Alaska's Ecology

REVISION 2018

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The *Alaska Wildlife Curriculum* is a resource for educators teaching today's youth about Alaska's wildlife. We dedicate this curriculum to you and your students.

Alaska's Ecology was revised from the original 1986 unit "Web of Life" of the Alaska Department of Fish and Game's Alaska Wildlife Week series. Alaska's Ecology is from a set of materials called Alaska Wildlife Curriculum. The following materials are currently available:

Alaska's Forests and Wildlife
Alaska's Tundra and Wildlife
Alaska's Wildlife for the Future
Alaska Ecology Cards

Susan Quinlan, Alaska Department of Fish and Game, wrote, illustrated and produced the original Alaska Wildlife Week materials on each of the above topics. Each has been revised.

The Alaska Department of Fish and Game has additional information and materials on wildlife conservation education. We revise the Alaska Wildlife Curriculum periodically. For information, or to provide comments on this book, please contact us:

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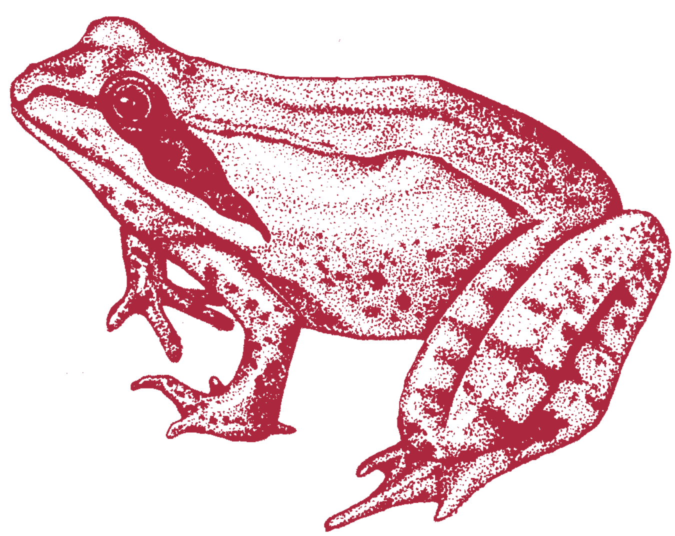
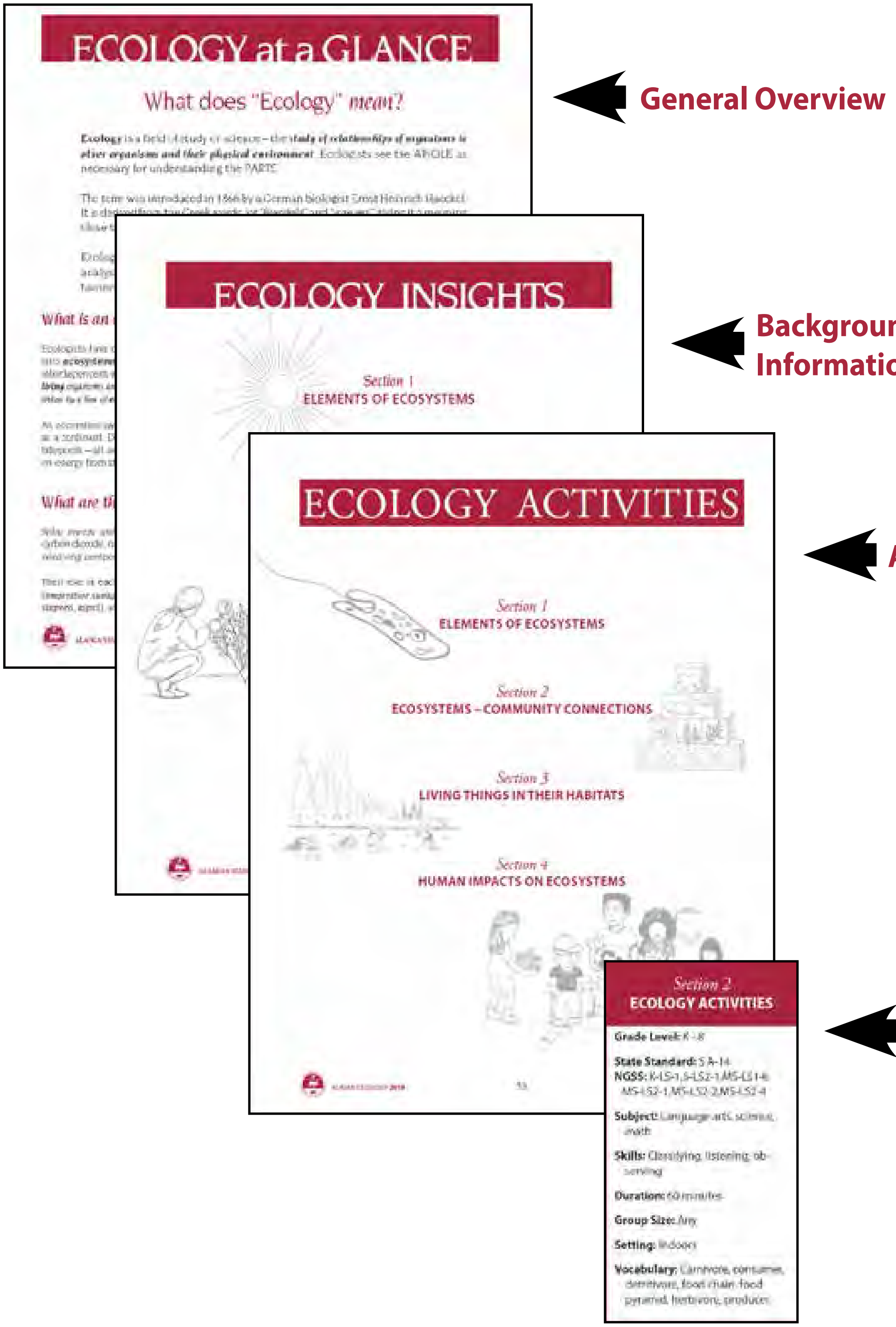


Alaska's Ecology is dedicated to the memory of Val Chabot

Val was the kind of teacher whose enthusiasm for the natural world inspired her students and everyone around her. She motivated students to recognize, celebrate, and take responsibility for their roles in ecosystems. Val edited and improved these teaching materials after she moved to Alaska in 1993.

Val's accidental death in 1994 while banding peregrine falcons in Interior Alaska was a profound loss for education. We hope this booklet and other materials in the Alaska Wildlife Curriculum will inspire and support teachers like Val.

How to use this curriculum



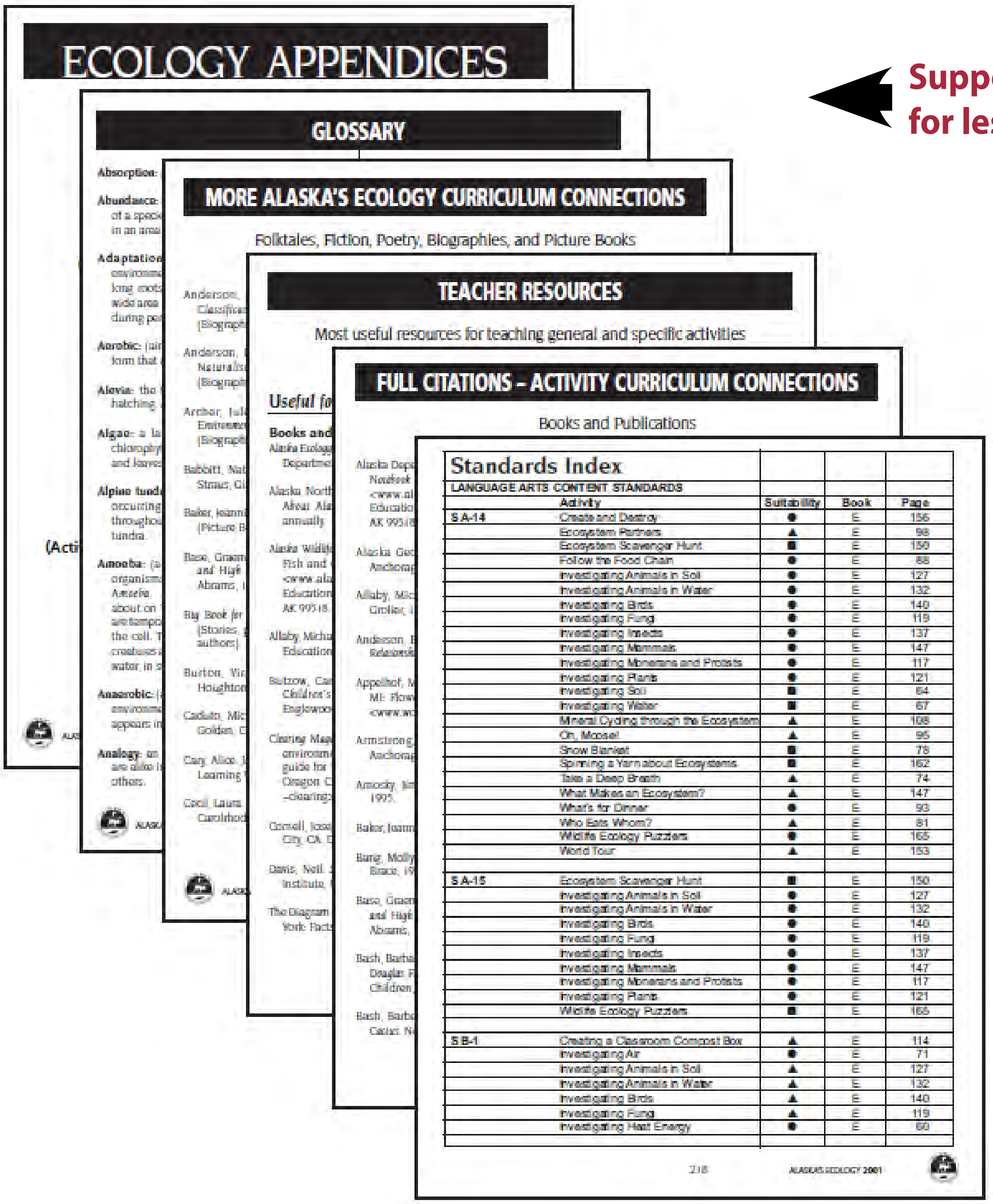
General Overview

Background Information

Activities

Student activity boxes provide a quick planning reference

How to use this curriculum CONTINUED



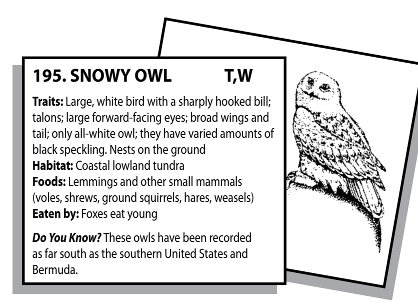
Support materials for lesson planning.

ALASKA ECOLOGY CARDS

Alaska Ecology Cards* – Student-directed learning resources in ready-to-copy sheets applicable to all books in the *Alaska Wildlife Curriculum

Several lessons require or may be improved by use of the Alaska Ecology Cards. *To order, contact the Division of Wildlife Conservation/Wildlife Education.*

For more animal facts, refer to the Alaska Wildlife Notebook Series *available on the Web at* **www.adfg.alaska.gov**



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ECOLOGY at a GLANCE

What does "Ecology" *mean*?

Ecology is a field of study or science – the ***study of relationships of organisms to other organisms and their physical environment***. Ecologists see the WHOLE as necessary for understanding the PARTS.

The term was introduced in 1866 by a German biologist Ernst Heinrich Haeckel. It is derived from the Greek words for "household" and "economy" giving it a meaning close to the *economy of nature*.

Ecology draws on many other sciences including climatology, hydrology, soil analysis, oceanography, physics, chemistry, geology, biology, physiology, taxonomy, and mathematics.

What is an ecosystem?

Ecologists have classified the world's environments into **ecosystems** and each can be studied as an interdependent whole. An ecosystem *is the complex of **living** organisms and their **nonliving** (physical) environment linked by a flow of **energy** and a cycling of materials.*

An ecosystem can be as small as a pond or as large as a continent. Desert, rainforest, tundra, wetlands, tidepools – all are examples of ecosystems. All run on energy from the sun.

What are the nonliving parts?

Solar energy and elements such as water, oxygen, carbon dioxide, nitrogen, and other nutrients are vital nonliving components of every ecosystem.

Their role in each ecosystem is shaped by **climate** (temperature, sunlight, wind, rain), **topography** (elevation, steepness, aspect), and **soil** (composition, depth, permafrost).

What are the living parts?

All nonliving elements determine what living things can survive in each ecosystem.

There are five kingdoms of living things – from microscopic, one-celled organisms (**monerans** and **protists**) to mosses and trees (**fungi** and **plants**) to 80-foot-long whales (**animals**). All five kingdoms exist in Alaska.

How does energy link the system?

Producers (green plants and algae) can make their own food energy from the nonliving environment – solar energy, carbon dioxide, and water – through the process of **photosynthesis**. All other life forms **consume** this energy, either directly or indirectly.

Herbivores (moose, snowshoe hares, some whales, geese) are the next link in a **food chain** as they eat the producers. **Carnivores** (humans, wolves, hawks) eat herbivores and other carnivores. **Omnivores** eat both herbivores and carnivores.

Last in a food chain are **detritivores** or **decomposers**. They obtain their energy by eating waste materials and dead organisms. Detritivores are a critical link in all ecosystems because they return minerals stored in the food chains to the soil for reuse by producers. Without detritivores, producers would soon run out of the minerals they need to make food, and an ecosystem would smother in tons of debris.

Are there other interactions?

Any organism that can get more water, more minerals, more energy, more space, or better shelter than its neighbors will grow better and leave more offspring. **Competition** can occur within and between species.

Opposite of competition is **symbiosis** — when at least one of two organisms cannot survive without the other.

Symbiosis takes three forms: mutualism, commensalism and parasitism. **Mutualism** is a symbiosis where both of the organisms involved benefit by living together. **Commensalism** is a symbiosis in which one of the organisms involved benefits, and one is not affected. **Parasitism** is a symbiosis where one of the organisms (the parasite) benefits, while the other (the host) is harmed.

What impacts ecosystems?

Change comes from three general sources: **physical elements** such as floods, drought, volcanic eruptions, fire, and earthquakes.

Biological catalysts such as population explosions of a species. The most visible example is the spruce bark beetle outbreak that killed white spruce trees in Alaska's forests.

Human-caused change has been accelerating in the past century. We are responsible for changes varying from extinction of species *(the Steller's sea cow in Alaska, for example)* to clearing of forests or filling of wetlands to pollution that spreads through many ecosystems.

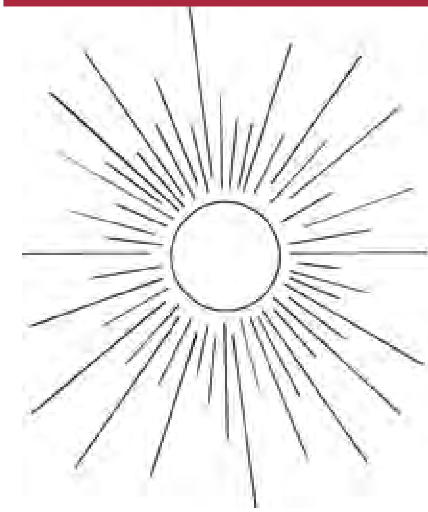
What about the future?

The variety and abundance of living organisms in an ecosystem or habitat – its **biological diversity (biodiversity)** – can provide flexibility to withstand some damage or change. The greatest threat to biodiversity is loss of habitat.

Because all living things are inter-connected within their ecosystem, impact has a radiating effect. Removing a species or a habitat shakes the whole web of life.

We are still learning about all the interactions in ecosystems. Our decisions and actions regarding wildlife and habitat today may have consequences tomorrow that we do not currently understand.

ECOLOGY INSIGHTS



Section 1

ELEMENTS OF ECOSYSTEMS

Section 2

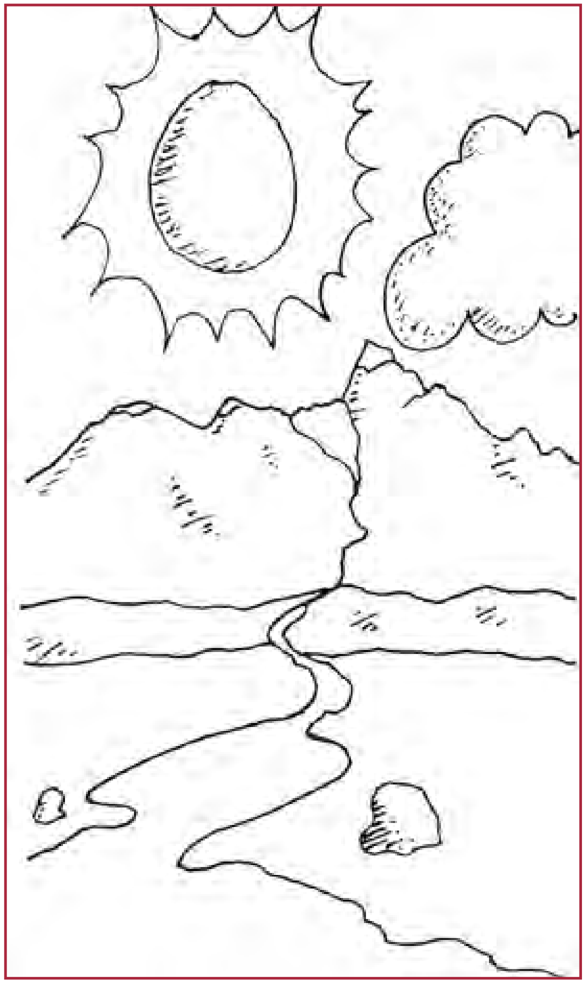
ECOSYSTEMS - COMMUNITY CONNECTIONS

Section 3

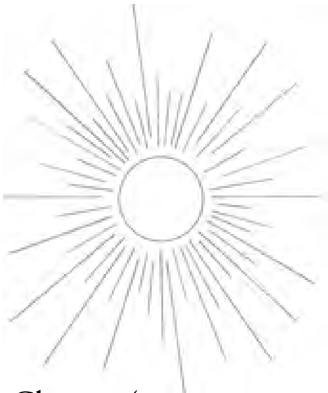
LIVING THINGS IN THEIR HABITATS

Section 4

HUMAN IMPACTS ON ECOSYSTEMS



NON-LIVING THINGS + LIVING THINGS + ECOSYSTEMS



Elements of ECOSYSTEMS

Section 1
ECOSYSTEM INSIGHTS

Sun's Energy
Alaska's Landscape poster:
Nonliving+Living
  Things=Ecosystem
Nonliving Elements
  Climate & Ecosystems Snowy
  Blanket Topography
  Soil
Living Things – 5 Kingdoms
  Monerans
  Protists
  Fungi
  Plants
  Animals (Invertebrate)
  Animals (Vertebrate)
Energy Exchange

Climate (temperature, sunlight, wind, rain), topography (elevation, steepness, aspect), and soil (composition, depth, permafrost) are the major nonliving elements that shape ecosystems for all living things and the energy exchange that links them.

Imagine a landscape devoid of living things. In a way, a lunar landscape, but with familiar landmarks. That is the canvas for painting an ecosystem – the complex of living organisms and their physical environment. These living and nonliving elements are linked by a flow of energy and a cycling of materials.

An ecosystem can be as small as a pond or as large as a continent. Prairie, rainforest, tundra, wetlands, coral reef – all are examples of ecosystems. All run on energy from the sun.

SUN'S ENERGY - ESSENTIAL FOR LIFE

Energy from the sun heats the surface of the earth to temperatures where life can exist. Both the amount of energy that reaches the surface and the duration of time the energy is present determine the **temperature**. The tilt of the earth's axis changes both of these factors on a daily and seasonal basis. This sets the stage for world **climate** differences, a major determinant of whether our local ecosystem is tundra, trees, or desert.

CLIMATE & ECOSYSTEMS

The sun's energy not only warms the environment to a degree where life can occur, but is a key ingredient in **photosynthesis** (food production from light energy, water, and carbon dioxide). This food production serves as the foundation for all life.

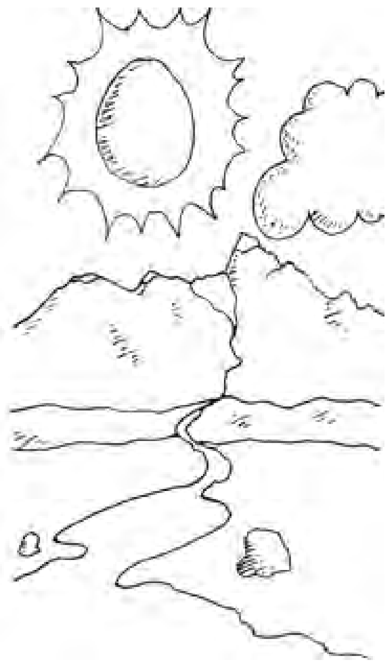
Photosynthesis Process. Plants and fungi absorb photons of sunlight from dawn to dusk. The energy contained in the photons is used by the cells to restructure chemical bonds and manufacture food sugars from mineral nutrients and water from the soil and carbon dioxide from the air.

Winter Dormancy. Plants cannot photosynthesize at temperatures below 19.4°F (-7°C). Other metabolic processes such as respiration also do not occur at temperatures much below this point. When cold temperatures and meager sunlight halt photosynthesis, growth stops and plants become dormant.

Summer Growth Surge. When temperature and sunlight allows, Alaska's plants grow more rapidly in order to complete their cycle in the short time available. Scientists studying white spruce in Alaska and Massachusetts found that the Alaska trees produced the same number of a certain cell, but in half as much time.

Comparative Study. Ironically, when scientists moved Alaskan trees to the Lower 48, they grew very slowly. In order to make them grow as fast as they do in Alaska, the length of daylight has to be increased to match Alaska summers.

ALASKA'S LANDSCAPE ICE AND FIRE



Glaciers and volcanoes have played major roles in shaping Alaska's landscape. About 100,000 glaciers still exist in Alaska, covering about 29,000 square miles or 5 percent of the state. Active volcanoes number more than 80.

Superlatives. Alaska's 365 million acres encompass about 34,000 miles of marine coastline, more than 3 million lakes, 39 mountain ranges (including North America's tallest mountain at 20,320 feet), places with more than 200 inches of precipitation annually, and places receiving as little as 5 to 7 inches of total precipitation.

Extremes. Alaska spans the latitudes of 51˚13' to 71˚23' north. The state experiences temperatures ranging from the 30s to 90s during the summer to the 50s to minus 70s during the winter. Daily sunlight varies from several months of total darkness to several months of total daylight above the Arctic Circle.

Permafrost Enhances Precipitation. Areas of **permafrost** *(perennially frozen ground)* which underlie a majority of Alaska keep water on or near the surface. Water seems abundant because snowmelt and rain cannot drain away. Because of that, even though **precipitation** in Arctic and Interior Alaska is similar to that of deserts, it is enough to support plant growth.

Rainy Coast. By contrast, Southeast and Southcentral Alaska's coastal lands are awash in rainfall. There is no permafrost. The rain makes the area prone to erosion if vegetation is stripped from the steep slopes.

ALASKA'S SNOWY BLANKET

Precipitation in Alaska comes from snow as well as rain. Snow affects the ecosystem in several ways.

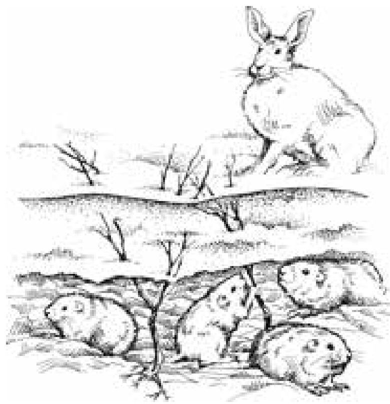
1. **Extends Darkness.** Deep snow cover significantly reduces the amount of sunlight reaching buried plants, extending the period of darkness and reducing the time available for photosynthesis. *(See adaptation fact sheets in Alaska's Tundra & Wildlife,* INSIGHTS *Section 3.*)

2. **Protects or Scours.** In many wind-blown areas, snow helps to shape vegetation patterns. Under its protective drifts, more plants can survive and thrive. On exposed ridges, wind-blown snow acts as an abrasive to scour away all but the most hardiest or smallest plants.

3. **Retains Earth's Heat.** Snow has great insulating qualities that help life survive in severe environments. Snow is a good insulator because air is trapped in between snow crystals. The trapped air, a poor conductor of heat energy, insulates the ground from winter temperatures

When snow falls in autumn it covers soil that has stored heat energy over the summer. Without additional input of radiant energy from the sun, the ground cools gradually, but **uncompacted** snow acts as an insulating blanket and traps some of the heat given up by the ground. As a result, the ground stays warmer than winter air, remaining close to 32°F (0°C) – as long as there is a sufficient covering of snow. The ground cools, or gives up heat energy relatively slowly as winter progresses.

Life Under Snow. Some animals are **subnivean** and remain active under the snow. Voles, shrews, and lemmings burrow under the snow and dig paths between feeding and resting sites. Ptarmigan and grouse fold their wings and dive into loose snow for protection from cold and predators.



Some dormant insects rely on the insulating properties of snow to protect them from cold and wind. Insect eggs, cocoons and adults find shelter under vegetation and in the soil.

TOPOGRAPHY & ECOSYSTEMS

Sea Level to Mt. McKinley. Since Alaska rises from sea level to the highest mountain on the continent, the topography of the land plays an important role in shaping the pattern of our weather and our ecosystems. Mountain ranges block rain systems, make their own weather and winds, or concentrate rainfall.

Drainage or Pooling? Steep slopes drain moisture quickly and hamper soil development, limiting what can grow there. Low-lying areas or flats may be underlain by permafrost, creating boggy soils that limit plant growth by drowning their roots. Plant growth on dry sites are different from those on wet sites.

Look for a Sunny Slope. The **aspect** or compass direction of a slope determines exposure to sunshine or wind, how soon the soil warms in spring, and if snow will be scoured away or lay as a protective blanket. Plant communities on north-facing slopes have different members from those on south-facing slopes.

SOIL & ECOSYSTEMS

Alaska's Young Soils. Recent glaciation over much of Alaska left behind coarsely crushed rock and fine rock flour devoid of organic material. These **young soils** lack variety and depth.

Other Plants Prepare a Base. Plants need a foundation for their roots. Trees especially depend on many years of other plant growth and accumulation of plant debris to form the **organic soils** that will support their growth.

Permafrost's Chilling Effect. Permafrost is most common in areas with a mean annual soil temperature below 27°F (-3°C). Locally, on south facing slopes or in areas of good drainage, no permafrost may exist.

Roots Need to Breathe. Soil depth and standing water affect a plant's ability to "breathe." Cells in leaves and the branches absorb **oxygen** from the air, but the cells in the roots must absorb oxygen from the soil. Trees literally drown if their roots become waterlogged. Even in arid environments like the Interior, trees and other plants can become waterlogged because permafrost does not permit water to drain away from their roots.

Cold Creates Treeless Muskeg Soils. Cold temperatures slow the growth and decay of plant materials and that slows the development of organic soils. If dead plants accumulate faster than they can be decomposed, an acidic basin called a **muskeg** forms. Muskeg soils, often found within boreal forests, are notoriously poor environments for most tree and plant growth.

Bacteria Make Nutritious Soil. Plants must also have **nitrogen** in order to grow. Most of the nitrogen on earth is in the air, but plants are only able to use nitrogen that is in the soil. Without the soil's nitrogen provided by microscopic bacteria called "nitrogen- fixers," plants could not survive.

LIVING THINGS – 5 KINGDOMS

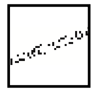
To the various nonliving environments we now add a cast of living things. Living things can move in response to their surroundings they grow and they reproduce. The presence or absence of certain nonliving things dictates which living creatures will survive in a certain area.

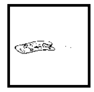
Stars are Easier to Count. It is said that scientists have a better understanding of how many stars are in our galaxy than how many species are on Earth. Estimates range from two million to 100 million. New species are still being discovered.

Hey, You! Only 1.4 million species have been named. Only a small fraction of the insects, fish, and non-animal species have been scientifically described and cataloged.

Naming Things. The Swedish naturalist, Carolus Linnaeus, was the first person to devise a method of naming living things. Linnaeus used two categories or **kingdoms** to classify all living things: **Plants** and **Animals**. His system has been modified many times, evolving along with the expanding knowledge of biologists.

More Kingdoms. While scientists are still debating about how to classify some organisms, they now agree on the following five classifications of living things:


Monerans (one-celled organisms such as blue-green algae and bacteria)


Protists (one-celled organisms including algae and protozoans)


Fungi (such as mushrooms and lichens)


Plants


Animals

The following fact sheets explain the characteristics of each kingdom and highlight some of its members found in Alaska.

1 AND 2 – MONERANS AND PROTISTS

Small but mighty

Monerans and protists create soil and clean up forest debris. Until recently, these microscopic living things were considered to be small versions of plants and animals. But the more scientists learned about them, the less they seemed to fit in either category.

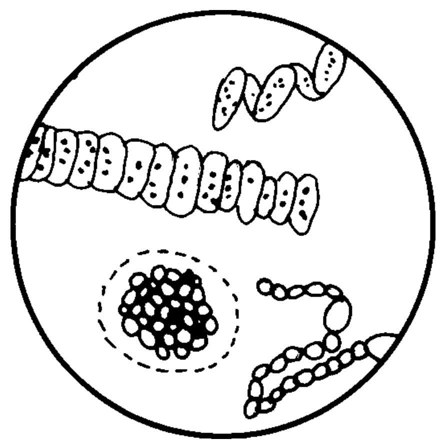
Given Their Own Kingdoms. Some not only make their own food, like plants, but also move around and catch and eat other living things. Additionally, their cell structure is quite different from those of either plants or animals.

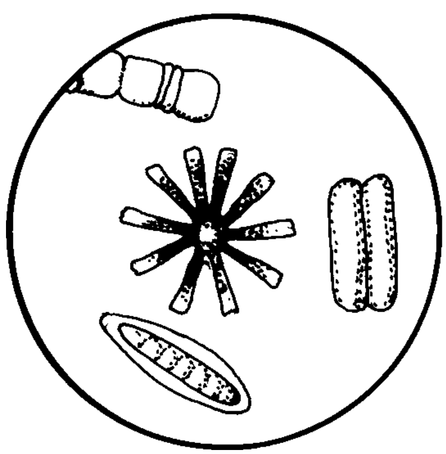
MONERANS, the smallest microscopic organisms, do not have nuclei in their cells. **Bacteria** and **cyanobacteria** (or **blue-green algae**) are examples of monerans. *A million monerans would fit on the head of pin.*

PROTISTS are larger microscopic organisms that have cell nuclei. These include **algae**, **paramecia**, **amoebas**, and many others. *Some protists live together in large groups that can be seen without a microscope,* but the individual organisms are microscopic.

All Ecological Roles. Some monerans and protists are **producers**. Like plants, they are able to photosynthesize *(to make food from air, water, and sunlight)* and are food for very small animals. Others are **herbivores** or **carnivores**.

Unsung Heroes. The majority, however, are **detritivores**, especially monerans. Some are "nitrogen-fixers," taking nitrogen from the air and converting it to a form usable by plants. These unsung heroes recycle waste and dead things. Their recycling allows life to continue.





Microscopic organisms are abundant and important in all ecosystems, including forests. The majority are detritivores that replenish the soil with recycled nutrients.

3 – FUNGI

An out of body phenomenon

Fungi are by far the most prolific of all the **detritivores** in our forests because they are adapted to acidic soils. Mushrooms, shelf fungi, and less noticeable molds, mildews, and rots are some examples.

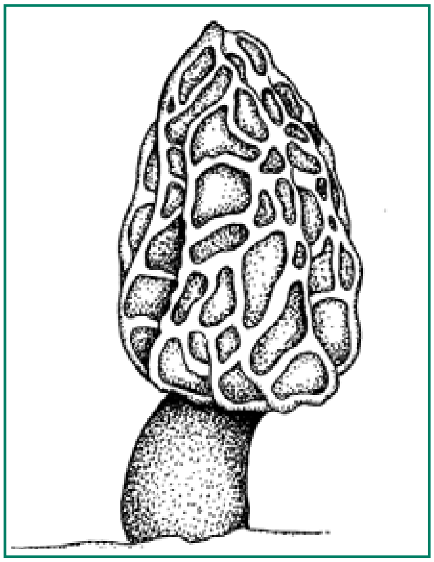
Fungi are similar to plants in that they are immobile. In fact, scientists used to consider them to be plants. But fungi are very different from plants in cell structure and in the ways they live, so scientists now place them in a separate kingdom of living things.

More Than Meets the Eye. Usually, we see only the fruiting, or reproductive part of a fungus *(a mushroom, for example).* Its main body is hidden from view. The body of a fungus is made up of **hyphae**, microscopic hair-like structures that reach out through the wood, soil, leaf litter, roots, or other material on which the fungus is growing. A handful of forest soil may contain over two miles of fungal hyphae!

Unusual Way of Eating. Fungi use their hyphae and digest their food outside their bodies! The cells of fungal hyphae give off digestive enzymes like those found in our own stomachs. These enzymes break down wood, leaves, and other material. Then the fungal hyphae absorb the scattered sugars and minerals and use them to grow.

Trading Minerals for Sugars. Some fungi form symbiotic associations with plants and help them obtain needed minerals *(nitrogen, potassium, phosphorus)* from the soil in exchange for the sugars the plant produces. More than 90% of the plants in Alaska, including all our trees and berry-producing plants, could not grow without these mycorrhizal fungi.

Mutual Symbiosis. Lichens, one of the most visible fungi in forests, are actually a partnership between a fungus and alga or cyanobacteria. The fungus provides the structural protection, and the alga produces the food.



Mushrooms are the fruiting, or reproductive parts of certain fungi. Tiny hair-like structures, called hyphae, are the main body of many fungi.

Lichens are the most visible fungi in forest ecosystems.

4 – PLANTS

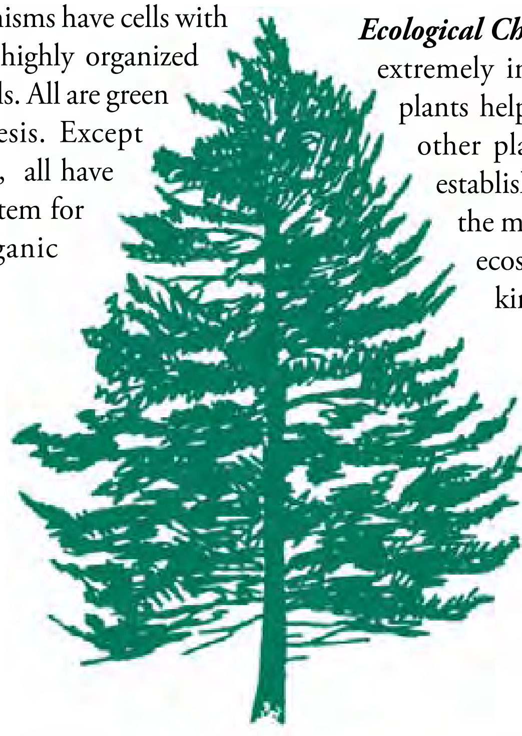
From small to tall

Trees are the dominant plants in forest ecosystems. Nevertheless, the texture of the forest is rich with many other plants as well. This kingdom includes small to tall – mosses, liverworts, ferns, and horsetails to spruce and birch trees.

Green Producers. These organisms have cells with nuclei and a cell wall and a highly organized arrangement of their many cells. All are green and capable of photosynthesis. Except for the mosses and liverworts, all have leaves, roots, stems, and a system for transporting water and organic materials among the cells.

Help Accepted. All plants live a stationary life. Many rely on wind, insects, birds, and some mammals to pollinate their flowers or to help carry their seeds to new areas. Plants can live for a remarkably long time. Some bristlecone pines are more than 4,000 years old.

Ecological Champions. Plants are extremely important ecologically. (1) **Pioneer** plants help to create the organic soils that all other plants need before they can become established in a new location. (2) They are the major **producers** *(of food)* in terrestrial ecosystems. Without them, the animal kingdom would not survive.



5A – ANIMALS (Invertebrates)

Mind-boggling multitudes

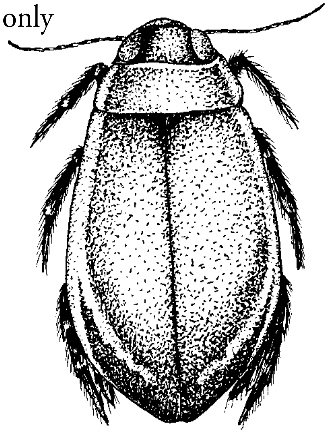
Invertebrates animals are multicellular organisms that lack a backbone or spinal column. They make up the majority of the animal kingdom, both in number of species and in populations.

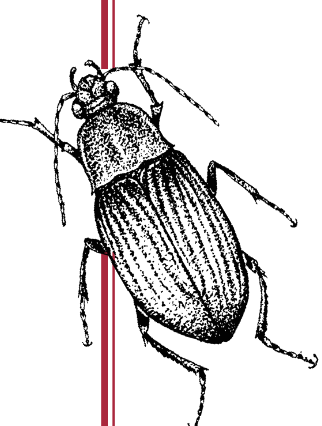
Like other animals, invertebrates obtain energy and minerals by eating other living things – plants, fungi, or other animals. They are **consumers**. Many also function as **detritivores**, helping to recycle the minerals and nutrients in dead organic material.

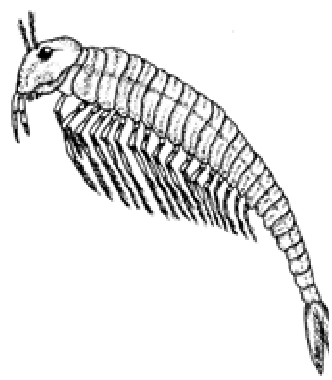
Need External Warmth. Invertebrates need external warmth to function. Forest invertebrates are only active during the warmer months which in the boreal forest is limited to a few summer months. Even then, despite their numbers, few humans notice them.

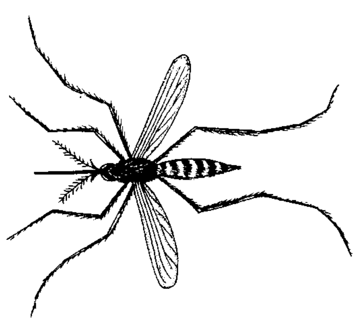
Mosquitoes and Other Buzzing. Arthropods *(spiders, centipedes, millipedes, and insects)* are the most conspicuous. Flying insects include butterflies, bumblebees, moths, ichneumonid wasps, crane flies, and midges. Mosquitoes, blackflies, and other biting flies can occur in great abundance.

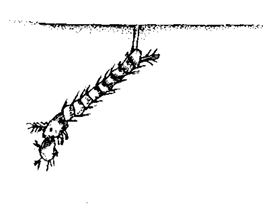
Look Under Bark, Logs. Forest invertebrates also include segmented worms, snails, and slugs. Sawflies, aphids, bark beetles, carrion beetles, and ground beetles are among the insects that live on plants or in the leaf litter. *For a more complete list and illustrations, see the Alaska Ecology Cards.*

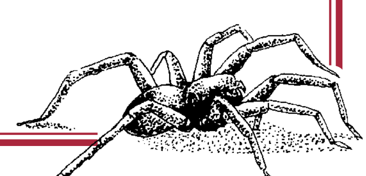






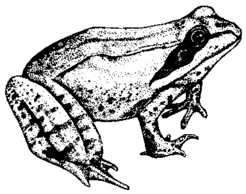


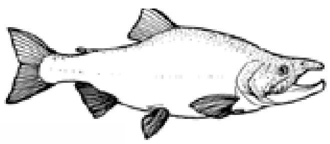


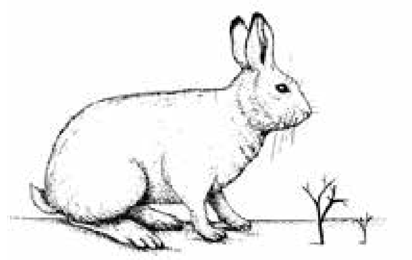


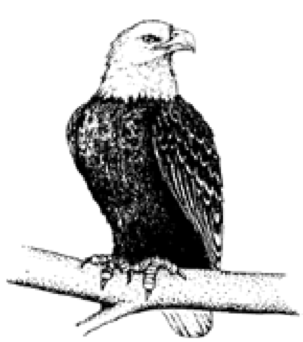
5B – ANIMALS (Vertebrates)

Frogs, Bats, Hummingbirds – in Alaska!









Vertebrate animals are multicellular organisms with a backbone or spinal column. Alaska's forest vertebrate animals include humans and other mammals, birds, fishes, and all five of the state's amphibians *(wood frog, spotted frog, western or boreal toad, long-toed salamander, and rough-skinned newt).*

Reptiles are the only major group of vertebrate animals absent from Alaska and its forest ecosystems.

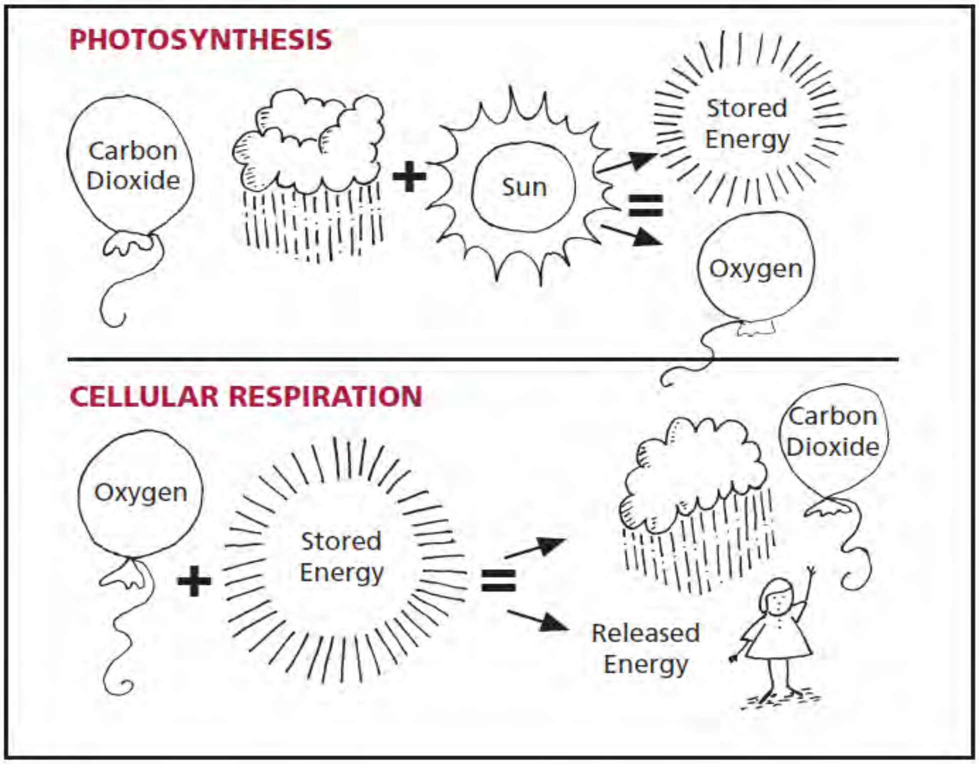
No Producers, Only Consumers. All animals obtain energy and minerals by eating other living things – plants, fungi, or other animals. They are mainly **herbivores** and **carnivores**. Vertebrate animals can move about and actively search for food.

Fishy Habitat. Lakes and rivers in forested areas are prime habitat for Alaska's fishes including lake trout, whitefish, and the salmon species that hatch in the clear, cool waters and then migrate to the ocean before returning to spawn.

Stick Nests and Plenty to Eat. Bald eagles feast on those fish and nest in the huge trees. Forest birds are abundant and varied, including the northern goshawk, at least five species of owls, three species of grouse, the rufous hummingbird, and woodpeckers and other songbirds that eat insects or seeds.

Forests Fit Many. Red squirrels, flying squirrels, snowshoe hares, porcupines, coyotes, wolves, black bear, Sitka black-tailed deer, moose, marten, mink, and river otters are forest animals. Little brown bats also live here. *For a more complete list and illustrations, see the Alaska Ecology Cards.*

ECOLOGY FACTS - ENERGY EXCHANGE



Energy and its exchange are the glue that hold living and nonliving things together in an ecosystem.

Energy (the capacity to move or do work) is present in various forms in both living things and their nonliving surroundings. Examples include sunlight, heat, electricity (both static and lightning), wind, and motion. Energy is also stored in the bonds between atoms in molecules.

TAKE A DEEP BREATH

We breathe in oxygen because our cells need oxygen to release the energy stored in food. This process is called cellular respiration. It is similar to the process of combustion in which oxygen combines with fuel to release heat (as in the burning of candle wax) or explosive force (as in gasoline engines).

Cellular Respiration:
Oxygen + stored energy (sugars) =
Carbon dioxide + water + released energy

Photosynthesis:
Carbon dioxide + water + sunlight =
Stored energy (sugars) + oxygen

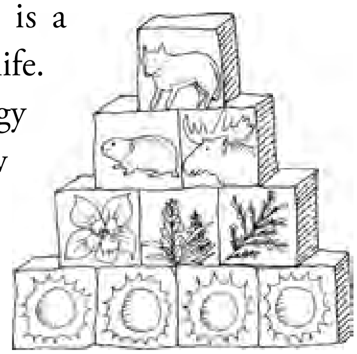
The living cells of plants and animals combine some types of digested food with oxygen to produce energy and carbon dioxide.

Photosynthesis is, in some ways, a reversal of the process of respiration. In photosynthesis, energy (from sunlight) combines with carbon dioxide to make stored energy and oxygen.

Will We Run Out of Oxygen? Since almost all living cells use oxygen from the air, it might seem possible that growing populations of respiring organisms would eventually consume all the oxygen in our atmosphere. Fortunately, the photosynthesizing aquatic plankton and terrestrial plants resupply much of the oxygen in the earth's atmosphere.

ECOSYSTEMS – Community Connections

Where the next meal comes from is a constant priority in any organism's life. The following pages trace how energy is transferred in ecosystems and how materials are recycled. (*Recycling in ecosystems is not just an option, but is critical to continued survival.*)



Section 2
ECOSYSTEM INSIGHTS

FOOD WEBS – *WHO EATS WHOM?*

[*See the "5 Living Kingdoms" fact sheets in* INSIGHTS, *Section 1, and the Alaska Ecology Cards for species illustrations*]

Producers. A plant is exquisitely equipped to convert the nonliving — air, water, minerals, and sunlight — into food for itself and others through **photosynthesis**. Plants and algae that make food from nonliving materials are called **producers**.

Consumers. All other living things in an ecosystem depend on food manufactured by producers. Called **consumers**, they use a process called **cellular respiration** to convert the carbohydrates, fats and proteins found in plants or other animals into another form of energy that their cells can use (see INSIGHTS Section 1: "Energy"). organisms that eat dead or decaying material).

Consumers are divided into four groups:

- **Herbivores** (organisms that eat plants)
- **Carnivores** (animals that eat other animals)
- **Omnivores** (animals that eat both animals and plants)
- **Detritivores**(organisms that eat dead or decaying material)

The pathway of **energy** and **minerals** from the nonliving environment, through producers, to consumers, and back again through detritivores creates a **food chain**. All the food chains of an ecosystem are connected into a **food web** – the energy circulatory system of that ecosystem.

Energy. At each intersection in the web, some energy is returned to the nonliving environment as heat. That energy is not passed on and cannot be reused by living things. The lost energy is replaced during photosynthesis by the capture of energy from the sun.

Minerals. Minerals are always passed along at each web intersection until the detritivores return them to the environment in their original form. The producers can use them again to make new food.

PRODUCERS CONVERT RAW MATERIALS

Using the process of **photosynthesis**, producers combine energy from sunlight with carbon dioxide from the air and minerals from water, soil, and rocks to produce the sugars and oxygen that help all other living things survive. They are the first living link in all food chains.

Plants are the main producers in forest and tundra ecosystems, while algae (including seaweeds) are the main producers in ocean ecosystems. Both plants and algae are important in wetlands. Some monerans are also producers.

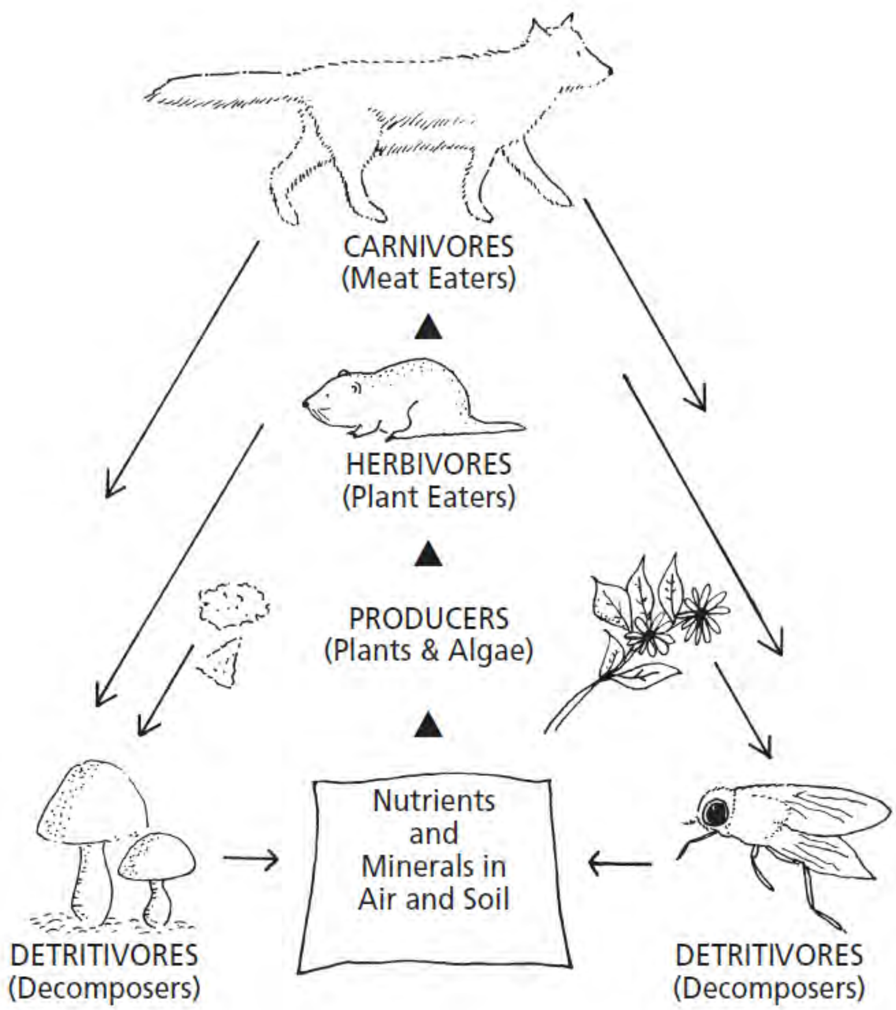
HERBIVORES EAT PRODUCERS

Herbivores are the next link in the food chain and come in all sizes. Moose, deer, and snowshoe hares receive all their nutrition from the stems, bark and leaves of plants. Caribou survive harsh winters by eating lichens. Red squirrels and pine grosbeaks prefer seeds.

Yet, these "common" wildlife examples are overwhelmed in number by the smallest herbivores – the millions of leaf-eating, wood-drilling, sap-sucking, twig-boring insects and other often overlooked invertebrates.

Each herbivore is adapted to eat specific kinds of plants and cannot live in an ecosystem or area where those plants are absent.

FOOD WEB

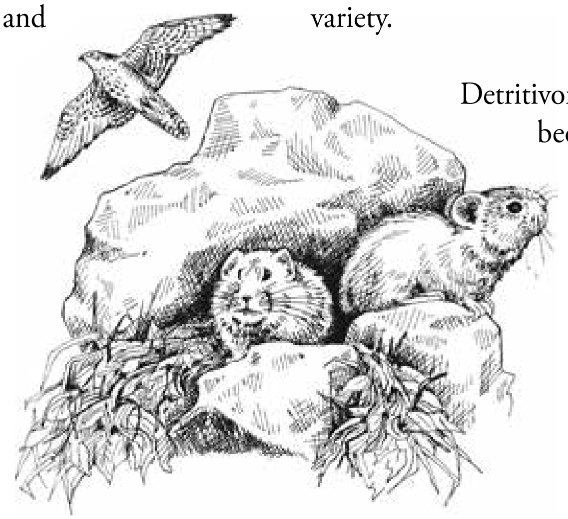


CARNIVORES EAT HERBIVORES – AND EACH OTHER

In the next link in the food chain, the plant-eating herbivores become food for carnivores (flesh-eaters).Owls, spiders, centipedes, woodpeckers, foxes, and wolves are examples of carnivores. Another name for carnivore is predator, one that kills and eats other living things.

Carnivores do not limit themselves to dining on herbivores. All will eat each other if the opportunity arises. This represents a second carnivore link on longer food chains.

Carnivores cannot survive without adequate populations of prey. So the numbers and kinds of herbivores in an ecosystem help to determine the presence and abundance of carnivores.



OPPORTUNISTIC OMNIVORES

Food in an ecosystem can be scarce, especially for big eaters. Therefore, consumers that eat a variety of foods have a better chance of survival.

Bears are good examples. They eat roots, grasses, herbs, and berries as well as small and large mammals, insects, fish, and carrion. With an omnivorous diet, bears are well-adapted to food is available.

Chickadees and many other birds eat plant seeds as well as insects. Waterfowl young gain their initial growth from aquatic insects before turning to marsh vegetation later in the summer.

Mosquitoes are infamous for their abundance in Alaska. Both male and female mosquitoes sip plant nectar as herbivores, but the female is omnivorous. She needs a blood meal from a warm-blooded animal to produce the eggs she will lay on the surface of any nearby water.

DETRITIVORES REUSE AND RECYCLE

Last in a food chain – but certainly far from "least" – are detritivores, or decomposers. They obtain their energy by eating waste materials and dead organisms. They overshadow all other consumers in both number and variety.

Detritivores are a critical link in all ecosystems because they return all the minerals stored in the food chains to the soil for reuse by producers. Without detritivores, producers would soon run out of the minerals they need to make food, and an ecosystem would smother in tons of debris.

Bald eagles, crabs, ravens and other large creatures that **scavenge** dead animals are detritivores because they eat dead flesh. But the most important detritivores are tiny, extremely numerous – and ignored. These include animals that live in the soil, slime molds, many **fungi**, and hundreds of thousands of **microscopic organisms**.

(*For more information about the Five Living Kingdoms including Fungi, Protista, and Monera, Plants, and Animals see* INSIGHTS *Section 1, Elements of Ecosystems.*)

Animal detritivores eat more plants than moose! In one square mile of boreal forest, the mass of detritivores equals the body weight of 43 moose.

ECOLOGY FACTS - ALASKAN FOOD CHAINS AND WEBS

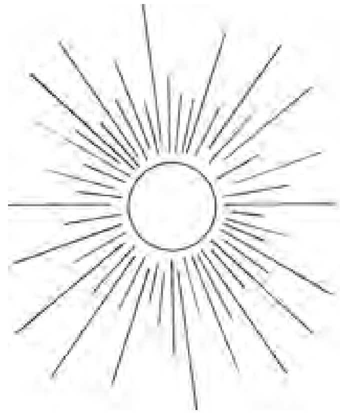
Six food chain examples for forest, tundra, wetland, and ocean are shown in bold letters. Make food webs by using the other foods of each living thing (listed in small letters below its name) to find other interconnections.

	Producer	Herbivore	Carnivore 1	Carnivore 2	Detritivore
Forest	1. White Spruce	**Red Squirrel** Berries, mushrooms	**Marten** Voles, bird eggs		**Mushroom** Any dead plant
	2. Willow	**Snowshoe Hare** Birch, grass, fireweed	**Lynx** Voles, squirrels		**Raven** Any dead animal
	3. Grass Seed	**Red-backed Vole** Berries, fireweed	**Boreal Owl** Flycatcher, woodpecker		**Fly** Any dead animal
	4. Lingonberry	**Pine Grosbeak** Spruce and birch seeds	**Goshawk** Squirrel, flycatcher, woodpecker		**Bacteria** Any dead thing
	5. Fireweed	**Moth** Flies, beetles	**Alder Flycatcher**	**Merlin** Pine grosbeak	**Beetle** Any dead animal
	6. White Birch	**Bark Beetles** Spruce	**Downy Woodpecker** Moth, berries		**Shelf Fungus** Any dead wood
Tundra	1. Lichen	**Caribou** Dryas, willow, sedge	**Brown Bear** Sedge, grass, blueberry		**Bacteria** Any dead thing
	2. Dryas	**Dall Sheep** Willow, sunflower, sedge	**Wolf** Caribou, marmot		**Raven** Any dead animal
	3. Willow	**Redpoll** Willow, sunflower, sedge	**Arctic Fox** Singing vole, any dead animal		**Flies** Any dead animal
	4. Grass	**Singing Vole** Sedge, sunflower, dryas	**Short-tailed Weasel** Redpoll		**Springtail** Any dead wood
	5. Sunflower	**Butterfly** Blueberry, mountain avens	**Golden Plover** Flies, springtail, blueberry	**Jaeger** Redpoll, vole	**Bacteria** Any dead thing
	6. Sedge	**Marmot** Grass, sunflower	**Wolverine** Fox, any dead animal		**Mushroom** Any dead plant
	7. Blueberry	**Willow Ptarmigan** Willow, sedge	**Golden Eagle** Marmot, weasel, sheep (lamb only)		**Fly** Dead producers, protozoans
Wetland	1. Algae	**Water Fleas** Dead plants, protozoans	**Stickleback** Midge, rotifer	**Common Loon** Frog	**Bacteria** Any dead thing
	2. Pondweed	**Pintail** Algae, seeds of sedges	**Peregrine Falcon** Phalarope		**Rotifer** Dead producers, protozoans
	3. Algae	**Midge** Algae, dead plants	**Wood Frog** Flies, mosquitoes	**Sandhill Crane** Stickleback, sedges	**Water Flea** Any dead producer, rotifer
	4. Sedges	**Muskrat** Pondweed	**Mink** Stickleback, phalarope		**Bacteria** Any dead thing
	5. Willow	**Moose** Willow, sedge	**Wolf** Muskrat, pintail		**Flies** Any dead animal
	6. Algae	**Mosquito Larvae** Protozoans	**Red Phalarope** Midge, water flea, rotifer	**Parasitic Jaeger**	**Protozoans** Any dead material, algae
Ocean	1. Green Algae	**Sea Urchin** Kelp	**Sea Otter** Crab, sculpin, sea star		**Tanner Crab** Any dead animal
	2. Kelp	**Snails** Green algae	**Sea Star** Sea urchin, sea cucumber, shrimp		**Flatfish** Dead animals, snails, fish
	3. Diatom (algae)	**Amphipod** Other algae, kelp	**Sculpin** Shrimp, sand lance	**Sea Anemone** Sand lance, snails	**Shrimp** Any dead material
	4. Sea Grass	**Brant** Green algae	**Bald Eagle** Herring, guillemot, dead animals		**Marine Worm** Any dead plant, algae
	5. Brown Algae	**Copepods** Other algae, sea grass	**Sand Lance** Amphipod, euphausids	**Pigeon Guillemot** Sculpin, herring	**Sea Cucumber** Any dead thing
	6. Red Algae	**Euphausids** Other algae, diatoms	**Herring** Copepods, sand lance	**Harbor Seal** Sand lance, flatfish	**Gull** Any dead animal

ECOLOGY FACTS - TRACK THE ENERGY

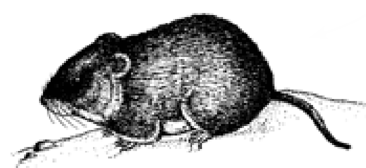
When living things consume food, they consume **energy** as well as mass. All living things use energy to move, respond to the environment, reproduce, grow, and keep warm. As a result, less energy is available to pass on at every link in a **food chain**.

WHO EATS WHOM?

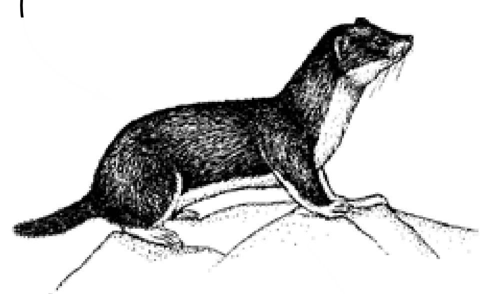


Producer. Through photosynthesis *(water, carbon dioxide, and **energy from the sun**),* a spruce tree feeds itself and produces seeds in cones.

Herbivore. A vole eats fallen spruce cone seeds containing 1000 calories of energy. Although the vole uses most of this energy for moving about and for staying warm, some of the energy goes through the vole's digestive system as waste, and the rest (*about 10% of the original 1000 calories, or 100 calories*) is stored in the vole's tissues, ready to be passed on to the next consumer in the food chain.



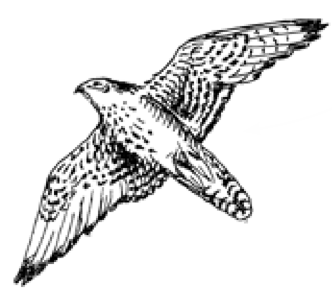
Carnivore. Suppose that the next consumer is a weasel who eats the vole. The 100 calories (*10% of the original 1000 calories*) from the spruce seeds stored in the vole's body are passed to the weasel. The weasel uses those calories to move, reproduce, and stay warm. Some calories from the vole are excreted as waste, and the rest (10% of the 100 calories) is stored in the weasel.



Second Carnivore. A hawk catches and eats the weasel. Only 10 of the original calories remain to used by the hawk. *Less energy is available to pass on at every link of a food chain. As a result, carnivores are less numerous than herbivores, and food chains rarely have more than four links.*

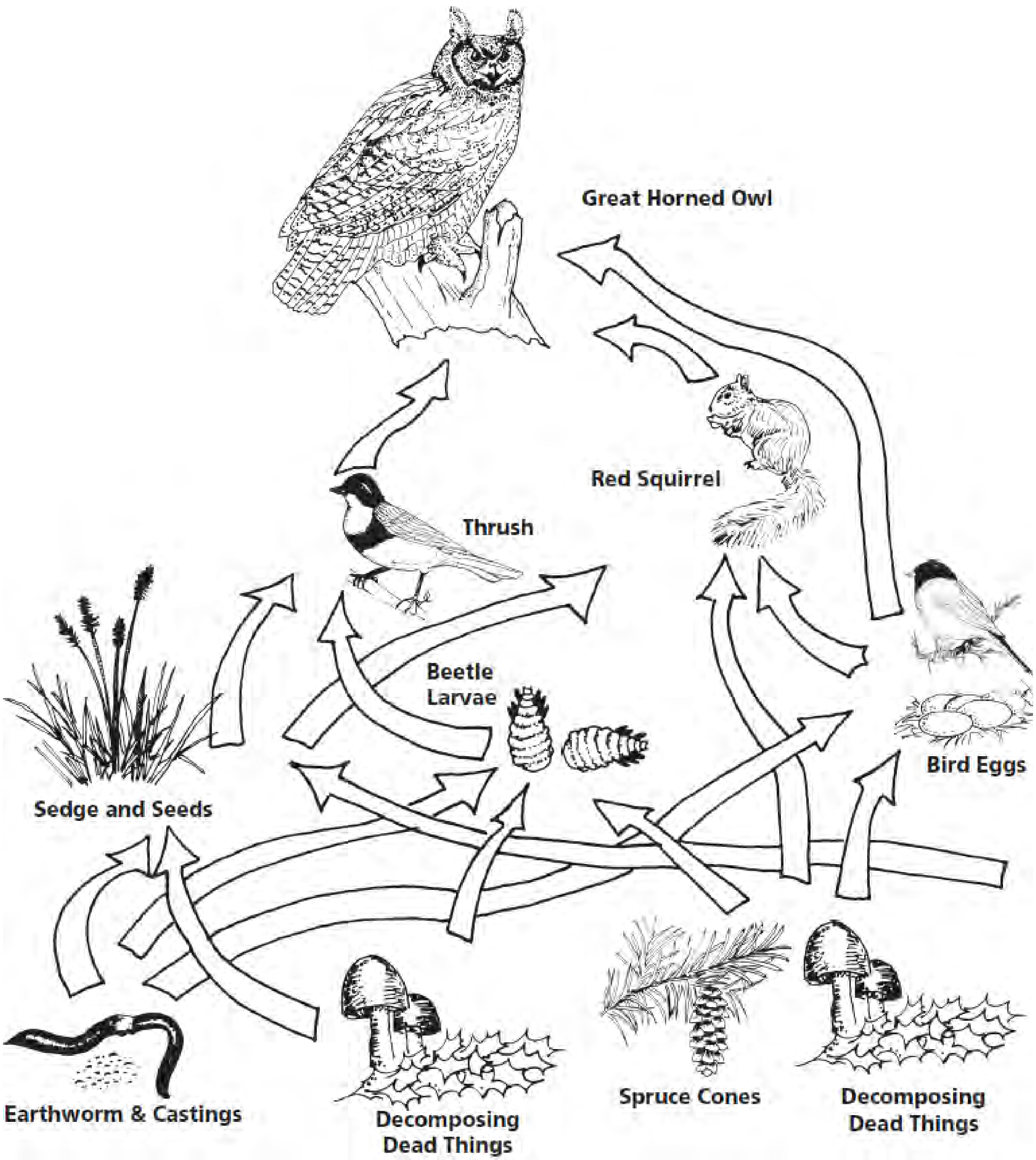
Detritivores. When the hawk dies, the 1 calorie of original energy that remained is used as the detritivores break down the body. They return only the minerals to the ecosystem.

Thanks to the Sun, new energy is on its way!



Producers (Again!). Green plants, algae, and some **monerans** will change the sun's energy and minerals from the nonliving surroundings into forms other living things can use.

ECOLOGY FACTS - ALASKA GREAT HORNED OWL FOOD WEB



Alaska's great horned owl is a nocturnal predator in woodlands that might be seen at dawn and dusk. The illustration traces one of its food webs. Evidence of the owl's diet can be found by examining a pellet of bones and feathers coughed up after a night of hunting. (*See the activity "Follow a Food Chain" in Section 2.*)

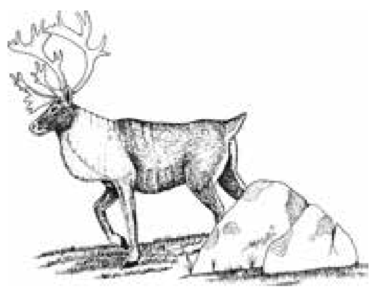
GROWTH HAS LIMITS

The size of each ecosystem's "web" is limited. Limiting factors control the number and variety of plants, animals, and other organisms that can live in an ecosystem. Limiting factors include climatic elements, disease, and competition for scarce resources (food, water, shelter, or space).

Domino-Effect in Arctic

In the Arctic, the entire tundra ecosystem is limited by the length of the growing season, the extreme low temperatures, and the lack of liquid water. As a result of the long, cold winter in which light and warmth are scarce, plants can only photosynthesize and grow three to four months each year.

Detritivores are **dormant** during the winter in the Arctic as well. Therefore, mineral recycling is very slow, impoverishing the soil and limiting the rate and size of plant growth.



In turn, reduced plant growth limits the number and length of food chains. Arctic animals such as the caribou must migrate great distances to obtain enough food and not deplete an area's resources.

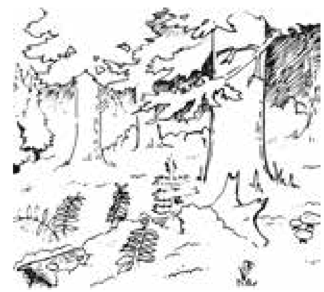
Tropical Plenty?

One might assume that a warmer, wetter climate with more daylight hours in winter months would produce a limitless ecosystem. A tropical rainforest, in contrast to the arctic tundra, does have more variety and abundance of plants and animals. Yet even a tropical rainforest is limited by its physical environment.

In areas of very high rainfall, precipitation leaches minerals from the soil's surface making them unavailable for plants. Although dead material rots and returns to the soil quickly in tropical climates, the recycled mineral nutrients are taken up immediately by the roots of existing rainforest canopy trees, shrubs, and vines. These plants monopolize the mineral nutrients, leaving little available for new growth.

Thus, both rainforests and arctic tundra are examples of ecosystems that are limited because something is unavailable – in this case, enough minerals in the soil.

COMPETITION IS A CONTEST



Competition over scarce resources, one of the limiting factors, is another thread of ecosystem community interactions. Any organism that can get more water, more minerals, more energy, more space, or better shelter than its neighbors will grow better and leave more offspring. The competition can occur within and between species.

For example, plants compete with each other for water, soil minerals, and access to sunlight. Tall trees shade any young trees trying to grow below. Seedlings of cottonwood and alder trees cannot survive in the shade of spruce trees. Hemlock seedlings, however, are shade-tolerant and can grow in a dark spruce forest.

Thick-billed murres, a cliff-nesting seabird, compete among each other for the most secure and sheltered nesting sites. Bull moose, caribou, and fur seals compete with males of the same species for the chance to breed with the females.

SYMBIOSIS – LIVING TOGETHER

Opposite of competition is symbiosis — when at least one of two organisms cannot survive without the other.

Symbiosis takes three forms: mutualism, commensalism and parasitism. Mutualism is a symbiosis where both of the organisms involved benefit by living together. Commensalism is a symbiosis in which one of the organisms involved benefits, and one is not affected. **Parasitism** is a symbiosis where one of the organisms (the parasite) benefits, while the other (the host) is harmed.

Predation might, at first look, be considered a form or parasitism, or vice versa. But parasites, in contrast to predators, are usually much smaller than their hosts, and generally harm rather than kill their hosts. Also, in parasitic relationships, the parasite must live either on, or in its host.

The following are examples of symbiotic relationships that can be found in Alaska's ecosystems. ***See also the activity "Ecosystem Partners" in Section 2 for more examples illustrated on cards***.

Examples of Mutualism – the friendly symbiosis

- Many plants need to exchange pollen to create seeds. Wind carries some pollen, but many plants depend on animals to perform this task. These plants produce colorful or sweet-smelling flowers and nectar (a sugary liquid) that attracts bees, butterflies, moths, and hummingbirds. While sipping the nectar, these animals get a dusting of pollen which they then carry to other flowers.

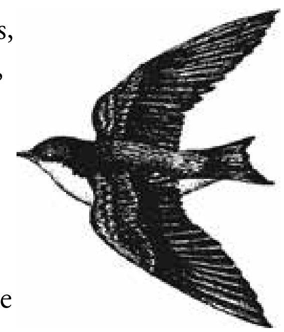
- Blueberry, dogwood, raspberry, and cranberry plants produce edible berries that animals eat for the berries' fleshy outer coats. The hard-coated seeds inside pass through the herbivore's digestive tract intact and are deposited in a new area – with a bit of fertilizer. Some seeds do not germinate readily unless passed through an animal's digestive tract.

- Spruce and birch trees, blueberry, cranberry (and perhaps 80 percent of all plants) depend on mycorrhizal fungi to give them needed minerals from the soil in exchange for sharing some of the sugars the plants produce. The fungi (the underground hyphae of mushrooms) live in or on the roots of the plants.

- Lichens are the ultimate examples of mutualism. Two separate living things, a fungus and a **cyanobacterium** (formally called blue-green algae), join forces. The fungus provides the structure and ability to retain water; the alga photosynthesizes food. By living together they can grow in harsh environments where neither could live alone.

Examples of Commensalism – no harm done

- Some plants enlist animals to carry their seeds without aiding the animal. These plants produce seeds with small hooks or awns that catch in animal fur. In this way they get a free ride to a new area.



- In Alaska's forests tree swallows, American kestrels, buffleheads, golden eyes, boreal and saw-whet owls, and flying squirrels nest in dead trees. These animals cannot dig their own nest holes. Instead, they have to find holes already made by some other living thing – especially woodpeckers.

- The woodpeckers dig new nesting and roosting holes for themselves each year. But not just any dead tree will work. Woodpeckers can only excavate a hole if the wood is partly decayed or rotted. Thus woodpeckers depend on fungi that rot and decay wood.

- Most fungi can only eat dead wood. So these fungi rely on other organisms to kill the trees. They depend on insects that parasitize and kill trees, microscopic organisms that cause tree diseases, and large animals (beavers or porcupines) that kill trees as they gather food.

Examples of Parasitism – a win/lose situation

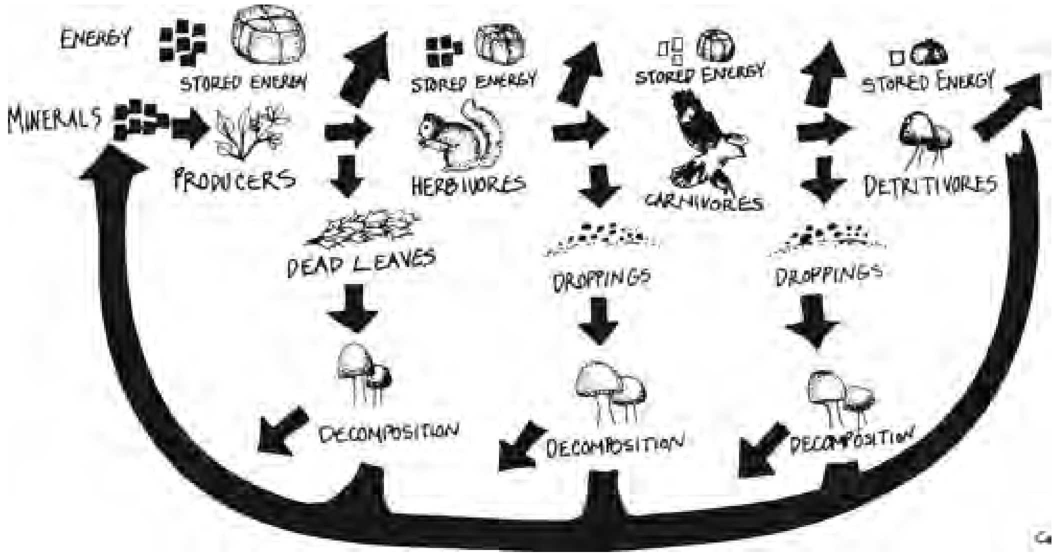
- A fungus (the parasite) lands on a tree (the host) and penetrates the bark. The hyphae of the fungus spread up and down from their entry point. As they grow, the hyphae break down and digest the tree trunk. The tree fights back by walling off the sections invaded by the parasite. The tree resists the fungal invasion and survives for many years, but eventually some fungi kill the tree.

- Warble flies need a host to carry their eggs. They lay them on caribou hair. The larvae burrow under the animal's skin and then feed on its tissues. The following spring, they emerge, drop off and develop into adult warble flies on the ground. The warble fly larvae derive food and shelter from the caribou, and the caribou are harmed by loss of tissue and the open sores caused by the larvae emerging through their skin.

- Botflies are another parasite living on caribou. These insects inject their larvae into the nasal passages of the caribou. The larvae develop into pupae in the throat of the caribou and are coughed out in spring. After a few weeks, they develop into adult botflies and begin the cycle again.

An ecosystem is more than a place and its inhabitants. What defines an ecosystem are all the invisible strands connecting the living organisms and their nonliving surroundings. Break a strand and the whole web shakes.

ECOLOGY FACTS - MINERAL CYCLING THROUGH THE ECOSYSTEM



Living things need **energy** to survive, but energy alone is not enough. All living things need nonliving **minerals** – element such as iron or carbon. Minerals are limited in supply but can be reused.

Let's look at (1) how minerals occur in nature, (2) how they are taken up and used by living things, and (3) how they **cycle** through the ecosystem.

(1) Natural Forms. Minerals occur as **solid** substances in rocks and soil, as **liquids** (such as water), as **solutions** dissolved in water, and as **gases** in the atmosphere (*such as* **carbon dioxide** *or* **nitrogen**). Minerals can either exist as a single element (*such as nitrogen or carbon*) or as a **compound**, which is a mixture of elements (*such as water or carbon dioxide*).

> **Amazingly, 99% of all living matter is made of only 6 elements in different combinations.** These six elements are carbon, hydrogen, nitrogen, oxygen, phosphorus and sulfur. Combinations of these elements make up the three most important elements on earth: water, air, and soil.

(2) Pathways. Important minerals occur in soil, water, or air but the form must be just right for use by each organism. For example, most organisms need oxygen for **cellular respiration**. Fish can absorb through their gills the oxygen dissolved in water. Humans cannot. Mammals, birds, plants, and fungi need oxygen as it occurs in air. The usable form determines the path from the nonliving environment through living things.

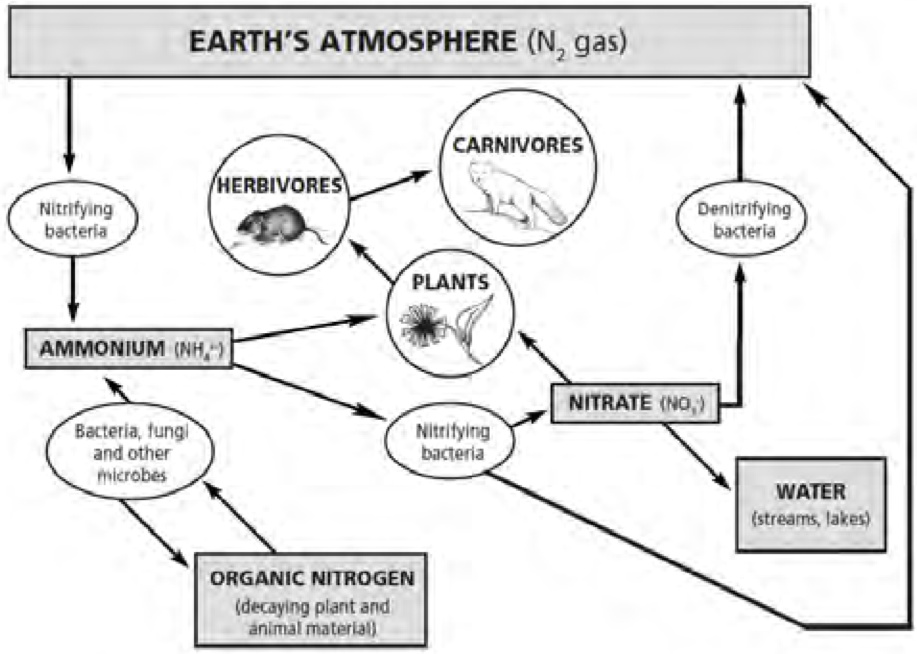
(3) Cycling. Pathways vary, but minerals cycle through food webs repeatedly. Minerals taken from the nonliving environment by living things (typically plants or **producers**) may pass through **herbivores** to **carnivores**, but eventually they are returned to the nonliving environment by **detritivores**. Then another producer can use it to start a new cycle.

IMPORTANCE

If the cycle were somehow interrupted, the supply of usable minerals would soon be used up and new living things couldn't survive. We see an example in the rainforest after it is cleared. The land is fertile for agriculture for several years and then no crop will grow. The big trees that held most of the minerals are no longer replenishing the forest and rain leaches remaining minerals out of reach.

(*See the activity "Mineral Cycling through the Ecosystem" in Section 2.*)

ECOLOGY FACTS - THE NITROGEN CYCLE



Nitrogen is an essential nutrient of most living organisms. It is an important component of amino acids – the building block of proteins. Proteins make up enzymes, which are important for chemical reactions. Therefore, most organisms require nitrogen for every day activities. Unfortunately, available nitrogen is in short supply in most ecosystems. Nitrogen in fact, is a limiting factor, especially in Alaska's boreal forest.

Much of the nitrogen on earth is in the atmosphere in the form of gas. Seventy-eight percent of earth's atmosphere is nitrogen gas (N2). However, very few organisms are able to use nitrogen in this gaseous form. Rather, animals absorb nitrogen when they eat plant material, and plants absorb nitrogen from the soil through their roots. Nitrogen in the soil comes mainly from microorganisms, which absorb nitrogen when they decompose animal waste, animal carcasses and dead plant material.

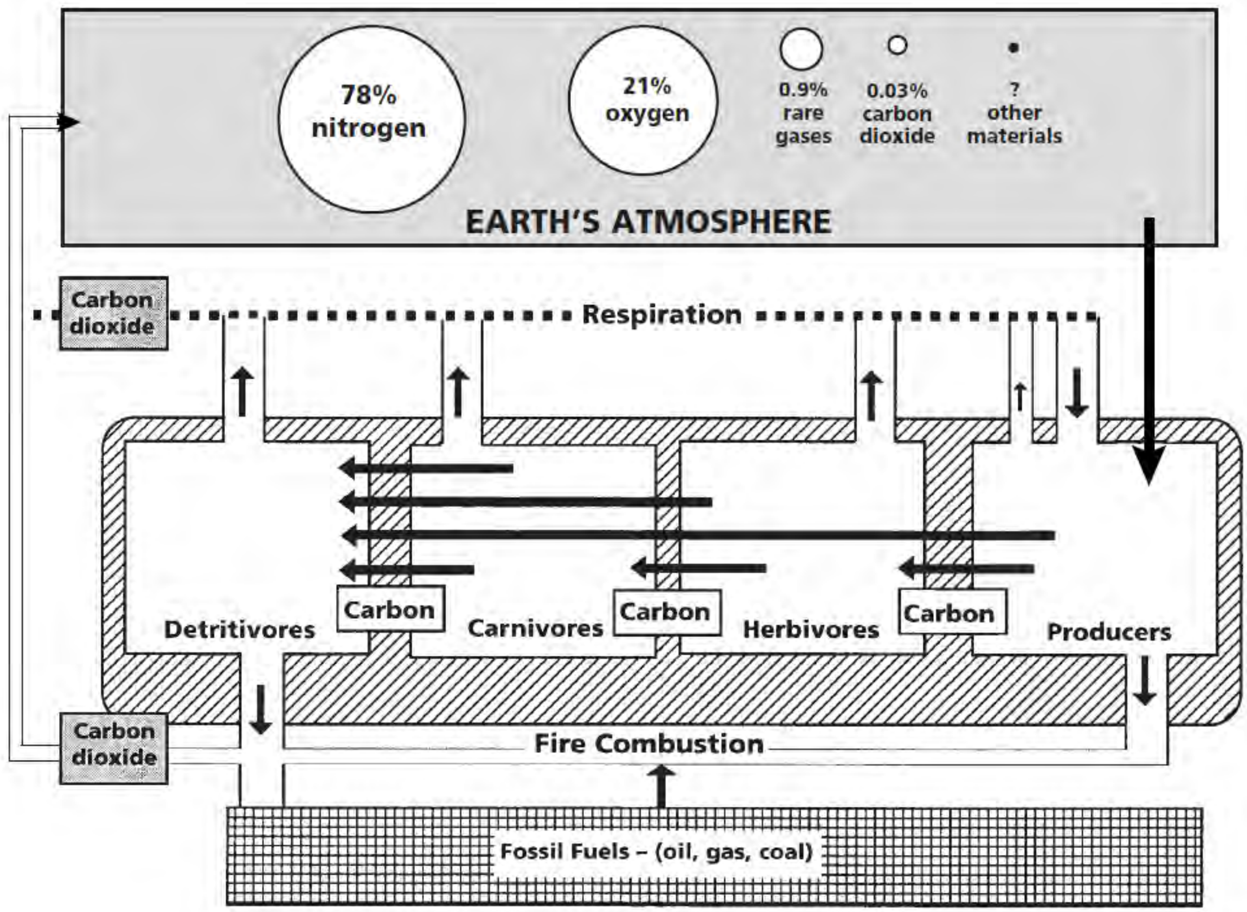
Unlike these microorganisms, plants cannot make use of the organic nitrogen in decaying material. Plants instead rely on decomposing microorganisms such as bacteria and fungi to convert nitrogen from the organic form to a mineral form that can be taken up by the roots – ammonium (NH4+). The microbes take what ammonium they need for themselves. Remaining ammonium is used by the plants.

A different group of bacteria called nitrifiers converts ammonium into nitrate (NO3-) – the other form of mineral nitrogen plants can use. This process is called nitrification. Nitrate is also the most common source of fertilizer nitrogen that farmers use on their crops. Unfortunately, nitrate dissolves easily in water, and thus is often leached away from the ecosystem as soon as precipitation occurs. During nitrification, some nitrogen gas also escapes to the atmosphere.
In some soils, a third group of bacteria called denitrifiers will convert nitrate to nitrogen gas in the process of denitrification. This process allows nitrogen to be returned to the atmosphere. Dentrification is also a source of N2O, which is a very potent "greenhouse" gas (a gas that traps heat in the atmosphere and causes global warming).

So how does nitrogen get from the atmosphere to the soil? In the process of biological nitrogen fixation, some bacteria, called nitrogen-fixing bacteria, are actually able to convert atmospheric nitrogen gas into ammonium, but this process requires very large amounts of energy. Therefore, the bacteria often team up with a plant. The plant supplies energy to the bacteria, in exchange for nitrogen from the atmosphere. Plants having a mutualistic arrangement with nitrogen-fixing bacteria include all members of the pea family, alders, some members of the rose family, and a few other shrubs.

Humans have also figured out how to convert nitrogen gas into ammonium and nitrate for fertilizer. Once again the process is very energy intensive, requiring the use of fossil fuels. Lightning also contains enough energy to change the nitrogen gas. Lightning storms are thus another way nitrogen can be transferred from the atmosphere to the soil. However, these two processes are far less significant to the nitrogen cycle than biological nitrogen fixation.

ECOLOGY FACTS - THE CARBON CYCLE



Respiration – Sugar is combined with oxygen to release carbon dioxide gas, water, and energy.

Photosynthesis – Carbon dioxide, water, and sunlight energy are combined to make oxygen and carbon chains or sugar.

Carbon is present in the nonliving environment as the gas, carbon dioxide, and in a dissolved form in the sea. Carbon from the nonliving environment is incorporated into living things by producers through photosynthesis. This carbon is then passed through food chains. Some carbon is returned to the environment at each link in the food chain by respiration.

Huge amounts of carbon are stored in fossil fuels – the wastes and remains of the living things of past millennia (includes oil, gas, and coal). Large amounts are also trapped in sea sediments, wood, and detritus. This stored carbon is slowly returned to the nonliving environment through respiration by detritivores. It is also returned to the nonliving environment very quickly by fire (combustion).

Nearly all living things are dependent on the carbon cycle. Three billion years ago (before photosynthetic life forms evolved), the earth's atmosphere contained a large amount of carbon dioxide and no oxygen. Today, due to photosynthesis by producers, the atmosphere is about 21% oxygen and about 0.03% carbon dioxide.

Mini Food Web Lesson

DEFINITIONS

Compost – a mixture of *decomposing* **organic** material (*formerly living*) typically used to fertilize soil.
Humus – *decomposed* organic material. The end product of composting.
Soil – mixture of humus and **inorganic** (*sand, clay, dust, rock*) material.

WHY?

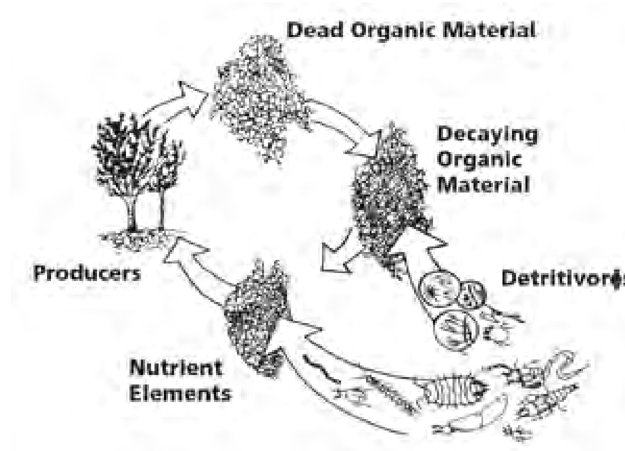
Plants need humus in soil because it provides the **nutrients** for growth and survival. Just as we get nutrients by eating plants, plants get their nutrients by "drinking" them from the soil.

The natural process of **decomposition** (*breaking down formerly living things into their nutrient molecules*) is critical in the natural world. Imagine what would happen if all of the plants and animals that died before now were still around!

Detritivores (including bacteria, fungi, worms, and other insects) are the world's natural recyclers. They feed on what we would call garbage and turn it into humus, rich with minerals and nutrients that plants can use for new growth.

METHODS OF COMPOSTING

1. **Aerobic – with oxygen**. The detritivores here need oxygen to do their job. Worms are the most common aerobic detritivores. They break down organic waste quickly, usually within three or four weeks.
2. **Anaerobic – without oxygen**. Detritivores adapted to working without much oxygen break down the compost at a much slower rate – **several years**! Bacteria are the most common anaerobic detritivores. They typically produce the soil at the bottom or edges of bogs, marshes, ponds, and swamps. Examine the top layer of "muck" or "peat" from wetlands, and you will find a high percentage of only partially decomposed material because detritivores cannot devour the supply fast enough.



CLASSROOM COMPOSTING BOX

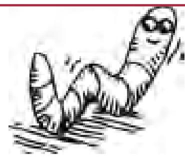
An aerobic composting worm box, kept in the garage or in a classroom, is an easy way to recycle vegetable food waste while learning about food webs. Food and yard wastes make up about 30 percent of our garbage in the United States.

Low Maintenance. Redworms (*detritivore of choice in indoor composting*) eat their weight in garbage everyday. The worm box takes minimal maintenance. Worms can be fed weekly. Little or no watering is required once the process starts because worms can get moisture from food scraps. *Meat and fat scraps should NOT added because they require different detritivores and attract scavengers.*

Mini Ecosystem Balance. Redworms multiply rapidly. They lay eggs which hatch in 14 to 21 days and reach maturity in 85 to 100 days. Eight worms will multiply into 1,500 in six months (*if none dies*). The compost pile, however, is a mini ecosystem. If worms multiply beyond the amount of food you supply, they will simply die and become food for other worms. Thus, the worm population will achieve a balance suitable to the amount of food that is available.

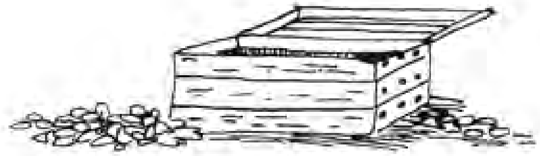
(*See the activity "Create a Classroom Compost Box" in Section 2*)

ECOLOGY FACTS - AS THE WORM CHURNS



1. Build or obtain a container. Drill holes in 2 sides and on the bottom.

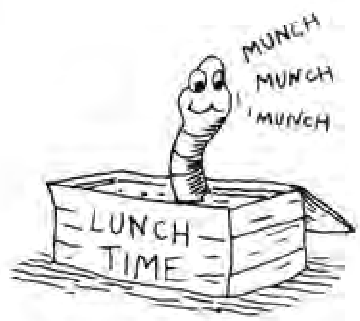
2. Shred paper for bedding.



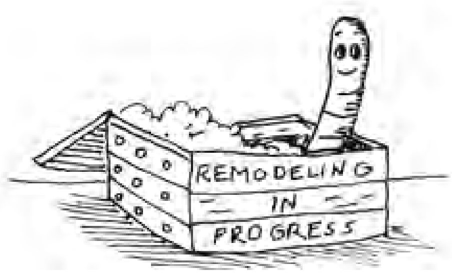
3. Wet the bedding and squeeze out excess water in the sink.

4. Put bedding material in the bottom of the box. Sprinkle in 1 or 2 eggshells.

5. Place worms in the box.



6. Bury garbage for food once a week (be sure you rotate the placement of the garbage).



7. Change the bedding every 3-6 months and remove the newly made soil.

*Adapted with permission from Away With Waste: A Waste Management Curriculum for Schools. 1989. Washington State Department of Ecology, 300 Desmond Drive SE, P.O. Box 47600, Olympia, WA 98504-7600

LIVING THINGS in their Habitats

What is in your local ecosystem? There is no better way to know) your environment than by going out and taking a close look. It be the beginning of an *ecological study.*

Section 3
ECOSYSTEM INSIGHTS

ORIGINS OF "ECOLOGY"

The term **ecology** was introduced in 1866 by a German biologist Ernst Heinrich Haeckel. It is derived from the Greek words for "*household*" and "*economy*" giving it a meaning close to the *economy of nature*.

Ecology is now defined as the **study of relationships of organisms to other organisms and their physical environment**. The science developed in part from Charles Darwin' studies of adaptations of organisms to their environment and from plant geographers' studies of world plant distribution.

Alaska's earliest scientific study was conducted in 1741 by Georg Steller, the naturalist on Vitus Bering's voyage.

Steller was allowed less than a day ashore on Kayak Island east of Prince William Sound. In that time, however, he determined the land they saw was indeed North America – because he found a bird in the jay family he knew to exist only on this continent. (*That bird is now known as the Steller's jay.*)

ECOLOGY TODAY: Modern ecologists are still asking questions about how each organism interacts with its fellow species, with other species, and with all the elements of its nonliving environment.

Support from Many Fields of Study. In the quest for answers, ecology draws on other sciences — geology, climatology, hydrology, oceanography, soil analysis, physics, and chemistry, biology, animal behavior, taxonomy, physiology, mathematics, — and many more.

TYPES OF ECOSYSTEMS

Ecologists have identified hundreds of types of ecosystems in the United States and the world, defining many to very specific levels at specific locations. Each system is a collection of interdependent parts functioning as a unit.

Also Called Biomes. Often ecosystems are identified by their **biomes** – their living community of plants and associated animals. For use in this text, however, we use the concept of ecosystems in order to explore the nonliving components, the interactions, the energy flow, and the mineral cycling.

Alaska has four major ecosystem types: tundra, forests, wetlands, and ocean. Within each major category are further divisions.

TUNDRA: Alaska has both alpine or high elevation (mountain) tundra and arctic or (high latitude) tundra. Alpine tundra exists anywhere in the world there are mountains – even on the equator. Climate and other nonliving elements prevent the growth of trees. The name tundra came from the Finnish word meaning treeless.

Adapted for the Physical Environment. The plants and wildlife that do live in tundra ecosystems have adaptations to survive freezing temperatures, short summers, and slow mineral cycling. Rainfall is so low, tundra would qualify as a desert.

Some birds fly thousands of miles to partake in the tundra's summer abundance of insect life. These birds and some of the mammals (such as caribou) then **migrate** elsewhere for the winter. Others find life under the snow a cozy way to survive harsh winters.

Where to Find More Information. The Alaska's Tundra & Wildlife is a companion book in the Alaska Wildlife Curriculum series with detailed information and student activities using tundra environments to study ecology.

FORESTS: Alaska has two main forest ecosystems – boreal forest and temperate rainforest. The boreal forest reaches to the lower edge of the tundra and its organisms face some of the same rigorous climatic conditions.

Trees Protect their Environment. The temperate rainforest fringes the coastline. In keeping with its name, Some coastal rainforest areas collect more than 200 inches of rain. Forests protect our water table and our streams by preventing erosion. Trees also play a major role in the water cycle by returning water vapor to the atmosphere.

More than any other ecosystem, forests help to maintain the balance of oxygen and carbon dioxide in our atmosphere, keeping the air breathable for all living things.

Multiple Layers, Multiple Homes. With many layers – from sky-scraping tree tops to mossy ground cover, forest ecosystems provide homes to a variety of wildlife. The increased plant life supports greater populations of **herbivores** and they, in turn, support more **carnivores** than in tundra ecosystems. The **detritivores** are plentiful – and busy.

Alaska's Forests & Wildlife is a companion book in the *Alaska Wildlife Curriculum* series with detailed information and student activities using forest environments to study ecology.

WETLANDS: Wetland ecosystems are found within tundra and forest ecosystems and many others. Coastal wetlands types include estuaries, river deltas, and saltwater marshes. Inland wetlands include stream and river corridors, marshes, ponds, lake shores, bogs, muskegs.

What Makes It a Wetland? Three factors help to define what makes a wetland.

1. How much water is present (the water regime),
2. Water-retaining soil,
3. Plants adapted to growing in soils with low or no oxygen.

Alaska's wetland ecosystems are some of the most productive wildlife habitats. For example, many of our commercial fisheries depend on fish hatched in freshwater streams. Alaska's wetlands are also the primary nursery for much of our nation's waterfowl.

Large Food Base. Wetlands are so productive for the larger, more visible wildlife because this ecosystem includes an abundance of microscopic organisms and small invertebrates that serve as food for high level consumers.

Wetlands & Wildlife, K-12 Curriculum, is a good source of information and student activities about wetlands by the US Fish & Wildlife Service and the Alaska Department of Fish and Game.

OCEAN: With 34,000 miles of marine coastline, Alaska has all varieties of ocean ecosystems from tidal flats and lagoons to deep sea trenches and sea mount upwellings.

Zooplankton to Whales. The ocean ecosystems are highly productive despite Alaska's harsh climate. They support a **food web** that ranges from tiny zooplankton to humpback whales.

Millions of seabirds are a vital part of the ocean ecosystem. They spend nine months of the year at sea, coming to land only to nest. Salmon, herring, halibut, and pollock are some of the major fishes.

Calling all Ecologists. But Alaska's marine ecosystems have shown signs trouble. In some areas the once abundant Steller sea lion and sea otter have declined sharply, for reasons yet unclear. Ecologists have been called to discover the causes.

Sea Week Curriculum by the University of Alaska – Fairbanks is a good source of information and student activities about the ocean ecosystem. *Alaska Oil Spill Curriculum* published by the Prince William Sound Science Center is another source, as is *Learn About Seabirds*, by the U.S. Fish & Wildlife Service.

HOME SWEET HABITAT

Who lives in each ecosystem? Only the organisms that find suitable **habitat** (*food, water, shelter, and space*) within a particular ecosystem. (*Some wildlife use multiple habitats, either daily, periodically, or seasonally.*)

The Right Stuff. Sitka black-tailed deer cannot survive in the arctic tundra ecosystem even though there are food, water, shelter, and space – they are NOT *the right kind* of food, water, shelter, and space for a temperate rainforest mammal. The environment that meets all of the needs of an animal is called its habitat.

The habitat of the red squirrel, for example, is a spruce forest – a place where trees provide plentiful seeds to eat, hiding places to escape from predators, and nesting areas to raise young squirrels.

Different in Different Seasons. An animal's habitat requirements may be different at different seasons and times in its life. Here are two examples. A female polar bear will den (*shelter*) from November through April to give birth to cubs. After the cubs are old enough to emerge from the den, she will not use a den again until the next time she is pregnant.

A brown bear will dine hungrily on tender roots and sedges in spring when few other foods are available. When salmon swim into nearby streams from the ocean, the brown bear will walk past sedges to fish for the high protein salmon. In early fall, the bear will gorge itself on berries.

Where Do I Find It? The key to understanding habitat – and knowing where to find an animal – is to look at each animal's specific needs and where in nature those needs are met. The Alaska Ecology Cards available as part of this curriculum are handy references for habitat and food requirements of Alaska organisms from all five kingdoms.

SMALL IS INTERESTING TOO – TIPS FOR INVESTIGATING

When Alaskan's hear the word "animal," we think about large furry **mammals** such as moose or bears. The investigations included in this section remind students to take a close look at all living organisms to discover the richness of the local ecosystem.

SOIL ANIMALS: There are many animals that live on and in the soil including **insect larvae**, snails, worms, spiders, and small mammals. These animals spend most of their life in the dark, living on other animals or nutrients found in the soil.

Many of the soil critters that students might find have special **adaptations** that allow them to thrive on or in the soil. While investigating the soil habitat, look for evidence left by soil animals, as well as for the animals themselves.

WATER ANIMALS: Not all water animals are fish, ducks, or sea otters. Ponds, streams, rivers, and other wetlands are rich with kinds of animal life that we seldom see.

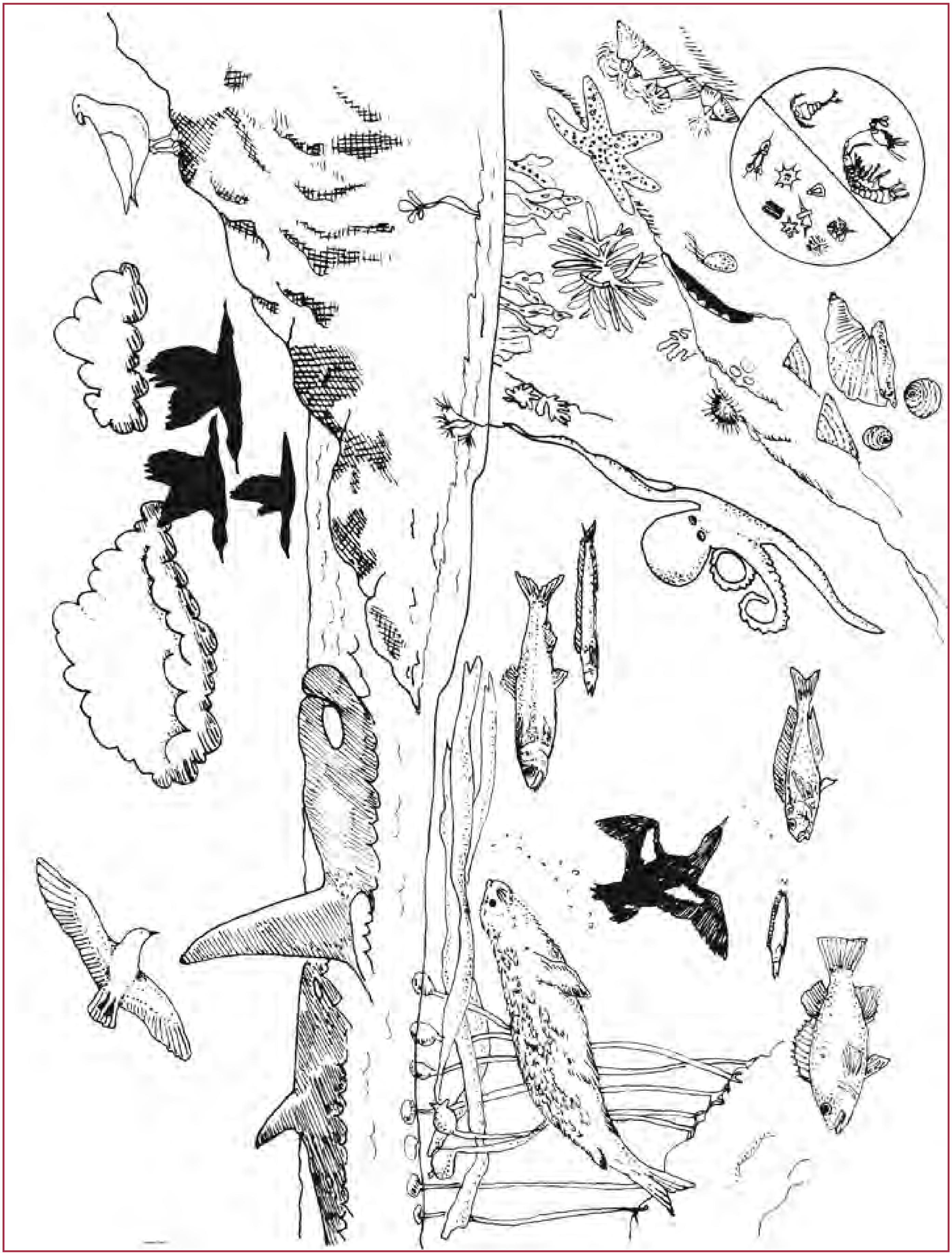
Each spring as ice thaws, wet areas in Alaska erupt with young **invertebrates** (*animals such as worms and insects that have no backbone*). These invertebrates are extremely important food sources for many of the fish that other animals eat (including humans).

Don't Forget Mosquitoes! Many of the easily recognizable flying insects in Alaska such as mosquitoes and dragonflies lay their eggs in water. **Larvae** and **pupae** develop from these eggs and carry on complex predator – prey, and consumer – consumed relationships.

Investigating water habitats reveals usually hidden creatures that form essential links in the food chains of wetland ecosystems. A pond will never seem so ordinary again!

PLANTS: Within one calendar year **annual plants** grow from seeds or buried roots, flower, produce new seeds, and die. In fall and winter only remnants of annual plants such as dead leaves, tubers, seed pods, and roots are left as evidence of their presence. They are providing energy for the decomposers and detritivores.

While investigating the plants in your local ecosystem, look also for evidence of perennial plants such as fireweed, dwarf dogwood, and cow parsnip. Though their summer appearance is fleeting, plants are vital in the web of ecosystem interactions of living and nonliving things.



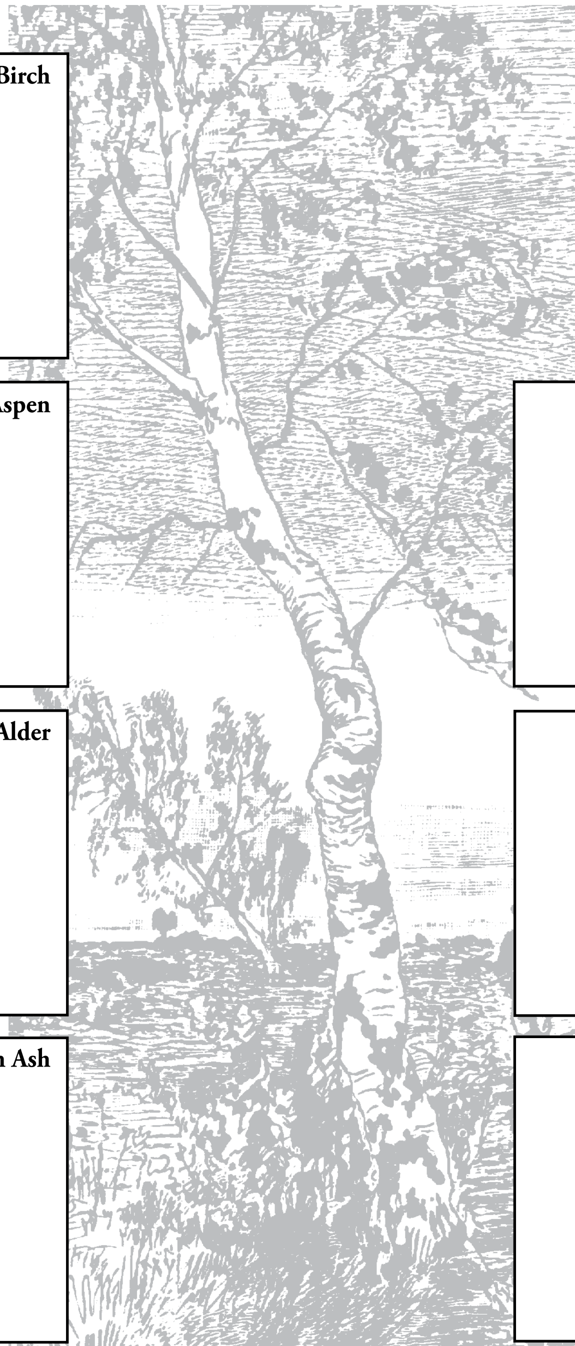
ALASKA'S BROADLEAF TREES

Look at the leaves.

• If they are broad, flat leaves, the tree is a **broadleaf, angiosperm,** or **hardwood**.

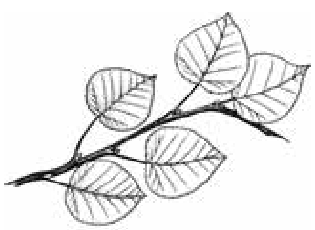
Broadleaf trees have flowers as well as broad, flat leaves. Flowers on a majority of Alaska's broadleaf trees are small and green and do not look like a typical flower petal.

Broadleaf trees in Alaska are **deciduous**, losing their leaves in the fall. They become **dormant** as an **adaptation** to the cold and reduced daylight.

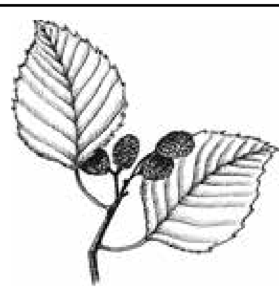


Birch

Aspen



Alder



Mountain Ash

Willow

Balsam Poplar

Black Cottonwood

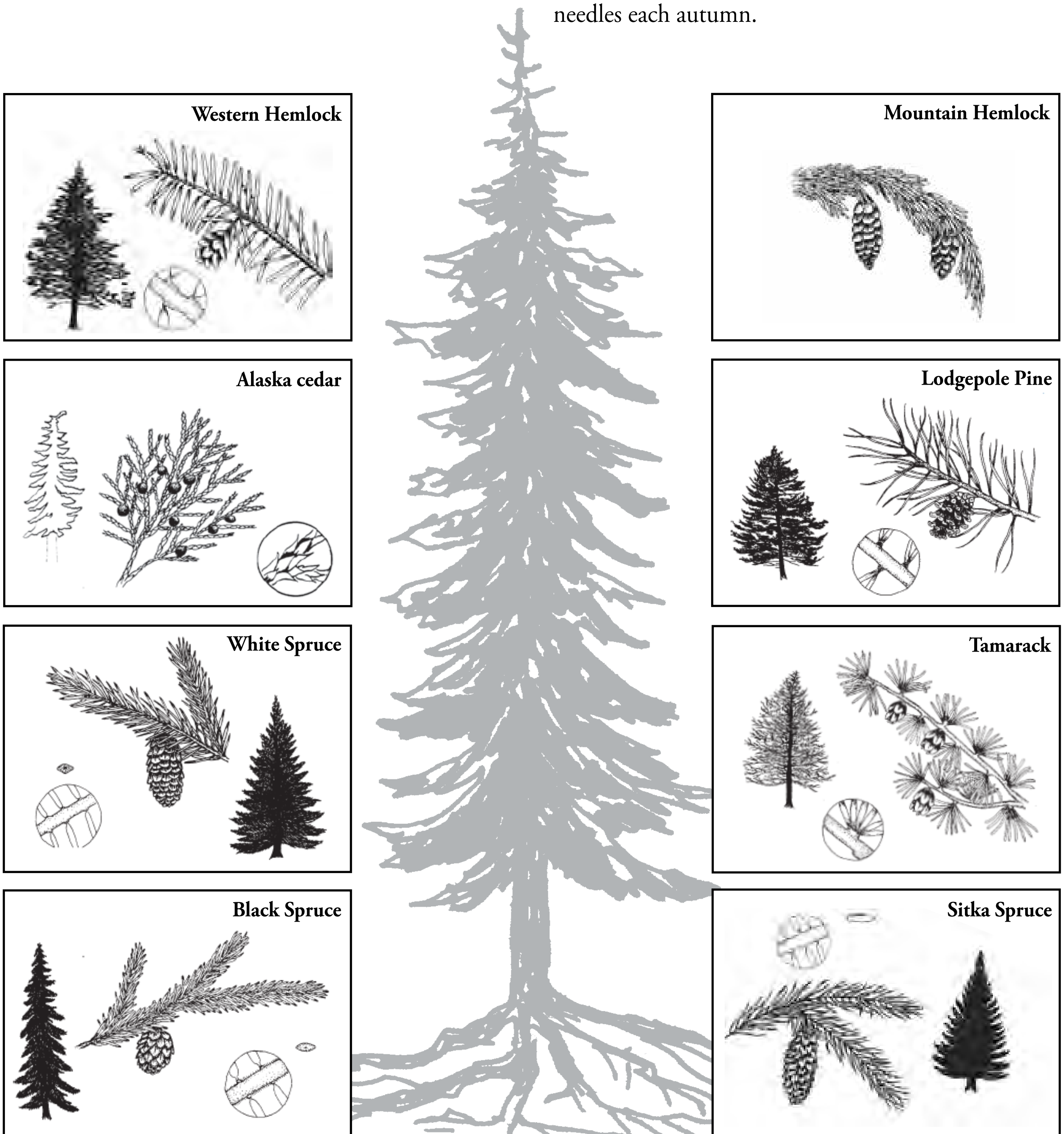
ALASKA'S CONIFER TREES

Look at the leaves.

- If the leaves look like needles or scales – just picture a Christmas tree – the tree is a **conifer, gymnosperm**, or **softwood.**

Conifer seeds grow inside **cones** rather than flowers and sometimes hang on the tree for several years. The tree's **crown** looks like a cone as well.

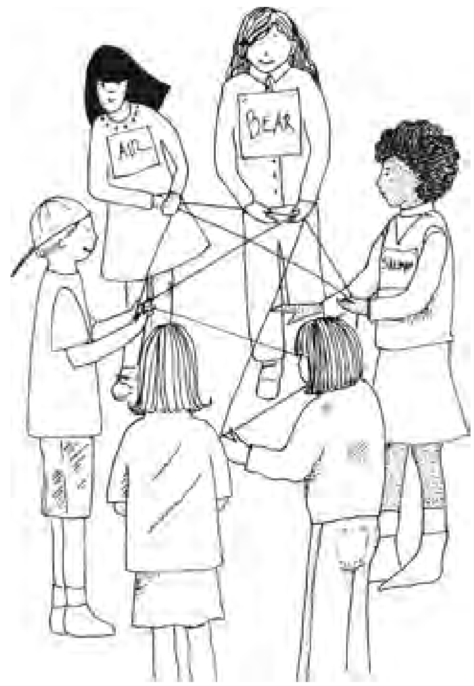
Since conifers typically keep their narrow, needle leaves all winter they are also called **evergreens**. One Alaskan conifer – the tamarack – is **deciduous** and loses its needles each autumn.



Section 4
ECOSYSTEM INSIGHTS

Human Impacts on ECOSYSTEMS

In tracing the web of connections within an ecosystem, ecologists are explaining how changes in the nonliving environment affect every living member of that ecosystem – because all things interact, either directly or indirectly.



PHYSICAL CATALYSTS

Alaska has an example of ecological change in geologic time and scale. Until 13,000 years ago, much of the world's northern areas were covered by glaciers and ice sheets while the interior of Alaska was ice-free. Woolly mammoths and steppe bison thrived in this grassland steppe ecosystem.

Prehistoric Global Warming. As the climate warmed over thousands of years, the ice sheets melted and the glaciers retreated. Grassland steppe ecosystems gradually became forests and tundra ecosystems. Some scientists theorize that woolly mammoths and other prehistoric animals could not adapt to life in forests, and therefore became extinct.

Similarly, but on smaller scales and shorter timeframes, flooding, drought, volcanic eruptions, fire, and earthquakes can change local ecosystems.

Quakes Shake Ecosystems. Alaska's 1964 earthquake uplifted some lands and drowned others, so each area is changing to organisms that can survive in different water regimens – wetlands changing to shrubs along the coast of the Copper River Delta; forests and former townsites turned into tidal marshes at old Valdez and along Turnagain Arm.

BIOLOGICAL CATALYSTS

Sometimes an animal's abundance triggers an ecological change. The spruce bark beetle is one recent example.

The Beetle that Roared. Weather and other natural factors allowed rapid expansion of this parasitic beetle's population. In mass, they kill large white spruce by boring into the trunk to feed and lay their eggs. Large numbers overwhelm a tree's normal defenses. Next spring all those newly hatched beetles fly to more trees and soon a forest is under siege.

Miles and miles of spruce forest in Southcentral Alaska fell victim to the swarms. As a result, the forest ecosystem is changing. Former dense spruce forests are becoming grassy meadows or changing to birch and aspen-dominated forests.

Caribou Migrate for a Reason. Alaska's caribou herds are another example of population explosions changing an ecosystem.

Caribou, always on the move, migrate hundreds of miles each year. As they move, they graze on plants and lichens. By this habit, they don't eat all their favorite plants in one area nor crush the fragile lichen that take decades to grow.

When caribou populations expand rapidly, a population crash is usually not far behind. Too many caribou eat or destroy their food sources, leading to low reproduction and starvation. They leave an ecosystem out of balance, with plant communities depleted and predators looking for new prey.

HUMAN CATALYSTS

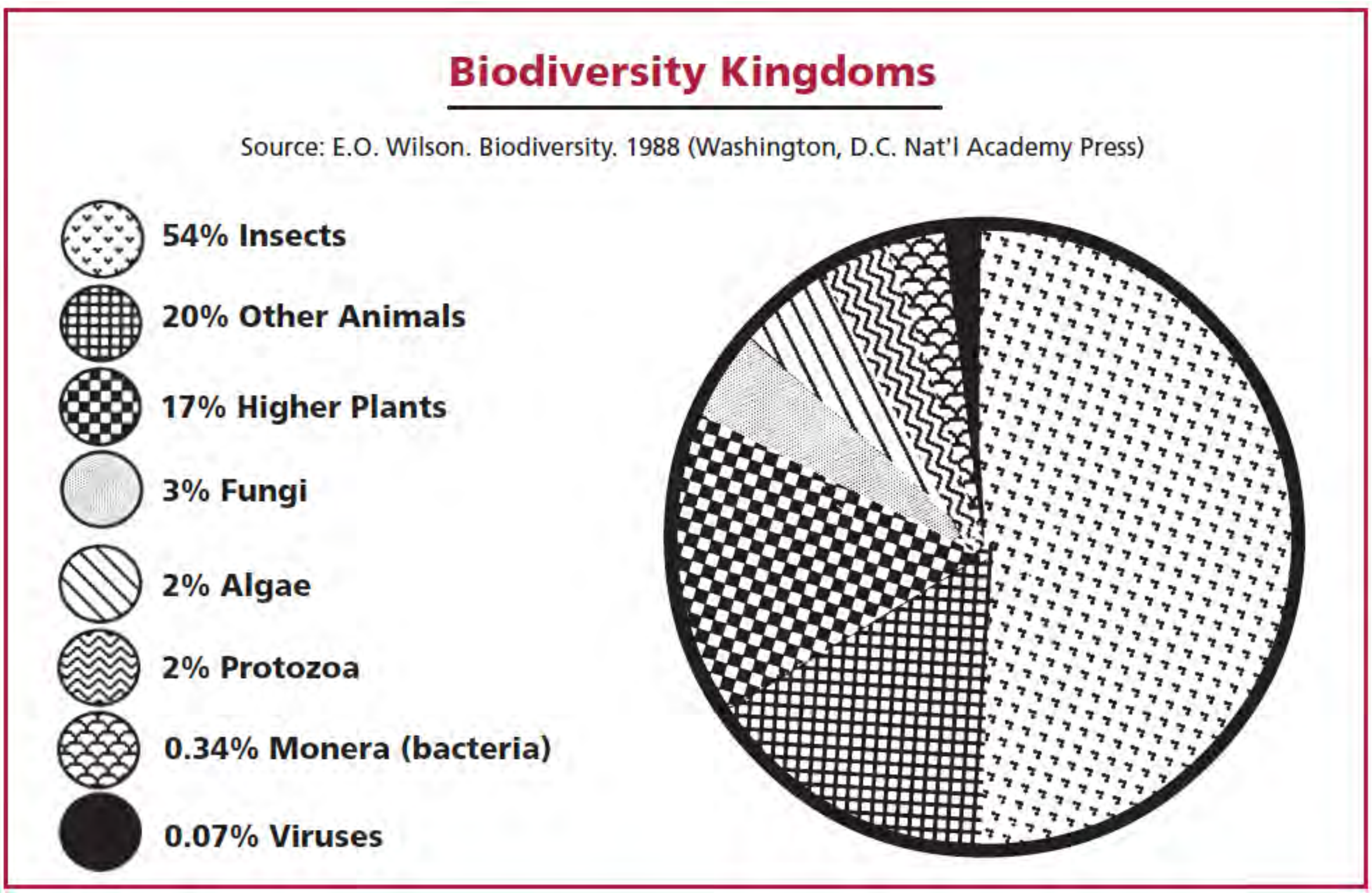
Throughout our history, we have records of human caused changes in ecosystems. From extinction of species (the Steller's sea cow in Alaska, for example) to clearing a forest or filling of wetlands.

Oil Spill Starts Changes. The Exxon Valdez oil spill in 1989 introduced about 11 million gallons of North Slope crude oil into the marine ecosystem of Prince William Sound and west along the Gulf of Alaska to the Alaska Peninsula. Many kinds of wildlife immediately began washing up dead or dying on the beaches.

Shaking the Whole Food Web. Less visible were the deaths and changes in health of the many invertebrates and microscopic organisms so vital to the smooth running of an ecosystem. Because they are the foundation for all other consumers, their losses or damage continued to be felt years after the spill.

Are the Effects Over? In addition, hydrocarbons of oil remained present in the substrate of beaches and in the water column. Scientists continue to study and puzzle over the ecological changes.

(*See the Alaska Oil Spill Curriculum published by the Prince William Sound Science Center for student activities and further background.*)



Other examples of human-caused changes in ecosystems can be found in the fact sheets with the student activity "Ecology Puzzlers" in Section 4.

BIODIVERSITY – SIGN OF HEALTHY ECOSYSTEMS

The variety and abundance of living organisms in an ecosystem or habitat determine its **biological diversity** or **biodiversity**.

Why is Diversity Important? Like the old saying "variety is the spice of life," a diversity of plants, animals, and microscopic organisms fills all the "jobs" in an ecosystem.

Abundance and variety of parts give an ecosystem flexibility. That flexibility insures the smooth and continued functioning of the whole as, over time, an ecosystem is buffeted by change and damage.

Radiating Effects of Loss. Nevertheless, since all living things are connected to others in their ecosystem, impacts have a radiating effect. Removing a species shakes the whole web of life.

Scientists are still learning about all the interactions in ecosystems. Our decisions and actions regarding wildlife today may have consequences tomorrow that we do not currently understand.

Habitat Key to Diversity. The greatest threat to biodiversity is loss of habitat. Destroying habitats can threaten the extinction of species and the destruction of entire ecosystems.

Humans are reducing the world's biodiversity at an increasing rate. In the United States scientists estimate that more than 125 types of ecosystems are either threatened or endangered.

CONSERVATION – USE FOR THE FUTURE

Conservation is the *use of minen in a way that assures their continuing availability to future generations.*

Two Categories of Resources.
Resources are **renewable** if they have the capacity to replenish themselves over time through natural processes. Solar energy and wind are examples of inexhaustible resources. Pure water, plants, and animals are renewable resources – provided humans practice conservation and do not pollute or consume them faster than they are naturally reproduced.

Nonrenewable resources are limited in supply and can only be replaced in geologic time, not human time. Examples include oil, coal, copper, and gold. They require humans to think and conserve for all future generations.

THE BIODIVERSITY OF ALASKA

How many species ... a sampling

	ALASKA	WORLD
Amphibians	6	+4,200
Birds	452	+9,000
Fishes	430	+18,800
Mammals	108	+4,000
Plants	+1,500	+248,000
Reptiles	0	+8,300

NO HUMAN IS EXEMPT

People often see themselves as separate from the surrounding wilds. Like all other living things, however, humans are a part of the Earth's ecosystems.

Can We Do Without Land, Oxygen, Food? We need water, minerals, and air from the nonliving environment. We need plants and algae to produce oxygen and maintain the composition of our atmosphere. We also need these producers to make food for animals and ourselves.

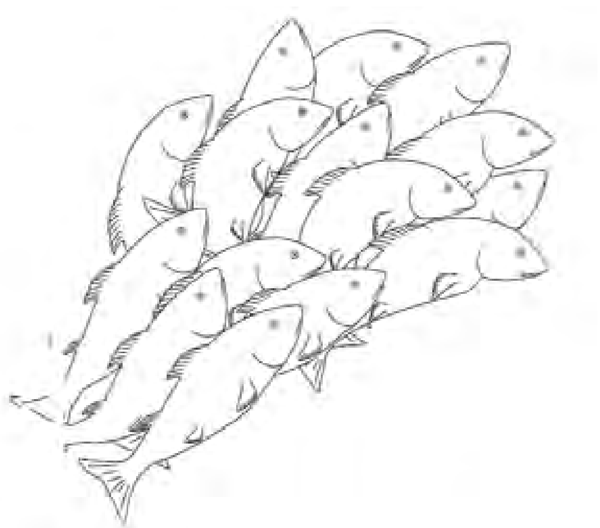
We depend on plants to reduce soil erosion, moderate our climates, and maintain the water cycle. We depend upon nitrogen-fixing bacteria and denitrifying bacteria to maintain the nitrogen cycle.

Global Garbage Recyclers. We need other bacteria and fungi to break down waste materials to replenish the soil for plant growth. About 80% of each year's biological production (leaf litter, dead animals, fecal wastes, for example) is ultimately broken down by **detritivores**. Without detritivores, all that biomass would accumulate in a mountain of waste.

Humans also use certain chemicals produced by bacteria, fungi and other organisms as medicines. We need many of the materials made by plants and animals for clothing, shelter, and tools (*for example, wood, paper, cotton, silk, wool, rayon, rubber, certain oils*).

Balance in the System. We also depend on predators,

CONSERVATION CASE STUDY



What does it take to ensure a future for something we value? Let's look at salmon. During the life cycle of a salmon, it uses the following ecosystems:

- Clean, cool **streams** water and gravel beds (where the salmon eggs are laid and hatched).
- Unobstructed, clean **rivers** that the salmon use to migrate to and from the sea.
- Food-filled, unpolluted **ocean** (where the salmon feed and grow to adult size).

The salmon also depends on the following nonliving and living parts of these ecosystems:

- Non-acidic rain water (to fill the stream and river).
- Organisms that produce the oxygen in the water (so the salmon can breathe –phytoplankton and aquatic plants).
- Shrubs and trees that grow beside the stream (to provide cover and shade that keeps water cool)
- All the living things the salmon eat (stoneflies and other aquatic insects –after salmon hatch; herring and sand lance –as adults)
- The organisms that feed these prey species (dead plant materials and zooplankton)
- Detritivores that recycle minerals, the animal pollinators and seed carriers, and the fungi or bacteria that help them obtain certain minerals.

Thus, if we intend to conserve salmon populations, we must also conserve the entire ecosystem in which they live.

parasites, and disease-causing microscopic organisms to keep populations of other organisms in check. *Predators, parasites and disease-causing micro- organisms also effect humans, but not enough to limit human population growth in modern times.*

Changes in the earth's ecosystems, therefore, have direct effects on people as well as all other living things. Even an activity that seems to affect only insects, only fungi, only the upper atmosphere, or only ground water supplies can have far-reaching consequences. Can we live with each change or the cumulative effects of many changes? What kind of environment will future generations inherit?

SOLVING PROBLEMS LOCALLY

If your students notice something is askew in the ecosystem around your school, then you have a great opportunity to make learning both tangibly productive and fun. Your class can transform creative thinking into problem-solving actions that make a difference in your school and your community.

> Ecology contributes to the understanding of environmental problems.

I Can Make a Difference! Students should not feel responsible for solving all the world's problems. But that doesn't mean they can't try to solve some. Vital steps that give students a feeling of "I can make a difference" include the following.

- **SINGLE PROBLEM:** Allow students to choose a single problem to solve.
- **MANAGEABLE FOCUS:** Help students keep the size of the problems manageable.
- **BUILD SKILLS:** Help students build the skills they need for accomplishing each step.
- **TIME:** Give students time and resources to work on their problem.
- **SUPPORT:** Help students gather community support.

Perhaps the school uses disposable packaging for school lunches. Students might propose that the school purchase reusable plates and a dishwasher, and look for ways to raise money to purchase them.

Perhaps your town or village has a problem with drinking water pollution by leaking gas storage tanks. Students could mount a campaign to encourage clean-up and prevention of leaks.

Perhaps your community has a problem keeping garbage away from bears. Students could survey possible solutions such as incinerator installation or bear-proof cans or dumpsters.

Problems that seem small, such as moose browsing in a playground near young children, may be excellent research subjects that lead to resolution by the students. Students could solve the moose problem by providing moose with better access (for example, snow removal) to an alternative browse area. Trees and shrubs that attract moose could be replaced by plants less attractive to moose.

Chosen (Owned) by Students. Whatever the problem, it is important that it be identified by students. Teachers may think a particular project is fascinating, but it does not capture the interest of students. Then the teacher gets exhausted trying to motivate and invigorate their class.

Ask students to look around their ecosystem and see if there's anything that bothers them. Their own energy can be limitless (while your energy may not be!).

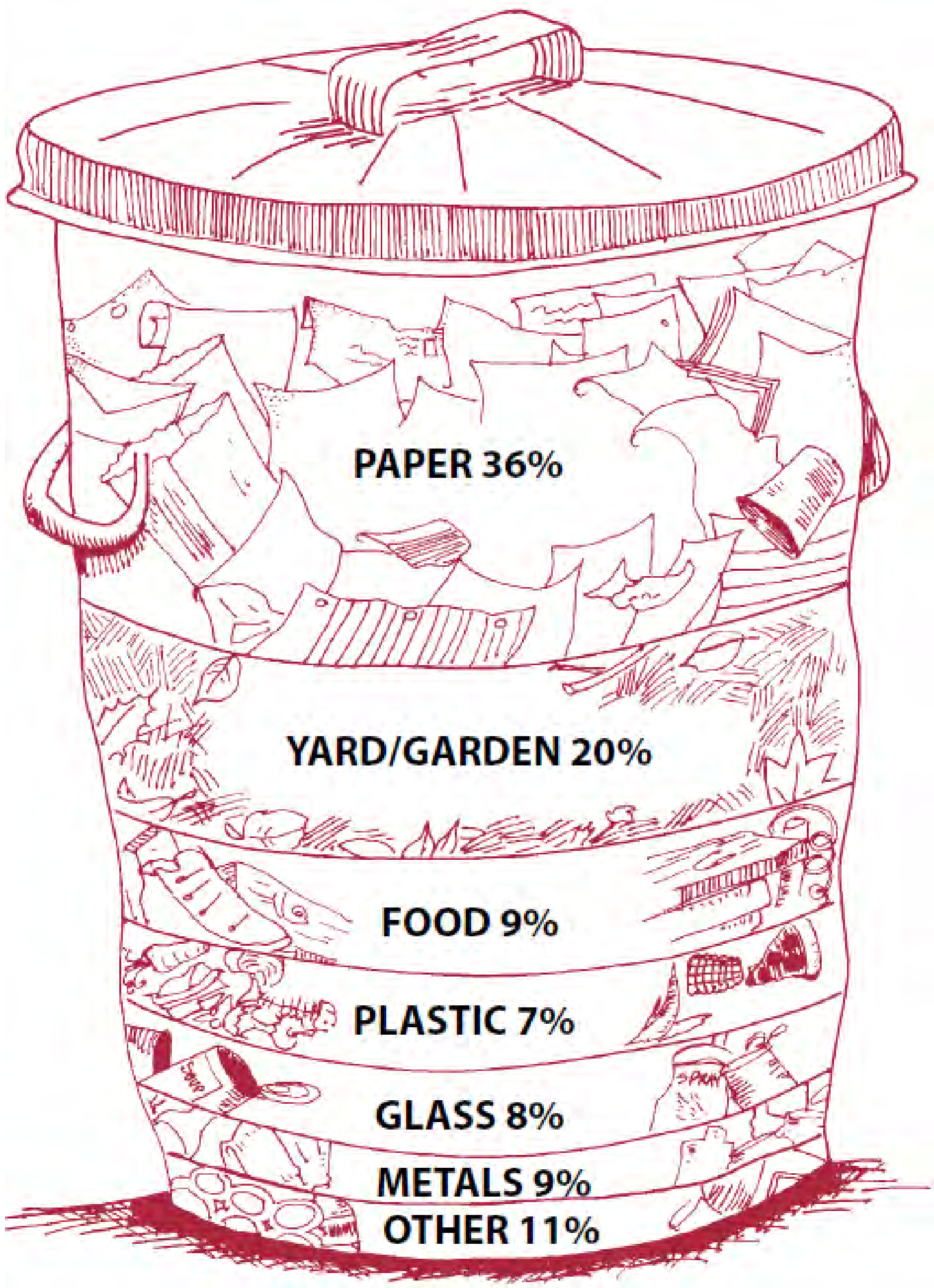
ECOLOGY FACTS - WATCHING YOUR WASTE

Our human population has grown so large that the amount of garbage we produce overwhelms the population of naturally-occurring detritivores that decompose and recycle dead things.

Detritivores are absolutely essential to ecosystems because they provide renewed sources of mineral nutrients and help keep our surroundings clean. But they cannot keep up with our wastes without our help.

The average American generates about 1,300 pounds of solid waste (other than bodily waste) each year. This material has to go somewhere! Much of our food and sewage waste is recyclable back into the soil with detritivore help. But humans produce a lot of synthetic waste, such as plastics, that detritivores don't eat.

Many synthetic goods are produced from nonrenewable resources (limited in nature like aluminum). If materials are not recycled, future generations may run out of them. We can make some waste items available for reuse just as the detritivores do if WE practice recycling.



Solid Waste in Anchorage, Alaska
Statistics reported by Anchorage Recycling Center, Anchorage, Alaska