Greater Yellowstone is a fire-adapted ecosystem. Smoke may be visible from ongoing fires during the fire season, typically July through September.

Fire

Fire has been a key factor in shaping the Greater Yellowstone Ecosystem (GYE). Several native plant species evolved adaptations so they survive and, in some cases, flourish after periodic fires. Fire influences ecosystem processes and patterns, such as nutrient cycling and plant community composition and structure. Fire regimes in the western United States changed with the arrival of European and American settlers. Most naturally occurring fires were suppressed to the extent possible. The National Park Service (NPS) aims to restore fire's role as a natural process in parks when and where this is feasible.

In Yellowstone, lightning may ignite dozens of forest fires during a single summer, but most of them go out naturally after burning less than half an acre. Others torch isolated or small groups of trees, become smoldering ground fires, and eventually go out on their own. On rare occasions, wind-driven fires have burned through large areas of forest, as in 1988, when multiple fires crossed more than one million acres in Yellowstone and on surrounding federal lands despite massive efforts to extinguish them. Without frequent small and occasional large fires to create a mosaic of plant communities in different growth stages, biodiversity declines and needle litter and deadfall accumulate much faster than they can return nutrients to the soil through decay.

Evidence of fires that burned before the park was established in 1872 can be found in soil profiles, charcoal found in lake sediments, landslides, and old-growth trees. Research shows large fires have been occurring in Yellowstone since forests became established following the last glacial retreat 14,000 years ago. Yellowstone's fire season typically lasts from July to the end of September. The number and extent of fires that occur each year depend on climate and what efforts are made to suppress the fires,

FREQUENTLY ASKED QUESTIONS:

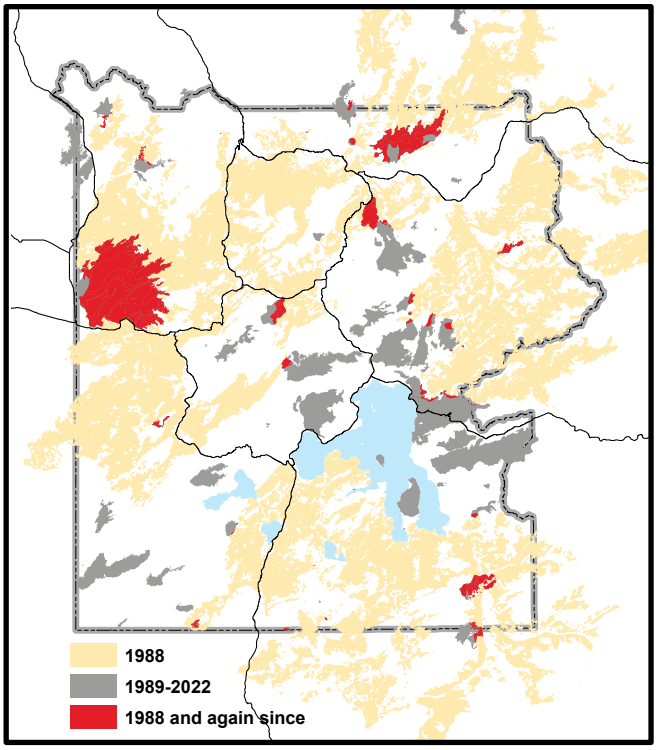
How does fire benefit Yellowstone?

Fires are a natural part of the Greater Yellowstone Ecosystem. Some vegetation species have adapted to fire and, in some cases, may be dependent on it. Fire promotes habitat diversity by removing the forest overstory, allowing different plant communities to become established, and preventing trees from becoming established in meadows. Fire increases the rate nutrients become available to plants by rapidly releasing them from wood and forest litter and by hastening the weathering of soil minerals. This is especially important in a cold and dry climate like Yellowstone's, where decomposition rates are slower than in more hot and humid areas. Additionally, natural fires provide an opportunity for scientists to study the effects of fire on an ecosystem.

Why aren't burned trees removed?

Burned trees and those that have died for other reasons still contribute to the ecosystem. For example, dead standing trees provide nesting cavities for many types of animals; fallen trees provide food and shelter for animals and nutrients for the soil. However, park managers will remove dead or burned trees that pose safety hazards along roads or in developed areas.

as well as weather conditions such as the number and timing of lightning storms and the amount and timing of precipitation.



Burned areas in Yellowstone from 1988 to 2022. Until 2016, the large fires of the 2000s were burning in areas largely unaffected by the 1988 fires. In 2016 alone, 42,425 acres burned in 1988 fire scars.

Ignition

Afternoon thunderstorms that release little precipitation occur frequently in the northern Rockies. Yellowstone receives thousands of lightning strikes in a typical summer, but most do not result in fires. A snag may smolder for several days and then burn out because fuels are too moist to sustain combustion or too sparse to allow the fire to spread. Most of the park's forests have few shrubs; understory fuels are predominantly young trees. The moisture content of both live and dead vegetation tends to drop as summer progresses, temperatures increase, and relative humidity decreases. Fuels have often dried out enough to ignite the first wildfire of the year by July.

A forested area that has burned recently enough to contain only young stands of trees usually doesn't have enough combustible fuel to carry a fire, except under extreme weather and climate conditions. But as the years pass, trees that don't survive the competition for light and other resources die and eventually fall over. On living trees, older branches die and fall off as they are shaded by new foliage growing above. As a stand grows older and taller, the canopy becomes more broken. This allows enough light to reach the forest floor for a shade-tolerant understory to be established. The accumulation of fuel on the forest floor and the continuity of fuels among the ground, understory, and canopy make older stands more vulnerable to fire. Some forests in Yellowstone may not have burned in at least 300 years and may be particularly prone to lightning ignition.

Quick Facts

Numbers in Yellowstone

- In 2022, 6.4 acres burned from 7 known wildfire starts. Two human-caused and 4 lightning-caused fires were suppressed due to hazardous conditions. One lightning caused fire was managed for resource objectives due to its remote location, inaccessibility, and high elevation.
- Since 1972, when reliable fire records began, the park has averaged 24 fires, and 5,466 acres burned per year. The number of fires has ranged from five to 78 each year, and acres burned has ranged from one to 793,880 each year.
- The most active fire year since 1988 was 2016, with 70,285 acres in Yellowstone burned.
- In Yellowstone, approximately 78% of fires are caused by lightning, and 22% are human-caused.
- During the last 30 years (1993–2022), Yellowstone has averaged fewer fires per year, but more acres burned per year, than in previous decades.
- About 76% of fires in Yellowstone never reach more than 0.1 hectares (0.25 acres) in size.
- About 92% of fires in Yellowstone never burn more than 40 hectares (100 acres).

Characteristics

- Yellowstone's landscape has been shaped by naturally caused fire for 14,000 years. Factors affecting fire size and severity include: vegetation type; location; time since the last fire; moisture in the dead and down logs; length of drought; temperature; humidity; and wind.

Management Issues

- The park is required to protect human life as well as the approximately 2% of Yellowstone's 2.2 million acres that are considered developed from the threat of fire—while at the same time letting fire carry out its ecological role as much as possible.

Fire Behavior

Nearly all of Yellowstone's plant communities have burned at one time or another, but their varied characteristics cause fires to behave differently in them. To quickly assess a fire start and its potential to spread, park staff use different vegetation communities as indicators of fuel load, dominant vegetation, and time since the last fire or other disturbance.

The moisture content of dead and downed woody debris, climate, and weather trends are the main factors determining the severity of a given fire season. While fires can occur no matter the fuel moisture, many times conditions are too wet for fires to spread. In fact, 88% of all fires burn fewer than 10 acres in the park. However, in Yellowstone, when 1,000-hour fuel moistures fall below 12%, fires can grow quickly. If extreme drought continues, most forest types and ages are likely to burn.

To determine how much water is in the fuel, Yellowstone fire monitoring staff weigh and oven dry fuel samples to determine the moisture content. In a normal fire season, 1,000-hour fuels within the park may average 14–20% fuel moisture. (Dead fuels are classified according to size, and how long they take to dry out when completely soaked; "1,000-hour fuel moisture" refers to the moisture in large fuels such as downed timber that would generally dry out within 42 days. Kiln-dried lumber is 12%.)

Fire behavior is generally not observed until 1,000-hour fuel moisture contents are less than 18%, and only minimal areas are burned until moisture levels drop to 12%. At that point, a fuel moisture threshold is crossed; lightning strikes in forested areas can quickly result in observable smoke and, if fuel and vegetation conditions are right, the fire spreads. Below 12% fuel moisture, younger and more varied forest types may burn, especially when influenced by high winds. During extreme drought years, 1,000-hour fuel moistures may drop as low as 5%.

Depending on the forest type, fuel moisture, weather, and topography, fires can grow in size by isolated or frequent torching and spotting (transport of burning material by wind and convection currents), or by spreading from tree crown to crown. Fires in Yellowstone's subalpine forests seldom spread significantly through ground fuels only. Like weather, terrain can be either an ally or adversary in suppressing unwanted wildfires. A few natural barriers such as the ridge from Electric Peak south to Mt. Holmes; Yellowstone Lake; and the Absaroka Mountains along the eastern boundary of the park are likely to prevent the spread of a low-to-moderate-intensity fire, but fire may cross these features by spotting, covering two to three miles.

Fire managers may be able to predict a fire's behavior when they know where the fire is burning (vegetation, topography) and the fuel moisture content. However, predicting fire is much more difficult during prolonged drought periods, such as was experienced in 1988, 2003, and 2016.

Ongoing research in Yellowstone is also showing that forests experiencing stand-replacing fires can affect fire behavior for up to 200 years. When a fire

Of the fires that occur in Yellowstone National Park, 76% are less than 0.25 acres and another 12% range from 0.25 to 9.9 acres. These smaller, less intense fires play a role in this ecosystem by helping to thin out smaller trees and brush, and boost the decay process that provides nutrients to the soil.

Some fires burn with higher intensity and rapid rates of spread. These large, fast-moving fires send plumes of smoke thousands of feet into the air and receive much of the public's attention. These large fires (>100 acres) only occur 8% of the time in the park.

encounters a previously burned forest, its intensity and rate of spread decrease, except under prolonged drought conditions. In some cases, the fire moves entirely around the burned area. Thus, fire managers have another tool for predicting fire behavior: they can compare maps of previous fires with a current fire's location to predict its intensity and spread.

Frequency and Severity of Fire

Fire return intervals since European American settlement have ranged from 20–60 years for Douglas-fir and meadows on the northern range to 300 years or more for lodgepole pine forests on the central plateau and subalpine whitebark pine stands. Douglas-fir typically burns frequently but with low intensity (e.g., ground fires). Lodgepole pine burns every few hundred years at high intensity (e.g., crown fire).

Until 1900, written records on fires in Yellowstone were sketchy, with generally only large fires reported. From 1900 through 1972, fire records became slightly more reliable, but only records from 1972 until present day are considered reliable and used for fire occurrence statistics. From 1972 through 2022, the park has averaged 24 fires per year, and 5,466 acres burned per year. These data exclude 1988 as it is such an outlier year for number of acres burned within the park. These yearly data range from five fires (2014) to 78 (2003) fires per year, and one acre burned (several years between 1972 and 2020) to 793,880 acres burned (1988) per year.

The largest fire in the park's written history prior to 1988 occurred when approximately 18,000 acres burned near Heart Lake in 1931. In 1989, fire ecologists William Romme and Don Despain suggested that without the fire suppression efforts that began in the 1880s, large fires might have occurred during the dry summers of 1949, 1953, 1960, or 1961. They believe that fire behavior in 1988, in terms of heat release, flame height, and rate of spread, was probably similar to the large fires that burned in Yellowstone in the early- to mid-1700s.

In 1988, 50 fires burned a mosaic covering just under 800,000 acres in Yellowstone as a result of extremely warm, dry, and windy weather. Some of the largest fires originated outside the park, and a total of about 1.4 million acres burned in the Greater Yellowstone Ecosystem.

Some of the areas that burned in 1988 have burned again during the drought conditions of subsequent years, although unique conditions are required for such areas to reburn. Rare, high wind events (greater than 20 mph), more than 80% ground cover of cured elk sedge (*Carex* spp.), or a continuous fuel bed of 1000-hour logs during very dry conditions, seem required for fires to again carry through areas burned in 1988. Understanding the conditions necessary for recently burned areas (less than 50 years old) to reburn, modeling for the type of fire behavior seen in these areas, and the regrowth of vegetation after a short return interval fire is a current area of interest for fire managers in Yellowstone.

Consequences of Fire

In the first years after a major fire, new vistas appear while the lush growth of new, young trees emerges from the burned ground. Today, decades after the 1988 fires, those young trees are renewed forests, once again filling in vistas. Some visitors still feel the Yellowstone they knew and loved is gone forever. But Yellowstone is not a museum—it is a functioning ecosystem in which fire plays a vital role.

Vegetation

Some of the vegetation in the Greater Yellowstone Ecosystem has adapted to fire and, in certain cases, is dependent on it. Some plant communities depend on the removal of the forest canopy to become established. They are the first to inhabit sites after a fire. Other plants growing on the forest floor are adapted to survive at a subsistence level for long periods of time until fires open the canopy. Fire creates a landscape more diverse in forest age, which reduces the probability of disease or fire spreading through large areas.

In 1988, fires burned a mosaic covering 1.4 million acres in the Greater Yellowstone Ecosystem as a result of extremely warm, dry, and windy weather.

One of the two types of cones produced by lodgepole pines, which make up nearly 80% of the park's forests, is serotinous. Serotinous cones will not release their seeds until the resin sealing them melts, requiring a temperature of at least 113°F (45°C). This adaptation helps ensure the seeds do not disperse until fire creates conditions that favor the establishment of lodgepole pine seedlings: diminished litter on the forest floor and plenty of sunlight through an open canopy.

Fire can limit trees in the meadows of Yellowstone. For example, Douglas-fir seeds require conditions that exist only in rare microhabitats in these meadows. If a seed reaches such a microhabitat during a favorable year, a seedling may develop. Once the tree is growing, it begins to influence the immediate environment. More tree habitat is created and a small forest island eventually appears. Periodic fire kills the small trees before they have a chance to become islands, thus maintaining the open meadow.

The thick bark on mature Douglas-fir trees resists damage from surface fires. Historically, in areas like the park's northern range, frequent surface fire kept most young trees from becoming part of the overstory. The widely scattered, large, fire-scarred trees in some of the dense Douglas-fir stands in the northern range are probably remnants of these communities.

Trees in Greater Yellowstone are adapted to fire. This serotinous cone from a lodgepole pine tree was opened by fire, allowing it to release its seeds.

Some soils respond quickly after fires, but other soil types may continue to support less vegetation.

Although Engelmann spruce and subalpine fir have thin bark, they grow in cool, moist habitats where conditions that enable fires to burn are infrequent. In 1988, 28% of the park's whitebark pine burned, though it grows in open, cold, high-altitude habitats that accumulate fuel very slowly and have only a short season between snowmelt and snowfall during which fires can ignite and carry. Caches of whitebark pine seeds collected by red squirrels and Clark's nutcrackers and the hardiness of whitebark pine seedlings on exposed sites give this tree an initial advantage in burned areas over conifers dependent on wind to disperse seeds. However, this slow-growing and long-lived tree is typically more than 60 years old before reaching full cone production, and young trees may die before reproducing if the interval between fires is too short or if faster-growing conifers outcompete them.

Tree seedlings sprout and grow at variable rates between the surviving trees and the fallen and standing snags. As root systems of standing dead trees decay and lose their grip on the soil, the trees fall—sometimes hundreds at once in the presence of a strong wind. However, many trees remain upright for more than a decade after dying by fire or other cause.

Fires may stimulate regeneration of certain species of shrubs and trees, but their growth is also affected by other influences such as climate and wildlife browsing. Aspen have thin bark, but the clones are connected by a network of underground roots that can survive even very hot surface and crown fires. Although the above-ground stems may be killed, fire stimulates the sprouting of suckers from the roots, and fire leaves bare mineral soil suitable for the establishment of aspen seedlings.

Soils in Yellowstone that support little vegetation

have been largely unaffected by fire. Soils that have dense, diverse vegetation before a fire are likely to respond quickly after the fire with a variety of species and nearly complete cover. Though above-ground parts of grasses and forbs are consumed by fire, the below-ground root systems typically remain unharmed, and for a few years after a fire these plants commonly increase in productivity because fire rapidly releases nutrients from wood and forest litter. The regrowth of plant communities begins as soon as moisture is available, which may be within days at some sites.

Wildlife

Wildfires do not significantly affect the abundance of most wildlife species in Yellowstone. Relatively few animals died as a direct result of the large fires in 1988, and most of those deaths were caused by smoke inhalation. Of Yellowstone's seven native ungulate species, only the moose experienced a population decline that appeared after 1988. Although moose population estimates are imprecise, it appears that with less willow and subalpine fir available for winter browse, and snow accumulating more deeply with many forest canopies gone, moose winter mortality increased in 1989.

Mortality in all ungulate species was unusually high in the winter after the fires, but it is difficult to know how much of that was the result of burned forage rather than drought, large herd sizes, and the relatively severe winter. Elk, bison, and deer populations soon rebounded.

Of the 38 grizzly bears wearing radio transmitters when the fires began, 21 had home ranges burned by one or more of the fires. Thirteen of those bears moved into burned areas after the fire front had passed, three adult females without young stayed within active burns as the fire progressed, three bears remained outside the fire perimeters, one adult female was not located for another two years, and another adult female was never located again at all. Large predators such as grizzly and black bears, cougars, and wolves simply move out of the way of a fire. Bears have been observed frequently grazing in burned areas after the vegetation has started to return due to the increase in vegetation in years following a fire. Even the fires in 1988 had no discernible impact on the number of grizzly bears in the Greater Yellowstone Ecosystem.

Rodents probably have the highest fire-related mortality of any mammals. Although many can escape fires in burrows, they can die of suffocation as fires come through. They also become more exposed to predators because they temporarily lose the cover of grasses and other plants. But, because of their capacity to have multiple litters with many young per year, rodents quickly repopulate burned areas.

Most birds are not directly harmed by fires, and some benefit. Raptors hunt rodents fleeing a fire, but young still in nests may die. Post-fire habitat changes help some birds. Cavity-nesting birds, such as Barrow's goldeneye, flickers, and bluebirds have many dead trees for their nests. Robins and flickers find ants and worms more easily. Boreal owls, however, may lose some of the mature forests they need.

Managing a Natural Process

The National Park Service may allow lightning-ignited fires to burn in Yellowstone provided they are not a threat to human life and property. The park is required to protect human life as well as the approximately 2% of Yellowstone's 2.2 million acres that are considered developed (e.g., roads, buildings, and other infrastructure), which includes almost 2,000 buildings, from the threat of fire while at the same time letting wildfire carry out its ecological role in the landscape as much as possible.

Yellowstone National Park operates under the 2009 Federal Wildland Fire Policy. These guidelines allow fire personnel to manage a lightning caused fire for multiple objectives. Fire personnel can suppress one side of a fire to protect buildings and people, while allowing another side to burn to achieve natural fire benefits.

The Antelope Fire of 2010 was an example of managing a fire for multiple objectives. It was

Wildlife continue to use burned areas after fires.

suppressed on its west flank to protect people using the roads and other values at risk. It was monitored, but not suppressed, as it moved south and east away from developed areas. A similar strategy was used in the 2009 Arnica Fire, which burned in 300-year-old lodgepole pine forests but threatened visitor travel, power lines, and Lake Village.

Working Across Boundaries

Wildfire is a great example of interagency cooperation and coordination. Federal agencies, state and local governments, and private contractors all play a role in managing fire in the park. For example, the NPS sometimes relies on Forest Service smoke jumpers to assist with the park's remote fires. In return, the National Park Service sends its helicopter or engine to the Silver Gate or Cooke City areas, which are located on or adjacent to the Custer Gallatin and Shoshone national forests. Programmable radios ensure communication between NPS and Forest Service dispatch, which improves firefighter safety. The NPS also works with its partners to develop Community Wildfire Protection Plans to help plan and prepare for a wildfire that may threaten homes.

History of Fire Management

Fire suppression in Yellowstone began with the arrival of the US Army, which was placed in charge of protecting the park in 1886. The Army, which was in Yellowstone until 1918, successfully extinguished some fires in the belief that suppression would help save the forests. However, it is difficult to determine how much effect a small group of men could have had on overall fire size or the extent of fires in a large park without motorized vehicles or good roads. Fire suppression was most successful on the northern range, which is relatively accessible from the park headquarters in Mammoth Hot Springs.

More effective fire suppression techniques and airplanes became available after World War II, but even then, fire suppression did not result in a significant increase in fuel loads except perhaps on the northern range. Records indicate fire was almost completely excluded (suppressed) from the Douglas-fir, sagebrush steppe, and aspen communities on the northern range from 1886 until 1987.

By the 1940s, ecologists recognized fire was a natural and unavoidable change agent in many ecosystems, including relatively arid portions of the Rocky Mountains. In the 1950s and 1960s, other parks and

Monitoring fire behavior and weather on the Maple Fire, 2016.

forests began to experiment with controlled burns. In 1972, Yellowstone became one of several national parks to initiate programs that allowed some lightning-caused fires to burn. Two backcountry areas in the park totaling 340,000 acres, Mirror Plateau and Two Ocean Plateau, were designated as locations where fires could burn.

After three years, during which 10 fires burned a total of 831 acres in the two fire zones, the non-suppression area was expanded to include most of the park, except for developed areas and a buffer zone on the park boundary. Starting with Yellowstone and Bridger Teton National Forest in 1976, cooperative agreements were adopted among all Greater Yellowstone federal lands that by 1986 allowed natural fires to burn across shared public land boundaries.

From 1972 to 1987, 235 fires were allowed to burn 33,759 acres in Yellowstone. The summers of 1982–1987 were wetter than average, which may have contributed to the relatively low fire activity during that period. Yellowstone's fire managers began revising the park's fire management plan. The new plan permitted some lightning-caused fires to burn under natural conditions; provided for suppressing fires that threatened human life, property, special natural features, and historic and cultural sites; and recommended prescribed burns when and where necessary and practical to reduce hazard fuels. It was in the final stages of approval in spring 1988.

However, Yellowstone's "new" fire management plan was suspended in July 1988 as a consequence of the large fires that occurred that summer. After

History of Fire Management in Yellowstone

The Issue
For the first 100 years of the park's existence, managers believed fires had to be extinguished to preserve park resources. Subsequent scientific research revealed

- fires have occurred in Yellowstone for as long as there has been vegetation to burn,
- fire plays a role in creating the vegetation patterns of the landscape,
- fire is a part of the ecosystem park managers want to preserve, and
- suppressing fires alters the natural landscape and diminishes diversity.

History

- 1886–1918: US Army suppresses fire in Yellowstone.
- 1940s: More effective fire suppression techniques become available after World War II. Around the same time, ecologists recognize fire is a natural and unavoidable change agent in many ecosystems.
- 1972: Yellowstone begins allowing some natural fires.
- 1972–1987: 235 natural, unsuppressed fires burned 33,759 acres—mostly in two dry years: 1979 and 1981.
- Spring 1988: Approval of a new fire management policy for Yellowstone is suspended.
- 1988: 793,880 acres burn in Yellowstone, sparking an increase in the public understanding and acceptance of the role of fire in wildland areas.
- 1989: A national policy review team reaffirms the importance of natural fire policies in national parks and wilderness areas.
- 1992: Yellowstone issues a new fire management plan incorporating the 1989 review team's recommendations.
- 2004: Yellowstone's fire management plan is revised.
- 2009: Yellowstone begins operating under the 2009 Federal Wildland Fire Policy, which allows the park to manage fires for multiple objectives.
- 2014: Yellowstone's fire management plan is revised.

these fires, a national policy review team examined the fire policy again and reaffirmed the importance of natural fire policies in national parks and wilderness areas. However, the report also offered recommendations: establish more specific criteria for conditions under which fires are permitted to burn, and increase efforts to reduce hazard fuels near developed areas. These recommendations were incorporated into Yellowstone's 1992 fire management plan. Other revisions occurred to the park's fire management plan in 2004 and 2014.

More Information

Barker, R. 2005. *Scorched Earth: How the fires of Yellowstone changed America*. Island Press/Washington.

Franke, M.A. 2000. Yellowstone in the afterglow: lessons from the fires. YCR-NR-2000-3. Mammoth, Wyo.: Yellowstone Center for Resources.

Greenlee, J., ed. The ecological implications of fire in Greater Yellowstone: proceedings of the second biennial conference on the Greater Yellowstone Ecosystem. Fairfield, Wash.: *International Association of Wildland Fire*.

Higuera, P.E. et. al. 2010. Linking tree-ring and sediment-charcoal records to reconstruct fire occurrence and area burned in subalpine forests of Yellowstone National Park, USA. The Holocene.

International Association of Wildland Fire: www.iawfonline.org

National Interagency Fire Center: www.nifc.gov

National Park Service Fire and Aviation Management: www.nps.gov/fire

Renkin, R.A. and D.G. Despain. 1992. Fuel moisture, forest type, and lightning-caused fire in Yellowstone National Park. *Canadian Journal of Forestry Research* 22(1):37–45.

Simard, M. et al. 2011. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? *Ecological Monographs* 81(1): 3–24.

Turner, M.G., et al. 2003. Surprises and Lessons from the 1988 Yellowstone Fires. *Frontiers in Ecology and the Environment*. 1(7):351–358.

Westerling, A.L. et al. 2011. Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. *Proceedings of the National Academy of Science*.

Yellowstone Science. 2009. 9th Biennial Scientific Conference: The '88 Fires: Yellowstone and Beyond. 17(2).

Staff Reviewers
Becky Smith, Fire Ecologist