Unit II
Fire's Effects on the Ecosystem

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

An Overview

Tundra and Forest Fire Triangle (5-12)
By playing a card game, students create fire triangles and identify fuel types.

How Hot Is It? (8-12)
Students participate in a card game simulating fire intensity and fire lines.

Tundra and Boreal Forest Fire Hunt (4-12)
Students investigate real and hypothetical burn sites.

Fire Effects on Forest and Tundra Wildlife (3-6)
Students will depict an ecosystem by creating a mural.

Looking at Fire in the Ecosystem (2-8)
In this writing activity, students consider the effects of fire through the eyes of people, plants, and animals.

True or False, Forest Fire Misconceptions (3-12)
Students try to determine if statements about wildland fires are true or false.

Good or Bad Effect of Fire in the Tundra or Forest – Who's to Say? (8-12)
Students individually evaluate some effects of wildland fires and compare them to group evaluations. Students also discuss how different view and opinions are generated.

Boreal Forest and Tundra Crossword Puzzle (6-12)
Students complete a crossword puzzle to reinforce vocabulary used in Unit I and Unit II.

Role of Fire
UNIT II: FIRE EFFECTS ON THE ECOSYSTEM

Background

ARE FIRES NATURAL?

Fires have occurred in the boreal forest of interior Alaska for thousands of years. This is clearly shown by charcoal layers in soil, fire scars on trees, and the mosaic pattern of the boreal forest. The history of fire in tundra regions is less studied and less obvious. However, there are historical records of tundra fires since the early 1900’s, and lightning is known to have caused some recent tundra fires. Scientists believe that lightning-caused fires have occurred in Alaska's boreal forest and tundra since at least the last ice age, 10,000 years ago.

Fire records compiled by the U.S. Bureau of Land Management show that in interior Alaska, during the 40 years between 1940 and 1979, more than 4,000 fires were ignited by lightning. These lightning-caused fires burned over 18 million acres of boreal forest and tundra (over four times the area burned by human-caused fires during the same period). This provides clear evidence that lightning-caused fires are a powerful, natural phenomenon.

Humans have caused fires since their arrival in the boreal forest and tundra. Humans caused two-thirds of known fires between 1940 and 1979. However, lightning-caused fires accounted for 83 percent of the lands burned. This discrepancy is probably a result of human-caused fires being more common along road systems and near human habitations. Here they are more likely to be detected, to be an immediate threat, and to be put out (see Figs. 3 and 4).

HOW LONG BETWEEN NATURAL FIRES ON THE SAME SITE?

A **fire Interval** is the length of time that passes between naturally caused fires in a given location. Fire intervals can be estimated by examining the occurrence of ash layers in the soil, or by looking at the age of trees on various sites. Such research in the boreal forest indicates that the fire interval varies widely from site to site. However, most boreal forest sites burn at least once every 200 years. Many burn as frequently as every 40 to 130 years.

Less research exists on the occurrence of fire in tundra. Some tundra sites are thought to burn as often as every year. In other tundra areas fires may never occur under natural conditions due to the absence of lightning or inadequate supplies of dry fuel. In general, tundra fires tend to be much smaller and less frequent than boreal forest fires.

HOW DOES FIRE AFFECT THE BOREAL FOREST AND TUNDRA?

Research on the occurrence and effects of fire in Alaska's boreal forest and tundra is still underway, and much remains to be learned. But scientists have discovered that fires have many important, beneficial effects in the boreal forest ecosystem. Fires also have some beneficial effects in tundra areas but they are less understood. Fires affect the soil, vegetation, and wildlife of burned areas.

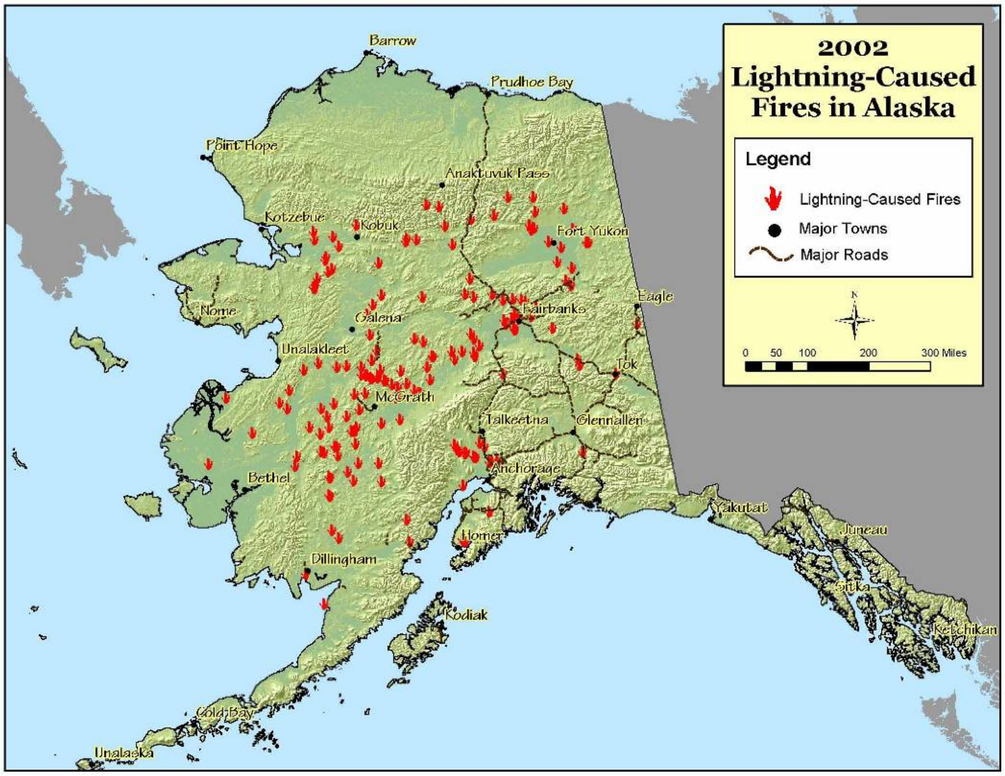


Figure 1. Distribution of lightning-caused fires in 2002. (Courtesy of Alaska Fire Service, BLM)

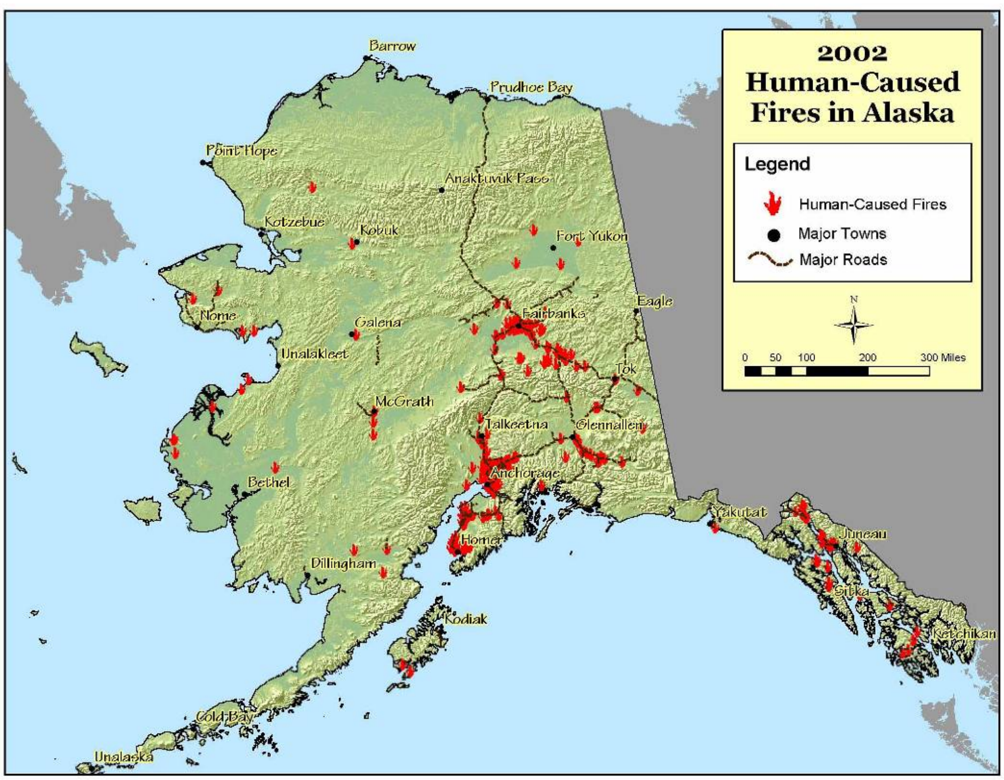
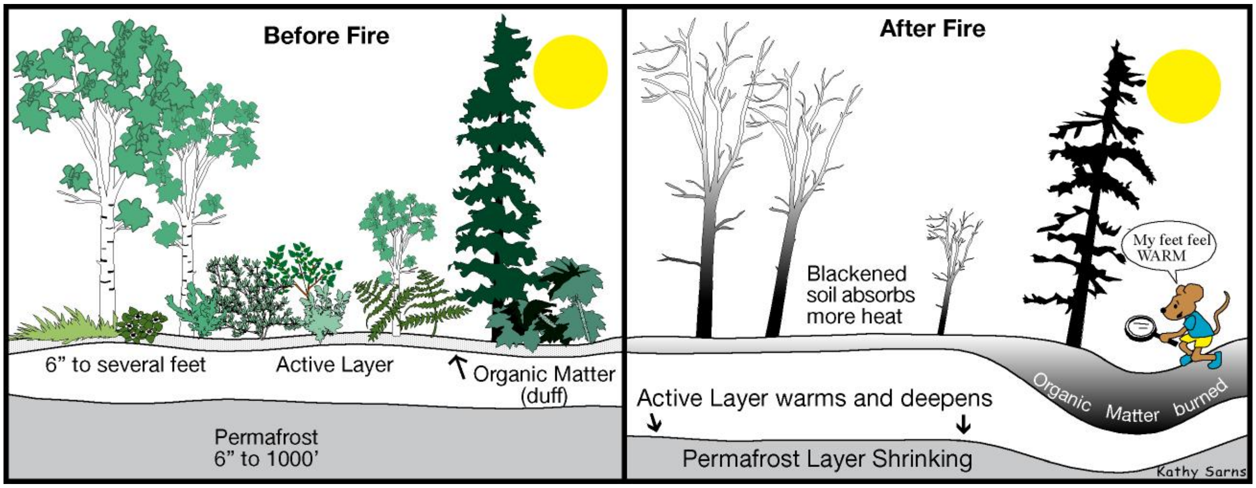


Figure 2. Distribution of human-caused fires in 2002. (Courtesy of Alaska Fire Service, BLM)



How Does Fire Affect Forest And Tundra Soil?

Changes in soil nutrients and temperature are among the first environmental changes triggered by fire. When plants and dead vegetation are burned, the minerals trapped in their leaves, stems, and wood are released and returned to the environment in the form of gases and ash. The ashes left by fire are rich in calcium, phosphorus, potassium, and other minerals. These minerals, previously trapped in organic material, enrich the soil.

Fire also helps enrich the soil indirectly by affecting the depths of the permafrost and active layers. Few fires directly thaw the permafrost layer. It is usually insulated from the heat of fire by the active layer, a thick mat of organic material and soil. But fire indirectly thaws the permafrost by burning some of the organic mat, blackening the soil surface, and reducing the insulating qualities of the active layer. These changes cause the soil to absorb more of the sun's heat. The depth of the active layer increases as the permafrost layer shrinks. In interior Alaska, researchers measured the active layer of soil in a burned site. They discovered that it increased from only 18 inches (45 cm) before the fire to 72 inches (183 cm) 8 years later (and the depth was still increasing).

In a few cases, the warming of the active layer and the melting of permafrost sometimes leads to soil erosion problems. This can be a serious problem on ice-rich permafrost soils on steep slopes. More often, however, deepening of the active layer has positive effects on the soil. It can improve drainage and create drier soils. Warmer soil conditions and a deeper active layer on permafrost sites lead to increase decomposition by bacteria, fungi, and invertebrates that remain in or invade the soil of a burn site. Increased decomposition adds more minerals to the soil, in addition to those contributed directly by the fire. The resulting warmer, better-drained, mineral-rich soil provides good conditions for lush plant growth.

How Long Does It Take For A Burned Site to Return To Its Pre-Fire Appearance?

The most obvious effect of a fire is the burning and blackening of most plant material. But this dramatic visual change does not destroy the forest or tundra. Instead, it changes the site's appearance by reverting to an earlier successional stage (see Unit 1 on succession). Through succession, most burned sites gradually return to their pre-burn appearance. In the boreal forest, succession from a burn site to an mature aging forest may take 50 to 200 years.

The exact pattern and timing of succession on any site is difficult to predict because of variations in the physical environment and variation in fire impact. Most burned tundra sites are not as drastically changed by fire, and most return to their pre-burn appearance in only 6 to 8 years. The return to pre-burn appearance takes more time in tundra areas where lichens dominate. Lichens are often entirely consumed, even by light fires. Since lichens are slow growing and slow to invade burned sites, they may not return to a burned tundra site for 100 years or more.

HOW DOES THE PHYSICAL ENVIRONMENT AFFECT SUCCESSION?
The rate and pattern of succession depends partly upon the physical conditions of the burned site as different species of plants have different soil, temperature, and moisture requirements. Boreal forest succession on permafrost sites proceeds differently from that on non-permafrost sites. Similar differences occur in tundra. Certain sedges and mosses grow only in wet soils; many shrubs and cushion and mat-forming plants prefer dry sites.

As mentioned previously, a fire can deepen the active layer of soil in permafrost areas by blackening the soil surface and removing a portion of the organic layer. This in turn can affect soil drainage. In places where fire has indirectly caused the permafrost to melt, wet meadows, ponds, and even small lakes may be created. Not surprisingly, these changes in soil conditions have a strong influence on the kinds and numbers of plants that return to a burned site.

How Does Fire Affect Succession?
Succession is the natural, orderly change in plant and animal communities that occurs over time. Lightly burned sites recover much more quickly and in a more predictable fashion than heavily burned sites. On lightly burned sites, thousands of **rhizomes** (root like stems,) roots, and seeds remain alive underground. In some places, even aboveground parts may survive. Nourished by the minerals released by the fire, surviving plant parts may sprout within days after the fire. Re-establishment of plants thus occurs very quickly on lightly burned sites.

In boreal forest areas, most of the surviving seeds, roots, and rhizomes are from the plant species that occurred on the site before the fire. However, some of the seeds buried in the soil may be from plants that have not grown on the site for 150 to 200 years. The seeds of wild geranium sprout only after a fire removes the shading trees and creates the warm, nutrient-rich soil conditions, which this plant needs to grow. Generally, the plants that return to a lightly burned forest site are those that grew on the site before the fire.

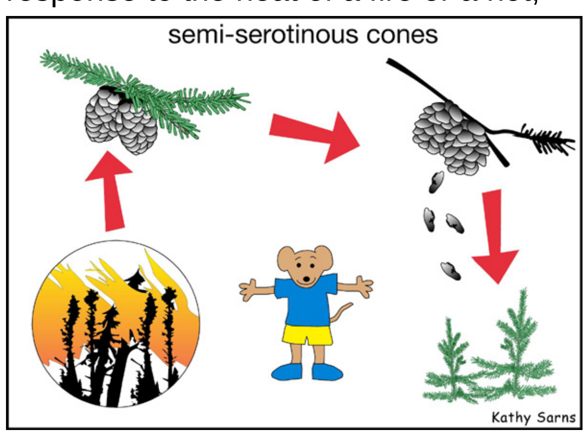
In tundra areas, most fires burn lightly due to lack of fuel so the extensive underground parts of most tundra plants usually survive fire. Their roots usually re-sprout within a year. Little change generally occurs in the species of tundra plants following a fire. However, due to the influx of nutrients from ash and increased decomposition, the returning plants may grow faster and produce more leaves, flowers, seeds, and berries than they did prior to the burn--at least during the few years immediately following fire. Most tundra sites return to their pre-burn appearance and productivity in less than ten years. Lichen-dominated tundra may require 100 years or more to return to its pre-burn appearance.

WHAT HAPPENS ON A HEAVILY BURNED SITE?

Heavily burned sites frequently occur in the boreal forest. But due to lack of accumulated dry fuel, heavily burned sites are rare in tundra areas. Heavily burned sites lack the full storehouse of roots and seeds that exist in lightly burned soils. Plants must generally re-invade these areas by seed. This kind of reestablishment may take some time, especially if the burn occurs late in the growing season.

The kinds of plants that re-invade a heavily burned site depend upon what seeds reach the site. The kind of seeds that reach a site are affected by 1) the kinds of plants present before the fire, 2) the kinds of plants present on adjacent, unburned sites, and 3) the timing of the fire. Variability in these factors makes it difficult to predict the exact pattern of succession on a heavily burned site in the boreal forest.

1) The kinds of plants present before the fire affect the revegetation of a heavily burned site because the dead plants may still be a source of seeds. This is particularly true if the plants on the site were black spruce. Black spruce trees do not drop their seeds each year like other conifers. Instead, these trees retain their cones, which are sealed shut with a touch of resin. The cones do not open until the resin is dried by many years of summer sun or by the intense heat of a fire. As the cones of black spruce open after a fire, millions of seeds rain down onto the charred forest floor. If conditions are suitable, the seeds germinate, and a dense forest of black spruce forms. (The black spruce cone is called **semi-serotinous** because it can remain on the tree long after the seeds have matured. The cone opens and releases the seeds in response to the heat of a fire or a hot,



dry summer. No other Alaskan tree has serotinous or semi-serotinous cones.)

Occasionally, post-fire conditions allow other kinds of trees to reseed themselves after a fire. Sometimes a ground fire in a stand of birch, aspen, or white spruce may kill trees without burning the seeds, which are produced in the upper branches. If the fire occurs at a time when the seeds are ripe, the unburned seeds can reestablish these species.

2) The kinds of plants in adjacent unburned sites are important seed sources for heavily burned sites. Seeds from adjacent areas may be blown into the burn site by wind or carried in by animals. The lightweight, cottony seeds of fireweed, aspen, and balsam poplar can be carried long distances by wind; these species can easily invade a large burn. The heavier seeds of white spruce rarely fall further than 150-200 feet (45-61 m) away from the tree that produced them. Thus, white spruce cannot easily invade a heavily burned site, unless white spruce trees survive in unburned patches within the burned area.

3) The timing of a fire also affects the kind of plants that invade a heavily burned site as different kinds of plants produce seeds at different times of year. Aspen and balsam poplars drop their seeds in June. White spruce and birch seeds ripen in late summer. Seeds that arrive on the site first germinate first and grow into seedlings. These seedlings generally out-compete seedlings that sprout later. The available space, water, sunlight, and nutrients are limited - the plants that flourish on a burn site are generally those that arrive first.

In summary, a fire kills some of the plants in the areas it burns. Plants regrow on burn sites from roots, rhizomes, and seeds that survived in the soil and/or from seeds blown or brought in from elsewhere. The exact pace and pattern of plant succession on a burn site is extremely difficult to predict because of the great variability in physical environments, fire impact, the kinds of plants present before the fire, the kinds of plants present on adjacent, unburned sites, and the timing of fires.

DO FIRES EVER CAUSE UNEXPECTED CHANGES IN PLANT COMMUNITIES?

Exceptions to the general patterns of plant succession do exist. In places where the boreal forest grades into tundra, fires can change forest into tundra - or tundra into forest - by altering the depth of the active layer. The addition of minerals from fire may create such lush tundra plant growth that the depth of the active layer decreases due to increased vegetative insulation. If the active layer decreases too much, trees cannot survive. Tundra created in this fashion has been called **pyrogenic tundra** - fire-created tundra. Pyrogenic tundra has been reported in Siberia and Canada, but so far no one has determined whether or not it occurs in Alaska. In contrast, Dr. Les Viereck of the Institute of Northern Forestry speculated that when fires expose mineral soil and provide a suitable seed bed, trees may become established in areas formerly dominated by tundra vegetation.

DON'T FIRES HARM WILDLIFE?

Certainly some animals, including nesting birds, voles, squirrels, and hares, are killed by fire. But surprisingly few dead animals are found after fires. Many birds and large mammals apparently escape the flames by flying or running away. Small mammals, such as voles and squirrels, sometimes escape fire by moving into underground burrows. Scientists think most vertebrate animals killed by wildland fires die of suffocation from the smoke rather than from the heat. Most invertebrate organisms in the surface soil and on vegetation are killed by fire.

The most important effects of fire on wildlife are not the deaths caused by the flames and smoke, but the indirect effects caused by changes in plant communities. Some wildlife species are harmed by these changes, while other species benefit. By removing trees, shrubs, herbs, and lichens, fire essentially removes the food and cover (habitat) for some wildlife. These cannot find homes in recently burned areas and are forced to move to other areas or die. But other kinds of wildlife move into and use burn sites. The species and numbers of animals that move into a burned area depend largely upon the kinds of plants that become re-established and the rate at which these plants grow. In general, as plants re-invade a burned area and succession

proceeds, wildlife also reappears and some species flourish. The "Effects of Fire on Wildlife Populations" handout **(**page 115**)** provides more information on the effects of fire on specific species of wildlife.

HOW DO FIRES IN THE BOREAL FOREST AFFECT WILDLIFE POPULATIONS?

The general patterns of wildlife use during post-fire succession in the boreal forest are discussed below.

Wildlife Use of Recent Burns

A few wildlife species find food and cover in a burn site immediately after a forest fire. Bark beetles have built-in smoke detectors and heat sensors to help them locate burned areas. These wood-boring beetles fly through the smoke and flames in search of burned trees. They feed on the inner bark (cambium) and wood of trees. Trees injured or killed by fire are unable to resist the attacks of these insects, so the beetles find an abundant food supply in burned areas. As growing numbers of beetles attack the burned trees, their predators, three-toed and black-backed woodpeckers, congregate in the burned areas to feed. Other predators such as foxes, coyotes, hawks, and owls often hunt in recent burns, probably because the voles and other small mammals that remain have little cover and are easy prey. This initial wave of animal invaders takes advantage of short-lived conditions. The predators soon clean up the small mammals that lost their homes in the fire. Within three to four years the beetles run out of injured trees to attack. Soon after, the numbers of beetles and woodpeckers in the burn area decline.

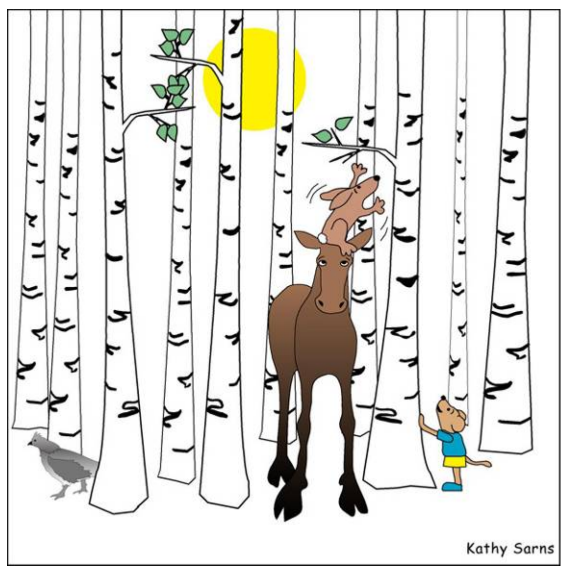
In the meantime, plant succession is proceeding. Soils enriched by ashes provide the nutrients needed for a flush of plant growth. Grasses, herbs, and seedling shrubs and trees provide a rich source of food for insects and seed-eating birds and mammals. Far from devoid of life, a young burn is often alive with a wide variety of insects, along with hares, voles, shrews, sparrows, and flycatchers. These animals attract predators like foxes, coyotes, red-tailed hawks, northern hawk-owls, and American kestrels.

Wildlife Use of The Shrub Stage

Wildlife begins to flourish as the plant communities develop. Young trees and tall shrubs provide new nesting and feeding sites for birds. New species, including some warblers, sparrows, thrushes, and sharp-tailed grouse, may begin using the burn site at this stage. Due to abundant herbs, grasses, shrubs, and cover provided by fallen trees, the shrub stage of succession may provide habitat for larger numbers of small mammals and certain ground-nesting birds than any other successional stage. This abundance of prey supports similarly high numbers of predators, including foxes, weasels, and marten. In general, these species of predators are more abundant in this early stage forest than in any other stage. If hardwood trees and shrubs are abundant, moose and snowshoe hares may also find an abundant and nutritious food supply in this successional stage. As their numbers increase, predators such as wolves and lynx may also move into the burn area.

Wildlife Use of The Young Forest And Mature Forest Stages

Once the saplings have grown into trees, they shade out smaller shrubs, other saplings, and many ground cover plants like fireweed and grasses. Animals that needed these plants die out or are forced to move to other areas in search of appropriate food and cover. Among the affected species are moose and hares when tree branches have grown out of their reach. Many of the seed-eating and shrub-nesting birds are also displaced, including most sparrows. But other species of wildlife, including ruffed grouse, Swainson's thrushes, yellow-rumped warblers, and sharp-shinned hawks, find ideal habitat in this forest stage.

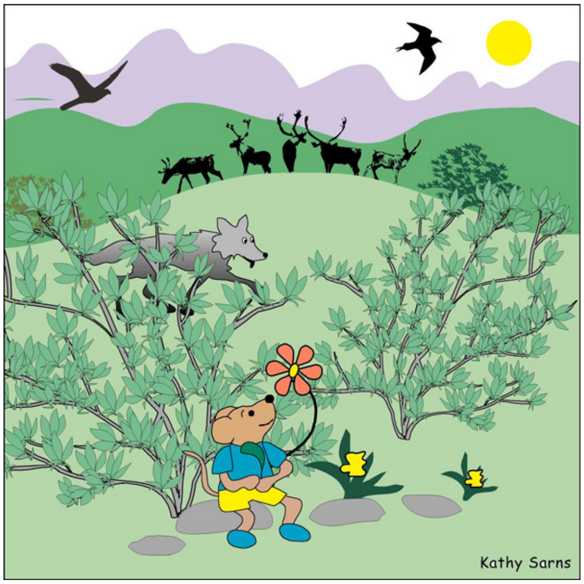


Wildlife Use of the Aging Stage
As hardwood trees are replaced by spruce, wildlife that prefers spruce trees replace those that need hardwood forests. Porcupines, red squirrels, northern flying squirrels, caribou, white-winged crossbills, brown creepers, spruce grouse, boreal chickadees, goshawks, Swainson's thrushes, and Townsend's warblers are among the wildlife typical of old stands of spruce trees.

Fires rarely burn evenly. They burn in patches, completely burning some parts of the forest or tundra and leaving other parts untouched. This patchy burning pattern helps maintain a mosaic of different successional stages. The areas of the mosaic where different habitat types meet are called edges. Because many species of wildlife require more than one habitat type to provide their needs, edges offer the opportunity for the greatest diversity of wildlife. Many wildlife species prefer the edges found between vegetation types, using these areas for feeding and travel. Many species that feed in earlier successional stages seek cover in old forests, particularly during winter. These include snowshoe hares, lynx, bear, marten, moose, and resident birds.

In summary, many of the wildlife of the boreal forest depend upon repeated and sporadic fires to create and maintain the forest mosaic. Just as plant populations change throughout succession, so do those of wildlife. Some boreal forest wildlife find the best habitat in recent burns or the shrub-sapling stage of succession, while others find their habitat needs met by old forests (see "Effects of Fire on Wildlife Populations Handout page 115). Some species apparently require both early and later stages of succession. The abundance of wildlife in the boreal forest is largely a result of the variety of habitats and edges provided by the forest mosaic.

How Do Tundra Fires Affect Wildlife Populations?
The effects of tundra fires on wildlife are often short-lived. The lush plant growth that occurs in the years immediately following a fire (due to the soil changes discussed above) can lead to higher populations of plant-eating organisms and their predators. Lemming and vole populations may increase a few years after a fire, providing abundant food for foxes, weasels, and jaegers. In areas where tundra fires lead to formation or maintenance of wetlands and ponds, waterfowl and other aquatic animals such as beavers and muskrat may benefit. In general, as plants re-invade a burned area and succession proceeds, wildlife also reappear and some species flourish.



The long-term effects of tundra fires on wildlife have not been fully studied. Since the effects of fire on tundra plant communities are fairly short-lived, it seems likely that tundra fires cause few long-term changes in wildlife populations. However, scientists disagree about the effects of fires on caribou. Since these animals eat lichens for winter food, some scientists are concerned that fires may reduce the amount of winter habitat for them. However, research into the effects of fire on the size of various caribou herds has not shown any clear pattern. Some herds have increased following large fires, while others have declined. At present, most caribou biologists think that fire is less important than other factors in determining the size and health of caribou populations.

TUNDRA AND FOREST FIRE TRIANGLE

Grade Level: 5-12
Alaska State Content Standards: Geography C-1, C-2; Science B-3
Subject: Science
Skills: Construction, Description
Duration: 30 minutes
Group Size: 4
Setting: indoors
Vocabulary: fire triangle, fuel, surface fuel, ground fuel, duff, canopy fuel, oxygen, heat

Objective
Students will describe a fire triangle and its three components.

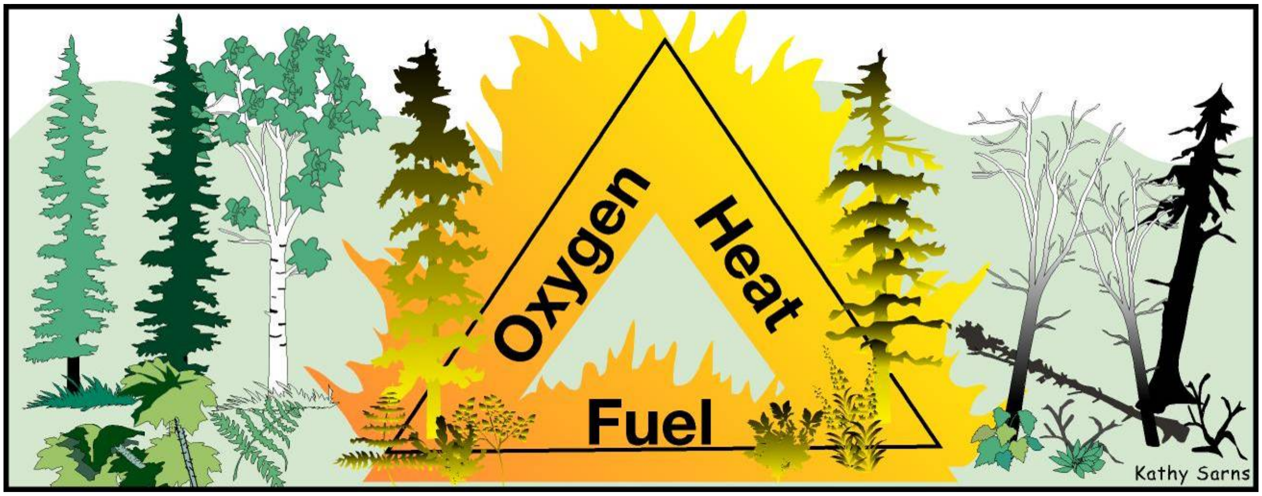
Teaching Strategy
Students will create fire triangles by playing a card game. They will then use their fire triangles to identify fire fuel types.

Materials
- Tundra or Forest Fire Component Cards, 1 set per 4 students
- "Tundra and Boreal Forest Fire Fact Sheet", 1 per student

Complementary Activities:
Meeting the Fire Triangle page 185 , Testing the Fire Triangle, page 208

Teacher Background
Fire is a rapid chemical reaction that combines fuel and oxygen to produce heat and light. An external source of heat is usually required to start the reaction. Once the fire has started, it produces the heat needed to continue burning. There are three components needed to start a fire: **fuel**, **oxygen**, and **heat**. This is called a **fire triangle**. If any one of the components is missing, a fire cannot occur.

A **fuel** is anything that will burn in a fire. **Surface fuels** lie on or right above the ground; surface fuels can be leaves, grass, dead wood, partially decomposed plants, stumps, or brush. **Ground fuels** lie beneath the ground surface. Duff is the organic layer of soil consisting of decaying leaves, roots, or other plant material. This material makes up much of the ground fuel. **Canopy fuels** include tree branches and leaves, dead standing trees, hanging beard lichens, and high brush.



Oxygen is found in the air. The amount of fresh oxygen available to a fire is often influenced by the wind. Compare this to making a campfire. What happens when you blow on the fire? Wind also helps the fire by blowing the heat towards more fuel, moving the fire by carrying sparks, and drying out the fuel through evaporation.

Heat is provided by nature in the form of lightning or volcanoes. In interior Alaska lightning starts many fires. Matches, campfires, and cigarettes are often the sources of heat in many human-caused fires.

To stop a fire the triangle must be broken. To slow down a fire, one of the three components of the triangle must be changed. Think about ways that large and small fires are controlled. A way to remove heat is to throw water onto a fire – the water absorbs heat and also cuts off oxygen. You could stop the flow of oxygen by throwing dirt on the fire, using a fire extinguisher, or dropping fire retardant from planes. The fuel supply could be removed by building a fire line around the fire.

Advanced Preparation

Copy, cut out, and laminate the **Forest** or **Tundra Fire Component Cards**. Make enough cards so that each student will receive three. Be sure there are equal numbers of fuel, heat, and oxygen cards.

Procedure

1. Discuss a fire triangle with the class as outlined in the Teacher Background section. To begin the discussion the teacher may wish to light a candle and ask the students what it needs to burn. Can you think of other ways fires might be started? Remember that once the fire has been started it produces its own heat. Place a jar over the candle. Students will probably know that the flame will go out. Why? (The oxygen has been eliminated.) How else could we extinguish the flame? (Cutting the wick from the candle removes the fuel. Wetting the flame removes oxygen and absorbs heat.) Draw a diagram of the fire triangle on the board.

Variations

1. Each student is given only one card. Students would then be instructed to locate two other students to form a fire. At the end of the activity, each group of students would discuss the fire they had created.
2. Limit the number of fires by limiting the number of fuel, oxygen, or heat cards distributed. This will create a situation in which not all of the students will be able to form a fire triangle, demonstrating to the students that without all three components no fire can occur.

2. Discuss the different types of fuels, again found in the Teacher Background section. Pass out a copy of the "Tundra and Forest Fire Fact Sheet" handout to each student. Write examples for your ecosystem on the board.
3. Shuffle the **Forest** or Tundra Fire Component Cards and give 3 to each student. Each student will try to create a fire by obtaining cards that could be arranged in a fire triangle. Students trade cards with each other until a triangle can be made. When successful, he or she stops and sits down.
4. After all the trading is completed, allow the students to tell the class what components made up their fire. Make sure that each fire has all three components. If an incomplete triangle is formed, point out that no fire would have been started in that situation and discuss why. Ask the student or the class to describe the kind of fuel their fire used (ground, surface, or canopy). Students may be creative in solving this fire activity. If unusual triangles are created, ask the students to explain them to the class.

Evaluation

Have students write their own Fire Component Cards with fuel from all 3 sources (ground, surface, and canopy).

Extensions

Students bring in newspaper articles on local fires. Discuss what the three fire components were in each case. If the fire was put out, how did the strategy work within the fire triangle concept? How was it extinguished?

References

Used with permission from In Fire, the Story Behind a Force of Nature, “Fire: The Force in With Us” by Jack DeGolia, KC Publications, 1989.

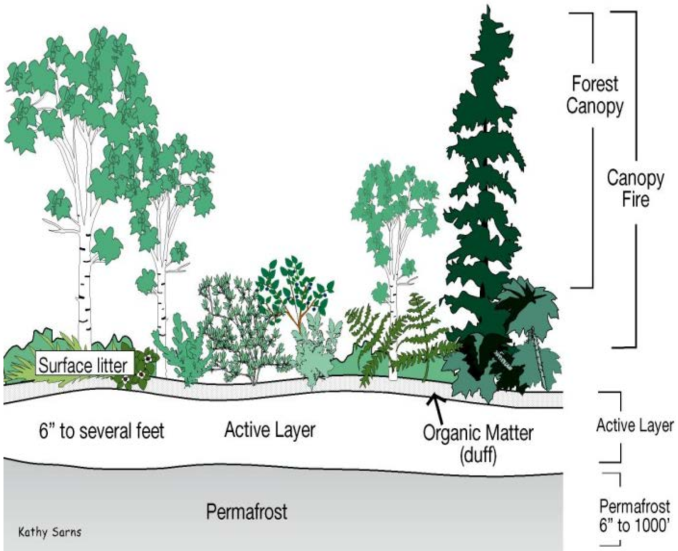
TUNDRA AND FOREST
FIRE COMPONENT CARDS

Cut each component card the size of a large mailing label.

Oxygen – Calm	**Heat –** Thunderstorm lightning
Oxygen – Winds 40 MPH	**Heat –** Campfire left
Oxygen – Winds 20 MPH	**Heat** - Lightning on steep slop
Oxygen – Winds 5 MPH	**Heat –** Cigarette thrown into grass
Oxygen – Winds Calm	**Heat –** Lightning 90 F. No rain
Oxygen – Winds 15 MPH	**Heat** – Thunderstorm lightning with heavy showers
Oxygen – Winds 10 MPH	**Heat –** Lightning on flat land
Oxygen – Winds 30 MPH	**Heat –** Fire gets away

Tundra Fuel - Grass	**Boreal Forest Fuel** - Grass
Tundra Fuel – Mosses and lichens	**Boreal Forest Fuel** - Low brush
Tundra Fuel - Shrubs of Dwarf birch, dwarf willow	**Boreal Forest Fuel** - Tops of spruce trees
Tundra Fuel – Very dry, deep organic layer	**Boreal Forest Fuel** - Roots and organic matter in soil
Tundra Fuel - Large amount of dead material	**Boreal Forest Fuel** - Stumps and downed logs
Tundra Fuel - Cottongrass	**Boreal Forest Fuel** - Snags (dead standing trees) and high brush
Tundra Fuel - Shrubs Labrador tea, blueberry	**Boreal Forest Fuel** - Deep duff and decaying material
Tundra Fuel - Wet, sedge-grass tundra	**Boreal Forest Fuel** - Fire burned here 10 years ago leaving very little fuel build-up
Tundra Fuel - Fire burned here last year so there is little fuel build up	

FOREST FIRE FACT SHEET



Canopy Fires: Burn all green and dead materials located in the upper forest canopy
Fuels: Include tree branches and crowns, dead standing trees (snags), old mans beard lichen.
Surface Fires: Burn all materials lying on or immediately above the ground.
Fuels: Include needles or leaves, duff, grass, small dead wood, downed logs, stumps, large limbs and low and high brush.
Ground Fires: Burn all fuels lying within and beneath the organic soil layer.
Fuels: Include deep duff, roots, and other woody materials.

Fire Intensity describes the amount of heat a fire produces. Fires can be low, moderate, or high in intensity. Factors that influence fire intensity include:

Fuel - Fuels that are small in size and very dry (grass) produce cool, fast fires. The more woody the fuel, the hotter the fire. Spruce burns much hotter and faster than most deciduous trees.

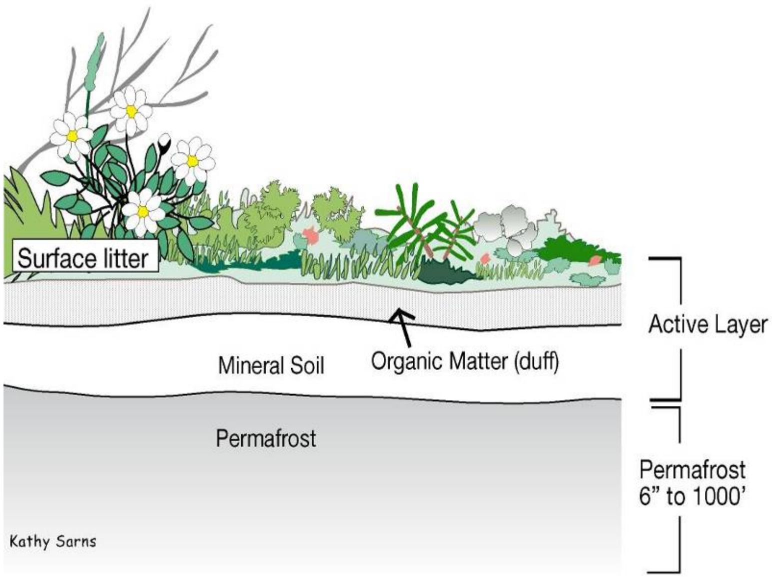
Moisture - The more moisture (or humidity) present the cooler the fire will be. Fires that burn in the spring are less intense than fires that burn during the dry summer months. Rain will lessen the intensity of a fire.

Topography - Slopes that face south, southwest, and west tend to be drier because they receive more sun and will burn more readily than north-facing slopes. Fires burning up a steep slope will burn more rapidly than on level ground. The fire creates its own updraft.

Wind - Wind will fan a fire, causing increased intensity.

Temperature - The higher the air temperature, the drier the fuel and the more intense the fire is likely to be.

TUNDRA FIRE FACT SHEET



Surface Fires: Burn all materials lying on or immediately above the ground.

Fuels: Include needless or leaves, litter, duff, grass, small dead wood, limbs, and low and high brush.

Ground Fires: Burn all combustible materials lying beneath the soil surface.

Fuels: Include deep duff, roots, and other woody materials.

Fire Intensity describes the amount of heat a fire produces. Fires can be low, moderate, or high in intensity. Factors that influence fire intensity include:

Fuel - Fuels that are small in size and very dry (grass) produce cool, fast fires. The more woody the fuel, the hotter the fire.

Moisture - The more moisture (or humidity) present the cooler the fire will be. Fires that burn in the spring are less intense than fires that burn during the dry summer months. Rain will lessen the intensity of a fire.

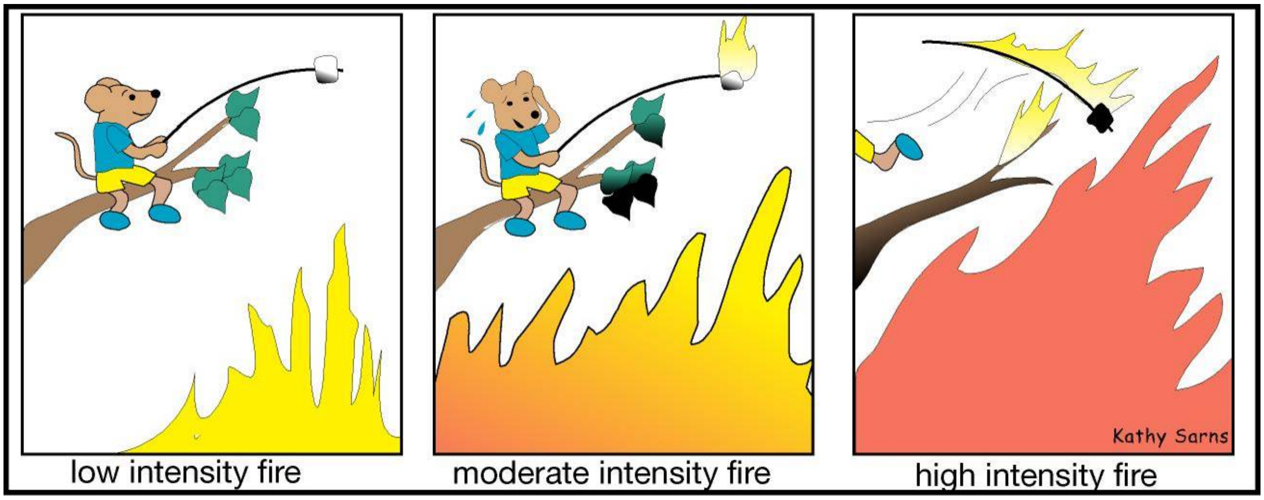
Temperature - The higher the air temperature, the drier the fuel and the more intense the fire is likely to be.

Topography - Slopes that face south, southwest, and west tend to be drier because they receive more sun and will burn more readily than north-facing slopes. Fires burning up a steep slope will burn more rapidly than on level ground. The fire creates its own updraft.

Wind - Wind will fan a fire, causing increased intensity.

Temperature - The higher the air temperature, the drier the fuel and the more intense the fire is likely to be.

HOW HOT IS IT?



Grade Level: 8-12
Alaska State Content Standards: Science B-1; Geography C-1, C-2, F-3.
Subject: Science
Skills: Application, Classification, Description
Duration: 1 class period
Group Size: 1-4
Setting: indoors
Vocabulary: fire intensity, low intensity fire, moderate intensity fire, high intensity fire, crown fire, ground fire, surface fire, canopy fire.

Objective
Students will describe the factors that affect fire intensity.

Teaching Strategy
Students use cards to create a fire intensity line.

Materials
- "Tundra and Boreal Forest Fire Fact Sheet" (from "Fire Triangle" activity)
- Small pieces of paper and tape
- Tundra and Forest Fire Component Cards (from "Fire Triangle" activity)

Teacher Background

Fire intensity is a term used to describe the amount of heat a fire produces - it will be a hot, cool, or moderate fire.

Most people have heard about the fire that burned out of control near Tok, Alaska, during the summer of 1990. There have been many other fires in Alaska that firefighters were not able to stop. These fires are often controlled only after a change in weather helps to cool the fire. What makes these fires burn so hot? Topography, ground slope, humidity, temperature, and the amount of fuel all work together to determine fire intensity.

Topography is important when discussing fire intensity. Slopes that face south, southwest, and west tend to be warmer and drier because they receive more sun. Fires on these slopes will burn more readily than fires on north-facing slopes. Fire will burn up a steep slope more rapidly than on level ground because the fire and heat move up more quickly and dry out the vegetation.

Moisture in the air and air temperature also affect how fuels burn. Fires that occur in the spring burn less intensely than fires during the dry summer months because of lower temperatures and increased moisture in the soil and air. While rain can cause fires to cool down and lessen in intensity wind can fan a fire and cause the intensity to increase.

A **low intensity fire** means that the fire is burning slowing and is not very hot. These usually occur in moist areas, in wetter months, low winds, and minimal fuels.

A **moderate intensity fire** is faster burning and very hot. They usually occur in dryer months and in moderately dry conditions. There are adequate fuels to continue the fire.

A **high intensity fire** is one that burns very fast and extremely hot. These usually occur in dry months with dry soils and a large amount of fuels. These fires are very hard to contain and ignite other areas quickly often traveling great distances.

The amount and condition of available fuels will also influence fire intensity. There are three basic types of fires: surface, ground, and canopy (crown) fires. Each burns differently depending on the kind of fuel present.

A **surface fire** burns fuels that are on the ground as well as shrubs and trees. Fuels small in size and very dry (e.g. branches, bark, broken and downed trees, dead shrubs, etc.) will cause a fast moving fire. Grass fires generally produce lower temperatures and burn quickly. A fire through brush such as alder or willow burns quickly with high temperatures because of the woody fuel. Some shrubs, such as Labrador tea, have an oily sap that is very flammable. If a fire burn fast, but without much intensity, the soil and trees are often not damaged. Surface fires can help keep surface fuels from building up and will stimulate herb and shrub regrowth.

A **ground fire** can occur when the duff layer becomes very dry. Duff is the organic layer of the soil consisting of decaying leaves and other plant parts, dead branches, and wood. It can be from a few inches to several feet thick. A ground fire can creep slowly through the duff, similar to the way charcoal burns. It not only burns the dead leaves and wood, but will also burn the roots of living trees and plants. Generally ground fires are of moderate intensity but, like the charcoal on a grill, can smolder and burn much longer than a surface fire.

A **canopy (crown) fire** burns the higher leaves and branches of trees and shrubs, moving from tree to tree through the treetops. The worst canopy fires occur in dense forests.

The fire will usually begin in the shrub layer, spreading into the dry, lichen-covered lower branches and into the canopy. If there is a strong wind the fire can build very quickly. Large fires can create their own winds as they use up large amounts of oxygen and as heat from the fire rises. The winds from these huge fires can flatten stands of trees and scatter them like toothpicks! These fires are so powerful they can create their own weather by heating and drying out vegetation. The moisture rises above the trees and forms cumulus clouds, which can then cause lightning that starts other fires.

Procedure

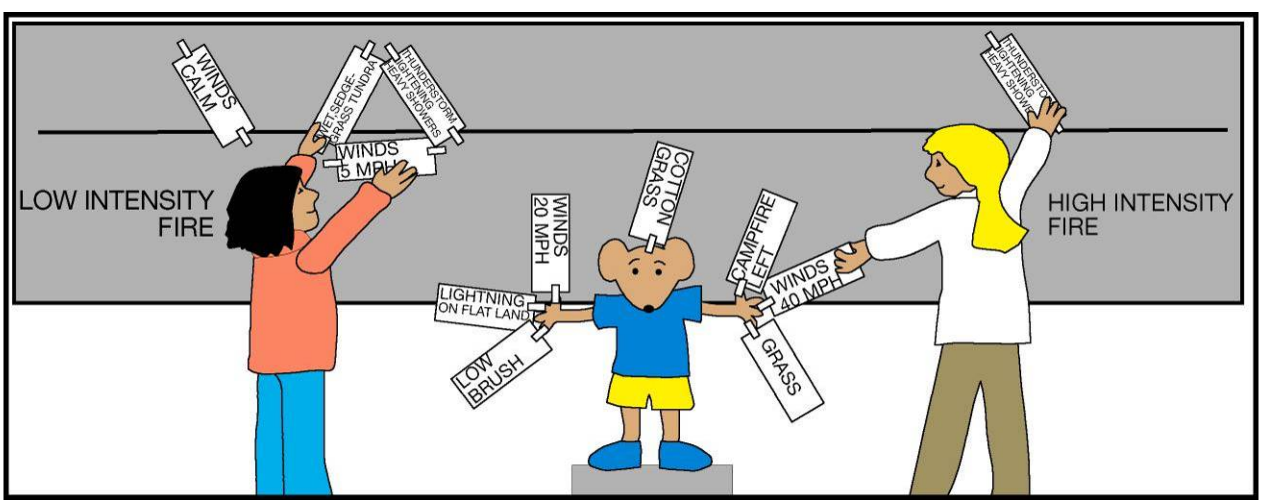
1. This activity is done after the "Fire Triangle" activity. Students use the fire triangle they created in that activity.
2. Discuss with students the fuels that create surface, ground, and canopy fires using the "Tundra and Boreal Forest Fire Fact Sheet" for a reference. Talk about fire intensity and the factors that make some fires more intense than others.
3. Draw a fire intensity line on the blackboard or bulletin board. Label the left hand side "low intensity fire." Label the right hand side "high intensity fire."
4. Students or groups of students will write the three components of their fire triangle on a small piece of paper. They then use the "Tundra and Boreal Forest Fire Fact Sheet" to categorize their fires as surface, ground, or canopy fires. Finally, they will use the heat, oxygen, and fuel information given them on the "Tundra and Boreal Forest Fire Fact Sheet" to determine their fire's intensity. It may be difficult to distinguish between the intensities of some fire triangles; each fire has its own individual characteristics and is subject to many, often rapidly changing, influences.
5. Individual students are to read to the class the components of their fire triangle and the type (surface, ground, or canopy) of fire. They then tape their triangle (slips of paper) onto the fire intensity line. Class discussion may occur if there are questions about where each fire triangle is placed along the line, fires of similar intensity can be clustered together. Students can add magazine pictures of fire to make the intensity line more interesting.

Variation

Show and discuss a videotape like Northland Wildfires "Lessons Learned" to help the students visualize what fighting a fire is really like. This videotape and many other resources are available in the Role of Fire Kit. Then have each student become a fire boss who must decide what resources they are going to need and how those resources are going to be deployed. They must explain all the factors that would enter into this decision. After these papers are written, divide the class into groups of 3 or 4 students and have them discuss all their ideas. Now have them explain, to the class, how the group would fight this fire.

Evaluation

Have the students list as many factors as they can that would affect the intensity of a fire.



TUNDRA OR BOREAL FOREST FIRE HUNT

Grade Level: 4-12
Alaska State Content Standards: Art A-1; Geography C-1, C-2; Science C-2
Subject: Science
Skills: Observation, Classification, Comparison, Description
Duration: 1-2 class periods
Group Size: whole
Setting: outdoors
Vocabulary: fire impact, heavily burned, moderately burned, lightly burned, fuel, vegetation mosaics, permafrost, active layer, surface fire, canopy fire, crown fire, ground fire, rhizomes, semi-serotinous cones

Objective
Students will describe some of the effects of fire on a boreal forest or tundra ecosystem.

Teaching Strategy
Students will investigate real or hypothetical burn sites.

Materials
- "Field Notebook: Tundra Burn Site" or "Field Notebook, Boreal Forest Burn Site" worksheets (pages 106, 107).

Teacher Background

Tundra Burn Site
Fire impact is the overall effect of a fire on an ecosystem, including the effect on vegetation and soils. Fire impact is determined by the amount of organic soil material (decaying plant and animal matter, roots, etc.) removed by a fire. The condition of the organic soil material will determine the kind of vegetative growth that will occur following a fire. Fire impact is classified in three levels:

1. **Heavily Burned -** Most or all of the organic material in the soil is burned and the remaining soil is charred and dark. A heavily burned area may have had soils with a thick organic layer and low soil moisture. All the plants have been burned, and there is a deep, mineral-rich ash layer present. Fires can bake soils to a point where they will not absorb water, which may increase the potential for erosion.
2. **Moderately Burned -** Some of the organic material in the soil is burned. Some woody twigs of plants are present. These fires do not seriously affect the quality of the soil. Erosion may occur to some degree.
3. **Lightly Burned -** Plants may be charred or scorched. Mosses and twigs are still visible. Some mosses and other plants have turned brown or yellow.

Fuel is any material that will burn. The type and quality of fuel determines how hot a fire will burn and the effect the fire will have on the habitat. A build-up of organic material and brush will fuel a hot surface fire. Highly flammable fuels allow hot ground fires to start and spread quickly. These fuels include shrubs of the heath family, such as Labrador tea, which contain a highly flammable, oily sap. Grass fires are generally fast burning, but cool, and do less damage to the organic layer of the soil than more intense shrub fires.

In a lightly to moderately burned area, seeds and roots buried in the remaining organic layer will revegetate rapidly, sending up new shoots. Plant nutrients in the form of ash are put back into the soil, resulting in rich new plant growth. Grass and sedge tussocks quickly sprout new shoots. Herbs and shrubs come back from rhizomes (underground, root-like stems), roots, and seeds. Plant species with deep roots, such as wild rose and Labrador tea, are less likely to be damaged by moderate intensity fires and will re-sprout quickly. Shrubs such as willows sprout from stumps as well as from roots.

In heavily burned sites, plants and roots are destroyed. New growth depends on unburned seeds buried in the organic layer or those brought in from other areas by animals or wind. The high concentration of minerals in the heavily burned soils provides a good seed bed for the germination of seeds. Grasses, herbaceous plants such as fireweed and horsetail, and mosses are some of the first plants to begin growing in bare, mineral soils. Most of the same plants that grew in the area before the severe fire will return; however, species percent composition may be different.

In tundra areas, most fires burn lightly due to lack of fuel. Thus, the extensive underground parts of most tundra plants usually survive fire. Their roots usually re-sprout within a year after a fire. Little change generally occurs in the species of tundra plants following a fire. Most tundra sites return to their pre-burn appearance and productivity in less than ten years. The return to pre-burn appearance takes more time in tundra areas where lichens dominate. Lichens are often entirely consumed, even by light fires. Since lichens are slow growing and slow to invade burned sites, dense lichen stands may not return to a burned tundra site for 100 years or more.

Fires in the tundra typically burn in a spotty, erratic pattern, leaving islands of vegetation unburned. This creates a **vegetation mosaic** of plants representing different tundra plant habitats.

Fire can also have effects on areas of **permafrost,** or permanently frozen ground. The active layer, the layer of soil that freezes and thaws each year, insulates permafrost. Fire removes the plants and organic matter and exposes the active layer. This exposed layer absorbs more of the sun's heat, and the depth of the active layer increases. This can affect soil drainage by indirectly causing the permafrost to melt and creating wet meadows, ponds, and even small lakes.

The effects of tundra fires on wildlife are often short-lived. The lush plant growth following a fire can lead to higher populations of plant-eating animals such as lemmings and voles. These provide abundant food for foxes, weasels, and beavers. Scientists disagree about the effects of tundra fires on caribou. Since these animals eat lichens for winter food, some scientists are concerned that fires may reduce the amount of winter habitat for them. In areas where tundra fires lead to formation or maintenance of wetlands and ponds, waterfowl and other aquatic animals such as beavers and muskrat may benefit.

Boreal Forest Burn Site

Fire Impact is the overall effect of a fire on an ecosystem, including the effect on vegetation and soils. Fire impact is determined by the amount of organic soil material (decaying plant and animal matter, roots, etc.) removed by a fire. The condition of the organic soil material will determine the successional stages that occur following a fire. Fire impact is classified in three levels.

1. **Heavily burned --** Most or all of the organic material in the soil is burned and the remaining soil is charred and dark. A heavily burned area may have had soils with a thick organic layer and low soil moisture. All the plants have been burned, and there is a deep, mineral-rich ash layer present. Fires can bake soils to a point where they will not absorb water, which may increase the potential for erosion.
2. **Moderately burned --** Some of the organic material in the soil is burned. Logs may be deeply charred. Some woody twigs of plants are present. These fires do not seriously affect the quality of the soil. Erosion may occur to some degree.
3. **Lightly burned** -- Plants may be charred or scorched. Mosses and twigs are still visible. Some mosses and other plants have turned brown or yellow. Logs are not deeply charred. Fire-resistant trees will not be seriously affected.

This classification system illustrates how a **surface fire** can have a greater effect on the forest floor than a **canopy (crown) fire.** In some instances, a canopy fire may burn the leaves and branches of trees, but do little harm to the soil. (The activity "How Hot a Fire?" will acquaint the class with the characteristics of **surface, ground, and canopy fires.**)

Fuel is any material that will burn. The type, quantity, and arrangement of fuel determine how hot a fire will burn and the effect the fire will have on the habitat. A build-up of organic material and brush will fuel a hot surface fire. Highly flammable fuels allow hot ground fires to start and spread quickly. These fuels include shrubs of the heath family, such as Labrador tea, which contain a highly flammable, oily sap.

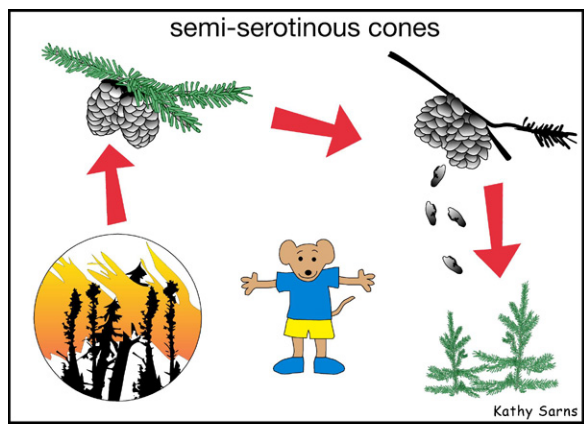
Grass fires are generally fast burning and do less damage to the organic layer of the soil than a more intense shrub fire. Because the live foliage of deciduous trees is more fire-resistant than that of spruce, canopy fires are more likely among spruce than deciduous trees. Regardless of fuel type, fire intensity is also affected by other factors, such as moisture and topography.

In a light to moderate burned area, seeds and roots buried in the remaining organic layer will revegetate rapidly, sending up new shoots. Plant nutrients in the form of ash are put back into the soil, resulting in rich new plant growth. Grasses and sedges quickly sprout new shoots. Herbs and shrubs come back from **rhizomes** (underground root like stems), roots, and seeds. Shrub and tree species with deep roots, such as wild rose and Labrador tea, are less likely to be damaged by moderate intensity fires and will re-sprout quickly. Shrubs such as willows sprout from stumps as well as from roots.

Light and moderate intensity fires, if they do not burn long in the area, can be beneficial to the habitat. These fires do not generate high soil temperatures, which destroy all plant life, and they return important nutrients to the soil. Frequent, **low (or light) intensity fires** help prevent the build-up of fuels. When fuel is allowed to accumulate, intense fires may result during a dry year. It takes years for the soil and vegetation to recover from such fires.

In heavily burned sites, plants and roots are destroyed. New growth depends on unburned seeds buried in the organic layer or those brought in from other areas by animals or wind. The high concentration of minerals in the heavily burned soils provides a good seed bed for the germination of these seeds. Grasses, herbaceous plants such as fireweed and horsetail, and mosses are some of the first plants to begin growing in heavily burned sites. Deciduous trees will sprout from roots, stumps, or seeds. Most of the same plants that grew in the area before the fire will return; however, species percent composition may be different.

Fires may not burn an entire area, particularly under wet conditions; they may burn in a "patchwork" pattern, leaving islands of vegetation unburned. This creates a **vegetation mosaic** of plants in different stages of succession, which supports a wide diversity of wildlife species. New herb and shrub growth provides abundant shoots to feed forest wildlife. Low shrubs are good cover for small mammals.

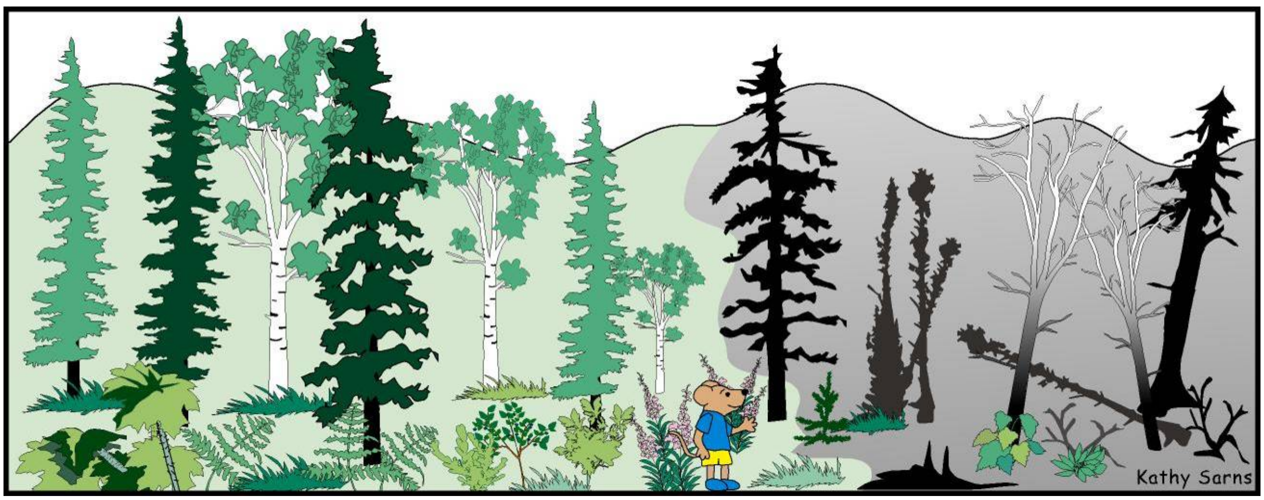


Some plants have become well adapted to fire. Black spruce trees have cones that remain on the tree for many years. These cones are **semi-serotinous**. They are sealed with a tough resin and open only when the resin is dried by fire or years of hot summer sun. When a fire burns through a black spruce forest, the cones open and thousands of seeds fall to the ground. If conditions are suitable, the seeds will germinate. White spruce trees lose their cones each year, so they do not have the seed reserve that black spruces have.

Fire can also have effects on areas of **permafrost,** or permanently frozen ground. Permafrost is insulated by the **active layer** of the soil. This is the layer of soil that freezes and thaws each year. Fire removes the plants and organic matter and exposes the active layer. The exposed active layer absorbs more of the sun's heat, and the depth of the active layer increases, making deeper nutrients available to plants. In addition, the burning of the organic layer returns nutrients to the soil. However, thawed soils near a stream or river or on a hill are more likely to erode

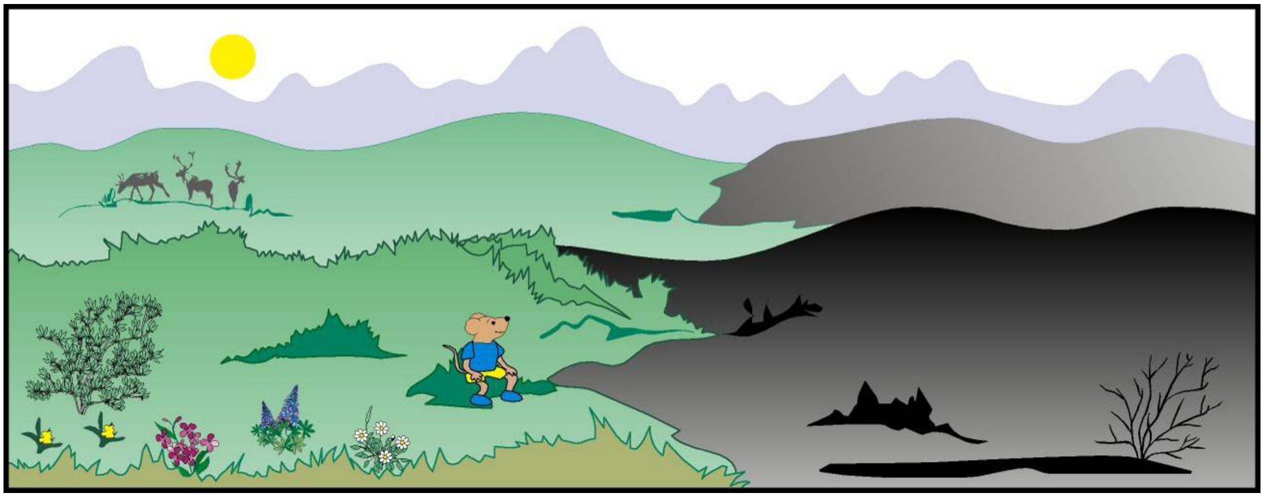
.

Procedure: Boreal Forest



1. Visit a burned area. The burn does not have to be recent. Village elders may be able to help locate a burn site that is not recent. Try to answer the questions on the "Boreal Forest Burn Site" worksheet to determine what kind of fire occurred and its impact.
2. After answering the questions about the burn site, draw and color how the vegetation might come back or continue growing after the fire.
3. Have students share the plants they drew in their burn site picture and why they thought the plants they drew would be the ones to come back to the area.
4. If you don't have a burn site, view the videotape "Fire in the Forest" from the Role of Fire In Alaska Kit.

Procedure: Tundra



1. If possible, visit a burned area. The burn site does not have to be recent. Village elders may be able to help locate burn sites that are not recent. Try to answer the questions on the "<u>Tundra Burn Site</u>" worksheet to determine what kind of fire occurred and its impact.
2. After answering the questions about each burn site, draw and color how the vegetation might come back or continue growing after the fire.
3. Have students share what plants they drew in their burn site picture and why they thought the plants they drew would be the ones to come back to the area.
4. If you don't have a burn site, visit any area and try to determine how likely it would be for a fire to occur there. You may want to consider the amount of brush and organic material present. When do you think a fire last occurred in the area?

Evaluation

1. Following discussions, visit another area near your school that has not been burned. Have students try to determine how likely it would be for a fire to occur there. You may want to consider the amount of brush and organic material present. What kinds of trees are present? Deciduous trees or spruce? Would a canopy or a surface fire most likely occur? Based on the area's stage of succession, roughly estimate when you think a fire last occurred in the area.
2. Then have students draw, or explain, what they think the area they visited would look like in 50 years.

A picture of a wildland fire site that burned during the summer of 1999 in the Yukon Flats Wildlife Refuge. This portion of the fire was allowed to burn naturally because there were no identified resources threatened. This picture shows the kind of mosaic created by wildland fire.

FIELD NOTEBOOK
TUNDRA BURN SITE

1. What clues can you find that might tell you how hot the fire was?

    a. Can you find signs that bare, mineral soil was exposed as a result of this fire? Explain.

    b. Are there any islands of vegetation that were not burned?

    c. How would you classify this burn site: heavily burned, moderately burned, or lightly burned?

2. When do you think the fire occurred? Look at the amount of new vegetation. Do you think it happened during the wet or dry part of the season?

3. What was the most interesting thing you observed?

FIELD NOTEBOOK
BOREAL FOREST BURN SITE

1. What clues can you find that might tell you how hot the fire was?

    a. Can you find signs that bare, mineral soil was exposed as a result of this fire? Explain.

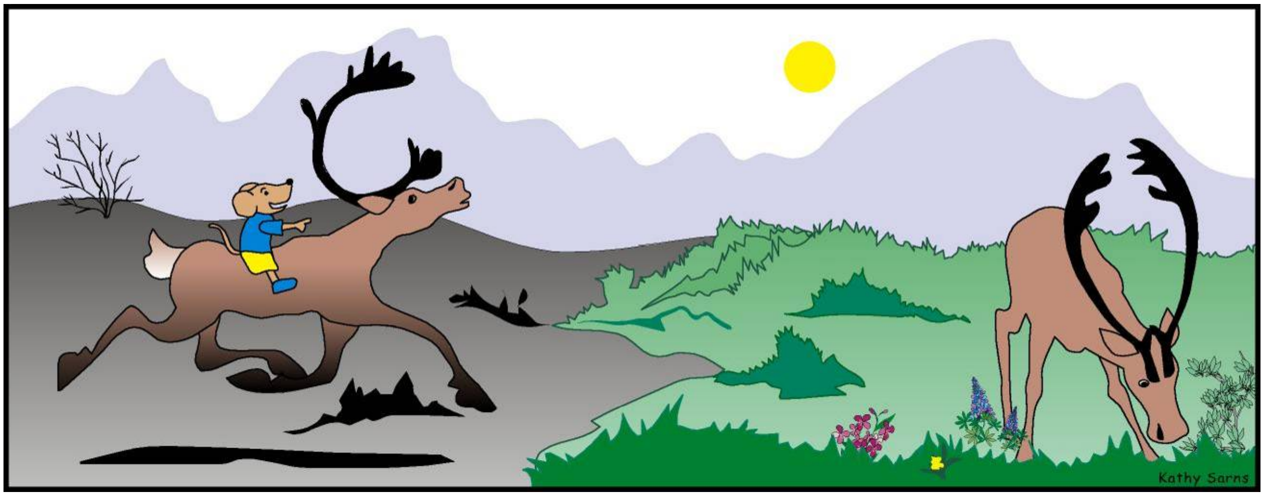
    b. Are there any islands of vegetation that were not burned?

    c. How would you classify this burn site: heavily burned, moderately burned, or lightly burned?

2. What kind of fire do you think it was, surface, ground, or canopy and why?

3. When do you think the fire occurred? Look at the amount of new vegetation. Do you think it happened during the wet or dry part of the season?

FIRE'S EFFECT ON FOREST AND TUNDRA WILDLIFE



Grade Level: 3-6
Alaska State Content Standards: Art A-1, A-5; Geography C-1, C-3, E-6; Language Arts A-4, A-6; Science C-2, C-3
Subject: Science, Language Arts
Skills: Comparison, Description, Generalization
Duration: 1 class period
Group Size: 3-4
Setting: indoors
Vocabulary: successional stage

Objective
Students will identify the habitat needs of wildlife, comparing the list of needs to the long and short-term effects of a fire.

Teaching Strategy
Students will depict forest or tundra ecosystems by drawing and coloring these ecosystem habitats.

Materials
- *Alaska Ecology Cards* (page 271).
- White butcher paper
- Crayons, markers, or paints

Teacher Background
Tundra
While tundra areas receive little precipitation, they are often moist or wet because cool temperatures cause low evaporation rates and the water cannot seep into frozen permafrost soils. The soil also contains a high amount of organic material due to the slow rate of decay in cold climates.

Because the organic layer underneath the surface vegetation is moist and will not easily burn, fires often travel fast, burning only the grasses and other plants that are above ground. These types of fires remove the buildup of dead material and return nutrients to the soil. Surviving roots send up new shoots and abundant regrowth occurs. In very dry years, a creeping ground fire can burn the organic layer of the tundra. This type of fire will destroy giant roots and can smolder for many months, even occasionally through the winter. When this occurs, succession progresses from seeds brought in or roots growing back from those in surrounding unburned areas.

Tundra fires may be started directly by lightning or by fires spreading from adjacent forests. They usually occur during late May, June, and early July when temperatures are warm and fuels are dry. If it has been a dry year, there may be fires later in the summer, which could develop into a creeping ground fires that burn deep into the organic layer. Fire is unique in tundra areas because there is less lightning in the northern and western parts of Alaska where tundra predominantly occurs. One area of tundra may burn almost every year, and other areas may never burn.

To evaluate the potential effects of a tundra fire on wildlife it is important to consider when the fire occurred. The tundra supports many migrant animals that may stay for a very short time and may depend on a specific food source found at a specific time of the year. If that food source is destroyed during a fire, the short-term effect may be slight if the animal is not a current resident of the tundra. However, the impact may be greater if the animal returns and cannot find the important foods needed for migration.

The following examples can be discussed with students to help them consider how wildlife use the tundra during various times of the year:

1. Many migrating birds arrive in Alaska during April and May. Waterfowl consume mosquito larvae and plants during breeding and nesting. A fire in early summer could have a detrimental short-term effect on nesting waterfowl. The birds may be forced to abandon their nest or be killed. If the fire occurs late in the nesting period, there may not be enough time to nest again. After eggs have hatched, the young birds can move into lakes or rivers where they can escape fire. Most bird species leave the tundra during August and September and would not be affected by late season fires.
2. It is also important to recognize the long-term effects of fire. In years following a fire, dense grass cover often grows around the shorelines of wetlands. This thick grass provides good nesting cover, which can increase nesting production. Fires also release nutrients back into the soil and nearby water sources. These nutrients increase mosquito larva populations and underwater plant production, providing important food for ducklings.
3. Tundra fires can have both short and long-term effects for caribou. A tundra fire (depending on its size) may have less of an impact on migrating caribou since they can move to other areas to feed. The Western Arctic herd calves and spends the summer on the North Slope feeding on young sedges and willow shoots. In the fall they return south to Western Alaska where they over winter, eating grasses, shrubs, and lichens. The short-term effect on grasses, sedges and shrubs appears to be mostly positive because of the abundant regrowth available to caribou. However, for some species of lichens that take 30-40 years to develop, fire has a more detrimental long-term effect. There is still some question as to how essential lichens are in the winter diet of the caribou.

Boreal Forests

Fires have occurred in the boreal forest of interior Alaska for thousands of years. This is clearly shown by charcoal layers in soil, fire scars on trees, and the mosaic pattern of the boreal forest. Scientists believe that lightning-caused fires have occurred in Alaska's boreal forest and tundra since the last ice age, 10,000 years ago. These natural fires, as well as man made fires, have helped create the boreal forests we have today. These fires both harm and help wildlife.

Certainly some animals, including nesting birds, voles, squirrels, and hares, are killed by fire. But surprisingly few dead animals are found after fires. Many birds and large mammals apparently escape the flames by flying or running away. And small mammals, such as voles and squirrels, sometimes escape fire by moving into underground burrows. Scientists think most vertebrate animals killed by wildland fires die of suffocation from the smoke rather than from the heat. Most invertebrate organisms in the surface soil and on vegetation are killed by fire.

The most important effects of fire on wildlife are not the deaths caused by the flames and smoke, but the indirect effects caused by changes in plant communities. Some wildlife species are harmed by these changes, while other species benefit. By removing trees, shrubs, herbs, and lichens, fire essentially removes the food and cover (habitat) for some wildlife. These organisms cannot find homes in recently burned areas and are forced to move to other areas or die. Other species of wildlife move into and use burn sites. The species and numbers of animals that move into a burned area depend largely upon the kinds of plants that become established and the rate at which these plants grow. In general, as plants re-invade a burned area and succession proceeds, wildlife also reappears and some species flourish. The "Effects of Fire on Wildlife Populations" handout (page 115) provides more information on the effects of fire on specific species of wildlife.

A few wildlife species find food and cover in a burn site immediately after a forest fire. Bark beetles have built-in smoke detectors and heat sensors to help them locate burned areas. As growing numbers of beetles attack the burned trees, their predators, three-toed and black-backed woodpeckers, congregate in the burned areas to feed. Other predators such as foxes, coyotes, hawks, and owls often hunt in recent burns, probably because the voles and other small mammals that remain have little cover and are easy prey. As plant succession proceeds soils enriched by ashes provide the nutrients needed for a flush of plant growth. Grasses, herbs, and seedling shrubs and trees provide a rich source of food for insects and seed-eating birds and mammals. Far from devoid of life, a young burn is often alive with a wide variety of insects, along with hares, voles, shrews, sparrows, and flycatchers. These animals attract predators like foxes, coyotes, red-tailed hawks, northern hawk-owls, and American kestrels.

As the shrub stage develops wildlife begins to flourish. Young trees and tall shrubs provide new nesting and feeding sites for birds. New species, including some warblers, sparrows, thrushes, and sharp-tailed grouse, may begin using the burn site at this stage. Due to abundant herbs, grasses, shrubs, and cover provided by fallen trees, the shrub stage of succession may provide habitat for larger numbers of small mammals and certain ground-nesting birds than any other **successional stage**. This abundance of prey supports similarly high numbers of predators, including fox, weasels, and marten. In general, these species of predators are more abundant in this early stage forest than in any other stage. If hardwood trees and shrubs are abundant, moose and snowshoe hares may also find an abundant and nutritious food supply in this successional stage. As their numbers increase, predators such as wolves and lynx may also move into the burn area.

Once the saplings have grown into trees, they shade out smaller shrubs, other saplings, and many ground cover plants like fireweed and grasses. In this maturing forest animals that needed these plants die out or are forced to move to other areas in search of appropriate food and cover. Among the affected species are moose and hares when tree branches have grown out of their reach. Many of the seed-eating and shrub-nesting birds are also displaced, including most sparrows. Other species of wildlife, including ruffed grouse, Swainson's thrushes, yellow-rumped warblers, and sharp-shinned hawks, find ideal habitat in this forest stage.

As hardwood trees are replaced by spruce, wildlife that prefers spruce trees displace those that need hardwood forests. As this forest matures or ages, porcupines, red squirrels, caribou, white-winged crossbills, spruce grouse, boreal chickadees, goshawks, Swainson's thrushes, and Townsend's warblers become the wildlife typical of old stands of spruce trees.

Fires rarely burn evenly. They burn in patches, completely burning some parts of the forest or tundra and leaving other parts untouched. This patchy burning pattern helps maintain the vegetation mosaic of different successional stages. The areas of the mosaic where different habitat types meet are called **edges**. Because some wildlife require more than one habitat type to provide their needs, edges offer the opportunity for the greatest diversity of animals. Many wildlife species prefer the edges found between vegetation types, using these areas for feeding and travel. Many animals will feed in earlier successional stages and seek cover in old forests, particularly during winter. These include snowshoe hares, lynx, bear, marten, moose, and resident birds.

Many of the wildlife of the boreal forest depend upon repeated and sporadic fires to create and maintain the forest mosaic. Just as plant populations change through succession, so do those of wildlife. Some boreal forest wildlife find the best habitat in recent burns or the shrub-sapling stage of succession, while others fulfill their habitat needs in old forests (see "Effects of Fire on Wildlife Populations" handout, page 115). Some species apparently require both early and late stages of succession. The abundance of wildlife in the boreal forest is largely a result of the variety of habitats and edges provided by the forest mosaic.

Procedure

1. Divide the class into groups of 3 or 4.
2. Randomly distribute several Forest or Tundra "*Alaska Ecology Cards*" to each group. Have the groups discuss the habitat needs of each wildlife species.
3. Give each group a large piece of white butcher paper and something to color or draw with. Each group is to design either a forest or tundra ecosystem that provides all the necessary habitat requirements for their wildlife. Students can be creative and design habitats that they think would be more beneficial to the wildlife than a natural ecosystem might be.
4. When the students have completed their drawings, each group will present their ecosystem to the class and explain how it supports each type of wildlife included. As the presentations are completed, place the drawings in a display on the wall and tape the wildlife cards to each drawing.
5. Have each student write a paper explaining the short-term and long-term effects of fire on each wildlife species in their habitat drawings. Try to answer the following questions:

    a. If fire burned through just one of the drawings, would there be habitat available for all the wildlife to move into the habitats provided by the other drawings?

b. Would the fire's impact on wildlife be different if the fire burned early or later in the summer?

c. In a boreal forest habitat, what would be the effect of the area developing into the next successional stage?

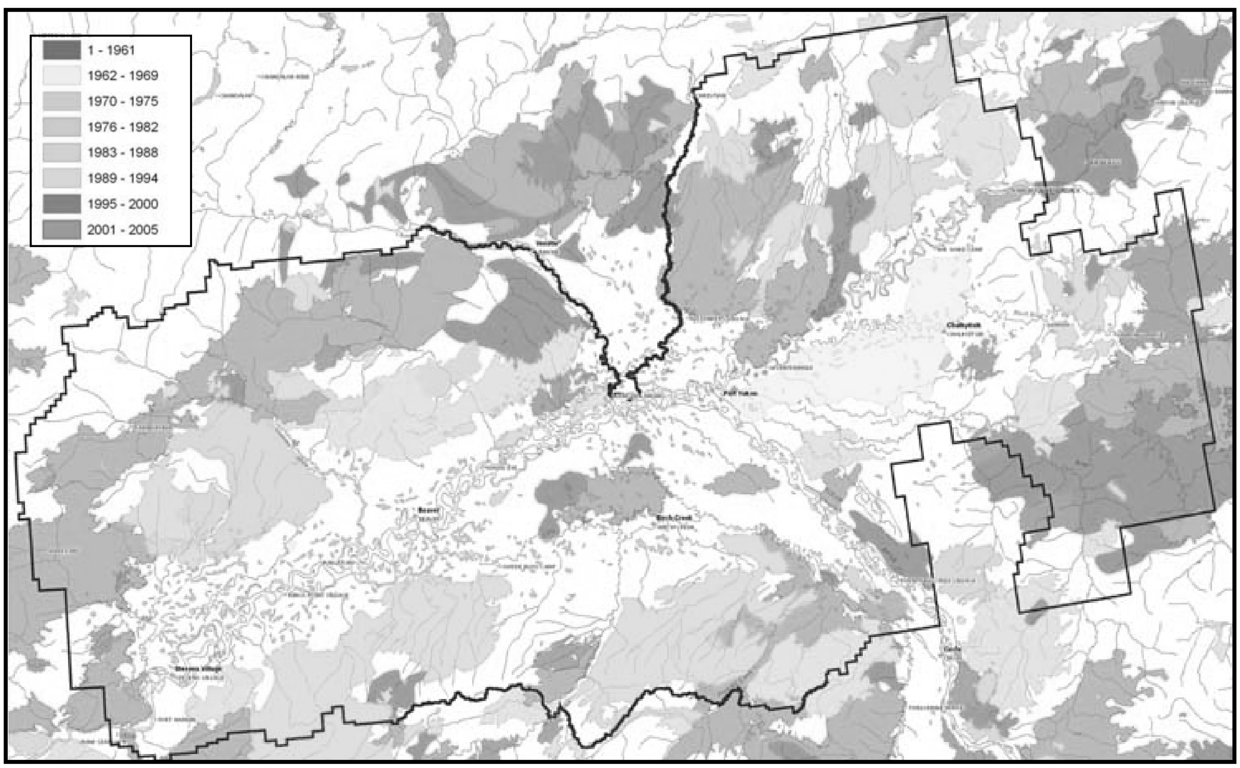
d. If there was a village on the edge of one of the drawings, how would fire affect the people? Would the fire affect subsistence?

e. Discuss how diversity in vegetation will support a larger diversity in wildlife. Notice that the different drawings create a vegetative mosaic.

Evaluation
Have students choose one animal in their drawing and write a story about the effects of a fire from the animal's point of view.

Extension
Students may wish to make diagrams of habitats needed by their wildlife.

Yukon Flats National Wildlife Refuge fire history 1950-2005. The map shows how the burned areas will create a mosaic of areas in different stages of succession after fires have burned.



LOOKING AT FIRE IN THE ECOSYSTEM

Grade Level: 2-8
Alaska State Content Standards: Geography C-1, E-6, F-3; Language Arts A-1, A-4, D-1a; Science C-2.
Subject: Science, Language Arts
Skills: Description, Generalization
Duration: 1 class period
Group Size: individual
Setting: indoors

Objective
Students will describe the effects of boreal forest or tundra fires on people and wildlife.

Teaching Strategy
In this writing activity students consider the effects of fire through the eyes of people, wildlife, and plants.

Materials
- Paper and pencil
- The Effects of Fire on Wildlife Populations student handout, page 115.

Teacher Background
Refer to the background information section of Unit II.

Procedure
1. Discuss the positive and negative effects of fire and how they relate to wildlife and people.
2. Tell students they will be looking at a fire from a viewpoint different than their own. Read the list of roles below and ask students to brainstorm any others they would like to add.

Tundra List
Look at the effects of fire through the eyes of a
- insect
- fox
- ptarmigan
- nesting bird
- caribou
- wolf
- lichen
- blueberry
- mineral
- pilot
- firefighter
- home owner
- trapper

(For more ideas go to the Tundra *Alaska Ecology Cards*)

Forest List
Look at the effects of fire through the eyes of a insect

- fox
- spruce hen
- nesting bird
- moose
- beaver
- tree
- blueberry
- mineral
- pilot
- firefighter
- trapper
- home owner

(For more ideas go to the *Alaska Ecology Cards*) (page 271).

3. Assign a role on the list to each student (repeat the roles, if necessary). Place students in groups of 3.
4. Show and discuss pictures of burned sites to the class to help them visualize a burn scene. As a class have students close their eyes for 2-3 minutes imagining a burn site and looking at the effects of the fire with their assigned role in mind.

Encourage students to discuss, within their groups, how they would view the effects of fire from the perspective of their assigned role. Have students write a short essay describing the viewpoint.

5. Have the groups share their viewpoints with the class. The essays can be read aloud or displayed on the wall

Evaluation
Students draw pictures of a burn site through the eyes of their assigned role and share with the class.

Extension
Ask a firefighter to visit the class and describe his or her experience with fire.

EFFECTS OF FIRE ON WILDLIFE POPULATIONS.

While fires kill some individual animals, the most important effects of fire on wildlife populations are due to changes in the vegetation. In tundra most of these changes last for less than 10 years, but in the boreal forest fire begins a series of changes that may last from 50 to 200 years. The most important effect of fire on wildlife in the boreal forest is that it creates and maintains the mosaic of forest ages and types. The fire-maintained mosaic provides habitat for a greater abundance and diversity of wildlife than would otherwise occur.

The following lists the effects of fire on the animals found in boreal forests or tundra ecosystems.

Moose	Moose generally benefit from fire because their preferred foods are shrubs and saplings. These plants are most abundant and most productive in burned areas. Habitat for moose is generally improved for about 1 to 30 years following fire depending on the impact of the burn and other factors affecting plant succession. However, fires in stands that lack aspen, birch, willow or other browse plants do not benefit moose.
Caribou	Scientists disagree about the effects of fire on caribou. Since caribou rely on lichens for winter food some scientists are concerned that fires may reduce the amount of winter habitat for them. Lichens are slow growing and may require 50 to 100 years to recover from a fire. However research into the effects of fire on the size of various caribou herds has not shown any clear pattern. Some herds have increased following large fires while others have declined. At present most caribou biologists think that fire is less important than other factors in determining the size and health of caribou populations.
Dall Sheep	Unknown. Sheep may temporarily benefit from increased nutrient-rich plant growth in the few years following fire if a fire occurs in alpine tundra or a forested area near treeline.
Muskox	Unknown. Muskoxen could potentially benefit from increased nutrient-rich plant growth in the few years following fire.
Bear	Fires generally benefit bears by increasing plant growth and berry crops, and possibly by increasing numbers of prey animals. Heavily burned sites that clear large areas of forest may reduce black bear numbers but are unlikely to affect brown bear populations. A severe burn may adversely affect salmon streams and reduce bear populations.
Wolf	Research on the effects of fires on wolves has not been conducted. Wolves are known to hunt in burn areas and they could benefit from increased populations of moose and other prey.
Coyote and Fox	The effects of fires on coyotes and foxes have not been thoroughly researched. However these animals often hunt in burned areas and likely

benefit from increased populations of small mammals such as voles and lemmings.

Weasel	Weasels prey on small mammals and their numbers are likely to reflect the availability of prey. Since voles are generally more abundant in early successional stages, weasels likely benefit from fire.
Marten	Scientists once thought that fires reduced marten habitat but research on this subject has revealed that marten often benefit from fire both in the short-term and long-term. Marten may benefit from fire in the short-term due to increased populations of voles, their primary prey. Research indicates that marten numbers generally return to or exceed preburn levels within 10 years following fire. While marten do appear to need mature forest for denning sites, small islands of unburned forest within a large burn can provide adequate cover. Marten thus benefit from sporadic fires that create or maintain the forest mosaic. Large fires that completely clear out forests from extensive areas may be harmful to marten but such fires are more likely to result from fire suppression which allows accumulation of fuel. Thus complete fire suppression must be considered detrimental to marten populations in the long-term.
Wolverine	Unknown.
Lynx	Fires are considered generally beneficial to lynx because they increase food for snowshoe hares, the primary prey of lynx. In one study by the Alaska Department of Fish and Game, scientists found that the harvest and evidence of lynx were higher in a recently burned area than in nearby mature forest. Some biologists think that lynx may require mature forests for cover. If so lynx would benefit most from fires that maintain the forest mosaic.
Voles	The effects of fire on vole populations depend upon the impact of the fire and the rate at which plant succession occurs. In lightly burned areas where plant regrowth occurs quickly and where adequate ground cover exists, voles may quickly repopulate a burn site and numbers inside burn areas may eventually exceed those in unburned areas. However, in heavy burns where little cover remains and where vegetation is slow to recover, small mammals may not re-invade burn sites for several years. Also different species of small mammals may respond differently to fire. Research indicates that red-backed voles quickly re-invade burn areas (where conditions are suitable) while tundra voles may not use burned areas for several years. Information on other species is lacking.
Lemming	The effects of fire on lemming populations are unknown.
Porcupine	Porcupines need mature forest for winter habitat but use burned areas for feeding in spring and summer. They are likely to benefit from small burns but be harmed by large fires. No research has been done on the effects of fire on porcupine populations.

Beaver	Beaver benefit from fire because they require young forest or earlier stages of succession where birch aspen and willow predominate. Beaver cannot survive well in forests dominated by spruce.
Muskrat	Research on the effects of fire on muskrats in Alaska is lacking. Elsewhere fire has been shown to benefit muskrats by helping maintain marshlands and increasing growth of plants used by muskrats. In permafrost areas fire may lead to thawing of permafrost and the formation of wetlands and ponds. The value of such ponds to muskrats has not been researched but they may provide additional habitat.
Red and Northern Flying Squirrels	Red and northern flying squirrels live in mature forests, which suggests that fire would be harmful to them. Fire is more likely harmful to red squirrels since they require large stands of spruce to get adequate seeds for winter. Northern flying squirrels feed on mushrooms and berries that may be more abundant in early post-fire successional stages. Large burns that remove extensive forest areas are undoubtedly harmful to flying squirrels but smaller fires that help maintain the forest mosaic likely improve habitat for them.
Ground Squirrel	No research is available. However some scientists think that fires benefit ground squirrels by promoting lush growth of their primary food plants.
Woodchuck and Marmot	No information is available. Lush plant growth following fire could provide short-term benefits.
Hare	Snowshoe hares benefit from fires that maintain the forest mosaic. They feed on young willow, aspen and birch shrubs and saplings. Since these are more abundant and productive in burn areas, hares generally benefit from the increased food created by fires. However, hares also require dense black spruce or willow and alder thickets for cover, particularly during winter. Thus large fires that remove extensive areas of forest can reduce hare numbers. Fire suppression that leads to fuel accumulation and the potential for large fires pose a threat to hare habitat.
Loons and Grebe	No research is available. Fires that blacken the soil surface and remove some, or all, of the insulating organic mat can lead to the formation of ponds from the thawing of permafrost in some areas. These wetland areas could potentially provide habitat for these birds if the ponds were large enough and productive enough to support populations of small fish.
Ducks, Geese, and Swans	Little research information is available for Alaska but elsewhere fires are used to maintain wetland habitat for wildlife. Some biologists think fires may benefit Alaskan waterfowl by helping maintain marshlands and/or increasing plant and invertebrate productivity in wetland areas. Fires that blacken the soil surface and remove some or all of the insulating organic mat can lead to the formation of ponds from the thawing of permafrost in

some areas. These wetland areas could potentially provide habitat for waterfowl if the ponds supported suitable aquatic vegetation and insect populations.

Shorebirds	Although no information is available it can be speculated that fire is beneficial for the same reasons as with waterfowl.
Owls	No research has been done on the effects of fires on owls. Several species of owls would likely benefit from fires because they feed on small mammals in open habitats. These include northern hawk owl, short-eared owl, great-horned owl, and great gray owl. Boreal owls, great-horned owls, and great gray owls nest in mature trees so fires that remove large forest areas may be harmful to them. Sporadic fires that maintain the forest mosaic should be beneficial.
Grouse	The effects of fire on grouse vary by species. Spruce grouse, which live mainly in mature, white spruce forests, are likely harmed by fire in the short-term. On the other hand, sharp-tailed grouse that need shrub lands and ruffed grouse which live in young deciduous forest benefit from occasional fires that maintain their habitat. Willow ptarmigan also benefit from fire; during winter they feed mainly on buds of birch, aspen and willow along forest edges or in young forest.
Hawks and Falcons	The effects of fire on hawks vary by species. Some species, including rough-legged hawks, red-tailed hawks, and American kestrels feed on small mammals in open habitats. They benefit from increased feeding areas that result from fire. Sharp-shinned hawks and goshawks feed and nest in mature deciduous or mixed forests; in the short-term, fires likely reduce their populations. However, complete fire suppression could lead both to a reduction in the extent of deciduous forests (as these are replaced by spruce forests) and to large heavily burned areas that would clear out extensive areas of mature forest. Sporadic fires that maintain the vegetation mosaic are beneficial to these species.
Woodpeckers	Black-backed woodpeckers, three-toed woodpeckers and hairy woodpeckers quickly respond to the increase in bark beetle populations that occur immediately following fire. Scientists think that black-backed woodpeckers may be nomadic and depend upon fires in the boreal forest to create suitable feeding and nesting habitat. Northern flickers benefit from fires as they nest and feed in open deciduous or mixed forests or recent burns. Downy woodpeckers do not use recently burned forests, but they depend upon sporadic fires to maintain their habitat - areas of young deciduous forest.
Swallows	Swallows feed in open areas and two species (tree swallows and violet-green swallows) nest in old woodpecker holes in dead trees. Fires likely benefit these species by clearing out forests and improving woodpecker habitat.

Thrushes	The effects of fire on thrushes vary by species. Robins and gray-cheeked thrushes use early successional stages and benefit from fire. The effects on hermit thrushes are unclear as they are found both in mature forests and in forest openings. Varied thrushes and Swainson's thrushes prefer mature or old mixed forests.
Chickadees and Creepers	Black-capped and boreal chickadees and brown creepers prefer old mature forests for feeding and nesting and may be adversely affected by fire.
Warblers	Fires benefit some species of warblers including yellow warblers, orange-crowned warblers, and Wilson's warblers, as these species prefer shrub habitats. Yellow-rumped warblers and Townsend's warblers prefer mature forests. Populations of these species may decline as a result of fire.
Crossbills	Fires reduce habitat for crossbills as these birds feed mainly on the seeds of mature spruce trees.
Sparrows	Most sparrows, including white-crowned, golden-crowned, Lincoln's and Savannah sparrows prefer the early successional stages resulting from fire. Dark-eyed juncos nest in all ages of forest but are also most abundant in early successional stages.

TRUE OR FALSE, WILDLAND FIRE MISCONCEPTIONS

Grade Level: 4-12
Alaska State Content Standards: LE-2
Subject: Language
Skills: Application
Duration: 1/2 class period
Group Size: individual
Setting: indoors
Vocabulary: prescribed burn

Objective
Students will discuss misconceptions about wildland fires in Alaska.

Teaching Strategy
Students determine if statements about wildland fires are true or false.

Materials
- True or False, Forest Fire Misconceptions Student Woorksheet

Teacher Background
See True or False, Forest Fire Misconceptions Answer Sheet.

Procedure
1. Brainstorm some of the beliefs students may have about wildland fires (such as "fires should never be allowed to burn" or "prescribed burns always start larger forest fires.")
2. Give each student a copy of the student worksheet, True or False, Forest Fire Misconceptions. Have them read the statements and mark them as true or false.
3. Use the answer sheet to discuss their answers.

Evaluation
Pass out the student page again and have students refine their answers.

TRUE OR FALSE, WILDLAND FIRE MISCONCEPTIONS

Circle true or false for each forest fire statement listed below.

1. Some wildland fires in Alaska are allowed to burn naturally without any attempt to contain, extinguish, or diminish them. **T or F**
2. Wildland fires kill all of the wildlife in the forest. **T or F**
3. Forest fires in Alaska, once started, burn everything growing in the forest. **T or F**
4. Wildland fires in Alaska create vegetation mosaics. **T or F**
5. Lightning is the most common cause of wildland fires in Alaska's interior. **T or F**
6. In an act of fairness, Alaska manages all wildland fires the same throughout the state. **T or F**
7. Prescribed burns always start as larger, out of control fires. **T or F**
8. All wildland fires are detrimental to wildlife. **T or F**
9. All wildland fires are detrimental to plants and trees. **T or F**
10. Wildland fires are part of a healthy ecosystem. **T or F**
11. One large burn is better then frequent small burns. **T or F**
12. Wildfires are fought to save the forest. **T or F**
13. If you pour water on your campfire and the smoke stops coming out, then the fire is completely extinguished. **T or F**

TRUE OR FALSE, WILDLAND FIRE MISCONCEPTIONS ANSWER SHEET

1. *Some wildland fires in Alaska are allowed to burn naturally without any attempt to contain, extinguish, or diminish them.* **T**

   In the Alaska Interagency Wildland Fire Management Plan there are four (4) fire management options:
   1) Critical Management Option is the highest priority given to suppression action when there is a threat to human life, inhabited property, designated physical developments, and structural resources designated as National Historic Landmarks.
   2) Full Management Option protects cultural and historical sites, uninhabited private property, and natural resources.
   3) Modified Management Option intends to provide a higher level of protection when fire danger or risks are high, and a lower level of protection when fire danger risks are low. It balances acres burned with suppression costs to accomplish land and resource management objectives.
   4) Limited Management Option is for areas where the cost of suppression may exceed the value of the resources being protected. Suppressing the fire may have negative effects on the resources, or suppressing the fire may have negative effects on the fire dependent ecosystem.

   (From the US Government Printing Office: 2000-573-278/21012 Region 8)

2. *Forest fires kill all of the wildlife in the forest.* **F**

Most of the wildlife living in the area will move out of the area or seek underground shelter until the fire passes. Very little wildlife is lost due to fires.

3. *Wildland fires in Alaska, once started, burn everything growing in the forest.* **F**

There are 3 different kinds of fires: 1) **canopy fires** which burn in the tree tops, 2) **ground fires** which burn under the organic layer of the ground, and 3) **surface fires** which burn on the surface of the ground. These fires can be of low intensity or high intensity. Only high intensity fires burn most everything in the area of the fire.

4. *Wildland fires in Alaska create vegetation mosaics.* **T**

Wildland fires rarely burn in the same way or same intensity or totally sweep and entire area. They often skip around, leaving tracks of untouched forest in between burn. Throughout a forested area you may find a variety of successional stages from meadows to shrubs to mature stands.

5. *Lightning is the most common cause of wildland fires in Alaska's interior.* **F**

In a typical year, lightening strikes cause about half (200) as many fires as those caused by humans (400).

6. *To be fair, Alaska manages all wildland fires the same throughout the state*. **F**
(See answer explanation to #1.)

7. *Prescribed burns always start as large, out-of-control fires.* **F**

The purpose of a prescribed burn is to start a low intensity, small fire that will minimize the forest fuel. When done frequently, it can minimize the chance for high intensity fires.

8. *All wildland fires are detrimental to wildlife.* **F**

Wildland fires create a vegetation mosaic that is beneficial to many animals.

9. *All wildland fires are detrimental to plants and trees.* **F**

There are many species of plants and trees that need fire in order to reproduce. Some fires can be beneficial to plants by providing more sunlight to sun-loving species. Fire also releases nutrients and warms the soil, making plant growth more successful.

10. *Wildland fires are part of a healthy ecosystem.* **T**

Wildland fires are needed to create plant diversity and animal diversity. Fires release nutrients, warm the soil, and encourage regeneration of certain species.

11. *One large burn is better than frequent small burns.* **F**

Smaller, lower intensity fires are better for a forest than a large, high intensity burn. A small fire will burn out the excess fuel, warm the soil, and create plant diversity.

12. *Wildfires are fought to save the forest.* **F**

Forests do not need to be “saved” from fire as fire is a natural part of the forest. Wildland fires are fought to protect human life, human property, or natural resources deemed valuable.

13. *If you pour water on your campfire and find no visible smoke, then the fire is completely extinguished.* **F**

While smoke may not be visible, the campfire can be burning underground in a **ground fire** sometimes as far as a foot or more under the surface. Pour soil on the campfire along with water and stir. You will know the campfire is out when the area around it is cool to the touch.

GOOD OR BAD EFFECTS OF FIRE IN THE TUNDRA OR FOREST WHO IS TO SAY?

Grade Level: 8-12
Alaska State Content Standards: Language Arts B-3, D-1a, D-4, E-2; Geography C-1, C-2; E-4, E-6; Science G-1, G-3
Subject: Language Arts, Science, Geography
Skills: Analysis, Application, Generalization, Problem-Solving
Duration: 2 class periods
Group Size: 8-12
Setting: indoors
Vocabulary: short term effects, long term effects

Objective
Students will describe some of the differing viewpoints about tundra and boreal forest fires.

Teaching Strategy
Students will individually evaluate effects of fires and compare them to group evaluations. Students will discuss how different views and opinions are generated.

Materials
- "Effects of Fire on the Tundra Game Cards" or "Effects of Fire on the Boreal Forest Game Cards", cut into cards

Teacher Background
Refer to the "Facts about Fire, Unit 2, Effects of Fire" for background information.

Advanced Preparation
Cut out and laminate game cards from "Effects of Fire on Tundra" or "Effects of Fire on the Boreal Forest", depending on your location.

Procedure
1. Discuss with students that people perceive the effects of fires differently.
2. Divide the class into groups of 8-12 students.
3. Have students number a piece of paper 1-18 down the left side. Label two horizontal column headings across the page as "My Vote" and "Group Vote." For the student's reference, write the following answer code on the board: B = Beneficial, H = Harmful.
4. Have one student in each group read each of "Effect of Fire on the Forest or

Tundra" cards to the group. Do not read references to ST(short-term) or LT(long-term). Have students write whether they think the effect is beneficial (B) or harmful (H) in the "My Vote" column.

5. When individual students have voted on **all** the effects, give each student one or two "Effect of Fire on the Forest or Tundra" cards.

6. In numerical order, have students read their cards aloud to the group and have the group vote. The group is to vote by a show of hands whether they thought the effect was beneficial or harmful. Have students record the results in the "Group Vote" column. They should record both the "beneficial" and "harmful" votes for each card.

7. Have the student who read the card tell why he or she decided the effect was beneficial or harmful. Remember that it may be difficult to determine whether an effect was beneficial or harmful.

8. Bring the class back together to discuss the following questions with the students:

    a. How did individual student answers compare with class answers?

    b. Was it difficult to decide if some effects were beneficial or harmful?

    c. If you were a developer would you have a different view than if you were a hunter or a trapper?

    d. What are some important things to remember when facing an issue with many opposing views and interests?

9. Opinions about fire effects may be influenced by whether a person perceives the effects to be short-term or long-term. Each card is coded ST (short-term effect in 0-8 years), LT (long term effect in 9 or more years), or a combination. Write the headings "short-term," "long-term," and "combination" on the board. List each effect card under the appropriate heading (or headings). Have the class brainstorm other fire effects third write them on the board under the appropriate heading.

Evaluation

Select several of the questions above for students on which the students should write.

EFFECTS OF FIRE ON THE TUNDRA

Game Cards

Cut each game card.

Smoke causes delays in airplane flights (ST)	Fire increases the depth of the active layer (the soil that seasonally thaws above the permafrost (ST)
Ash from both prescribed burns and wildland fires adds to the greenhouse effect (LT)	Some species of lichens take as long as 100 years to recover after a burn (LT)
Fire removes above ground vegetation and blackens soil so the soil can be warmed by the sun for better plant growth (ST)	Food for wildlife and humans is destroyed by fire (ST)
Fire returns nutrients to the soil (ST)	Fire creates plant diversity and vegetation mosaics (ST & LT)
Hot, intense fires destroy underground plant parts, making revegetation very slow in the area (ST)	Re-sprouting of grasses, sedges, and shrubs provides food and cover for some wildlife after a fire (ST & LT)

In very old growth tundra, lichens do not grow well. Light fires have been known to stimulate regrowth of lichens (ST & LT)	Caribou will forage on a recent burn for 1-2 years and then may not use the area for a number of years (ST)
Recent burn areas are good hunting grounds for some predators (ST)	Fire fighting requires the purchase of local goods and services (ST)
Trapping and hunting are better in recently burned areas (within 5-10 years after burn) (LT)	Fires burn cabins and trap lines (ST)
Smoke from fires makes your eyes and throat burn (ST)	Fires provide fire suppression jobs (ST & LT)

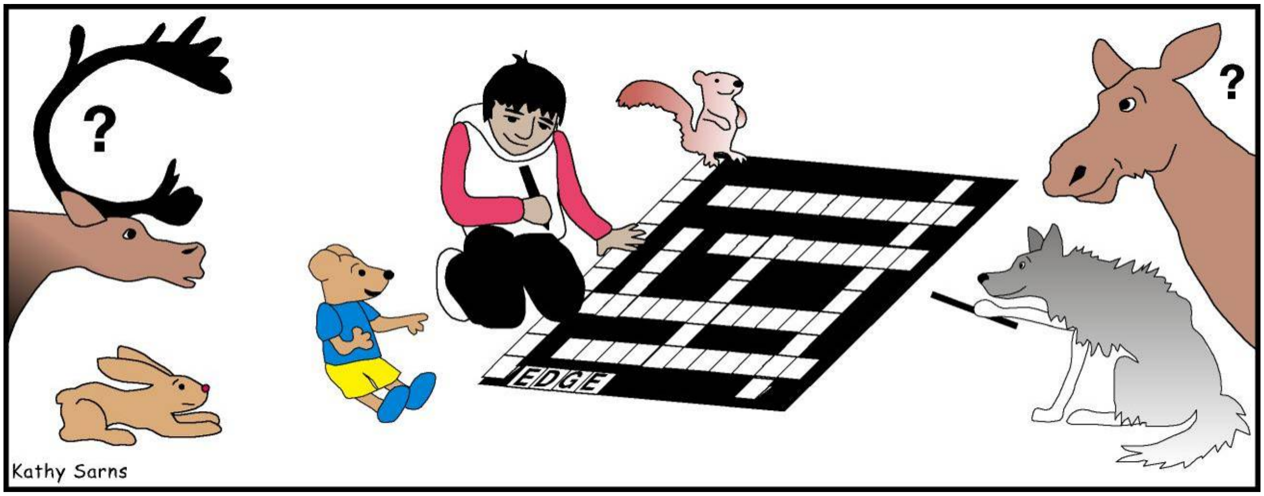
EFFECTS OF FIRE ON THE BOREAL FOREST

Game Cards

Cut each game card.

Fire removes vegetation and blackens soil, so the soil can be warmed by the sun for better plant growth (ST)	Recent burn areas are good hunting grounds for birds of prey (ST)
Fire returns nutrients of plants and animals to the soil (ST)	The shrub stage of a burn area provides abundant cover for small mammals such as mice, which are food for larger mammals such as fox (LT)
Bare, burned soil erodes easily (ST & LT)	There is little, if any, food and cover for most wildlife immediately after a fire (ST)
Some plants, like black spruce, depend on fire to reproduce (LT)	Fires provide fire suppression jobs (ST & LT)
Fire sometimes helps to prevent insect attacks since it often encourages plant diversity in an area (LT)	Trapping and hunting are better in recently burned areas for some species (within 5-10 years after the burn) (LT)
Food for wildlife and humans is destroyed by fire (ST)	Fires burn cabins and trap lines (ST)
Smoke from fires makes your eyes and throat burn (ST)	Ash from both prescribed burns and fires adds to the greenhouse effect (LT)
Burn areas have dead trees (snags) for cavity-nesting birds, including woodpeckers and some ducks such as goldeneye and bufflehead (ST &LT)	

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE



Grade Level: 6-12
Alaska State Content Standards: none
Subject: Science
Skills: Vocabulary building
Duration: 25 minutes
Group Size: individual
Setting: indoors

Objective
Students will be able to define the terms used when describing boreal forest and tundra ecosystems or fires.

Teaching Strategy
Students will complete crossword puzzles.

Materials
- Boreal Forest and Tundra Crossword Puzzle #1 (easy)
- Boreal Forest and Tundra Crossword Puzzle #2 (moderate)
- Boreal Forest and Tundra Crossword Puzzle #3 (difficult)

Procedure
Review the terms on the crossword puzzles. Give one or more puzzles to each student and have them complete.

When everyone is finished, review the vocabulary words and their meanings.

Evaluation
The puzzles can be used as the evaluation.

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #1
Key – Easiest Level Puzzle

								8 F						
								I						
		7 F						R						
		U			1 B	O	R	E	A	L				
		E						F						
		2 L	I	G	H	T	N	I	N	G				
								G					10 S	
								H					P	
				3 S	A	F	E	T	Y				R	
								E					U	
				4 T	U	N	D	R	9 A				C	
									5 S	M	O	K	E	Y
									P					
									E					
6 F	O	O	D		C	H	A	I	N					

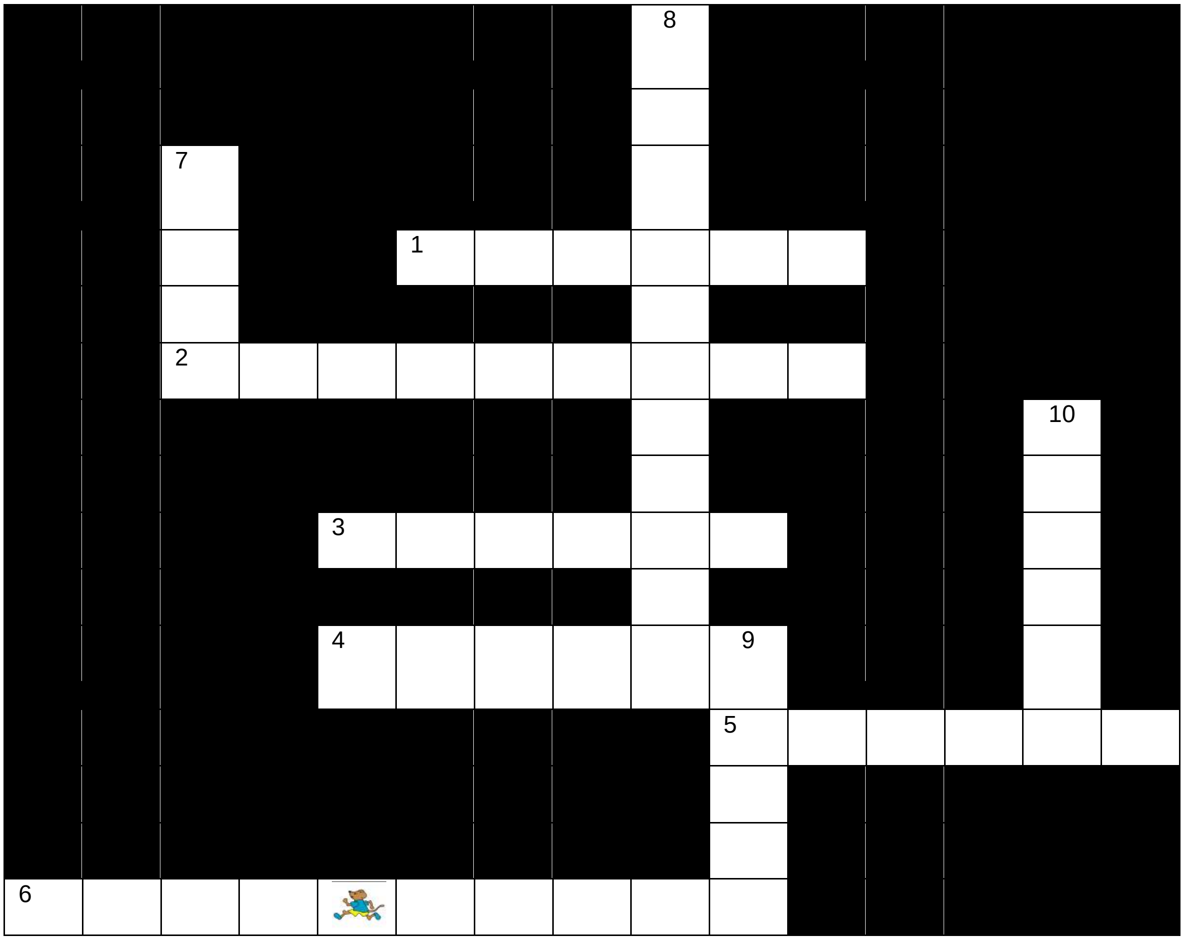
ACROSS

1) The northern most forest in the world (boreal)
2) Most natural wildland fires are caused by this. (lightning)
3) The most important thing when managing fires. (safety)
4) A mostly treeless landscape in Alaska. (tundra)
5) He says "Only you can prevent forest fires." (Smokey)
6) "The big fish eats the little fish." Two words. (food chain)

DOWN

7) Anything that burns. (fuel)
8) The person that puts out fires. (firefighter)
9) A common broadleaf tree. (aspen)
10) The most likely to burn tree in the boreal forest. (Spruce)

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #1



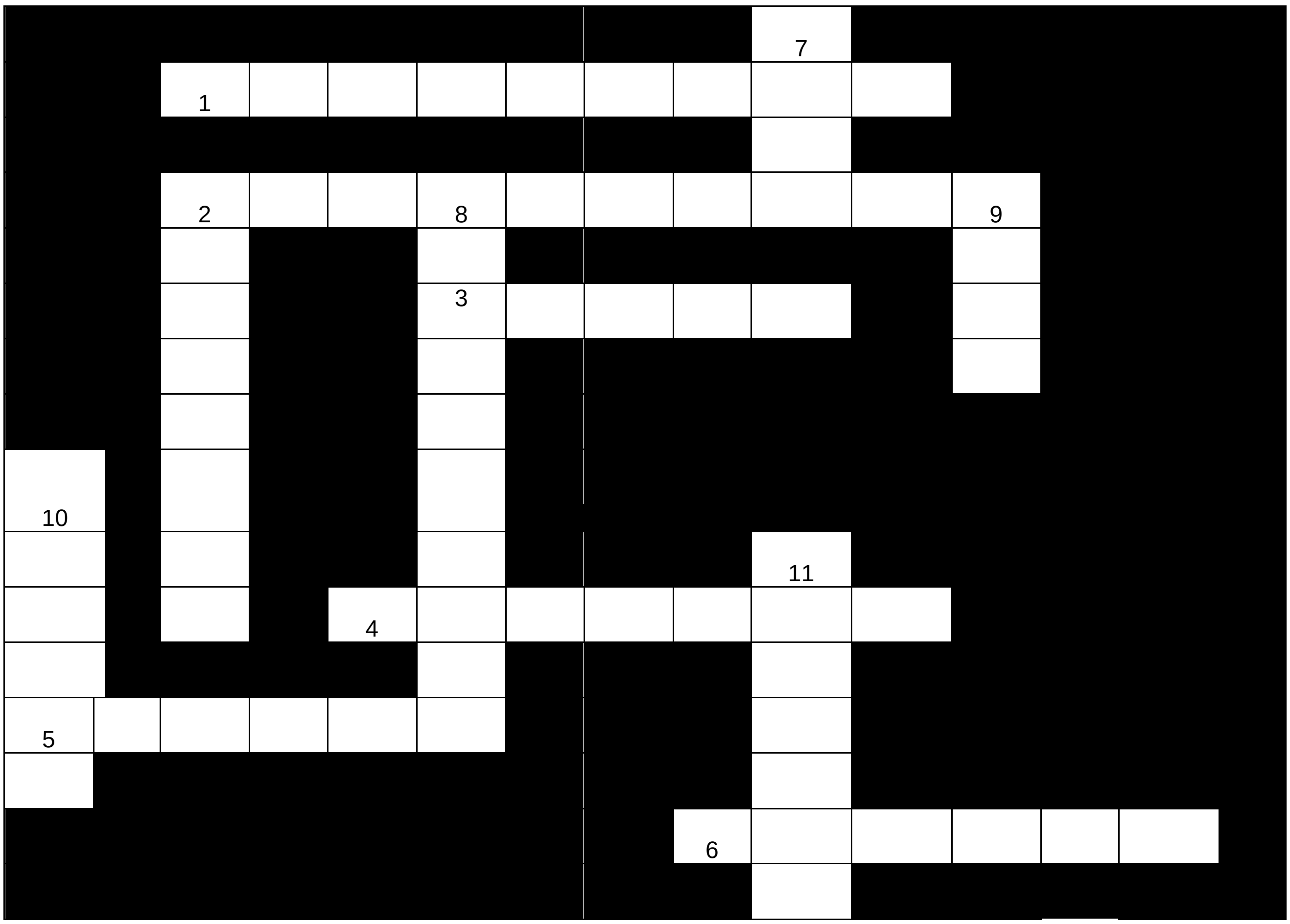
ACROSS

1) The northern most forest in the world
2) Most natural wildland fires are caused by this.
3) The most important thing when managing fires.
4) A mostly treeless landscape in Alaska.
5) He says “Only you can prevent forest fires.”
6) “The big fish eats the little fish.” Two words.

DOWN

7) Anything that burns.
8) The person that puts out fires.
9) A common broadleaf tree.
10) The most likely to burn tree in the boreal forest.

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #2



ACROSS

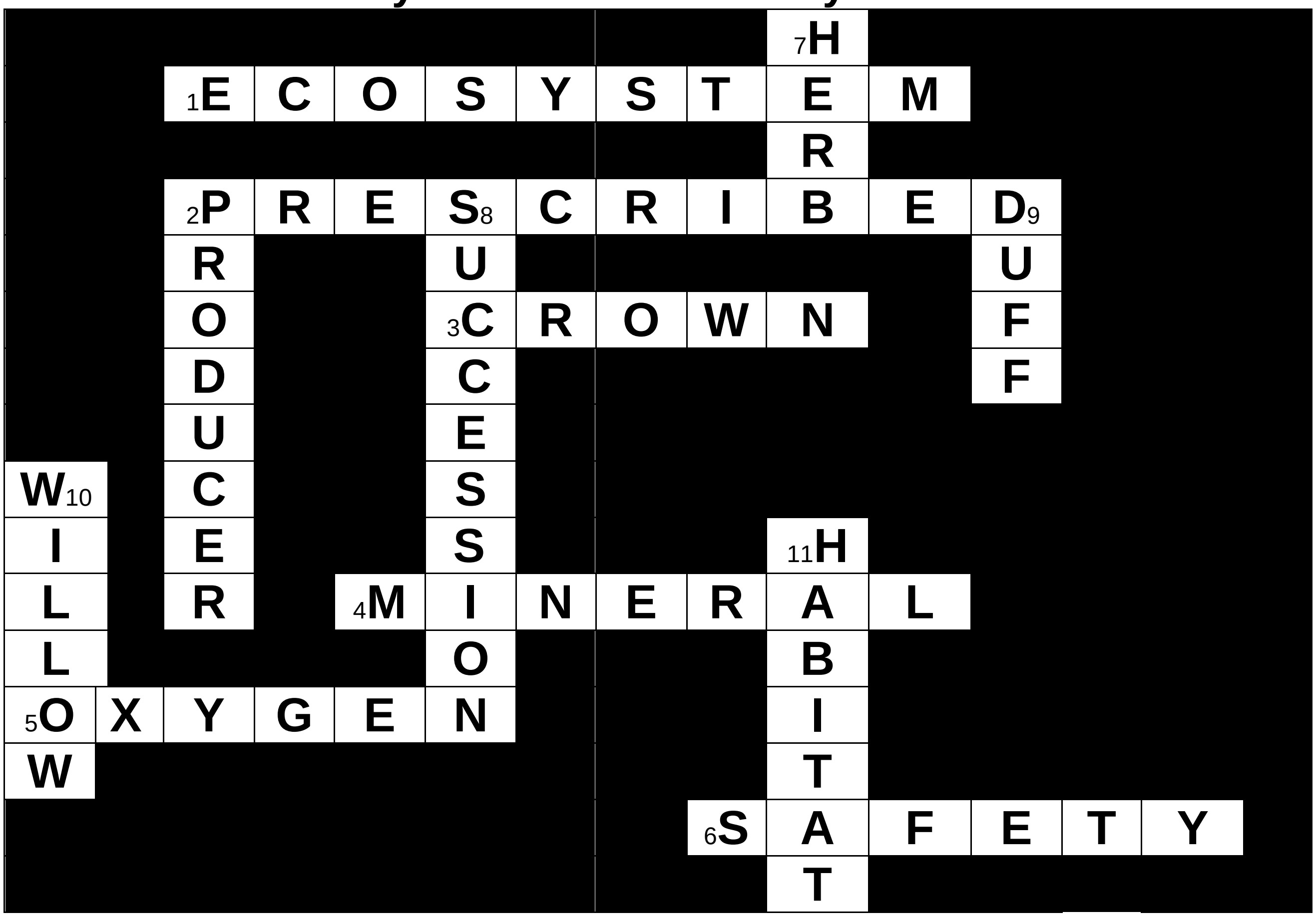
1) All living and non-living things in an area.
2) A carefully monitored fire that managers use to meet goals.
3) A fire in the upper forest canopy.
4) The type of soil exposed in heavily burned areas of a fire.
5) The gaseous element that fire needs to burn.
6) The most important thing when managing fires.

DOWN

2) An organism that makes its own food.
7) The earliest stage of succession is the _____ stage.
8) The natural orderly change in plant and animal communities over time.
9) The organic soil layer made up of decaying plant parts.
10) The favorite food of moose.
11) The natural home of a plant or animal.

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #2

Key – Moderate Difficulty Puzzle



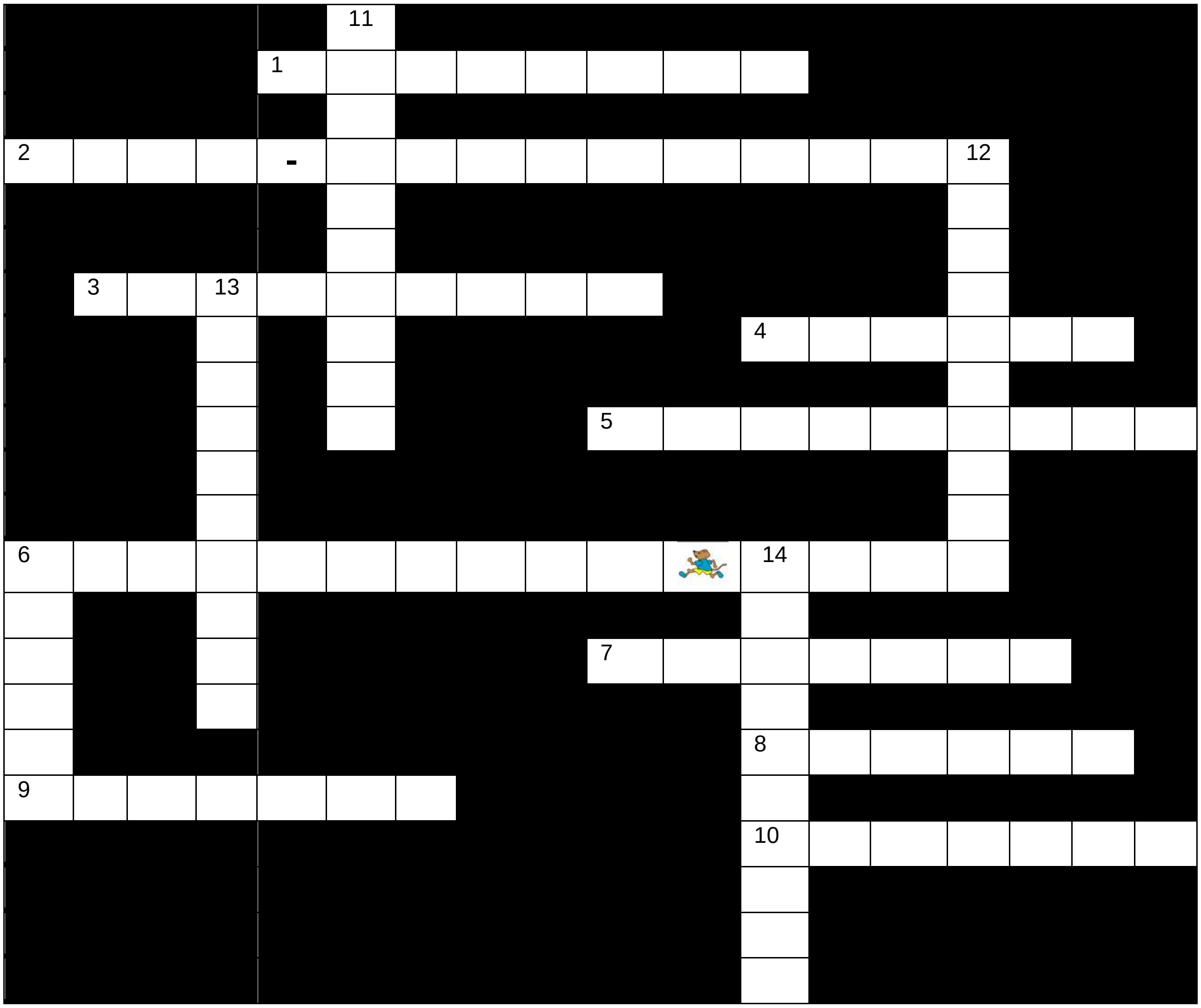
ACROSS

1) All living and non-living things in an area. (ecosystem)
2) A carefully monitored fire that managers use to meet goals. (prescribed)
3) A fire in the upper forest canopy. (crown)
4) The type of soil exposed in heavily burned areas of a fire. (mineral)
5) The gaseous element that fire needs to burn. (oxygen)
6) The most important thing when managing fires. (safety)

DOWN

2) An organism that makes its own food. (producer)
7) The earliest stage of succession is the _____ stage. (herb)
8) The natural orderly change in plant and animal communities over time. (succession)
9) The organic soil layer made up of decaying plant parts. (duff)
10) The favorite food of moose. (willow)
11) The natural home of a plant or animal. (habitat)

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #3



ACROSS

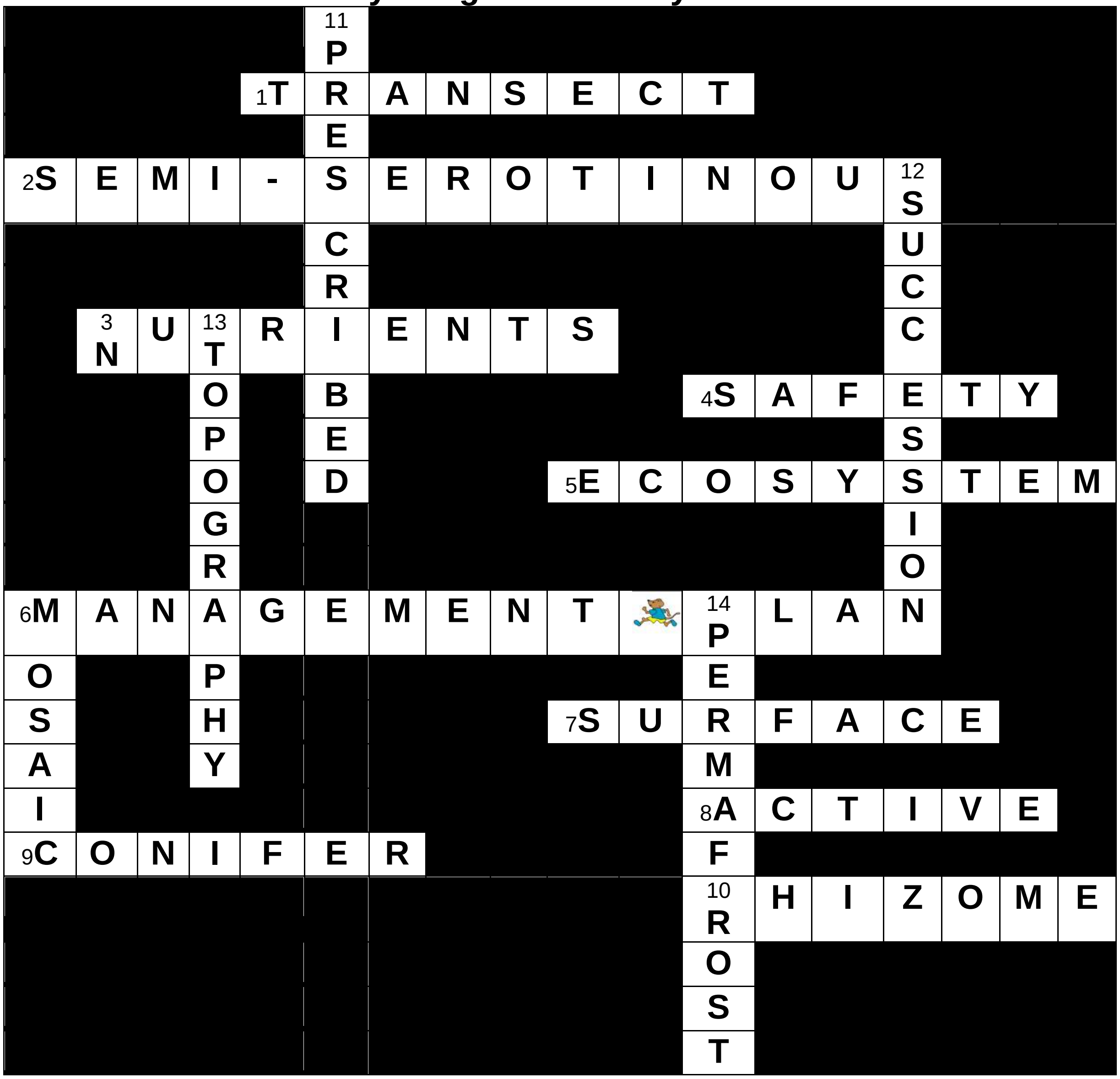
1) A straight line study plot for research and monitoring.
2) A ___________ cone that requires heat to open.
3) Fire adds __________ to the soil.
4) The most important thing when managing fires.
5) All living and non-living things in an area.
6) Provides the course of action taken with regard to wildland fires in Alaska.
7) A fire that burns fuels on the ground but not in the canopy.
8) The layer of ground that freezes and thaws each year.
9) Plants with needle-like or scale-like leaves.
10) A stem-like root that resprouts after fires.

DOWN

6) Patchwork pattern of vegetation.
11) A carefully monitored fire that managers used to meet goals.
12) The natural orderly change in plant and animal communities over time.
13) The physical features of a region.
14) A layer of soil that remains frozen.

BOREAL FOREST AND TUNDRA CROSSWORD PUZZLE #3

Key – Higher Difficulty Puzzle



ACROSS

1) A straight line study plot for research and monitoring. (Transect)

2) A __________ cone that requires heat to open. (semi-serotinous)

3) Fire adds _________ to the soil. (Nutrients)

4) The most important thing when managing fires. (safety)

5) All living and non-living things in an area. (ecosystem)

6) Provides the course of action taken with regard to wildland fires in Alaska. (Management plan)

7) A fire that burns fuels on the ground but not in the canopy. (Surface)

8) The layer of ground that freezes and thaws each year. (Active)

9) Plants with needle-like or scale-like leaves. (Conifer)

10) A stem-like root that resprouts after fires. (Rhizome)

DOWN

6) Patchwork pattern of vegetation. (Mosaic)

11) A carefully monitored fire that managers used to meet goals. (prescribed)

12) The natural orderly change in plant and animal communities over time. (succession)

13) The physical features of a region. (Topography)

14) A layer of soil that remains frozen. (Permafrost)