FORESTS

Forest Ecology

Forest ecology can be broadly considered the study of how trees and forests interact with their environments. The physical environment that affects forests includes such factors as

- Climate (temperature, sunlight, precipitation)
- Soil
- Geology
- Topography

Trees are similar to most plants in that they reproduce from seed. However, trees differ from many other plants because they may not produce seed until they're 10 to 40 years old, depending on the species. The seeds of some trees take two seasons to mature. The seeds of many tree species ripen in the fall. However, the seeds of some trees may actually be dormant even though they appear to be ripe.

If seeds germinate in the fall, the young seedlings will probably not survive the winter. However, many seeds must go through an extra ripening period on the ground. Their seed coats may be very hard and not allow water or oxygen (elements required for germination) to get into the seed. Other seeds may be internally immature. In most cases, going through a winter will soften the seed coat and allow time for the seed to mature. After this dormant period, the seeds are ready to germinate in the spring.

A large percentage of seeds will never survive until springtime. While they're on the ground, they may be eaten by rodents and other animals (e.g., turkey or deer). Or the seeds may be destroyed by insects or infected with destructive fungi.

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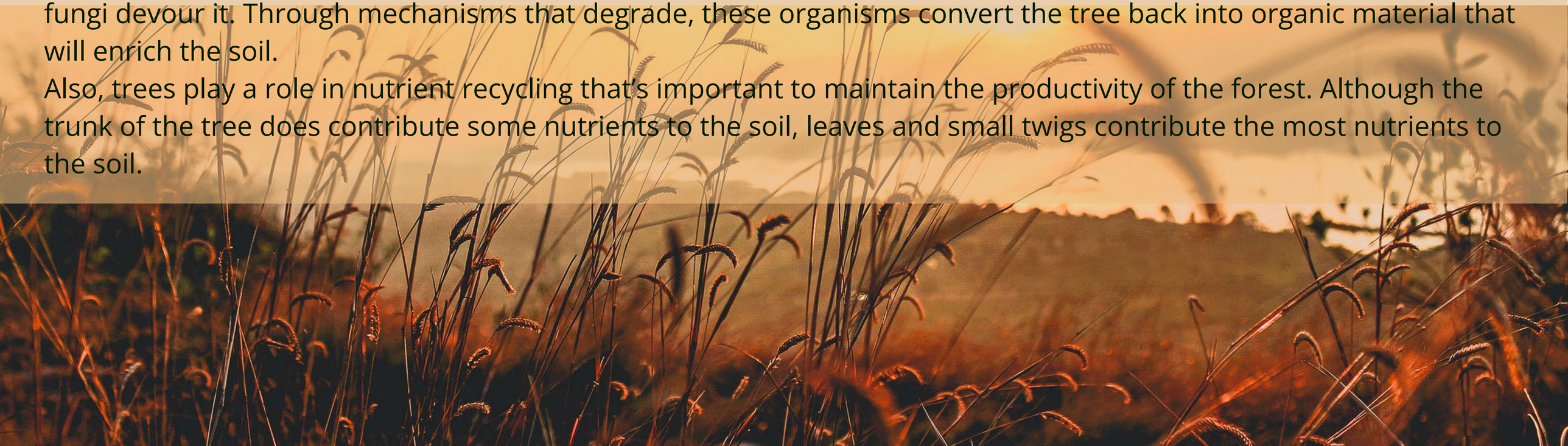
As trees become biologically mature, they produce a variety of flowers. Some of these flowers, as in species like yellow-poplar and black cherry, contain male and female parts in the same flower. Other trees such as spruce, fir, and pine have male and female flowers on the same tree but in different locations. In these conifers, the female flowers tend to be found higher in the crown (treetop), whereas the male flowers are found lower in the crown. Still other trees, such as aspen and ash, have separate female and male trees. Male flowers are found on one tree, and the female flowers are found on other trees.

As trees grow old, diseases or insects may infect them. Or they may just die of old age. Death is an important part of the forest ecosystem (an area where plants, animals, and physical environments interact together). Dead trees serve as habitat for many different animals and insects. After the tree falls to the ground, insects, microorganisms, and fungi devour it. Through mechanisms that degrade, these organisms convert the tree back into organic material that will enrich the soil.

Also, trees play a role in nutrient recycling that's important to maintain the productivity of the forest. Although the trunk of the tree does contribute some nutrients to the soil, leaves and small twigs contribute the most nutrients to the soil.



Forest Ecology

Water. Trees require adequate water to grow well. The amount of water available in the soil depends on a number of factors.
Soil content and water. The relative amounts of clay, silt, and sand particles affect the water available for trees to use. Clay soils tend to hold water well. However, in many cases the water is held tightly by the soil particles and isn't available for tree roots. Clay soils can easily be saturated because all of the pore spaces get filled with water. Most trees do poorly in these waterlogged sites. Sandy soils tend to be droughty because the water runs quickly through the sand particles. Most trees also do poorly in droughty sites.
Slope of the land and water. Steep slopes also affect water availability. Quick runoff leads to less water available as compared to flatter areas. However, very flat areas tend to be poorly drained. The direction or exposure a slope faces (aspect) also affects water availability. South- and west-facing slopes tend to be drier than north- and east-facing slopes. This is because south and west slopes receive the hotter afternoon sun during the growing season. In the northern regions of the Northern Forest, south- and west-facing slopes can be the most productive because the growing season may be a little longer in these areas. However, in the Rocky Mountain and Pacific Forests, south- and west-facing slopes are less productive because they dry out too much with more direct afternoon sun. In general, northeast slopes are the most productive.
Soil texture. This factor influences the availability of nutrients for trees. Sandy soils tend to be nutrient poor because sand particles don't hold the minerals well.
The best site for trees tends to be a loamy soil (mixture of sand, silt, and clay particles). This soil tends to have an adequate supply of available nutrients and be well drained but still moist.
Topography. This factor also affects soil productivity. Steep slopes and ridgetops tend to have shallow soils that are less productive. Gentle slopes and the lower one-third of a slope normally have more productive soils. Trees will grow faster on these sites and reach a larger size at maturity compared to the steeper sites with the poorer soils.
Availability of light. Trees need sunlight to grow. However, a tree can receive too much sunlight. The sun can cause high temperatures that can damage seedlings and cause excess water loss from trees and soil. In other cases, trees don't receive enough sunlight due to competition from other trees and less desirable plants.

Forest Ecology

Trees have three different growth points: root tips, buds, and cambium.

Root tips (root growth). This type of growth occurs at the root tips. Roots grow outward and downward, depending on the species and the soil conditions. Roots also grow in diameter in the same way a tree trunk does. However, large roots actually contribute little to the uptake of water and nutrients. Actually, it's in the fine roots that water and nutrients are taken up for use by the tree.

Buds (height growth). This growth occurs at the tips of the branches and stems. Trees grow from the top upward, not from the ground up, as do many herbaceous plants. Height growth isn't significantly affected by the density of the stand, except in extreme conditions.

Cambium growth (diameter growth of stems and branches). The third growth point is the cambium layer. The cambium is a single-cell layer that encircles the tree just underneath the outer bark. New cells produced to the outside of the cambium become phloem (inner bark). The phloem is the layer that conducts the sugars made by the leaves (through photosynthesis) down to the roots and other parts of the tree. Cells produced to the inside of the cambium become xylem (wood). The xylem conducts water and nutrients from the roots to the leaves.

Diameter growth is significantly affected by stand density. The denser the stand, the slower and smaller is the diameter growth. Wood volume is influenced much more by diameter than by height. Many intermediate management treatments (discussed in the silviculture section) for stands increase the rate and amount of diameter growth.

Forest Ecology

Silviculture can be defined as the manipulation of individual trees and stands based on economic and ecological principles to meet landowner objectives. The goal of silviculture is to maintain the long-term health and productivity of the forest.

Liberation cuts. These cuts are used to provide more light to young trees. Liberation cuts release (free from competition) young trees from an older overstory (trees whose canopies form the top of the stand). The trees being released are in the sapling stage or younger. The trees being cut are from an older age class. The trees cut can be used for a wood product if they're of the proper size. Otherwise, they can be left in the woods.

Cleanings. This technique is done to control the composition (particular species) of a stand to favor certain species at the expense of others. Cleanings are done in a stand of saplings or younger trees. The trees being cut threaten to overtop the Forest Management, Part 1 desired trees. The trees being cut are also of an undesirable species. Only enough of the favored trees are released to become crop trees (those trees that meet the landowner's desired objective[s]). The entire stand doesn't have to be treated. The trees cut and the trees being favored are of the same age class. The undesirable trees being cut are disposed of in the most thrifty way possible because they're not yet salable. In this case thrifty disposal involves methods that minimize damage to the remaining trees, such as use of herbicides.

Timber stand improvement. This approach improves composition and form (shape [e.g., many versus few branches, straight versus crooked stems]) in an uneven-age stand. An improvement cut is done when trees being released are beyond the sapling stage. The trees being cut are dominating these better-quality saplings.

Forest Ecology

Thinning. This method is done in even-age stands. The primary objectives are to

- Maintain wood volume production of the stand with the fewest number of trees that will provide full use of the site
- Cut trees that might die naturally
- Have the forest manager—instead of natural forces— choose what trees will be the final crop

Sanitation cutting. This technique is done in a stand that's being threatened by insect, disease, or some other health problems. The trees cut aren't yet dead. However, there's a high probability of death among these trees before the next thinning or improvement cut would occur. Another purpose of a sanitation cutting is to limit the spread of the damaging agent to other healthy trees. This method is used in trees that are generally of salable size. Thus, sanitation cutting can produce some income for the landowner.

Salvage cutting. This method is used in a stand where some problem (insect, disease, fire, or other natural disaster) has killed or is killing numerous trees. The purpose is to salvage the wood that would be lost due to the disaster. Note the subtle difference between salvage and sanitation. Sanitation cutting prevents the spread of the problem to undamaged trees. On the other hand, salvage cutting removes already damaged wood that would be lost because of the problem. Although protecting residual trees (remaining undamaged trees) isn't the primary objective, salvage cutting can sometimes serve the same purpose. Salvage cutting should either be profitable or at least break even.

Pruning. This technique is an intermediate method used to improve the quality of the bottom 16-foot log (first 16 feet of the tree). Pruning is done on selected, high-quality crop trees no smaller than the pole stage. This process involves pruning off all branches (living and dead). Pruning smaller trees will remove too much of the live crown, which can lead to slow growth and even tree death. Removing these lower branches will help the tree grow quality, knot-free wood on the log from which the branches have been pruned. The fewer the knots, the better the quality of the log.

F**ertilization.** This method is occasionally used to improve the growth of stands. Most fertilization is done by helicopter over large areas. Because application costs are high, fertilization is rarely done for trees that yield timber only. Several western forest industry companies will fertilize some of their forests that contain high-value trees.

Forest Health

An example of the beneficial effects that microorganisms have on forests is mycorrhizae. This term refers to the symbiotic relationship (beneficial to both host and fungus) between a group of fungi and plant (in this case tree) roots. Tree species involved in this symbiotic relationship are varieties of pine, fir, spruce, and hemlock. The fungus “infects” the roots of the host plant. Fungal structures called hyphae become extensions of the tree’s root system. This increased surface area heightens the roots’ ability to uptake water and nutrients. It also helps make some forms of nutrients more available for plant use.

At the same time, the fungus takes some of the nutrients that it needs from the plant. In many areas trees wouldn’t be able to grow and survive without this symbiotic relationship, especially on poorer soil sites.

There are many other examples of the beneficial effects that microorganisms have on forests. However, there are just as many examples of the damaging roles played by insects, fungi, viruses, and bacteria.

The study of forest insects is called forest entomology. The study of fungi, viruses, and bacteria that cause forest tree diseases is called forest pathology.

Forest Health

Defoliators. These insects feed on a tree's leaves. They can eat the leaves completely. Or they can "mine" the leaves by eating the insides of the leaves, leaving the very thin layer of tissue forming the outside of the leaf. If the leaves are entirely cleaned off the tree, the tree can't make the sugars it needs for growth.
Hardwood trees can sprout new leaves after they've been eaten. However, this activity uses up energy the tree would normally store for the next season. A single defoliation in a season isn't generally life-threatening. However, successive defoliations within a season or for consecutive seasons can kill trees.

One of the best known and infamous defoliators is the gypsy moth (Lymantria dispar). This insect originated in Europe and Asia. It was introduced into the United States in 1869. The first outbreak occurred in 1889. The gypsy moth feeds on a wide variety of hardwood trees. However, it prefers oaks— especially the white oaks.
In the late summer fertile female gypsy moths lay eggs in brown, furlike masses about the size of a quarter. The eggs are generally laid on tree branches and trunks or rocks. They're also laid on the underside of trucks and cars. This is one way that gypsy moths spread long distances. This spreading method is important, because adult females can't fly. Males fly only short distances in pursuit of females.

Forest Health

Wood-boring insects. These insects are some of the most damaging. There are many types of wood-borers. Beetles and moths are the most common. Adults will lay their eggs on tree branches, twigs, or trunks. Or they can lay their eggs directly into the wood itself. The larvae, which generally appear as white grubs, bore into the tree and feed on the wood.

Wood-borers will kill trees directly by girdling (eating around the tree) and cutting off the supply of water, nutrients, and sugar to the tree. Wood-boring insects are very difficult to control using the usual aerial spraying of insecticides. This is because

1. The pesticide can’t get far enough into the tree to kill the larvae.
2. The timing for pesticide application to kill egg-laying adults is difficult because adults appear for only a short period of time. This time period varies according to the weather.

The mountain pine beetle (Dendroctonus ponderosae) is a wood-borer that prefers lodgepole, ponderosa, sugar, and western white pine. During epidemics, this insect can kill thousands of acres of these species, especially lodgepole pine. The beetle spends almost its entire life under the bark of a preferred host.

The bark beetle also likes to attack pine trees. After one of these adult beetles becomes established in a tree, it (like the gypsy moth) emits a pheromone that attracts other bark beetles. Once a tree becomes infested by these beetles, there’s little a forest manager can do to control the problem.

Forest Health

Sap-sucking insects. These insects feed on tree sap (watery solution in a tree). Examples of such insects are mites and aphids. They have mouthparts that are constructed for piercing leaf or bark tissue to obtain the sap. Although these insects suck the sap from the tree's tissues, they rarely cause tree death. However, leaves damaged by this type of feeding aren't effective in producing the sugars that trees need to grow. Heavy infestations can weaken trees and make them susceptible to other more damaging insects or diseases.

Seed-eating insects. Insects such as weevils, beetles, and moths don't kill trees. Rather, they feed on acorns, cones, and other seed sources from the trees. However, heavy infestations of seed-eating insects can destroy an entire seed crop. This result can be serious following a regeneration harvest. Regeneration failures can then result. Also, wildlife populations that depend on seeds can be adversely affected.

Evaluating the need for insect control. Forest managers can help control insect populations in a variety of ways. Maintaining a forest in a healthy condition through proper management can help discourage outbreaks of certain pests. Good management can also help limit the negative impact of an outbreak.

As a rule of thumb, healthy trees are better able to survive an insect infestation. The first step involved in deciding if control is needed is determining if there's a potential for high populations of damaging insects. The forest manager generally determines this during the winter before the insects are active.

After estimating the potential population, the forest manager determines if an economic threshold will be reached. This economic threshold can be considered the point at which damage caused by the insect exceeds what the forest manager and client consider to be an economically acceptable level. For high-value tree species that are relatively close to harvest, the threshold may be lower than for a less valuable species. The economic threshold is also generally low for trees that yield specialty-type products (e.g., sugar maple trees).

Forest Health

Chemical control. Once the forest manager has determined that control of some kind must be taken, there are a number of options. The most common method is spraying with an insecticide. These insecticides can be broad- or limitedspectrum insecticides. A broad-spectrum insecticide will kill a wide range of insects, both the target insect as well as nontarget insects. This latter class of insects is likely to include those that act as parasites or predators of the target insect.

A limited-spectrum insecticide won't kill as many different insects. Thus, if you're dealing with more than one type of insect, a limited-spectrum insecticide may not be as effective as a broad-spectrum insecticide. Please check with your county extension agent for the specific insecticides available in your area.

Other types of insect control measures. Not all insecticides are chemical. There are a variety of organic or biologic type insecticides. These are generally bacteria or other types of organisms that infect the target insect. Some of these measures are more effective than others.

Biologic control is the use of

- Insects that are predators of or parasites to the target insect
- Biologic insecticides (diseases that infect the target insect but are applied like insecticides)

Silvicultural control consists of using silvicultural methods such as

- Thinning
- Timber stand improvement
- Sanitation and salvage cutting (see Forest Management, Part 1)

These silvicultural methods discourage insect outbreaks and maintain the forest in a healthy condition.

Appropriate use of a combination of all insect control methods is called integrated pest management. This approach is generally the most effective method in limiting the damage caused by insect pests.

Forest Health

Parasitic plants: dwarf mistletoe. This parasitic plant can be a problem in western forests and some northern coniferous forests. Dwarf mistletoe is a seed plant that grows on stems and branches of other trees. This plant is unable to make the sugars it needs. However, it takes its nourishment from the plant on which it grows.

Dwarf mistletoe rarely kills trees. However, it can cause a severe reduction in tree growth. When dwarf mistletoe is found on the trunk of the tree, it causes a weak point. A strong wind may cause the tree to break at this point.

Secondary infection. Many tree diseases (in most cases fungal) are secondary infections. This means that they'll rarely successfully attack a healthy tree. Trees that become diseased have been stressed from either insect attack or some sort of physical damage. Often, the primary source of injury, such as a defoliating insect, may be blamed for causing the death of a tree. However, in many cases the actual cause of death is the secondary infection.

Primary infection. Sometimes the disease may be a primary infection. In this case it may cause death directly. Or the disease may weaken the tree to the point that a secondary infection or insect infestation may become established. Then the secondary problem may be the actual cause of the tree's death. In other cases the disease may not kill the tree. However, it may reduce growth or make the wood unusable as a marketable product.

Fungi. Fungi are by far the most common form of disease in the forest environment. These diseases infect roots, stems, leaves, and the vascular system (channels for moving fluid [sap]) of trees. Fungi also cause canker (open or visible wounds), rust, and rot diseases.

Many of the wood-rotting fungi must enter through a damaged area that might be caused by a skidder (bulldozer) hitting a tree or a poor pruning technique. When branches die naturally, the area may become a potential spot where fungi can successfully enter the tree.

Disease control. For many diseases of forest trees, there's no chemical treatment that works. Homeowners can treat some tree diseases in their yard because it's relatively easy and inexpensive to treat individual trees. But for forest managers, controlling diseases is aimed at limiting disease spread through silvicultural methods such as timber stand improvement and sanitation cutting.

Forest Health

The following are some useful forest management techniques that can prevent insects from devastating a stand of trees:

- Regularly remove diseased, damaged, or declining trees
- Regularly thin stands by removing trees that are too close together
- Make sure that trees have good soil drainage
- Plant healthy, disease-resistant species (and mix them)
- Use only the healthiest nursery stock
- Select appropriate sites for species being planted

it’s very important to follow these safety guidelines whenever you’re using pesticides:

- Read all package instructions before using any chemical, and follow all directions carefully. These instructions reflect years of research into the correct and safe use of the chemical. These instructions will also include recommendations for cleanup, storage, and the safe use of equipment, so be sure to read them completely before using the chemical.
- Wear all appropriate and recommended safety gear when using a pesticide, such as protective clothing, safety goggles, face masks, and gloves. This gear will prevent skin contact with the chemical.
- Chemical fumes are toxic and can cause illness or even death. Never inhale the fumes from any pesticide.
- Solvents (liquid chemicals) and their fumes are often very flammable. Keep chemicals away from open flames, sparks, and any source of heat (including the sun).
- Avoid all skin contact with the chemical. Even a tiny amount of exposure can be hazardous to health. If skin contact occurs, immediately wash the area thoroughly to remove all traces of the substance. Wash clothes and tools thoroughly after using any insecticide.
- Don’t allow any pesticide to enter bodies of water, such as fishponds, streams, lakes, or creeks.
- Don’t allow a pesticide to form puddles that birds, animals, or people could accidentally come in contact with.
- Never allow a pesticide to be sprayed directly on or near people, birds, or animals.
- Store all chemicals and spraying equipment in safe areas where children, birds, and animals can’t possibly get at them.

Forest Health

Fire helps reseed a forest. For example, in some areas lodgepole pines have serotinous cones. These cones won't open to release seed under normal conditions. A fire is necessary to produce enough heat to melt the pitch that keeps the cones closed. When the cones open, the seeds are released in the favorable environment created by the fire. This environment is favorable for the lodgepole pine seeds for two reasons:

1. The fire creates a mineral seed bed, which is good for germination.
2. There's essentially no competition from other plants, because the lodgepole pine's seeds are the only seeds present.

Types of fires. There are three types of fires:

- Ground
- Surface
- Crown

Fire control. In order to control and extinguish a fire, one of the legs of the fire triangle needs to be broken. This means removing either the heat source, fuel, or oxygen. Today all fire control efforts are directed against these three factors. Removing the heat source. This measure entails some sort of method to cool the burning fire. The most common method used is to apply water to the burning fuel. Controlling surface fires can generally be done using water. Fire trucks, tankers, and hoses are the most common equipment used to put water on a surface fire. For large fires, helicopters with large buckets may fly to a nearby lake or pond, get water in their buckets, fly back to the fire, and then dump the water on the fire area Removing oxygen. Covering burning material with soil will remove the oxygen supply. This is done by either hand tools such as a shovel or a bulldozer.

Removing fuel. Breaking the fuel leg of the triangle requires a lot of work. For large fires and fires in remote areas, firefighters use hand tools and bulldozers to build fire lines down to mineral soil. (Mineral soil won't burn.) Mineral soil contains sand, silt, and clay particles (and the minerals contained therein).The depth to mineral soil varies according to the environment. Once mineral soil is reached, the fire line separates burning fuels from unburned fuels.

Forest Health

The fire danger rating accounts for all of the permanent factors that affect how easily a fire may spread. These permanent conditions include

- The amount and type of fuel present
- The elevation, topography, and slope of the area
- The level of fuel exposure
- The types of plants found in the area that can carry fire
- The number and type of firebreaks present
- The accessibility of the area to firefighters
- The normal fire risk of the area for the season

The following are some of the variable factors that affect the fire danger rating:

- The current wind speed and direction
- The current relative humidity of the atmosphere
- The current moisture content of the fuel
- The air and fuel temperature
- The current visibility and atmospheric stability

Forest Health

The volume of smoke is classified in one of three ways:

1. Small (about the size of one campfire)
2. Medium (about the size of ten campfires)
3. Large (anything bigger)

The character of smoke is classified in five ways:

1. Thin (narrow and not very dense)
2. Heavy (more dense)
3. Billowy (a large volume of smoke rising straight up, perhaps with a mushroom shape)
4. Drift (a long, strung-out column of smoke following the air current)
5. Blanket (a heavy layer of smoke over a large area)

The color of smoke is helpful because it indicates the fuels that are burning. Smoke color is classified in five ways:

1. White (usually means grasses are burning)
2. Gray or coppery (usually means light brush, sage, or buckwheat are burning)
3. Black (usually means heavy brush or oily chemicals are burning)
4. Blue (usually means heavy brush is burning—less dense brush than with black smoke)
5. Yellow (usually means pine trees are burning)

Forest Health

When the direct attack strategy is used, firefighters work directly on the edge of the fire (Figure 30). A direct attack is used only when the fire is spreading slowly and isn't too hot. During a direct attack on a medium-size or large-size fire, firefighters usually try to build a fire line by scraping the dirt down to the subsoil. They may rake the burning litter back into the fire, too. Pumping water on the fire is often the best extinguishing method (if available). When attacking small fires, firefighters may beat them out with green branches, wet sacks, or specially-designed swatters. If only one tree is burning, the smokechaser (the first person sent to check out smoke reported from the fire tower) may just cut it into sections and throw dirt and water on it.

Hot spotting is the specialized job of suppressing the "hot spots" of a forest fire, which are the most rapidly advancing heads along a fire's perimeter. Hot spotting is essentially a delaying tactic that allows other crews to construct the main fire line around the fire without having some stray head spread the fire. The use of aerial tankers can be very efficient in controlling the forward movement of a fire, giving ground crews a chance to contain the fire.

When the edges of a fire perimeter are relatively "cold," fire crews go back and clear small fire lines to ensure that the fire won't spread there. This is called cold trailing. It starts when the fire's edge is completely out or when fuel is smoldering with only occasional flare-ups. To prevent the fuel from igniting again, it's necessary to build a trail into the clean soil that's wide enough to prevent flames, sparks, or failing material from spreading across the line.

Backfiring is a technique used in indirect attacks. In a backfire, one or more small controlled fires are set to create a firebreak for the main fire. (The backfire burns up fuel before the wildfire can reach the backfire area.) Backfiring is a practice that requires skill and extensive knowledge of fire behavior, and should only be carried out by very experienced firefighters. Backfires shouldn't be set unless they're absolutely necessary. Conditions that would justify the use of backfires to combat a larger fire are: a very high rate of spread, intense heat, hazard to human life, or extreme difficulty in suppression by direct action.