

OPPORTUNITIES FOR IMPROVED FIRE USE AND MANAGEMENT IN CALIFORNIA: LESSONS FROM WESTERN AUSTRALIA

Rick J. Sneeuwjagt^{1†}, Tim S. Kline^{2*}, and Scott L. Stephens²

¹ Department of Environment and Conservation,
17 Banksia Terrace, South Perth, Western Australia 6151, Australia

² Department of Environmental Science, Policy, and Management,
University of California, Berkeley,
137 Mulford Hall, Berkeley, California 94720, USA

*Corresponding author: Tel.: 001-510-642-4934; e-mail: tkline@berkeley.edu

ABSTRACT

As the large scale of fuel treatments needed to promote ecosystem health and reduce heavy fuel loads becomes clear in California's mixed conifer forests, managers are beginning to focus on how to scale up prescribed fire use in order to treat a meaningful portion of the landscape. We look at the example of Western Australia's large-scale and highly successful prescribed burning program by their Department of Environment and Conservation as a model for emulation by land management agencies in California. Focusing on: 1) novel management practices, 2) inter-agency collaboration, 3) regulatory collaboration and policy, 4) research integration, 5) cultural acceptance, and 6) political support of prescribed fire, we make recom-

RESUMEN

A medida que se esclarece la necesidad de usar grandes escalas en los tratamientos de combustibles necesarios para promover la salud de los ecosistemas y reducir las altas cargas de combustibles en los bosques mixtos de California, el manejo está empezando a orientarse a la implementación del uso de quemas prescritas para tratar porciones significativas del paisaje. Analizamos el ejemplo de las altamente exitosas quemas prescritas a gran escala del oeste australiano, implementadas por el Departamento de Ambiente y Conservación, como un modelo a emularse por las agencias de manejo de tierras en California. Con un enfoque en: 1) prácticas innovadoras de manejo 2) colaboración interagencias, 3) colaboración en regulaciones y políticas, 4) integración de la investigación, 5) aceptación cultural, y 6) apoyo político a las quemas prescri-

[†] Rick Sneeuwjagt, recently retired State Manager of Fire Management Services, Western Australia Department of Environment and Conservation (DEC), visited California in March of 2012. He toured the state with Scott Stephens (UC Berkeley) and Tim Kline (California Fire Science Consortium), meeting with a variety of fire managers, air quality regulators, and regional staff from federal and state land management agencies. He also attended two regional fire meetings—the Fire and Smoke Management Symposium in Clovis, California, and the Northern California Prescribed Fire Council spring 2012 meeting in Chico, California. E-mail: rick.sneeuw@gmail.com

mendations for a new approach to the management and regulation of fire use in California's mixed conifer forests.

tas, hacemos recomendaciones para un nuevo enfoque en el manejo y la regulación del uso del fuego en los bosques mixtos de California.

Keywords: California, eucalypt forest, fire management, mixed conifer, prescribed fire, Western Australia, wildfire

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INTRODUCTION

Western Australia's tall eucalypt forests and the mixed conifer forests of California share many similarities in regard to wildland fires. Both have a Mediterranean climate of hot dry summers and cool moist winters, and both have large areas of fire-adapted wildlands and wildland-urban intermix lands at risk from large, severe wildfires. Extensive high-severity wildfires present serious risks to communities and ecosystem health in both regions. The managers of Western Australia's eucalypt forests and California's mixed-conifer forests each use prescribed fire as a means to restore and maintain ecosystem health and remove excessive fuel loads that contribute to high-severity wildfires. Despite these shared circumstances, the use of prescribed fire in Western Australia's forests has been far more extensive, and consequently more successful, than in California.

Many factors have influenced the differing levels of use of prescribed fire in each region. These factors include management practices, regulatory collaboration and policy, research conducted, research integration, and cultural acceptance and political support for prescribed fire. For over 50 years, the Department of Environment and Conservation (DEC) has implemented a highly successful prescribed burning program within the dry eucalypt forests in the south-west of Western Australia, where it has land and fire management responsibilities over crown (public) lands throughout the state.

These responsibilities include 26 million hectares of land including national parks, state forests, nature reserves, and other designations of public land. Each year the DEC aims to conduct prescribed burns over 6 % to 8 % of the 2.5 million hectares of forested lands within the DEC-managed estate. These burns have documented and quantified benefits in terms of enhancing community safety from wildfires and improving ecosystem health, diversity, and resilience. (Underwood *et al.* 1985, Abbott and Burrows 2003, Boer *et al.* 2009, Cheney 2010).

While the DEC's annual prescribed burning program of around 200 000 hectares has largely been maintained for 5 decades in southwest forest ecosystems, the achievement of this program has become increasingly difficult in recent years due to a drying climate, patterns of forest harvesting, changing land uses on adjoining private lands, and more stringent risk management requirements.

Land management agencies in California, in contrast to the DEC's successful prescribed burning program, struggle to treat the considerable backlog of fire-suppressed lands across the state (North *et al.* 2012) despite the fact that prescribed fires in mixed conifer forests have been shown to reduce fuels, improve habitat diversity, and improve ecosystem health in general (Stephens *et al.* 2012). The result is well known in the western US: large high-severity fires that threaten communities and leave large areas of forestland damaged by homogeneous tree mortality (Miller and Safford

2012), with the associated degradation of wild-life habitat, water quality, and general ecosystem functioning (Miller and Urban 2000).

In the following report, we will attempt to address some of the factors that lead to these differences in prescribed fire use. While keeping in mind that these two regions contain different landscapes and operate under different government laws and regulations, we still believe that many of the practices used in Western Australia to improve the outcomes of prescribed fire use can be implemented in California and throughout the western United States.

MANAGEMENT PRACTICES

In order to implement an annual prescribed burning program that aims to treat 200 000 hectares (about eight percent of public forested lands) each year, the DEC employs a number of management strategies:

Treatment Size

Prescribed burn units are generally much larger than those implemented in the western US, with burns averaging in excess of 2000 ha, with some as large as 10 000 ha. The widespread use of fixed-wing aircraft and helicopters for aerial ignition within the large treatment areas allows DEC fire managers to take advantage of the relative few safe burn windows of opportunity that are dictated by the narrow ranges of suitable weather, forest fuel moisture, and smoke dispersal conditions.

The large treatment blocks have a low perimeter to area ratio, which minimizes the boundary treatment and control costs per hectare treated. The variation in vegetation fuel types that usually exists within large blocks results in a greater range of fire intensity within each unit, creating a fine-scale mosaic of patch burns, fuel ages, and habitat types (Burrows 2003). The diversity of burn outcomes is not usually possible in small treatments, in which it is unsafe to leave large unburnt pockets of vegetation close to the burn perimeter.

Treatment Planning and Design

The DEC explicitly emphasizes the need to identify and use all potential burn windows to achieve its program through extensive planning and scheduling. Managers will use weekends and nights for prescribed burning, if conditions are favorable, and will have multiple burn plans in place in each region in order to be able to quickly implement treatments in which conditions and weather are suitable. Local and statewide monitoring of fuel moisture levels and weather conditions ensure that favorable burn windows are quickly identified and utilized. Statewide GIS mapping is used to coordinate potential treatments, and priorities are set prior to each fire season to ease planning time when burn windows become available. For example, by planning spring-time burns a year ahead, managers can prepare and burn the edges of the fire perimeters in the preceding autumn, allowing for the spring burns to be quickly and safely implemented when conditions allow.

Training and Coordination of Fire Crews

The limited availability of experienced crews sometimes limits the ability of Californian managers to implement prescribed burns. The DEC begins training new seasonal crews on prescribed fires in the spring burning season. This not only increases the workforce available to implement prescribed burning, but also provides an opportunity for new recruits to receive important on-ground training and experience prior to the summer wildfire season. The crews are highly mobile and are frequently moved between regions to assist with burns whenever conditions are suitable in different locations throughout the state. Daily morning and late afternoon teleconferences between all DEC regional and district fire coordinators ensure agreement on burn priorities and locations, and facilitate the effective and efficient coordination and deployment of crews and ignition aircraft to bolster local resources

on large prescribed burns. The DEC leases up to three aircraft (fixed-wing and helicopters) during the peak burning months to enable multiple burns to be conducted concurrently when the weather and fuel moisture conditions meet the burn prescriptions. These incendiary-enabled aircraft are supported by a fleet of nine fire spotting aircraft (owned by the DEC), which are very important for providing ground crews with fire behavior intelligence and assisting with burn security and patrol.

Staged Burning

When high fuel loads and complex vegetation associations present challenges to introducing fire safely, DEC managers will usually implement burns in multiple stages as different fuel components dry out. Initial ignitions will consume finer and exposed fuels, which dry out first, allowing later ignitions over the next month or so to consume sheltered and larger fuel classes without the fire burning too severely. Staged burning is also applied over a span of several days or even weeks within treatment areas containing a wide variety of vegetation types that dry out at different rates. For example: early drying fuels such as those in open forests or exposed ridges are burnt in first ignitions, whilst sheltered fuels under dense canopy or shaded aspects will be consumed in later ignitions. The multiple staged ignitions will continue with a close monitoring of fuel moisture and flammability in order to achieve the overall objective of a 60 to 90 percent burnout of the entire block. The controlled application of prescribed fires at each stage of ignition is made possible by the skillful use of fuel moisture and fire behavior prediction systems developed by DEC scientists (Sneeuwjagt and Peet 2008).

While interagency cooperation, cost, and employee time restraints each presents hurdles to these approaches in California, the DEC's pragmatic approach to burn planning and implementation presents a model worth emulat-

ing. Reintroducing fire across California's mixed conifer forests will be a challenge—many areas have very high fuel loads and have not experienced fire for 100 years. Because of this challenge, novel approaches—including some of those now used by the DEC in Western Australia—should be applied in California to treat the large backlog of fire-suppressed mixed conifer forests. These include: 1) scaling up treatment sizes, 2) pre-planning and coordinating treatments between agencies, 3) using past fires and natural features as anchor points for large treatments, 4) expanding training and fire staff capabilities, 5) improving fuel moisture monitoring and prediction to improve prescribed fire planning (Estes *et al.* 2012), and 6) exploring staged burning as a potential treatment method for large prescribed fires.

JURISDICTION AND COLLABORATION

The DEC has responsibility for fire management across all public lands in the state of Western Australia outside of the Perth metropolitan area. As an agency with integrated responsibilities, the DEC is able to plan and implement a coordinated program of prescribed fire treatments across all of these land types and jurisdictions.

Regional integration provides significant flexibility to fire planners in achieving strategic protection and ecological outcomes across the entire landscape. Unlike some other Australian states, California, and much of the US, Western Australia is able to streamline the bureaucratic process associated with planning, implementing, prioritizing, monitoring, and resourcing for fire and land management programs across all public lands.

It is clearly impossible to combine the many county, state, and federal land management agencies of California under one umbrella agency within a common jurisdiction. Nevertheless, Western Australia's example demonstrates the advantages that could come from improved statewide collaboration and plan-

ning. Sharing staff and infrastructure, prioritizing treatments across agencies, and using shared models and documentation of treatments would all serve to optimize the use of limited resources, particularly in times of decreasing budgets for land management.

The widespread adoption of the Interagency Fuels Treatment Decision Support System (IFTDSS) in California, which provides a shared platform for all public agencies to plan and analyze fuel treatments, would be an important step towards improved collaboration. By improving access to a common fire treatment modeling program and generating standardized burn plans across all agencies, IFTDSS has the potential to streamline treatment planning and documentation.

While the DEC is able work across arbitrary lines of jurisdictions to achieve coordinated fire treatment plans, public land management agencies in California do not have that capability. Concerted efforts to increase collaboration and coordination between agencies will be needed as budget decreases and a warming climate (Westerling *et al.* 2006, Safford *et al.* 2012) increase the strains placed on fire programs in California.

AIR QUALITY REGULATION

Cooperation

California fire managers often cite the regulation of smoke from prescribed fires as a major hurdle to the use of fire for fuels management. Often available burn windows, which are designated by regulators in local air pollution control districts, do not line up with favorable burning conditions (such as fuel moisture) on the ground. Additionally, different agencies or districts can find themselves in competition for the same burn windows, adding to the difficulty of securing a window for a planned burn.

DEC fire managers face fewer hurdles to collaborations with regulators due to the fact

that a separate arm within the DEC agency, the Air Quality Management Branch (AQMB), has responsibility for protecting and maintaining air quality in Western Australia. The AQMB works closely with and provides regular advice to other sections of the DEC, including fire operators and other state and local government agencies, to ensure that national air quality standards and thresholds are not exceeded. Similar to air regulators in California, they are held responsible for maintaining emissions and visibility below threshold levels for public health and safety. The key difference is that intra-agency collaboration between fire managers and air-quality regulators is the default, and is mandated by supervisors within the DEC. Despite the large amount of land burned annually by the DEC fire program, the sharing of responsibilities for smoke management policy and prescribed burn practices (by both the fire program and AQMB) have successfully led to a reduced incidence of undesirable smoke and haze within Perth city and most other major population centers in Western Australia.

The DEC model presents much fewer obstacles to collaboration than the situation faced by managers and regulators in California, in which regulators and managers from multiple agencies must go out of their ways to collaborate without a default impetus to work together. Increased regional collaboration with air quality regulators is needed ensure that all burn windows are used. Similarly, a formal system of coordination between land management agencies and air districts is needed to avoid competition for burn windows. The extensive pre-fire season planning, prioritization of treatments, and twice-daily region-wide coordination of DEC fire operations demonstrate that an organized inter-regional prescribed fire program can avoid competition for burn windows between land managers and ensure that no suitable burn windows are left unexploited. A similar approach in California would allow agencies to coordinate treatments before the

fire season as a means of ensuring that all available burn windows are used and that all agencies and districts would have access to them.

Though a complete reorganization of regulatory bodies and federal and state land management agencies is clearly unlikely, fire and air quality managers in California should view the Western Australian model of “collaboration by default” as a goal. Collaborative efforts by groups such as the Interagency Air and Smoke Council, the Northern California Prescribed Fire Council, and the emerging Southern Sierra Nevada Prescribed Fire Council show increasing progress in collaboration among agencies and regulators, as more stakeholders work together to help implement needed treatments and avoid regular large high-severity wildfires.

Regulatory Framework

Although challenges in collaboration, planning, and communication do present hurdles to implementing prescribed fire treatments in California with regard to air quality, regulatory policies themselves also present significant disincentives to prescribed fire use for landscape-level fuel treatments. Depending on the region within the state, certain public land management districts in California must pay per-area costs to Air Pollution Control Districts (APCDs) for both prescribed and managed wildfire treatments. Emissions from these management fires are counted towards air quality thresholds, and emissions above these thresholds are termed “exceedances” or “in exceedance”. The APCDs, under the Clean Air Act, must pay fines to the Environmental Protection Agency (EPA) when certain emissions exceed these thresholds.

However, the comparatively large amounts of emissions from unmanaged wildfires that are being actively suppressed are not counted towards air quality thresholds, as they are deemed “exceptional events” outside of human control (EPA 2012). Accordingly, wildfires

carry no smoke-related costs to public land management agencies or APCDs. This creates a situation in which public land agencies must pay for the smoke from prescribed fire treatments that address unnaturally high fuel loads in wildlands, yet bear no costs or responsibility for the wildfire smoke that results from the high fuel loads that prescribed fires are often used to reduce. Paradoxically, this regulatory framework creates a disincentive for the use of prescribed fire for fuel treatments that would lower the incidence of high-severity wildfires in mixed conifer forests, which tend to emit higher levels of smoke than prescribed fires (Ahuja 2006) and can coincide with worse air quality trends in the Central Valley.

To remove this disincentive, all APCDs in California should stop charging per-area fees to land management agencies. Instead, flat fees that cover an entire fire season should be used to help pay APCDs for staff and monitoring efforts, which help to identify burn windows for land management agencies (currently, some APCDs charge no fee, some charge flat fees, and some charge per-area fees for prescribed burns and managed natural ignitions). This would remove the often-prohibitive costs associated with using fire as a management tool to address the root cause of large high-severity fires at the landscape level.

The Western Australian DEC Air Quality Management Branch, as a separate arm of the same agency that also includes fire operations, does not charge any fees or penalties for smoke and haze exceedances. The Australian National Environment Protection Measures (NEPM) for fine particulates provides for up to five allowable exceedances of the national standards per annum in designated population centers in acknowledgement of the importance of prescribed burning for community protection (Department of Sustainability, Environment, Water, Population and Communities 2005a, 2005b). This approach was agreed on by the air quality regulators in recognition that prescribed burns do reduce the incidence and ex-

tent of large wildfires with associated heavy smoke emissions, while at the same time recognizing that prescribed burns can be scheduled and managed to minimize smoke impacts on vulnerable communities. While the DEC and other fire agencies aim to avoid such exceedances in Perth city and other major population centers, these allowances make it possible to undertake important burns that may cause smoke to affect the airshed surrounding these population centers.

RESEARCH INTEGRATION

In addition to being a model of manager-regulator cooperation, the DEC is highly successful at using manager-researcher collaborations in prescribed fire treatments. Since the early 1960s, the DEC has made a significant investment in an in-house applied research capability, recognizing the importance of rigorous science in underpinning its fire management program. DEC scientists have also collaborated closely with federal science organizations, including the CSIRO and the Bushfire Cooperative Research Centre, on important large-scale fire research projects in Western Australia (McCaw *et al.* 2003, Gould *et al.* 2008, Wittkhun *et al.* 2011).

Similar to their counterparts in the US land management agencies, DEC scientists closely collaborate and consult with fire practitioners to maintain an active program of research in order to better understand fire behaviour and fire ecology in a variety of ecosystems as a basis for good fire management. Because of the good working relationship and a long history of science-based management in the DEC, research findings and local knowledge are quickly taken up by DEC fire managers and integrated into field operations. As well as carrying out applied fire research, many DEC scientists are actively involved in fire management planning and suppression operations as part of incident management teams.

What distinguishes the DEC use of science is the extent to which managers and research-

ers collaborate. DEC scientists concentrate their studies on problems that have been jointly identified between managers, planners, and researchers. Although most studies are done on specially designed experimental burns that are controlled by local management staff, in some instances the studies are undertaken on prescribed burns, the ignition of which may be modified to facilitate the research inquiries.

For example, a high level of knowledge of the fire regimes needed to conserve threatened fire sensitive fauna species has been gained as a result of the monitoring of the response of these species and their habitats to variations in burn regimes. The threatened quokka (*Setonix brachyurus*), a small mammal that has known specialized life history attributes and habitat requirements, is an example for which modifications applied by fire managers to the burn frequency, burn season, lighting patterns, weather, and fuel conditions have provided scientists and managers with valuable information on fire management programs that provide sustainable populations (Burrows 2008). Another example of the close working relationship between scientists and managers is the Walpole Fire Mosaics project, a large-scale adaptive management operation designed to investigate the benefits to biodiversity of fine-scale mosaic burning in south-west forests. The steering group for this multi-disciplinary project is chaired by the local fire operations manager.

CULTURAL ACCEPTANCE OF FIRE

The large body of research on fire behavior and ecology specific to Western Australia also aids the DEC's efforts to improve the public acceptance of prescribed fire by grounding outreach efforts in peer-reviewed science.

Similar to California, the use of prescribed fire in Western Australia is a contentious issue, particularly among urban residents who may not be aware of the role and benefits of prescribed fire in protecting community assets and improving ecosystem functioning. While

some opposition to prescribed burning remains in Western Australia, there is now a generally high level of community support for the large burning program applied by DEC on crown lands throughout the state. The achievement of this support has been gained through a number of strategies:

1. Publicity about the ecological and community benefits of fire use through pre-season community briefings, neighbor contacts, stakeholder workshops, articles in DEC's *Landscape* magazine and other publications, local community newspapers, and the DEC website.
2. Provision of bi-annual public consultation maps of proposed burns, which offer important information on the location, size, purposes, and burn treatment strategies.
3. Creating direct event awareness through daily radio advisories on active fires and prescribed burns, and face-to-face outreach to neighbors and to nearby communities.
4. Support for the development and implementation of secondary and tertiary school curriculum, and field programs on fire management and associated land management programs.
5. Proactive involvement by key fire staff in media interviews and provision of opportunities for media to view prescribed burns and successes.
6. Hosting bushfire research forums designed to provide results and management implications of latest fire research findings to fire practitioners, researchers, and members of the public (Abbott and Burrows 2003).

Public land management agencies in California have been improving their public outreach to inform the public of the benefits of prescribed fire. Social media, in particular, has allowed some agencies to improve outreach

around large wildfire events. What is lacking is a concerted publicity campaign coordinated across agencies to demonstrate the benefits of prescribed fire treatments and justify their expanded use. This is no small task, but it will be necessary to counter the century-long narrative of fire suppression.

POLITICAL SUPPORT

The maintenance of firm political and community support for the Western Australian large burn program has been made easier as a result of the large amount of evidence showing that the prescribed burn use has resulted in very low incidences of loss of life and property from wildfire. These benefits from prescribed burning in Western Australia have been well documented through existing research (Gould *et al.* 2008, Boer *et al.* 2009, Wittkuhn *et al.* 2011) and public outreach efforts, and are essential in garnering and maintaining political and community support for the prescribed burn program.

Current and past state governments of both major political parties have strongly supported DEC's approach to active prescribed burn use. The proven success of the program in the long-term helps to consolidate this support, even when smoke from prescribed burns may occasionally impact the air quality in the Perth metropolitan area (population: 1.83 million) and other regional centers. This bi-partisan support has been important to DEC staff in the planning and implementation of prescribed burns that may be contentious to some members of the community, particularly those located at the urban-rural interface.

The political and community support for the fire program has been severely tested in recent times as a result of a serious escape from a DEC-managed prescribed burn in November 2011 that destroyed 32 residential and holiday homes nestled in a long-unburnt coastal heath shrubland near the community of Margaret River. Fortunately, no lives were lost in this

event. Since the inception of the prescribed burn program in Western Australia over 50 years ago, this was the first instance of a loss of homes from a DEC burn escape. As a result of these losses, a more stringent risk management assessment of the program involving other agencies has been implemented. Despite the community anxiety following this tragic incident, support for the continuation of an extensive prescribed burn program remains high.

Political support is maintained at high levels in the government through the provision of regular briefings and reports on fire management policies, strategies, achievements, and potential contentious matters to senior ministers, local members of Parliament, and local government authorities. When new key officials are elected or appointed, the DEC will familiarize them with the fire management program if they are not aware of it. This helps to ensure ongoing support from politicians.

Despite the large attention in the media paid to wildfire events in California, the vast majority of the public and politicians are not aware of the value of prescribed fire as a viable management tool for reducing fuel loads and improving ecosystem health and biodiversity. This is in part because California, unlike the DEC, lacks a track record of proven benefits from landscape-scale fire treatments with which to advocate for prescribed fire. Additionally, the century-long history of fire suppression in the state has created a powerful narrative that conflicts with the concept of using fire as a management tool.

Like public outreach, a concerted effort needs to be made, with the support of supervisors within the public land management agencies, to advocate politically for prescribed fire use. There is a litany of arguments in support of prescribed fire that would have political traction: firefighter safety, ecosystem services, and significantly lower costs than wildfire suppression, to name just a few. These benefits and others will need to be more fully quanti-

fied and publicized to communities and politicians if California land managers hope to expand fire treatments.

CONCLUSION

The management practices, highly organized planning, and collaborative endeavors with regulators, scientists, and politicians all serve to make Western Australia's prescribed fire program highly effective at both protecting communities from wildfire and encouraging ecosystem functions and biodiversity. Based on the DEC's successful program, we make the following general recommendations for California:

1. Management practices
 - a. Increase treatment sizes and seek out novel approaches to reintroducing prescribed fire in mixed conifer forests.
 - b. Undertake extensive pre-season planning to have multiple treatments "ignition ready" when burn windows are available.
 - c. Invest in the training of fire crews, and use fire crews for both fire suppression and prescribed fire treatments
 - d. Take advantage of recent wildfire or prescribed fire areas as strategic anchor points for subsequent burns.
2. Regional coordination. Standardize prescribed fire planning, documentation, and implementation practices as much as possible between agencies. This will allow for improved cohesiveness and collaboration, as well as cost reductions.
3. Air quality
 - a. Plan and coordinate treatments between land management agencies and districts to avoid competition for burn windows.

- b. Increase collaboration with air quality regulators to make sure that available burn windows are used.
 - c. All air pollution control district fees for prescribed burning should be flat, rather than based on area burned. This will avoid creating disincentives for fuel treatments that reduce the risk of high-severity fires and re-introduce the fundamental ecosystem process of fire into the landscape.
 - d. Emissions from prescribed fires in mixed conifer forests should qualify for exemption from air quality exceedances, as fire is a natural process in most of those forests in the state. Additionally, prescribed fires generally have less emissions than high-severity wildfires and can be timed to avoid periods of poor air quality.
4. Research
 - a. Expand collaboration between managers and researchers, particularly in testing the ecological effects, smoke management, and implementation methods of larger prescribed fire treatments in California. Multidisciplinary teams that include specialists in fire operations, ecology, and research should plan wildland fire use.
 - b. Expand fuel moisture and fire behavior monitoring and prediction systems to allow for effective multi-stage ignitions and safe burn-out in complex fuel types.
 5. Public outreach
 - a. Use science as the basis for outreach efforts: make research knowledge accessible to a variety of audiences. The work of the Joint Fire Sciences Program Regional Consortia shows considerable progress towards improving access to science, but more needs to be done to reach out to the public.
 6. Political support
 - b. Pursue and invest in a coordinated outreach effort between land management agencies to advocate for prescribed fire.
 - c. Use a variety of outreach strategies, including social media, printed publications, and local meetings. Seek out coverage in print and television.
- We recognize the significant challenges to implementing these recommendations in terms of bureaucratic inertia and limited budgets and staff availability. The alternative of the status quo, though, is unacceptable. Longer and more active wildfire seasons will become more likely each year from global warming (Westerling *et al.* 2006), and achieving ecosystem resilience and community safety will become increasingly costly as the backlog of fire suppressed lands continues to rise (North *et al.* 2012). The landscape-scale application of prescribed fire treatments presents a viable solution to making our landscapes resilient to high-severity fire, but it will take a concerted effort from the land management and regulatory agencies. The Western Australian DEC's fire program represents a highly successful program that has used prescribed fires to successfully manage a large landscape for community and environmental benefits, and can be used as a model for a similar program in California.

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