Woodlot Management
Home Study Course

Module 7

Woodlot Ecology

Preface

An educational priority of the Nova Scotia Department of Natural Resources is to help woodlot owners increase their understanding of forest ecology and management.

As part of the Department's Home Study Program, this manual will help landowners learn how their woodlot works from an ecological point of view. Other Home Study manuals in the series cover specific woodlot management techniques.

This module on Woodlot Ecology is divided into five lessons:

Lesson one: Introduction to Ecology and the Forces Which Shaped Your Woodlot

Lesson two: Cycles, Rhythms, and Seasons: Systems Which Make Your Woodlot Work

Lesson three: The Structure and Interdependence of the Woodlot Community

Lesson four: Plants and Trees: Growth and Changes Over Time

Lesson five: Human Disturbances and Woodlot Stewardship

At the end of each lesson you will find a True/False quiz to test your understanding of the material. The end of the manual contains a list for further reading and a glossary which defines key terms used in the module.

This module is the seventh in a series of
Woodlot Management Home Study Courses
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Lesson One

Introduction to Ecology and the Forces that Shaped your Woodlot

Introduction

Whenever you change something on your woodlot you affect a complex and interesting community. American naturalist Jack McCormick calls the forest "nature's city". He paints a vivid picture of a densely populated community with high rises (trees), shops (plants on the forest floor) and basement apartments (underground dwellers). The most obvious citizens of McCormick's city are farmers (green plants) that sustain everybody. Animals are full-time or part-time residents who plant seeds, harvest plants , and perform clean-up jobs. All residents must in their own way find food, light, water, and space. It is a harmonious but not a tranquil city. This is a place that bustles with life and death, where all residents compete with each other and, at the same time, depend on each other for survival. The forest "city" and its ecology (how it works) is the subject of this module.

This first lesson defines ecology, explains two important foundations of the forest city - climate and soil, and gives a brief history of woodlots in Nova Scotia.

Definition of Ecology

The word ecology comes from a Greek word meaning a house or place to live. Today it means the study of living things and their relationship to each other and their environment, home, or community.

This study can be on global scale. World forest ecology is the study of forests throughout the world, and their relationship to each other and the earth as a whole. The term ecology can also be applied in a more limited sense; for example, we can talk about the ecology of the earthworm. In this case, the earthworm is examined for the way it lives and fits into its environment. In this module we will be looking at the ecology of a woodlot.

Ecologically speaking, your woodlot is a complex association of plants and animals known as ecosystem . An ecosystem is a community of plants and animals which interact through a series of cycles and processes on a particular site. Non living factors such as the air and soil are also an important part of any ecosystem.

Importance of Understanding Ecology

People have been interested in their environment since primitive times. In earlier days people needed to understand plant and animal communities as a matter of daily survival. Today, we don't depend on the forests in the same way, but we still can not survive without a healthy, clean environment. With modern technology, we have a tremendous influence on our natural environment. Headlines in the newspaper, radio and television programs all tell us how destructive we can be in this role.

It's important to understand woodlot ecology because our actions influence the way a forest ecosystem works and changes. If we understand natural systems, we can act in ways which will help our woodlots stay healthy.

Woodlot owners have an important role as planners in the forest city. You are stewards of our forests and most Nova Scotians are proud of their woodlot heritage. Because of the importance of our forests, woodlot owners have a great responsibility to ensure that the future forests of Nova Scotia remain healthy. Whenever you carry out an activity such as tree harvesting or building a road, you affect the woodlot ecosystem. Understanding the system you are affecting is particularly important because over half of the province's forested land is owned by about 30,000 woodlot owners.

Woodlots in Nova Scotia have many uses. Besides economic uses like the production of timber, pulpwood or firewood, woodlots are important habitats or homes for animals and plants. Woodlots are also places where we spend our leisure time fishing, hiking, bird watching or enjoying other aspects of the outdoors.

Above all, it is important to understand that people are a part of the forest ecosystem and depend on it for survival.

All the food we eat comes from plants, or animals that eat plants. Without the oxygen that plants release into the air, we could not breathe. Forests have sometimes been called the “lungs” of the earth. Your woodlot is part of this breathing system. Without trees to act as air filters, our world would be noticeably more polluted. About 0.5 hectares (1 ac) of trees can remove almost 13 tons of dust and gases every year from the surrounding environment.

The Nova Scotia Woodlot: Climate, Soil, and History

The Acadian Forest

The Acadian Forest covers about 80 percent of the land area in Nova Scotia. This forest is a transition zone between the northern coniferous forest which contains softwoods such as fir, hemlock, spruce, and pine and the southern deciduous forests which contains hardwoods such as maple, oak, popular, and birch. Much of the forested land in Nova Scotia is mixed, containing both hardwood and softwood. However, there are many areas that are purely softwood and hardwood.

It's difficult to characterize a "typical" woodlot in Nova Scotia since the province has six distinct forest regions. These regions range from the red spruce-hemlock-pine zone of the Annapolis Valley to the sugar maple-yellow birch-fir areas of Cape Breton (Figure 1).

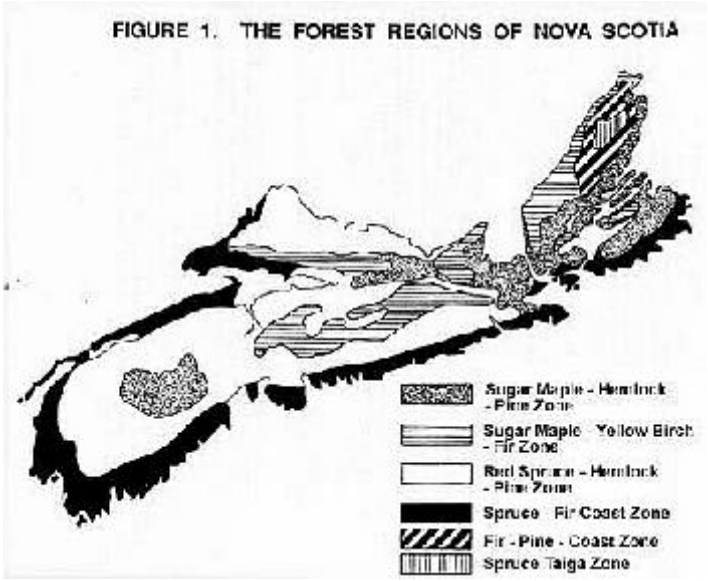
Nova Scotia was formed several hundred million years ago when two continents met. The landscape of that time was very different from what we have today. Like most of Canada, Nova Scotia was once covered by glaciers but because it was at the edge of the huge ice mass, the ice movements caused many variations in land forms. When glaciation ended about 10,000 years ago, it left behind sediment and deposits of varying size and form. Current land forms were shaped by ice movements

when the thick sheets of ice moved across the land. As our climate changed, conditions became better suited for growing trees. Soon after, forests of spruce, fir, and birch began to grow. Over time, other tree species also became established.

Many of the birds, mammals, animals, fish, reptiles, amphibians, and insects we know today also became established at this time.

Five thousand years ago, before there were pyramids in Egypt, native North Americans hunted game and used tree species that are still present today. As time passed, European settlers brought new plants and animals to our province, sometimes purposely, and other times by accident.

Despite its small size, Nova Scotia has a very diverse landscape and habitat. This has happened because of the way ice moved across our province, and because we are a transition zone between the warm southern and harsh northern climates. After the last glaciers, the climate and soil of Nova Scotia became roughly what they are today.



The climate and soil on your woodlot are two of the many important factors that influence what lives and grows there and the patterns in which they occur. These physical factors make up the forest site.

Climate

Generally, our climate has ample precipitation, a wide but not extreme temperature range, and a late and short summer. Our varied climate can change dramatically from day to day and from one place to another. Anyone who has traveled across the province knows how diverse our climate is. Listening to weather forecasts on the radio tells us that one region may have quite different weather than another.

How close your land lies to the coast affects the humidity and temperature of your woodlot. Climate also changes with elevation. Within your own woodlot there may be land forms and weather patterns that create climatic differences. A small depression might cause frost damage to one plant while another plant close by receives no damage. On any given day, one part of your woodlot may be sheltered and warm, another may be open and windy. These differences in local climate are called microclimates and can affect plant and animal growth and presence in your woodlot.

Climate is responsible for the following essentials of life on your woodlot:

* light and gases in the air needed to produce green plants
* heat to warm the soil and air so plants can grow
* air movement to create wind to spread pollen and seed
* precipitation to supply water

Light

Energy in the form of sunlight is required by all living things. Solar energy from the sun is the main fuel of the woodland city.

Without solar energy, plants could not manufacture food. The amount of energy produced is impressive. Just 2.5 hectares (1 ac) of beech-maple forest can use as much solar energy in one year as the amount of electricity needed to supply an average home for 50 years. Therefore, one of the most important aspects of a climate is the amount of light, or solar radiation received by the woodlot.

The tops of the trees form the forest canopy and receive the greatest amount of light. The denseness or thickness of the canopy determines how much light will filter to the forest below. Even in one day the light changes constantly, depending on clouds, smoke, or other factors. Some plants, like moose maple, grow large leaves in order to take advantage of the limited amounts of light in its early growth stages.

Light also acts as a signal to inhabitants of the woodlot. The shortening days of summer trigger a chemical reaction in trees that slows down the growing process. In the same way, the lessening of light in the fall will signal birds to migrate south or snowshoe hare (rabbits) to turn white.

Temperature

Forests are important moderators of temperature. The earth absorbs heat during the day. Although the sun is the source of the heat, heat reflection and radiation play an important role in how cold or hot the temperature is.

During the day, the sun shines on the forest. The canopy acts as an umbrella and much of the heat is reflected off its top. Although some light filters down, the forest floor stays cooler than its top. During the night the forest floor slowly releases and radiates the stored heat. The canopy now acts as an insulator to keep in this radiating heat. If forests are not present, more heat stays on the ground, creating higher temperatures. The temperature range found in your woodlot determines what kinds of plants and animals live there.

All plants and animals function best within a specific temperature range. Injuries can happen if temperatures change too much, too quickly, or at the wrong time. If we talk on a cold winter day without the right clothing, we might get frostbite. Plants receive similar injuries when the weather is too cold during the growing season. Frost can damage flowers and leaves, and crack woody stems.

Alternate freezing and thawing can cause upheavals in the soil and uproot plants.

Animals like snowshoe hare and deer adapt to the cold by growing heavier coats in winter, while other animals, such as the chipmunk, become inactive in underground burrows. The groundhog is one of the few animals that truly hibernates for most of the winter.

During periods of above average heat or prolonged high temperatures, excessive loss of moisture is the most common injury to plants, trees, and animals.

If mammals are too hot they pant or sweat to cool down. Theses actions cause water to be evaporated. However, they can not do this for too long before they need to replenish their water supply. In a similar fashion, plants can only give off water for so long before they need to be replenished. Trees with needles have adapted to withstand temperature changes. The small, waxy surface of the needle does not lose as much water as a large, hardwood leaf.

Unusual changes in weather patterns can present unique problems to animals and plants. For example, swallows eat only insects that are flying. They can die from starvation if it is not warm enough for insects to fly when the birds return in the spring.

Wind

Wind or air movement plays a key role in the natural cycles in a woodlot. Although we will discuss these cycles in later sections, the following are some important functions of wind:

- It is a necessary component of the water cycle. It controls how much moisture evaporates from plants, transports water vapour from lakes and oceans to land, and moves around rain and snow.

- It moves atmospheric gases like carbon dioxide which makes the production of green plants possible; circulates hot and cold air which create weather patterns; and disperses pollutants in the air.

- It is a transportation system for pollen and seeds, as well as small animals like insects and spiders. Birds also glide and travel long distances in its air currents. Many strange and unusual birds are "blown" to Nova Scotia after a heavy windstorm.

- It influences the size and shape of trees by constantly blowing from one direction, causing sways or leans. Wind in coastal areas often carries salt. The combination of the drying effect of wind and salt, and constant movement of wind in one direction, can be seen in stunted and leaning spruce or white pine trees along the coast of Nova Scotia.

Although we tend to notice the effect of wind in the forest after a major windstorm, breakage and blowdown occur on a regular basis especially along the edges of clearings and cuttings. The wind breaks branches and tops, but it can also cause breaks or tears in tree roots. If the wind catches an

unprotected treetop, uprooting can occur. In well stocked woodlots, the wind is baffled by the trees and the chilling effect of the wind is reduced. Animals will often find shelter in these areas.

Soil

Soil is an essential part of the earth's surface because it stores the nutrients, minerals, and water necessary for plant and animal survival.

The crust of the earth is made up of many types of rocks. As these rocks weather or break down, they help produce soil. Soil holds plants and trees upright. It is also home for many earth-dwelling bacteria and fungi that are necessary for tree and plant growth and for burrowing animals like groundhogs, chipmunks, and mice. The health of the forest ecosystem is affected by soil fertility. Soil nutrients are necessary for healthy plants which provide the essentials foods for animals.

The soil on your woodlot may have developed from the original rock material or it may have been carried there by water, ice, or wind. Many of Nova Scotia's soils were formed after the end of the glacial period when previous soils were swept away. Soils are constantly being made and changed because of erosion and plant and animal decomposition.

Climate, plants, and animals also affect the make-up of soil. The amount and rate of precipitation and the freezing and thawing of this water affects how quickly rock weathers. Over time, rainfall seeps into cracks in the rock and dissolves minerals. Climatic conditions also influence how plants grow, which in turn affects the richness of the soil. Plenty of earthworms and small insects and animals in your soil will keep it loose and rich. We'll talk more about the importance of small soil animals later.

Soil Types

Generally when we talk of soil types we are referring to the texture of the soil. Most soils are characterized by sand, silt, or clay. A near equal mixture of these three materials is called loam.

At certain times you may have heard people talking about how well drained a soil is. This refers to how water moves in the soil in relation to the water table. Drainage patterns are related to the kind of material which makes up the soil. A clay soil will hold water while water will pass through a sandy soil. In poorly drained areas, the water table lies above the surface of the soil causing boggy or wet conditions.

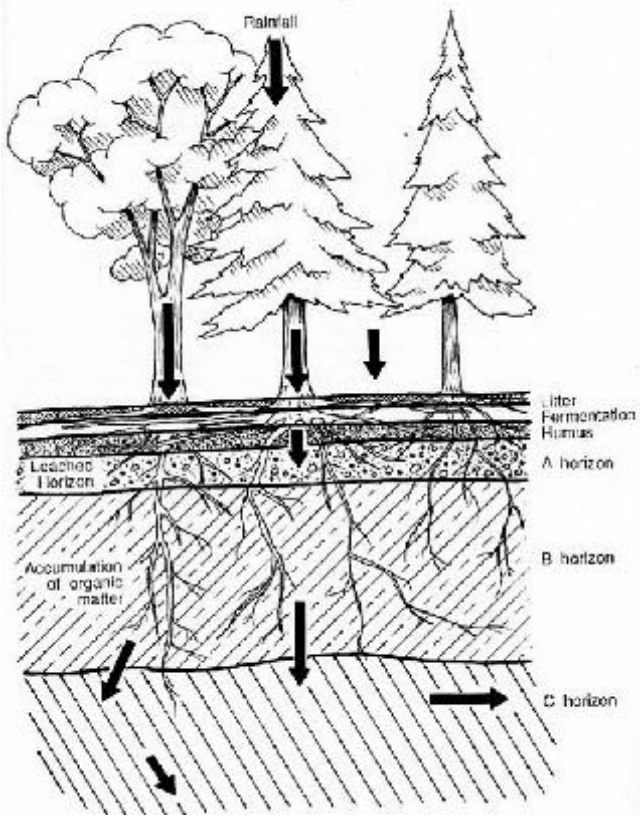
Soil Profiles

When someone talks about doing a soil profile they mean the different layers or horizons of soil you would see if you dug a pit. Usually soil is layered in the following way (Figure 2). Remember that all of these layers may not always be present.

1. **Litter**. The first layer contains recognizable decay of leaves, fruits, seeds, and plants. The

litter in softwood forests takes longer to decompose than hardwoods. The needles from softwood trees make the soil acidic, and as a result, there is less life in the soil to help decompose the needles. When talking about woodlots, the word litter is a positive word. This litter, unlike much of human litter, is useful and necessary to the forest ecosystem.

FIGURE 2. SOIL LAYERS



2. **Fermentation layer** (semi-decomposed litter). Some of the original decayed matter is recognizable. Hardwood leaves may still have skeletonized midriffs left, but most of the leaf surface is gone.

3. **Humus** (decomposed litter). In this layer, you can't recognize the original material. The first two layers are literally teeming with thousands of insects and other small animals, and millions of bacteria and fungi. Earthworms are an example of a soil animal. They can have a large impact on soil structure. As they burrow, the worms eat the soil, passing it through their digestive tract. Earthworms also eat decaying litter which decays further when it passes through the worm's system. Their continual burrowing overturns the soil and creates better growing conditions for plants. An English scientist estimated that the amount of soil passing through the digestive system of all the earthworms living on 2.5 hectares (1 ac) of land could range from 4 to 36 tons in one year.

4. **A Horizon.** The surface layer of mineral soil. Water generally leaches nutrients from this level to lower soil levels or into groundwater. As a result, roots travel through this layer taking up some of the minerals required to grow.

5. **B Horizon**. This layer is sometimes called the accumulation zone where minerals are deposited and accumulated. Most root systems are here.

6. **C Horizon.** This area contains parent rock materials that help to develop soil. Soil is created when parent material gradually breaks down. Some water seeps through this level to deep storage areas. Bedrock is normally below this level.

History of Nova Scotia Woodlots

Forests in Nova Scotia have been changing since they began. Some of these are natural changes caused by wind, insects, diseases, fire, and lightning. Other changes were caused by people as they cleared land for agriculture and harvested trees for various other purposes.

Fire

Most forests in the world have burned at one time or another. Fires occurred naturally through lightning or were deliberately set to clear land, improve grazing, clear underbrush, or combat insects. It is only in this century that humans have systematically attempted to control fire.

Fires can aid the beginning of life for trees by clearing forest litter, cracking open cones to release seeds, and reducing competition for space and light. Jack pine is dependent on fire since its cone are sealed with a resin that only opens at high temperatures.

Every year the earth experiences thousands of lightning storms which cause about 43 percent of the forest wildfires around the world. In Nova Scotia lightning is responsible for only a small fraction of forest fires. Here, about 99 percent of all forest fires are started by people.

Human Changes

Forest cutting by people has taken place in Nova Scotia over the last 300 years.

Our forests have been cut as many as three times. Wood was harvested in colonial times for ship masts, lumber, and home heating. Most of this cutting was done without the future in mind. This kind of harvesting, called highgrading, gave rise to inferior forests. Only the best trees were taken for lumber and ship masts and poor quality trees were left to regenerate the sites. Other trees, like hemlock, were cut and stripped of their bark for use in tanneries. The woodlots we have in Nova Scotia today are the result of many years of human intervention and use.

A great deal of land was also cleared for agriculture. In 1900 there was about three times as much cleared land in Nova Scotia as there is today. Abandoned fields and pastures have now grown back into white spruce forests. These white spruce forests are now old and many are being cut for pulpwood.

Summary

The influence of climate, water, and soil interact to determine what plants and animals will survive on a specific forest site. Each forest site is also a product of its past history and use. These elements shape the development of your woodlot and the distribution of what lives there. When analyzing a woodlot ecosystem, all these factors must be considered.

In addition, each component is influenced by another. You will notice in this manual that there is a constant stress on the interrelationships between different aspects of the woodlot ecosystem. That's because ecology, in essence, is a study of interrelationships. In the next lesson we'll look at how the forest community uses these components of the forest site.

Lesson One Quiz

Answer - True or False

1. Ecology is the study of living things and their relationship to each other.

T F

2. Forests cover 55% of Nova Scotia's land area.

T F

3. There are three different forest regions in Nova Scotia.

T F

4. A forest site describes the kind of trees that grow in a given area.

T F

5. Trees stop growing because the amount of daylight decreases in the fall.

T F

6. The most common injury to plants and animals during high heat periods is lack of water.

T F

7. A well drained soil is found where water lies above the tree roots.

T F

8. Forest litter means garbage that humans throw out.

T F

9. There is a lot of virgin forest in Nova Scotia (forests that have never been cut).

T F

10. There is more cleared land in Nova Scotia now than in 1900.

T F

Lesson Two

Cycles, Rhythms, and Seasons: Systems That Make Your Woodlot Work

Introduction

Within any human city there are important systems that keep it working. Our cities have electrical and water systems and ways of distributing food. The city is different during the night than during the day, and from season to season. The night- shift worker at a hospital has an entirely different living pattern than a teacher. As seasons change, so do cities. Lucky travelers migrate to the sun in the winter while the rest of us put snow tires on our vehicles. Similarly, the forest city has systems that respond to daily and seasonal changes. This lesson looks at the important cycles, rhythms, and seasonal changes in your woodlot.

Natural Cycles

The forest ecosystem needs fuel and water to keep it running efficiently. Energy from the sun flows through the ecosystem; water and nutrients move through the woodlot in cycles because the process is circular - from the air, to the plant, to the animal, to the ground, then back to the air; or from the soil, to the plant or animal, then back to the soil. A fundamental principle of ecology is that everything is connected through these cycles and flow of energy.

Understanding these interconnections is important because they are the foundations of all life. As well, a change in one may bring about changes in another. Energy flow, water and nutrient cycling can vary depending on the climate or soil of any forest site. However, the general processes are present on every woodlot.

Energy Flow

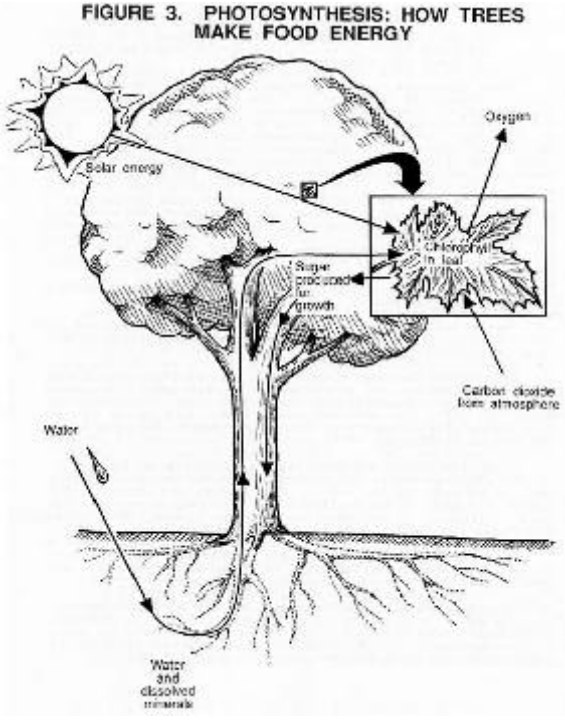
Photosynthesis

Solar energy in the form of sunlight is constantly bombarding the earth. Through a chemical process called photosynthesis, plants are able to use this energy to produce food, water, and oxygen. The food formed in this process provides the basis for all life on earth.

Photosynthesis is one of the most basic chemical reactions and also one of the most important to understand.

Simply put, photosynthesis is a process where green leaves trap sunlight and use it to creates food energy (sugar or glucose) so that the plant can grow (Figure 3).

FIGURE 3. PHOTOSYNTHESIS: HOW TREES MAKE FOOD ENERGY



Green plants are the energy factories of the forest ecosystem. Leaves or needles of the plants and trees are the factory workshops where sugar is produced. Photosynthesis can not occur unless chlorophyll, the green pigment found in plants, is present. When sunlight shines on a leaf it put energy into the chlorophyll. The chlorophyll uses the energy to take the hydrogen and oxygen from water. The oxygen is then released (respiration) into the atmosphere so that animals, including people, can breathe.

Hydrogen is combined with carbon dioxide from air to form a simple sugar. Tree sap is a mixture of sugar, water, and minerals. This runs through the tree and keeps the whole factory working and growing.

The Food Web

The energy produced in photosynthesis flows through the woodlot in the food web.

Energy flows (Figure 4) through the woodlot in a series of interconnected food chains that bind all citizens of the forest city together.

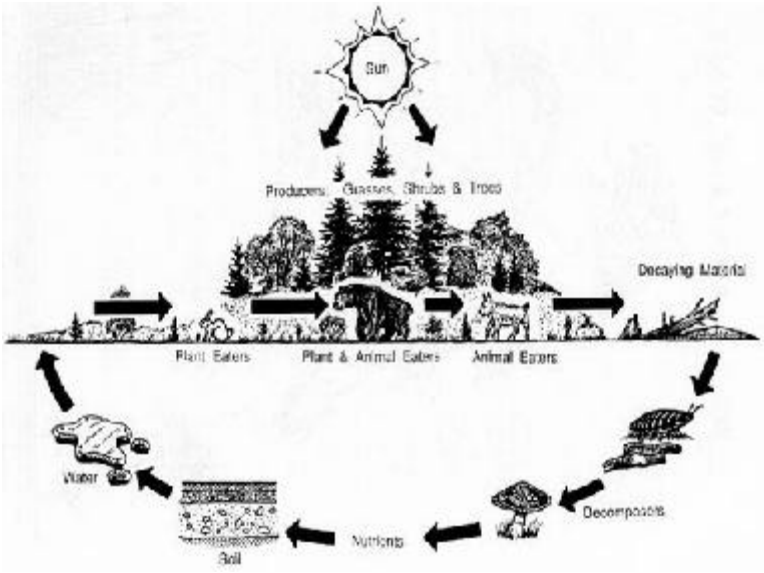


Figure 4. Energy Flow in a Woodlot

Food chains are a way of describing "who eats who or what" in the forest. For example, a aphid eats sap from plants, a spider eats the aphid, a dragonfly eats the spider, a small bird eats the dragon fly, and a hawk eats the small bird. Each member of the forest community is part of a particular chain. Figure 5 shows some sample food chains.

Green plants are the most important member of food webs. Besides trees, there are many other plants in the forest ecosystem; such as grasses, ferns, mosses, wildflowers, and shrubs. The numbers and types of these plants vary, depending on the soil and light conditions. These plants are important because they provide nutrition to the trees above them and food to animals.

Plants and trees provide food for animals which eat them such as deer, caterpillars, aphids, bugs, mice, squirrels, and groundhogs. These animals are called herbivores.

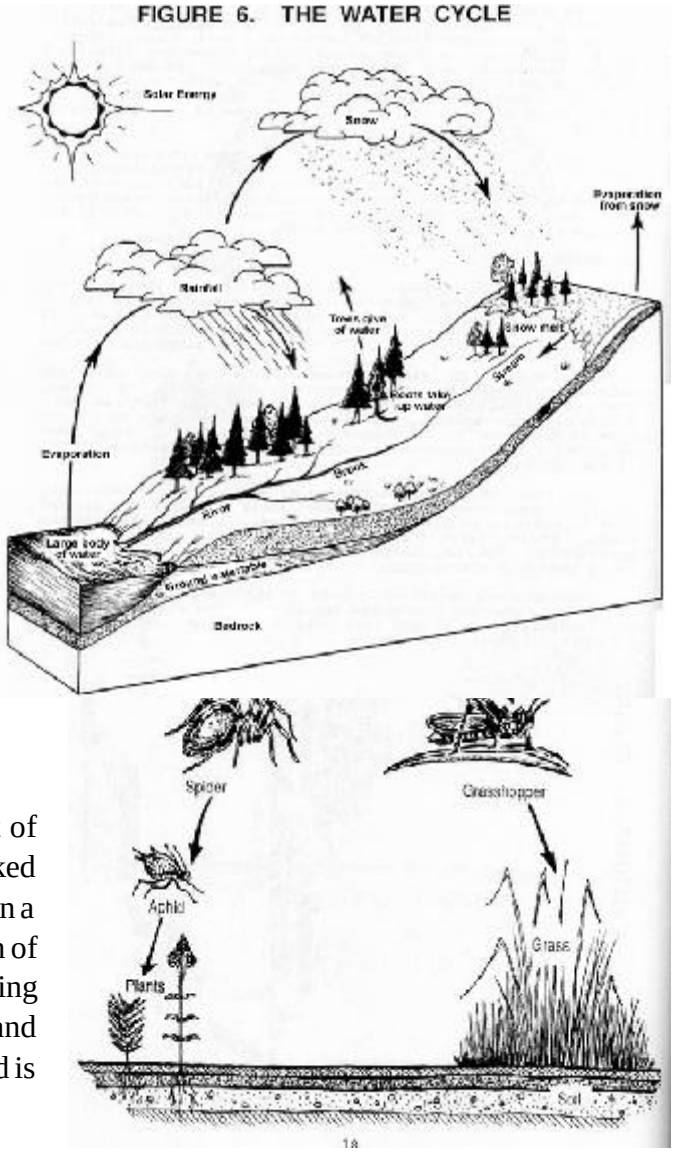
Carnivores, such as bobcats, are mainly meat-eaters. Snowshoe hares, which are plant-eating animals, are common food of bobcats. Other examples of carnivores include hawks and owls. It takes many mice to feed a pair of great horned owls so there are always more herbivores than carnivores in your woodlot.

Some animals such as bears are called omnivores because they eat both plants (eg. blueberries) and animals (eg. grubs). Other examples of omnivores are chickadees and raccoons.

The busy forest dwellers who handle recycling in the forest are called decomposers because they break down forest litter into a usable form of nutrients. Soil animals (worms, mites, springtails, beetles, insect larvae) break the litter into smaller pieces and bury them. They also churn the soil so that small bacteria and fungi come into contact with the decomposed material. Bacteria, which make up the biggest portion of the forest floor decomposers, have a large role in the decomposing process.

Less than one half of one percent of these important animals are visible to the naked eye. In a square foot of the first layer of soil in a hardwood forest there may be a population of ten billion recyclers! All through the recycling process nutrients are being used by plants and animals to continue living. Some of the food is used quickly and recycled again.

FIGURE 6. THE WATER CYCLE



The Water Cycle

Along with food, water is another important component for life. Plants need water to make food and to move nutrients through their system. Animal, including people, need water to live. In fact, over three-quarters of an animals body weight is water. A water source on your woodlot will attract many birds and animals.

The water cycle (Figure 6) uses energy from the sun as its driving force. Solar energy evaporates water from the oceans, lakes, ponds, and streams. This warm, moist air rises and forms clouds of water vapour. Wind moves the clouds over the land where some of the water falls as snow and rain. Melting of winter snow helps build large groundwater supplies needed by plants and trees in the spring.

Air temperature determines whether water falls as snow, ice, or rain. Some water evaporates immediately back into the air and some is released by plants (transpiration). Water falling on the surface

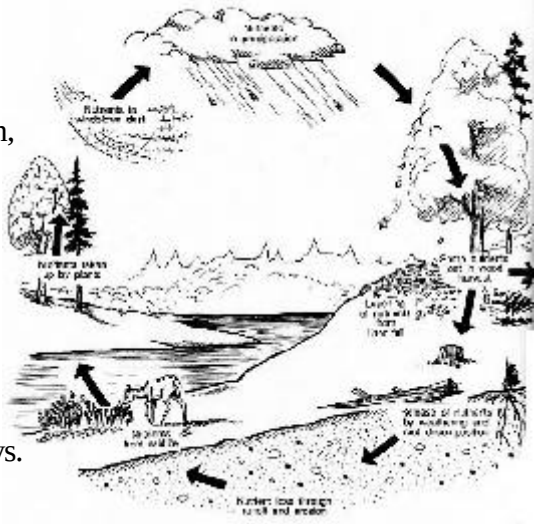
of the earth filters through the soil and collects as ground water. The rest enters waterways leading to lakes or oceans where the cycle starts again.

Woodlots are important because of their effects on the water cycle. If trees and plants are not present, the water that falls as precipitation will run back into the ground, but little is "breathed" back into the air.

The Nutrient Cycle

Nutrient cycling refers to the movement of all the nutrients necessary for life, including soil nutrients and gases from the atmosphere.

FIGURE 7. NUTRIENT CYCLING IN A WOODLOT



Nutrients in the soil generally include nitrogen, sulphur, phosphorus, potassium, and calcium. Minerals such as calcium and potassium are created by the effects of weather on rock. Magnesium, iron, boron, zinc, and sodium are also available in small quantities. Phosphorus comes from decaying plant matter. Sulphur and nitrogen originally come form the air.

Nutrient cycles can be looked at in several ways. Nutrients move from one ecosystem to another mainly by means of water flow. for example, nutrients from the forest move to the oceans by way of streams. However, within each ecosystem, such as the woodlot, there are also specific patterns of nutrient flow (Figure 7). Each nutrient has its own cycle or cycles.

Some nutrients have different ways of being moved in the woodlot. In many cases these movements are closely linked to food chains. here are a few specific examples of how small amounts of nutrients may be cycled in your woodlot:

A) Potassium from weathered rock in the soil is taken up by red maple leaves which are then eaten by deer. Eventually potassium will be returned to the forest floor in the urine of a coyote that ate the deer. This is only one example of how potassium is cycled; there are any more.

(B) Decomposing leaves release sulphur into the air; sulphur then falls in the rain and is absorbed in the soil; microbes in the soil turn the sulphur into a usable form; plants take up sulphur in their leaves; an animal eats the leaves, and excretes the sulphur in its waste, and the cycle starts again.

(C) Even slight soil differences resulting from different underlying rock can be reflected in the nutrient content of a plant. Scientists studying snow geese found that they could identify where the geese had bred by looking at the chemical composition of the bird's feather.

How efficiently nutrients move around the forest city depends on many things, but the most important are:

(A) How quickly litter decomposes and is taken up by the roots of plants.

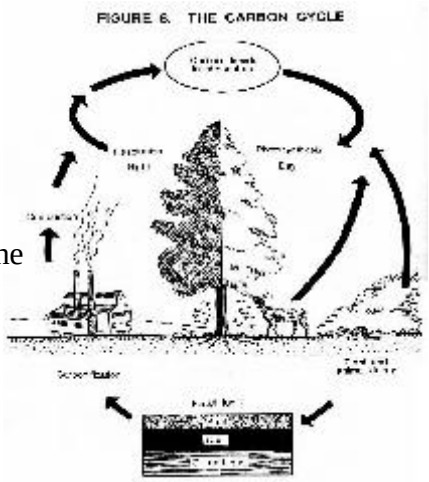
(B) How efficiently water moves through the ecosystem.

The decomposers in the food web are very important in the cycle of nutrients. In fact, without these small organisms on the forest floor our forests would not be green each spring. The small animals, insects, and fungi are the clean-up crew. They make sure that the forest city does not smother in its own litter and that the nutrients are recycled to the trees.

Each nutrient in the forest has its own cycle, just as each plant and each animal has its own cycle. The carbon and nitrogen cycles are two of the most important.

The Carbon Cycle

Without the carbon cycle (Figure 8) photosynthesis would not be possible, plants could not make food, and we could not live. In the woodlot, carbon is used and stored in many ways. Coal, oil, and gas, which most people use as energy, are forms of stored carbon.



Plants and trees remove carbon dioxide (CO_2) from the air during photosynthesis and use it to make food. Some carbon dioxide is released back into the atmosphere when plants and animals breathe. Carbon dioxide levels in the air change from day (when plants are busy making food) to night (when plants rest) and from season to season. Spring and summer have higher carbon dioxide levels than in the winter when the "green sugar factories" of plants are shut down.

Carbon dioxide which is not released is turned into carbon and stored in plant and animal tissue as sugar. When these plants and animals die and decay, the carbon is stored mainly in the ground. Peat, coal, oil, and gas are all forms of stored carbon. These fossil fuels are an accumulation of old decayed plant and animal material, and when they are burned, they release carbon dioxide into the air.

Forests store carbon longer than any other global ecosystem. Forest fires and the burning of forests for clearing also releases carbon into the air.

The Nitrogen Cycle

About 79 percent of our atmosphere is nitrogen which is the nutrient essential as a building block for all living things.

Nitrogen is taken from the atmosphere by a series of complex chemical reactions. Some nitrogen comes to the ground in rain, but most of it is produced by plants and bacteria working together.

Certain plants like those of the legume family (lupines, clover, vetch, and pea) make nitrogen available to other plants and animals by releasing chemicals that nearby bacteria use to "fix" or grab hold of atmospheric nitrogen. Other trees and plants, such as alder, are able to produce large amounts of nitrogen. Most of these plants grow in the early stages of the forest when the soil is usually low in nitrogen. This is nature's way of building up nitrogen stores in the soil.

Nitrogen is also produced by bacteria and algae and when animal waste breaks down. Much of the nitrogen that is taken up by trees is returned to the soil by falling leaves and needles. Successful tree growth depends on how quickly nitrogen is rotated through this system. When forest litter does not decompose, there will be a shortage of nitrogen for tree growth. Only about 1-3 percent of soil organic matter is nitrogen, but this small amount is used over and over again.

Daily Rhythms

At dawn and at dusk, there are major changes in the activities of forest dwellers. As sunlight disappears, the leaf factories shut down their energy making business and many birds and insects settle down for the night while night prowlers just begin their main activities. Butterflies gather nectar during the day when flowers are open; moths work at night when many yellow and white flowers open. The red squirrel you see all day goes to sleep as the flying squirrel wakes up to glide from tree to tree. While robins are resting, great horned owls are busy. These habits can change at different times of the year. Many birds migrate at night. All through the day and night, there are rhythms of activity going on within your woodlot.

Seasonal Changes

Many people attribute the changes in the season to changes in temperature, but in fact most animals change their behaviour not because it is getting colder, but because the days get shorter. Studies have shown that although there are variations in time from year to year, the actual patterns change little.

Many plants and animals operate on some kind of internal clock that alerts them to do certain things. This is a way that lifeforms adapt to their environment and the availability of food, water, and nutrients. A bee arrives just in time for the opening of a flower and the flower opens in time to be pollinated by the bee. Birds and mammals have their young in the spring because they have adapted their cycles to make maximum use of our climate conditions. In spring, food is available and weather is less severe. These inner clocks, as yet not well understood, affect the behaviour of most living things.

Summary

Food and water are constantly moving through your woodlot system to keep it functioning. Each cycle can be highly dependent on another cycle in order to work. The water cycle and the carbon cycle, for example, make photosynthesis possible which provides energy to the entire woodlot system. Understanding the fundamental functions of your woodlot not only helps you appreciate the interconnections in the woodlot community, it also illustrates the basic ingredients which are required for life and growth. These cycles keep the woodlot community growing.

Lesson Two Quiz

Answer - True or False

1. Photosynthesis describes how plants make food energy.

T F

2. Trees "breathe" oxygen into the air.

T F

3. Carbon dioxide is a pollutant and harmful to plants.

T F

4. The most important part of the food chain are carnivores.

T F

5. There are always more carnivores than herbivores present in your woodlot.

T F

6. Small soil animals and fungi create nutrients necessary for plant growth.

T F

7. Trees "breathe" water into the air.

T F

8. All of the forest's nutrient cycles start from rock material which forms soil.

T F

9. There is more carbon dioxide in a woodlot in a spring and summer.

T F

10. Nutrient cycles depend on the water cycle to work properly.

T F

Lesson Three

The Structure and Interdependence of the Woodlot Community

Introduction

Like human cities, no one forest city is exactly the same as another but there are many similarities. The structure of a human city depends on where it's located, what kinds of people work there, and how nature and people change the city. The forest city is no different. It's structure depends on the site, the plants and animals available in that area, and the changes brought by climate, time, season, and man. In this lesson we'll look at the citizens of the woodlot, how communities are diverse and varied, how populations develop and survive, wildlife roles, the places where communities meet, and the importance of water ecosystems.

The Citizens of the Nova Scotia Woodlot

Animal and plant life varies from region to region but taken together all of the forests in Nova Scotia are homes to:

- about 1900 seed-bearing plants including trees, shrubs, and herbs and many kinds of fungi, lichens, mosses, and ferns.

- many of the approximately 160 birds, including seabirds, that breed in Nova Scotia. Many more species of birds visit our province on both regular and rare occasions.

- about 50 types of mammals including small mammals like shrews and mice; common animals such as raccoon, skunk, and deer; and less common animals like marten and lynx.

- over 35 kinds of fish including speckled trout and Atlantic salmon.

- over 20 types of reptiles and amphibians (snakes, turtles, salamanders, frogs).

- thousands of insects and other small animals with no backbone. There are about 2,000 different kinds of moths and butterflies in Nova Scotia and about 3,000 different kinds of flies. Worms, slugs, snails, centipedes, millipedes, beetles, bees, wasps, ants, and spiders are also in abundance.

From an ecological point of view, each of these life forms has a place and function in the woodlot system.

Structure of Forest Communities

Like cities, woodlots have separate little suburbs or communities which are arrangements of animal and plant populations that usually live together in a certain area.

For example, certain plants and animals can be found in a dying tree while a different community can be found in a white spruce and a balsam fir forest. An association is composed of common groups of vegetation that normally occur together. Sample associations of trees in Nova Scotia include: spruce and balsam fir; spruce and white pine; yellow birch and red maple.

A community is most often described by the major types of plant growth that occur. All members of the community are linked by food, and all activity in the community is centred around survival.

Plants provide food for animals which have ecological roles that are essential for the existence of a woodlot. Wildlife spread pollen and seeds, decompose forest litter, and are an important part of forest food chains.

Even associations that have much in common can have differences because the forest is always changing or being disturbed or the soil and climate may vary. These factors alter the growth pattern of woodlots slightly so that one group of balsam fir and spruce may be slightly different from another or vary from woodlot to woodlot. Remember that your woodlot is unique.

Not all species in a community are equally important. In a community of many hundreds, only a few species exert a controlling influence over the rest of the community. The dominant species in a community are those that are most successful and which influence the other kinds of plants and animals. For example, the kinds of plants that grow on the forest floor are determined in part by the trees. Small plants, like spring beauties or dogtoothed violets, flower early in spring when the maple leaves are just budding and there is little shade. In spruce-fir dominated forests where shade is constant, plants such as mosses which require less light, will grow.

Diversity

Woodlots with many different species of animals and plants are diverse. Diversity is an important concept. A diverse ecosystem is stable and is able to handle disturbances. The size of your woodlot is not necessarily a measure of how diverse it is. A small woodlot with many different plants and habitats is likely to be much more diverse than a large woodlot containing one kind of tree and very few other habitat areas. Even if your woodlot is small, it can contribute to the diversity of your area. When grouped as one large woodlot, many small woodlots can provide habitat for many plants and animals.

If you have a variety of plants and trees at different stages of development in your woodlot, there will be greater opportunities for wildlife. Many wildlife species are not obvious. The greatest diversity of life in your woodlot is found in the soil. What lives and grows in areas adjacent to your woodlot also affects the plants and animals. Because animals and plants do not know manmade boundaries, actions in neighbouring areas can affect the health and population of species living in your woodlot.

If your woodlot has predatory animals at the top of food chains (i.e., owls, eagles, fox, and bobcat), you probably have a diverse woodlot because meat-eaters need many plant-eaters to survive.

It also indicates that your woodlot is producing plenty of green plants for food for all these inhabitants. If there are plenty of different kinds of plants and animals, the ecosystem is "richer".

Populations and Survival

The distribution of plants and animals is limited by climate, site conditions, the availability of food, and competition for space, water, and nutrients.

Plants, trees, and animals constantly compete with each other for food, water, or sunlight. The most successful survive.

When two species compete, one will always do better. In the long term, one species will adapt to a needed change. In some parts of Nova Scotia, deer and moose compete for the same territory. Things have been made even more difficult for moose because deer spread a parasite that fatally affects the moose's brain. Even though white-tailed deer were introduced to our province less than a hundred years ago, they have become very abundant. The success of the moose population will depend on how well it can adapt to the changes brought on by the presence of deer.

In a similar way, plants compete for space, light, water, and food. Two spruce trees, side by side, compete for the best growing conditions. Silviculture treatments are used in woodlots to reduce competition. Many of you probably know that a thinned row of carrots grows much better than a crowded one. In the forest, competition influences the makeup of the community. The species that best adapts to the situation will survive.

All plants and animals, including humans, have the same basic habitat requirements: sufficient food, water, shelter, and space. animals live in a woodlot that contains the right living conditions, or habitat. Each wildlife species in Nova Scotia differs in physical appearance as well as its particular habitat needs. Although some woodlots provide more habitat than others, they vary in the type and number of available habitats they provide.

Animals have physical and behaviourial characteristics that allow them the exploit certain habits. The differences in physical appearance in animals and plants is a reflection of how well they have adapted to their environment. For example, a moose can use areas with deeper snow and feed on saplings of greater height. As well, they browse on a greater variety of trees and shrubs. Their survival also depends on climate. Hard winters will reduce deer populations, but moose will be less affected.

Some animals have very strict habitat requirements and others do not. The bald eagle requires a tall, sturdy, fairly isolated nest tree near water while the American robin can take advantage of a number of nesting sites and has a much smaller territory. Some animals require a lot of space, while others do not require much. A moose requires several square kilometres; the chipmunk requires a hectare.

The forest city is always changing, from day to day, season to season, and year to year. Some things can adapt to change better then others. An aphid can land on a plant and move away if it is not suitable. In contrast, the Atlantic salmon is programmed to breed in one stream out of many hundreds.

When the salmon returns to the stream where it was born, it cannot go somewhere else if the conditions are not right.

Woodlots also change as new plant and animal species appear, die, or migrate. These changes are the result of natural or manmade disturbances and as these changes occur, the ecosystem functions in different ways.

Roles in the Community

One role of plants is to provide the basis of the food chain to all members of the community. In addition, each wildlife species has a specific niche in the forest ecosystem. The niche of an animal or plant refers to its role in the forest city. These roles are essential to ensure that the ecosystem works.

Small mammals like moles, shrews, and chipmunks have an important role in loosening the soil and removing decomposing material when they tunnel and burrow. Forest floor litter eaten by these animals passes through their digestive system where it meets new chemicals which help break down material.

Other wildlife species have roles as the city's architects and builders. Woodpeckers make holes in trees for themselves which can later be used by other animals and small birds. Nuthatches and chickadees nest in the abandoned cavities dug by woodpeckers. Groundhogs dig burrows that are used by snakes, foes, coyotes, skunks, mice, and squirrels. The great horned owl is one of the squatters in the forest city; it does not build nests, but will fix up an abandoned hawk or crow's nest.

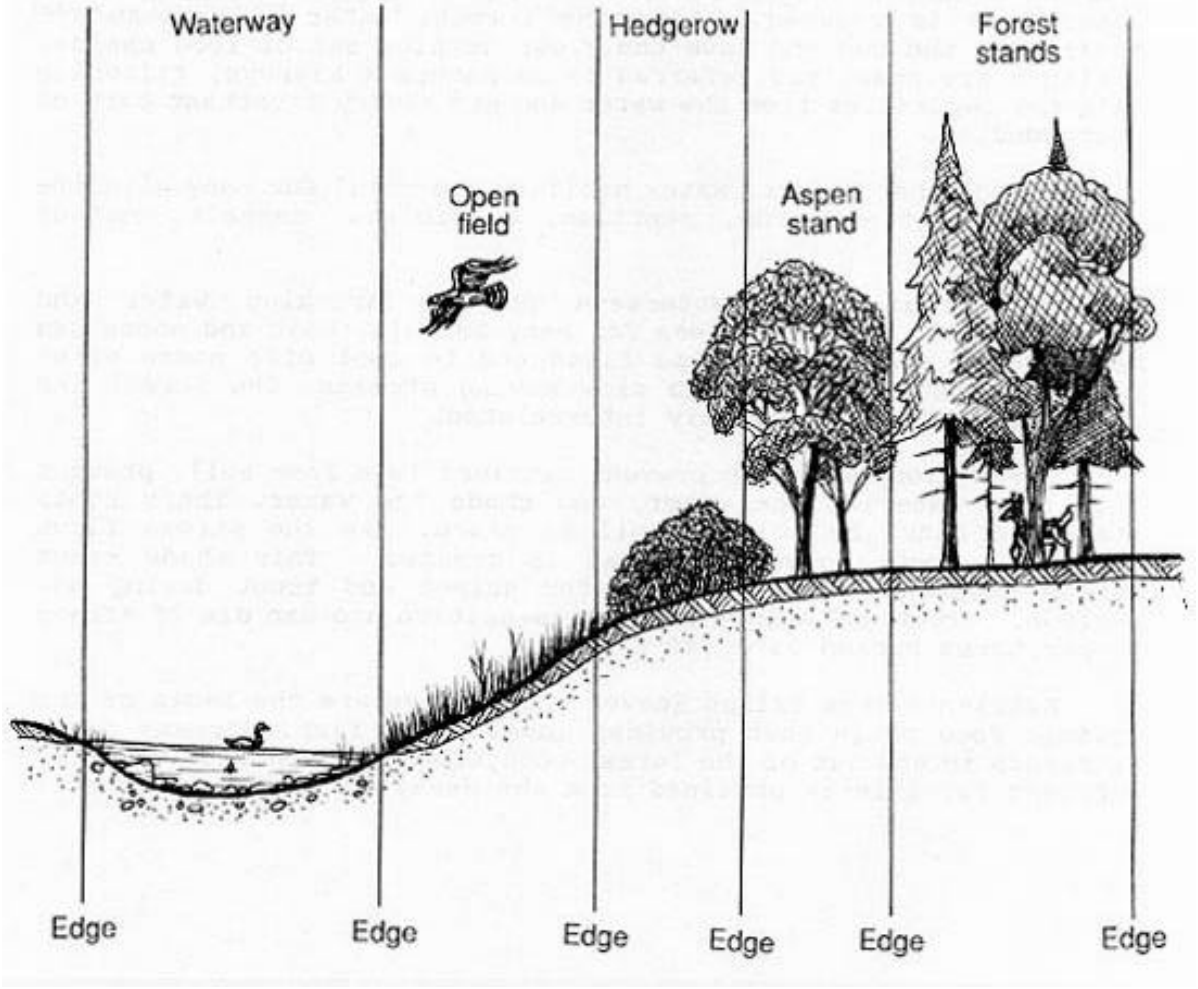
Many different wildlife species depend on each other. Aphids and ants often live and work together. Ants protect the aphids and in return receive a food supply of "honeydew" from the aphids. Bacteria living in the stomach of deer depend on the deer's stomach for warmth and the deer need the bacteria in order to digest food.

Insects are important members of the forest community. They pollinate plants, feed on waste, provide a food source for other animals, and also eat other insects. Some insects do feed on trees but these are a very small part of the forest insect community. In Nova Scotia some 10,000 insects live in our forests. Of these, only about 12 species will create problems in any given year.

Where Communities Meet

An edge is created where one community meets another. This may be a forested area meeting a waterway or it may be a place where two different communities of plants or trees meet. Thus, an edge is created where a spruce and an aspen stand meet. The border between a forest and an open field also creates an edge. Figure 9 shows how edge is created naturally. Edges can also be manmade - for example, where a harvested forest meets an uncut forest. The size and shape of the forest cut determines the amount of edge.

FIGURE 9. NATURALLY CREATED EDGE



Generally, edges are very important for wildlife because they offer more choices to animals for their food, water, cover, and space requirements. Wildlife has simultaneous access to both habitats, but can quickly move away if necessary. As a result, there are more wildlife in edge areas of a woodlot.

Although deer may shelter in a spruce forest, they will venture to the edge of that forest to look for red maple suckers in a nearby field or cutover. A hawk may perch in a tree on the edge of a field because there are more small mammals in this edge area for it to eat. Ducks will net in the "edge" area between a forest and a pond; the forest will provide cover from enemies near the duck's food source in the water.

Interactions with Water

Watercourses which flow through your woodlot might be a fast running brook, a larger river or lake, or bogs or marshes where water flow is reduced. Like the forest, water ecosystems are fuelled by the sun and have their own complex set of food chains. Wetlands are sometimes referred to as nature's kidneys, filtering silt and impurities from the water and are very important part of your woodlot.

Among other things, water habitats are vital for many wildlife species including birds, reptiles, amphibians, mammals, and of course, fish.

The areas along waterways provide drinking water and traveling and breeding areas for many animals. Deer and moose use wetlands in summer to escape flies and to cool off; moose often feed on plants in ponds and slow moving streams. The forest and water ecosystems are closely interrelated.

Trees along a stream prevent nutrient loss from soil, prevent silt from entering the water, and shade the water. Their roots stabilize banks by holding soil in place. As the stream flows under the roots, cover for fish is created. This shade keeps stream temperatures low enough for salmon and trout during hot periods. Trout and salmon are very sensitive and can die if stream temperatures exceed 25 C (80 F).

Nutrients from fallen leaves and needles are the basis of the aquatic food chain that provides insects for fish. Streams carry nutrients in and out of the forest ecosystem. Phosphorous, a vital nutrient for life s obtained from the decay of forest litter.

Summary

Both plant and animal life are influenced by climate, soil fertility, and the history of disturbance in your woodlot. In turn, the structure and population of species on your woodlot is determined by the dominant plants that grow there. The interactions of any community are linked primarily by food and losing even one link in the food chain can upset the entire order of an ecosystem. Woodlots that have a variety of plants usually have a larger variety of animals. In turn, this diversity is influenced by the presence or absence of other unique habitats like watercourses. Because of the importance of plants and trees in determining the basic structure of communities, we will discuss their growth and change patterns in the next lesson.

Lesson Three Quiz

Answer - True or False

1. Nova Scotia has about 50 different types of mammals.

T F

2. Common plant communities are the same from one woodlot to the next.

T F

3. Diversity is best explained by how many trees of one species you have on your woodlot.

T F

4. Availability of food is one of the main factors affecting what you will find in any community.

T F

5. All animals need food, water, space, and shelter in order to live.

T F

6. All birds are very particular about where they will nest.

T F

7. The niche of any animal refers to the role it has in the community.

T F

8. Small animals like shrews and moles help prepare soil for the next generation of trees.

T F

9. There are more different kinds of wildlife in edge areas.

T F

10. Trout and salmon prefer water that is very warm.

T F

Lesson Four

Plants and Trees: Growth and Changes over Time

Introduction

When we think of a forest community, we often think of its most obvious inhabitants - trees and green plants. However, we often fail to understand the complexity of their growth and development. Jack McCormick called trees the high rises in the forest city but trees and plants are actually more like complex factories. Learning how these factories operate is an important step to further understanding your woodlot ecosystem.

The study of flora (plants) is complex. In Nova Scotia there are hundreds of species, each of which belongs to a plant family that has its own distinctive structural and life characteristics. For example, the spruce tree belongs to the "cone-bearing" or coniferous group with leaves like needles. Plants and trees vary in number and where they grow. Some plants such as bunchberry are very common, whereas others like the water pennywort are extremely rare. In this province, we even have plants, such as the pitcher plant and sundew, that eat insects.

Because evergreen and deciduous trees are the biggest inhabitants of the woodlot, we will use their life and growth as the primary example in this lesson to look at how trees and plants grow and how your woodlot naturally changes over time.

The Movement of Water and Nutrients

It's important to "see" a tree or plant as existing below the ground as well as above. Roots are really underground branches; they provide nutrients and water, and anchor the plant or tree. The roots are the beginning of the factory's assembly line where material is collected for use in food production and the connector to all the natural cycles in the woodlot.

As the plant or tree grows new leaves or branches, new roots grow underground. In trees, surface roots extend near the top of the soil and will spread at least as wide as the widest part of the tree's crown. Other roots that extend deeper into the ground search for water. However, most roots are part of a dense network of feeding roots that move in the top layers of the soil. The type of plant or tree, type of soil, amount of available water, and the number of other plants growing nearby all affect the root system.

Some roots have hairs that make it easier for the trees to gather water and nutrients. Others have a complicated arrangement of fungi that help the root to grow. The fungi release a chemical that stimulates root growth, and when the fungi are attached to the roots, it helps them absorb nutrients and moisture. The plant, in turn, gives the fungi sugar for growth.

The trunk or stem of a tree or a plant is the elevator shaft of the factory. This stem supports the plant and has an amazing array of channels that pass sap, water, and food from one part of the tree to another.

The bark which protects a tree has various widths. The bark of a birch tree is only about a 0.64 cm (1/4 in) thick, whereas a sequoia tree in California has bark that can be 60 cm (two feet) thick. The inner bark is soft and moist and is used to pass sugar from the leaves to the roots. The outer bark is usually harder and protects the tree from temperature changes, insects, and diseases. A strong trunk can hold a massive factory and gives the tree an advantage over other plants that may be competing for the same water and nutrients in the soil.

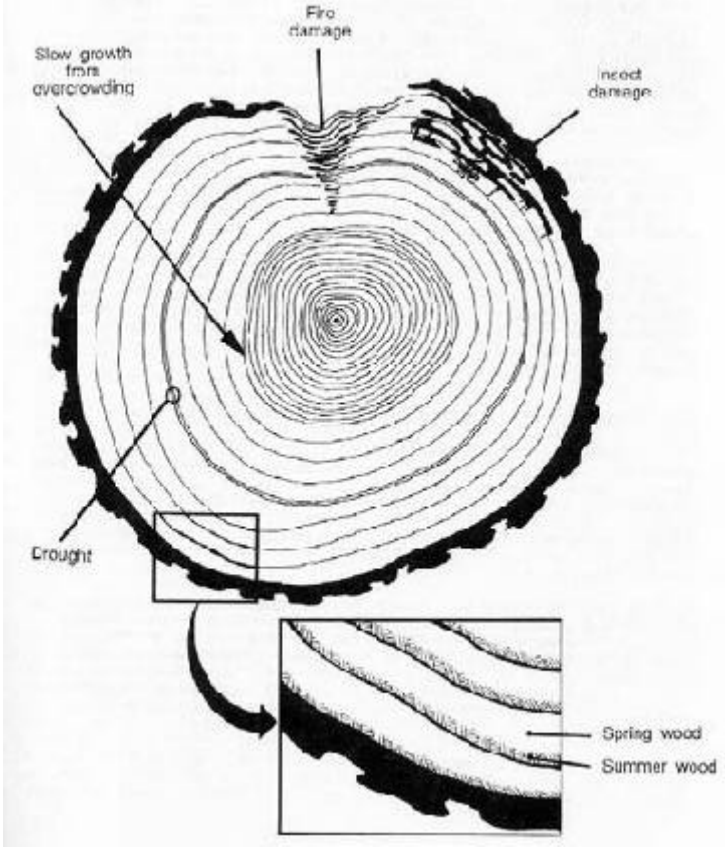
The trunk enlarges at a thin cambium layer between the bark and the wood. The new layer of wood added to a tree each year appears as a ring in the tree stump. The number of rings tell us how old the tree is - but these rings can also tell us a lot more. The way the rings grow (Figure 10) can tell us many stories about the lives of trees. In softwoods you can see the "spring wood" (wood grown in the spring) and the "late summer wood". The big spurt of growth in the spring is outlined by the slower summer growth which creates a dark thin edge in the ring.

The distances between the rings tells us how quickly the tree grew. If growing conditions are good, the tree will grow more quickly and the rings will be further apart.

Many people try to guess the age of a tree by looking at how thick the trunk is. Yet there are many small, thin, spindly trees that are old. These trees have not had enough space to grow or have encountered other problems. Black spruce growing in bogs become waterlogged and trees growing on barrens are smaller because they don't have enough nutrients.

The rings also can tell us information about climate, pollution, insects, wind, fires and other influences on a tree's life. Droughts will limit the width of a tree ring. Insects and pollution will leave telltale bumps and markings. Fires will leave scars in the rings, and the wind can cause a tree to lean which is partially reflected in compressed rings on one side. Each tree owes its appearance to the environment where it has grown.

FIGURE 10. STORIES IN TREE RINGS



Food Production

The crown of a tree is made up of branches or limbs, twigs, leaves or needles, buds, flowers, and fruit.

The leaves are the photosynthesis factories that make the food. The branches pass this food around the tree. The beautiful red and yellow colours we see in the autumn are present in the leaf all summer but are masked by the green colouring (chlorophyll) used in photosynthesis. Leaves turn colour in the fall because the production of the chlorophyll stops. What remains in the leaf is moved from the leaves in the fall to be stored in the tree's branches so that the tree can begin growing again in the spring.

Softwoods have leaves that are needle-shaped. In almost all softwood trees (larch being the exception) the tree is always green because the needles stay on the tree for a few years. This is where the term "evergreen" comes from. However, old needles are being shed constantly and new ones grown.

Some leaves change their positions during the day to take advantage of changing light and temperature. Others, like the clover plant, change their leaf position at night, folding inwards, perhaps as a protection from cold and frost. The leaf is not only important as the producer of food but also because the surface has minute openings (stomata) where the plant can release water and oxygen to the air.

Sex in the Plant and Tree World

Flowers which are the sex organs of plants and trees are necessary for reproduction. Most people are surprised that trees have flowers. The black spruce has a small reddish cone-like flower that many people do not notice. These flowers depend on the wind for pollination so they do not have to attract insects. The flowers of an apple tree and most smaller plants depend largely on the insects for pollination so they must be large and fragrant to attract the insects.

A tree is adult and ready to reproduce when it can produce flowers and seeds. The length of time it takes for trees to mature varies. A tree' stability to flower has more to do with size and growing conditions than age, so a crowded apple tree in a corner of your woodlot may be "old", but it may not flower because it does not have enough room to grow. In contrast, annual plants such as dandelions, produce a flower each year and may take only 4-6 weeks to produce seeds.

Trees such as pines and oaks have both male and female flowers on the same tree. Other trees are either male or female, such as poplar, willow, and ash. Cherry, elm, and linden trees, and most small flowering plants have male and female parts that are combined in one flower.

Tree reproduction begins when pollen released from the male flowers fertilize female flowers. The pollen is commonly carried by wind and trees are usually fertilized by surrounding trees. Every spring people mistake large floating masses of pollen in ponds and other waterways for some form of

pollution. Insects (bees, wasps, flies, beetles, butterflies, moths), hummingbirds, and bats also carry pollen from one tree to another and are responsible for the pollinating most of the small flowering plants.

The Lives of Trees

Environmental conditions such as space, light, and moisture, all affect the final shape of a plant or tree. However, plants, like people, come from a certain stock and inherit certain characteristics from their parents.

The straightness, shape, and structure are determined by factors inherited from the seed. When early Nova Scotians cut the tallest and straightest trees, they left poorer trees to produce seed for future forests. Trees also adapt to their environment. most northern softwood trees have evolved into a conical shape to help them withstand the heavy pressure of snow and ice.

Seeds: The Beginning of Life

The male produces the pollen, and the female, when fertilized, produces a fruit or seed. trees produce seeds which vary in size and shape at different times. Softwoods are called conifers because their seed is enclosed in a cone.

Trees don't produce seeds every year. Generally, intolerant trees such as poplar and birch have a shorter amount of time between each period of seed production. Slower-growing, tolerant trees such as beech and sugar maple have longer intervals between seed production and generally produce fewer and larger seeds.

Comparing red maple and white pine trees provides a good example of the different timing and release of seeds. A red maple flowers early in the spring and releases thousands of small seeds about 4-6 weeks later. Each seed contains the ingredients for a tree, an enclosure to give it food for the first year of life, and some sort of wing to help it move in the wind or spring waters. Seeds can also be carried by birds and animals in their feathers, fur, and intestinal systems. By contrast the seeds of a white pine tree need 2-3 years to develop and are released in the fall or winter to lie on the forest floor or blow across the snow surface. In the spring they germinate and grow. White pine produces a good crop of seeds about every 3-5 years.

Getting Established in the Forest Community

Some trees depend on fire, flooding, wind-throw or other disturbances to get started. These events open up areas of the forest that previously had little or no light. Trees are adapted for the difficult conditions found in the forest and establish themselves in three major ways:

1) Pioneer trees (grey birch, poplar, cherry) quickly establish following a disturbance such as flooding, fire, or cutting. These trees don't like shade and seeds grow quickly.

2) Intermediate trees (black spruce, white pine, red oak, white ash, red maple) can handle a little shade until some kind of disturbance helps them find a gap to grow more quickly.

3) Shade tolerant species (red spruce, sugar maple, balsam fir, beech, eastern hemlock) can grow in the dark, shady understory of a forest. Sometimes spaces are created for them when the bigger trees around them die or get blown over.

Other factors like soil temperature , moisture, and animals determine how well a seed germinates. Because seeds need heat to germinate, the soil's warmth can be important. Generally, more heat is absorbed on dark coloured surfaces because light coloured surfaces reflect heat. We also know that heat travels at different speeds through different materials. Heat is moved or conducted more quickly through wet soil than dry soil because water is a conductor or mover of heat.

Seeds also need adequate moisture to begin germinating. Dry springs and early summers (when many seeds are released) will create poor germinating conditions. When it's too warm and dry, seeds lay on top of the soil and dry out before they can germinate.

Animals play an important role in spreading, planting, and starting seeds throughout the forest. Animals and birds in your woodlot may plant a seed for you in their own manure. Some seeds go through the animal's digestive system where juices help to soften the seed. The seed is released as part of the animal's regular daily waste. In addition, the pellets of squirrels provide manure which contains bacteria and fungi that will aid the germination of the seed and provide fertilizer.

Animals and birds also make caches of seeds and forget about them. Bluejays, chickades, and many rodents hide seeds some of which eventually grow. Other animals, such as moles, carry out tunnelling which turns earth over in much the same way you would turn your garden over in the spring. The freshly turned soil creates a "garden" for seeds to begin growing.

The most difficult time in a tree's life is getting established in the busy forest city once the seed has germinated. Millions of seedlings perish in the is delicate stage - animals and fungi destroy them and heavy rains wash them away. There are many reasons why seedlings have trouble getting started. If seedlings are not eaten or destroyed, they compete with each other for food, light, and water. Those that are best adapted for the site and those with superior inherited qualities will grow the best.

Growth

Soil, climate, and water are the main influences on tree growth. Many trees do most of their growing in May and June when the water is plentiful and temperatures are not too warm. Early spring is the time for planting and transplanting trees because they are still dormant, there's moisture in the soil, and the roots are just starting to become active. The plants will have an entire summer to become established.

If plants and trees grow too late in the fall, the new growth will be killed by frost. Plant life in Nova Scotia is adapted for our weather and stop growing in the fall. Late summer and early fall are important times in the lives of trees as they are storing food for next spring. Root growth continues in the fall until the first frost. In winter, plants and trees are dormant.

Plant and tree growth depend on how well nutrients are cycled in the woodlot. Different tree species have varied nutritional requirements and some trees can handle a low level of nutrition better

than others. Generally, hardwoods require more nutrients than softwoods. Grass growing near seedlings can inhibit growth because of the many small, fine roots which take up a lot of nutrients.

Growth will also be inhibited if the tree is too crowded. In this case, not enough light, nutrients, and water are available for each tree because there are too many roots competing for limited resources. Trees that have been spaced grow more quickly because they do not have to compete with each other for the important requirements of life.

After light, water is the most critical element required for tree growth. How trees take up water varies, but they all use a vast amount. A single large tree on your woodlot can take up as much as a ton of water from the soil every day. The ability of a tree to pump water is truly amazing. A suction pump can carry water no higher than about 10 metres (32 feet). In a tall Douglas fir on the west coast of Canada, nature carries water up about 80 metres (262 feet).

Most of the water taken up by trees is absorbed through the roots. Less than 1 percent of the water that is taken up is actually used; the rest is eventually released (transpired) through the leaves and needles. As water is carried up through the tree it keeps the tree cool and brings with it most of the nutrients required for growth.

Because tree growth is limited when water is scarce, soil water and moisture in the spring months are keys to a healthy growing forest. Lack of water in the late summer months affects trees as well. Some trees, like birch, which have a longer growing season are affected more by late droughts than pine, maple, ash, beech, and oak which do most of their growing in the spring and early summer. However spring growers may have trouble the following year if a drought affects the moisture of the soil.

Compared to some other parts of the world, the lives of Nova Scotian trees are relatively short. Balsam fir mature in about 50 to 70 years. Although white pine can live up to 450 years, the average age is about 200 years. The oldest living tree in the world is a bristle cone pine that's over 4000 years old and is found in the southwestern United States.

Dead and Dying Trees

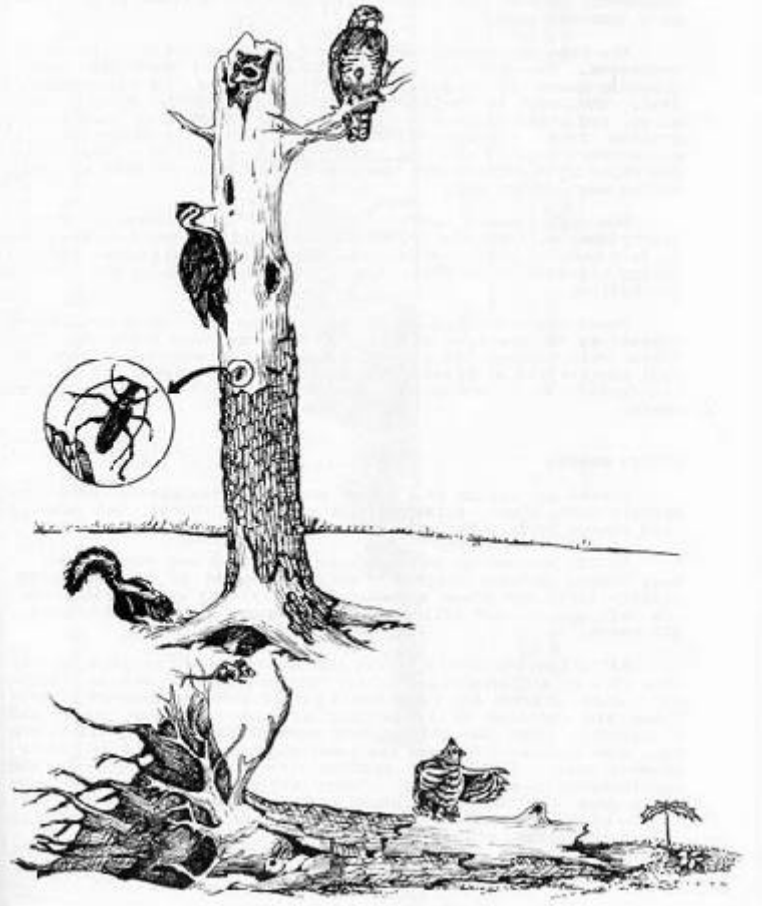
As we learn more about forest ecology, we have come to recognize a tree's importance as it dies and decomposes. Sometimes called snags, cavity, or wildlife trees, they are used by many forest dwellers at different stages of the decaying process for apartment buildings, supermarkets, and look-out posts (Figure11). It's estimated that up to one-quarter of the wildlife in Nova Scotia use dying or dead trees for some purpose during their life.

As a tree ages, the bark loosens or gets injured by fire, lightning, animals, or humans. Injuries such as broken tops, form entry points for various types of fungus which show up as conks on the tree.

Insects start to invade the bark, making the tree softer and easier to penetrate. Carpenter ants begin mining the wood. birds, like the pileated woodpecker that eat the ants, drill into the bark. The next spring a smaller woodpecker or other bird that lives in cavities or holes in trees, drills into this soft feeding area to make a nest hole. As the tree rots and the hole becomes bigger, it becomes a home for

a family of flying squirrels or a group of wintering raccoons or a nesting area for a wood duck or merganser. A hawk uses the bare branches of the standing dead tree as a look-out post.

FIGURE 11. THE USE OF DYING AND DEAD TREES



The tree eventually rots and falls down as activity inside it increases. When the tree falls, a new section of the forest opens, creating space for new plants and trees to grow. The log, although dead, continues to shelter a multitude of life. Fungi, ants, mites, and other insects recycle the log, breaking it down into a smaller form. Other animals like spiders, centipedes, and salamanders come to eat the insects and find shelter. Earthworms and other soil animals eat the remains and their "casts" or waste become part of the soil.

The log becomes useful to many different animals. Grouse (partridge) will use the log as a drumming spot. Small animals use it as a nesting place. A salamander may bury itself under the log during hibernation in the winter. A porcupine family may live in the hollow.

Fungi and bacteria grow in the decaying log. the fungi attach themselves to new tree roots; the bacteria help break down the litter even further. Thus the log further decomposes and feeds the next generations of trees. Eventually a new seedling can grow in the fertile soil left by the decayed tree, and the cycle begins again.

Forest Change

Forest succession is a way of describing how plants replace or succeed each other. Animal populations also change, but usually this change is directly related to changes in plants and trees.

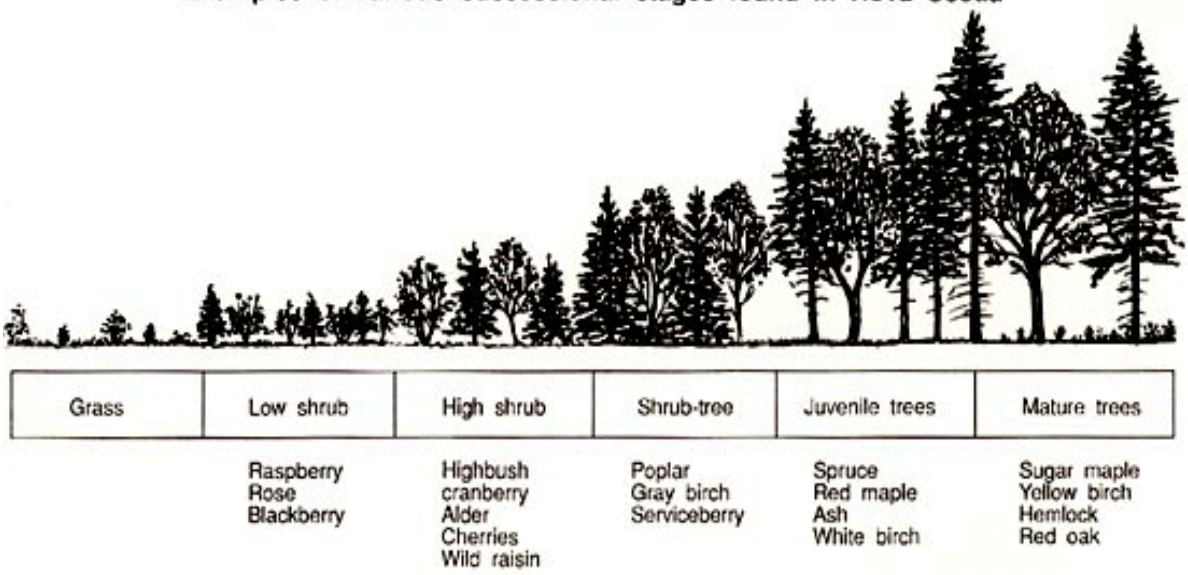
Forest succession on most poorly drained and moist areas in Nova Scotia evolves towards a softwood forest of hemlock, pine, eastern larch, and black spruce. Well drained, upland sites that are left undisturbed will tend towards sugar maple, yellow birch, and beech.

Let's imagine that a forest has recently been cleared because of a fire or a clearcut and follow the successional stages (Figure 12). First grasses and other small plants such as fireweed appear. These

are replaced by the low shrubs such as raspberry, rose, and blackberry. Over time, high shrubs such as hobble bush, alder, and pioneer tree or intolerant species like pin cherry, poplar, and serviceberry begin to grow. Under these trees, spruce and red maple grow, followed by tolerant trees like sugar maple, red oak, yellow birch, and eastern hemlock. This last successional stage is called the climax stage.

FIGURE 12. CHANGES IN THE FOREST: SUCCESSION

Examples of various successional stages found in Nova Scotia



Not every forest will follow this exact formula. The succession of trees is largely influenced by the site conditions discussed in the first lesson and the kinds of species present. However, this successional system describes a general natural order of things over time.

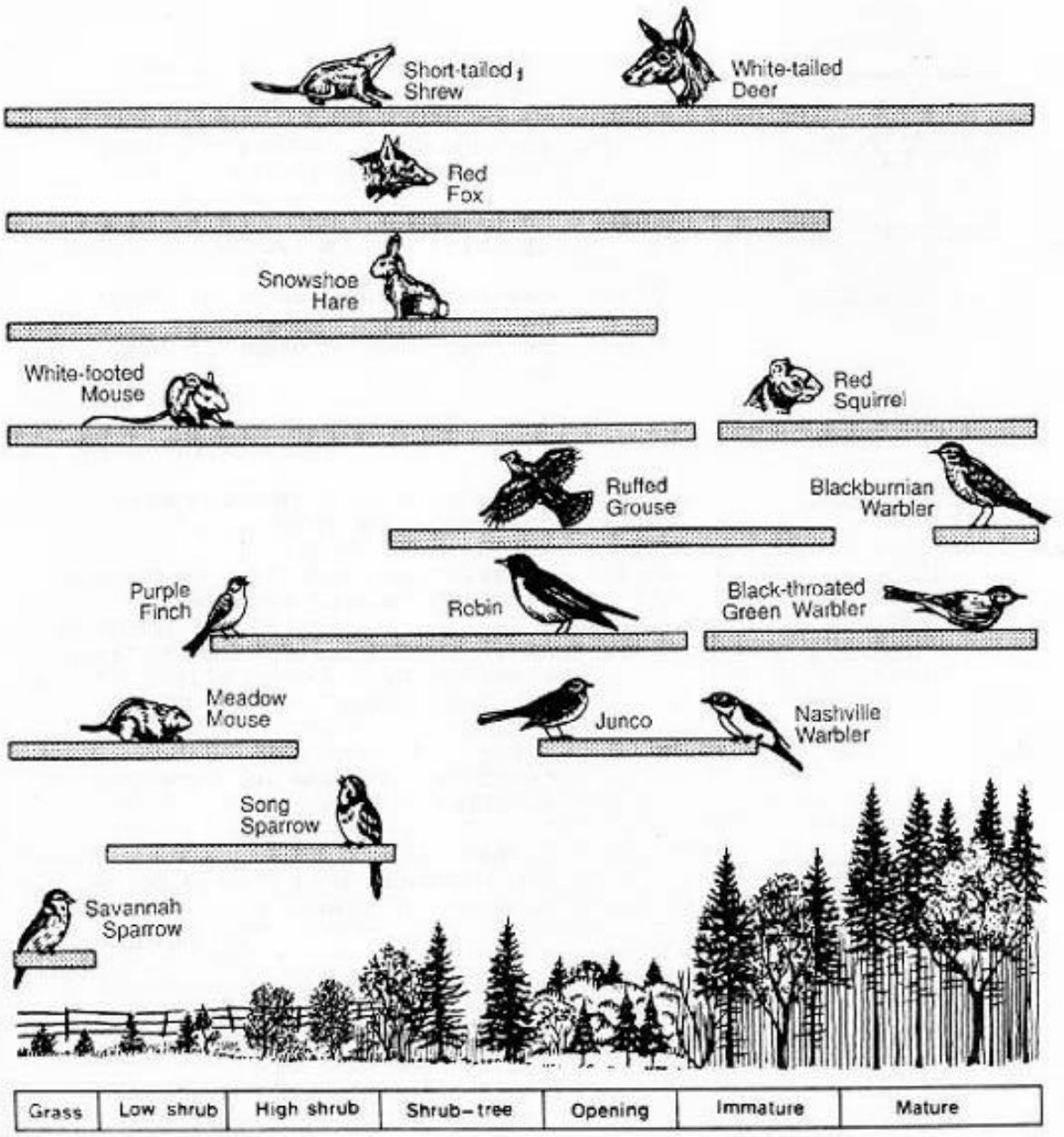
Animals can influence how long a forest stays in a particular stage by constantly eating. The heavy browsing or eating by animals like snowshoe hare, porcupine, and deer can help delay a forest at one successional stage or alter the composition of the surviving species.

Animal populations, as well, constantly change as the woodlot itself changes. The pileated woodpecker lives mainly in older forests where the trees are dying. When there are no dead or decaying trees for the woodpecker to feed from and nest in, it will hopefully find another location. Figure 13 illustrates some wildlife use of the different forest stages in Nova Scotia.

Summary

The form of trees and plants is determined by the genetic characteristics inherited through seed. The growth of the plant or tree depends on how successfully it competes for light, water, and nutrients. Forests are constantly changing and moving through a series of successional stages which dominate the woodlot and influence the kinds of wildlife that will be found in the community. These changes can also be dramatically influenced by the activities of humans which we will look at in the next lesson.

FIGURE 13. WILDLIFE USE OF FOREST STAGES IN NOVA SCOTIA



Bars cover areas where species are normally found.

Lesson Four Quiz

Answer - True and False

1. The feeding roots of a tree extend deep into the ground.

T F

2. The bark of a tree gives it its strength and stiffness.

T F

3. You can tell the age of a tree by the size of its trunk.

T F

4. Leaves turn color in the fall because the green material is removed and stored in the tree branches.

T F

5. Most trees are pollinated by the wind.

T F

6. Beech is a fast growing tree which does not like shade.

T F

7. Animals play an important role in spreading pollen and seeds.

T F

8. About half of the water that is taken up by a tree is used to help the tree grow.

T F

9. Dying and dead trees are used by about one-quarter of Nova Scotia's wildlife.

T F

10. If people did not cut down balsam fir forests that would grow for hundreds of years.

T F

Lesson Five

Human Disturbances and Woodlot Stewardship

Introduction

As we learned in Lesson One, people have been using the forest city for a long time. This lesson examines how some of the effects of disturbances like cutting and clearing. We will also take a look at global ecological changes and how these might affect the Nova Scotia woodlot. As we have already learned, the study of ecology examines how nature and our woodlots are interconnected. The lesson finishes with some ideas on how you can put your new knowledge of ecology to work and become involved in active stewardship of your woodlot.

Human Disturbances

Forestry Operations

The effect of logging in a forest depends on the size and shape of the cut, the method of harvesting, and the forest site. Partial cuts, selection cuts, patch cuts, and clearcuts all affect an ecosystem in different ways. Judging the effect of logging is difficult because it depends on how the forest ecosystem is evaluated. In the past, scientists tend to look at the effect of operations on one wildlife species or another. Now, as the ecological view has become more accepted and understood, scientists are beginning to develop ways of measuring the effects of forest cutting from an ecological perspective.

Forestry operations can have a great impact on water ecosystems within the woodlot. Ruts from machinery can collect water run-off and carry silt down into waterways. Because even very small feeder streams are used by fish as "nurseries", silt or mud can be very damaging if it enters water systems. Small feeder brooks always connect with bigger streams and rivers, and silt is moved along the system from where ever it enters. If machinery crosses wet areas, it can also create silt which will work its way further down the system. Poorly planned and built stream crossings can be a major cause of erosion and siltation of watercourses.

Scientists are currently studying the effects of forest cutting on stream and water flow. Generally, clearcutting temporarily increases the flow of small streams because the trees which normally take up a great deal of water, have been removed.

Most studies on the effect of forestry on water levels have been done in large scale watershed areas. It is more difficult to assess the impact of smaller woodlot operations. One of the most important things to keep in mind when assessing the effect of forestry operations is to look at the size of the cut and the amount of land that has been cut near your woodlot. A small clearcut on your woodlot may not have a large impact, but if adjacent areas have also been cut or are planned for cutting, the impact is greater.

Forestry operations affect wildlife. Cutting can benefit wildlife because it opens up new feeding areas. The operations may be damaging to one species, but helpful to another. For example, a clearcut may be favourable to a red-tailed hawk because it creates an opening for small mammals to live. The hawk will perch in or near the cut to look for prey. A squirrel, however, loses its home in a clearcut and will move to another site. Thus, a kind of succession has taken place; some species move out and others move in. The veery (a bird that lives in older, mature forests) may be replaced by the song sparrow which like low shrubs. Generally, cutting will change the kinds and numbers of wildlife species in an area.

Of course, forest cutting affects nutrient cycles, soil chemistry, and just about every aspect of woodlot ecology as any other disturbance would. Other modules in the Home Study Course will help you understand the effects of forestry operations on your woodlot and make suggestions on how to harvest wood while keeping the ecosystem in mind.

Land Clearing

As we learned earlier, much of our province was once cleared for agriculture. These old fields were subsequently abandoned and have now grown back into about 400,000 hectares 91 million acres) of white spruce. Fortunately, when land is cleared in Nova Scotia much of it will regenerate naturally. Our forests are different from those of the tropics because rain forests are rooted in very poor, shallow and with most of the nutrients are stored in the trees. This occurs because recycling of nutrients happens very quickly in the tropic heat. n contrast, the temperate forests of our region store many nutrients in the soil and therefore it is much easier for our forests to regenerate.

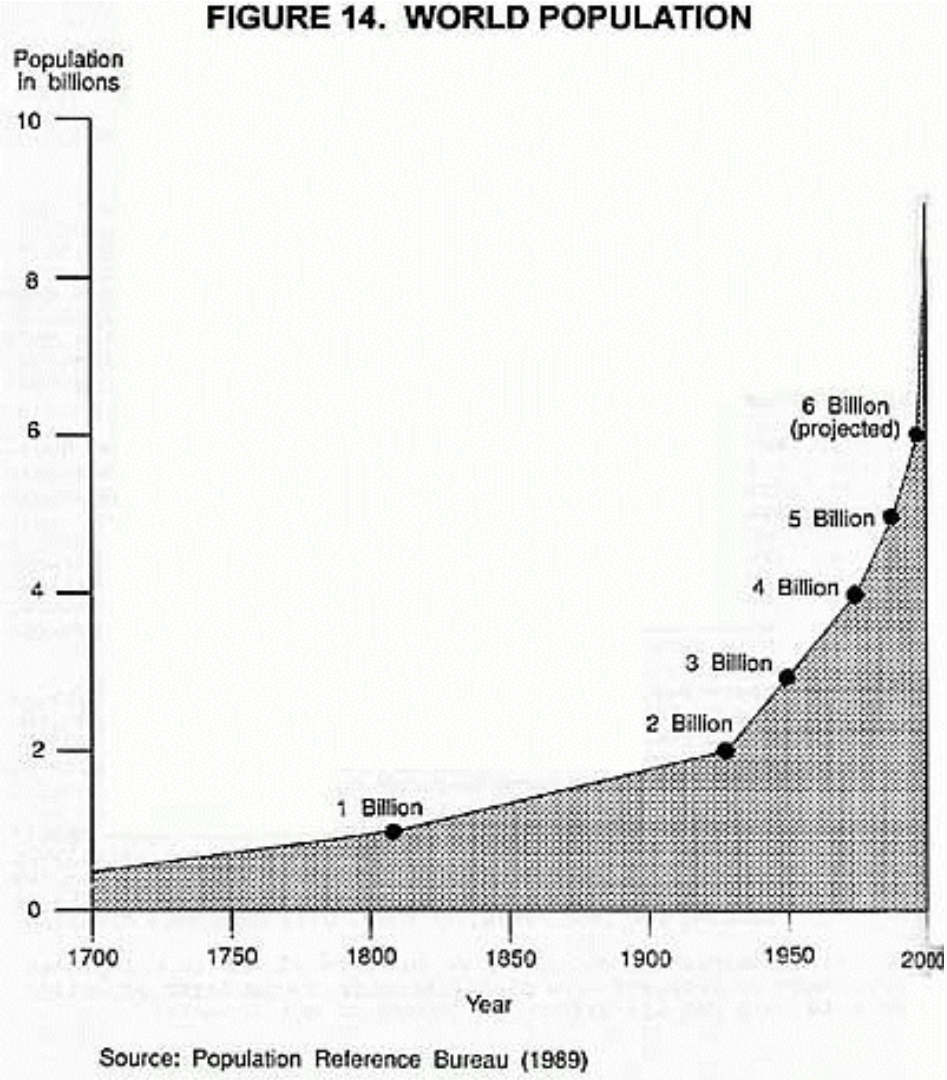
Changes in Global Ecosystems

The advent of space travel was an important step on understanding global ecology. When scientists first studied the earth from space, they realized how interconnected the whole world is. They could see for the first time how the ecology of one area of the world affected another and also see some of the human activity affecting our planet. With these new perspectives, it has become impossible to view ecology on your woodlot without thinking about the bigger picture.

World Population

Many of the changes in our global ecosystem are linked to an increase in the number of people on our planet. The world population is increasing at a rate of about 95 million people each year (Figure 14). Primarily, this means that more and more of the forest resource is being consumed. People use wood to make more than 5,000 products including lumber, paper, furniture, cellophane, moulded plastics, adhesives, and rayon clothing. Over 50 percent of our drugs come from plants and trees.

In many parts of the world, forests provide the basic essentials for shelter and cooking. Woodlot ecology in Nova Scotia can be affected by this ever increasing global population in several ways:



- Forested lands are going to become increasingly important in terms of global ecology and climate. Even the smallest woodlot makes an important contribution to the natural cycles and climate. Many small woodlots put together can have an even bigger impact.

- There may be an increased demand for forest products as the world population increases. At the same time that the world needs more trees to keep it healthy, people will be demanding more tree products. This will put pressure on small woodlot owners to harvest more wood.

- There will be increased need for space for all the people in the world. At this time, Nova Scotia is relatively unpopulated compared to other parts of the world. As the world population swells, more and more people will be looking for land. This, in turn, will mean more clearing.

With increased population, we add more stress to our planet. Environmental problems like global warming, ozone layer depletion, and acid rain can all affect the health of our forests.

Woodlot Stewardship

Stewardship means looking after or managing something so that it has the best possible care and will be in better condition then when you found it. As we said at the beginning of this manual, woodlot owners have an important role to play in the stewardship of our forests. When faced with all of the global and local problems associated with woodlots, you may feel a little overwhelmed and wonder what the best course of action is for you to take. There are several points to always keep in mind:

1. Change is always happening in a woodlot and it is not necessarily bad.

2. Information about many of these topics changes from day to day. It's important to take the best information available and make decisions. One can never be completely sure about a topic as complex as ecology, but we can do our best to understand it.

3. Be observant. By examining the stumps on your woodloot you can learn a lot about the history of your land. By looking at the individual trees you can make judgements about the health of your forest ecosystem. You can monitor the health of the trees in your woodlot by selecting a few individual trees and recording their growth and history. Remember that a year is a hosrt time to a tree, but keeping track of some of the trees in your woodlot from year to year will help you understand how well the cycles of nature are working. If you notice serious changes in the growth of plants and trees, or habits and numbers of wildlife, notify the Department of Natural Resources and perhaps they can help you identify the cause.

4. What you do on your woodlot can make a big difference. Plan your activities carefully. Planting trees, keeping machines and cattle out of streams, and harvesting wood to encourage wildlife are some examples of good stewardship on oyur woodlot.

5. Share the information in this manual with your children. They are the stewards of tomorrow's forests. Tell them about the history of your woodlot and point out interesting plants and animals. If children have contact with nature when they are young, it will help them develop an interest in our forests.

6. Understanding woodlot issues and finding answers is not always easy. Get help if you need it. Government officials, local natural history and wildlife groups all may be able to help you.

With care and management we can keep our forests healthy and use them at the same time. This module has been designed to help you understand the "inner workings" of teh fascinating and intricate forest city you have on your woodlot. With a better understanding of the cycles of nature and the interconnectedness of your woodlot, you can make well informed decisions for you and the inhabitants of your woodlot. Other manuals in this series will give you management options and ideas.

Lesson Five Quiz

Answer - True and False

1. The effect of logging in a forest depends on the size and shape of the cut, the method of harvesting, and the forest site.

T F

2. Small feeder streams are not important to fish.

T F

3. Cutting the forest removes all wildlife habitat.

T F

4. Nova Scotian forests are like tropical rainforests and don't grow back after they are cut.

T F

5. The population of the world is growing by about ten million people a year.

T F

For Further Reading

General Ecology

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Nova Scotia Department of Lands and Forests and the Nova Scotia Museum. 1983. Natural history of Nova Scotia. Government Printers.

Roland, A.E. and Smith, E.C. 1969. The Flora of Nova Scotia. The Nova Scotia Museum.

Single copies of the following are available free at your local Natural resources office or by writing: NSDNR, P.O. Box 68, Truro, Nova Scotia, B2N 5B8.

Trees of Nova Scotia
Notes on Nova Scotia Wildlife
Summer Key to the Woody Plants of Nova Scotia
Identification of Nova Scotia Woody Plants in Winter
Improving Wild Apple Trees for Wildlife
Forest/Wildlife Guidelines and Standards for Nova Scotia

Other modules in the Woodlot Management Home Study Course:

Module 1: Introduction to Silviculture. 1987.
Module 2: Harvesting Systems. 1987.
Module 3: Stand Spacing. 1987.
Module 4: Wildlife and Forestry. 1990.
Module 5: Stand Establishment. 1992.
Module 6: Chainsaw Use and Safety. 1992.

GLOSSARY

ACID RAIN: A pollutant produced when too much sulphur dioxide and nitrogen oxide are released into the air from electrical plants, smelters, other industries, and vehicles. The chemicals fall with rain and affect soil and water health.

AMPHIBIANS: Animals who lay their eggs in water or moist places and have soft skin. Salamanders and frogs are examples of amphibians in Nova Scotia.

BOG: An area of land where water drainage is blocked; they all have cushiony vegetation (mosses), and an accumulation of peat.

BROWSE: To eat the twigs and leaves of woody plants. Deer, moose, and hares are browsers.

CAMBIUM: The layer of tissue between the bark and wood from which new wood and bark develops.

CANOPY: The top of a forest formed by the leaves and branches of the trees. The density of the canopy determines how much light reaches the forest floor.

CARBON CYCLE: One of the essential nutrient cycles. Carbon dioxide is taken from the atmosphere to make food energy and then stored in trees or decayed plant and animal tissue.

CARNIVORES: Animals that eat animals, e.g., trout eat insects, bobcats eat hares.

CAVITY TREES: Living or dead trees with natural or excavated holes or cavities.

CLIMATE: Light, temperature, wind, lightning, carbon dioxide, precipitation combined.

COMMUNITIES: Groups of plants and animals that live together. Soil and climate largely influence how communities are made up.

CONIFEROUS: Trees with cones and needles; softwoods.

DECIDUOUS: Trees with leaves which fall off in the autumn; hardwoods.

DECOMPOSERS: Fungi and animals that break down once living material, producing essential nutrients for new forest.

DIVERSITY: An index of the variety of plants and animals in an ecosystem.

ECOLOGY: The study of living things and their relationship to their environment, home, or community.

ECOSYSTEM: An interrelated and interdependent community of plants and animals and their

habitats.

EDGE: A zone created where two stands, two habitat types, or two successional stages meet.

ENERGY FLOW: How energy moves through an ecosystem. In the forest sun is the main energy source. This energy is converted to green plants which in turn are eaten by animals and decompose to be recycled into nutrients and used again.

FERMENTATION LAYER: The second layer of soil where you will find partially decomposed material.

FOOD CHAIN: "Who eats who" in the ecosystem.

FOOD WEB: The groups of food chains that bind an ecosystem together.

GLOBAL WARMING: Heating of the earth's atmosphere due to CO2 and other gases being released and trapped in the earth's atmosphere.

HABITAT: The place where an animal lives.

HABITAT REQUIREMENTS: Food, water, shelter (cover). and space in the right combinations at the proper time of year.

HERBIVORES: Animals that eat plants, e.g., white-tailed deer eat red maple.

HIGHGRADING: A way to describe harvesting systems which remove only the biggest and best trees.

HORIZON: See soil horizon.

HUMIDITY: The amount of moisture or dampness in the air.

HUMUS: A layer of soil (usually the second layer) made up of decomposed forest litter.

INTOLERANT: Plants and trees which do not grow well under the shade of another tree.

LOAM: A soil type that is made up of near equal amounts of clay, sand, and silt.

MARSH: Wetlands which are dominated by grasses and reeds.

MICROCLIMATE: A different climate within the same area due to slight changes in elevation, soil, etc.

NICHE: The role an animal plays in an ecosystem.

NITROGEN CYCLE: The movement of one of the necessary nutrients in the forest ecosystem. Nitrogen mainly comes from the atmosphere and is "fixed" into a usable form by plants, fungi, and bacteria.

NUTRIENTS: The minerals in the soil and gases in the air which make plant growth possible.

NUTRIENT CYCLING: The way nutrients are moved around and used in an ecosystem.

OMNIVORES: Animals that eat plants and animals, e.g. black bear eat blueberries and grubs.

OZONE LAYER DEPLETION: An environmental problem caused by the release of chemicals called chlorofluorocarbons (CFC's) into the atmosphere which in turn causes the ozone layer to be broken down. The ozone layer protects us from ultra-violet rays of the sun.

PHOTOSYNTHESIS: The process by which the sun's energy is used by plants to create sugar, oxygen, and water.

RADIATION: Reflection of warmth - the sun radiates heat and trees radiate heat back into the air.

REPTILES: Animals with protective shields or scales that lay leathery eggs on land. Snakes and turtles belong to the reptile family.

RESPIRATION: The release of gases (mainly oxygen) when plants and animals breathe.

SILVICULTURE: The science and art of growing and producing forest crops based on a knowledge of tree form and life.

SITE: A particular area with similar conditions or characteristics of vegetation, soil, and climate.

SNAGS: Standing dead trees.

SOL ANALYSIS: A breakdown of the chemical make-up of soil.

SOIL HORIZONS: Distinguishable layers of soil in the ground.

SOIL PROFILE: A list of the different soil layers or horizons.

SOLAR ENERGY: Energy from the sun.

SOLAR RADIATION: See radiation.

SUCCESSION: The natural replacement of one plant community by another over time.

TOLERANT: Plants and trees which can grow under the shade of other trees.

TRANSPIRATION: The release of moisture through the skin of animals or the leaves of plants.

VEGETATIVE REPRODUCTION: The new growth of trees and plants by suckering and sprouting rather than pollination (sexual reproduction).

WATER CYCLE: The way water is moved through the ecosystem.

WEATHERING: The effect of climate on an item. Rocks "weather" to turn into soil.

WILDLIFE: Wild animals including fish, amphibians, reptiles, mammals, and birds.

Answers to Quiz Questions

Lesson 1:	Lesson 2:	Lesson 3:	Lesson 4:	Lesson 5:
1. True	1. True	1. True	1. False	1. True
2. False	2. True	2. False	2. False	2. False
3. False	3. False	3. False	3. False	3. False
4. False	4. False	4. True	4. True	4. False
5. True	5. False	5. True	5. True	5. False
6. True	6. True	6. False	6. False	
7. False	7. True	7. True	7. True	
8. False	8. False	8. True	8. False	
9. False	9. True	9. True	9. True	
10. False	10. True	10. False	10. False	