Arizona Fires

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Disclaimer: Study of fire behavior and control has become a highly developed science in the past several decades. The author makes no claims to be an expert in this field, but only offers general points on this subject based on personal experience and study of the ecology of vegetation and soils in Arizona.

Introduction

This summer, Arizona is again experiencing some very large and potentially dangerous wildfires – one has already joined the list of the 10 largest in Arizona's recorded history. These fires can be very destructive and sometimes cause great loss of property and even lives. But fire can also have beneficial effects on vegetation, wildlife habitat, livestock forage, and watersheds. Aldo Leopold, in his 1933 book on "game management," recognized fire as one of the agents that destroyed wildlife habitat but also could be used as tool to restore it (the others were the plow, the cow, and the axe). So, what are some of the pros and cons of fire, both wildfire and prescribed fire?

Some Fire Basics

The effects of fire on vegetation and soils depend on many interacting factors which determine the intensity of the fire, its duration, and its frequency, as well as the type of vegetation and the weather conditions that occur following the fire.

Fire severity depends on the amount of fuel available to burn – the more fuel, the higher the intensity. It is also affected by the size classes of the fuel (leaves, twigs, trunks, etc.) and the moisture content which affects the tendency to burn and the rate of burning. Moisture is obviously higher in living plants, but even dead material varies a lot in moisture content due to weather and its position on or above the ground. Presence of oils in the foliage also can cause plants to be more inflammable and burn hotter (e.g., in juniper, pine, eucalyptus).

Weather is also a major factor determining the ease of ignition, burning conditions, and spread of fires. High temperatures, low humidity, and high winds all raise fire danger and severity. Topography also plays a role. Broken topography with many changes in slope (fires tend to spread faster upslope than downslope), rock outcrops, deep arroyos, running streams, etc. can all hamper the spread of fires under most conditions, so fires typically burn best in gentle to rolling topography. (Although this may not be true under extreme conditions of weather or fuel where embers and long flames carry fires across canyons and steep ridges.)

Head fires (those that move with the wind) are faster moving than backing fires (those that move against the wind). Thus, the intensity of head fires may be great, but the length of time exposed to fire is usually less than with backing fires.

All fires reduce the amount of vegetation and litter that protect the soil from erosion by water or wind – some completely remove this protection. Therefore, until cover is restored, the soil is vulnerable to increased erosion. This increased susceptibility to erosion may last only a short time or it may last for years depending on the fire intensity, vegetation type, soil type, slope, and intensity of rainfall or wind events following the fire.

Low intensity fires may have little effect on the soil or the ability of vegetation to regrow or reestablish from seed stored in the soil. High intensity fires may destroy the organic material in the soil and the bacteria, fungi, earthworms, insects, and other organisms that have vital functions in making the soil productive for plant growth. In addition, nitrogen and some other nutrients can be lost by volatilization during the fire or by erosion afterward. In these situations, it may require many years to regain a stable and productive soil.

Surface Fires vs Crown Fires

Forest and rangeland fires are of two general types – surface fires or crown fires. Surface fires burn grass, forbs, and smaller shrubs in grasslands and in the understory of woodlands and forests. If trees are present, the fire does not reach into the canopy of the trees, although they may be scorched or even top-killed. Crown fires are those that spread from one large shrub or tree to the next through the crowns of the trees where the canopy cover is dense enough to allow it, and weather conditions, especially wind, are favorable. Surface fires may become crown fires where "ladder fuels" (e.g., larger shrubs or dead trees) allow the fire to spread upward and ignite the tree canopies. Crown fires in forests and woodlands often result in "stand replacing" fires, i.e., those that totally destroy the overstory shrubs or trees so that a completely different vegetation type results, at least until the woodland or forest can regenerate.

Plant Response to Fire

Different kinds of plants have different responses to fire, just as they do to drought, grazing, cutting, or other factors. Annuals (plants that only live one year then come back from seed next year) are easily killed by fire. However, unless the fire is so intense that it kills all the seed on or below the soil surface, these plants generally come back with the first rains.

Perennial grasses and forbs (herbaceous plants other than grasses) usually are not killed by light intensity fires typical of grasslands. The tops will be removed but the buds at or below the soil surface will generally allow the plant to regrow. If the fire is sufficiently intense these buds may be killed, and regeneration has to come from seed. Grasses with an abundance of old growth (thatch) may experience greater temperatures and thus be more apt to be killed by fire. Some grasses are not very fire resistant and may be fairly easily killed by fire, but have the ability to reestablish from seed, i.e., they produce a lot of viable seed which reestablishes easily. Lehmann's lovegrass is not fire resistant but comes back after fire from seed, much like annuals. Some native grasses react similarly, e.g., dropseeds, three awns. Native grasses which reproduce mainly vegetatively, such as black grama, blue grama, and tobosa, may require a long time to reestablish if killed by fire. In general, fires will tend to favor annual and perennial grasses and some forbs over shrubs or trees

Woody plants (shrubs and trees) also respond to fire in several different ways. Some are easily killed by fire, e.g., one seed juniper, Utah juniper, big sagebrush. Many may be top-killed by fire, but re-sprout readily from buds near or below the soil surface, e.g., mesquite, alligator juniper, live oaks, some chaparral species. Some trees have thick bark that protects them from damage by ground fires, but they may be killed by crown fires, e.g., Douglas-fir, ponderosa pine. Any plant will be completely killed if the fire is sufficiently intense. For example, creosote bush is usually not considered to be vulnerable to fire. But this is probably because it usually does not grow where there is sufficient fuel to support a fire of sufficient intensity to kill it – if there is enough fuel, it is not very resistant to fire.

Cactus, and some other succulents, are usually not well-adapted to fire. Since they are full of moisture, they do not burn well, but the heat will usually kill them. For example, recent fires have killed many of the saguaros that occur in the deserts near Tucson and Phoenix.

It is often stated that fires benefit the growth of plants by the fertilizing effect of the ash. Ash is the unburnable portion of plants, which include plant nutrients formerly stored in live or dead plant tissue. These nutrients are deposited on the soil surface and can be carried into the soil by water where they become available for uptake by plants. Thus, the fire does have the effect of making some nutrients available in larger amounts than they would have been otherwise, so there may be a "fertilizing" effect – nutrients are not added but may be made more available. On the other hand, nutrients can be lost due to fire either by volatilization or by erosion of ash and topsoil after the fire. Grasslands that have been burned often appear to be invigorated by the fire because when regrowth occurs it is obvious and not obscured by old dead plant material. In some cases, the removal of old dead thatch can stimulate growth of grasses, and the forage quality of the grasses is improved since it is all new growth. However, in general, the beneficial effect of fires in grassland is due to control of competing vegetation, not to stimulation of grass growth, which is why range managers generally recommend a period of grazing rest after fires. The situation is somewhat different with browse shrubs. When browse stands reach high density and size, the plant growth may be limited by competition for moisture or sunlight, current leaf and twig growth may decline, and it may grow out of reach of browsing animals. Burning can remove a lot of the old growth and result in regrowth of younger shoots which improve access and nutrient content of the browse, i.e., the value for browsing animals is improved.

Fire History in Arizona and Its Effects

There have been many changes in the vegetation type of Arizona since the area was settled by Europeans, particularly since the late 1800s. These changes have been documented based on journals of explorers, records and observations by resource professionals (e.g., Forest Service), repeat photography comparing present vs previous vegetation (e.g.,Turner, et al 2003;, Humphrey 1987; Webb, et al. 2007), tree ring studies, and studies of pack rat middens, archaeological sites, etc. Various theories have been put forward to explain these changes, including overgrazing, arroyo cutting, wood harvesting, extreme drought, climate change, changes in native animals, and fire, or lack of it. It is generally agreed that most vegetation types in Arizona, and in fact across much of the United States, were affected by fire to some extent. Some vegetation types are considered to be fire dependent; that is, they would not persist without periodic fire (e.g., aspen, some grasslands). Others are affected by fire at varying intensities and frequencies and take on a different character if that regime is changed. In general, there is considerable agreement that many of the changes we have seen in vegetation in Arizona over the past 150 years are consistent with a change in fire regime from that experienced prior to European settlement of the West. In most places there has been increased shrub and tree cover with a corresponding decrease in herbaceous understory – changes that are consistent with the response of these plant types to fire. The risk of fire and the severity of fire have been affected by many factors, including livestock grazing, wood harvesting, drought, wet years, invasive species, and by human intervention. The changes and the causes have differed somewhat in different vegetation types, so it is worth looking at several in more detail.

(Note: There are also suggestions that increased CO_2 in the atmosphere, changing weather patterns, elimination of prairie dogs, and other factors are involved in these changes. There may be merit to some of these theories, but, as of yet, they have not been convincingly demonstrated).

FORESTS

Arizona has over 3 million acres of ponderosa pine forests, reputed to be the largest area of ponderosa pine in the U.S. Fire played an important role in shaping these forests prior to settlement and the role of fire has been extensively studied and documented for this vegetation type. The dates of fires can often be determined going back several hundred years by analyzing tree rings and identifying fire scars that occurred on the trunk of the tree while it was growing. Studies show that low intensity ground fires – started by lightning or set, accidentally or deliberately – burned about every 5-10 years. In pre-settlement times, the forests consisted of relatively open stands of large trees with a fair to good understory or grass and low shrubs, and some younger pine trees. The fires tended to prevent excessive growth of young trees and large shrubs, and so the incidence of crown fires was low. A forest ranger told me that his father, who worked for the Forest Service in Flagstaff in the early 1900s, said that if they got a report of a fire, he and another ranger would ride out on horseback with a shovel and a rake and put it out! The fires were nothing like the large and destructive fires that have occurred in recent years, e.g., the Rodeo-Chediski Fire and the Wallow Fire, which burned hundreds of thousands of acres and completely destroyed thousands of acres of pine timber. So, what happened?

> "In the nineteenth and twentieth centuries overgrazing by livestock removed many of the grasses that carried ground fire. Large, old-growth trees were logged. Fires were suppressed. As a result, small pines have proliferated, while grasses and wildflowers have declined. Today, when fire begins, it has the opportunity to burn quickly through the closely packed crowns of extremely dense pine stands. These crown fires are dangerous to human communities and can be ecologically devastating, destroying large areas of wildlife habitat, causing erosion, and degrading watershed values." (Fact Sheet: Restoring the Ecological and Social Integrity of Western Forests, NAU Institute of Ecological Restoration www.coconino.az.gov).

When the national forests were created in the early 1900s, one of the objectives was to protect the forests from wildfire. Some very catastrophic wildfires had occurred in the late 1800s in the Lake States and elsewhere which burned thousands of acres and resulted in great loss of human life. The Great Peshtigo Fire of 1871 killed 1,500 people in Wisconsin and the "Great Fire of 1910" burned more than 3 million acres in Idaho, Montana, and Washington, with 87 fatalities including 78 firefighters. So, it is no wonder that the Forest Service has had a policy to prevent and control wildfires from the start – and this prevention and control got a big boost with the introduction of Smokey Bear in 1944. The effort to control fires was helped by livestock grazing, which was generally much heavier than presently that reduced fine fuels and reduced competition for young tree seedlings to establish. In more recent times, bark beetles and disease, exacerbated by drought and excessive tree density, have contributed to increased danger of intense crown fires resulting in replacement of the pines by alligator juniper or Gambel oak, at least for some years.

Mixed conifer and spruce- fir forests that occur at higher elevations, higher precipitation, and cooler temperatures than ponderosa pine had a fire history very different from ponderosa pine. These forests did not experience frequent fires due to moister conditions, but when they burned, they generally experienced stand replacing crown fires. In many locations, aspen thrived after these burns. Fire suppression has resulted in a great decrease in aspen throughout the Rocky Mountains.

PINYON-JUNIPER

Pinyon-Juniper Woodlands cover about 11 million acres in Arizona, making it the largest woodland type in the State. (The type is usually called pinyon-juniper even though it may or may not have much pinyon. There are several species of juniper – one seed, Utah junipers being the most common, and several species of pinyons also. No effort is made here to separate the different types). The pinyon-juniper type has greatly expanded its range over the past 150 years across most of the West, including Arizona, by invading into adjacent vegetation types such as grassland, chaparral, pine forest, sagebrush, and other types. In Arizona, the area of pinyon-juniper older than 150 years is estimated to about 54 % of its present range, the remaining is younger than 150 years (roughly the time since settlement) (Shaw et al 2018). In other words, pinyon-juniper has about doubled in acreage during the past 150 years and continues to increase. In addition, many areas that formerly supported a fairly open stand of pinyon and/or juniper have seen increased density and canopy cover of these species with a consequent reduction in understory grasses and browse. Schussman and Gori (2004) estimated fire frequency in the Plains/Great Basin Grasslands and Great Basin Pinyon-Juniper Woodlands as 10-30 years.

As in the case with ponderosa pine, the reasons for these changes are complex and may differ from place to place depending on soil, climate, and other factors (Romme et al 2009). The most common juniper species (one seed and Utah juniper), and all the pinyon species, are killed by fire of sufficient intensity (some junipers do sprout after fire, i.e., alligator juniper). Therefore, it is fairly easy to explain why they would not invade neighboring vegetation types, such as grasslands, chaparral or ponderosa pine, all of which have a history of repeated fires and plants that are better adapted to fire than juniper or pinyon. Lack of fire in the grassland, chaparral, and forests, perhaps coupled with reduced competition for seedling establishment due to heavy historic livestock grazing, could account for the great and continuing expansion of pinyon-juniper. But the situation seems more complex in those stands which have always supported pinyon-juniper.

Romme et al (2009) conducted a very intensive analysis of what we do and don't know about pinyon-juniper expansion and infilling and various causal agents. Their analysis divided the pinyon-juniper vegetation into three basic types. They found that the role of fire may be different in all three, although evidence is not adequate to make confident statements in some cases.

1. <u>Persistent Pinyon-Juniper</u> – areas which support very old stands of pinyon-juniper. Romme et al (2009) concluded that these pinyon-juniper types were not influenced by fairly frequent surface fires, as some others have indicated. They found little evidence for surface fires and concluded that these types tend to experience stand-replacing crown fires at long intervals – several hundred years. They concluded that recent high severity fires in pinyon-juniper in the Great Basin may not reflect either increased frequency or severity of fire in such types, although they did indicate that invasion of annual grasses and changing weather patterns may have increased the risk of fire.
2. <u>Juniper Savannah</u> – areas which have generally open stands of pinyon-juniper with grass understory. These areas may have experienced fairly frequent surface fires due to a good cover of grass understory. These fires may have killed some pinyon-juniper, or sometimes all of them, and would rarely reach the level of crown density needed for stand replacing crown fires. However, the evidence for fire frequency and effects in these juniper types is inadequate to make specific projections.
3. <u>Wooded Shrublands</u> – areas with pinyon-juniper but a good understory of shrubs, e.g., sagebrush. These types are somewhat similar to the savanna type, except the main understory is mainly shrubs. Therefore, surface fires might be less frequent than in grass dominated understories, but the effects might be more severe due to higher fuel loadings in shrublands.

Romme et al (2009) concluded that these types would probably not reach sufficient density to support crown fires, nevertheless all pinyon-juniper could be killed by hot surface fires.

The study by Romme et al (2009) appears to play down the role of fire suppression in pinyon-juniper stands, especially those they classified as "persistent." They did, however, state that the expansion of pinyon-juniper into other vegetation types is well documented and that these expansions are likely due, at least in part, to fire suppression and fuel reductions by grazing. Their study included analysis of literature on role of fire in pinyon-juniper across the entire West, including Arizona. They indicated that the role of fire may differ in different areas.

Chaparral

Chaparral is a fairly extensive vegetation type that occurs mainly in the "transition" zone between the forests and pinyon-juniper of the Colorado Plateau and Great Basin, and the desert shrub or desert grassland in the drier parts of Arizona. It consists of many different, mostly evergreen shrubs which occur in various mixtures. Some of the most common are turbinella oak (shrub live oak), manzanita, cliffrose, mountain mahogany, buckbrush, and algerita, to name a few. Most of these species are considered resistant to fire, either because they re-sprout or will come up from soil seedbanks after fire. Although the chaparral is considered a "fire type," it did not presumably have a short fire return frequency as might be expected. Chaparral tend to occur on fairly deep, coarse soils, especially where winter rains predominate. These soils are not very favorable for shallow rooted grasses because the soil within reach of their roots stores relatively little water, and most of the rain comes when the grasses are dormant. The chaparral species can reach deeper into the soil for this water and they make some growth during the cooler months. Chaparral has probably not extended its areas since settlement, and in fact has widely been invaded by juniper.

Estimates of fire return frequency in Arizona chaparral are about 75-100 years. Apparently, after a fire in chaparral, it takes a long time to accumulate enough fuel to support a burn. Efforts to use prescribed fire in chaparral have often been limited by lack of sufficient fuel to burn except under extreme conditions. As the plants grow and mature there is an increasing amount of leaf litter, dead branches, and total biomass, so that when conditions are right an intense fire will be possible. It is possible that fire protection has allowed some chaparral stands to reach density, height, and fuel loadings that would likely have been prevented by wildfire in the past. Thus, some chaparral fires that occur today may be more intense and damaging to soil and vegetation than formerly.

Grasslands

There are three main types of grasslands in Arizona. One is the Great Basin/Plains Grassland of northern Arizona, one is the Semi Desert Grassland found mainly in southeastern Arizona, and the other is the mountain grasslands found in fairly small areas of the White Mountains and upper elevations along the Mogollon Rim.

The mountain grasslands have been invaded in some areas by pine or juniper, perhaps due to lack of fire. These grasslands have a higher cover of grasses and forbs than other grasslands and thus provide more competition for invading shrubs or trees than the others.

The Great Basin/Plains Grasslands are a mixture of cool season plants from the Great Basin and warm season plants more typical of the Great Plains grasslands. These grasslands typically have substantial amounts of smaller shrubs such as 4 wing saltbush and winterfat. Due to lack of fire, and reduced competition from grasses due to historic heavy grazing, these grasslands have been invaded by juniper and in some areas by sagebrush or rabbitbrush.

The Semi Desert Grassland ranges from dense stands of big sacaton on floodplains, to tobosa grass swales, to diverse mixed stands of mid and shortgrasses. Typically, there is a considerable component of low shrubs, cactus, yucca, etc. This grassland is thought to have burned fairly often in pre-settlement times. It is more difficult to establish the frequency or severity of burns because grasses don't have rings to count, and the early explorers were less apt to comment on these fires, since the burned area returns to normal fairly quickly. Not all areas would have burned as often or as intensely as others. Rocky, broken sites may have always supported a lot of shrubs and cactus because they were not favorable to grass growth.

For many years, most scientists believed that historic overgrazing was the main reason for the observed increases in shrubs in what was once mainly grassland. Mesquite, catclaw, whitethorn, prickly pear, burroweed, and many other shrubs and succulents, including creosote bush, have increased over the past decades. Dr. Robert Humphrey was an early champion of the idea that lack of fire, due in great part to heavy grazing, was the main reason for such invasion, and he has gained increasing support in more recent years. The invasion continues even where careful management or no grazing at all is practiced. As with juniper, when the cover of mesquite and other shrubs reaches critical levels, the production of understory vegetation is reduced, bare ground increases, runoff and erosion may increase, and wildlife habitat is reduced, at least for many species. Unfortunately, most of the invading shrubs are sprouters and thus will not be controlled by fire alone. They were kept out of the grassland by fire which killed the seedlings, not the mature plants.

Desert Shrub Types

Very large areas of southern and western Arizona are occupied by desert shrub vegetation characteristic of either the Chihuahuan, Sonoran, or Mohave Deserts. There are some different species in these deserts but creosote bush, bursage, paloverde, and many species of cactus are characteristic of most of the area. These vegetation types generally occur in areas receiving less than 10 inches of precipitation per year, and much of it only gets 3-6 inches. Under pre-settlement conditions, these desert shrub types had a sparse stand of perennial grasses (e.g., big galleta, bush muhly) but not enough to normally carry a fire. Therefore, fire is not considered to have played an important role in shaping the nature of this vegetation. The return interval is estimated to be over 250 years (Schussman and Gori, 2004). That would indicate it only occurred in very unusual circumstances.

The situation has changed in the deserts, however. Non-native annuals, mainly cool season plants, have invaded the deserts. These plants are mostly of Mediterranean origin and are adapted to cool season precipitation. Examples include cheatgrass, red brome, Mediterranean grass, filaree, many mustards, etc. These plants were accidently introduced long ago, some dating back to the Spanish conquistadores and missionaries who inadvertently brought these plants with them from Spain in harness, saddles, and other gear. These plants can grow in the deserts because they do not have to endure long dry periods like perennials. They grow when there is rain and exist the rest of the time as seeds. They produce a large amount of biomass in wet winters that soon dries out and furnishes ample, dry fuel to carry fires. Consequently, the risk of fire, the frequency of fire, the intensity and ability to spread are greatly increased. Many of the native shrubs and cactus are not well-adapted to fire and are killed or severely damaged by fire. Even some of the most common native perennial grasses are not very fire tolerant. This destruction of Arizona's iconic plants, such as saguaro, is concerning to many people.

More recent arrivals that are causing concern in the deserts, especially the Sonoran Desert, are buffelgrass and Lehman's lovegrass. Both of these perennials are warm season plants and thus respond mainly to summer moisture. But they have a similar effect to the cool season annuals, i.e., they greatly increase the risk and intensity of wildfire to the detriment of desert shrubs and cacti.

Lehman's lovegrass was introduced from Africa in the late 1930s for erosion control and range seedings. It has been widely planted along utility corridors, highways, and other disturbed areas because it has a greater chance of successful establishment than most other plants. Because of its prolific seed production, it is easily spread by the wind, animals, running water, or vehicles and has spread throughout southeastern Arizona into New Mexico and Texas in the general range of 10-16 inches of precipitation. It also occurs in some locations in northwestern Arizona. It is mainly an invader of semi desert grasslands but does extend into desert shrub, at least in the higher rainfall zones.

Buffelgrass is a native of Africa and the Middle East. It is a fairly productive forage plant and has been widely planted in Texas and Mexico for livestock forage. Early trials in Arizona found it was not sufficiently cold tolerant to survive, but later importations, aimed mainly at stabilizing mine tailings, included more cold tolerant strains. For the past 30-40 years, it has been spreading into parts of the Sonoran Desert and there is widespread concern that it will continue to do so.

Riparian Systems

Riparian areas can be of many types ranging from mountain wet meadows to so called xeric (dry) riparian areas along desert washes. Thus, it is difficult to generalize about fire in these systems. Some would never burn, and some would burn when adjacent upland fires spread into them. In general, the true riparian types, with running water, would burn fairly infrequently. However, they can burn when understory vegetation is abundant, and kill or damage overstory gallery forests of cottonwood and willow, as has been demonstrated along the San Pedro River for example. Areas invade by salt cedar (tamarix) are especially prone to wildfire due to their dense growth and flammable nature. Webb et al (2007) examined changes in riparian vegetation for all the main rivers in Arizona using repeat photography. Their study showed that, contrary to popular belief, riparian woody vegetation has increased except in areas where ground water pumping or stream diversion for irrigation or municipal purposes had dried up streams, or where dams had inundated the streambanks. The increase occurred mainly after 1940 and the greatest amount occurred in the last third of the 20th century. Numerous factors related to this increase were discussed, including fire.

The Current Situation

Arizona has experienced 10 of the largest fires ever recorded since 2000 (see page 12 for a list), ranging in size from 70,000 to over 500,000 acres. Similar events have occurred in Colorado, Utah, Nevada, California, and other states. These fires have been more severe than earlier fires and have caused: damage to resources and aesthetics, soil erosion, flood damage, property damage, and loss of life. In addition, they have cost a lot of money to control. While the fires will have some long-term benefits to wildlife habitat, streamflow, springs, and forage production, the severity of these fires will require a longer time to recover than less severe fires.

There are differences of opinion on why these fires are occurring. Active fire suppression for many decades has allowed denser tree and shrub growth in forests and woodlands, and increases in fuel loads, to unprecedented levels. The wet years of the 1980s, especially the wet winters, contributed greatly to increased shrub growth in some areas. Arizona has experienced a long period of drought conditions over the past 20 years, rivaling some of the previous droughts of the past (e.g., 1930s and 1950s). This period has also seen record high temperatures. Some believe this is due to global climate change. Others observe that there have been long droughts, wet periods, warm and cold periods for centuries, so the current conditions are only part of that cycle. However, most agree that the current weather patterns contribute to the fires. Other factors that may contribute are increased population which increases the chance of human caused fires and increases the potential damage to property and life. Another factor that has not received much attention is that livestock grazing, especially on federal lands, has been greatly reduced over the past 50 years or so, resulting in increased grass and other fine fuels to carry fires. Whatever the reasons for the current fire situation, it is clear that it is not desirable, neither from an ecological or an economic standpoint.

"Natural" Fire Regimes

As understanding of the role of fire in shaping vegetation communities in the U.S. has increased over the past several decades, there is increased interest in the use of fire to produce desired vegetation types, even, and perhaps especially, among environmental groups. There has finally been a realization that simply protecting the forest, or other vegetation, from human activity such as logging, grazing, hunting, etc., and also from wildfire, does not maintain or restore a "natural" system as it existed before European settlement. There has been a lot of research into trying to understand what the "natural" fire regimes were in different vegetation types by the Forest Service, The Nature Conservancy (TNC), and many others. The Forest Service has published data on the these regimes (https://www.feis-crs.org/feis/) and the Bureau of Land Management (BLM) has used a Fire Regime Condition Class rating to describe vegetation where the conditions that would support a "natural" fire regime have changed so that the incidence of fire would be either reduced or increased compared to the natural regime. The underlying assumption of these efforts is that "restoring" the natural fire regime would be desirable and is thus the management objective.

It is very useful to study the role of fire in natural systems in order to understand how they work and how we can use fire in land management. But the implicit assumption that "restoring" the natural system, or something very close to it, is the goal of forest and rangeland management is, in my opinion, misguided and not very useful for guiding modern resource management. This focus on "pre-settlement" conditions has also been a dominant paradigm in other aspects of resource management which persists in spite of lack of scientific support. Here are a few points with respect to "natural" fire regimes.

What is "natural"? In general, the pre-European settlement vegetation is considered to be the "natural" vegetation, i.e., about mid- to late-1800s. Why do we think that natural? First, it is historically documented that Native American Indians set fires both accidentally and on purpose. Purposeful fires were used for various reasons, like to attract game or drive game in a particular direction for hunting advantage, to harass enemies, etc. Is this kind of purposeful fire "natural"? By the time European settlers reached the country the Native populations had been reduced due to disease, and their habits altered to some extent by the introduction of horses and migration of the tribes. For example, the Apaches did not arrive in Arizona much before the Spanish. In addition, the Little Ice Age that occurred from about 1300-1860 was a cooler and moister period than "normal," so the vegetation that existed at about the time of European settlement of the West may not have been typical of what existed before that cool period, and many of the changes we have seen since may be due to climate change after 500 years of cooler conditions

The assumption seems to be that if we could restore the vegetation to something like its pre-settlement condition, and restore the natural role of fire, this would be a very desirable thing, i.e., it would restore the balance of nature, maximize diversity, resilience and resistance to change, and general productivity of the ecosystem. Why should we think that the natural vegetation and fire regime of the past meets our current needs better than some alternative? If lightning strikes my house and burns it down, that is natural, but is it good?

The fact is that it is not possible to “restore” the natural vegetation with fire or anything else. Climate is the major factor affecting vegetation growth and the other ecosystem properties related to it. Climate changes – we had the Medieval Warm Period (950-1250), the Little Ice Age (1300-1860), and a warming trend since, apparently accelerating in recent years. Going back in time is not possible. The vegetation we see now is the product of these changes along with weather cycles and human effects during the entire process. Invasion of new species of plants, insects, animals, and life forms has altered the vegetation in ways that cannot be reversed in many cases.

Even if we desired to “restore” the natural fire regime, there are other impediments to accomplishing it, as some of the pro fire interests recognize. We have a lot more people today and the numbers are increasing. Houses and summer homes are scattered throughout much of the countryside, meaning that fires are both a threat to property and to human safety and often health. To take off on a familiar saying – “Where there is fire, there is smoke.” As anyone who lives in Arizona knows, during fire season, the skies are hazy, and the smell of smoke is in the air. Even the limited prescribed burning in the forests often creates smoke that causes complaints from local residents. Reintroducing fire frequencies similar to the “natural” fire regimes would involve burning very large acreages each year. For example, TNC (Schussman and Gori 2004) estimated there are about 5,000,000 acres of grassland that is relatively shrub free and another 5,000,000 that has been invaded by shrubs where a natural fire regime could be used to maintain or restore the grassland. If the “natural regime” was a fire about every 10 years that would be about 1,000, 000 acres burned every year on average, a 20-year interval would still be 500,000 acres per year. And this doesn’t count burning in the forests, woodlands, and chaparral.

TNC classified several types of situations with respect to wildfire:

- Type A: Fire not desired at all – in deserts or where risks are too high
- Type B: Fire not desired because of current conditions – excessive fuel loads, etc.
- Type C: Wildfire desired but there are constraints, such as air quality
- Type D: Wildfire is desired and there are no constraints

Their analysis (performed for BLM) indicated that only a relatively small portion of BLM lands fell into Type D category. Their underlying assumption is that a “natural” regime of “wildfire” would be desirable unless there are factors that prevent or constrain its use – a questionable assumption in my opinion. However, at any rate, their analysis indicates that on much of the forest and rangeland achieving desired conditions of reduction of fuel and management of vegetation will have to depend heavily on use of herbicides, mechanical treatments, grazing, and prescribed burns, which may or may not emulate “natural” fires.

So, What Can Be Done?

The big fires since 2000 have stimulated increased effort to reduce fuel loadings to make fires less severe and easier to control, especially in the vicinity of towns and subdivisions. Wildfire-Urban Interface Zones have been identified, in which cities, counties, state, and federal agencies work to reduce underbrush and thin trees in the vicinity of dwellings and other property. The Forest Service has done extensive cutting, piling, and burning of smaller trees to remove ladder fuels and create fuel breaks in the pine forests. Dense stands of juniper are being cleared mechanically in many areas, mainly to improve watershed conditions, but also to reduce the chance of stand replacing fires, such as what has occurred in Utah.

Many advocate the "re-introduction" of fire into the ecosystem as a means of keeping fuel loads low and the use of "prescribed burning" has gained support among resource managers in recent years. This makes sense because fire, along with grazing, are practices that can be applied over large areas with relatively low costs and low impacts to soil and other resources compared to thinning with machinery or hand labor. However, the use of prescribed burning (some call it controlled burning, but I think the only fire that is controlled is in a stove) encounters some constraints.

In some cases, fuel loads will have to be reduced before a prescribed burn can be done safely. This may require cutting and removal or piling and burning. In other cases, it is difficult to get a light severity fire to burn because the vegetation will only carry a fire under extreme conditions of wind and weather. This is the case in some juniper stands – basically they won't burn unless "red flag" conditions prevail. Concerns about liability may discourage burning under such conditions. Removal of juniper, or thinning it, may increase the growth of grass and other fine fuels and make prescribed burning a way to control the re-invasion of juniper.

Chaparral is also difficult to burn unless fuel loads are high and weather conditions extreme, and then the risk is great. It would be desirable to use a prescribed fire in chaparral every 20 years or so to maintain a better herbaceous understory, keep the shrubs vigorous, and reduce excessive fuel that eventually supports catastrophic fires. A possibility is to treat "younger" stands with herbicides to kill or topkill some shrubs to provide enough fuel to allow a burn of moderate intensity under conditions when it can be controlled. This would benefit watersheds and wildlife habitat in particular.

Grasslands are the vegetation type where prescribed burning is most often feasible without expensive mechanical treatments, although they will often require rest from grazing for a year or so to provide enough fuel to burn well. Grass fires can help keep shrubs from dominating the grasslands, which reduces grass growth and often causes increased runoff and soil erosion. Where grass cover has been excessively reduced by shrub invasion, and especially where the invading shrubs will sprout after fire (e.g., mesquite, catclaw), it may be necessary to kill the shrubs with herbicides or remove them mechanically to increase grass growth so that prescribed fire can be used to maintain the grassland. (Grass fires will usually kill these shrubs when they are small.)

The situation in the deserts is different. Here the problem is not one of "re-introduction" of fire because fire basically played no part in their formation. Rather the problem is one of increased risk of fire, due mainly to invasion of non-native grasses and forbs, and the damage done by fire to the native vegetation, e.g., desert shrubs, cacti, etc. The objective in these areas is to prevent fire in order to maintain the desert vegetation and prevent its conversion into an annual grassland, as has happened in some sagebrush areas where cheatgrass is dominant. These non-native annuals are here to stay; there is no known way to eliminate them, so we must manage them. The same is probably true for the perennials, e.g., buffelgrass and Lehman's lovegrass. So, as the title of this section states, what can be done?

One way to do this, and the only practical way in my opinion, is to use **livestock grazing** to reduce fuel loads. As repeated many times in previous paragraphs, one of the causes of lack of fire in almost every vegetation type is livestock grazing, especially the heavy year-round grazing that often occurred in the open range days. So, there is no question that livestock grazing can reduce the risk and/or severity of grass fires. Grazing management specifically designed to reduce fuel could greatly aid in reducing the occurrence, severity, and rate of spread of fires in the desert areas and desert grasslands, without damaging the native vegetation which is mostly not grazed by livestock if other forage is available. Of course, livestock grazing can also be used to aid in fire prevention and control in other vegetation types. Using grazing as a tool may require some adjustments in thinking of some of the anti-grazing interests.

Largest Arizona wildfires by acres burned (inclusive of fires from 2000-2020):

1. Wallow, 2011 – 522,000+acres
2. Rodeo-Chediski, 2002 – 468,000+ acres
3. Cave Creek Complex, 2005 – 243,000+ acres
4. Horseshoe 2, 2011 – 222,000+ acres
5. Bush Fire, 2020 – 174,000+ acres
6. Woodbury, 2019 – 123,000+acres
7. Willow, 2004 – 119,000+ acres
8. Aspen Fire, 2003 – 82,000+ acres
9. Edge Complex Fire, 2005 – 72,000 acres
10. Tank Complex Fire, 2005 – 69,000+ acres

Note: The Yarnell Hill Fire (2013) was not one of the largest fires in state history, burning only 8,400 acres, but it is considered to be the deadliest Arizona wildfire, claiming 19 lives. Since the list was compiled, the Bighorn Fire in the Catalina Mountains has burned more than 119,000 acres which would move it into the 10 largest.

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