Unit I
Forest and Tundra Ecology

National Wildlife Refuge System
1011 E. Tudor Road
Anchorage, Alaska 99503
http://alaska.fws.gov/fire/role/

UNIT I: FOREST AND TUNDRA ECOLOGY

An Overview

Reading the Alaskan Environment (K-12)
In an outdoor activity, students closely observe their environment.

Identifying Objects (3-8)
Students learn about dichotomous keys and how they are used to identify plants.

Critter Search (K-12)
Students look for evidence of small animals and their tracks in an outdoor setting.

The Summer Plant Keys (6-12)
Student use a game format to construct a dichotomous key representing the summer plants of the boreal forest.

Blind Walk (K-12)
In an outdoor activity, students explore the local ecosystem using only their sense of touch and smell.

Transect Study (6-12)
Students set up transects near the school to systematically study the local ecosystem.

Making the Forest and Tundra Wildlife Connection (5-12)
Students participate in an active game to form food chains of the boreal forest.

The Succession Race (5-8)
Students play an active game in which they pretend they are plants. As the plants progress through boreal forest succession they encounter conditions which affect them.

Boreal Forest Succession (5-8)
Students observe and record the different stages of forest succession around their school grounds, and illustrate succession in the boreal forest by making field notebooks and a mural.

Living on the Edge (5-8)
Students play a game to create a vegetation mosaic and discuss their influence on wildlife diversity.

AND ADAPTED AND/OR REPRINTED FROM ALASKA'S FORESTS AND WILDLIFE (from the Alaska Wildlife Curriculum):

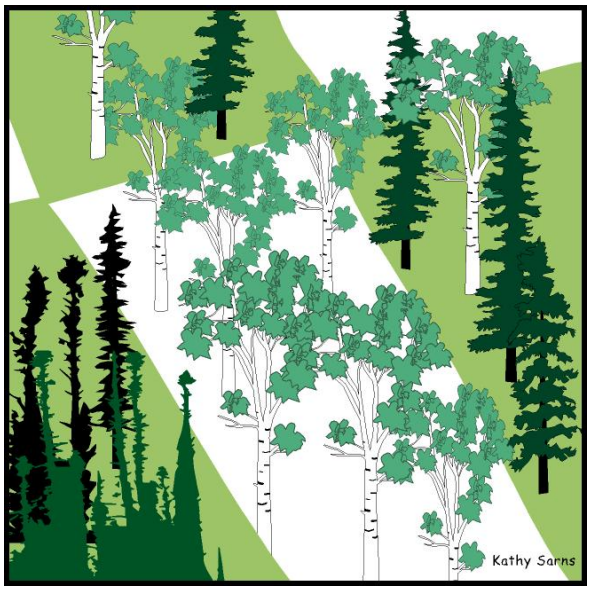
Tree Leaf Relay (3 – 12)
Students learn the identifying characteristics and names of several Alaska tree species by examining leaves, and participating in a relay race.

Tree History – Your History (K – 12)
Students learn dendrochronology techniques to determine the age of trees and the dates that trees died or were logged, as well as the dates of important forest events.

Role of Fire
UNIT I: FOREST AND TUNDRA ECOLOGY
BACKGROUND

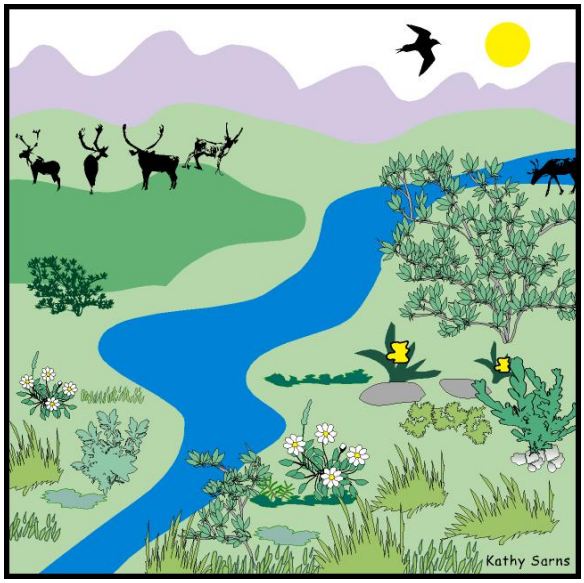
Central and western Alaska is dominated by two major ecosystems, the boreal forest and the tundra. Although these ecosystems look very different, they are similar in many ways.

WHAT IS THE BOREAL FOREST?
The boreal forest is the largest and northern most forest ecosystem in the world. The boreal forest is the predominant ecosystem in interior Alaska. Viewed from the air, this forest looks like a giant patchwork quilt or mosaic. Large patches of scraggly black spruce trees on poorly drained and permafrost soils, contrast with hillsides of light green birch, aspen and tall white spruce.



WHAT IS THE TUNDRA?
Tundra is an environment characterized mainly by the absence of trees. At first glance, tundra appears monotonously the same. But closer examination reveals that, like the boreal forest, the tundra is a mosaic. It is a mosaic of wet, sedge-grass meadows, thickets of low shrubs, and dry areas vegetated by cushion and mat-forming plants.

Tundra occurs predominantly at higher elevations and in the western and northern areas of Alaska (Fig. 1). However, the boreal forest and tundra frequently occur together. Patches of tundra are often found within the boreal forest areas, and patches of forest can be found in tundra areas.



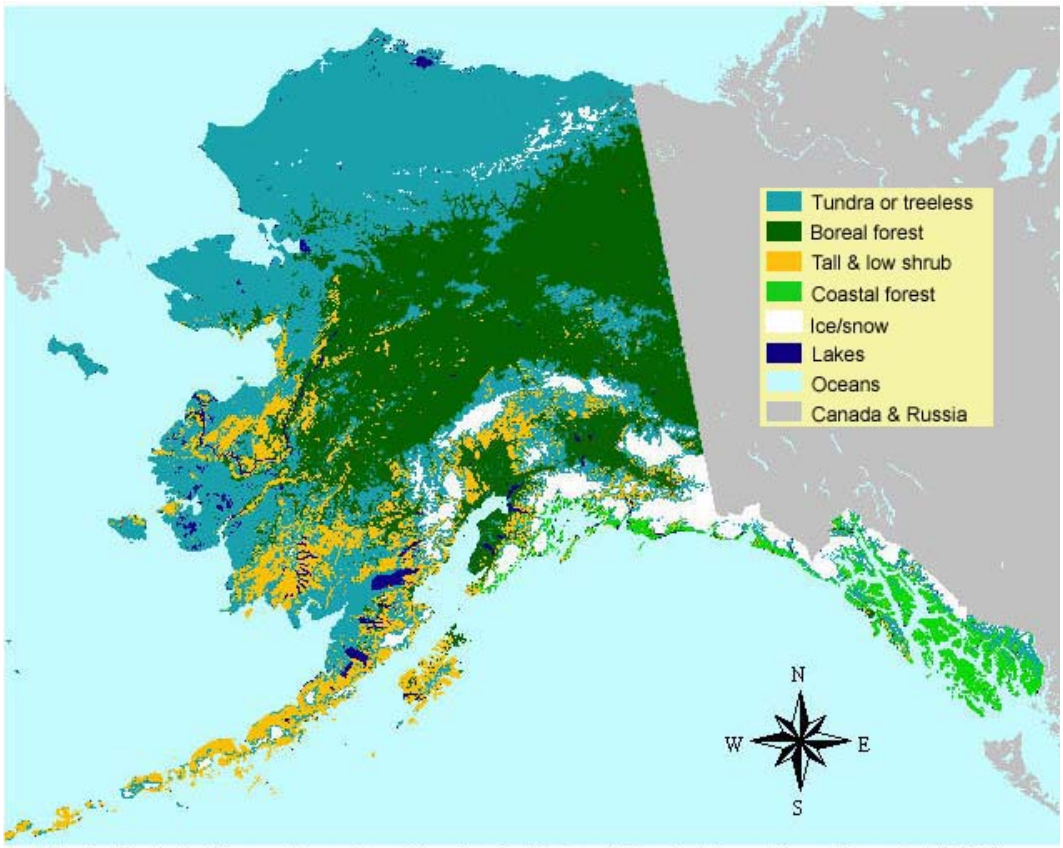


Fig. 1 - Extent of boreal forest and tundra in Alaska. Adapted from Flemming et.al. (1991)

WHAT ARE THE NONLIVING COMPONENTS OF BOREAL FOREST AND TUNDRA?

Like all land ecosystems, Alaska boreal forest and tundra include the nonliving components of air, water, soil, and energy (in the form of sunlight). These form the physical surroundings of the ecosystem. Some physical features of the boreal forest and tundra are:

1. strong seasonal patterns (severe winters and short, warm summers)
2. permafrost
3. little precipitation
4. lightning-caused fires
5. ice jams and floods

Seasonal Patterns

In winter, when the northern regions are tilted away from the sun, the land receives only a few hours of light each day. During these few hours, the sun barely rises above the horizon. The winter sun delivers little heat and light to the forest and tundra, and more heat is lost to the atmosphere than is received from sunlight. Winter air temperatures plunge below zero, often reaching extremes of -40^{o} F (-40^{o} C) or colder.

During summer when the earth's northern latitudes are tilted towards the sun, day length is nearly 24 hours and the sun rises higher above the horizon and delivers more light and heat per hour. The boreal forest and tundra then receive more heat in sunlight than they lose. Thus, temperatures rise. Air temperature extremes above 90^{o} F (32.2^{o} C) regularly occur in the boreal forest. In the tundra, summer temperatures are usually cooler, but may still reach extremes of 68^{o} F (20^{o} C).

Permafrost

Despite the warmth of summer, the climates of both the boreal forest and tundra are dominated by the severe cold of winter.

Thus, permafrost, or permanently frozen ground, occurs in some areas. Surface soils called the active layer thaw out each summer and refreeze in winter. Beneath the active layer, permafrost remains frozen year-round.

Permafrost underlies most tundra areas and occurs throughout the northern portions of the boreal forest. In these northern areas, permafrost is continuous, occurring everywhere. In other areas of the state, permafrost is discontinuous, occurring only in some places but not everywhere. Where permafrost is discontinuous, it generally underlies north-facing hillsides and poorly drained lowlands. Permafrost is absent from most south-facing hillsides and from the well-drained sandy soils around large bodies of water. In the southernmost reaches of the boreal forest, permafrost is sporadic or absent (Fig. 2).

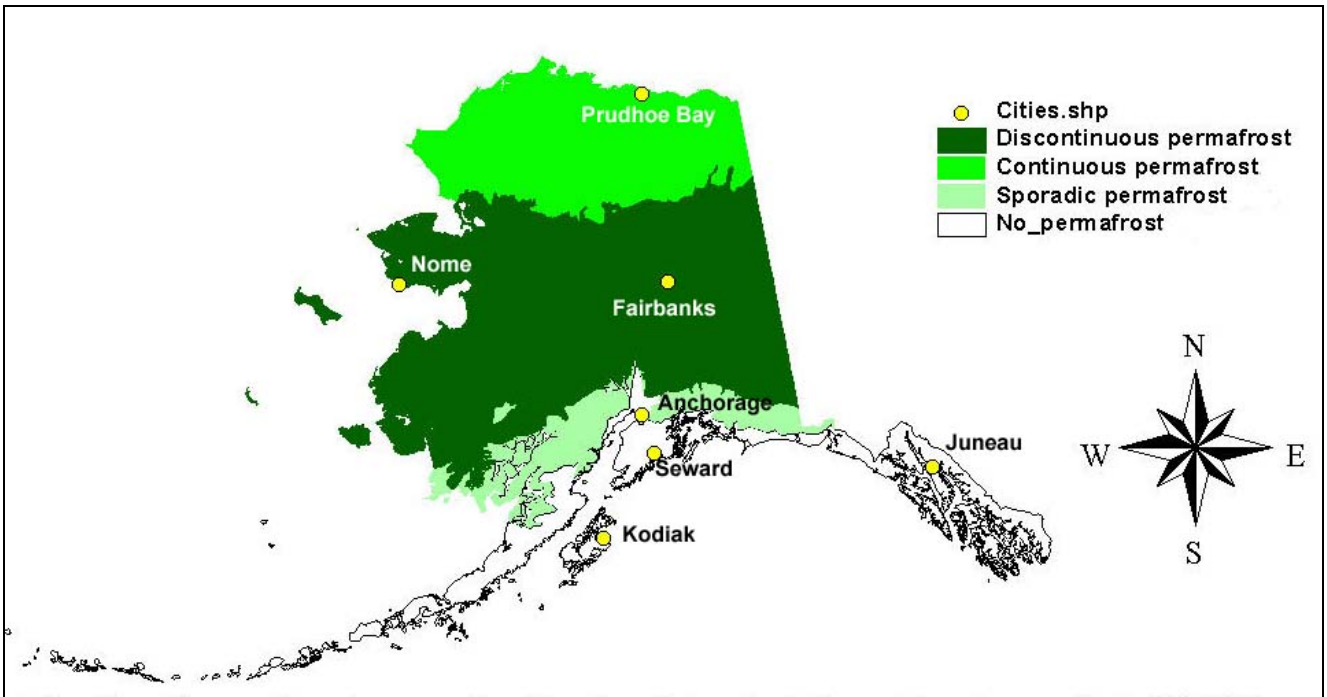


Fig. 2 - Permafrost areas in Alaska. Adapted from Ferrians et al. (1969).

Precipitation

The boreal forest and tundra receive little precipitation; in both ecosystems the average annual precipitation is only 5 to 12 inches (120-300 mm). This is similar to the amount of precipitation in many deserts of the world. However, unlike a desert, many sites in the tundra and boreal forest are moist or wet.

Moist and wet conditions occur despite low precipitation partly because cool temperatures cause low evaporation rates. In addition, water cannot seep into permafrost soils.

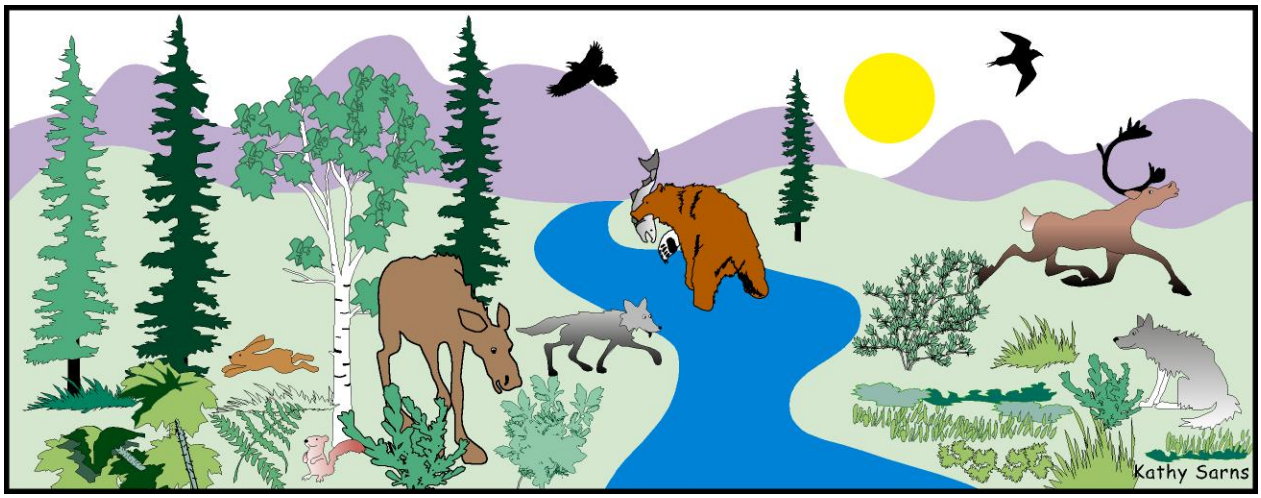
Fire

Wildland fires caused by lightning are a natural part of Alaska's boreal forest and tundra ecosystems. Layers of charcoal in lake beds, wetlands, fire-scarred trees, and logs provide evidence that fires have occurred in the boreal forest environment for thousands of years. Due to the absence of trees, tundra fires leave little long-lasting evidence of their passage. Therefore, the history of fire in tundra regions is less clear. Based on historical fire records, scientists think fires naturally occur in some tundra regions, such as the Seward Peninsula, but are rare or absent from other tundra areas. In general, fires occur less frequently and

burn smaller areas in tundra than in the boreal forest. However, large tundra fires have been recorded. Fire is one of the greatest forces of change in the boreal forest and tundra.

Ice Jams and Flooding
During spring thaw, ice quickly breaks up on the rivers of Alaska. The ice pushes it's way downstream, scouring the banks and often leaving tree and plant roots exposed. This ice can also pile into ice jams which may dam the river and cause extensive flooding.

WHAT ARE THE LIVING COMPONENTS OF THE BOREAL FOREST AND TUNDRA?



Many kinds of living things inhabit the boreal forest and tundra, including microscopic organisms, fungi, plants, and a wide variety of animals (insects and other invertebrates, birds, and mammals).

Microscopic Organisms
The **microscopic organisms** of the boreal forest and tundra include bacteria, algae, and protozoa. These creatures are easy to overlook since a microscope is needed to observe them. But, they are important parts of the forest and tundra. They live in the soil, water, and air and inside other living things.

Fungi and Lichens
Fungi of the boreal forest and tundra include mushrooms, molds, rusts, mildews, and rots. Most are important **decomposers**, meaning they help break down or decay dead plants and animals. Other fungi live together with certain kinds of algae and are called lichens. **Lichens**, like plants, **photosynthesize** (they convert air, water, and sunlight into sugars for food).

Lichens are a dominant organism in some tundra regions and an important nutrient source for caribou.

Plants
Plants are the most noticeable of the living components of both the boreal forest and tundra. The dominant species of trees of the boreal forest include black and white spruce, birch, aspen, and balsam poplar. A variety of shrubs, herbs, grasses, mosses, and ferns grow in association with these trees. The boreal forest is often classified into several forest cover types based on the dominant species of trees and associated plants.

Tundra areas are predominately treeless, but the dominant tundra plants vary from area to area. Mosses and sedges are the most abundant plants in wet tundra. In moist sites, dryas, dwarf shrubs such as willow, bog birch, crowberry, and Labrador tea are important. Mat and cushion plants such as moss campion and arctic bearberry grow in dry tundra.

Animals

The animals of the boreal forest and tundra include birds, mammals, amphibians, and insects and other invertebrates. See the *Alaska Ecology Cards* for a detailed listing.

Birds

Birds of the boreal forest and tundra of Alaska include residents (birds that live here year-round) and migrants (birds that nest here but winter elsewhere).

Typical boreal forest bird residents include gray jays, black-capped chickadees, redpolls, pine grosbeaks, and common ravens; hairy, downy, three-toed, and black-backed woodpeckers; ruffed and spruce grouse; boreal, great-horned, great gray, and hawk owls; and goshawks. Migrant birds include several thrushes, warblers, swallows, sparrows, and waterfowl.

Few bird species are tundra residents, but a wide variety of migrants return to the tundra each year to nest. The few resident species include ptarmigan, snowy owls, and ravens. Common migrant species include loons, ducks, geese, swans, shorebirds (plovers, sandpipers, phalaropes, gulls, and jaegers), short-eared owls, rough-legged hawks, and a few songbirds (snow buntings, Lapland longspurs, and water pipits).

Mammals

Many of the same species of mammals live in both the boreal forest and tundra. Common species of the boreal forest include moose, caribou, snowshoe hares, red-backed voles, red squirrels, beavers, porcupines, coyotes, red fox, pine marten, wolves, and black and brown bears.

Common tundra species include moose, caribou, voles, lemmings, arctic ground squirrels, red fox and arctic fox, wolves, wolverines, and brown bears.

Did you know that voles are some of the first mammals to re-establish homes in an area after a fire? Voles play a critical role in Alaskan ecosystems because they help distribute plant seeds throughout the burned area and they provide food for many birds and mammals. Alaska has seven species of voles. Yellow-cheeked voles, and red backed voles are some of the most common. Do you know what types of voles are found in your part of the state?

Throughout this document we have a very special vole, Vince, who is often found in unusual places (for a vole). Look for Vince in the pictures!

Amphibians

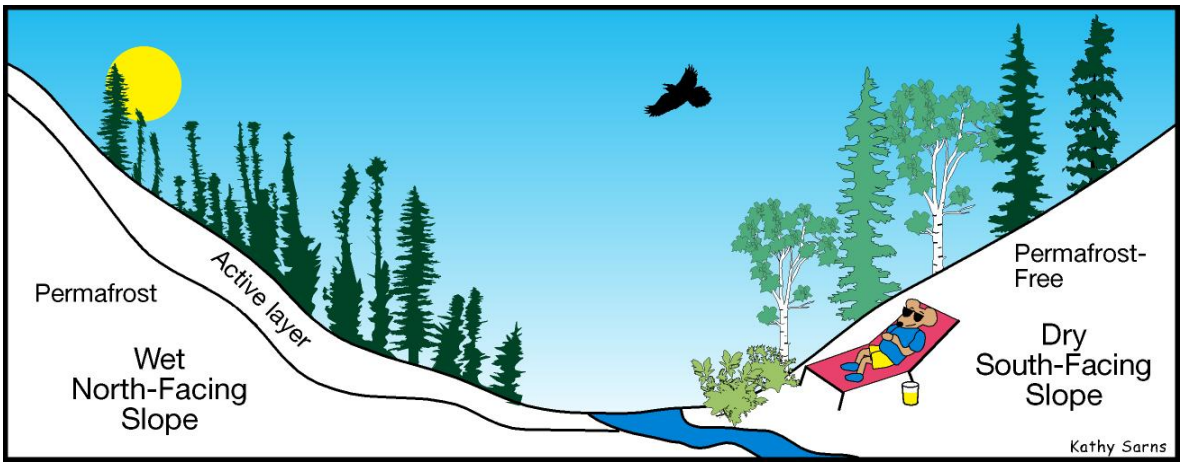
The wood frog is the only amphibian that occurs throughout the boreal forest in Alaska. The wood frog is absent from most tundra areas, though it has been recorded in a few locations.

Invertebrates

Invertebrates (animals without backbones) are the most abundant animals in both the boreal forest and tundra. Despite their small sizes, the combined weight of all invertebrates is greater than the combined weight of all mammals and birds. Invertebrate animals live in the soil and

water and on plants. Ants, bees, wasps, butterflies, moths, mosquitoes, lacewings, aphids, beetles, leaf hoppers, and dragonflies are just a few of the kinds of insects that occur in these environments. Centipedes, spiders, mites, slugs, and segmented worms are some of the other invertebrate groups that occur.

HOW DO THE NONLIVING COMPONENTS AFFECT THE LIVING THINGS?



The strong seasonal patterns, permafrost, and low precipitation of the boreal forest and tundra combine with the **topography** (landforms) to create a mosaic of physical environments. The **mosaic** is most visible in the boreal forest. There, in areas of discontinuous permafrost, most south-facing hillsides are relatively warm, dry, and free of permafrost. In contrast, north-facing hillsides and poorly drained lowlands are cool, wet, and underlain by permafrost.

Since plants are adapted to specific environmental conditions, these different physical environments create a mosaic of forest types. Warm, dry, south-facing hillsides and well-drained sites along rivers provide conditions suitable for aspen, birch, balsam poplar, and white spruce. Black spruce and tamarack (or larch) are permafrost indicators and dominate in the cold, wet soils.

A similar but less obvious mosaic occurs in tundra. In most tundra areas, permafrost is continuous, but the depth of the active layer (the layer of soil that thaws each year) varies depending on the topography and soil. Freezing and thawing of the active layer over the permafrost creates a variety of landform features such as pingos (mounds of earth formed by frost action) and polygons (blocks on the soil surface caused by freezing and thawing.) Soils high in clay content tend to inhibit drainage while gravely soils allow better percolation. Flat, low-lying sites tend to be flooded or wet, while slightly elevated or sloped sites may be well drained and drier. Certain plants grow best in wet sites; others prefer the drier sites. In many tundra areas, a few inches of elevation change results in a very different physical environment and a complete change in the plant species present. In a very small area one may find dry tundra plants on top of **tussocks** and wet tundra plants in between.

This continually evolving mosaic of forest and tundra types created by environmental variation is complicated. It is constantly modified by physical factors such as fire, floods, drought and frost action. Living organisms affect the mosaic in several ways. Insects kill trees. Beavers dam streams and flood forests. Humans change the mosaic by logging, mining, development, and land clearing. These events and actions affect the mosaic by changing the pattern of succession.

WHAT IS SUCCESSION?

Succession is the natural, orderly change in plant and animal communities that occurs over time. The successsional timeline has been divided into stages that portray the slow, continuous changes in an environment. When an existing environment is disturbed by fire, insects, development, resource extraction, flood, or extreme weather, it generally reverts to an earlier successional stage. Herbs and shrubs dominate the earliest stages of succession. Intermediate stages follow, dominated by tall shrubs and young trees. Finally, a mature forest stage and an old growth forest stage may follow. The pace of succession may be affected by soil conditions, climate, permafrost, topography, and natural forces.

Each species of plant has particular **habitat** requirements. These habitat requirements include specific amounts of light, heat, soil nutrients, and water. As succession occurs, tall plants create shade. Layers of moss insulate the soil and cause a drop in soil temperatures. More and more minerals become tied up in living and dead plant material. These changes in the physical environment change the suitability of a site for different plant species. The species and numbers of plants present change as the physical conditions of the environment change.

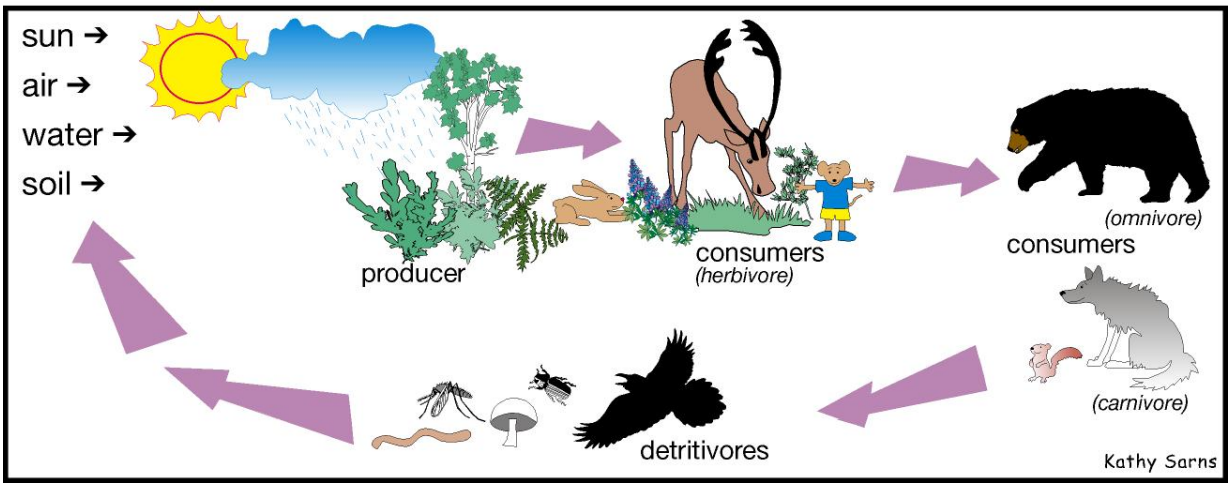
Like plants, wildlife also has specific habitat requirements. Each species of animal needs the right kinds and amounts of food, water, cover, and space; wildlife populations change during succession, too.

Succession strongly affects wildlife use of the boreal forest. Some wildlife, such as white-crowned sparrows fulfill their habitat needs in the shrub thickets of early forest succession stages. Others, such as white-winged crossbills, need large expanses of mature aging spruce forests to survive. Much boreal forest wildlife need a mixture of forest ages to meet their habitat needs. Snowshoe hares are a good example. Young willow and birch shrubs, which flourish in the early stages of succession, provide the food snowshoe hares need. But, when seeking shelter either from a predator or winter weather, hare need the shelter provided by the spruce forest. The area where several habitats meet is called an **edge** and generally holds the largest diversity of wildlife.

Succession exists in the tundra as it does in the boreal forest, although it is not as clearly understood and is extremely slow in comparison. Early succession is visible where lake levels have lowered and plants grow on the newly drained soil. Cottongrass tussocks take a long time to establish and don't grow in recently disturbed sites; if cotton grass is evident, then the area is probably in the later successional stages. Trees or shrubs with thick, gnarled, lichen covered stems are found in the later successional stages as well. Because little research has been done regarding tundra succession, less is known about its effects on plant and animal communities.

.

IN WHAT WAYS DO THE LIVING AND NONLIVING COMPONENTS OF THE BOREAL FOREST AND TUNDRA INTERACT?



A **food chain** describes the path of energy and nutrients from the nonliving parts of the ecosystem, through the living components, and back to the nonliving environment. By cycling nutrients, food chains connect the nonliving and living components of the boreal forest and tundra.

The basic link of every food chain is formed by the energy and minerals in the nonliving components of air, water, soil, and sunlight. Most organisms cannot use energy and minerals directly from the nonliving environment. Those organisms that can are called **producers** and form the next link in the food chain. They are called producers because they make, or produce, food for themselves and all other living things. Plants are the most important producers in the forests and tundra; lichens, algae, and some bacteria are also producers.

Consumers form the next link in food chains. All organisms other than producers are called consumers because they obtain energy and minerals by consuming (eating) other living things.

Consumers are grouped according to the type of foods they eat. **Herbivores** eat producers such as plants. Herbivores of the boreal forest and tundra include moose, caribou, voles, lemmings, grouse, redpolls, and many insects and other invertebrates. Carnivores eat these herbivores.

Carnivores include meat-eating animals such as wolves, coyotes, foxes, lynx, owls, jaegers, hawks, and insect-eating animals such as chickadees, warblers, shrews, centipedes, spiders, and dragonflies. Some consumers feed on a wide variety of organisms, including both living and dead plants and animals. These consumers are called **omnivores**.

Producers and consumers store some energy and nutrients in their tissues. They also lose energy and minerals in their wastes and use some energy to move around and grow. Consumers that eat dead organisms and waste materials are called **detritivores**. Detritivores include some large animals such as ravens; but the most important detritivores of the forest and tundra are invertebrates, fungi, and microscopic organisms. Many of these live in the soil where most of the dead organisms, animal droppings, and other waste materials accumulate.

The process of waste materials being broken down and decayed by detritivores is **decomposition**. The minerals and nonliving materials released by decomposition are returned to the soil and air to possibly be reused by producers.

DOES SUCCESSION AFFECT THE PROCESSES OF PRODUCTION AND DECOMPOSITION?

Energy flow in the boreal forest is continually changing. The total amount of organic material manufactured by producers (**annual production**) is greater in early successional stages (particularly following fire). In early succession, the fast growth of herbs, shrubs, and deciduous trees results in high annual production. In contrast, annual production in late succession is lower and is dominated by mosses, lichens, and spruce trees. This affects the food chain as few consumers can digest mosses, lichens, or spruce needles. Thus, fewer consumers live in old growth forests than in younger forest stands.

Decomposition occurs more rapidly in young forests than in older ones. Spruce needles and mosses are difficult to decompose and soil temperatures in older successional stages are often lower due to the insulating effects of the organic mat and the shading effect of larger trees.

The effects of succession on production and decomposition rates in tundra have not been well documented. There is some evidence that annual production and flowering of some plants increases during the first years following a tundra fire due to the warmer, mineral-rich soil. Increased depth of the active layer also leads to faster rates of decomposition during the initial years following fire. In the long-term, however, lush plant growth resulting from fire may increase the insulation of the soil. This ultimately decreases the depth of the active layer and thus decreases decomposition and production rates. More research is needed on the complex interactions between fires, plant succession, production, and decomposition in tundra areas.

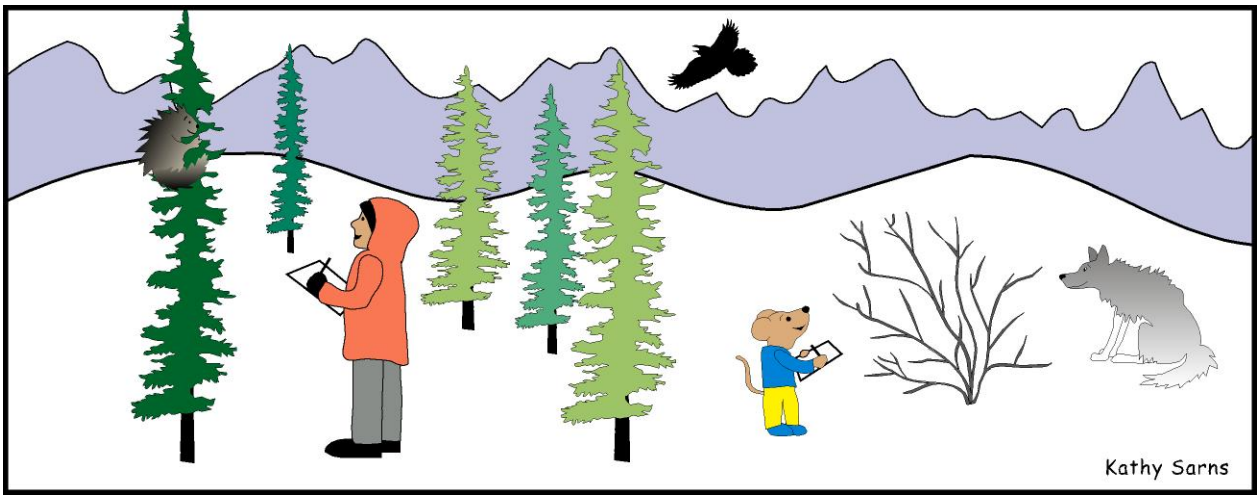
HOW DO LIVING THINGS AFFECT THE PHYSICAL ENVIRONMENT?

Plants of the boreal forest and tundra also affect the occurrence of fires. Fires could not occur if not for the fuel provided by the growth and accumulation of plant materials (wood, branches, dead leaves and stems, and dead mosses). These accumulated fuels decompose slowly due to cool soil temperatures. The plant species mix also influences the extent and intensity of fires due to variation in growth forms and chemical composition. Heaths (such as blueberries, cranberries, huckleberries, and Labrador tea) contain volatile compounds and are highly flammable. They allow surface fires to start and spread quickly. The drooping branches of black spruce also aid the spread of fire by providing a continuous fuel ladder from the ground to the crowns of trees.

Animal activities may also affect the occurrence of fire. For example, outbreaks of certain insects such as bark beetles can kill hundreds of trees and create optimum conditions for a fire to start and spread. Beavers help to prevent the spread of fires by creating large ponds that act as fire breaks; conversely they enhance the chances of fire by injuring and killing trees which then provide more available fuel. Large piles of spruce cone bracts created by red squirrels provide sources of dry fuel. Animals may also influence the kind and density of plants that occur, which in turn, affects the occurrence of fire. Some scientists have suggested that the

prevalence of highly flammable, oily and resinous plants (such as spruces and certain shrubs) is the result of selective grazing and browsing on more palatable species by wildlife. In some cases, intensive browsing of shrubs and saplings by moose and hares may slow the rate of plant succession. Thus, the frequencies and intensities of forest and tundra fires may be influenced by the animals, as well as by the plants and physical conditions of these environments.

READING THE ALASKAN ENVIRONMENT



Grade Level: K-12
Alaska State Content Standards: Science A-1, A-3, C-2, C-3; Geography C-1; Art A-1
Subject: Science
Skills: Observation
Duration: 1 class period
Group Size: individual
Setting: outdoors
Vocabulary: terminal bud, lateral bud, deciduous trees, hedging, flagging, fungus.

Objective
Students observe a boreal forest or tundra ecosystem.

Teaching Strategy
Students participate in a field trip near their school to observe the characteristics of their local ecosystem.

Materials
- Reading the Alaskan Environment student worksheet
- Boreal Forest Observations and Tundra Observations
- Clipboards or other hard surface to draw on
- Paper and pencil

Advanced Preparation
Before the field trip, look over the outdoor site available to your students. Try to find as many different features as possible. Check the area to see if there are any hazards that should be avoided. If the area you want to use is not public property, get permission prior to taking your students to the site.

Procedure
1. Explain to the students that they will be going outside to observe areas around the school that have distinct forest or tundra features. Review the Boreal Forest or Tundra Observations with students. If you live in an area that has both tundra and forest you may want to review both sheets.
2. Before heading outdoors, review the "Don't Tear Me Apart or Crush My Home" guidelines for investigating an environment.
3. Take students to your designated area. Give students time for the observations outlined in field notebook page.
4. Back in the classroom, compare observations. Ask the following:

a. What was the most interesting thing you observed?

b. Did you see something today that you have never noticed before?

c. What do you think you saw that made this boreal forest or tundra environment unique from one another and other ecosystems?

Evaluation

Divide the class into partners and trade field notebook pages. Students choose an observation from their partner's book and discuss how it is unique to the boreal forest or tundra ecosystem. Students compare and critique one another.

"DON'T TEAR ME APART OR CRUSH MY HOME"

GUIDELINES FOR INVESTIGATING AN ENVIRONMENT

"Yikes! Watch Out! You almost stepped on my home! **Ouch!** You just crunched me with your big foot!"

If plants and animals could talk, this is what they might say to someone who is carelessly tromping through their home. It is important to be aware of your actions when going out to explore wildlife habitat. Here are several guidelines to follow so that minimal damage will be done to the environment as a result of your visit.

1. When visiting private property or public lands, it is your responsibility to know the rules and to follow them. Be sure to get permission from the owner before you visit private land.

2. Stay on the trail whenever possible. If it is necessary to go off the trail, try to avoid stepping on plants and well-camouflaged ground nests.

3. Do not eat any plants or fruits (berries) before asking your teacher or an adult who can positively identify that it is edible.

4. When collecting samples for the classroom, take as few samples as possible and share them. Remember that whatever you take cannot be enjoyed by others who visit the area after you. If many people use the area, collecting should be discouraged, and in many instances collecting may not be permitted at all.

5. When taking a sample, take from the ground before taking from the plant. If you do take from the plant, take only a leaf or a small branch from the side of the plant, not from the top. Some plants have compound leaves, so get a whole leaf and not just a leaflet for identification.

6. Carefully remove the branch or leaf to avoid tearing the bark or damaging the remaining plant.

7. Take bark from dead trees only.

8. Do not take any live eggs or eggshells for classroom samples unless your teacher has a collection permit.

9. When collecting samples, carry the samples carefully so they will be good specimens when you return to the classroom.

10. If collecting a whole plant, loosen the soil around the plant and roots with a digging tool, so roots can be easily removed. Try to collect the entire root or at least a representative portion. Fill in the hole with loose soil to protect plants nearby.

11. If you are interested in viewing wildlife, you must be very quiet and move slowly so you won't frighten the wildlife away before you get a chance to see it!

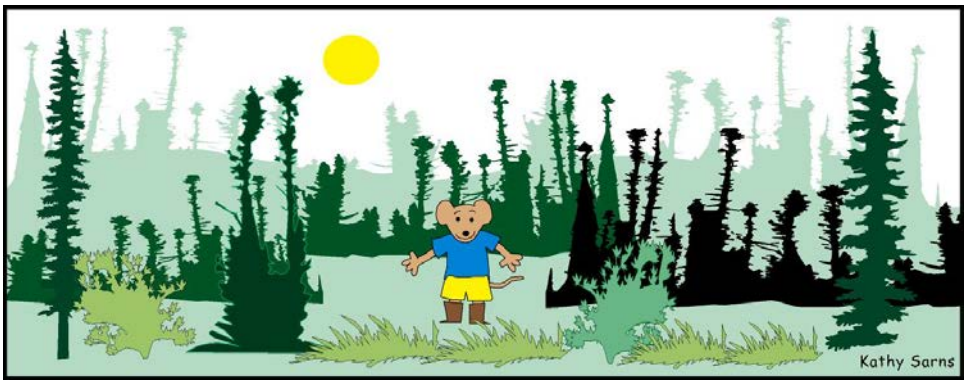
12. A safe distance should always be keep from any animal for your protection and theirs.

Boreal Forest Observations

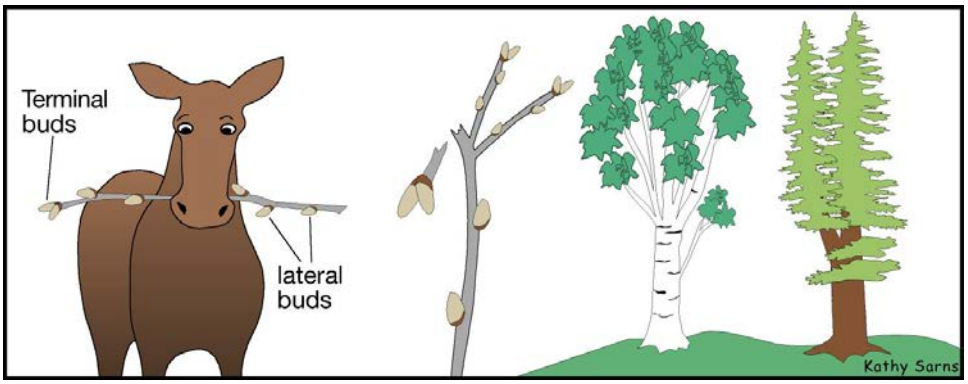
A walk through a forest can tell you about the history and characteristics of the area. Species and condition of the vegetation can give clues to the areas non-living components and to what events have taken place in the past. Look for some of the following features in your forest.

In the boreal forest, if you see white spruce and large aspen trees, you know you have a dry area.

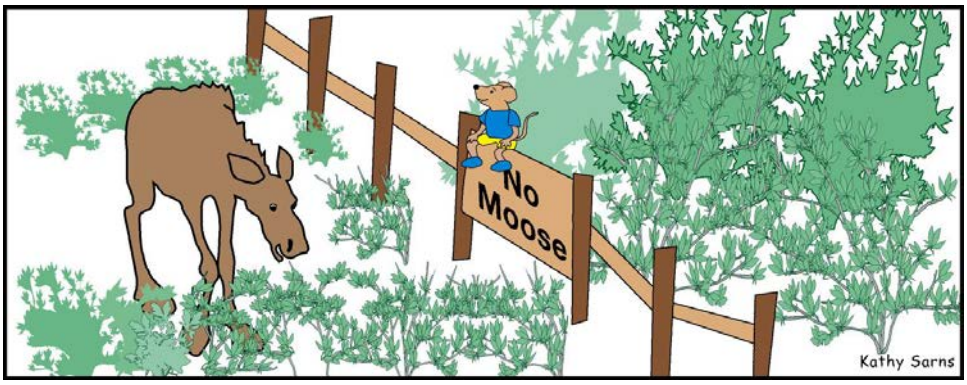
Scrawny black spruce and members of the willow family designate wet or swampy areas.



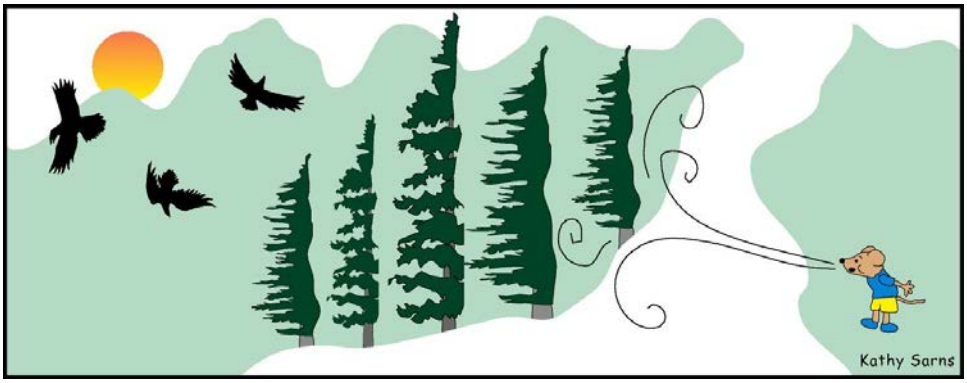
The shape of a tree can tell you about certain events in its life. When the **terminal bud** (top) is damaged or broken off, the **lateral buds** (sides) take over growth. This results in trees or bushes that may look like this. What events might have caused this?



If several trees in an area show these characteristics, it may indicate that insects, over browsing, wind or avalanches have affected that area. When many of the willow and **deciduous trees** (trees that lose all their leaves in the fall) in the area show **hedging** (trees or shrubs that are bushy and cropped at about the same height), it shows that animals like moose are feeding heavily in this area.

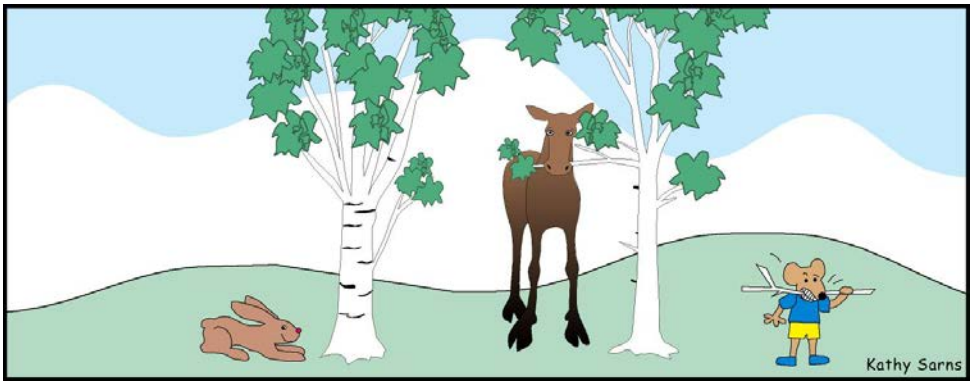


Flagging is caused by having the terminal buds on one side of the tree damaged by wind or avalanches. If you find this condition you should be leery of setting up camp.

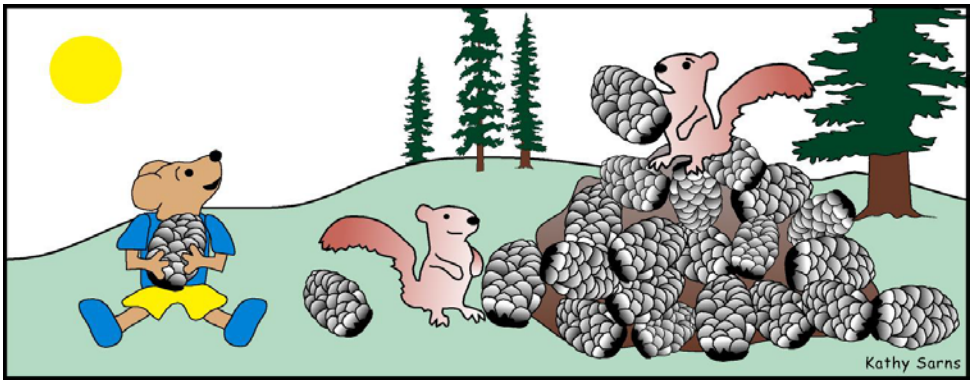


Look closely for sap lines, small holes and sawdust piles on trees. These are signs of insect infestation. When an insect infestation is severe, trees may die. Examples of entire forests affected by insects can be seen on the Kenai Peninsula.

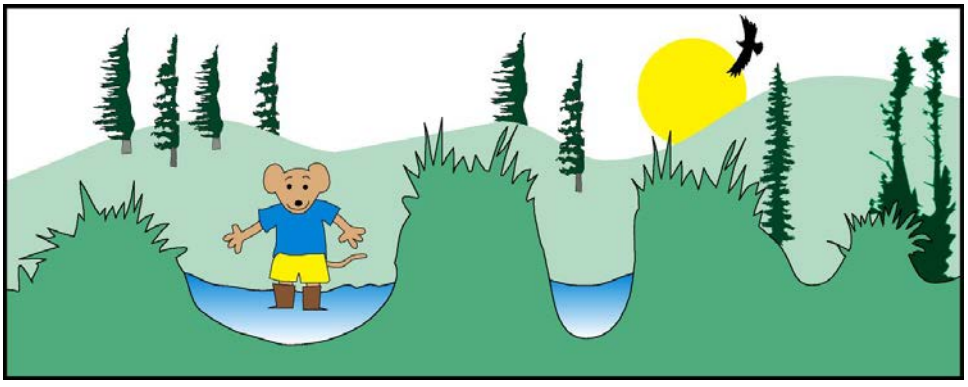
Trees or shrubs with the bark chewed off or broken branches indicate that animals may have used them for food. The height of the damage will help you determine what animal ate it and the time of year when it occurred. You will want to look around these areas for tracks or scat.



Look for caches of cones or piles of cone scales. These indicate that squirrels or other animals have been feeding. Listen carefully for the call of these animals.



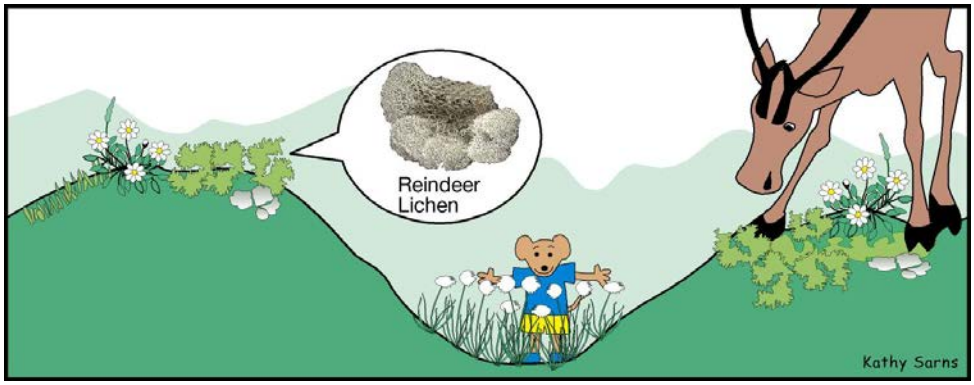
Look for evidence of non-living components such as permafrost (displayed by frost heaves, non-draining water, or pingos,) exposure of the slope (south facing or north facing,) composition of the soil or direction of prevailing winds.



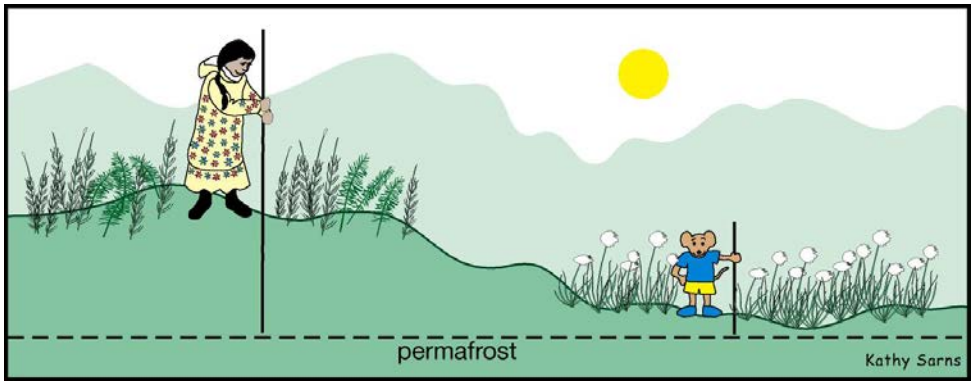
Tundra Observations

A walk through the tundra can tell you about the history and characteristics of the area. Species and condition of the vegetation can give clues to the areas non-living components and to what events have taken place in the past.

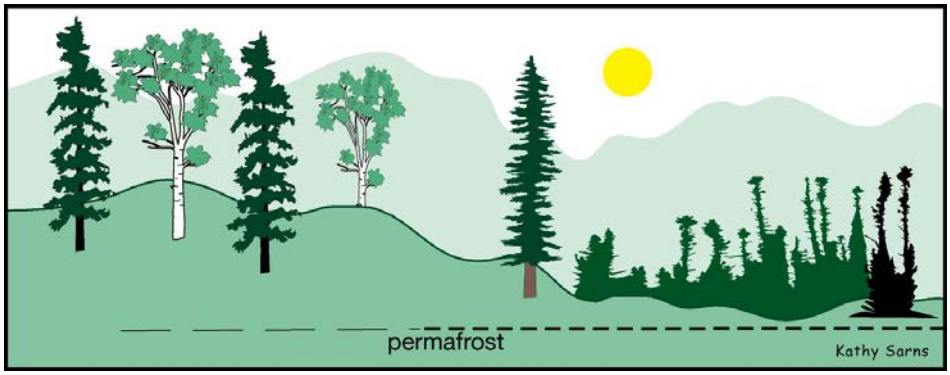
One of the interesting things about tundra is that areas can be dry, wet, or both. Wet tundra supports mosses and sedges. Dry tundra has dryas and reindeer lichens. In some areas the dry plants will grow on top of hummocks and the wet plants in the low areas between.



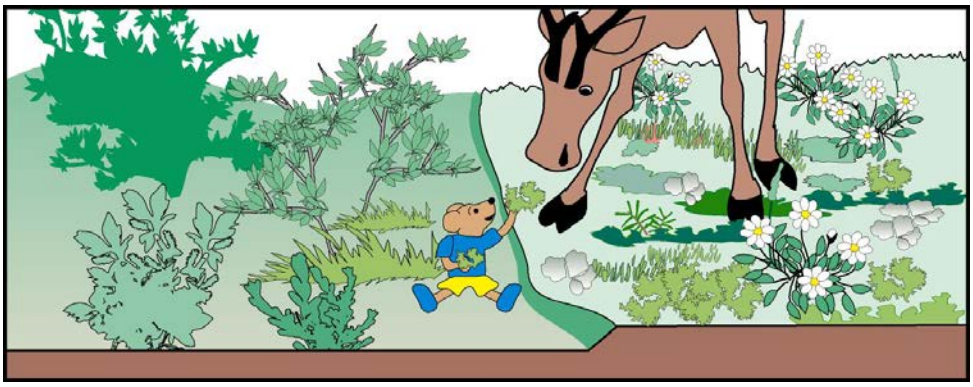
Horsetail plants (equisetum) have deeper roots than most tundra plants. If horsetail is present, permafrost is not very close to the surface. You can use a probe to find the permafrost layer. Push the probe straight down through the tundra. Depending on the time of year, permafrost may be a few inches or a few feet below the surface.



If trees are present on the landscape, look for permafrost under the black spruce. There will be no permafrost under big healthy aspen or white spruce.

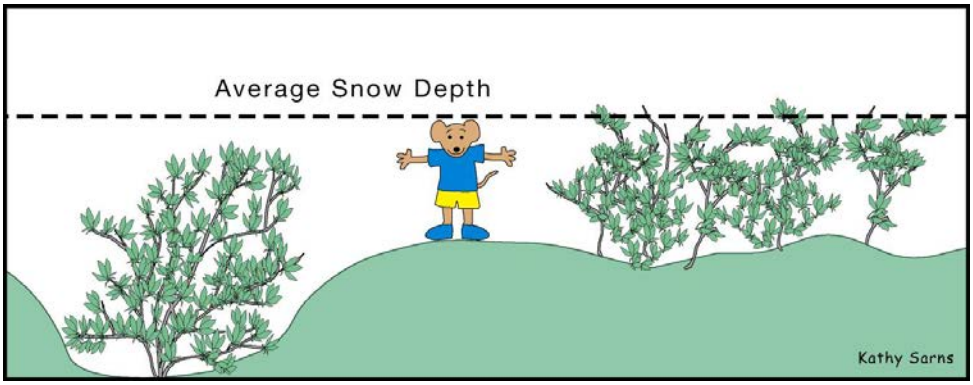


Moss and lichen grow slowly; a thick mat of either plant indicates that the area has been undisturbed for a long time. This thick mat makes it hard for other plant seeds to grow. Many tundra plants reproduce vegetatively, meaning they re-sprout from roots. After a mat is removed by fire, and the mineral soil is exposed, plants seeds can sprout more easily. Any disturbed ground will have different tundra plants than in an area of no disturbance.

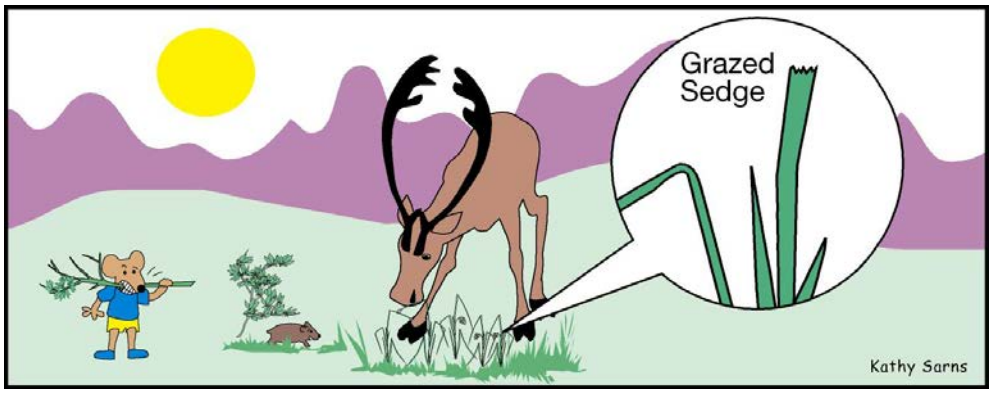


Galls, or knots of wood caused by insects, can often be found on willow. Rusts on shrubs that are damaged by disease in the tundra can also be seen.

On the tundra, average annual snow depth can be estimated by the shrub height. Tundra shrubs do not send branches out higher than the snow cover as the wind and snow rips them off or kills the plant altogether. Usually there are taller shrubs in gullies along creeks and behind bluffs where they are protected from the winter winds.



Grazing sign on sedges and shrubs may be seen. Caribou and lemmings usually graze the plants to the base, so often evidence can only be seen when looking up close.



Reading the Alaskan Environment

Look for evidence of the following. Write and draw a description of what you observe.

Evidence of both wet and dry ecosystems.

Evidence of an important non-living component of this habitat.

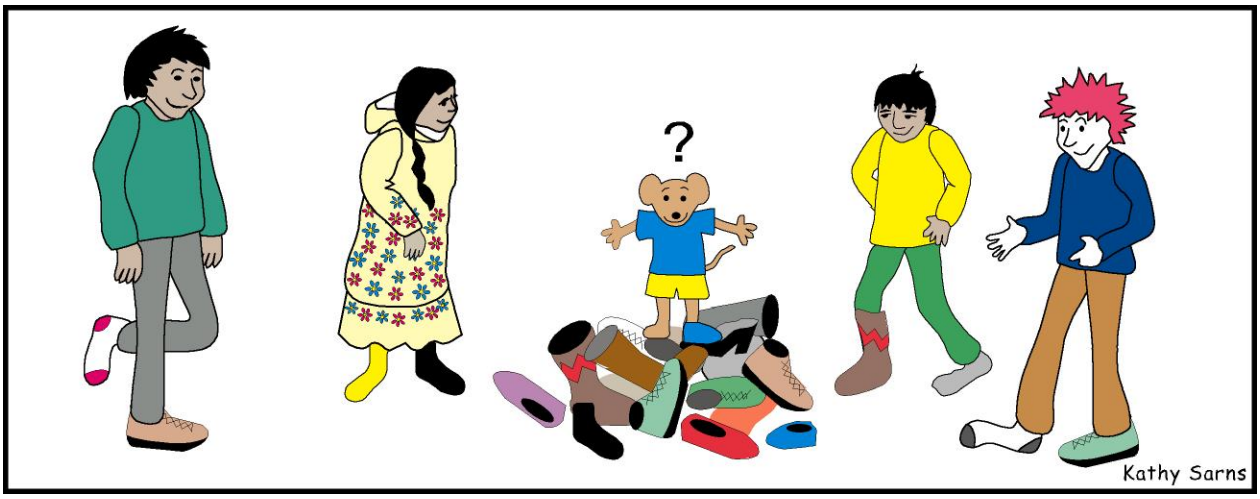
At least 3 things animals eat.

Evidence that animals have eaten here.

Damage to the trees or plants caused by animals, weather, or something else.

Something unique to the ecosystem

IDENTIFYING OBJECTS



Grade Level: 3-8
Alaska State Content Standards: S A-1
Subject: Science
Skills: Classification
Duration: 1 class period
Group Size: whole group and 2-4
Setting: indoors
Vocabulary: dichotomous key

Objective
The students will use a dichotomous key to identify local trees.

Teaching Strategy
The students will participate in a variety of activities that help them to understand a dichotomous key.

Complementary Activity:
Tree Hunt Relay (page 67).

Materials
- Plant Key
- Examples of tree leaves from the area (leaves or twigs)

Advanced Preparation
Familiarize yourself with dichotomous keys. A **dichotomous key** is a classification / identification tool that continually divides the characteristics of objects to be identified into two branches or parts until all are identified. Look at the "Alaska Trees and Shrubs" identification guide (see Role of Fire Kit) for an example of a working dichotomous key.

Procedure
1. Divide students into groups of 7-8. Have them stand or sit in a circle. Each should take off one shoe and put it in a pile in the center of the circle.

2. Have students divide the eight shoes or other objects into two piles, according to any criteria they wish (color, style, shape, etc). For younger students the teacher may want to model this first. Next divide each pile into two piles according to a specific criteria written by the students. Continue dividing the shoes until they have only one shoe in each pile.

3. Explain a **dichotomous key**. Draw a diagram on the board of the dichotomous key that was created here to identify the names of shoes.

4. Choose a shoe that was not used in the creating the key. Using the key on the board to identify it.

5. Again, review that these are dichotomous keys. Scientists use them out in the field to identify plants.

6. Divide the class into teams of 2-4. Give each group a Plant Key and some tree leaves from the area. Have students identify the trees using the key.

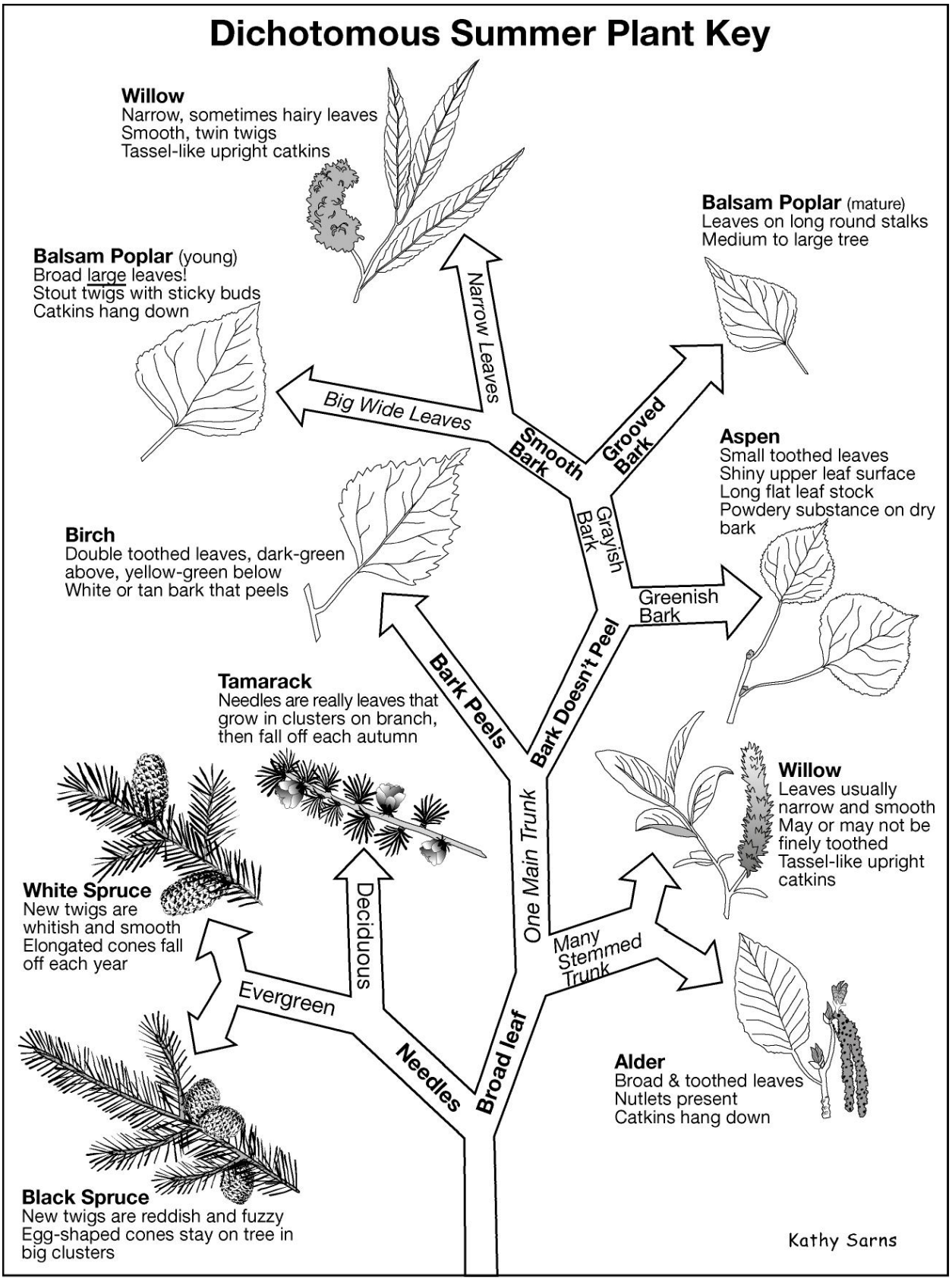
Extension

Do the same activity as above using the Winter Plant Key. Bring in twigs, branches and cones or take your students on a winter plant hike!

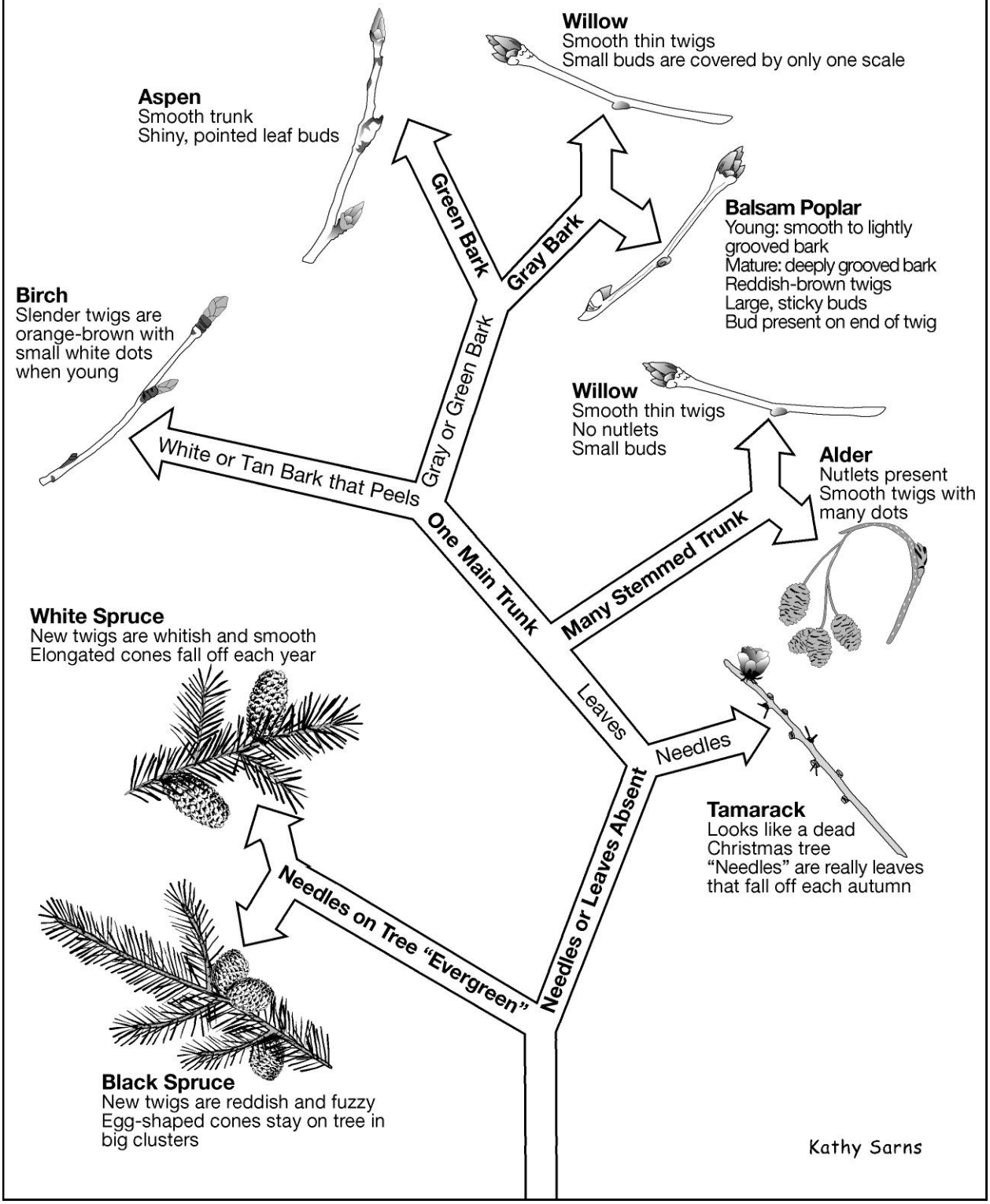
Evaluation

Give each student at least 10 different leaves. Using the Plant Key, the student successfully identifies as least 5 plants from the sample of leaves.

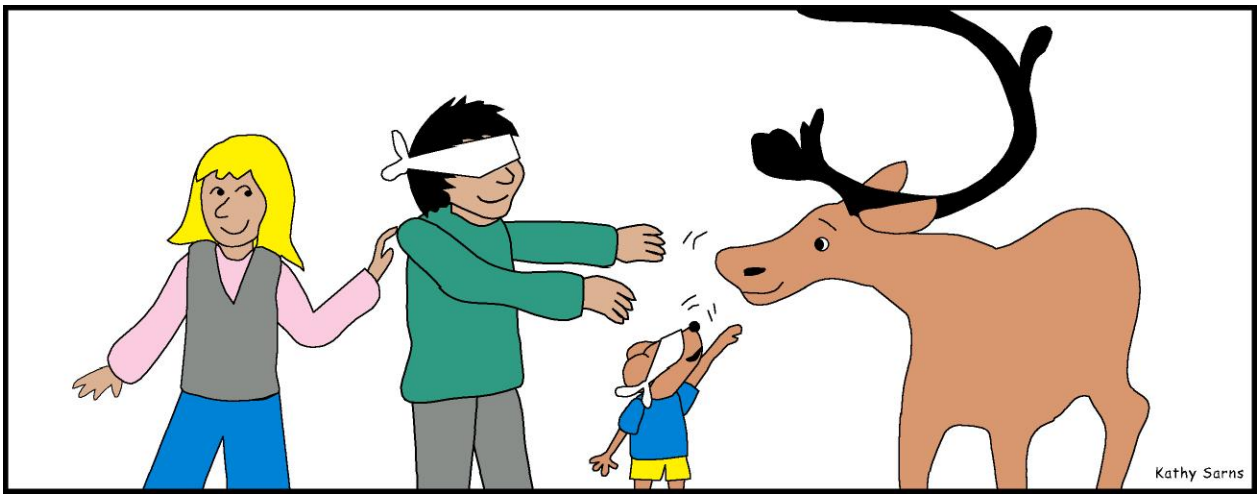
Dichotomous Summer Plant Key



Dichotomous Winter Plant Key



BLIND WALK



Grade Level: K-12
Alaska State Content Standards: S A-3
Subject: Science
Skills: Classification, Observation
Duration: 1 class period
Group Size: 2
Setting: outdoors

Objective
Students will observe, classify, and illustrate plants and animals of the boreal forest and tundra.

Teaching Strategy
Through a field trip, students observe a boreal forest or tundra ecosystem.

Materials
- Blindfolds - 1 for 2 students
- Blind Walk student worksheet - 1 each

Procedure
1. Before visiting the boreal forest or tundra review the "Don't Pull Me Apart or Crush My Home!" (page 19) handout. Talk to the students about preserving natural areas and why these areas should be left as undisturbed as possible.
2. Explain that the students will be divided into partners. Each person will have the chance to be blindfolded, using only the sense of touch and smell to observe his/her surroundings. Discuss the responsibility that each student has for his partner's safety. The leader should gently guide his blindfolded partner being very careful to watch for logs, low branches, uneven ground, prickers, etc.
3. Take students to your designated area and have them follow the directions on their Blind Walk worksheets.
4. After returning the classroom, discuss their observations as well as their notebook pages. Ask the following questions:
    a. What was the most interesting thing you observed?

b. Where your observations different without the use of your eyes? If so, how and why?

c. Where you able to find a specific plant previously observed once the blindfold were removed? Was it hard or easy? Why?

Evaluation

Use the worksheets as an evaluation tool.

References

Adapted with permission from Alaska Wildlife Week Unit 5 Alaska's Forests - More Than Just Trees, by Susan Quinlan, Alaska Department of Fish and Game, 1987 and Alaska Wildlife Week Unit 6: Alaska's Living Tundra, by Susan Quinlan, Alaska Department of Fish and Game, 1988.

BLIND WALK WORKSHEET

Follow the directions listed below. Remember you are responsible for your partner's safety! Leave the area as you found it. You don't want to disturb someone's home.

A. Blindfold your partner and lead him/her to any plant (plant, shrub, or tree). While your partner is exploring the plant ask the following questions. Discuss the answers.

1. What kind of plant is it? Is it a plant, herb, or tree?
2. Is this plant alive? How do you know?
3. How big is the plant? How did you make your guess?
4. What does the plant smell like? Do different parts smell different?
5. What do the leaves and stems feel like? Are they smooth, rough, oily, sticky, thick, or thin?
6. Does it have bark? Does the bark feel thick or thin?
7. Describe the texture of the leaves.

B. When you have finished asking questions, take your partner several steps away from the plant and slowly turn him around a few times. Take off the blindfold and have your partner try to find the plant he/she was exploring.

C. Write down the name of the plant. _____

D. List three of the most interesting things you noticed about the plant.

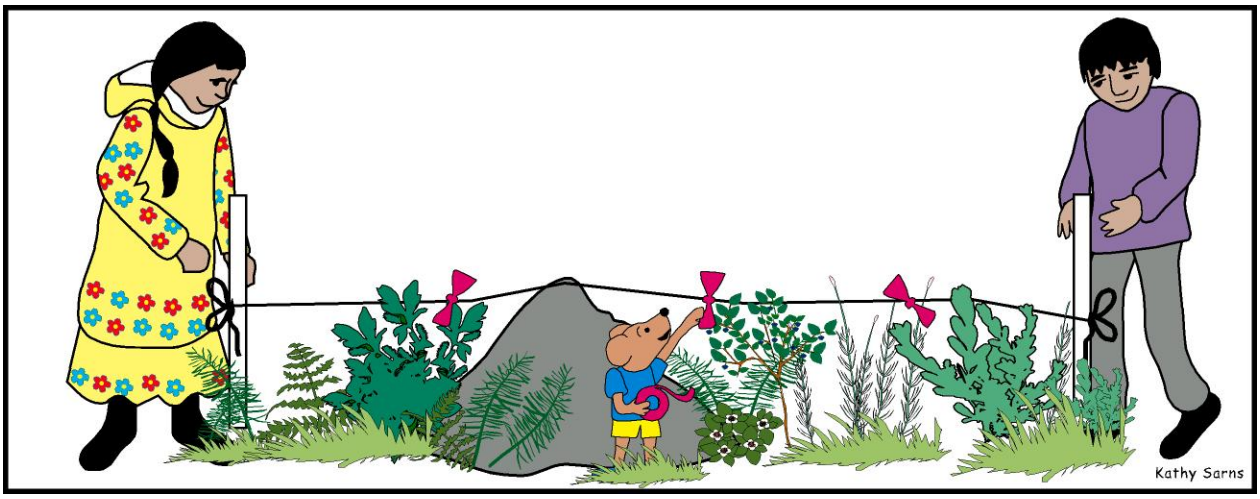
a) _____

b) _____

c) _____

E. Switch places and do the exercise again.

TRANSECT STUDY



Grade Level: 6-12
Alaska State Content Standards: Geography C-3, Math A-2, A-3, A-6, E-2, E-3, Science A-1, A-3.
Subject: Science, Math
Skills: Classification, Generalization, Observation, Research
Duration: 2 class periods
Group Size: 4
Setting: outdoors
Vocabulary: transect

Objective
Students set up a transect and observe/classify plants found on it.

Teaching Strategy
In this outdoor activity, students prepare transects following their field notebook guidelines. Students then identify those living and non-living items on their transect.

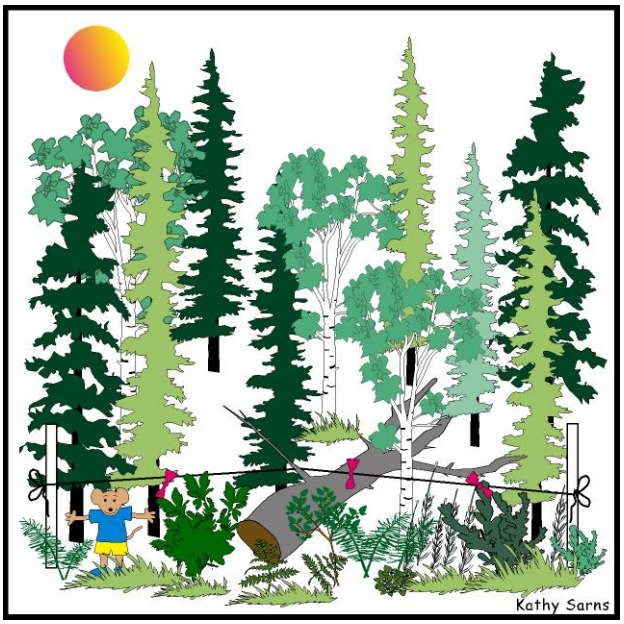
Teacher Background
A **transect** is a straight line profile that creates a cross-section of an area to study plants. Transects are used by botanists and biologists to get representative samples of an area's vegetative cover. The following transect protocol is an accurate, easy tool for students to use.

Materials
- 24' length of string for every four students (marked into four equal sections)
- 2 stakes for every 4 students (sticks, rulers, or pencils can also be used)
- 12" ruler for each student
- orange, green, red, or yellow flagging tape
- Transect Study Field Worksheet
- "Don't Tear Me Apart or Crush My Home" handout, (page 19).
- 1 field guide to the plants in your area for every 2-4 students (see the Teacher Resources section in the back of the book for ideas)

Advanced Preparation
Choose a site to visit which has a large enough area for 8 to10, 25-foot transects.

Procedure

1. Review the handout on page 19, "Don't Tear Me Apart or Crush My Home".
2. Show students how to set up a transect by stretching their string into a long line along the ground and staking it at either end. The string is then divided into 4 equal sections, marking the string with flagging tape. Those plants touching the string are identified and recorded. The non-living components that fall directly under the string are also identified.
3. Divide the class into teams of 2. Explain that the students will be following the directions on the Transect Study Field worksheet, looking at both the living and the non-living components. Encourage them to take accurate notes for the evaluation portion of the lesson.
4. Take students outdoors and have them follow the directions on the worksheet pages.
5. Back in the classroom, have each team make a bar graph to represent the number of herbs, shrubs, mosses, lichens and trees along the transect.
6. Have each group present their data to the class and add it to a large whole class graph on the board.
7. Following the graphs, ask the students the following:
    a. What is the average number of plants everyone found?
    b. How many different species did the class find?
    c. Did everyone find the same things or were transects different? Why?
    d. (If appropriate) Why do you think different plants were found in different areas? Why aren't (or are) they the same?



    e. Did any of the results surprise you?
    f. What was the most interesting thing you observed?
    g. Do you think if you made a longer transect, maybe 96 feet long (4 times what you did) would you find different things? Why or why not?
    h. Why do you think transects may be important tools scientists use when studying tundra or boreal forests?

Evaluation
Leave transects in place on the study site. After you have completed your follow-up discussions, have each team trade their notebooks and graphs with another group. Revisit the area and have each group identify another group's transect based on what they reported. Ask the following questions again:

    a. Did anything surprise you?
    b. What was the most interesting thing you observed?
    c. Do you think if you made a longer transect, maybe 96 feet

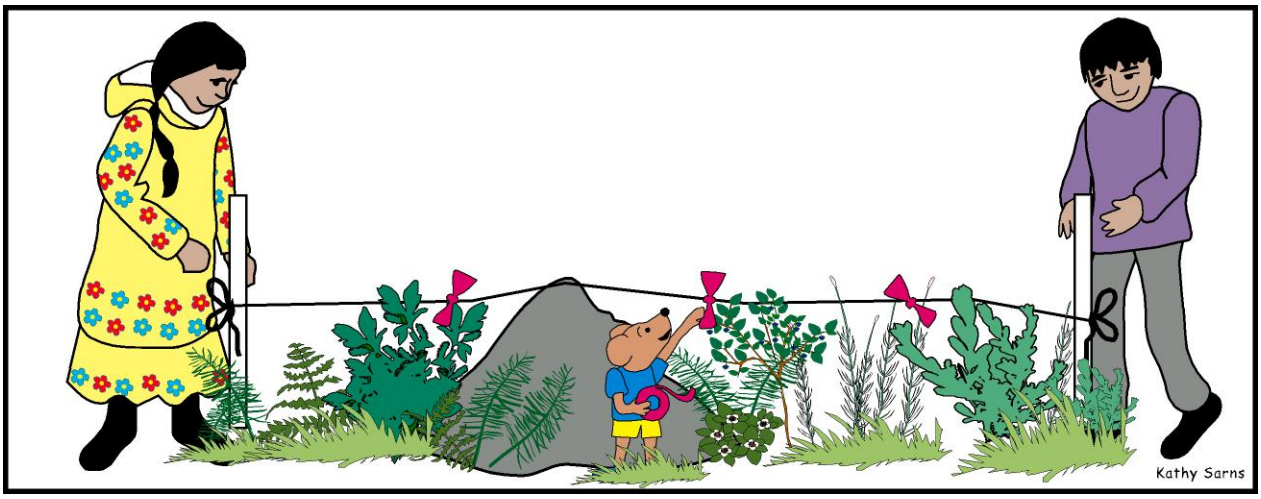
long (4 times what you did) would you find different things? Why or why not?

d. Why do you think transects may be important tools scientists use when studying tundra or boreal forests?

References

Adapted with permission from Alaska Wildlife Week Unit 5 Alaska's Forests - More Than Just Trees, by Susan Quinlan, Alaska Department of Fish and Game, 1987 and Alaska Wildlife Week Unit 6: Alaska's Living Tundra, by Susan Quinlan, Alaska Department of Fish and Game, 1988.

TRANSECT STUDY FIELD WORKSHEET



1. Choose an area that has a wide variety of plant types. Set your transect. You need to place your string on or close to the ground in a straight line. Stake both ends making the string as tight as you can. Mark your string into four equal parts by tying a piece of flagging tape onto the string.

Sketch Your Transect Here

2. Observe the plants touching your string. Using your field guide, try to identify the different species. In the boxes below, draw the plant (include only the feature used to identify it such as the leaves or bark). Count the number of identical plants along the transect.

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

Plant name: _____

Draw it here

quantity in section 1: _____
quantity in section 2: _____
quantity in section 3: _____
quantity in section 4: _____

3. Observe the soil carefully. Using at least four (4) descriptive words, thoroughly describe the soil in each of your transect sections.

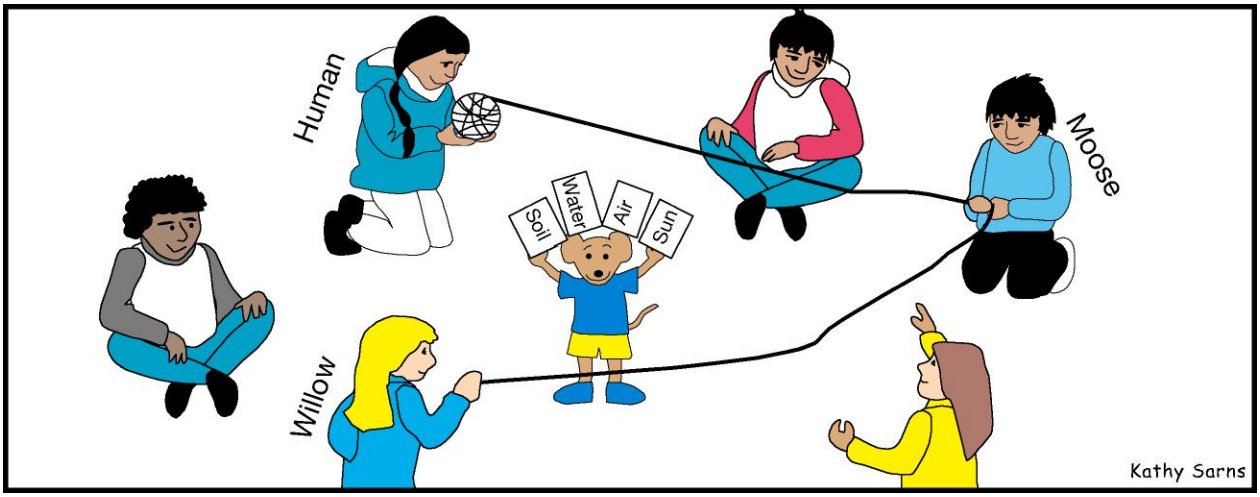
a) _____

b) _____

c) _____

d) _____

MAKING THE FOREST AND TUNDRA WILDLIFE CONNECTION



Grade Level: 5-12
Alaska State Content Standards: S C-3
Subject: Science
Skills: Classifying, Predicting
Duration: 45 minutes
Group Size: whole group
Setting: indoors
Vocabulary: food chain, food web, producer, consumer, herbivores, carnivores, omnivores, detritivores

Objective
Students will be able to form boreal forest and tundra food chains.

Teaching Strategy
Students will participate in an active game to form food chains of the boreal forest.

Materials
- *Alaska Ecology Cards* (see Advanced Preparation)
- String
- Tape

Teacher Background
A **food chain** describes the path of energy and nutrients from the non-living environment, through the living environment, and back to the non-living environment.

At the base of the food chain are the building blocks of the ecosystem: air, water, soil, and energy from the sun. Plants that use these building blocks to grow and to make their own food are called **producers**. Producers in the boreal forest and tundra include plants, lichens, algae, and some bacteria.

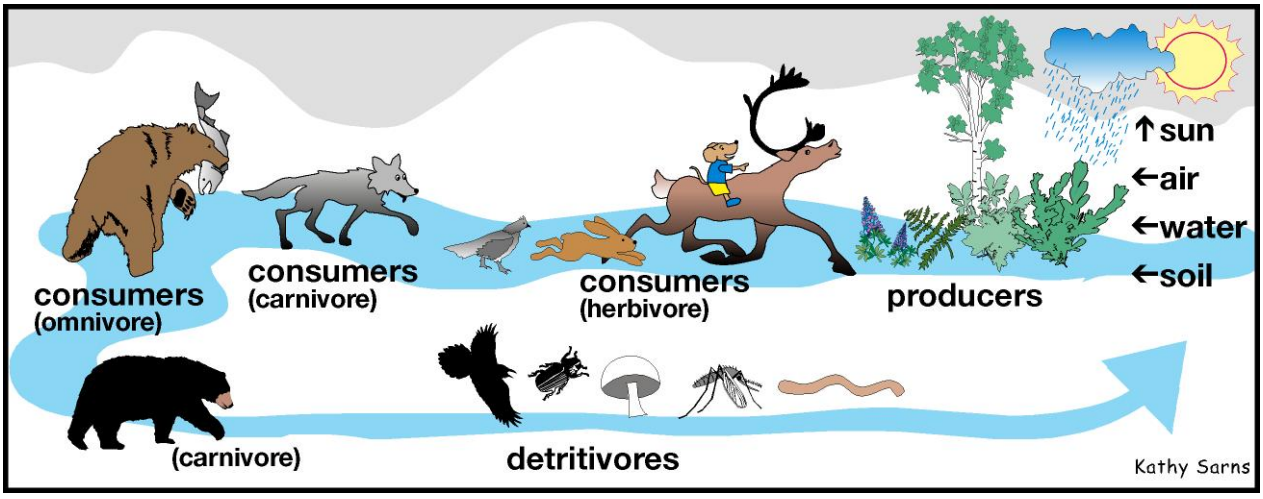
All organisms other than producers are called **consumers** because they obtain energy and nutrients by eating, or consuming, other living things. There are four major groups of consumers: **herbivores**, **carnivores**, **omnivores**, and

detritivores. Animals that eat plants are called herbivores. Willows (producers) are eaten by snowshoe hares (herbivores). Animals that eat meat are called carnivores. An herbivore can be prey for a carnivore. For example, a snowshoe hare (herbivore) may be eaten by a lynx (carnivore). Animals that have few or no predators are consumers found at the top of the food chain. Omnivores eat both plants and animals. Bears are a good example of an omnivore, feeding on mammals, berries, and fish.

There is no "waste" in nature. Every plant or animal that dies is decomposed and returned to the soil. Detritivores are consumers that eat dead organisms and waste material. They break down, or decompose, dead plant and animal material, returning the nutrients to the soil where they are available again for plant growth. Without detritivores, producers would soon run out of the minerals and nutrients that they need to make their food. Detritivores include some large animals, such as ravens; however, the most important detritivores are invertebrates (such as insects), fungi (such as mushrooms), and microscopic organisms (such as bacteria).

All plants and animals are part of at least one food chain and often more than one. Many interconnecting food chains form a **food web.**

When forces such as fire, flood, insect outbreak, or human activities cause changes to the plants, animals, or non-living components of the ecosystem, the entire food chain is affected. As a result, plant or animal populations may increase or decrease depending on where the population is in the food chain. It is important to learn about the food chains of the boreal forest and tundra so that we can understand how changes to the environment affect forest and tundra populations.



Advanced Preparation

1. Make 4 large cards, each one reading: water, sun, soil, air.
2. Select the Boreal Forest or Tundra *Alaska Ecology Cards* from the list below, starting at the top of the list

And moving downward; have one card for each student in the class. Be sure that you include the habitat and food information provided on the cards. You may wish to laminate the cards before doing this activity.

BOREAL FOREST
Foliose Lichens
Caribou
Brown Bear
Marten
Red Fox
Voles
Club Mosses
Springtails
Molds, Mildews, and Rusts
Ground Beetles
Common Raven
Small Thrushes
Merlins
Segmented Worms
Low Bush Cranberry
Pine Grosbeak
Sharp-shinned Hawk
Fireweed
Snowshoe Hare
Lynx
Great Gray Owl
Aspen
Moose
Wolf
White Spruce
Porcupines
Cottongrass
Soapberry
Willow
Aphids
Spiders
Redpolls
Bat and Warble Flies
Humans
Blueberry
Wild Rose
Raspberry
Balsam Poplar

TUNDRA
Foliose Lichens
Caribou
Brown Bear
Club Mosses
Heather
Springtails
Ground Beetles
Mosquitoes
Northern Shrike
Common Raven
Short-eared Owl
Lowbush Cranberry
Ptarmigan
Red Fox
Bog Blueberry
Lapland Longspur
Weasel
Willow
Tundra Hare
Wolf
Grasses
Lemming
Rough-legged Hawk
Loon
Goose
Vole
Sedges
Musk Ox
Humans
Cottongrass
Bot and Warble Flies Geese
Dall Sheep
Moss Campion
Arctic Ground Squirrel
Labrador Tea

Procedure

1. On the board write a list of the cards you are using. Discuss the concept of a food chain and give one or two examples using some of the animals and plants listed on the board. Show how two predators may share the same prey, causing branching of the food chains to form a food web.
2. Give each student a card and some tape. Students read about their plant or animal noting in particular its foods and its predators. Students tape their card face up on the front of their clothes.
3. Have the group sit in a circle. In the center of the circle place the cards for air, water, soil, and sun. Give the ball of string to a student who has a plant card. The student then passes the string to an organism in the circle with which that animal interacts. This process goes on around the circle until all the organisms are linked together by the string. Finally the ball is returned to the first student.
4. The students now increase the size of the circle until the string is taut. The teacher tugs on one part of the string. When each student feels a tug, they tug gently on the string. This should cause the entire circle to vibrate from end to end. Ask the students to explain how this vibration would be felt in an ecosystem.
5. Have one of the students drop out of the circle. Find out how many other students must, then also, drop out because of their dependence on that organism. How would this affect the rest of the ecosystem circle? After a discussion about food chains and food webs, discuss the nonliving factors upon which everything depends.
6. As the class continues to hold their string, have them imagine that a fire burns through the area. Which animal populations would be affected? These animal populations will decline and be unable to support their predator populations. Their predators will have to find alternate prey to feed on. Can these predators find other prey in the food web or will they have to move to another area in search of food? How long will it take for predator and prey populations to recover in the area? Two important factors determine when a burn site can support wildlife: 1. How severe the fire was that burned the area, and 2. If there are unburned areas left in the burn site.

Evaluation

Have each student draw a new food chain, and food web, using other *Alaska Ecology Cards*.

References

Adapted with permission from Teacher's Guide – Fire in the Boreal Forest and Tundra of Alaska, US Fish and Wildlife Service, Susan Quinlan, 1991.

CRITTER SEARCH

Grade Level: K-12
Alaska State Content Standards: Art A-1; Geography C-1, C-3; Science A-3;
Subject: Science
Skills: Classification, Observation
Duration: 1 class period
Group Size: 2
Setting: outdoors
Vocabulary: edge

Objective
Students will identify what animals have frequented a local ecosystem and how they have used the environment.

Teaching Strategy
Students will explore a local ecosystem to observe the evidence of animal activity.

Materials
- Animal track field guides
- Hand lens
- Critter Search Treasure Hunt worksheet

Teacher Background
By observing the evidence left by animals in an area, more can be learned about the ecosystem as a whole. Animal tracks can be a relatively easy indicator of animals living in a specific habitat. Other signs are scat or pellets, plant shoots nipped cleanly by hares or torn and crushed by moose, bark stripped from spruce by porcupines, or bark nibbled from willows by moose. All of these indicators are easily observed by students of all ages.

Procedure
1. Locate an area where students can find animal tracks, scat or pellets, and/or evidence of browsing.
2. Divide the class into teams of 2. Explain that students will be working together to locate evidence that animals have been in the area. Discuss what these signs may look like and how to use the animal track field guides.

3. Have students follow the Critter Search Treasure Hunt worksheet to locate different animal clues.
4. Students then compare their findings, sharing them with the class. Ask the following questions:
    a. What was the most interesting thing you found?
    b. How many different types (species) of animals live here?
    c. How many animals total do you think live here?
    d. What were the easiest things to find? What were the hardest?
    e. Do you think your findings would be different at a different time of year? If so, why?
    f. How do you think studying animal signs may help wildlife biologists?

Evaluation

Ask the students to write a detailed answer to the following:
If you were an animal living here, who would you be and why? (Make sure students include something about the food, water, and shelter resources in the area).

Extension

To extend the activity, choose an ecosystem **edge** as a location for study. An edge is an area where two (2) or more different habitats meet such as the border of a meadow and forest. Edges are usually more diverse than other areas as they provide a larger variety of food and shelter for the local animals. After studying an edge and a non-edge ecosystem, students can compare the two.

CRITTER SEARCH TREASURE HUNT

Locate the following and then draw a small picture of your finding next to the listed item. You don't need to find all of the items on this list.

1. The track of a bird.

2. Evidence that a bird ate here.

3. The track of a small animal such as a fox, hare, porcupine, lynx, or squirrel.

4. Evidence that a small animal ate here.

5. The track of moose or caribou.

6. Evidence of a moose or caribou eating here.

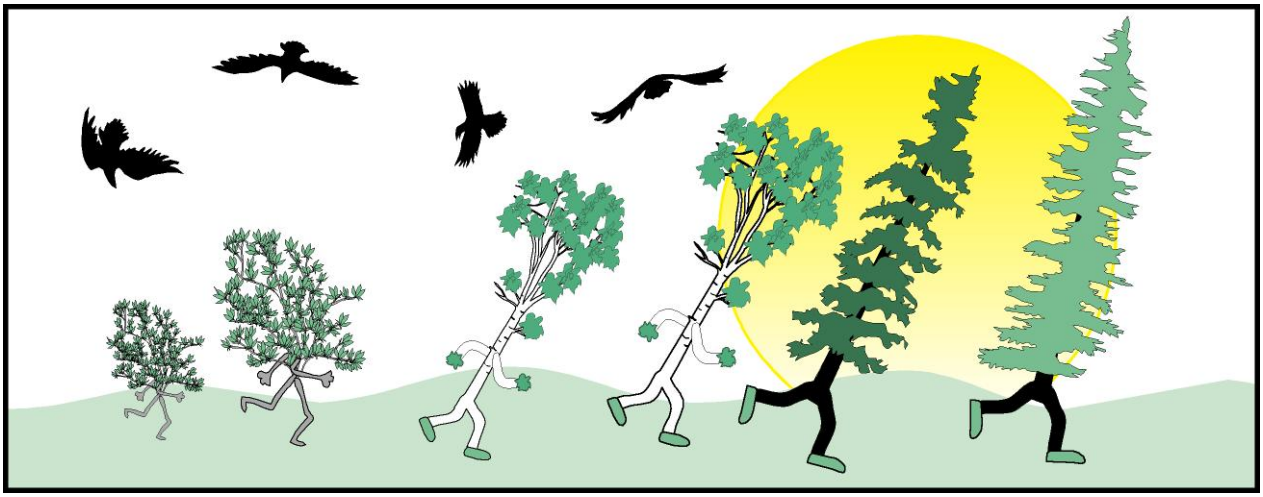
7. The track of a mouse or lemming.

8. Evidence that a lemming ate here.

9. More than one animal eating off one plant.

10. Something interesting that is not listed here.

THE SUCCESSION RACE



Grade Level: 5-8
Alaska State Content Standards: Science C-1; Geography C-1, C-2, C-3
Subject: Science
Skills: Analysis, Description, Generalization
Duration: 1 class period
Group Size: whole group
Setting: indoors or outdoors, large playing area
Vocabulary: succession, successional stage, herb stage, shrub stage, young forest stage, mature forest stage, maturing aging forest stage, habitat, minerals, vegetation mosaic

Objective
Students will list the factors that affect succession in a boreal forest.

Teaching Strategy
Through a game, students portray plants progressing through the boreal forest succession, affected by agents of change.

Materials
- Butcher paper
- Succession Cards (starting page 53)

Teacher Background
Succession is the natural, orderly change in plant and animal communities that occurs over time. The successsional timeline has been divided into stages that portray the slow, continuous changes in an environment. When an existing environment is disturbed by fire, insects, development, resource extraction, flood, or extreme weather, it generally reverts to an earlier successional stage. Herbs and shrubs dominate the earliest stages of succession. Intermediate stages follow, dominated by tall shrubs and young trees. Finally, a mature forest stage and an mature aging forest stage may follow. The pace of succession may be affected by soil conditions, climate, permafrost, topography, and natural forces.

Some agents of dramatic change in the boreal forest are:

- Insect invasion
- Bark beetle attack
- Flood and/or ice jams
- Land slides
- Too many moose
- Very hot, slow fire
- A fast fire
- Person building a house
- Development or roads
- Clearcut logging

Many stages of succession may be represented in a relatively small area. For instance, you may be walking through a dark, thick forest and come upon a clearing or meadow. Some agent of change affected that particular part of the forest, perhaps insect, disease or a small fire, and killed all of the mature trees. As you continue your walk you may come upon a thicket of bushes. This part of the forest is now in the shrub stage and may have, at one time, been a meadow and before that a mature forest. This patterning of various successional stages containing different plants is called a **vegetation mosaic**. Because fire can jump from place to place within a forest or may burn at different times and different intensities in various parts of the forest, fire is often the cause of vegetative mosaics.

Each species of plant has particular **habitat** requirements. These habitat requirements include specific amounts of light, heat, soil nutrients, and water. As a particular site progresses through successional change, tall plants create shade. Layers of moss insulate the soil and cause a drop in soil temperatures. More and more **minerals** become tied up in living and dead plant material. These changes in the physical environment change the suitability of each site for different plant species. The kinds and numbers of plants present change as the physical conditions of the environment change. As each part of the forest changes, the vegetation mosaics change.

Like plants, wildlife species also have specific habitat requirements. Each species of animal needs the right kinds and amounts of food, water, cover, and space. Therefore, wildlife populations change in response to successional change.

The process of succession strongly affects wildlife use of the boreal forest. Some wildlife, such as white-crowned sparrows, fulfill their habitat needs in the shrub thickets of early forest succession stages. Others, such as white-winged crossbills, need large expanses of mature aging spruce forests to survive. Many boreal forest wildlife need a mixture of forest ages to meet their habitat needs. Snowshoe hares are a good example. Young willow and birch shrubs, which flourish in the early stages of succession, provide the food snowshoe hares need. In winter, hares need the shelter provided by spruce forests.

The variety and abundance of wildlife in the boreal forest is largely a result of the habitat diversity provided by the vegetation mosaic. The complex and constantly changing boreal forest mosaic is created and maintained by the continual pace of succession.

Succession progresses in the tundra as it does in the boreal forest, although it is not as clearly understood and is extremely slow in comparison. Early succession is visible

where lake levels have lowered and plants grow on the newly drained soil. Cottongrass tussocks take a long time to establish and don't grow in recently disturbed sites; if cottongrass is evident, then the area is probably in the later successional stages. Trees or shrubs with thick, gnarled, lichen covered stems are found in the later successional stages as well. Because little research has been done regarding tundra succession, less is known about its effects on plant and animal communities.

Advanced Preparation

1. Copy and cut the Succession Cards making one set per student. Note that each stage is represented by a different color.
2. Make 5 large signs labeled "Herb Stage", "Shrub Stage", "Young Forest Sage", "Mature Forest Stage," and "Mature Aging Forest Stage." These signs may be color-coded to match the Succession Cards.

Procedure

1. Before beginning the game share the information about succession with your students as found in the Teacher Background section. Review the five succession stages with the class. Brainstorm with students some of the factors that could affect the progression of succession to the "Mature Aging Stage."
2. Set up the playing field. Mark 5 lines across a field or other large playing area, with approximately 20 feet between each line (this distance could be smaller for small groups). Place the "Herb Stage" sign at one end of the field; the other end is labeled the "Mature Aging Stage." Place the remaining signs for the "Shrub Stage," "Young Forest Stage," and "Mature Forest Stage" in the remaining sections according to the diagram above. The color-coded Succession Cards are placed (face down and scattered the width of the field) in their appropriate stage areas; no cards will be placed in the "Herb Stage." There will be more cards at the "Shrub Stage" and "Young Forest Stage" than at the "Mature Aging Stage."
3. Students line up at the "Herb Stage" to begin the game. Explain to them that they are plants in various successional stages of the boreal forest. Their goal, as a forest, is to reach the "Mature Aging Stage."
4. The teacher starts the game by calling "Start Succession!" Everybody runs from the "Herb Stage" to the "Shrub Stage" where they each pick up a card and read it. The teacher should emphasize the importance of reading the cards since information contained on them will be discussed later. The cards at each stage will give students information about succession. They will instruct students to proceed to the next successional stage or to start over at the "Herb Stage". Students returning to the "Herb Stage" must put all their cards back (face down) in the color-coded stages before starting again.
5. As the game progresses the students should spread out over the stages of succession. The game ends when the first person reaches the "Mature Aging Stage" and calls out "Stop Succession!". Everybody must stay where they are. The first person over the line should have 4 cards. If that student does not have 4 cards, he/she puts the cards face down at the correct stages, starts

over at the “Herb Stage”, and the game continues. If they do have all 4 cards, it is time to have a hot crown fire burn the area and kill all the trees of the young forest and the mature aging forest. All the trees at these stages return to the herb stage.

6. At the end of the game count how many plants are in each stage of succession. Discuss the following:
    a. Why don’t all the plants reach the “Mature Aging Stage”? Why is this important?
    b. What are some of the things (agents of change) which can cause succession?
    c. How is this like and not like real succession in the boreal forest?
    d. Is succession important? Why or why not?
    e. Does succession happen to a plant or a forest? Explain.

7. Continue the game until all the cards have been used and no student can move. Give each student paper and pencil. Ask all to write how forests might be affected by disturbances such as insects, flood, fire, logging, etc. and the advantages or disadvantages of an area returning to an earlier stage of growth. Discuss ideas and answers.

Variations

The teacher may stop the game at regular intervals to allow students time to look around and see how the number of plants at each stage changes. A graph could be kept on the blackboard or a large pad to record the changes.

Stop the game when there are students in each of the stages. Discuss the benefits of a variety of habitat stages (vegetation mosaics). Think of ways both wildlife and humans could use each stage. How would wildlife and humans be affected if the trees were in just one stage? Could fire help maintain a wide diversity of plants and animals?

Stop the game and tell all the students to put their cards back in the stages and return to the “Herb Stage”. Ask the students what might have happened to cause the entire forest to return to the “Herb Stage.”

Evaluation

Have each student list at list 10 things that could cause the progress of succession to revert to an earlier stage.

SUCCESSION CARDS - SHRUB STAGE

Directions: Copy on GREEN paper. Make one copy for every 5 students.

A snow machine runs throughout your portion of the forest forcing you to return to the herb stage.

Fire burns you and you must return to the herb stage.

A disease kills shrubs and you return to the herb stage.

A flood kills shrubs and you return to the herb stage.

There are so many moose eating the stems of your young shrubs that you must return to the herb stage.

The permafrost has thawed causing a landslide that takes the organic layer and vegetation away. You return to the herb stage.

There is abundant sun and water, allowing you to reach the young forest stage.

There are so many porcupines eating your shrubs that you must return to the herb stage.

There is not enough sunlight to grow, so you return to the herb stage.

The hare population decreases and you grow, reaching the young forest stage.

The moose population decreases and you grow, reaching the young forest stage.

There is abundant sun and water, allowing you to reach the young forest stage.

SUCCESSION CARDS – YOUNG FOREST STAGE

Directions: Copy on BLUE paper. Make one copy for every 5 students.

A snow machine runs throughout your portion of the forest forcing you to return to the herb stage.

Fire burns you and you must return to the herb stage.

A disease kills trees and you return to the herb stage.

A wind storm blows down your trees, returning you to the herb stage.

Landslide! You go back to the herb stage.

Moose population very high and they are eating all of the young trees. You remain in the young forest stage.

The porcupines are so thick that they are eating all of the young trees. You must return to the herb stage.

There is not enough sunlight to grow, so you return to the herb stage.

There is unusually sunny, warm weather so you grow to the mature forest stage.

The moose population decreases and you grow, reaching the mature forest stage.

You have been able to get so much more sun, water and nutrients you are able to go to the mature forest stage.

SUCCESSION CARDS – MATURE FOREST STAGE

Directions: Copy on YELLOW paper. Make one copy for every 5 students.

The land is cleared by humans, you return to the herb stage.	Your trees are chopped down for firewood, returning you to the herb stage.
A very hot fire burns you back to the herb stage.	A beetle outbreak kills your trees, returning you to the herb stage.
A disease kills trees and you return to the herb stage.	Loggers leave, allowing you to grow to the mature aging forest stage.
Landslide! You go back to the herb stage.	There is a warm summer and plenty of snow for water and you grow to the mature aging forest stage.
You have been able to get so much more sun, water and nutrients you are able to go to the mature aging forest stage.	You have been able to get so much more sun, water and nutrients you are able to go to the mature forest stage.

SUCCESSION CARDS – MATURE AGING FOREST STAGE

Directions: Copy on RED paper. Make one copy for every 5 students.

Land is cleared by humans, you return to the herb stage.	There is a warm summer and plenty of snow for water; you stay in the mature aging forest stage.
Very hot fire returns you to the herb stage.	Your trees are chopped down for firewood, returning you to the herb stage.
Beetles attack another tree, returning you to the herb stage.	A beetle outbreak kills your trees, returning you to the herb stage.
	You have been able to get so much more sun, water and nutrients you are able to stay in the mature aging forest stage.

Succession of the Boreal Forest After Fire

Student Handout

Herb Stage (0-5 years)	**Shrub Stage (6-25 years)**	**Young Forest Stage (26-50 years)**	**Mature Forest Stage (51-150 years)**	**Climax Forest Stage (150-300 years)**
Fire has burned the forest, returning minerals to the soil in the form of ash. Herbs (wildflowers, grasses, sedges) may grow from seeds and sprout from roots. Mosses and lichens may revegetate as well. In addition, seeds from outside the area may be brought in by wind or animals. Shrub seedlings often sprout from unburned roots, and many trees sprout from stumps. If the fire occurred in a mature or over-mature forest, dead trees called snags may still be standing.	Shrub and tree seedlings grow larger and begin shading the grasses and other small plants. Shrubs and tree seedlings offer good cover for many animals such as birds, mice, and snowshoe hares. Foods for wildlife, including berries, seeds, buds, and leaves are plentiful. Tree snags that have fallen are decaying.	Sapling trees such as birch, aspen, and poplar (all hardwoods) have grown too tall for their leaves to be eaten by most animals. The forest canopy has become more dense, shading the forest floor. Only shrubs, herbs, and mosses that are shade-tolerant can grow under low light conditions found in this stage. Spruce begin growing among the hardwoods; however, their growth is slow. Most tree snags have fallen.	Mature hardwood trees become less abundant as some die, opening the canopy for spruce to grow taller. Hardwood saplings, tall shrubs, herbs, mosses, and lichens also grow in the canopy openings.	The canopy is more open. The forest is mostly spruce trees. Hardwoods, tall shrubs, herbs, mosses, and lichens grow in the openings. There are dying and dead trees still standing which provide food and cover for some animals. Boreal forest succession depends on soil, climate, water, and the presence or absence of permafrost. For example, in cold climates where there is permafrost and little rainfall or snow, succession may not progress beyond the shrub stage. Only dwarf trees and shrubs can grow in such environments.

BOREAL FOREST SUCCESSION

Grade Level: 5-8
Alaska State Content Standards: Art A-5; Geography C-3; Science A-3, C-1, C-2;
Subject: Science
Skills: Classification, Observation, Comparison, Description
Duration: 1 class period
Group Size: 2
Setting: outdoors
Vocabulary: succession, successional stage, herb stage, shrub stage, young forest stage, mature forest stage, maturing aging forest stage, habitat, minerals, vegetation mosaic

Objective
Students describe the progressive successional stages of a boreal forest.

Teaching Strategy
Students will observe and record different stages of forest succession around their school grounds and create mural.

Materials
- "Succession of the Boreal Forest After Fire" handout, 1 per student
- 3-4 sheets of plain paper per student
- pencils, crayons, markers, etc.
- large sheets of white paper (for mural) for each student
- colored construction paper

Teacher Background
The forest is always changing! Plants are growing, using the nutrients in the soil, and dying. Animals are feeding in the forest, leaving their waste, growing, and dying. Even the smallest organisms in the soil, bacteria, are very important. Bacteria break down dead organisms, putting nutrients back into the soil for plants to use.

Succession is the natural, orderly change in plant and animal communities that occurs over time. If left undisturbed, an open field may become an "aging" forest in 150-300 years. However soil conditions, climate, permafrost, topography, and natural and unnatural forces may affect the pattern of succession.

Weather, fire, flood, insects, and human activity can disrupt the forest, altering the pattern of succession. The "Succession of the Boreal Forest After Fire" handout will give you a detailed description of each stage. Although

many disturbances may impact forest succession, fire is the only one that returns important nutrients to the soil.

The boreal forest provides many animals with their basic needs--food, water, shelter, and space. During the process of forest succession, an area may become more suited for some wildlife species and less suited for others.

In the "**Herb Stage**," (contains seed plants whose stems wither away to the ground each winter) insects and small rodents feed on the grasses, herbaceous plants, and seeds. Songbirds, such as flycatchers and warblers, feed on insects. Sparrows and grosbeaks feed on seeds, birds of prey (hawks, owls) feed on rodents (mice, voles), and game birds (ptarmigan, grouse) feed on seeds and buds. As the diversity of plants increases so does the variety of wildlife species.

Plants continue to flourish in the "**Shrub Stage**." Shrubs (usually low woody plants with several permanent stems instead of a single trunk,), herbs, and fallen trees provide abundant nesting cover for songbirds, rodents, game birds, and snowshoe hares. These animals attract predators such as foxes, weasels, marten, and lynx. Moose feed on shrubs and sapling trees. These animals, in turn, attract large predators like wolves.

As the forest progresses into the "**Young Forest Stage**," the quantity and diversity of shrubs and herbaceous

plants decreases. With less variety in food available, the number of wildlife species decreases. Songbirds and birds of prey nest in the trees of a young forest. Beavers use young trees to build their lodges and feed on the tender branches.

In the "**Mature Forest Stage**" hardwood trees begin to die, opening the canopy for the growth of spruce. Shrubs return and make more food and cover available to songbirds, game birds, and rodents.

In the "**Mature Aging Forest Stage**," dead trees called snags provide homes for woodpeckers and other cavity-nesting birds. Porcupines, squirrels, spruce grouse, and several songbird species are typical of old stands of spruce trees.

Advanced Preparation
Choose several sites on the school grounds that will illustrate forest succession.

Procedure
1. Have students make blank field notebooks by folding 3-4 sheets of paper in half and stapling them together.
2. Prepare students for a field trip by giving them copies of the "Succession of the Boreal Forest After Fire" handout. Review on the

board the stages of boreal forest succession and the major plant groups in each stage. Have them add this handout to their field notebooks.

3. At each different successional site, have students determine the major plant groups. Have students list, illustrate, or take pictures of what they see for their field notebooks. Ask students to guess, based on their observations, what stage of succession they see. Remember that successional stages may not be readily apparent and that stages may blend together. You may not find all successional stages near your school.
4. Back in the classroom, give the students time to review their field notebooks and add any finishing touches.
5. Ask students to share their findings and their conclusions. Ask them the following questions:
    a. How many different successional stages did you observe? What stages where they and why do you think so?
    b. Was it hard to determine what stage the forest was in?
    c. Based on the stages seen, what do you think happened to cause the succession? What clues to you have? How could you find out if you are correct?
    d. What was the most interesting thing you observed?

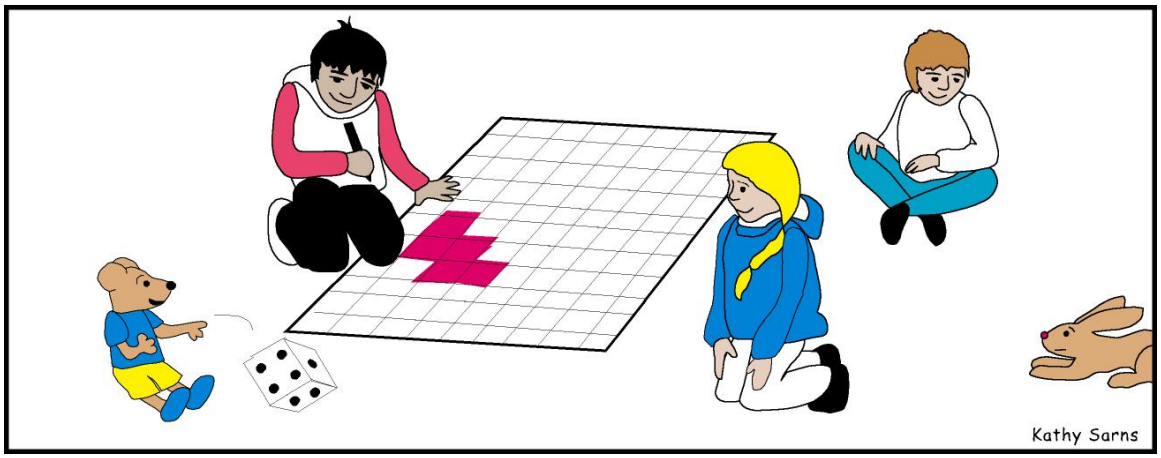
Evaluation

1. Using the notes and observations from the field trip, have students describe the stages of succession they observed.
2. Divide the class into small groups. On a large sheet of white paper have each group make a mural about local boreal forest succession using construction paper and other materials. Encourage students to be creative and suggest illustrating how fire impacts the forest and those animals living there.
3. Have each group present their mural to the class explaining the types of plants and animals found in each stage of succession. Comparisons should also be made between the field experience and the mural creation.

References

Used with permission from the “Wildfire and Wildlife” pamphlet, Alaska Department of Fish and Game, Fairbanks.

LIVING ON THE EDGE



Grade Level: 5-8
Alaska State Content Standards: Geography C-1, C-2, C-3; Science C-2.
Subject: Science
Skills: Application, Construction, Description
Duration: 1 class period
Group Size: 2
Setting: indoors
Vocabulary: vegetation mosaic

Objective
Students will describe a vegetation mosaic, how it is created, and its influence on wildlife diversity.

Teaching Strategy
Students play a game to create a vegetation mosaic and discuss their influence on wildlife diversity.

Materials
- 1 die for every 2 students
- crayons or colored pencils for every 2 students
- 1 Living on the Edge Forest Graph Paper attached for every 2 students
- 1 Living on the Edge Key attached for every 2 students
- *Alaska Ecology Cards* (page 271)

Teacher Background
Interior Alaska's vegetation is primarily a result of fire. Fire rarely spreads evenly through a forest: its path is often an erratic one - totally burning some areas,

while barely touching others, and completely skipping other areas. Viewed from a distance, forest fire in the boreal forest burn in a patchwork pattern called a **vegetation mosaic**. Successive fires in the same area help maintain the variety of meadows, shrub lands, and forest stands of different ages. This diversity of vegetation helps create a diversity and abundance in wildlife. The different plant communities that are maintained by fire provide the **diversity** of habitat needed for a healthy ecosystem.

The effects of fire on habitat are generally more significant than the effects on animals themselves. Forests of different ages support different kinds of wildlife. Different types of birds and mammals seeking food and shelter are

attracted to different types of forest types. All of these animals, in turn, need a variety of resources to provide shelter, food, water, and space. These resources are often found on the borders of two or more plant communities, such as meadow / black spruce or birch / shrub. These edges are created by fires and other disturbance and are beneficial to maintaining a healthy wildlife habitat. Many small fires occurring in Alaska usually create more edges than one large burn. In fact, the majority of species generally do best in forest that provides a combination of habitats.

Fires can have a short-term negative impact on animals by temporarily displacing them or disrupting their reproductive activities. Larger animals are rarely killed by fire; most simply escape by moving away from the flames. Some, such as voles and squirrels, may escape by moving into underground burrows. Some animals, primarily small rodents, may be killed by fire.

Many of the animals present in the interior of Alaska are thriving here because of fire, not in spite of it. The grasses, seedling shrubs, and trees that reestablish burned areas provide an ideal environment for many small seed-eating mammals and birds, such as voles and sparrows. This abundance of small prey attracts predators like foxes, red-tailed hawks, and weasels. Burned trees provide sites for cavity nesting birds like flickers, kestrels, and chickadees. Woodpeckers thrive on the insects that invade fire-killed trees.

As the natural habitat changes from low-growing plants and shrubs, to small trees and larger shrubs, the forest wildlife community changes accordingly. The tall shrubs and tree saplings which are found in an area 5-30 years after a fire, provide excellent shelter and forage for a great variety of wildlife. New nesting sites abound for more bird species, such as warblers and thrushes. Abundant grasses and shrubs create perfect cover for ground-nesting birds and ever-increasing small mammals. In addition to the small rodents, moose, snowshoe hares and ptarmigan use these young forests. More predators follow; foxes, marten, weasel, and lynx prey on the small animals, while wolves may move in to hunt moose. Blueberries and cranberries can also become abundant after a burn, particularly in upland areas. These are an excellent food source for many wildlife species, including black and grizzly bears.

By the time the forest has matured into birch, aspen, and spruce stands, many of the grasses, sapling, and smaller shrubs have been shaded out. Animals that relied on these plants have moved elsewhere. Some new animals may be found, including ruffed grouse and hermit thrushes. In the later stages, as the hardwoods are replaced by spruce, porcupines, spruce grouse, red and northern flying squirrels become common residents. These old, mature coniferous forests support fewer numbers and species of wildlife and are considered by us less productive.

When fires burn naturally a vegetation mosaic of different forest types is created. This provides a great diversity of vegetation and consequently a greater diversity of wildlife species. Some wildlife species prefer a particular forest type while others use and need all ages and types of the boreal forest.

Background from Fire and Wildlife, US Fish and Wildlife Service.

Procedure

1. Ask students if they think a forest burns all in one sweep? Use the Teacher Background section to

discuss vegetation mosaics and their importance to wildlife.

2. Explain to the students that they will be creating their own model of a vegetation mosaic in a game format.
3. Explain that the graph paper represents 160 acres of forest. The roll of the die represents the kind of fire (low intensity, moderate intensity, high intensity) and the amount of acreage burned. It also represents where the fire burned. For instance, if you were to roll a 3, this represents a high intensity fire that burns 10 acres of the forest in the SE quadrant. The student then marks 10 squares in the lower right hand corner of the grid.
4. Students continue to roll 10 times, each roll representing the fires for that year only. Each year is marked on the grid in a specific color. For instance, using the example above of a student rolling a 3, if that roll was done on the 4th year, then those 10 squares would be marked in yellow. If the roll was made on the 5th year, then the squares would be blue.
5. Students should always mark adjoining squares whenever possible, but if there are no adjoining squares left in the quadrant, they can mark any that are open. If there are not enough left to mark, then students may choose to mark over a square that has been marked in a previous round. Explain that fires do burn in the same place more than once occasionally, but not often as there usually isn't enough fuel left to make it a significant burn.
6. Note that after the grid is complete, each year represents a specific forest stage. Those burning in the 6th-10th years are all meadows. Those burning in the 1st-5th years are all in the shrub stages. Those not having been marked at all, or burned, are mature forest stands.
7. After students have created their grid, ask them the following questions:
    a. Does this explain how vegetation mosaics are created? How or how not?
    b. If you were a lynx (who prefers access to mature forest, meadows, and shrub areas) where would you live?
    c. Do you think a low intensity fire would burn fewer acres than a high intensity fire? Why or why not? Do you think the high intensity fires were canopy fires or ground fires? Why?

Evaluation

Have each student write a description of vegetation mosaics, including how they are created and why they are important. Then have each student use the Alaska Ecology Cards (page 271) to choose 2 animals that would live in the meadow stage only, 2 in the shrub stage only, 2 in the mature stand only, and 2 that would require a combination of stages to live. Next, have them mark on their graph where each of these animals would find their best habitat.

Living on the Edge Forest Graph Paper

Living on the Edge Key

ON YOUR TURN:

Years	Colors
Year 1	Orange
Year 2	Purple
Year 3	Brown
Year 4	Yellow
Year 5	Blue
Year 6	Green
Year 7	Red
Year 8	Black
Year 9	Turquoise
Year 10	Gray

WHAT YOU ROLL:

FIRES	INTENSITY	ACREAGE BURNED	WHERE
1	low	1 square	northwest
2	moderate	4 squares	central
3	high	10 squares	southeast
4	high	8 squares	northeast
5	low	3 squares	southwest
6	low	2 squares	anywhere

THE FOREST STAGE

YEAR	FOREST STAGE
Year 1- 5	shrub
Year 6 – 10	meadow
Unburned	mature forest stand

This photo shows the fire-caused vegetation mosaic on part of the Yukon Flats National Wildlife Refuge.