Wildland Fire Overview
This chapter outlines the basic information communicators should know about wildland fire in order to effectively communicate this complex topic to various audiences. A concise section on the science of wildland fire and its role in ecosystems is included as background information. You can craft meaningful messages using this information, your existing knowledge, and the science of wildland fire in your particular area.

Introduction

> An excellent resource for a more detailed understanding of fire behavior concepts is the NWCG course S-190: Introduction to Wildland Fire Behavior.

Wildland fire is any non-structure fire that occurs in an area in which development is essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Three distinct types of wildland fire have been defined by the National Wildfire Coordinating Group (NWCG):

- **Wildfire:** An unplanned, unwanted wildland fire including unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out.
- **Wildland fire use:** The application of the appropriate management response to naturally-ignited wildland fires to accomplish specific resource management objectives in pre-defined designated areas outlined in Fire Management Plans.
- **Prescribed fire:** Any fire ignited by management actions to meet specific objectives, e.g., the establishment/maintenance of healthy forests and grasslands or the enhancement of certain wildlife habitat. Prescribed fire is a well-established practice on public and private lands throughout the world, and is based on years of scientific research. Resource managers carefully calculate meteorological factors, fuels, slope of land, and other relevant conditions in planning prescribed fires. Utmost care is taken to protect human life and property, manage impacts of smoke, protect historical and archeological resources, and protect the ecological integrity of the physical and biological resources.

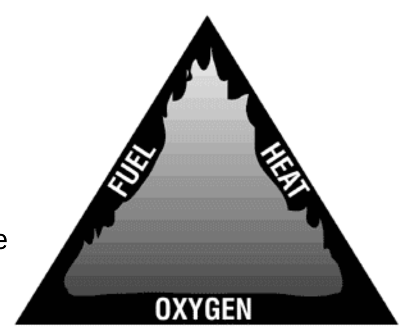
When communicating about wildland fire management issues, it is important to be aware of the basic scientific tenets of wildland fire, including the combustion process and the factors influencing wildland fire behavior. This chapter is intended to provide you with an overview of these topics.

Ecological Aspects of Wildland Fire

Depending on the expertise of the audience, you may choose to limit the discussion to a simple overview of the fire triangle, or expand the discussion to include the technical details of flame structure and fuel chemistry. This section is intended to provide you with an overview of the scientific processes occurring with wildland fires.

The Fire Triangle

The first step in teaching about wildland fire is to begin with the essentials as illustrated by the fire triangle and its three equal components: heat, fuel, and oxygen. The interaction of all three is required for the creation and maintenance of any fire. When not enough heat is generated or when water is used to reduce the heat level; when the fuel is exhausted, removed, or isolated; or when the oxygen supply is limited, then a side of the triangle is broken and the fire is extinguished. The underlying concept is that wildland fire personnel seek to manage one or more of the three elements to suppress an unwanted fire or guide a prescribed fire.



Heat

A heat source is needed for the initial ignition of wildland fires. Heat is also generated by the fire. Heat transfer is a critical issue in the study of wildland fire. For a fire to grow and spread, heat must be transferred to the initial and surrounding fuel. Heat allows fire to spread by removing (evaporating) the moisture from the nearby fuel, enabling it to ignite or travel more easily. The mechanism and the speed of heat transfer play a great role in wildland fire behavior.

Three mechanisms of heat transfer exist: convection, radiation, and conduction. All three contribute in different ways to the combustion process, depending in part on the fuel distribution, the wind speed at the fire site, and the slope of the terrain.

- **Convection** is the transfer of heat through the flow of liquids or gases, such as when hot air rises through a chimney. Convection currents are often responsible for the preheating of the higher shrub layers and canopy, carrying the ground fire upwards into the canopy.
- **Radiation** transmits heat by rays, such as from the sun or a flame. Radiation accounts for most of the preheating of fuels surrounding a fire. The temperature of these fuels can sometimes rise so high that the fuels ignite prior to contact with flames, spreading the fire.
- **Conduction** moves heat from one fuel particle to the next, as when the stove burner heats a pan and its contents. Conduction allows the heat to be transferred inside and throughout the fuel, rather than only heating the surface. Because wood is a poor heat conductor, meaning heat does not pass through it easily, conduction is usually not the primary mechanism of heat transfer in a wildland fire.

Helping your audience(s) understand the fire triangle concept is critical to helping them understand why certain actions are taken. Without this understanding, especially in a suppression situation, firefighters' actions may be misunderstood.

Fuel

The fuel side of the fire triangle refers to both the external and internal properties of the fuel. External properties refer to the type and the characteristics of the fuel material. Internal properties of fuel address aspects of fuel chemistry. Fuel is characterized by its moisture content, size and shape, quantity, and the arrangement in which it is spread over the landscape.

- The ***moisture content*** of any fuel will determine how easily that fuel will ignite and burn. Live trees usually contain a great deal of moisture while dead logs contain very little. Before a wet fuel can burn, the moisture must be converted to vapor through the heat process. The greater the moisture content, the higher the heat temperatures required to dry the fuel. The presence of moist fuel can affect the rate and direction that a wildland fire spreads. High moisture content slows the burning process since heat from the fire must first expel moisture.
- The ***size and shape*** of fuel in part determines its moisture content. Lighter fuels such as grasses, leaves, and needles quickly dry out, and therefore burn rapidly. Heavier fuels, such as tree branches, logs, and trunks, take longer to warm and ignite. In areas of light fuel, the temperature required for ignition is lower than in areas of heavier fuel. The oxygen surrounds lighter fuels and allows the fuel to burn with greater intensity, quickly exhausting the fuel supply.

Types of fuel include living vegetation, dead vegetation, (duff, twigs, needles, standing dead snags, leaves, and moss), organic subsurface material (peat and coal), and human built structures. Fuel can be defined as any combustible material.

- The ***quantity*** of combustible fuel in a given area is known as fuel loading. These fuels may be arranged in a uniform pattern and distributed continuously across the ground, allowing a wildland fire to travel uninterrupted. Or, the fuel may be distributed unevenly in a patchy network, forcing the fire to travel over rocks and other barriers by wind-borne embers.
- The ***vertical arrangement*** of fuel is also an important factor in wildland fires. Ground fuels are all of the combustible materials found below the ground surface, and include tree roots, duff, and organic material. Surface fuels are found at the ground level, including twigs, grass, needles, wood, and other vegetation. Ladder fuels are just above ground level such as tall grass and bushes and can carry flames into the tops of trees. Aerial fuels are standing vegetation including tree crowns, branches, leaves, snags, and hanging moss. Crown fires are able to burn independently of surface fires, moving through the treetops.

Oxygen

The third side of the fire triangle represents oxygen. Air contains about 21% oxygen; most fires require air with at least 16% oxygen content to burn under most conditions. Oxygen supports the chemical processes that occur during a wildland fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products, e.g., gases, smoke, particles. This process is known as oxidation.

Fire Behavior

All wildland fires begin with an ignition source. Lightning is a common ignition source of wildland fires. Nine out of ten fires, however, are started directly or indirectly by people, through debris burning, campfires, arson, discarded smoking products, sparks from equipment in operation, arced power lines, and other means. Fire behavior describes the manner in which fuels ignite, flames develop, and fire spreads. The fundamental influences on the spread of wildland fire include fuel type and characteristics, weather conditions in the area, and topography.

Fuel

Because of the complicated combustion process that occurs during the ignition and spread of a wildland fire, it may be useful to describe to your audience the difference between fire and flame. Fire is a chemical reaction, and flame is the visible indication of that chemical reaction. When a flame is visible, the combustion is termed "flaming combustion." With "glowing combustion" one will only see embers.

Fuels char at relatively low temperatures, but once charred can continue to burn by glowing combustion. As fire spreads, there is constant ignition of new fuels through one of the three heat transfer mechanisms described earlier, and the fire continues to advance.

Weather

Weather is the most variable of the factors that affect fire behavior. Wildland fires are affected by wind, temperature, and humidity in the burn zone. Strong winds can affect fire behavior by pushing the flames toward new fuel sources. Wind is able to pick up and transfer burning embers, sparks, and other materials that are capable of starting "spot fires." Blowing wind can also serve as a fuel drying source in moist areas. Wildland fires are capable of generating their own wind. Air above the hot flames becomes heated, causing it to rise. This movement allows fresh air to fill the vacuum provided; this fresh air supplies the fire with a fresh supply of oxygen. In essence, fires can generate their own winds, fanning their own flames.

During the day, sunlight heats the ground and the warm air rises, allowing air currents to travel up sloped landscapes. At nightfall, the process is reversed. The ground cools and the air currents now travel down the slopes. Often fires will burn upslope during the day and down slope at night. Temperature acts upon the spread of wildland fires because the temperature of the fuel affects how quickly or slowly they will reach their ignition point and burn. Because fuels are also heated by solar radiation, fires in the shade will not burn as quickly as those in the direct path of sunlight.

Humidity is a measure of the amount of moisture in the air. This moisture dampens the fuel, slowing the spread of flames. Because humidity is greater at night, fires will often burn less intensely at that time under normal circumstances, and therefore will not travel a great distance.

The combination of wind, temperature, and humidity affects how fast wildland fires can spread. These combinations will change throughout the day and night, and the presence of fire will impact each factor, causing even greater variation.

Topography

Topography of a landscape also affects the spread of wildland fire. Every wildland fire is different in the way that it behaves because of the changing combinations of so many factors, but topography remains constant and therefore allows for more constant predictions of how fire will behave in a specific area.

An explanation of topography includes the shape of the landscape, its elevation, the slope direction and its exposure to sunlight, and the slope steepness (aspect).

- The shape of the land determines how much sunlight or shade an area contains, affecting temperature and wind conditions. Certain fuels grow better under different conditions. In addition, if the landscape has barriers, including highways, boulders and rock slides, or bodies of water, the fire will not spread as quickly.
- Elevation and slope direction affect the type and temperature of the fuel to the degree in which there are shaded and sunny areas. Elevation also impacts how much wind and moisture the area receives.
- The amount of shade or sunlight, the temperature of an area, and moisture received by an area all determine the type of fuel available for wildland fires.
- Slope steepness is important in that it contributes to how quickly the fire will reach the crest of the land form. When a fire begins at the bottom of a slope, the fuels located uphill are preheated by the rising air, helping them to easily catch fire when they come in contact with flames. Fires that begin uphill may deposit burning material that rolls downward, allowing more fires to begin downhill.

The Complexity of the Fire Message

While helping your audience understand the basic concepts of fire, it is critical to convey the complexity. The science behind wildland fire requires knowledge of chemistry, physics, geology, meteorology, and ecology. That knowledge is then interpreted to help predict and explain fire behavior. Each situation is different in that fire does not function within the framework of a static model.

Wildland fire, as it moves, involves a changing situation. Fire itself changes its own environment, e.g., winds. In essence, in managing a fire the professionals are mixing a recipe in which the ingredients are known but the quantities going in and out of the recipe are constantly changing as is the heat. Such analogies may help your audience better understand why wildland fire management is a demanding art and a science.

Defining Fire Regimes

Wildland fire is a natural process, and many ecosystems depend upon it. As we tell the story of fire to illustrate the science of wildland fire management, we also need to tell stories that promote coexistence with wildland fire. In discussing and addressing fire as a conservation issue, it is important to recognize and understand the different roles that fire plays in different ecosystems. The broad ecosystem categories of vegetation responses to fire below can be helpful in communicating general concepts to the public.

- **Fire-dependent ecosystems** are those where fire is essential and the species have evolved adaptations to respond positively to fire and to facilitate fire's spread, i.e. the vegetation is fire-prone and flammable. They are often called **fire-adapted** or **fire maintained** ecosystems. Many plants and animals in these landscapes depend on fire to reproduce and grow. If fire is removed, or if the fire regime is altered beyond its normal range of variability, the ecosystem changes to something else, and habitats and species are lost. Fire dependent ecosystems vary greatly and need to burn under an appropriate fire regime if they are to persist in the landscape.
- **Fire-sensitive ecosystems** have not evolved with fire as a significant, recurring process. In these ecosystems, most plants and animals lack adaptations to respond to fire and generally lack the ability to rebound after wildfire. Vegetation structure and composition tend to inhibit ignition and fire spread. A wide variety of fire-sensitive ecosystems in the tropics and elsewhere are threatened by land use activities and vegetation conversion efforts that either use fire or increase the probability of ignitions.
- **Fire-independent ecosystems** are those where fire normally plays little or no role. They are too cold (tundra), too wet (rain forests), or too dry (deserts) to burn. Fire becomes a threat only if there are significant changes to these ecosystems brought about by land use activities, species invasions, or climate change.

As communicators, the questions we must be able to answer for the public are: "What ecosystem type or vegetation structure are we trying to conserve and/or manage?" and "Are the fires that are occurring in that ecosystem helping to maintain it or are they causing the ecosystem to change?"

It is important for you and your audience to understand that fire regimes, like the entire natural world, are diverse and particular to their specific sites. Fire helps determine where different types of habitats exist around the world. Plants and animals have developed different responses to fire, with some dependent on fire and others sensitive to fire.

A fire regime is a set of recurring conditions of fire that characterizes a given ecosystem. The combination of fire frequency, intensity, severity, seasonality, size of burn, fire spread pattern, and pattern and distribution of burn circumscribe those conditions. Fire regimes can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval.

An **ecologically appropriate fire regime** is one that maintains the viability of the ecosystem.

An **altered or undesirable fire regime** is one that has been modified by human activities to the extent that the current fire regime negatively affects the viability of desired ecosystems and the sustainability of products and services that the ecosystem provides.

Although fire is one of the most important natural disturbances in many of the Earth's ecosystems, inevitably, conservation practitioners addressing fire issues find that they must also deal with other threats or issues that, because they affect fuels, alter fire regimes. We cannot effectively restore ecologically acceptable regimes unless we also understand and address the underlying causes of alteration. Some general sources are listed below; however, you may have a source unique to your particular area that you need to communicate to your audience.

- Climate change
- Grazing or other land management practices
- Landscape fragmentation
- Rural and urban growth
- Arson
- Lack of or inappropriate fire management practices
- Crop production or non-compatible timber practices
- Invasive species or insect disease
- Loss of traditional and cultural fire use practices that promoted appropriate fire regimes
- Ecosystem conversion
- National policies

In many ecosystems, fire regime alteration is a slow and incremental process, sometimes occurring over decades, and is often linked to multiple sources of degradation related to the many ways that people utilize and interact with our landscapes. Therefore, the attention of the public and decision-makers often occurs after a triggering event, like prolonged drought and uncharacteristically severe fires.

Fire Regime Condition Class

Fire regime condition class (FRCC) is a standardized, interagency tool for determining the degree to which current vegetation and fire regime conditions have departed from historical reference conditions.

The Five Historic Natural Fire Regime Groups

Fire Regime Group	Frequency (Fire Return Interval)	Severity
I	0-35 years	Low severity
II	0-35 years	stand replacement severity
III	35-100+ years	mixed severity
IV	35-100+ years	stand replacement severity
V	>200 years	stand replacement severity

The fire regime groups are intended to characterize the presumed historical fire regimes within landscapes based on interactions between vegetation dynamics, fire spread, fire effects, and spatial context. You can access fire effects/fire ecology data to learn more about fire regime characterizations and summaries on plant, animal, and vegetation communities for your specific area by exploring the Fire Effects Information System (FEIS; http://www.fs.fed.us/database/feis/).

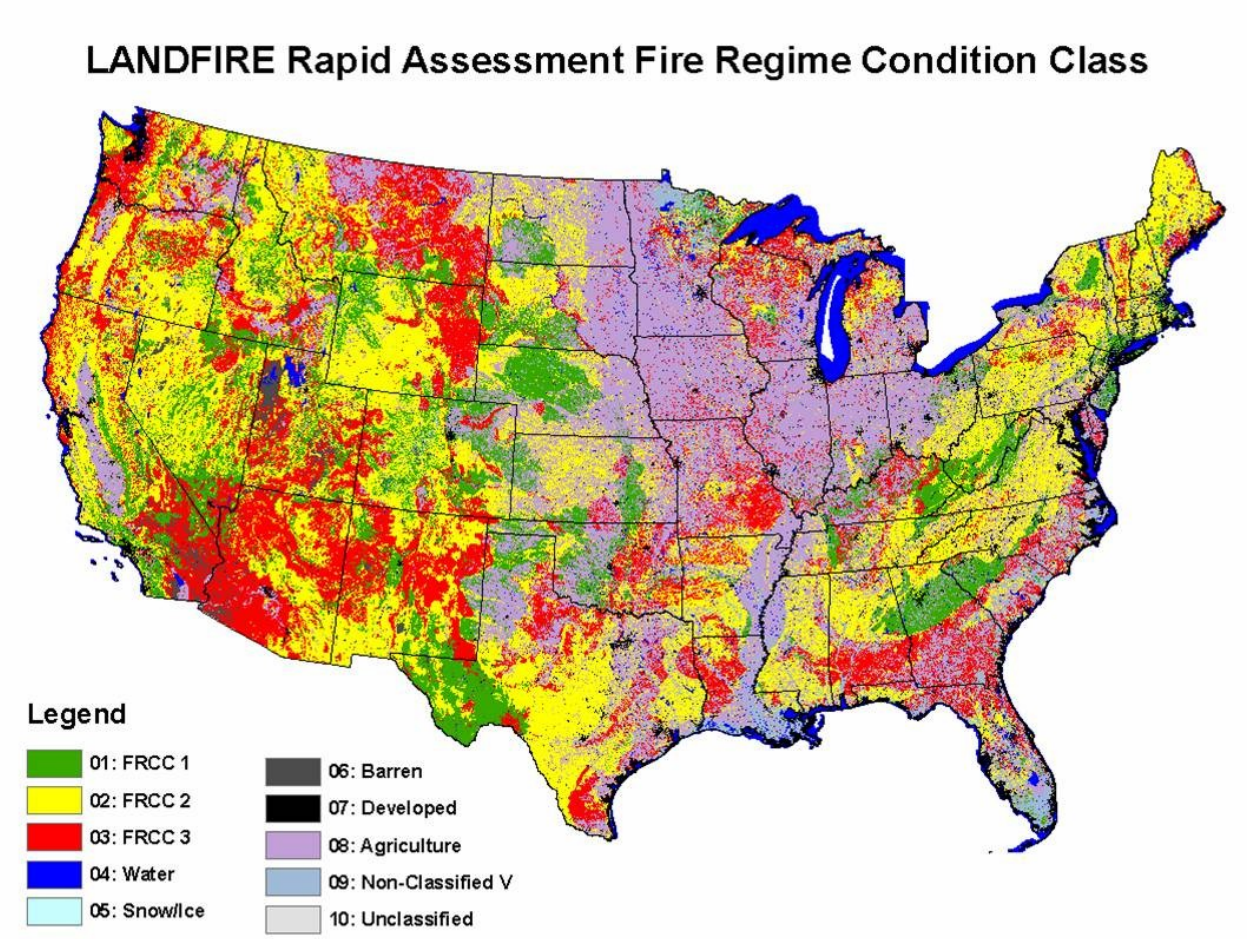
Condition class attributes is an approach to defining and interpreting the importance of fire frequency in ecosystems. This concept is useful in helping wildland fire communicators convey to their audiences the science and management behind wildland fire.

Current "condition class" is defined in terms of departure from the historic fire regime, as determined by the number of missed fire return intervals with respect to (1) the historic fire return interval, and (2) the current structure and composition of the system resulting from alterations to the disturbance regime.

Three "condition classes" have been developed to categorize the current condition with respect to each of the five historic Fire Regime Groups.

- **Fire Regime Condition Class 1**: For the most part, fire regimes in this Fire Regime Condition Class are within historical ranges. Thus, the risk of losing key ecosystem components from the occurrence of fire remains relatively low. Maintenance management such as wildland fire use and/or prescribed fire, mechanical treatments, or preventing the invasion of non-native weeds, is required to prevent these lands from becoming degraded.
- **Fire Regime Condition Class 2**: Fire regimes on these lands have been moderately altered from their historical range by either increased or decreased fire frequency. A moderate risk of losing key ecosystem components has been identified in these lands. Restoring these lands to their historical fire regimes may require some level of restoration through the use of fire, mechanical or chemical treatments, and the subsequent reintroduction of native plants.
- **Fire Regime Condition Class 3**: These lands have been significantly altered from their historical range. Because fire regimes have been extensively altered, risk of losing key ecosystem components from fire is high. Consequently, restoring these lands to their historical fire regimes may require multiple mechanical or chemical treatments and reseeding before some application of fire such as prescribed fire can be utilized to manage fuel or obtain other desired benefits.

A complete definition, background information, and the nationally consistent methodology for calculating and mapping FRCC are available at http://www.frcc.gov.



***Map generated from LANDFIRE Rapid Assessment data*.**
LANDFIRE is a multi-partner wildland fire, ecosystem, and wildland fuel mapping project. LANDFIRE's objective is to provide consistent, nationwide data describing wildland fuel, existing vegetation composition and structure, historical vegetation conditions, and historical fire regimes. For detailed information and additional maps and products go to www.landfire.gov.

Like many fire-adapted trees, longleaf pine requires mineral soil for seed germination, and thus ground fires prepare the seedbed by removing litter and releasing soil nutrients. The longleaf seedling grows slowly in the early years, devoting much energy to developing a thick root that is protected from fire, and to a dense protective layer of needles around the buds. Loblolly and shortleaf pines are less fire tolerant than longleaf pine, but the thick barks of these species also make them more fire tolerant than most other competitive tree species.

Jack Pine Communities of the Great Lakes Region

A mixture of pines and other tree species is found in the forests of the Great Lake states. Red, white, and jack pine grow among paper birch and aspen. Grasses, forbs, and shrubs such as big bluestem, little bluestem, raspberry, blueberry, and huckleberry grow under the trees of these communities. The communities of the Great Lakes states have had many disturbances since European settlement, making it difficult to determine the "natural" state of these ecosystems.

Dave Currie

Jack pines are small trees, rarely exceeding 80 feet (about 24 meters) in height. They occur in poor soils, usually in open "pine barrens," and often form savannahs when grasses are present on the thin soils. Fires occur in jack pine stands approximately every 125 to 180 years. Jack pine is well-adapted to fire. Serotinous cones, which have a waxy outer coating to protect the seeds, remain on the tree rather than dropping to the forest floor. Seeds can remain viable on the tree for 20 years or longer. When a fire occurs, the thick cone protects the jack pine seed from the intense heat. Jack pine seeds have been known to still be viable after exposure to heat at 1000 degrees Fahrenheit. That heat, however, opens the scales of the cone and releases the seed onto the ground where the fire has removed much of the existing vegetation and litter. Jack pine seeds require contact with mineral soil to germinate, so fire serves to prepare the seedbed, reduce competition from other plants, and release the jack pine seed. In addition, the short stature of jack pines makes crown fires a high likelihood; these very crown fires are necessary to release the seeds from dormancy.

When fire is withheld from jack pine stands, they are replaced by other boreal tree species, such as balsam fir, white spruce, and the hardwoods that occur in this ecosystem. Prescribed fire is used in jack pine stands in central Michigan in order to maintain habitat for the rare Kirtland's warbler, which requires young jack pine stands for nesting.

Alaska's Boreal Forest and Tundra

Alaska is a vast landscape covered with boreal forest and tundra, all prone to wildland fire. The boreal forest is found in southern Alaska extending as far north as Fairbanks. Tundra is found in the higher elevation of this zone. Tundra extends from the Brooks Range north to the Arctic Ocean.

While the boreal forest has large vegetation (e.g., spruce and birch trees) and nutrient-laden soil, the tundra is a low landscape comprised of scrubby and herbaceous vegetation, often only a few inches high. Much of the tundra soil and its nutrients are locked in permafrost. Often the soil is shallow; in some places it is no deeper than the shallow root structure of the tundra vegetation.