All About Wildfires: The Science Behind Wildfires

A wildfire is an uncontrolled fire in an area of combustible vegetation that occurs in the countryside or a wilderness area.

Other names such as brush fire, bushfire, forest fire, desert fire, grass fire, hill fire, peat fire, vegetation fire, and veldfire may be used to describe the same phenomenon depending on the type of vegetation being burned.

A wildfire differs from other fires by its extensive size, the speed at which it can spread out from its original source, its potential to change direction unexpectedly, and its ability to jump gaps such as roads, rivers and fire breaks. Wildfires are characterized in terms of the cause of ignition, their physical properties such as speed of propagation, the combustible material present, and the effect of weather on the fire.

Wildfires occur on every continent except Antarctica. In the United States, there are typically between 60,000 and 80,000 wildfires that occur each year, burning 3 million to 10 million acres of land depending on the year. Fossil records and human history contain accounts of wildfires, as wildfires can occur in periodic intervals. Wildfires can cause extensive damage, both to property and human life, but they also have various beneficial effects on wilderness areas. Some plant species depend on the effects of fire for growth and reproduction, although large wildfires may also have negative ecological effects.

Strategies of wildfire prevention, detection, and suppression have varied over the years, and international wildfire management experts encourage further development of technology and research. One of the more controversial techniques is controlled burning: permitting or even igniting smaller fires to minimize the amount of flammable material available for a potential wildfire. While some wildfires burn in remote forested regions, they can cause extensive destruction of homes and other property located in the wildland-urban interface: a zone of transition between developed areas and undeveloped wilderness.

Characteristics

Wildfires differ from other fires in that they take place outdoors in areas of grassland, woodlands, bushland, scrubland, peatland, and other wooded areas that act as a source of fuel, or combustible material. Buildings may become involved if a wildfire spreads to adjacent communities. **While the causes of wildfires vary and the outcomes are always unique, all wildfires can be characterized in terms of their physical properties, their fuel type, and the effect that weather has on the fire.**

Wildfire behaviour and severity result from the combination of factors such as available fuels, physical setting, and weather. While wildfires can be large, uncontrolled disasters that burn through 0.4 to 400 square kilometres (100 to 100,000 acres) or more, they can also be as small as 0.0010 square kilometres (0.25 acre) or less. Although smaller events may be included in wildfire modeling, most do not earn press attention. This can be problematic because public fire policies, which relate to fires of all sizes, are influenced more by the way the media portrays catastrophic wildfires than by small fires.

Causes

The four major natural causes of wildfire ignitions are: **lightning**, **volcanic eruption**, **sparks from rockfalls**, and **spontaneous combustion**. The thousands of coal seam fires that are burning around the world, such as those in Centralia, Burning Mountain, and several coal-sustained fires in China, can also flare up and ignite nearby flammable material. However, many wildfires are attributed to human sources such as arson, discarded cigarettes, discarded glass (and plastic) magnifying the sun's (light and heat) rays, sparks from equipment, and power line arcs (as detected by arc mapping). In societies experiencing shifting cultivation where land is cleared quickly and farmed until the soil loses fertility, slash and burn clearing is often considered the least expensive way to prepare land for future use. Forested areas cleared by logging encourage the dominance of flammable grasses, and abandoned logging roads overgrown by vegetation may act as fire corridors. Annual grassland fires in southern Vietnam can be attributed in part to the destruction of forested areas by US military herbicides, explosives, and mechanical land clearing and burning operations during the Vietnam War.

In the United States and Australia, the source of wildfires can be traced to both lightning strikes and human activities such as machinery sparks and cast-away cigarette butts.

On a yearly basis in the United States, typically more than six times the number of wildfires are caused by human means such as campfires and controlled agricultural burns than by natural means. However, in any given year there could be far more acres burned by wildfires that are started by natural means than by human means as well as vice-versa. For example, in 2010, almost 1.4 million acres were burned by human-caused wildfires, and over 2 million acres were burned by naturally-caused wildfires. However, far more acres were burned by human-caused fires in 2011, when almost 5.4 million acres were burned by human-caused wildfires, and only about 3.4 million acres were caused by naturally-derived wildfires.

Fuel Type

The spread of wildfires varies based on the flammable material present and its vertical arrangement. For example, fuels uphill from a fire are more readily dried and warmed by the fire than those downhill, yet burning logs can roll downhill from the fire to ignite other fuels. Fuel arrangement and density is governed in part by topography, as land shape determines factors such as available sunlight and water for plant growth. Overall, fire types can be generally characterized by their fuels as follows:

- **Ground fires** are fed by subterranean roots, duff and other buried organic matter. This fuel type is especially susceptible to ignition due to spotting. Ground fires typically burn by smoldering, and can burn slowly for days to months, such as peat fires in Kalimantan and Eastern Sumatra, Indonesia, which resulted from a riceland creation project that unintentionally drained and dried the peat.

- **Crawling or surface fires** are fueled by low-lying vegetation such as leaf and timber litter, debris, grass, and low-lying shrubbery.

- **Ladder fires** consume material between low-level vegetation and tree canopies, such as small trees, downed logs, and vines. Kudzu, Old World climbing fern, and other invasive plants that scale trees may also encourage ladder fires.

- **Crown, canopy, or aerial fires** burn suspended material at the canopy level, such as tall trees, vines, and mosses. The ignition of a crown fire, termed crowning, is dependent on the density of the suspended material, canopy height, canopy continuity, and sufficient surface and ladder fires in order to reach the tree crowns. For example, ground-clearing fires lit by humans can spread into the Amazon rain forest, damaging ecosystems not particularly suited for heat or arid conditions.

Physical Properties

Wildfires occur when all of the necessary elements of a fire triangle come together in a susceptible area: an ignition source is brought into contact with a combustible material such as vegetation, that is subjected to sufficient heat and has an adequate supply of oxygen from the ambient air. A high moisture content usually prevents ignition and slows propagation, because higher temperatures are required to evaporate any water within the material and heat the material to its fire point. Dense forests usually provide more shade, resulting in lower ambient temperatures and greater humidity, and are therefore less susceptible to wildfires. Less dense material such as grasses and leaves are easier to ignite because they contain less water than denser material such as branches and trunks. Plants continuously lose water by *evapotranspiration*, but water loss is usually balanced by water absorbed from the soil, humidity, or rain. When this balance is not maintained, plants dry out and are therefore more flammable, often a consequence of droughts.

A wildfire front is the portion sustaining continuous flaming combustion, where unburned material meets active flames, or the smoldering transition between unburned and burned material. As the front approaches, the fire heats both the surrounding air and woody material through convection and thermal radiation. First, wood is dried as water is vaporized at a temperature of 100 °C (212 °F). Next, the pyrolysis of wood at 230 °C (450 °F) releases flammable gases. Finally, wood can smolder at 380 °C (720 °F) or, when heated sufficiently, ignite at 590 °C (1,000 °F). Even before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front warms the air to 800 °C (1,470 °F), which pre-heats and dries flammable materials, causing materials to ignite faster and allowing the fire to spread faster. High-temperature and long-duration surface wildfires may encourage flashover or torching: the drying of tree canopies and their subsequent ignition from below.

Wildfires have a rapid forward rate of spread (FROS) when burning through dense, uninterrupted fuels. They can move as fast as 10.8 kilometres per hour (6.7 mph) in forests and 22 kilometres per hour (14 mph) in grasslands. Wildfires can advance tangential to the main front to form a flanking front, or burn in the opposite direction of the main front by backing. They may also spread by jumping or spotting as winds and vertical convection columns carry firebrands (hot wood embers) and other burning materials through the air over roads, rivers, and other barriers that may otherwise act as firebreaks. Torching and fires in tree canopies encourage spotting, and dry ground fuels that surround a wildfire are especially vulnerable to ignition from firebrands. Spotting can create spot fires as hot embers and firebrands ignite fuels downwind from the fire.

Effect of Weather

Heat waves, droughts, cyclical climate changes such as El Niño, and regional weather patterns such as high-pressure ridges can increase the risk and alter the behavior of wildfires dramatically. Years of precipitation followed by warm periods can encourage more widespread fires and longer fire seasons. Since the mid-1980s, earlier snowmelt and associated warming has also been associated with an increase in length and severity of the wildfire season in the Western United States. However, one individual element does not always cause an increase in wildfire activity. For example, wildfires will not occur during a drought unless accompanied by other factors, such as lightning (ignition source) and strong winds (mechanism for rapid spread).

Intensity also increases during daytime hours. Burn rates of smoldering logs are up to five times greater during the day due to lower humidity, increased temperatures, and increased wind speeds. Sunlight warms the ground during the day which creates air currents that travel uphill. At night the land cools, creating air currents that travel downhill. Wildfires are fanned by these winds and often follow the air currents over hills and through valleys. Fires in Europe occur frequently during the hours of 12:00 p.m. and 2:00 p.m. Wildfire suppression operations in the United States revolve around a 24-hour fire day that begins at 10:00 a.m. due to the predictable increase in intensity resulting from the daytime warmth.

Plant Adaptation

Plants in wildfire-prone ecosystems often survive through adaptations to their local fire regime. Such adaptations include physical protection against heat, increased growth after a fire event, and flammable materials that encourage fire and may eliminate competition. For example, plants of the genus Eucalyptus contain flammable oils that encourage fire and hard sclerophyll leaves to resist heat and drought, ensuring their dominance over less fire-tolerant species. Dense bark, shedding lower branches, and high water content in external structures may also protect trees from rising temperatures. Fire-resistant seeds and reserve shoots that sprout after a fire encourage species preservation, as embodied by pioneer species. Smoke, charred wood, and heat can stimulate the germination of seeds in a process called serotiny. Exposure to smoke from burning plants promotes germination in other types of plants by inducing the production of the orange butenolide.

Grasslands in Western Sabah, Malaysian pine forests, and Indonesian Casuarina forests are believed to have resulted from previous periods of fire. Chamise deadwood litter is low in water content and flammable, and the shrub quickly sprouts after a fire. Sequoia rely on periodic fires to reduce competition, release seeds from their cones, and clear the soil and canopy for new growth. Caribbean Pine in Bahamian pineyards have adapted to and rely on low-intensity, surface fires for survival and growth. An optimum fire frequency for growth is every 3 to 10 years. Too frequent fires favor herbaceous plants, and infrequent fires favor species typical of Bahamian dry forests

Utah Wildfires

1.) **Summer, 2012**
Nine major wildfires were burning across the state, including the Shingle fire that has burned 8,200 acres and threatened 550 cabins or summer homes and 300 other structures in Dixie National Forest, about 30 miles southeast of Cedar City, officials said. The Quail Fire in Alpine has scorched more than 3 square miles and destroyed one barn. About 325 homes were evacuated but some people were allowed to return Wednesday

2.) **June, 2012 – Saratoga Springs, Utah**
Crews battled a wildfire that burned more than 4,000 acres in Eagle Mountain and Saratoga Springs, forcing the evacuation of more than 9,000 residents and endangering the area's power grid infrastructure.

The fire started near the Saratoga Springs landfill, about 40 miles south of Salt Lake City. High winds then helped fan the flames onto tinder-dry grasslands.

The fire, which was sparked by target shooters threatened new homes as high winds pushed it across the hill.

Ash fell in the area, and winds caused water to turn into mist before it even hit the flames.

Governor Herbert said that there have already been 400 wildfires in Utah - 380 of which were human-caused. Bureau of Land Management officials said this is the 20th target-shooting related fire this year in Utah.

3.) **July, 2007 – Milford Flat Fire**
The Milford Flat Fire was the largest wildfire in Utah history. It was started by lightning on Friday, July 6, 2007 at 3:45 pm near Milford, Utah. The fire burned 363,052 acres (567 square miles) and caused large stretches of I-15 to be temporarily closed. Many veteran firefighters had stated this was the fastest moving fire they had ever seen.

On Saturday, July 7, smoke caused numerous wrecks on I-15, including a 5 car pile-up, and a fatal hit-and-run that killed 2 motorcyclists from California. The fire also caused 10 truckers to abandon their cargo trailers on the side of the road. A 93-mile (150 km) stretch of I-15 was later closed. The fire crossed the freeway around Cove Fort that afternoon, causing it to be evacuated. The fire narrowly missed the local Chevron gas station, but claimed 2 garage-like structures near it, including the Dog Valley Trading Post, as well as a crew cab pickup truck left in a Park-and-Ride lot. By that evening the fire had amassed to 160,000 acres (650 km2).

On Sunday, July 8, the fire slowed down somewhat, reaching the 283,000-acre (1,145 km2) mark by evening. The freeway was reopened, but later a 60-mile (97 km) stretch was closed for 5 hours. Also, FEMA announced the appropriation of federal funds to help fight the fire. Some evacuated residents of Cove Fort returned to view the damage.

On July 9, Firefighters were going to backburn parts of I-15, but the winds changed, and the plans were canceled. More crews arrived, bringing the total personnel from 200 to about 300 firefighters. By the end of the day, the fire had grown to 311,000 acres (1,259 km2), but was 10% contained.

July 10, more firefighters arrived, bringing the total to 400. The fire grew to 329,000 acres (1,331 km2), and was 30% contained by days end. July 15, the fire reached 100% containment.

4.) **Summer, 2000 - western U.S.**
As of Augst, 31 nearly 6.5 million acres had burned nationwide, more than double the ten-year average. States hardest hit included Alaska, Calif., Colo., Idaho, Mont., N.M., Nev., Ore., Tex., Utah, Wash., and Wyo.

5.) **June – early July, 2002 - western U.S.**
Hayman fire in Pike National Forest destroyed 137,760 acres and 600 structures, making it the worst wildfire in Colorado history. In central Ariz., the 85,000-acre Rodeo fire, which had already been declared the worst in Arizona's history, merged with the Chediski fire, destroying 468,638 acres and more than 400 structures. Large wildfires also burned in Alaska, southern Calif., N.M., Utah, Oregon, and Ga.

**** For a complete list of reported fires in Utah, go to:**
http://publicsafety.utah.gov/firemarshal/Statistics.html