FIRE ECOLOGY

Perhaps the image most often associated with wildland fire is one of destruction. While it is true that fire has a great potential for the destruction of homes, wildlife, and even human life, fire is just one of many natural forces within ecosystems.

Ecological Society of America

What is Fire Ecology?

Fire is a natural component of many ecosystems, which include plants and animals that interact with one another and with their physical environment. Fire ecology examines the role of fire in ecosystems. Fire ecologists study the origins of fire, what influences spread and intensity, fire's relationship with ecosystems, and how controlled fires can be used to maintain ecosystem health.

The Physical and Chemical Nature of Fire

For fuel to ignite it must be heated in the presence of oxygen to the ignition point or kindling temperature. Wood must reach about 800 degrees F to burst into flame. As the wood is being heated to this point it dries as water, oils, and resins are boiled away. The chemical structure of the fuel is broken down and flammable gases are produced. The ignition of these flammable gases is known as flaming combustion. Flaming combustion transforms the surface of the wood to charcoal. At cooler temperatures, glowing combustion consumes charcoal, producing ash, water, and carbon dioxide. Many factors such as fuel, weather, topography, and fire history influence the probability of ignition and combustion.

Elk near Sula Complex Fire, Montana
Photo Courtesy of Alaskan Type I Incident Management Team

Fire Behavior

Fire behavior is most often described by intensity and spread. Many factors influence this behavior. Five factors that influence intensity are available fuel, moisture and temperature, fuel composition, wind, and topography. Available fuel is quantified by size and arrangement. The more available fuel, the more intense the fire and cool, moist fuels combust more slowly than hot, dry fuels. Fuel composition can make a fire more or less intense. Oils and resins increase the heat yield of the reaction and cause a fire to burn intensely whereas other chemical factors, such as high concentrations of minerals, can reduce flammability. Wind increases oxygen supply, convects heat and can produce "spot fires" from fragments that blow down-wind. Finally, topography effects intensity. A fire ignited on the top of a slope is likely to spread slowly as it burns downhill, whereas a fire at the bottom of a slope will start rapidly and gain momentum as it burns uphill because warm air rises and preheats uphill fuels. Many of the factors that affect intensity also affect the rate of spread. For example, fires in dry, windy conditions with abundant fuel spread rapidly. Fuel continuity and topography also play a role in spread. Topographic features such as streams and lakes can create firebreaks, thus influencing the distribution of burns across landscapes. Finally, the composition of plant communities affects spread, as some species are more flammable than others.

The Effects of Fire on Ecosystems

There is much yet to be learned about how wildland fire affects ecosystems. This is in part because each fire and each ecosystem has unique properties. However, some generalities can be made.

Mosaic Patterns

Wildland fires create a mixture of totally burned, partially burned, and unburned sections called a burn mosaic. The varying degrees of burn are a result of many factors including wind shifts, daily temperature changes, moisture levels, and varying chemical composition of the vegetation. The burn mosaic results in varied regrowth rates that creates a vegetation mosaic.

Bison in a Burned Forest
Photo Courtesy of US Forest Service

Soil Conditions

Wildland fires can be both a detriment and a benefit to soil. The soil can become more nutrient-rich after a fire due to the high mineral content of the ash and charcoal and also due to the warm, moist conditions that increase microbial activity. The intense heat can also cause soil particles to become water-repellant, causing rainwater to run off. As the water runs off it can carry soil particles with it and lead to erosion.

Animal Populations

Some animals will perish in wildland fires, especially small animals, insects, and older and weaker individuals. However, fire has a greater affect on habitat than on individuals. While the vast majority of large mammals are able to flee fires, populations often suffer substantial losses in the months following a fire due to a loss of food sources. Food sources are scarce because of the fire itself and also because most natural fires occur shortly before winter. These habitat changes allow other animals to thrive. Scavenging animals find an increased abundance of food sources and predatory animals may benefit from reduced forest cover which makes prey more visible. Nutrient-rich new growth also benefits many animals and animals such as deer will even eat the nutrient-rich charcoal and ashes. Birds also thrive on increased seed availability and nesting sites in snags.

Plant Populations

Vegetation composition is one factor that determines how a fire behaves. The fire behavior in turn determines the extent to which the plant populations are affected. The more intense the fire, the more vegetation is killed. The initial vegetation losses may look harsh, but the reduced number of trees and shrubs minimize competition among the surviving individuals. The organisms that survive the fire gain more access to nutrients, light, and water. Plants may exhibit increased growth, benefiting from the additional minerals in the soil as a result of the fire. Fire may also rid some plants of their parasites, increasing plant health. For example, a high-intensity fire kills dwarf mistletoe, a parasitic plant of the lodgepole. Some plant species have adaptations that allow them to survive, thrive, and even require fire for survival. The giant sequoia can produce bark that is 2 feet thick as protection from fire. Other plants such as the chaparral snowbush require the heat of wildland fires to crack their seed coats.

Fire Regimes

Fire regimes are the patterns of wildland fires that include factors such as frequency, extent, intensity, type, and season. Regimes vary by ecosystem because each ecosystem has a different composition and structure determined by climate conditions, vegetation types, and ignition sources. Humans have altered many aspects of natural fire regimes over time. Currently, ecologists are studying evidence to try to determine historical fire records or natural fire regimes. Techniques include sampling fire scars on trees for evidence of a sequence of fires in the growth rings, sampling lake and reservoir sediments for extreme or unusual runoff events, using written and oral histories, and extrapolating from current patterns of weather, fuel build-up and lightning fires. Understanding natural fire regimes should lead to the most appropriate resource management policies. The variety of ecosystems and regimes dictates that there should be a variety of techniques and practices in any comprehensive management policy. One solution does not fit all.

Lodgepole Pine

The Lodgepole Pine (*Pinus contorta*) is a dominant tree of the northern United States and Canada. A lodgepole stand may live 250 to 400 years. During the first century of the stand's existence surface fires are unable to climb into the forest canopy because the lower branches of a lodgepole die and drop-off as the tree grows taller. Slowly shade-tolerant spruces and firs start to grow on the dark floor of the stand, blocking out the sun and preventing lodgepoles from sprouting. Eventually spruces and firs would dominate if there were no forest fires. However lightning usually ignites a fire that destroys the stand. After a fire, lodgepole pines are often the first trees to reappear because the bare, sunlit soil that remains after a fire is ideal for lodgepole seedling growth. Lodgepoles also have special serotinous cones that are coated with a hard waxy substance. Fire melts this coating, allowing thousands of seeds to be released. The Lodgepole Pine is just one of many species that is dependent upon fire.

Lodgepole Pine
Photo Courtesy of Neva Snell, CA Academy of Sciences

Logging Truck in Utah
Photo Courtesy of US Forest Service

Human Influence on Wildland Fire

The way a fire operates is largely determined by a region's wildlife. Altering these biotic components impacts the fire's effects. Humans have had one of the greatest influences on the biota of ecosystems. Native Americans and early settlers used fire extensively in their land management practices. Today, we clear vegetation for farming, homes, commercial buildings, and roads. We introduce nonnative species. We use forests to harvest timber. Our influences are countless. As a result, it is impossible to fully understand the extent to which humans have altered natural fire regimes. This makes fire management a complex and often controversial topic.

Prescribed Burns and the Reintroduction of Fire

One of the first fire management practices of the United States government was one of total fire suppression. In the 1930s researchers began to challenge this policy and argue that in some regions fire was an element essential for ecosystems to thrive. In the 1950s and 1960s national parks and forests began to experiment with prescribed burning, the practice of intentionally igniting wildland fires and permitting naturally occurring fires to burn.

Drip Torch Method for a Prescribed Burn
Photo Courtesy of National Interagency Fire Center

One goal of prescribed burns is to begin to restore the natural fire regime in areas where fire suppression has been the practice. Ecosystems where fire has been suppressed may take some time and several fires to restore a natural regime. Therefore, managers attempt to allow only low-intensity fires to burn in order to recondition the ecosystem to fire. Where fuels are quite dense or conditions such as high winds may cause high-intensity fires, fires continue to be suppressed. This strict management makes prescribed burns most useful in ecosystems where the past fire regime was one of low-intensity fires. In regions where high-intensity crown fires are the norm, prescribed burns are not as effective.

For More Information

Association for Fire Ecology, http://www.ice.ucdavis.edu/afe

United States Department of Agriculture, Forest Service, http://www.fs.fed.us

United States Department of the Interior, U.S. Fish & Wildlife Service, http://www.fws.gov

United States Department of the Interior, Bureau of Land Management, http://www.blm.gov/nhp/index.htm

The National Park Service, http://www.nps.gov

National Interagency Fire Center, http://www.nifc.gov

Tall Timbers Research Station, http://www.talltimbers.org/

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