CHAPTER 24

The Future of Fire in California's Ecosystems

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> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.
>
> ALDO LEOPOLD, 1952

> It's not a matter of if fire will occur but when it will occur.
>
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This book has covered a wide array of topics that are unified by wildland fire. In this concluding chapter, we take the opportunity to summarize the three parts of the book, focussing on some of the most important overarching concepts. We then address where the future is likely to lead us and end with a challenge for managing and living with fire in California.

Concepts of Fire Ecology

The vegetation in California is a product of its evolutionary past, current and past climates, topography, and fire. From the dense, moist forests of the North Coast to the grasslands of the Central Valley to the dry southeast deserts and Northeastern Plateaus, fire has played a varying but important role. Similarly, the forests of the Klamath Mountains, the Southern Cascades, and the Sierra Nevada have evolved with periodic fire. Nowhere in California, however, is fire more dramatic than in the chaparral-covered mountains of the South and Central Coasts. California's variety of fire regimes are products of its wide diversity of vegetation, climate, topography, and ignitions.

Although much of California's climate is mediterranean in nature, the state's climate in fact is as variable as its vegetation. Rainfall ranges from an annual average of 204 cm (80 in) along the north coast to 5 cm (2 in) in the desert. Normal temperatures vary from −4°C (24°F) in January in the Sierra Nevada to 39°C (102°F) in July in Death Valley. Winds are also variable, but the Santa Ana winds are the ones that have the greatest effect on fires, particularly in the mountains of the South Coast. Lightning strikes occur throughout California at all times of the year but are most prevalent in the Southeastern Deserts, the Northeastern Plateaus, and the Sierra Nevada, primarily in July and August. All of these variations create a diverse fire landscape with a wide variety of fire regimes.

Fire also interacts with the physical components of the ecosystem. The process of combustion is dependent on the presence of sufficient heat, oxygen, and fuel to sustain ignition and spread. Fire behavior characteristics such as rate of spread and intensity are influenced by the amount of available fuel, weather conditions, and topography. Fires with different behavior characteristics produce different fire types and effects. Fire also interacts with soil, water, and air ranging from minute changes in soil structure, to alterations in stream water quantity and quality, to changes in air quality across broad regions. However, these are not isolated effects, as fire interactions in one part of the ecosystem can influence outcomes in other areas. High-intensity fire can cause hydrophobic layers in the soil and result in elevated erosion when the rains come in the fall. Eroding soil affects water quality and chemistry and influences downstream stream channel morphology with pulses of sediment that both impact aquatic habitat and form the substrate for many riparian and wetland ecosystems.

Fire interactions with living components of the ecosystem are equally diverse. Effects to plants include the direct effects of heat and smoke and the indirect effects of changes in nutrient and light availability. Plant responses to fire can be categorized as fire dependent, fire enhanced, fire neutral, or fire inhibited. Many species have physical characteristics, such as thick bark, that enable them to survive fires. Other species are adversely affected by fire and proliferate during long fire-free periods. Fire regime attributes affect plant survival and reproduction and, consequently, plant community structure and composition. The plant community, in turn, affects fire regimes through feedback mechanisms. Fires affect animals through direct mortality and through indirect effects on habitats. Although individual animals may die and populations may be impacted, animal community health is maintained by fire fulfilling its ecological role. Fire maintains habitat complexity, recycles and makes available nutrients and water, and changes the trophic relationships between the various animal species in a given community. Since many animal species evolved with fire, it is essential for their continued existence that fire be retained as an important ecological process.

Our Changing Perceptions

Throughout this book, we have shown that fire is an integral part of California ecosystems, and that from an ecological perspective, it is rarely useful to view it as an exogenous disturbance. The state's diverse climate and topographic patterns have facilitated the development of a rich array of vegetation and habitats. Ecological processes including fire, flood, and erosion have sculpted the landscapes and plant communities into complex, continuously changing ecosystems. Therefore, fire should not be characterized as a disturbance or retrogressive event that delays progress toward some hypothetical, static, climatic climax, but as a vital, incorporated ecosystem process that has a major role in defining California's dynamic ecosystems.

The role fire plays in an ecosystem is characterized by the fire regime attributes that describe the pattern of fire occurrence, behavior, and effects. Temporal attributes include seasonality and fire return interval. Spatial attributes are fire size and spatial complexity of the burns. Magnitude attributes are fire intensity, fire severity, and fire type. Distributions of these seven attributes form the fire regimes. Fire regimes and vegetation are intricately linked, one perpetuated by the other as interdependent components within an ecosystem.

Fire regimes vary both within and between the bioregions. Variation is often pronounced along a gradient inland from the coast due to differential marine influence on fire weather and climate. Fire tends to be less frequent in the cool, moist conditions found on the immediate coast than in the more interior locations where it is typically hot and dry during the summer. Elevation gradients also produce variations in fire regimes that are moderated near the coast but become more pronounced in the Sierra Nevada, Southern Cascades, and Klamath Mountains. Within these three mountain bioregions, there is often a change in fire regimes due to the higher precipitation on western slopes and rain shadows on eastern slopes. In the Central Valley, variation in the fire regimes is more subtle and related to north-south gradients in climate and hydrology.

Additional sources of variation in fire regimes and responses to fire within and among bioregions include the duration of the fire season and the productivity of the sites. Wetter bioregions and wetter portions of drier bioregions produce abundant fuel, but there are fewer years and shorter seasons when fuel is dry enough to burn. Consequently, fire regimes in these areas are characterized by longer fire return intervals and a tendency toward higher fire severities. In drier bioregions and drier portions of other bioregions that produce less fuel, there are more years and extended periods of the year when the fuel will burn. These areas are characterized by shorter fire-return intervals and a tendency toward lower fire severities. In the harshest alpine climates of California, plant establishment and growth are restricted to the point where fires are limited by the lack of fuel and extremely limited fire season. Similarly, plants in hot, dry deserts produce little fuel and burn infrequently.

Fire regime descriptions are useful in determining and describing which attributes have changed and how these attributes differ from historic patterns. Comparison of the changed fire regime with the regimes of adjacent plant communities allows us to predict the trajectory of vegetation change and, potentially, the direction that plant communities will expand or contract. Land managers are now able to focus on the fire regime attributes that are biologically significant in their ecological restoration efforts.

Fire Is an Integral Part of California Ecosystems but Variability Occurs across Them

Martin and Sapsis (1992) introduce the notion that *pyrodiversity*—the variability within fire regimes over long periods of time—promotes biological diversity. This concept is needed to understand fire as an ecological process and its value in restoring and maintaining ecosystems. Pyrodiversity is particularly important in ecosystems where variation of fire severity provides much of the fine-scale habitat variability. Pyrodiversity promotes biodiversity in many fire regimes, especially those that are characterized by short fire return interval, low-intensity, and low-severity surface fires. Severity variation is also important in vegetation that depends on fire for providing age-class mosaics such as many riparian woodlands and red and white fir forests.

Although it is clear that the levels of pyrodiversity that historically occurred maintained the biodiversity, it is important to note that further increases in pyrodiversity beyond historic ranges may not always promote elevated levels of native biodiversity. Within the wide variety of fire-vegetation relationships, there are two general classes of settings in which pyrodiversity may not promote biodiversity:

1. The first is the group of ecosystems characterized by truncated fire return interval distributions. Only limited amounts of pyrodiversity can be tolerated because they are subject to type conversion when intervals between fires are too long or too short. For example, if closed-cone pine or cypress stands burn even a single time before seeds are produced, or remain unburned long enough to exhaust the seed source, these specialized conifers are lost. Effective fire suppression can exclude fire long enough for this to happen. This is an expansion of the variability in fire regimes that decreases biodiversity.
2. The second class of settings involves the fire-limited or fire-induced spread of native or non-native

invasive species. Annual grasses can temporarily expand the range of pyrodiversity in some deserts, but once they become dominant enough to provide a continuous fuel bed they reduce both pyrodiversity and biodiversity. Douglas-fir encroachment into Oregon white oak woodlands on the north coast increases pyrodiversity while reducing biodiversity by replacing the more species-rich woodlands.

Although pyrodiversity certainly does promote biodiversity in most California ecosystems, restoring and maintaining historic levels of pyrodiversity is the wise approach to take if natural levels of biodiversity are the goal.

Enough individual organisms of a given species must have the ability to survive fire, or to recolonize after fire, to remain a part of an ecosystem. They must be able to persist in order to reproduce and become a viable component of the biotic community. Even rare fires that occur in the wrong season, or that are too large, intense, severe, or uniform, can greatly reduce, displace, or even extirpate a species from an area. Enough individuals of a species need to persist throughout the range of variability that is characteristic of the fire regimes for that species to remain viable in fire-affected ecosystems.

California has a diverse flora comprised of plants that have evolved under a variety of climates and evolutionary pressures. Some species of chaparral are unequivocally dependent on fire and require smoke or chemicals from charcoal to germinate. Other species, primarily from moist regions, have low to no resistance to fire. But across all bioregions, many species have some characteristics that allow them to persist, and often thrive, with fire. Exclusion of fire has contributed to the demise of some endemic and rare species throughout the state.

Most of the state's dominant native vegetation depends on fire to maintain its structure, composition, and function, and the relationship of fire and California vegetation can be traced back for thousands of years. Giant sequoia, mixed conifer, ponderosa pine, and Douglas-fir forests are greatly influenced by fire. When fire is excluded for even a few decades, these forests take on an entirely different structure and provide a greatly different habitat. Coast redwood forests in the fog belt of the North Coast, blue oak woodlands on the hot, dry Central Valley foothills, and the rich array of shrub communities in the South Coast coexisted with recurring fire. The closed-cone pine and cypress communities, Oregon white oak woodlands of the North Coast, and quaking aspen stands in the high Sierra Nevada would likely be extirpated or drastically reduced without recurring fire. A significant portion of California's biological heritage is directly dependent on the recurrence of fire.

It is a mistake to assume that a given plant community always has the same fire regime. Several plant communities are characterized by more than one fire regime both within and between bioregions. Trees in open stands on sites that are unproductive, open, rocky, or ultramafic have very discontinuous fuels, and fires are typically limited to single trees that are struck by lightning. Where the same trees grow on more productive sites that produce more fuel, fires are larger and become a more important ecological process. Coast redwood, Douglas-fir, mixed evergreen, and a number of other communities occur over a wide range of environments and are thus characterized by more than one fire regime.

Over millennia, climate changes have occurred and vegetation has responded by changing geographic distribution and range. Bioregional climates have varied, as have the flora and fire regimes. Human-induced fire regime changes can also be the driver of vegetation change. Modification of fire regimes during post-European settlement has changed some of the boundaries between ecological zones. Fire exclusion has allowed the white fir zone in the Sierra Nevada to expand down to lower elevations. Removal of fire from sage communities on the east side of the Cascades and Sierra Nevada has allowed the expansion of juniper and pinion woodlands. Fire scar records in giant sequoia show evidence of decadal, centennial, and millennial variation. Exclusion of fire from these giant sequoia stands limits their regeneration and allows encroachment by other conifers. Separating the influences of climate change from the influences of fire exclusion on post-European fire biota is often a difficult, but important, consideration in understanding the current ecological role of fire in California.

Fire ecology is an emerging and rapidly expanding field of science—but there are many gaps in our knowledge. Until recently, research concentrated on chaparral in the South Coast and the mixed conifer forests of the Sierra Nevada. Information on the role of fire in the Central Coast, North Coast, Southeastern Deserts, and other bioregions has developed more recently. Research is beginning to be conducted on fire effects in the other bioregions of the state. Given the diversity of flora and fire regimes across California, we are far from having a comprehensive body of research on fire ecology. A targeted, strategic approach aimed at answers to key ecological questions that can be extrapolated across the broadest array of species and bioregions is needed.

There are also gaps in our knowledge about fire and management issues. The most common management issues transcend multiple bioregions and include invasive species impacts, urban development, habitat fragmentation, fuel hazard reduction, fire suppression impacts, at-risk species, and air quality.

Management of Fire in California Ecosystems Must Be Based in Ecology

California is the most populous state in the United States, and the challenge of living with fire is ever present in most parts of the state. As long as we choose to inhabit fire-prone ecosystems, our choices are to allow fire to occur on its own terms, to adjust our communities to fire, or to continue to interfere with the natural range of fire regimes and essential ecological function of fire itself. How we as a society decide to accommodate—or interfere with—fire will say a great deal about our social ecological sophistication and how much we value our native biota and natural environment.

It is impossible to separate the actions of people from ecosystems because we influence and are part of fire regimes and ecosystems. Humans have been using fire for hundreds of thousands of years to manipulate their environment. The use of fire shifted our status from foragers to cultivators and contributed to enabling our species to expand around the world. Fire application to California landscapes is as ancient as the first human occupation about 11,000 years ago. Fire was the most significant, effective, efficient, and widely employed vegetation management tool utilized by California Indian tribes, and they conducted purposeful burning to meet specific cultural objectives and maintained specific plant communities. The influence of Native Americans on California ecosystems has varied across a spectrum from little to none in remote areas to considerable in human-maintained ecosystems.

Since European explorers arrived in 1542, they have directly or indirectly influenced the state's fire regimes. Removal of anthropogenic fire from these ecosystems has allowed widespread changes to species composition, encroachment of invasive species, conversion to other vegetation types, and increased fire hazards. The California gold rush permanently established the European-American population in 1848. Formal fire policy arrived with establishment of large-scale forest reserves during the late 1800s and early 1900s. A series of devastating fires resulted in a policy of full fire suppression following the fires of 1910. Starting during the 1970s, federal fire policy changed to incorporate a combination of fire suppression and fire management. During the late 1990s and early 2000s, fire and land management have focused on managing the fuel that accumulates in ecosystems as a pre-suppression and ecosystem management treatment. Fire increasingly has become recognized as an important ecological process, and fire management is increasingly addressing ecosystem values by focusing on the restoration of natural fire regimes. It is important that we remember that humans have influenced fire regimes since our arrival and that we must take responsibility for knowing what effects our actions will have.

It seems that no matter how hard we try, total fire control still eludes us. Since the Berkeley fire in 1923, the issue of fire in the wildland-urban interface has become one of the most important land management issues facing Californians. Despite intensive efforts and the application of great amounts of technology and money to the effort to exclude wildfires, they continue to have great effects on society and ecosystems. The largest and most destructive fires are occurring at an increasing rate and the expansion and intermixing of urban and wildland areas make the impacts of the largest fires even greater. There is increasing recognition that if we are to moderate the impact of fires burning out of the wildlands into the urban landscapes, we must understand and manage both the fire regimes that are inherently associated with the ecosystems in the wildlands and the fuel characteristics of the urban areas.

Even though there are a greater number of large fires in California today, there is probably less fire overall in most of the state's landscape than in any point in time since the arrival of humans, yet we consider the occurrence of fire to be an environmental emergency. This is particularly true with fire effects on watersheds and air. Maybe we are the victims of our own success. We like our health, clean air, and clean water, and we would like to protect all of our native species and ecosystems. Historically, there was a lot of fire, a lot of smoke, and a lot of fire-accelerated erosion in California. But wildland fire produces smoke and other combustion byproducts that can be harmful to human health and particulate matter that reduces visibility. Fire increases erosion, reduces water quality, and kills vegetation. Although society might not like these changes because they can have detrimental effects on human health and quality of life, they are, to a large extent, natural. Today, we have excluded fire to the point where we have experienced, and are expecting far less fire impacts to air and water quality than existed before Euro-American settlement of California.

We clearly need to protect the quality of our air and water. The question is, how do we do this in fire-prone ecosystems? Uncontrolled wildfires are responsible for the most widespread, prolonged, and severe periods of air quality degradation, but local, state, and federal regulatory agencies focus on the activities that are considered discretionary, including managed fire. The challenge in managing wildland fire is to understand the tradeoffs of balancing public interest objectives while sustaining ecological integrity. Minimizing the adverse effects of smoke on human health and welfare, while maximizing the effectiveness of using wildland fire, is an integrated and collaborative activity.

Today, watersheds and fire regimes are highly altered by human activities. Past and current management practices including water development, mining, road building, urbanization, fire suppression, timber harvesting, and recreation are impacting watersheds. The largest erosion events typically follow very large, uniformly high-severity wildfires in steep, erosive landscapes. Fire and its associated pulses of sedimentation, mass wasting, and flooding are natural processes that work within ecosystems and are part of the process that creates and maintains watersheds. However, like air quality management, the focus of watershed management is often to minimize the impacts of prescribed fire because it is considered discretionary. Unless watershed managers, local communities, aquatic ecologists, and other resource mangers actively support the restoration of historic fire regimes for the management of their resources, it is likely that the exclusion of fire will continue. In some ecosystems, this means that fire will be less frequent, but the fires that do occur will be more uniformly high in severity and sometimes cause an elevated level of watershed instability.

One of the most significant ecosystem changes has been the arrival of non-native, invasive species, starting with the earliest European contact in the 1500s. Fire management in ecosystems with non-native, invasive plants creates unique challenges. In some ecosystems, fire facilitates the expansion of non-native, invasive species, and in other cases, fire can be used to control or eradicate them. In the dynamic cycle between grasses and fire, invasive grass species become established in an area dominated by woody vegetation. As the invasive grasses increase in abundance, a continuous layer of highly combustible fine fuel develops, resulting in increased rates of fire spread and fire frequency. Shrublands and forests composed of native species are converted to grasslands comprised mainly of non-native species. Although fire maintained native plant communities, invasive species are responsible for altering fire regimes in large areas in southern California chaparral, the Great Basin, the Central Valley, and the Mojave Desert. Managing fire and invasive species is an important area of future work.

When Aldo Leopold (1952) stated, "To keep every cog and wheel is the first precaution of intelligent tinkering," he spoke of species. The Federal Endangered Species Act and the California Endangered Species Act were specifically enacted to protect native plants and animals that are threatened or endangered with extinction. In California, fire and fuel management and at-risk species conservation and protection have more often been in conflict than in accord. Species protection often has meant fire exclusion. Although there are difficulties, there are also potential opportunities for fire management to aid in the protection of at-risk species. The use of prescribed fire may provide the best opportunity for these species where the absence of fire has degraded habitat or where fire is not likely to be allowed to return naturally. There are numerous examples across California where fire and fuel management activities, prescribed burning, fire suppression, or post-fire rehabilitation and restoration have been integrated while conserving and protecting at-risk species, their habitats, and ecological processes. Many at-risk species, and the ecological systems they depend on, cannot be sustained or recovered without the immediate and longer-term ecological functioning provided by fire. Fire as an ecological process is a necessary part of California's ecosystems, and if we really intend to keep all of the parts, fire should be returned to the extensive inventory of California's diverse "cogs" and "wheels."

Where Do We Go from Here?

As humans, we feel the need to control fire in our environment, and as we develop the ability to control fire, the role that fire plays in California ecosystems has become both more controlled and more unpredictable. However, controlling fires and extensively manipulating vegetation have not always benefited California's ecosystems or provided the control and assurance that society has desired. The fires of 1993 and 2003 exemplify how little control we really have and that other options must be considered. Although this book synthesizes and consolidates our understanding of fire, it does not answer the question of what we want our relationship with wildland fire to be. This is not an ecological question; rather it is a social one; and societal wants and needs are as dynamic as fire regimes and ecosystems. What is clear is that if fire is to continue to play out its role in ecosystems, we need to better understand that role and incorporate it into our land stewardship.

An assessment of the largest fires in California's recorded history will quickly give the impression that fires are getting larger and more destructive. It is true that the largest fires and the most destructive fires are occurring at an increasing rate. There are a number of explanations for this trend, but the answer lies in the nature of fire-ecosystem interactions and the history of our management practices.

It seems illogical that the more effective our firefighting forces become, the worse the fire events become. But it makes ecological sense. Ecosystems that are biologically productive but relatively non-flammable will tend to burn in fires that are infrequent and very high in intensity and severity. For example, southern California chaparral burns less frequently than most of the surrounding vegetation types, but because it burns in less frequent and more extreme weather conditions, the fires are often uniformly high in intensity and severity. Suppressing fires tends to eliminate the smaller and less intense fires burning in lighter fuel accumulations during less severe weather conditions. These fires are easily suppressed, resulting in atypical, uniform, high fuel loads and fires that spread only under severe weather conditions. This amplifies the naturally occurring high-intensity fire regime. Unless we can develop the technology to completely exclude fire from chaparral ecosystems, the more effective our fire suppression becomes, the larger and more severe the fires that do occur can become.

In terms of human loss, the most destructive fires burn out of the wildlands and into the rapidly expanding urban development. These are fires that are burning through landscapes much as they have for thousands of years. They are not necessarily more intense or more frequent or faster moving than they were before humans were present. The difference is that subdivisions or small communities lie in their path, and the only fires that we allow to reach the urban interface are those that are too intense to stop. As long as we continue to suppress all of the other fires and expand urban development into high-intensity fire regime wildlands, we will continue to see more and more destructive fires. Although the destructive fires cannot be eliminated, the design of the urban side, fuel management of the wildland side, and creation of buffers and barriers in the interface can moderate the level of damage.

The Future of Fire and Land Management

With the exception of aquatic ecosystems, sand dunes, extremely arid deserts with very sparse fuel, and alpine ecosystems, fire plays an essential ecological role throughout the state. The habitats and species on all of these landscapes have evolved with fire. Perhaps the most universal changes to California's ecosystems during the historic period have been the alteration of past fire regimes and changes in the pattern of fire on the landscape. Nearly all native biota and communities have been and are affected by these alterations.

However, no matter how important fire is to ecosystems, we will not universally restore fire to its historical role in California ecosystems. There are several reasons for this, including the fact that many of those ecosystems simply no longer exist and others are impacted by human actions beyond the point where restoration is feasible. Biologically, California ecosystems have been altered and are mostly composed of an unprecedented mix of native and non-native species from many continents. Discontinuities exist throughout the natural landscape, preventing fires from achieving their historic patterns. The only way that fire regimes will be fully restored to California is if humans were to value the restoration of historic ecosystems and processes to the exclusion of all other land uses—and that is against human nature.

In the wildlands where managing for natural ecosystems and processes are the priority, it is important that fire be incorporated into long-term management plans. Although land management planning needs to recognize the numerous constraints of society, prescriptions must incorporate the variability of fire regimes. Narrowly focused prescriptions that apply only parts of the historic fire regime or use mean values for the fire regime attributes do not restore historic fire patterns and need to be applied in very special cases or not at all. Without the dynamic nature of natural fire regimes, restored ecosystems are not likely to maintain historic levels and patterns of species distribution and diversity.

A few details are clear when looking into the future of fire and land management. The population of California will continue to grow, the wildland-urban interface will continue to expand, wildlands will be valued as both habitat and open space, and the regulation of fire and other land management activities will continue to increase. The understanding of fire and its role in ecosystems is vital to making land management decisions.

The restoration of fire as an ecosystem process is a complex undertaking. Substituting mechanical treatments that can only mimic some aspects of fire will accomplish only portions of fire's role. There is one simple rule that applies to the restoration of fire into ecosystems: To completely restore fire as an ecological process, there is no substitute for fire. In the words of Sue Husari, fire management officer for the Pacific West Region of the National Park Service and one of the true pioneers in fire management: "*You can't restore fire without fire*."

Ecosystems change, and it is a mistake to manage any complex, dynamic ecosystem for a single, static state or condition. It is contrary to the basic nature of ecosystems, because all ecosystems continuously change, develop, and cycle over time and space. It is that long-term pattern of change and subsequent species responses that allow those species to persist, adapt, and interact with the other biotic and physical attributes of the natural environment.

Intentionally or unintentionally, we are affecting fire regimes on all wildlands in which we manage or suppress fire. The management of fire regimes is among the most important land management activities on most wildlands. Fire exclusion has resulted in alteration of ecosystems on a massive scale, and this has influenced the habitats for thousands of species in hundreds of ecosystems. The decision to impose a fire regime on an ecosystem should be taken seriously. Whether we intentionally prescribe a detailed fire regime or simply decide to suppress all fires, we are making a decision about what our desired fire regime will be; there is no real "no action alternative."

Managing fuel should be an extension of managing fire regimes. Because both surface and crown fires rely on surface fuel to generate fire spread, treating surface fuel is an essential step in effective fuel management programs. Fuel treatments can make fire exclusion more effective by facilitating fire suppression. In other cases, fuel management is the first step in restoring historic fuel conditions for the purposes of restoring historic fire regimes. The intentional manipulation of fuel to achieve desired fire conditions should be the focus of a variety of fire and land management activities.

We will never know everything that we would like to know about fire in California ecosystems, but we do need to use what we do know. We have been influencing ecosystems by manipulating fire regimes for more than a hundred years. Most fires have been successfully suppressed because we were able to control and manage them. We currently have the ability to apply prescribed fire and manage wildfires, and in the future, we may be able to totally exclude wildfire. Clearly, California ecosystems will not be the same without fire playing its ecological role. If we are to maintain California ecosystems for future generations, it is time to start deciding if, where, and how we will move forward with restoration of fire. And this time, humans will be almost solely responsible for determining future fire regimes.

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