Elements that Create FORESTS

Section 1
FOREST INSIGHTS

Elements that shape forests
- Climate
- Soil
- Topography
- Temperate (Coastal) Rainforest
- Boreal Forest
- Tree Basics
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Of the many types of forests in the world, Alaska has two: **temperate rainforest** and **boreal forest.**

All of Alaska's ecosystems are shaped by the **nonliving environment** – **climate** (temperature, sunlight, precipitation, wind,); **soil** (characteristics, composition, texture, chemistry, depth), and **topography** (steepness, aspect).

These elements determine where we find forest ecosystems and where trees lose the battle of survival to the treeless tundra ecosystem (*see the companion student activities in* Alaska's Tundra & Wildlife).

The nonliving environment also separates where and how well our two major forest types grow as well as where certain wildlife will find **habitat** that meets their requirements.

CLIMATE

Life Needs Warmth. Plants cannot produce food through **photosynthesis** *(make sugar from light energy, water, and carbon dioxide)* at temperatures below 19.4ºF (-7ºC). Other metabolic processes such as respiration do not occur at temperatures much below this point.

Boreal forest trees are better adapted to cold and temperature extremes. Temperate rainforest trees grow where temperatures vary little from season to season.

Sunlight and Life. The sun's energy is doubly vital: it warms the environment to a degree where life can occur; and it is a key ingredient in photosynthesis as trees and other plants produce the food that serves as the foundation for all other life.

Photosynthesis Process. Tree leaves 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. When cold temperatures and meager sunlight halt photosynthesis, plant growth stops and trees become dormant. Boreal forest trees have a long dormancy; temperate rainforest trees, short.

Summer Growth Surge. When temperature and sunlight allow, Alaska's trees 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.

Permafrost Inhibits Growth. Areas of **permafrost** (*perennially frozen ground*) in Interior Alaska's boreal forest keep water on the surface and limit tree root development to shallow surface layers. Water seems abundant because snowmelt and rain cannot drain away. Amazingly, the total amount of **precipitation** that falls in the Interior is comparable to that of deserts.

Rainy Rainforest. By contrast, Southeast Alaska's coastal rainforest grows in a moderate, moist, cool climate. Awash in rainfall, the coastal forest risks losing its shallow soil if its vegetation is stripped on steep slopes. There is no permafrost.

SOIL

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

Roots Need to Breathe. Soil depth and standing water affect the tree's ability to "breathe." Without **oxygen**, tree cells die. Cells in leaves and 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 can become waterlogged because permafrost does not permit water to drain away from the tree roots.

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

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.

TOPOGRAPHY

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 forests.

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 tree growth by drowning their roots. Forests 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. Forests on north-facing slopes have different trees from those on south-facing slopes

TEMPERATE COASTAL RAINFOREST

LOCATION. Our coastal rainforest extends about 900 miles (1,440 km) along the Gulf Coast from the tip of Southeast Alaska north to Kodiak. The forest is a continuation of the temperate rainforest of British Columbia, Washington, Oregon, and Northern California.

Coastal Rainforest

CLIMATE. Like other temperate rainforests, Alaska's has a moderate, moist, cool, cloudy climate. Seasonal temperatures do not vary much, ranging from the upper 50s (13-16°C) in summer to the low 20s or mid 30s (-6 to +2°C) in winter.

Plenty of Rain. Annual precipitation is abundant, from 220 inches (near Ketchikan) to 25 inches (in Homer). Snowfall may be heavy, but much of the precipitation falls as rain.

So much water (both rain and snow) falls along Alaska's south coasts that it produces rainforests. So little falls in the Interior that the land qualifies as a desert.

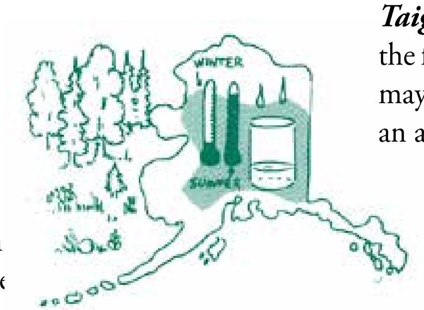
SOILS. Typically, soils in the coastal rainforest are relatively thin. Some glaciers are still receding and making way for future forests.

TOPOGRAPHY. Alaska's coastal rainforest grows from sea level to a treeline between 2,000 and 3,000 feet (460- 915 meters). The terrain is typically steep and rugged. Narrow fjords scallop the coastal edges.

Champion, Ancient Trees. Most of the trees are tall, conifers, predominantly western hemlock and Sitka spruce. Thus, the Alaska's coastal rainforest is often called the "hemlock-spruce" forest. These trees can live to be 300 to 1000 years old and grow to heights of 175 feet (53 meters) and greater. The tallest tree on record in Alaska is a Sitka spruce at 250 feet (76 meters).

Environmental Influences within Forest. Where the soil is soggy, Alaska cedar, western red cedar, and lodgepole pine grow. At high elevations, severe winter conditions exist. Mountain hemlock is the most common conifer. Hardwood trees are scarce in the coastal rainforest, but red alder, cottonwood, and some willow can be found, especially along rivers.

BOREAL FOREST



LOCATION. Alaska's farthest north forest grows in the Interior between th coastal rainforest and the tre less tundra of Western and Arctic Alaska. It is a circumpolar forest, also found across much of Canada, Scandinavia, and Siberia.

CLIMATE. Trees of the boreal forest are tested to the limit with climatic extremes. Winter temperatures below –40°F (-40°C) are common. In contrast, summer temperatures can soar into the 90s (above 30°C).

Permafrost Stretches Precipitation. Permafrost is scattered in the southern range of the boreal forest but it is continuous in the northern sections. Precipitation is light, less than 15 inches (38 centimeters) annually, but evaporation is low and permafrost inhibits drainage so bogs and wet areas are common.

Long, Dark Winters; Bright Summers. Snow cover persists from mid-October until mid-April. Daylight varies from up to 24 hours in summer to only a few hours in winter.

SOILS. Roots of boreal forest trees grow horizontally, rather than vertically, to take advantage of the shallow soil. Winds and floods can easily uproot the trees.

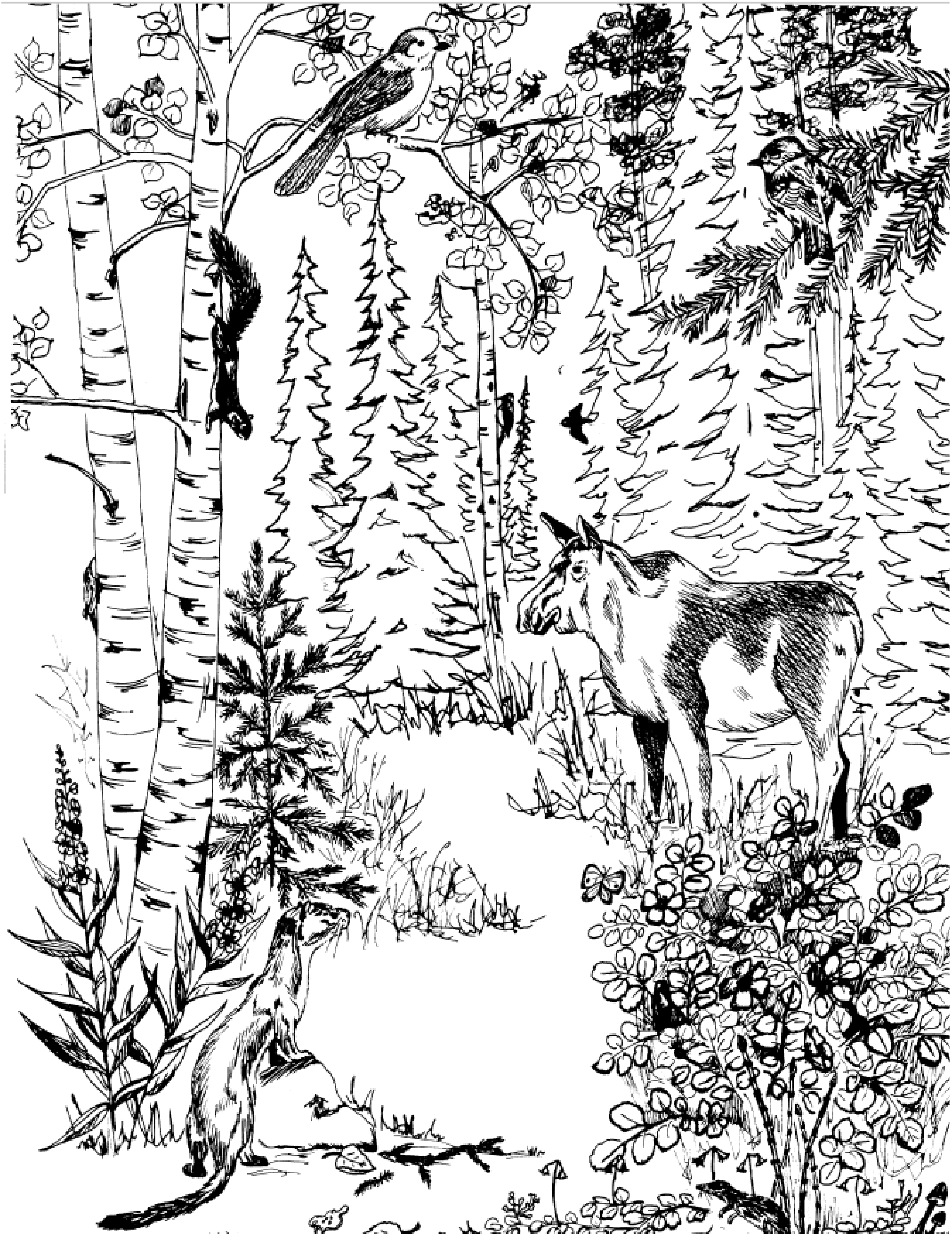
TOPOGRAPHY. Slope and aspect provide micro-climates of warmth and wind protection where the trees of the boreal forest can grow to their greatest potential.

Trees Under Stress. The boreal forest is a patchwork mosaic, affected by frequent lightning fires, permafrost, and slope. The trees are a mixture of white and black spruce, aspen, and birch. Because of this, the forest is also called "spruce-hardwood."

Different Sites for Spruce. White spruce grows best in warm, dry sites that are free of permafrost, while black spruce and tamarack often grow on wet, cold sites on top of permafrost.

Taiga. The trees tend to grow shorter and more sparsely the farther north one goes, until a 50 year-old black spruce may be only several meters tall. Russian's gave this forest an appropriate name: ***taiga*** – *land of little sticks.*

Boreal Forest



FOREST FACTS - TREE BASICS

Trees are plants with leaves, a tremendous underground root system, and stems and branches. Each part of the tree has a separate and important function.

PARTS OF TREES

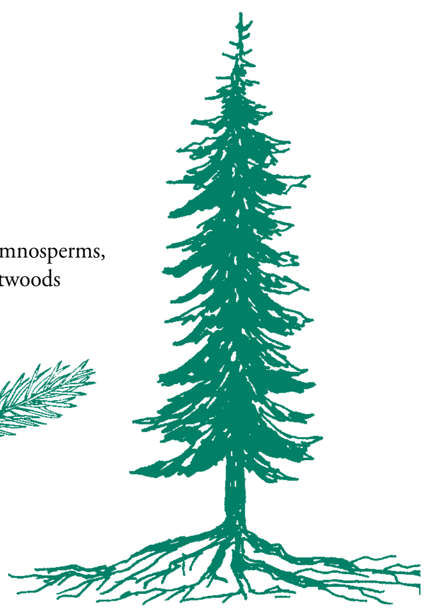
Roots **–** The roots anchor the tree to the ground and absorb water and minerals from the soil. In a majority of Alaska trees, the roots spread horizontally rather than vertically, often reaching outward as far as the trunk reaches skyward.

Trunk **–** The trunk of a tree and its branches connect the roots with the leaves. The trunk and branches are made of special cells that form long tubes for carrying water, minerals, and food between the tree's parts. Those cells also give the tree structural support.

Leaves **–** The leaves of a tree, like those of all plants, are chemical laboratories. They manufacture their own food by capturing light energy and combining it with air and the water pumped from the roots. This process of making food is called **photosynthesis**.

Trees use this food (along with minerals absorbed by the roots) to create new cells. Each year trees grow more roots, new leaves, taller and broader trunks, and more branches.

CONIFERS
are also called: gymnosperms, evergreens, or softwoods



TWO KINDS OF TREES

You can easily separate the two major kinds of trees by looking at their leaves.

• If they have broad, flat leaves – the kind that press nicely for fall classroom decorations – the tree is called a **broadleaf, angiosperm,** and **hardwood** (although some have soft wood).

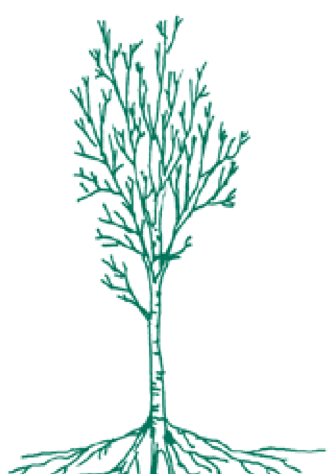
• If the leaves look like needles – just picture a Christmas tree – the tree is called a **conifer, gymnosperm**, and **softwood** (although some have wood that is quite hard).

Broadleafs **–** 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. (Some broadleaf trees in tropical areas keep their leaves all winter.)

Conifers **–** 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**.

A few conifers (the tamarack in Alaska) are deciduous and lose their needles each autumn.



BROADLEAFS
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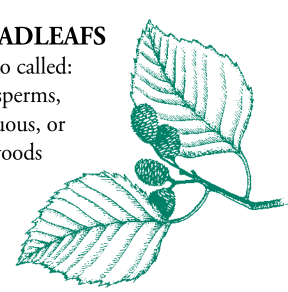


NAMING A FOREST

If a forest is mostly conifers, it is called coniferous. If broadleafs dominate, the forest may be described as hardwood. Some forests are called "mixed" when neither category of trees seems to be more abundant.

TREE TRUNKS

Trees are plants with a single large stem called a **trunk**. The trunk of a tree and its branches connect the roots with the leaves. The trunk and branches are made of special cells that form long tubes for carrying water, minerals, and food. Those cells also give the tree support.

Look at a Cross-Section

A **cross-section** of a tree trunk shows multiple rings of cells. Each has a special function. The outer layer of **bark** protects the inner parts from invasion by insects and diseases, and prevents loss of water. Just inside the bark is a ring of cells called the **phloem**. Channels in the new phloem cells carry dissolved sugars and nutrients made in the leaves *down* to other parts of the tree, including the roots.

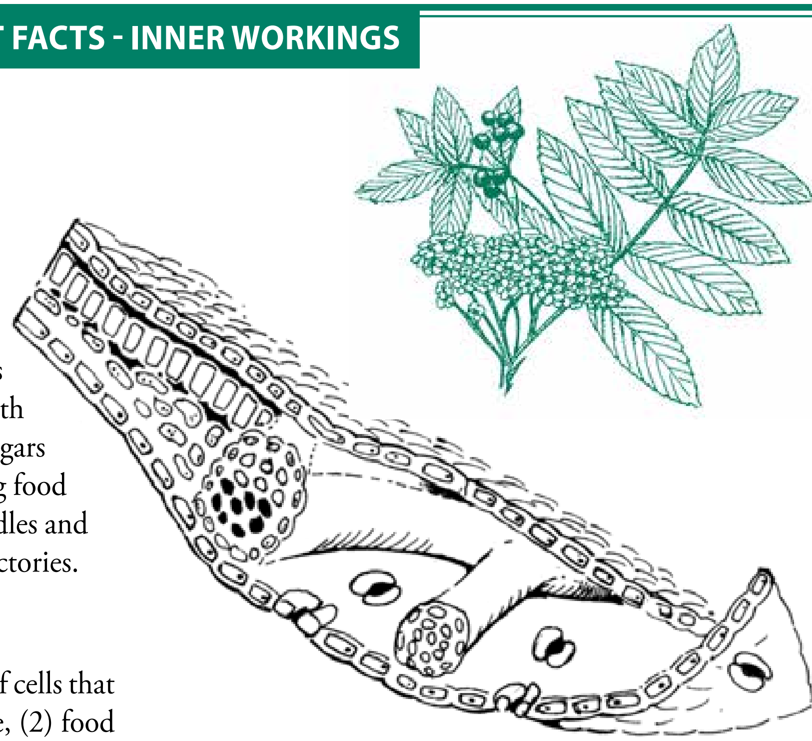
Beneath the phloem is the only growing layer of the trunk, the **cambium**. The cambium produces both the phloem cells and the next inner ring of cells called the **xylem**. New xylem cells carry water and dissolved minerals from the roots *up* to the leaves and other parts of the tree. Sometimes these cells are also called **sapwood**.

Special cells connect across the tree as well. They are called **parenchyma cells**, and their job is to carry food and water across the width of the tree.

As a tree grows, the cambium produces new rings of cells. The cells added in spring are light in color (*when more water is usually available*) and those added in summer are dark. This produces the easily visible rings in a tree trunk. One can discover the age of a tree by counting either the dark or light rings. When we count tree rings, we are counting the year's xylem growth. New cells are produced with the food made in the leaves and with minerals absorbed by the roots.

Trees grow taller only at the tips of their trunk and branches. The region where new growth occurs is called **meristematic tissue**. Each year trees grow more roots, new leaves, more branches, and broader trunks and stems.

As a tree trunk grows, part of its cells die. The old phloem cells form bark, and the old xylem cells become **heartwood** – the center of the tree trunk. Even though its cells are dead, heartwood is rigid and strong and supports the branches, leaves, and **crown** of a tree. Most of the trunk of a mature tree is heartwood. Loggers utilize the heartwood when they cut trees for timber.



TREE LEAVES

Leaves are the food factories of trees. Leaves capture light energy from the sun and gases from the atmosphere. They combine those with water pumped from the roots to make the sugars the tree uses for food. This process of making food is called **photosynthesis**. Skinny spruce needles and broad cottonwood leaves all work as food factories.

Look at a Cross-Section

A cross-section of a leaf shows several layers of cells that are organized in three systems: (1) protective, (2) food producing, and (3) transporting.

1. Protective

A protective "skin" covers the entire leaf. It has two layers: the **epidermis** and the **cuticle**. The cuticle is a waxy layer that is usually thickest in plants growing in windy or hot, dry regions. The skin lets in light, but blocks the movement of water and gases.

Little "mouths" or **stomata** in the skin on the under-side of the leaf open and close to let in carbon dioxide, release oxygen, and control the loss of water. A single leaf has many thousands of these little mouths. In most plants, the stomata open in the day for gas exchange during photosynthesis and close at night to prevent water loss.

2. Food Producing

The producing system of a leaf, the **mesophyll**, has several layers. The **palisade layer** has thin-walled cylindrical cells called **chloroplasts**. These close-packed cells contain **chlorophyll**, the pigment that absorbs light energy in photosynthesis.

Beneath the palisade is the **spongy layer** which has loose-packed, irregularly shaped cells that form large air spaces. Most gas exchange – oxygen (O_2) and carbon dioxide (CO_2) – occurs in this area.

3. Transporting

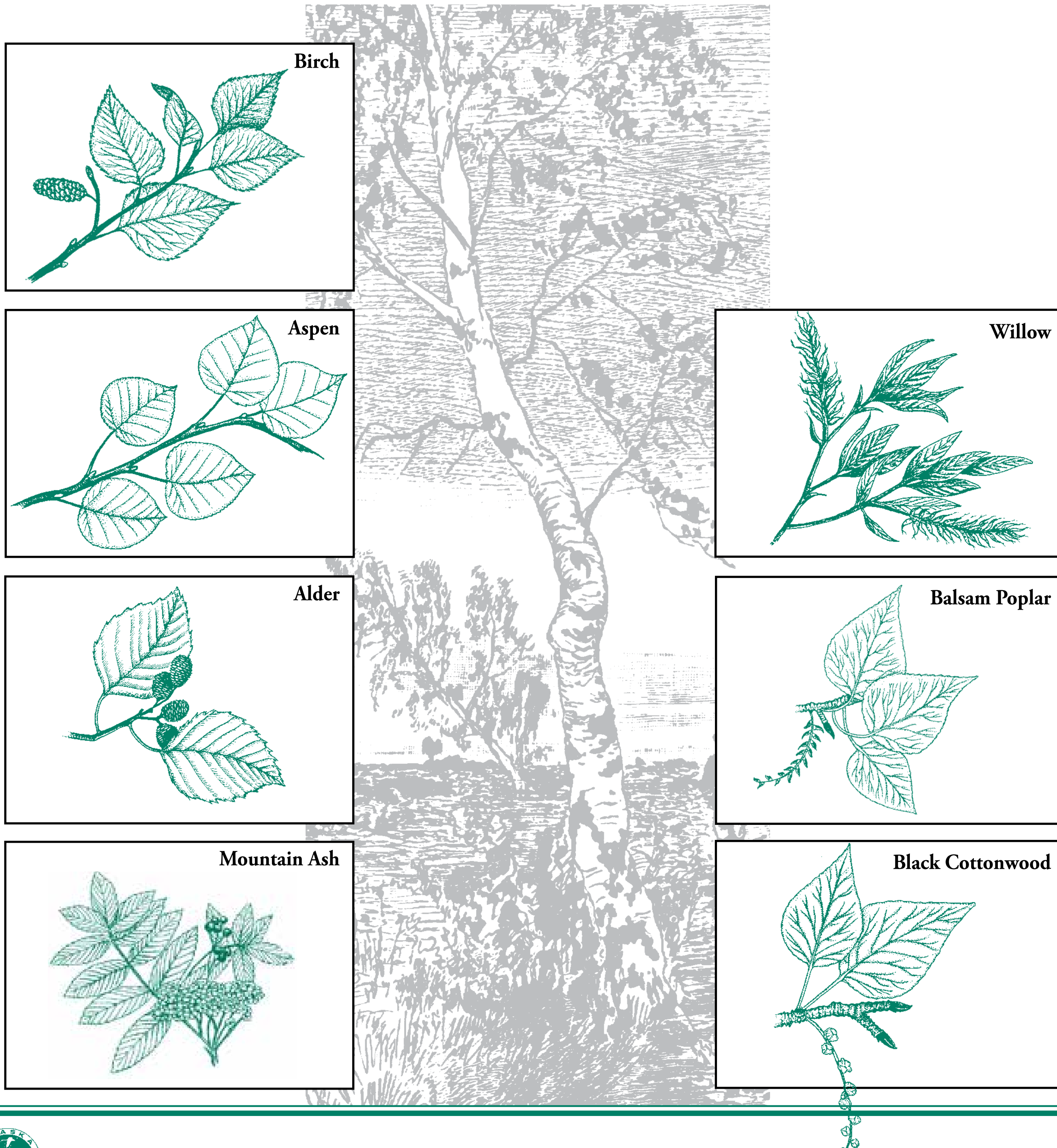
Veins transport materials to and from the leaf. The veins are tubes divided into the **xylem** and the **phloem**. The xylem carries water and minerals *up* from the roots. The phloem transports food produced by the leaf *down* to the rest of the tree.

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.



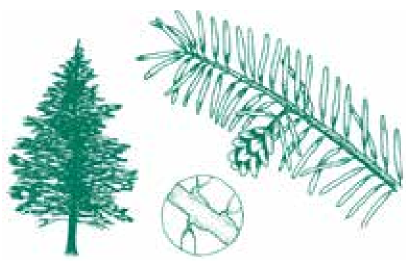
ALASKA'S CONIFER TREES

Look at the leaves.

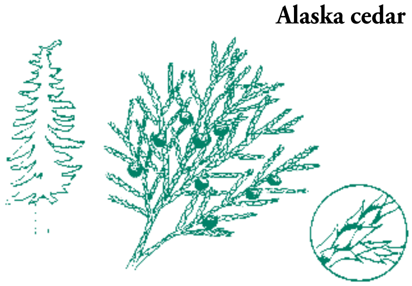
- If the leaves look like needles or scales – just picture a Christmas tree – the tree is a **conifer, gymnosperm**, or **softwood.**

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.

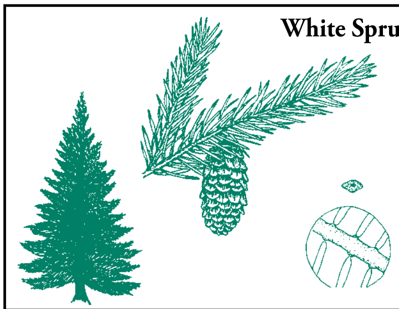
Since conifers typically keep their narrow, needle leaves all winter they are also called **evergreens**. One Alaskan conifer – the tamarack – is **deciduous** and loses its needles each autumn.



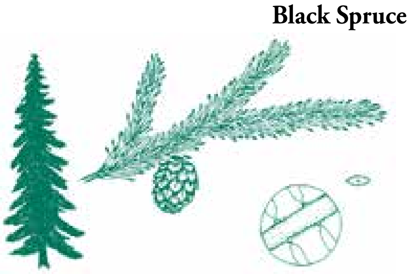
Western Hemlock



Alaska cedar

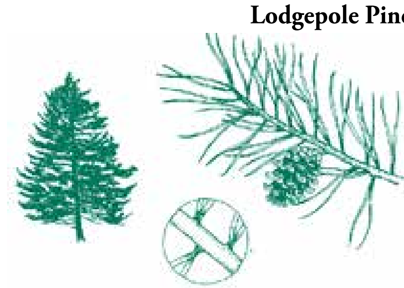


White Spruce

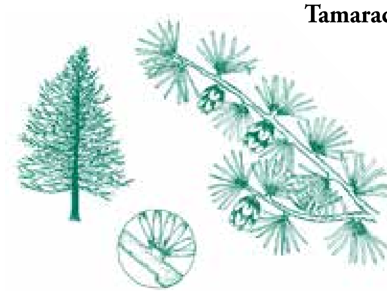


Black Spruce

Mountain Hemlock

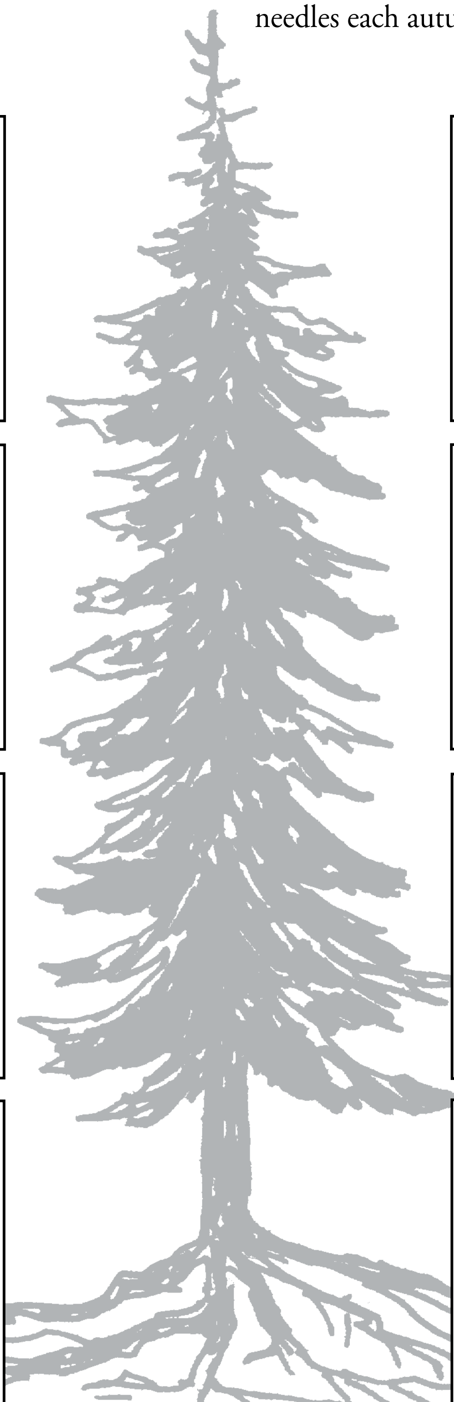


Lodgepole Pine



Tamarack

Sitka Spruce



PROFILES OF ALASKA FORESTS

Three Living Layers

Trees are not the only green, growing things in a forest. Three layers of plants make up our forests. They shade the forest floor, stabilize and aerate the soil, moderate the climate, and purify the air.

1. Canopy

Older trees form the top layer or **canopy** of the forest. Those trees receive the most sunlight.

2. Understory

Shrubs and young trees – closer to human height – grow protected and somewhat shaded beneath the old trees in the **understory**. The young trees will someday become the canopy.

3. Ground Cover

Small plants grow – under our feet — as **ground cover** on the forest floor.

Coastal Rainforest

Alaska's temperate rainforest doesn't fit the image many people have about rainforests. No steamy tropical jungles here, but do have plenty of rain!

1. Canopy

Hemlock and spruce trees

2. Understory

Blueberry, salmonberry, devil's club, and elderberry shrubs

3. Ground Cover

A dense jumble of ferns, mosses, dogwood, liverworts, twisted stalk, trailing bramble, and false lily-of-the-valley

Boreal Forest

Alaska's boreal forest struggles to survive. Where it loses the struggle, the treeless tundra begins.

1. Canopy

A mixture of white and black spruce, aspen, and birch

2. Understory

High bush cranberry, buffaloberry, Labrador tea, and wild rose

3. Ground Cover

Crowberry, dwarf dogwood, twin flower, low bush cranberry and some ferns, mosses, liverworts, and club mosses

THE GIVING FORESTS

Unique Contribution. Forests, more than any other plant ecosystem, contribute to the nonliving environment that originally shaped them. Their influence is felt both locally and globally.

Breath of Life.

Trees remove **carbon dioxide** from the air and return **oxygen** in the process of **photosynthesis**. Animals, including humans, need oxygen to breathe. After our lungs process the oxygen, we exhale a waste product – carbon dioxide. Just what the forest and other plants need!

Forests help to maintain the balance of oxygen and carbon dioxide in our atmosphere, keeping the air breathable for all living things. During the growing season, one average tree supplies the 360 liters of oxygen you need each day.

An acre of forest plants restores 2 to 3 times more air per day than an acre of meadow or tundra plants. About 10 million acres of the Tongass National Forest are comprised of trees. That's a lot of oxygen!

Air cleaner, wind break.

Studies have shown that air in forests contains much less dust and air pollutants than air in other areas. Leaves and branches trap dust and pollution particles, provide moisture, and slow the wind. A forest can reduce a howling wind to a gentle breeze.

Global water cycle.

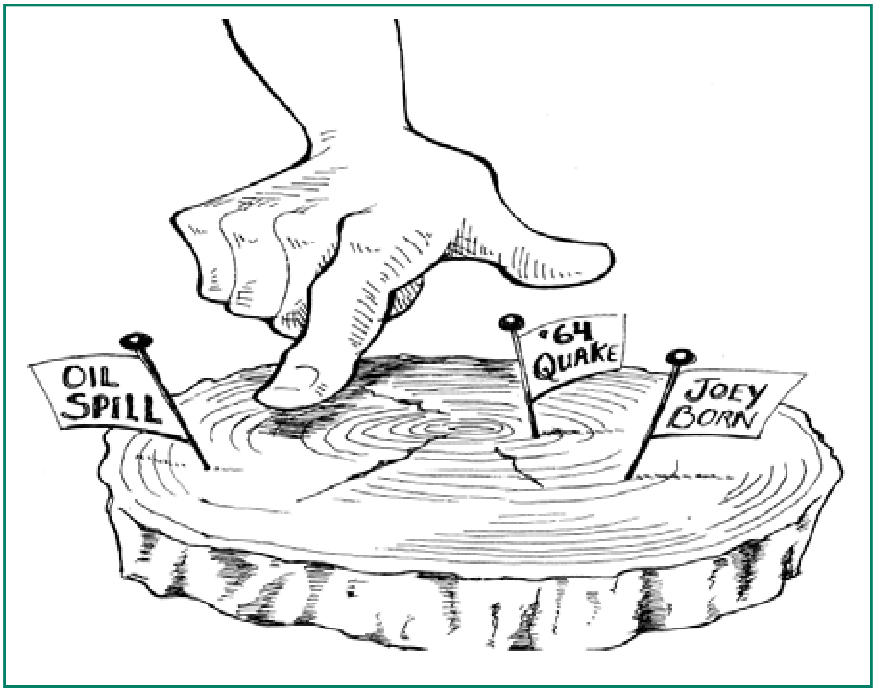
When scientists looked for the source of rain and snow clouds, they discovered the **water cycle** and the important role of trees in returning moisture to the atmosphere. Forests recycle water that falls to earth in two ways:

(1) Rain and snow are trapped on leaves and branches and then evaporate.

(2) Water that reaches the roots is used by the tree and then exhaled back into the atmosphere through **transpiration**. A single tree may pump 80 gallons of water into the air on a hot day.

In this way, forests help make the rain that falls on the earth.

READING TREE RINGS



1 – Age and Conditions of Growth
A **cross-section** of any tree trunk reveals the different layers that make up a tree *(see "Inner Workings – Tree Trunks" for details)*.

Each year the **cambium** forms a layer of light-colored cells in spring and a layer of dark-colored cells in summer. These are called **annual rings**. You can "read" the age of the tree by counting either the light or dark rings in a cross-section of the trunk.

The annual rings vary in width depending on the weather and growing conditions.

Because trees are sensitive to climatic changes, scientists can learn about past climates by studying the ring patterns of very old trees. This study is called **dendrochronology**.

An adequate amount of rainfall in the spring will ensure that the **earlywood** (*light-colored ring*) is relatively wide. In contrast, a period of summer **drought**, when little rain falls, will result in a narrower, darker band because the tree was unable to grow as much.

Bristlecone pines *(not found in Alaska)* are so long-lived that scientists can track rainfall during several thousand years!

Other events in the ecosystem also influence the size of the annual rings: forest fire, wind damage, attack by viruses or bacteria, and a long winter with a late spring. All are factors that affect the width of the growth rings.

Fires and parasites, for example, leave scars. In the past, people who managed forests tried to put out all fires. The Smokey the Bear campaign taught generations of Americans that fire is bad for forests. In studying fire scarring in tree rings, however, we see that periodic fires are a natural part of healthy forest ecosystems.

2 – Cross-Dating the Rings
Cross-dating is another important technique used by dendrochronologists. Cross-dating compares the growth rings from one tree to the growth rings of another tree and matches the ring patterns of the years when the two trees both lived.

Scientists take a **core sample** to look at the rings of a living tree without cutting it down. By drilling into the center of a tree trunk with an instrument called an **increment borer**, they can remove a piece of wood that is about the thickness of a soda straw.

The growth rings of the tree show up as lines on the core sample. Scientists count these lines to determine the tree's age *(see diagram next page)*.

HERE'S HOW CROSS-DATING WORKS:

1. Scientists first take a core sample from a living tree that produces distinct, reliable annual rings. *(Conifers growing in the American southwest produce some of the most reliable, drought-sensitive rings.)* By counting backward from the outer ring *(the current year)*, they can assign each ring a year, then figure out when the tree sprouted and how old it is.

2. Scientists find an older tree to compare with the younger tree. The older tree must (a) be the same kind of tree *(trees of the same species have similar growth rings)*, (b) grow or have grown in the same area, and (c) have been alive for part of the time that the younger tree was growing up.

(In cross-dating, scientists often use stumps, logs, beams in old building, or any part of a tree trunk that clearly shows the annual rings.)

3. Dendrochronologists then compare the inner *(oldest)* rings of the core sample with the outer *(youngest)* rings of the stump or log to find a section where the ring patterns match *(see diagram)*.

4. Since the scientists have already assigned dates to the younger tree, they can now assign the same dates to the overlapping rings on the older tree. Then they can count backward to date all the rings on the older tree.

5. By finding still older trees, and overlapping them with increasingly older trees, scientists have discovered cycles of drought from more than 10,000 years ago, the dates ancient cities were built, and even the age of the wood used to frame paintings done by Rembrandt! ***(Cross-dating is more accurate than radioactive carbon dating, a method used to tell the age of fossils and ancient artifacts.)***

CROSS-DATING TECHNIQUE