FIRE MANAGEMENT OF CALIFORNIA SHRUBLANDS

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ABSTRACT

Fire management of California shrublands has been influenced by policies designed for coniferous forests, however, in contrast to Western forests, fire suppression has not effectively excluded fire from shrublands and in most cases catastrophic wildfires are not the result of unnatural fuel accumulation. In addition, one of the primary drivers of large catastrophic fires is the coincidence of ignitions with extreme weather. As a result, there are limitations to the potential effectiveness of fuel management strategies. Due to the nature of fuel distribution in these crown-fire ecosystems, prescription weather conditions preclude burning at rotation intervals sufficient to reliably affect the control of fires ignited under severe weather conditions. Fire management strategies that attempt to create landscape scale age mosaics through prescription burning are not a cost effective method of controlling catastrophic wildfires. Pre-fire fuels management will likely have greater success focusing on intensive management along strategic buffer zones and moving away from measuring effectiveness strictly in terms of total area treated.

Continued urban sprawl into wildlands naturally subjected to high intensity crown fires is a major contributor to increased fire suppression costs and increased loss of property and lives. Fire management will need to play an increasingly active role affecting the planning process through (1) critical analysis of causal factors driving fire regimes and (2) better publicizing the limitations of fire hazard reduction. Fire management may need to consider designing strategies tailored to different regions as studies in central and southern coastal California indicate there are marked regional differences in fire regime. Presently far less is known about shrubland fire regimes from the Sierra Nevada and north coastal regions.

Keywords: Buffer zones, chaparral, coastal sage scrub, ecosystem management, fire history, fire management, prescription burning.

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INTRODUCTION

California shrublands are one of the most fire hazardous landscapes in North America because of dense contiguous fuels, summer drought, autumn foëhn winds, and an extensive urban/wildland interface. In contrast to much of the U.S., where, since the middle of the 20th century, fire suppression has produced dramatic reductions in area burned (Figure 1),

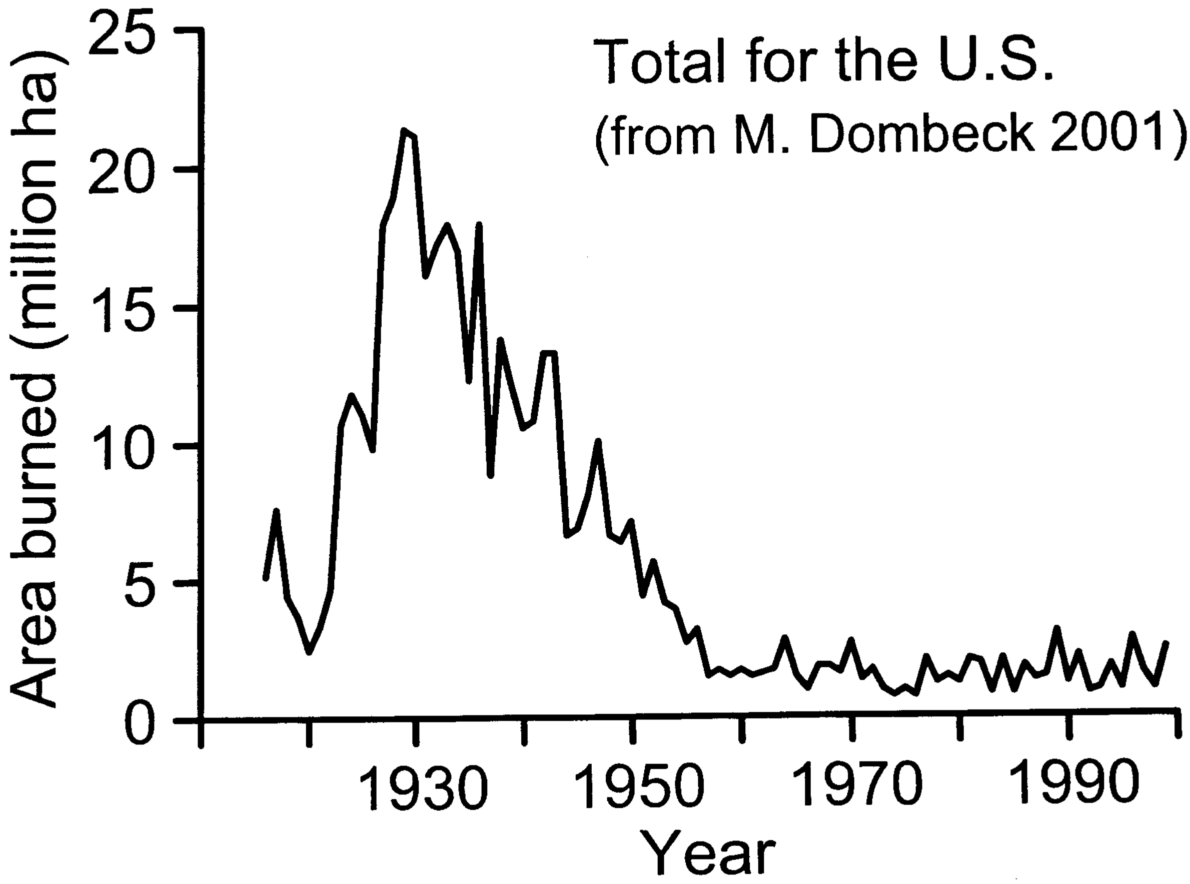

Figure 1. Total area burned in the U.S. during the 20th century (redrawn from Dombeck 2001).

California shrublands have continued to burn seemingly unabated (Figure 2). Indeed, since at least the middle of the 20th century, property losses from wildfires have increased every decade, despite concomitant increases in fire suppression expenditures, and in recent years there have been several wildland fires that have exceeded $1 billion in losses each (FRAP 1999).

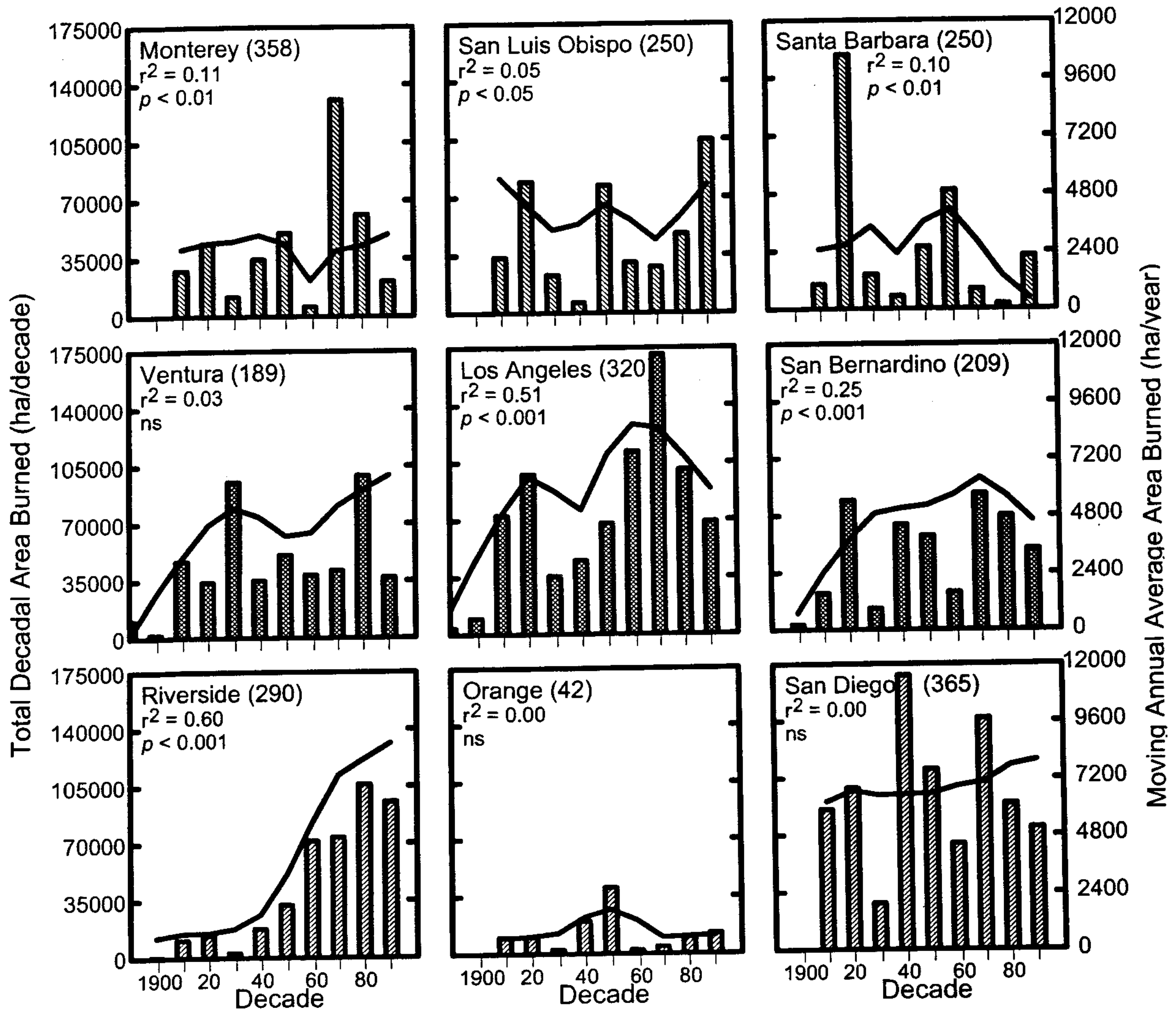

Figure 2. Area burned per decade and 10-year running annual average during the 20th century for 9 counties in central and southern California.[1]

Many have assumed that this fire hazard is unnatural and has developed because of fuel accumulation, arising from a century of fire exclusion (Dodge 1972, Bonnicksen and Lee 1979, Minnich 1983, Pyne 1995). This reasoning is a logical extension of the well-documented fire hazard in some western coniferous forests resulting from a century of fire exclusion (Agee 1993). Reduction of fire hazard in coniferous forests requires the reintroduction of fire through prescription burning and other fire management policies (e.g., Parsons and DeBenedetti 1979). Likewise, for California shrublands it has been proposed that there is an urgent need for massive prescribed burning, in order to reintroduce fire (Minnich and Dezzani 1991). Further, it has been suggested that creating landscape age mosaics through rotational burning can prevent large catastrophic wildfires (Countryman 1974, Minnich and Cho 1997, Minnich and Franco-Vizcano 1999). This fuel age hypothesis (Box 1) is reflected in fire management plans on shrubland dominated national forests in California (Conard and Weise 1998).

Ho:	Fire occurrence is constrained by the rate of fuel accumulation
Predictions:	Large catastrophic fires are a modern artifact due to fire suppression activities
	Large fires are dependent on old age stands of vegetation
	Landscape age mosaics created by prescription burning can prevent large destructive fires
Ha:	Fire occurrence is constrained by the juxtaposition of ignitions, adequate fuels, and weather
Predictions:	Large catastrophic fires are at best only weakly dependent on fuel age
	Coincidence of ignitions and severe weather are (and probably always have been) a primary determinant of fire size
	Age mosaics are not a reliable barrier to catastrophic fires

Box 1. Hypotheses on the primary drivers of fire in shrubland ecosystems.

The initial support for the fuel age hypothesis in chaparral shrublands was from modeling studies (Figure 3), which predicted that as stand age increases due to fire suppression, fire size increases. These models were interpreted to mean that prescription burning of small patches would create a landscape age mosaic capable of acting as a barrier to the spread of large

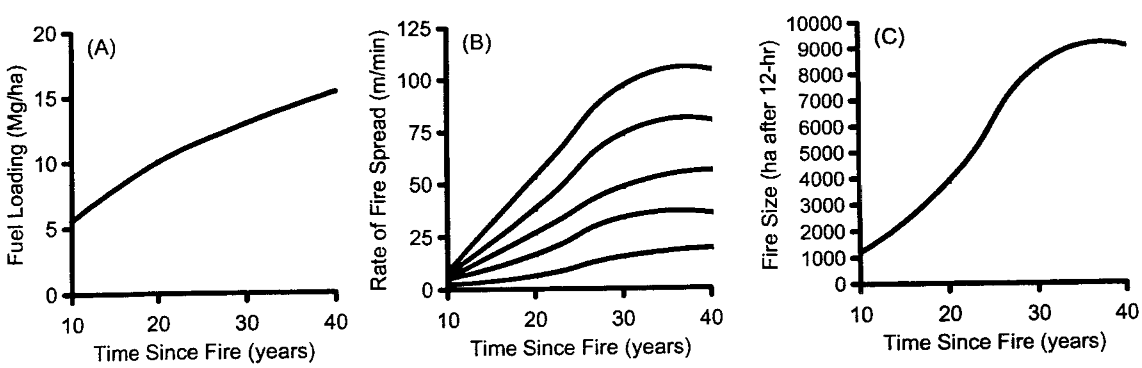

Figure 3. Modeling studies by Philpot (1974a, 1974b) with (A) assumed successional changes in fuel loads, (B) predicted rate of fire spread at increasing windspeeds from 10 to 50 kph, and (C) predicted fire size after 12 hours burning under sustained 50 kph wind speed.[2]

catastrophic wildfires. The primary support for this fuel age model has been a comparison of burning patterns north and south of the U.S. border (Minnich 1983, 1989, 1995, 1998, Minnich and Cho 1997). These studies reported a coarse grain pattern of large fires north of the border and a fine grain pattern of smaller fires south of the border. Although the conclusion that differences exist has been challenged (Strauss et al. 1989, Keeley and Fotheringham 2001a, 2001b), the primary problem is how to interpret burning patterns north and south of the border.

Minnich (1983, 1989, 1995, 1998) has assumed that the pattern of burning north of the border is the result of highly effective fire suppression activities, which have excluded fire and allowed an unnatural aging of chaparral. This assumption has largely gone unchallenged because countless fire history studies in western U.S. forests have shown fire suppression policy commonly results in fire exclusion. However, fire history studies of California shrublands have found that fire suppression has not excluded fire and as much or more area burns now than prior to vigorous fire suppression (Moritz 1997, 1999, Conard and Weise 1998, Keeley and others 1999, Weise et al. in press). These studies call into question the basic assumption behind the border comparison studies and make it doubtful that any differences in burning patterns north and south of the border can be held up as an illustration of the consequences of a fire suppression policy.

Likewise, two conclusions from the border studies are doubtful. One is that large destructive crown fires are a modern phenomenon, unknown on the California landscape prior to active fire suppression (Minnich 1989, 1995, 1998, Minnich and Dezzani 1991, Minnich and Cho 1997). Contradicting this conclusion is the fact that there has been no dramatic increase in large fires this past century (e.g., Figures 4A-B), and by the countless reports of large crown fires

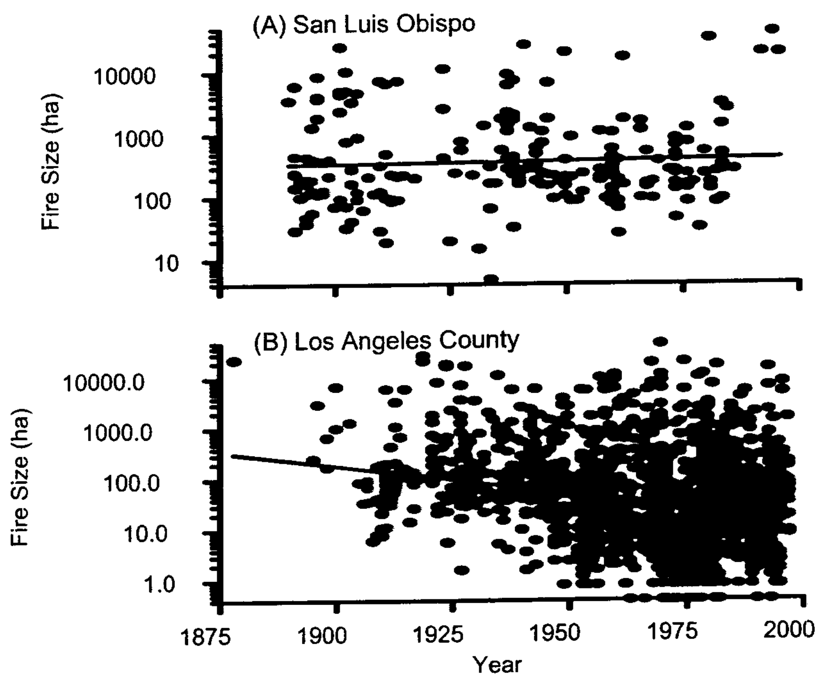

Figure 4. Fire size distribution during the 20th century in (A) the central coast and (B) southern California.[3]

in California shrublands during the 19th century (Kinney 1900, Barrett 1935, Brown and Show 1944, Brown 1945, Greenlee and Moldenke 1982, Greenlee and Langenheim 1990, Keeley et al.1999).

Another conclusion drawn from the border comparison studies is that shrubland fire regimes are constrained by the rate of fuel accumulation and are largely immune to external forcing functions such as severe fire weather (Minnich and Dezzani 1991, Minnich 1998, Minnich and Cho 1997). This is contradicted by studies north of the U.S. border that have shown fire hazard is either independent of age (Moritz 1999) or only weakly dependent up to 20 years (Peng and Schoenberg in press). Other evidence that fire behavior is not a deterministic function of fuel age is the fact that large catastrophic fires will readily burn through young stands and do not require old vegetation (Figure 5). For example one of the largest wildfires in California history was the 1970 Laguna Fire that burned over 10,000 ha of young age (5-20 years) classes (Dunn 1989).

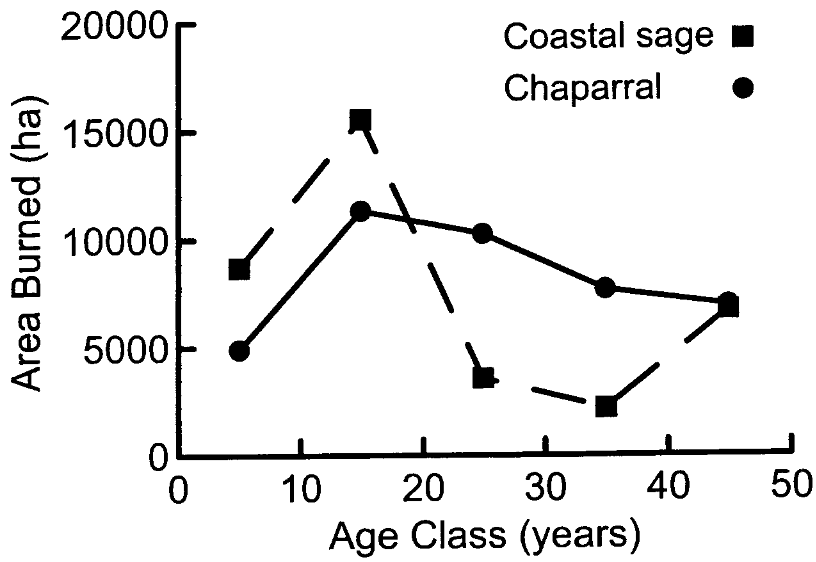

Figure 5. Age classes of chaparral and coastal sage scrub stands burned by all fires over 5,000 ha from 1967 - 1996 in the Santa Monica Mountains. [4]

Another example is the destructive 5,900 ha Romero Fire, half of which burned through 7 year age class fuels from an earlier fire (Gomes et al. 1993). In general, fuel age is of minimal value, either as a barrier to fire spread or for providing access for fire suppression forces, under weather conditions responsible for the most destructive wildfires. Almost without exception, the largest wildfires on shrubland dominated landscapes occur during severe fire weather conditions that include high temperatures, coupled with low humidity and high winds (Coffin 1959; Pirsko 1960; Schroeder et al. 1964; Weide 1968; Countryman et al. 1969; Phillips 1971; Countryman 1974; Dunn and Piierto 1987; Gomes et al. 1993; Davis and Michaelson 1995; Minnich and Cho 1997). These conditions are predictable events every autumn and are due to synoptic weather conditions that influence much of coastal California (Figure 6).

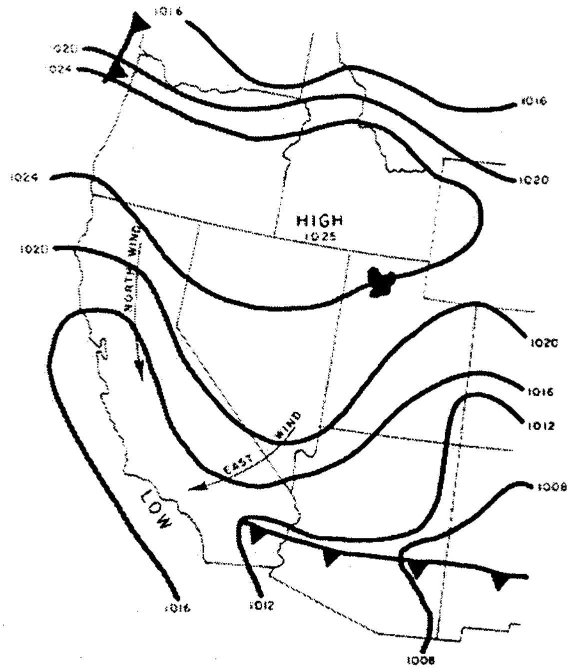

Figure 6. Surface weather map during the Great Basin high pressure airmass that generates foëhn winds in central and southern California (from Phillips 1971).

These findings strongly support fire management strategies that emphasize fire prevention and vigorous fire suppression, and raise questions about prescription burning programs that intensively treat landscapes with the goal of creating age mosaics.

PRESCRIPTION BURNING

Prescription burning may be justified as a means of enhancing natural resources as well as a means of reducing fire hazard. For example national parks consider resource benefits a primary goal of burning, whereas fire hazard reduction is typically the primary objective for the California Division of Forestry. Of particular importance is the reality that prescriptions reducing fire hazard may not always enhance resource values and sometimes may detract (Johnson and Miyanishi 1995).

Humans have long accounted for the majority of fires on shrubland landscapes in the coastal ranges and fire frequency has increased as populations have grown (Figure 7). Today fire rotation intervals throughout much of the region are far shorter than one might expect under natural conditions (Keeley et al. 1999, Keeley and Fotheringham 2001a). While lightning has long been a source of natural fires on these landscapes, it has been far less common and predictable then for many other parts of the Western U.S., for example for every 1,000 ha (2,470 ac) in Santa Clara County there is a lightning ignited fire only once every 200 years, and the pattern is similar up and down the coastal ranges (Keeley, 1982). There is little reason to expect ecosystem health in this region is suffering from a lack of fires, particularly because even the most fire-dependent shrublands are extraordinarily resilient to long fire-free periods (Keeley 1992). Therefore, by and large, there would seem to be little justification for using prescription burning for restoring the "health" of shrubland ecosystems. Of course, there are undoubtedly pockets of vegetation throughout this highly fragmented landscape that may stand as exceptions

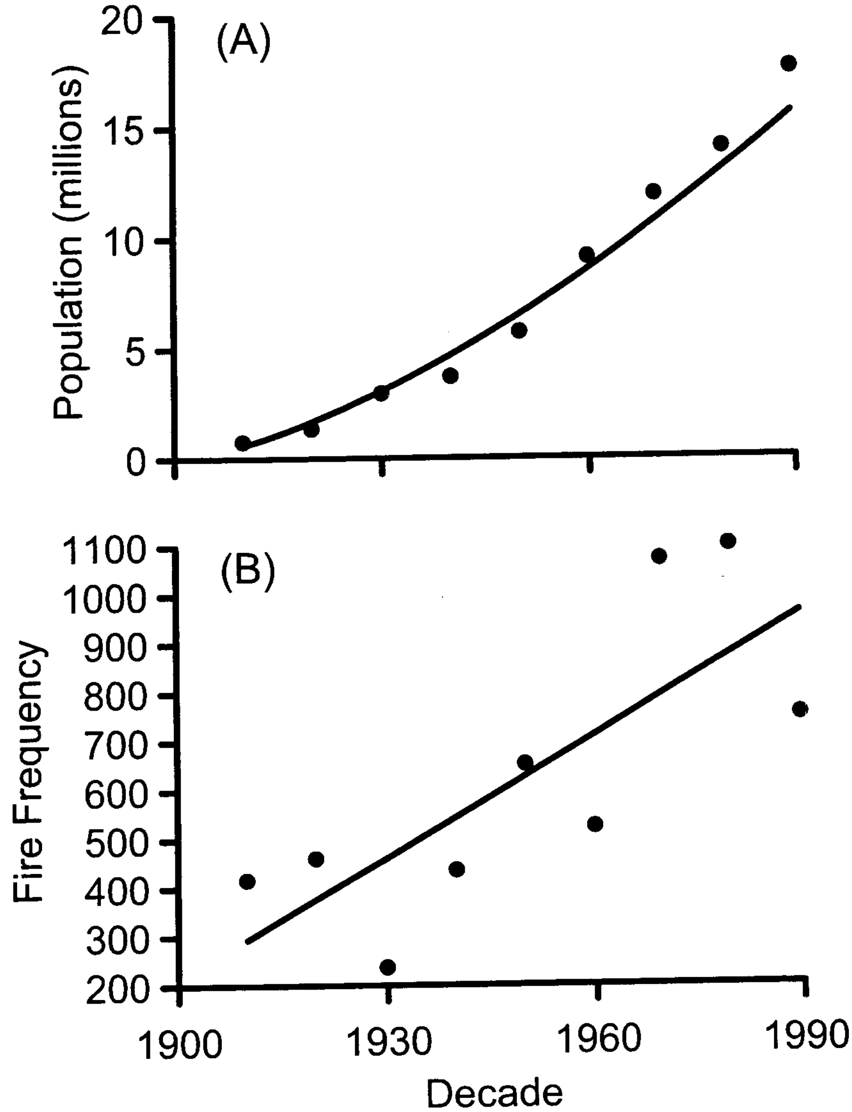

Figure 7. Twentieth century patterns of (A) population growth and (B) fire frequency from the central and southern California (includes all counties shown in Figure 2). Population data from the U.S. Department of Commerce, http://www.census.gov/populations/cencounts/ca190090.txt. Fire data source indicated in Figure 2 legend.

to this generalization. Other resource benefits from prescription burning include invasive plant control, but the primary invasive problems largely involve herbaceous species, which are favored by increased disturbance frequency (Keeley in press).

Most would agree that the primary justification for prescription burning in California shrublands is fire hazard reduction, and this is commonly accomplished by reducing fuels with prescription burning on a rotational basis. However, serious examination of prescription burning limitations and its consequent impact on constraining catastrophic wildfires is needed.

In selecting the rotational interval three factors are considered:
(1) Ability of trained personnel to contain the fire within pre-determined boundaries,
(2) Capacity of the vegetation to ignite and spread fire, and
(3) Effectiveness at reducing fire hazard.

Balancing these factors has been done quite successfully in coniferous forests where prescription burning is increasingly used as a means of reducing understory vegetation and other surface fuels. However, problems arise when applying prescription burning to crown-fire ecosystems such as California chaparral (Countryman 1974, Leisz and Wilson 1980). Often the limitations imposed by meeting the first two of these factors limits the effectiveness of prescription burning programs. In short, prescription burning can only be done safely under weather conditions that require mature chaparral, 20 years of age or more (Green 1981), but stands this age and younger will not form effective barriers to fire spread under severe weather conditions (Figure 6). Landscapes managed by such rotational burning may contribute to easier containment of fires burning under moderate weather conditions (e.g., prescription burn weather), but are of limited help under severe weather conditions (e.g., the annual autumn foëhn winds). However, it is these latter fires that become truly catastrophic and are responsible for the greatest losses of property and lives.

These considerations should not be interpreted to mean that prescription burning has no place in fire management of shrubland ecosystems, but only to emphasize the limitations to its effectiveness. Landscape scale rotational burning is unlikely to ever be a viable management strategy, both because it is ineffective against the most dangerous fires, and because it is neither economically feasible nor possible within the temporal window of burning opportunity constrained by air quality restrictions (Conard and Weise 1998). Although of minimal value in stopping fires under severe conditions, prescription burning may aid fire suppression under other conditions. The primary advantage to rotational burning is not because young age classes by themselves block the spread of fires but rather because they provide fire suppression forces with access to fires. Therefore, it would seem that strategic location of prescription burns is more critical than the sheer acreage burned. Therefore widespread prescription burning to create landscape age mosaics has less potential for success than the strategic placement of prescription burns that focus on well known fire corridors. This strategy also poses the least risk of unnaturally high fire frequency to shrubland resources, many of which are already threatened by unnaturally high fire return intervals (Keeley 2000).

CONCLUSIONS

California shrublands are just one of a number of vegetation types that typically burn in stand-replacing crown fire regimes largely driven by severe fire weather rather than by fuel accumulation (Bessie and Johnson 1995, Agee 1997). The costs associated with brushland fires in California have been steadily increasing for decades (Bonnicksen and Lee 1979, Kinney 1984, FRAP 1999). Bonnicksen (1980) pointed out that there was no relationship between fire control expenditures and area burned in California shrublands and claimed that this clearly indicated that the fire-exclusion policy was in error because it was responsible for the steady accumulation of older and older fuels. But, this conclusion rests on the assumption that the policy of fire suppression has actually worked to exclude fire, whereas in reality fire suppression has not effected fire exclusion in this region. Rather than increased expenditures being the result of an increasingly worse fuel situation, it would appear that increased expenditures are tied to increasing numbers of fires, which are tied to population growth (Figure 7). Increasing losses of property and lives is the result of continuing expansion of urban development into the high fire hazard wildland environment, placing more and more people at risk.

These facts point to the need for continued fire prevention to reduce the likelihood of ignitions during the annually-predictable severe fire weather known as Santa Ana, Mono, Northeastern, or Diablo winds (Schroeder and others 1964). In addition, it is apparent that current fire suppression activities are barely staying ahead of the increasing human ignitions on this landscape (Keeley 2001). It seems logical that constraining the rapidly expanding urban/wildland interface is critical to keeping fire hazard from getting worse on this landscape. Despite the likelihood that large wildfires will remain a feature of our landscape, there are management strategies that could limit its impact on the loss of property and lives. Most obviously would be different land planning that manages for limited human use in high-risk areas. Fire researchers and managers have an obligation to educate land planners and politicians to the causal factors driving catastrophic fires and the limitations to fire hazard reduction (Sapsis 2001). This is particularly important in light of trends towards increasing rural population growth (Bradshaw 1987).

NOTES

1. Fire data from the Statewide Fire History Data Base, California Department of Forestry, Fire and Resource Assessment Program (FRAP), Sacramento, CA, which includes historical fire records from the U.S. Forest Service national forests, California Division of Forestry ranger units and other protected areas, plus city and county records; minimum fire size recorded varied between 16 to 40 ha, dependent upon the agency). Shrubland area in 1000s of hectares shown in parentheses following the county name (from Callaham 1985).

2. From these models it was concluded that as chaparral stands increase in age due to fire exclusion, there is a resultant increase in fuels, fire spread rate, and fire size. Following suggestions by Countryman (1974), these models were interpreted to support a fire

management policy that relied heavily upon prescription burning to produce a landscape comprising a mosaic of age classes.

3. Data from source indicated in Figure 3 legend

4. (data from the U.S. National Park Service, Santa Monica Mountains National Recreation Area, Thousand Oaks, CA). Greater burning of young age classes of coastal sage scrub is likely due to more flammable fuels, longer fire season and the concentration of this vegetation adjacent to urban centers which are major sources of ignition.

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