of the soil sample
- the depth of sand
- the depth of silt
- the depth of clay.

Divide each of the depths of the three soil textures by the total depth and multiply by 100.

For example:

Depth of clay = 3 cm, Total depth of sample = 6 cm

$$(3 \text{ cm} \div 6 \text{ cm}) \times 100\% = 50\% \text{ clay}$$

Using the Percentages to Determine Soil Type

Sandy soils are typically comprised of approximately 80 - 100% sand, 0 - 10% silt, and 0 - 10% clay. Sandy soils are light and typically very free draining, usually holding water very poorly due to very low organic content.

Loamy soils are typically comprised of approximately 25 - 50% sand, 30 - 50% silt, and 10 - 30% clay. Loamy soils are somewhat heavier than sandy soils, but also tend to be fairly free draining due to low organic content.

Clayey soils are typically comprised of approximately 0 - 45% sand, 0 - 45% silt, and 50 - 100% clay. Clayey soils are not typically free draining, and water tends to take a long time to infiltrate. When wet, such soils tend to allow virtually all water to run-off. Clay soils tend to be heavy and difficult to work when dry.

Part 6 - Compaction:

To be healthy, a soil needs to be able to breathe and water needs to be able to move through it fairly easily. Compacted soils do not allow much air to circulate to the root zone and water (rainfall or irrigation) tends to just run-off. This increases erosion and strips away vegetation and topsoil. A normal, loosely compacted soil helps to absorb and retain water, releasing it slowly, and allows the root zone of plants to "breathe". These soils are generally more productive, since plants can grow much more readily. Dense, highly compacted soils typically have less plant growth, which increases runoff.

The rate of infiltration of water is an excellent indication of soil health. You can measure the water infiltration rate using the following method:

1. Get a large, empty can and cut off the bottom with a can opener (preferably one that seals the edges as it cuts).

2. Beginning about 6 cm from the bottom, mark the inside of the can every 1 cm with a permanent marker. If the edges are sharp, place an oven mitt over the hand you will be writing with. You should still be able to make a mark on the can.

3. Drive the can into the ground until the bottom-most line is even with the ground. (placing a board on the top of the can and pounding on the board with a hammer will help drive the can into the ground). Be careful not to irrigate the area first, since this will prevent you from getting an accurate measurement of the infiltration rate.) It should also have been at least 3 or 4 days since the last rainfall.

4. Fill the can with water to the top and begin timing the rate of infiltration. Measure the amount of water that has drained into the soil at the end of each minute for the first ten minutes. Use the lines you drew every 1 cm as your guide. Record this information in the data table on the next page.

5. Using the information from the section "***Using the Percentages to Determine Soil Type***", state which type of soil you believe this to be. Support your answer.

Data Table - Testing Your Soil

Part	Observations
Colour	Colour __________ Organic Matter __________ Erosion Factor __________ Aeration __________ Available nitrogen __________ Fertility __________
Moisture	Wet mass __________ Dry mass __________ Percent moisture __________
Organic Content	Original mass __________ Mass after heating __________ Percent organic content __________
Soil pH	Colour of extract __________ pH value __________
Rope Test	Soil type and reasoning: __________ __________ __________ __________
Jar Test	Total depth of sample __________ Depth of sand __________ Percent sand in sample __________ Depth of silt __________ Percent of silt in sample __________ Depth of clay __________ Percent of clay in sample __________ Soil type __________
Compaction	Depth after 1 minute __________ Depth after 2 minutes __________ Depth after 3 minutes __________ Depth after 4 minutes __________ Depth after 5 minutes __________ Depth after 6 minutes __________ Depth after 7 minutes __________ Depth after 8 minutes __________ Depth after 9 minutes __________ Depth after 10 minutes __________ Type of soil __________ Explantion: __________ __________ __________ __________

ANALYSE

1. a) Do the results from the Rope, Jar, and Compaction tests indicate the same type of soil?

   b) Why might the results be different from one type of test to another?

2. Most gardeners believe loamy soil with a pH between 6-6.5 and lots of organic content to be the ideal standard for growing most plants. Now that you have determined your soil's characteristics, describe how you could alter soil composition and fertility to the ideal standard.

3. Why would it be important to know about the soil surrounding your home?

Include the answers to the **Analyse** section and your data table in your completed assignment that you send to your marker.

POINT VALUES:

Colour - 1 point	Rope Test - 2 points	Analyse 1 - 2 points
Moisture - 2 points	Jar Test - 2.5 points	Analyse 2 - 3 points
Organic Content - 2 points	Compaction - 2.5 points	Analyse 3 - 2 points
Soil pH - 1 point		

MANAGING RESOURCES
LESSON 9

LEARNING OUTCOMES

Students will be expected to:

- explore and develop a concept of sustainability (114-1)
- explain why ecosystems respond to short-term stresses and long-term changes (318-4)
- explain factors that keep populations in equilibrium and within ecosystem limits (318-5)
- analyse the impact of external factors on an ecosystem (331-6)
- have a sense of responsibility for maintaining a sustainable environment (446)

INTRODUCTION

Effective resource management is one way to improve the sustainability of ecosystems. Some resources are limited and ecosystems need time to be able to replenish their supply of resources. In a modern economy, where depletion far exceeds replacement of resources, systems of resource management are continually being reviewed and strengthened.

The main scientific roles in environmental management are monitoring and impact or risk assessment. Scientists from many disciplines monitor stocks of non-renewable and renewable resources and populations of living resources to estimate depletion and replacement, and to ascertain the well-being of the ecosystem that sustains them. For impact and risk assessment, scientists use computer modelling to predict future patterns of depletion or effects from changes or disturbances to an ecosystem. While monitoring procedures and technologies have improved greatly, some resources remain difficult to estimate. Effects from disturbances to ecosystems can also be difficult to predict precisely. Fish stocks, for example, are difficult to count, and human and natural disturbances to fish habitat and spawning grounds are difficult to predict. As a result, government management of fish stocks has consisted mostly of limiting fish catch, and there is little monitoring or management of human activities that disturb fish habitat.

Overuse of shared resources has been common throughout human history, as witnessed by the number of extinction of species. The commercialization of many shared resources that were once available without charge - including common land, wild birds and animals, water - contributed to resource depletion, adding pressure for improved resource management.

Ecosystems are intricately connected with one another, as well as with their biotic and abiotic components. Many factors affect each of these links and the interconnections, so that predicting patterns or trying to reproduce or induce them is very challenging. The experiment with Biosphere II in Chapter 2 on page 38, demonstrates how difficult it is for people to imitate or build a natural system. The diagram in Figure 4.3 on page 109, ***SciencePower 10***, illustrates the dynamic relationships that exist within and among different ecosystems on Earth. Even the most detailed study of a single population cannot provide sufficient data to predict with certainty what conditions might be optimal within its ecosystem.

Human populations, which are also part of ecosystems, change and disturb their environment in ways that are also difficult to predict and assess. Some human populations, such as Aboriginal societies, try to live with their environment, taking human effects into account as they use land and resources. Aboriginal leaders and elders may resist using the terms "resource management", noting instead that it is the behaviour of people that needs to be managed rather than the natural world.

Other human populations view the environment as a provider of resources for use, without taking sufficient account of possible effects. In this view, the natural world is to be managed so that people can make even greater use of and profit from it. For several centuries, the idea that human ingenuity can impose order on nature dominated European thinking. Much of this thinking remains popular among Europeans, North Americans, and wherever else this paradigm has gained acceptance. Proponents of this view suggest that resource depletion can be countered by the technological and scientific development of substitute products or equipment.

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 102, 104-105, 109-111, complete questions 1-5 on page 111 of ***SciencePower 10***.

ASSIGNMENT 9
HUMAN IMPACT ON RESOURCE MANAGEMENT
DO AND SEND

Collect five articles from newspapers, magazines, and/or the Internet that demonstrate human impact on the ecosystem. These articles should demonstrate a range of positive and negative interactions between humans and the environment.

Write a brief summary of the content of the article, highlighting the impact of humans. Attach this summary to a copy of the article.

Send the articles and summaries to your marker. Each appropriate article is worth 2 points and each effective summary is worth 2 points.

Ecological Footprints
Lesson 10

Learning Outcomes

Students will be expected to:

- analyse the impact of external factors on an ecosystem (331-6)
- have a sense of personal and shared responsibility for maintaining a sustainable environment (446)
- want to take action for maintaining a sustainable environment (448)

Introduction

While humanity has constructed cities since the first millennium, it is urban growth that has marked the past thousand years. Not only do cities require vast areas of natural landscape, converting them into buildings and pavement, the needs of urban populations require the exploitation of vast quantities of resources (e.g., water, food, electrical power) from other environments. The calculation of an ecological footprint of human spaces such as cities offers some indication of impacts on the environment they occupy.

Ecological footprints can encourage people to think about where the resources they depend on originate and how human consumption is decreasing the biological productivity of most ecosystems. Eighty per cent of Earth's agricultural land is suffering from moderate to severe erosion. It is predicted that global fish stocks, crop and pasture lands, and forests will decline at a rate of 10-30 per cent by the year 2010. It is estimated that the productivity of global forests and grasslands has been cut by about 12 per cent. Deserts - the least productive ecosystems - are expected to have increased by 20 per cent by 2004 as a direct result of human activities.

Activity

After reading pages 112-113 of ***SciencePower 10***, complete the worksheet on the following page.

Calculating Ecological Footprints

The following table gives data for four cities. Use these data to answer the questions below. Before you begin, review the method for calculating an ecological footprint, on page 113 of your textbook.

City	A	B	C	D
Population	86 000	70 000	16 000	27 000

Needs	Land needed (ha/person)			
Farm land for meat production	1.5	0.7	5.5	3.0
Forest land for wood and paper production	0.3	0.5	0.9	0.3
Forest land to absorb CO_2 from fossil fuel combustion	0.2	0.5	3.5	0.4
Land for people to live on	2.5	2.0	4.0	1.3

1. Using the method you read about in the text, calculate the ecological footprint for an individual living in each of the four cities. Show your work.

City A:	**City B:**
City C:	**City D:**

2. Calculate the ecological footprint for the entire population of each city. Show your work.

City A:	**City B:**
City C:	**City D:**

REVIEW QUESTIONS - CHECK YOUR UNDERSTANDING

After reading pages 112-113, and 115, complete questions 1 - 4, and 6 on page 116 of ***SciencePower 10***.

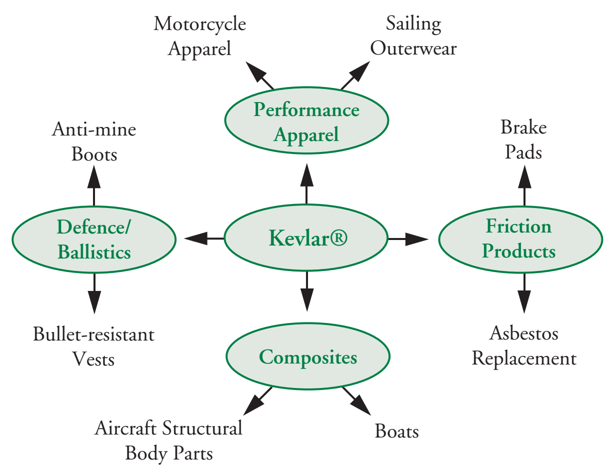
ASSIGNMENT 10
BIIGFOOT DISCOVERED IN NOVA SCOTIA
DO AND SEND

In this activity you will be completing an article analysis. Using the following Fact-Based Analysis Format, Kevlar® Example, analyse the article "*Bigfoot Discovered in Nova Scotia*".

FACT-BASED ANALYSIS
KEVLAR® BRAND FIBRE EXAMPLE

In 1965, Kevlar® fibre was developed by DuPont scientists. The unique properties of Kevlar® include enhanced strength (protection), light weight (comfort) and flexibility (freedom of movement).

Graphic Organizer - Kevlar®



Provide a list of five scientific facts about Kevlar® Fibres

1. Consist of long molecular chains
2. The chains are highly oriented with strong inter-chain bonding
3. Produced from poly-paraphenylene terephthalamide.
4. Low elongation to break high modulus or structural rigidity
5. Low thermal shrinkage

Applications, Significance, Importance: Kevlar® has unique properties that permit the fibre to be used in many applications from the rope used in the Mars space program to applications from tires to protective gloves, fibre optics to aircraft construction, gaskets to hockey sticks, life protection to skateboards. Anywhere lightweight strength really matters Kevlar® may be the fibre of choice.

Provide a brief abstract (a written summary or overview of essential points).

Kevlar® is a silky-soft, man-made fibre that is stronger than steel on an equal weight basis. It combines strength with lightness. Many industries apply this performance technology to products ranging from tires to protective gloves, fibre optics to aircraft construction, gaskets to hockey sticks and hockey gear. It is widely known for its use in bullet-resistant vests.

What science questions do you have about Kevlar® ?

1. Why do long molecular chains create strength and flexibility?
2. What is bonding?

Explain Kevlar® technology.

Kevlar® is an organic fibre. It is found in the aromatic polyamide (aramid) family. It is composed of long molecular chains produced from poly-paraphenylene terephthalamide. The chains are highly arranged with strong inter-chain bonding, which is the secret to the unique properties of Kevlar®. Organic polymers are based on "light elements"—carbon, nitrogen, hydrogen and oxygen—not "heavy elements" like iron. The benefit of organic polymers is low-weight structures. To realize the full potential of the technology the molecular chains within the organic fibre must be fully extended and perfectly aligned. The result is a strong, tough fibre.

Select five words related to or descriptive of Kevlar®.

Strong, light, aramid, arranged, unique

13 March, 2001

Ronald Colman, Ph D
Director, GPI Atlantic

Press Release
For Immediate Release:

BIGFOOT DISCOVERED IN NOVA SCOTIA
We Tread Less Lightly Than We Think

Study Recommends 1 Million Hectare Footprint Reduction by 2002 as "Genuine Progress" Target for Province

For a small province, Nova Scotia has very big feet. Ecological feet, that is. A new study finds that Nova Scotians are consuming more goods and producing more waste than the environment can handle.

Our "ecological footprint" measures our impact on the environment by calculating the amount of productive land and sea area it takes to meet current consumption levels. According to GPI Atlantic, a non-profit research group that is building a new index of wellbeing for the province, Nova Scotians currently need *8.1 hectares per person* to provide the resources and absorb the waste to support their eating, shopping, travelling and energy use habits.

That is one-third less than the average American's footprint, but 30 per cent more than the average West European's, and far in excess of the 1.8 hectares per person globally available. *If all the world's people were to consume at Nova Scotian levels, we would need four additional planets earth to provide the necessary resources and waste assimilation capacity.*

In other words, Nova Scotia's current use of food, energy, water and other resources takes up far more ecological space than we have. And unlike measures of progress based on economic growth in which "more" is always assumed to be "better", the 100 page GPI study, authored by GPI researcher Jeff Wilson, notes that a *smaller* ecological footprint would be a sign of genuine progress for the province.

A University of British Columbia study found that the average global ecological footprint is 2.8 ha per person, which means that human beings are depleting resources faster than they can regenerate and producing more waste than the world can handle, — at the expense of future generations. We are emitting more greenhouse gases than the air, land and sea can absorb, and we are using more timber and fish than the world's forests and seas can provide.

Living Beyond Our Means

According to GPI Atlantic director Ronald Colman, "This is like living in debt, with a gradually accumulating ecological deficit. Just as the present generation is paying for over-spending in the 1970s and 1980s with higher tuition and reduced government services, so future generations will inherit the debt of our current ecological overshoot. We may have already begun to see its effects in the collapse of Atlantic ground-fish stocks, global warming, higher child asthma rates, and new environmental illnesses."

Colman points out that we also consume more than is available at the expense of other peoples. Thirty percent of the world's population currently consume 70 per cent of the world's resources and produce 70 per cent of the world's waste. The average African's ecological footprint is just 1.3 hectares per person, while the average U.S. citizen's is 12.2 ha per person.

In fact, the richest fifth of the world's people, which includes Nova Scotians, consumes 45 per cent of all meat and fish, 58 per cent of all energy and 84 per cent of all paper, and owns 87 per cent of all cars. The poorest one-fifth consumes just 5 per cent of all meat and fish, less than 4 per cent of energy, 1.1 per cent of paper, and less than 1 per cent of all cars.

Of the 8.1 ha required by the average NS consumer, transportation accounts for 1.6 ha, food for 2.4 ha, residential energy use for 1 ha, and other consumption for the remaining 3.1 ha Just as global ecological footprints differ, not all Nova Scotian ecological footprints are the same size. The Halifax Regional Municipality has a footprint of 8.4 ha per person, 4 per cent larger than the provincial average. The wealthiest 20 per cent of Nova Scotians have a footprint of 10.7 ha per person (compared to 6.2 ha for the poorest 20 per cent) because the wealthy consume more resources and produce more waste.

The Nova Scotia ecological footprint has grown by 40 per cent in the last 40 years, and it is projected to increase by another 12 per cent to 9.2 ha per person in the next 20 years. Our transportation footprint is expected to increase by 25 per cent as more cars log more kilometres. The increase in fuel-inefficient SUV's, minivans and light trucks has expanded the transportation footprint sharply, with one SUV averaging three times the impact on the environment of a small car.

Reduce Footprint by 1 million hectares, Report Recommends

The GPI report concludes that Nova Scotians could quickly and easily reduce their collective ecological footprint by 1 million hectares from 8.1 ha per person to 7 ha per person without compromising their quality of life. Consuming less of some items, shifting certain consumption choices, and changing public policy priorities can actually improve wellbeing and quality of life while reducing our impact on the environment.

Suggested personal changes recommended in the GPI report include:

- Walking and riding a bicycle whenever possible.
- Carpooling or taking public transportation to work instead of driving alone.
- Driving smaller more fuel-efficient cars and keeping them well-maintained.
- Buying more locally grown foods and locally produced goods.
- Not overeating, but consuming the calories appropriate for our age and activity.
- Eating more grains, vegetables and natural foods.
- Reducing household energy use by turning off lights, turning down the temperature at night and when not home, hanging out the laundry to dry, and using energy efficient appliances.
- Reducing water consumption by using a water-efficient showerhead, turning off the tap when not in use, and collecting rainwater to water plants and lawns.

Beyond such individual choices, the GPI report also points to the social and political decisions that are necessary to reduce the province's ecological footprint to less than 7 ha per person, and to become a model of responsible and sustainable living. These social choices include:

- Investments in public transportation and bicycle lanes.
- Integrated land use / transportation planning to counter suburban sprawl.
- Tax incentives to support environmentally friendly co-housing developments.
- Support for local agriculture, nutritional education, and sustainable farming methods.
- Tax incentives to support renewable energy development, such as the Western Valley Development Authority's exploration of wind-powered electricity generation for the Annapolis Valley.

Nova Scotians have already dramatically reduced their solid waste footprint by 50 per cent in just five years by composting and recycling. "This proves that we can do it if we want to," says Colman, "and that we can certainly achieve the 1 million hectare footprint reduction target by 2002." Nova Scotians also cut energy use sharply in the early 1980s in response to the increase in fuel prices. Today our total energy footprint (4.5 ha/person) is still 25 per cent smaller than it was in 1979, but it is also 40 per cent larger than it was in 1961. The GPI report suggests that Nova Scotia can both build on past successes and learn from successful West European models to reduce its ecological footprint substantially and to tread more lightly on the earth without compromising its quality of life.

This report, the first *provincial* ecological footprint analysis undertaken in Canada, follows the release of other components of the Nova Scotia Genuine Progress Index, which is being developed as a pilot project for Canada. Earlier GPI reports have dealt with the value of volunteer work, unpaid household work, water resources, cost of crime, and health measures including the costs of tobacco and obesity. Upcoming report releases include natural resource accounts for the province's forest, fisheries, soils, air quality and greenhouse gas emissions.

The GPI report was produced with funding from the National Round Table on the Environment and the Economy, Clean Nova Scotia Foundation, Halifax Regional Municipality, N.S. Department of Environment, N.S. Public Interest Research Group, and GPI member contributions. GPI Atlantic welcomes the initiative of Clean Nova Scotia to assist Nova Scotians in reducing their ecological footprint.
For further information contact:

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Full report and summary are available at *www.gpiatlantic.org*

Colman, Dr. Ron (2001), GPI Atlantic, *Bigfoot Discovered in Nova Scotia*.

<http://www.gpiatlantic.org/pr_ecofoot.shtml>.

13 March. (Accessed 5 October 2002).