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FIRE FUNDAMENTALS
A PRIMER ON WILDLAND FIRE FOR JOURNALISTS

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What follows is a very brief distillation of some of the concepts and historic events useful to understand why the American fire scene looks the way it does. The primer is organized into four parts, each of which can be read independently of the others. Each section is organized according to frequently asked questions.

1) Some basics of fire, fire behavior, fire ecology
2) Some basics of wildland fire management
3) Issues in the contemporary American scene
4) Further reading

(1) SOME BASICS OF FIRE, FIRE BEHAVIOR, FIRE ECOLOGY

What is fire?

Unlike the other ancient elements, fire is not a substance but a reaction in which oxygen, fuel, and heat (a spark to ignite) combine into a self-sustaining process.

Fire is a creation of the living world. Life created the oxygen and fuel it requires, and in the form of humans life provides the vast majority of ignitions. The chemistry of combustion is a biochemistry: When it occurs in cells, it's called respiration. When it happens in the wide world, it's called fire. As soon as plants colonized the land, they began to burn. The oldest charcoal is 420 million years old.

Because it is a reaction, fire synthesizes its surroundings: it takes its character from its context. A single fire burning through a landscape can assume many forms as it encounters different conditions of air, land, and vegetation.

The strategy of fire control is to prevent those parts from coming together or to retard them after a fire begins by cooling (water and dirt), interfering with the reaction (retardants), and removing fuel (firelines or fuelbreaks, or extensive burnouts).

What is fuel?

Fuels are the biomass of plants, living or dead. But while all fuel is biomass, not all biomass is fuel. Only a fraction of biomass is actually available to burn, or will burn in ways that contribute to a fire's spreading perimeter.

What determines availability? Simply put, it's the size and arrangement of particles, and their internal fuel moisture. Both heat and moisture exchanges occur on the surface, so particles that have large surface-to-volume ratios react the quickest - conifer needles, grasses, shrubs, small branches. As an old adage runs, the fine fuels drive the fire.

Note that even after intense fires through a forest canopy, the trunks of trees remain. This is why logging is not a surrogate for fire. Fire burns the small stuff and leaves the large, logging takes the large stuff and leaves the small.

Note, too, that the impact of tree mortality from insects or drought varies over time. When conifers are dying, their needles loose moisture and turn red; this is a time of high fuel loading and hazard. When those needles fall to the ground, which they don in a year or so, they also shed that hazard. There is plenty of dead biomass, but only a fraction is now available to burn or contribute to a flaming front. An insect plague is thus a rolling risk.

Fuel moisture affects the ability of a particle to combust since water absorbs heat. Fuel moisture content (FMC) is measured relative to dry weight. A particle that weighs 100 grams in an oven will weigh 120 grams if its FMC is 20%. Particles exchange moisture across their surface, not just by wetting (through rain) but by differentials in relative humidity. Just as paper curls and wood doors swell during high humidity, so do wildland fuels. A fire will slow or even go out with a rise in relative humidity.

Living fuels thus present a curiosity because, during the growing season, they are flush with moisture. Most can burn only during their dormant season, which is why they tend to burn in early spring, before greenup and summer rains, or in late fall, before snow falls. That they burn at all is due to the fact that they contain organic oils with high caloric content that amplifies the heat output of the fire, enough to overcome the high moisture content.

Fuel moisture changes over time, and this accounts for the daily cycle and seasonality of burning. Drought upsets this normal rhythm by reducing FMC across all categories of fuel.

H*ow are fuels, and their associated fires, classified?*

Generally, there are three categories of fuels according to where they reside in a landscape.

Ground fuels consist of organic soils, sometimes shallow, sometimes deep as in peat or drained swamps. With tiny particles massed together, ground fires burn slowly but stubbornly, and usually end only when they have run out of fuel or are drowned.

Surface fuels consist of small shrubs, grasses and forbs(herbs), and litter like pine needles, leaves, and windfall that lie on the surface.

Crown fuels are particles that reside in the canopies. Crown fires are fires that burn through those canopies. Shrublands like chaparral are sometimes modeled for estimating fire behavior as surface fuels and sometimes as crown fuels.

Where fuels (such as young trees or shrubs) grow between the surface and canopy, they are often called *ladder* fuels because they can help carry fire from the surface to the crown.

Fuel particles are classified by how long it takes them to respond to changes in ambient moisture. As with burning, the small stuff reacts most quickly and matters most.

What are fuel treatments?

Fuel treatments try to modify the fuel array so that fires behave differently. Wildfires burn with less ferocity, which makes their control easier, and prescribed fires (controlled burns) are more likely to behave as we wish.

Treatments may intend to reduce fuel load overall, or to rearrange those fuels in more favorable ways. In some cases this means *thinning*, a kind of woody weeding to reduce surface and ladder fuels. In other cases it may mean woodchipping or masticating (crushing and chewing up). In the case of invasive grasses it may involve attempts to replace the problem grass altogether.

Treatments can be mechanical, chemical, or biological. Mechanical treatments include chainsaws, woodchippers, and masticators. Chemical treatments involve defoliants (which puts leaves on the ground rather than in the crowns) and alters their fuel moisture content. Biological treatments might include sheep, cattle, or goats where grass and shrubs are the primary concern, although it is tricky to get grazers and fuels in sync. Overgrazing in the 19th century helped remove fire over large landscapes, which led to a shift from grasses to shrubs and woods.

What causes fires?

Almost all natural fires start from lighting. There are a few exotic sources - spontaneous combustion, meteorites, volcanoes – but lightning accounts for the geological antiquity of fire. If people disappeared, fire would still flourish on Earth

The number of lightning bolts is not an index for ignitions. A map of lightning strikes is not a map of fires; only in central Florida do the two overlay neatly. What counts most is dry lightning, in which any precipitation is light, or evaporates before it hits the ground, or is separated from bolts.

Humans, however, changed the fundamentals, eventually holding a species monopoly over fire. They account for the vast majority of fires, roughly 90% for the U.S. overall. Again, more people do not mean more fires. In modern cities and residences there is little reliance on open flame (almost all those tasks are done with fossil fuels or electricity) and the built environment is constructed out of materials and in arrangements that retard burning. But where people intermingle in rural and wildland settings fires occur abundantly, and can overwhelm lightning fire. In traditional societies that use fire on the landscape the pattern is to burn often and lightly – pre-emptively - before the lightning season begins, thus preventing lightning from kindling wildfires in places people want protected. In this way human fires define the system.

In the American West most wildfires occur on public lands in which people do not reside permanently and in which human fire use is regulated. Lightning fire reasserts itself and because the land is 'wild' such fires account for most of both ignitions and acres burned. Today many land managers seek to reinstate humanity's fires through prescribed burning.

The primary causes of human fires in the past were escape fires from traditional rural burning; today, they result from carelessness, accidents, and arson, and indirectly from machinery and powerlines. In recent decades powerlines have become a prominent source of damaging fires because they cast sparks under high winds, exactly the condition needed for fast-spreading, high-intensity fires, and they often concentrate around settlements.

How does fire behave?

Fire burns in a zone of combustion. That zone changes its shape and dynamics as it moves through a landscape. In wildland settings, it typically takes the form of a burning perimeter, or flaming front. Behind the front, residual burning continues, but in a slower, disorganized way.

The principle factors that affect the shape of the flaming front are traditionally grouped into weather, terrain, and fuel. *Weather* includes all the features of the air mass that affect fire - wind, stability, relative humidity. *Terrain* (or topography) includes such features as slope (fires generally accelerate up slope), and characteristics that affect wind. *Fuel* is all the living and dead combustibles available for burning.

Historically fire research concentrated on the surface properties of fire spread and its interaction with horizontal winds. Over the recent past, however, it has begun incorporating a third dimension - how fire interacts vertically with the air mass around it, including firewhirls, plume (convective column) dynamics, spotting (the transport of embers long distances), and pyrocumulus cloud formation over intense fires. These are complicated phenomena, not easily modeled but more and more often recognized as relevant and make control of perimeters harder.

How all these factors interact can be complex, but if you know the wind and the place and time of ignition, you can forecast most (80-90%?) of the fire's spread.

What is fire ecology?

What we call fuels are (or were) actually plants, so they are subject to evolutionary selection and ecological processes. In other words, because they are organisms, they can adapt to fire and even encourage it, and their arrangement on landscapes reflects their interaction with other flora and fauna around them. Fire ecology is the study of these interactions.

Fire recycles nutrients, species, and landscapes. Particularly in arid (and semi-arid) landscapes, it is a primary means of decomposition. Without fire such ecosystems degrade (and pile up fuels, which is also to say, nutrients). In a sense, fire is 'creative destruction' in nature's economy.

Fire is not simply something that happens to a biota: it is something made possible by that biota. It's easy to imagine fire as a physical, mechanical process like a windstorm or a woodchipper. Because it feeds off the landscape, it's more accurate to liken it to a locust infestation. Ice storms and hurricanes can exist without anything living; fire cannot. Likewise, organisms can come to expect and even need fire as part of their adaptation. The absence of fire in places that have long known it can be as disruptive as the introduction of fire to places that haven't.

The many interactions can become complicated, but the essence is that landscape fire is more than heat and hydrocarbons. When a wildland fire is blowing and going, or a fire is burning in a built environment like a city, it makes sense to consider fire as simply a physical process that can be met by physical countermeasures. Managing fire, however, requires that we consider the full ecological setting.

What is a fire regime?

Over time and space fires show patterns, called a fire's regime. It's a statistical concept, like climate. Phoenix and Akron can experience similar thunderstorms but the way temperature and rainfall appear over the years gives them very different climates. Similarly places can experience comparable fires but the arrangement, frequency, seasonality, and so on can give them different fire regimes.

In fact, climate provides one of the fundamental properties of a regime, the rhythm of wetting and drying. A place has to be wet enough to grow fuels and dry enough to burn them. Deserts experience fires after heavy rains, forests after droughts.

So it is with fire. Some places experience fires that remain on the surface, some in the crowns, some in mixtures of burning. Some landscapes have many small fires, others a few large ones. The average arrangement is its regime. Species adapt not to fire as such but to its regime. In many places fire's regime has shifted, and this is birthing fires different from those to which the biota has adapted.

The LANDFIRE program has attempted to map how far from historical patterns American landscapes have moved. Remediation efforts try to nudge them back to their former regimes. The project is complicated, however, by climate change, so there is uncertainty about what regimes should be.

Sources: https://www.landfire.gov/

How does fire compare to other natural disturbances and disasters?

Fire differs from hurricanes, tornadoes, floods, earthquakes, and the like because it requires a matrix created by life. Those other disturbances can occur without a particle of life present; fire cannot. It literally feeds off of suitable biomass. That makes it more complicated, because there are profound evolutionary and ecological feedbacks possible, but also accessible to treatments because it provides a point of intervention not possible with other natural risks.

(2) SOME BASICS OF WILDLAND FIRE MANAGEMENT

What are the fundamental strategies for managing fire on a landscape?

There are basically four strategies possible:

1) *Leave it to nature* (or as much to nature as possible). This is the ideal for wilderness areas, many national parks, and places with a large, and largely uninhabited, backcountry. Combined with monitoring, it is standard practice in Alaska outside urban zones.

2) *Substitute tame fire for wild fire.* Accept that fire will happen and often needs to happen, and replace wild fire with controlled (or prescribed) fires. This is how humans have traditionally lived in fire-prone landscapes. Florida remains the paragon in the U.S., burning about 2.5 million acres a year (they would like to burn twice that). The practice is also fundamental in prairie landscapes.

It has not, however, worked widely in the American West. For many reasons, it is just not happening at scale. In public lands fire officers seem to be moving more toward a "managed wildfire" system, a hybrid of suppression and prescribed burning.

3) *Change the fire environment.* Basically this means rearranging the fuels so that we can control wildfires more easily and set prescribed fires more readily and with better safety. In many parts of the world - for example Europe - close cultivation, including grazing, is the primary way to contain the threat of wildfire.

4*) Exclude fire.* Remove fire by not burning and by suppressing fires that do occur. This is a common approach that treats wildlands like cities.

It can work in landscapes that are not naturally fire-prone, that is, in places where fire only exists because people put it there. It has been tried in places where fire thrives naturally (or in fire-sustained cultural landscapes, and in such settings it fails. It may take a few years or a few decades but the ecosystem will deteriorate and the fuels will increase and the paradoxical outcome is a worsening of the fire threat.

How are fires fought?

The time-honored techniques are divided between direct and indirect attacks. *Direct* suppression means working the flaming front as closely as possible. Since the majority of fires are small and slow, it is possible to 'go direct' on most responses. An *indirect* attack occurs when fires are too intense or are burning too rapidly. In this case, fire officers will determine a defensible line ahead of the fire that they can build and then burn out the intervening fuels. A 'black line' is considered the most secure. A fire may be divided between burned and unburned, or 'the black' and 'the green.'

When multiple fires occur in close proximity and can't be attacked directly, they may be corralled into a single 'complex'. The entire complex will be handled through indirect attack.

How did American fire policy evolve?

Colonization created many large, damaging fires because it felled forests and left massive slash on the land, distributed fire widely on the land, and erected cities out of wood. Those conflagrations - far worse than contemporary fires - inspired the state to intervene. State-sponsored conservation targeted 'fire and axe' as the twin terrors. The Great Fires of 1910 traumatized the young U.S. Forest Service (USFS) into aggressive action.

For 50 years the U.S. tried to remove fire from the land as fully as possible. The USFS provided a matrix that, with the 1911 Weeks Act, joined federal agencies and the feds to the states. The approach hardened in 1935 with the adoption of a 10 am policy that established a universal mandate to control every fire by 10 am the following day.

The unhappy consequences – good fires were taken out as well as bad fires - were apparent by the 1960s. In 1968 the National Park Service revised its policy to encourage the restoration of fire by deliberate (prescribed) burning and by granting natural fires some room to roam. The U.S. Forest Service followed in 1978. The fire revolution has had mixed results. The Southeast made the transition, most of the West has not. At the same time, governance has moved from the USFS to interagency collaboration and intergovernmental alliances.

Now we seem to be in another transition. Fire's restoration in the West is coming by means of wildfire, and there are efforts to manage wildfire to lessen the damages to human life and property while also encouraging some good fire. A single fire may have many different responses along its perimeter. Similarly, the number of participating players has expanded, which has left governance unclear. Who has responsibility? Who pays?

Who oversees fire?

America has no fire czar. Each federal agency has its own fire program to meet its particular mission. Coordination occurs through several institutions. The National Interagency Fire Center (Boise, Idaho) coordinates suppression resources across the country. The National Wildfire Coordinating Group ensures common standards in equipment and practice. The National Association of State Foresters brings a collective presence for the states. The national Coalition of Prescribed Fire Councils promotes prescribed burning. And so on.

From early on fire agencies sought allies and signed cooperative (and mutual aid) agreements that allow personnel and equipment to move between them. Fire management increasingly involves ever greater numbers of actors, not only federal agencies (including DoD and FEMA) but non-governmental organizations like the National Fire Protection Association and the Nature Conservancy (which burns as much each year as the National Park Service). The proliferation of fires along the frontiers of urban sprawl means that states, counties, cities, and volunteer fire departments have also become part of the national fire infrastructure.

The 2009 FLAME Act mandated that the federal agencies devise a National Cohesive Strategy for Wildland Fire to help bring all these pieces together. It adopted a three-part goal: to create fire-adapted communities, to promote fire-resilient landscapes, and to improve capacity to manage fire in all its forms. The NCS has no funding or political charge, but it has put together regional organizations for the South, North, and West. One state, Utah, has effectively enacted its principles into law.

Clearly, this is a political issue that needs clarification over roles, rights, and responsibilities - and of course who pays for what. The states and federal agencies have different legal charges, which can make coordination difficult. The country could use a fire constitution.

Sources: https://www.forestsandrangelands.gov/leadership/; National Interagency Fire Center [https://www.nifc.gov/index.html]; National Association of State Foresters (fire links) [https://www.stateforesters.org/our_partners/fire_links]; NIFC [https://www.nifc.gov/index.html]

How are large fires managed?

For management purposes fires are distinguished by a hierarchy of complexity, ranked from the simplest (Type 6) to the most complicated (Type 1). Large fires in remote sites may be managed at a low level, small fires near towns or valued assets may require a high level.

Fires are organized according to the incident command system (ICS), an emergency response protocol first devised for wildland fires and now embedded in FEMA for all incidents. To cope with higher-level events, management (or overhead) organizes and trains as incident management teams (IMT) that include planning, fireline operations, logistics, financing, safety, public information, and so on. The ICS is elastic enough to incorporate local services such police and sheriff departments, emergency medicine, and various officials. Complex incidents will be overseen by a 'unified command' of the critical actors, with representatives of all involved jurisdictions.

Type II teams are considered primarily regional resources. Type I teams are available for national assignment. Fire teams have been mobilized for the 9/11 Twin Towers crisis, hurricanes, even the crash of the space shuttle *Columbia*.

Sources: https://www.fema.gov/national-incident-management-system

(3) ISSUES IN THE CONTEMPORARY AMERICAN SCENE

What is America's fire problem?

The country does not have a fire problem. It has many fire problems that can best be understood according to local conditions. Some of the issues are technical - we know how to keep houses from burning. Some are cultural - what is the best way to manage fire in national parks and wilderness? All are political. The U.S. has an estimated billion burnable acres.

Basically, we have too much bad fire, too little good fire, and too much combustion overall. Too many fires are slamming into towns and threaten assets like municipal watersheds. Too few fires are nudging out-of-whack ecosystems in ways that will also calm wildfires. And we are combusting too much fossil fuel, which shrinks our arena for managing landscape fire by altering the climate, competing for airsheds, and arranging how we live on the land.

What is the driver for the worsening fire scene?

The causes are many, and they integrate in various ways. Climate change, fuels, urban sprawl, invasive species, ignitions, and institutional arrangements - all are contributing. In a commentary I put it this way:

The American fire scene is the outcome of people and nature interacting; neither is in control. Fire is a driverless car, integrating everything around it, responding variously as different features loom larger. Sometimes it must respond to road hazards called fuel left by previous wrecks; sometimes to a tricky intersection called the wildland urban interface; sometimes to a dangerous curve called climate change; sometimes to a distracted driver called carelessness, swerving onto the shoulder and throwing sparks; sometimes to a reckless driver called politics, or to that crisis blizzard in which everything seems to happen at once and obscures the field of vision.

If you want to reduce it all to a single cause, invoke the Anthropocene. It's a world powered by fossil fuels that is increasingly expressing itself in feral flames.

What is the wildland-urban interface?

The WUI is the geeky name given to that increasingly fiery border where urban sprawl meets a wild or feral landscape. In most of the country it more resembles an intermix than an interface. In a sense, the wave of fires sparked by agricultural settlement in the 19th century is being repeated by a wave of urban settlement into formerly rural lands.

The issue was first identified and named by the wildland fire community. But rather than wildlands with houses mixed in, the WUI might better be imagined as bits of cities with peculiar landscaping. Defined as urban enclaves the solutions are obvious: treat these places as we do cities with the same codes, zoning, standards, and so on. There is a substantial body of research to suggest that the best way to protect towns is to harden the houses. Most initial structures burn from embers, and then if enough structures are involved, the fire spreads from building to building.

The problem first arose in Southern California, but it has leaped across the West, and in recent years has moved eastward. Fires have burned outside Austin, Texas and through Gatlinburg, Tennessee. The prevailing narrative has been one in which dumb westerners are building houses where the fires are. If climate change models are correct, we may be seeing the fires moving to where the houses are. The region most at risk would then be the southeast.

It's worth noting that the WUI is not restricted to the U.S. It affects all industrial (or industrializing) countries. Comparable fires have afflicted Australia, Canada, Russia, South Africa (Cape Town), Greece, Portugal, southern France, and others. Again, climate change and land use promise to bring fire to places that have mostly been spared it in recent times.

Sources: Firewise (USFS) [https://www.fs.fed.us/fs-tags/fire-wise]; Firewise (NFPA) [https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA]

What is the impact of climate change?

The fire community recognized in the 1960s that the country had a fire problem that required serious action and completed institutional and policy reforms by 1978. Climate change has acted on those pre-existing conditions and generally amplified them.

The western fire scene inflected into something like a new normal in the mid-1980s. The best known expressions are the 1987 'fire siege' in Northern California and the 1988 Yellowstone National Park fires. The West undergoes periodic bouts of drought, but this one seems to have a climate-change signature to it. It’s worth noting that global warming is also a product of human combustion practices. Climate history is becoming a subset of fire history.

Climate change is accentuating trends toward more bad fire. - call it a performance enhan cer. The principle effects seem to be a reduction in winter and spring precipitation, which has lengthened the fire season and made more fuels available, and hot dry spells, which drops relative humidity. More frequent and wilder swings of wetting and drying promote more intense burning. (In principle such changes could also widen the windows for prescribed fire as well.)

Moreover, there are lots of knock-on effects, including beetle infestations, drought-killed trees, and so on, and the prospects that future weather may exhibit more dry lightning and high winds. What will reclaim burned sites is unclear. Eventually a new fire regime will establish itself.

Because fire integrates so many variables, burned area is not as good an index as most observers would like. At the same time, because fire synthesizes so many factors, it is possible to mitigate its behavior without having to solve global climate change. There are many points of intervention possible.

There are also arguments for the reverse effect, a feedback loop. By burning landscapes out of sync with historic regimes, wildfires are releasing more greenhouse gases, which then aggravate global warming. Conversely practices using good fire can store carbon by keeping fires on the surface and allowing carbon to stockpile in living trees.

The current explosions cannot continue indefinitely. A new regime will establish itself that differs from its predecessor. The most explosive cases will involve areas that have plenty of fuel but because of more frequent droughts or secular drying burn intensely. They will regrow with less fuel and so burn less savagely. As nature adapts to the new conditions, so will fire.

Sources: https://www.firescience.gov/Digest/FSdigest1.pdf

Wouldn't more money and resources allow us to control these fires?

They would certainly help, but only if they go to where they can matter most.

The critical financing need is to end the 'fire borrowing' that the Forest Service has had to engage in and that now lets fire suppression absorb over half its total budget. This is money that is not going to fire prevention, fuels mitigation, recreation, research, anything and everything else the agency does. Only in late 2018 did Congress begin to remedy this circumstance.

Beyond that it is not clear that throwing more dollars, people, engines, and aircraft at fires will stop all bad fires. To be effective we would have to create the fire equivalent of a police state. Some fires will inevitably escape - under the worst conditions - and these will burn the lands previously protected, and probably burn them more ferociously. Moreover, the more we exclude fire the worse the fundamental conditions become. As fire crews like to say, we're not putting fires out, we're putting them off. Urban and wildland fires are essentially different, as distinct as hydrants and drip torches. What works in one setting doesn't work in the other.

Aerial firefighting is most effective at the very start of fires. Once fires are big, large airtankers make good TV but lose their effectiveness. Some political theater is how the world works, but we should understand that we are not going to bomb fires away.

More sensible would be to continue programs that put equipment, training, and assistance in the hands of local fire departments, often volunteer, who have become the front line in the wildland-urban interface, and to help communities harden themselves against fire.

Also, since the 1980s larger portions of wildland fire operations have been privatized, from catering to aircraft to even hand crews and engines. This has created a lobby for suppression, the National Wildfire Suppression Association - what critics have termed the fire-industrial complex. More money might well go to more suppression rather to than prevention and remediation.

Are firefighter fatalities increasing?

Yes, and no, mostly no. Records are incomplete except for the USFS and for more recent decades. The greatest single loss of life occurred during the 1910 Big Blowup in the Northern Rockies (78 firefighters). A series of multiple-fatality fires broke out during the 1930s and rolled over into the mid-1960s. The modern era began with loss of 14 firefighters on the 1994 South Canyon fire, and the 19 lost on the 2013 Yarnell Hill fire. Formal inquiries follow every fatality, and there are also legal liabilities possible for mismanagement (incident commanders have been charged criminally). Even OSHA has become involved.

The majority of fatalities do not happen as a result of burnovers, but from vehicle and aircraft accidents, medical crises (like heart attacks), and falling trees. Many of the fatalities recorded recently involve volunteer fire departments; whether this departs from historic levels is unclear since there has been no national depository for records.

Formal training to reduce fatalities began in 1957 with the 10 Standard Firefighting Orders, amplified by the 18 Situations That Shout Watch Out in the 1970s. A concern with reducing firefighter risk is a major consideration in contemporary fire tactics, and a reason why fire officers are willing to fall back and burn out in rugged terrain or amid dangerous fire behavior.

Sources: https://www.nifc.gov/safety/safety_HistFatality_report.html

Why don't we see more prescribed fire?

Actually a lot of prescribed burning goes on under the rubric of agricultural fire, a quantity captured on satellite maps but only partially entered into formal ledgers. The best source is the national Coalition of Prescribed Fire Councils, which issues reports that tally the acres on a state-by-state basis. The most recent survey identifies a 12% reduction nationally, although most of this represents part of the pyric transition, in this case a loss of traditional agricultural burning.

The Southeast dominates the national prescribed (Rx) fire numbers, with Florida alone burning approximately 2.5 million acres a year. The Great Plains, too, has a lot of burning for prairie management and agricultural matters (eg, reducing eastern red cedar infestations). The West has struggled, for many reasons, not least issues of public health and smoke. California's Central Valley has some of the worst air quality in the country, which makes burning off millions of acres in the mountains a tricky proposition.

Prescribed fire also has burdens of liability if something goes wrong. (In response, Florida and other southeastern states have rewritten liability laws to promote prescribed fire.) Doing something on federal lands can make every action a federal case. And there are agency cultures that have grown up with suppression and often find it hard to redirect.

Instead, in the West, fire officers seem to be using, working with, wildfires - suppressing them where necessary, assisting them to burn out to suitable barriers elsewhere (a 'box-and burn' strategy). It's a hybrid practice, half fire fighting and half fire lighting. It's likely that this variety of burning will serve much of the West as prescribed fire does the Southeast.

Sources: http://www.prescribedfire.net/

How good are fire statistics?

Not very. We don't have good data, especially historical data, on prescribed and agricultural fire. Even wildfire statistics are skewed by agency interest. Alaska burns, on average, a million acres a year, but was not reported until the 1960s; in the 2015 season, with a 'record' 10 million acres burned nationally, Alaska contributed over half that total. The record from states has been hit-and-miss. The National Interagency Fire Center has had to post caveats that statistics prior to 1983 are unreliable. In some categories that warning could be expanded.

The historic trajectory shows a slow wave of burning, with frequent eruptions of large fires, moving west with settlement. The first identifiable megafire came in 1825(Maine, New Brunswick); the worst, a series of conflagrations fed by logging slash from 1871 to 1918 (mostly in the Lake States), and then tapering off to a wave of big burns in the early 1930s - forestry's answer to the Dust Bowl. The 1903 fire complex in the Adirondacks burned 600,000 acres. The 1910 Big Blowup in the Northern Rockies racked up 3.25 million acres. The scene calmed from the 1950s to the mid-1980s. The NIFC statistics begin as the contemporary era starts to ratchet upward again.

Besides, burned area is a troubled statistic. It just integrates too many factors to be diagnostic of any one. Moreover, there is a good case that we don't have enough acres burned. We need more burning by good fire - a lot more - while pushing for less by bad fire. Our statistics aren't capturing that fact.

Who does research on fire?

As with so much of fire, the U.S. Forest Service was the responsible agency for most of the 20th century. It inaugurated formal research in 1916 at its experiment stations and supported studies through forestry departments at universities, but not until the post-World War II era did fire science really escalate and leave the confines of forestry. Military and civil defense funding helped. The USFS established three dedicated fire labs - at Macon, Georgia, Missoula, Montana, and Riverside, California. Just as other agencies created separate fire programs to support their particular missions during the fire revolution, so they sponsored research. During the 1980s Forest Service fire research experienced a funding crisis that led to the eventual closing of the Macon lab.

In 1998 Congress funded a Joint Fire Science Program that added to the pool of funds and was available to all interested parties. Since then fire research has enjoyed a renaissance and has bonded with many disciplines - not only fire researchers looking out to other disciplines, but other disciplines looking to incorporate fire. With JFSP support a fire science exchange network has emerged with 15 regional bodies. The program has produced a growing roster of topical surveys on all aspects of fire – a veritable library of written tutorials.

The issue, however, is not the amount of science, but the fact that the fundamental questions are not scientific. They concern how we choose to live on the land, with what tradeoffs and risks, how we manage public lands and assets - they are cultural concerns that properly belong with politics. The failure to manage fire does not signify a failure of science, but of social discourse, as mediated by politics.

Sources: Joint Fire Science Program [https://www.firescience.gov/index.cfm]

(4) FURTHER READING

Some books (weighted toward my own)

Stephen Pyne, *Fire: A Brief History* (2001)

_______, *Fire in America. A Cultural History of Wildland and Rural Fire* (1982)

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Andrew Scott et al, *Fire on Earth: An Introduction* (2014)
Stephen Arno and Carl Fiedler, *Mimicking Nature's Fire. Restoring Fire-Prone Forests in the West* (2005)
David Carle, *Burning Questions. America's Fight with Nature's Fire* (2002)
Peter Hoffer, *Seven Fires. The Urban Infernos that Reshaped America* (2006)