MANAGEMENT OF FIRE REGIME, FUELS, AND FIRE EFFECTS IN SOUTHERN CALIFORNIA CHAPARRAL: LESSONS FROM THE PAST AND THOUGHTS FOR THE FUTURE

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ABSTRACT

Chaparral is an intermediate fire-return interval (FRI) system, which typically burns with high-intensity crown fires. Although it covers only perhaps 10% of the state of California, and smaller areas in neighboring states, its importance in terms of fire management is disproportionately large, primarily because it occurs in the wildland-urban interface through much of its range. Historic fire regimes for chaparral are not well-documented, partly due to lack of dendrochronological information, but it appears that infrequent large fires with FRI of 50–100+ years dominated. While there are concerns over effects of fire suppression on chaparral fire regimes, there is little evidence of changes in area burned per year or size of large fires over this century. There have been increases in ignitions and in the number of smaller fires, but these fires represent a very small proportion of the burned area. Fires in chaparral seem to have always burned the largest areas under severe fire weather conditions (major heat waves or high winds). Patterns of fuel development and evidence on the effectiveness of age-class boundaries at stopping fires suggest that, while fire in young stands is more amenable to control than that in older stands, chaparral of all ages will burn under severe conditions. We recommend a two-part strategy of: 1) establishment of strategically placed dynamic fuel management zones in wildland areas to provide access and opportunities for fire control, and; 2) intensive fire risk management zones (managed and developed cooperatively with local agencies and landowners) to protect values in the wildland-urban interface.

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INTRODUCTION

Appropriate management of fire and fuels in southern California is a complex problem that crosses traditional disciplinary boundaries and requires integration of social and biological issues. The relationship between past and present fire regimes and how they are impacted by changing ignition and suppression patterns is not well understood. The impacts of fire regimes on ecosystem processes and environmental quality (vegetation development, erosion and hydrology, air and water quality, endangered species populations and habitats) are not well-documented. Our knowledge of fuel characteristics and their importance to fire behavior is incomplete. We must be realistic about the benefits and difficulties of wide-scale prescribed burning. And we must address the special concerns of managing chaparral fire regimes in areas with large wildland-urban interfaces. The impacts of management objectives on ecosystems and society need to be clearly identified. It is critical to evaluate alternative strategies for achieving those objectives, especially in light of air quality and other environmental concerns surrounding prescribed fire, and the practical hazards of conducting prescribed burning in chaparral vegetation, where the natural fire regime is one of high-intensity stand-replacement fire. This paper reviews the state of our knowledge of chaparral fire regimes and discusses the implications of possible strategies for fuel and fire management in southern California chaparral.

Chaparral is a complex of shrubby vegetation types, characterized by evergreen sclerophyll shrubs in genera such as *Adenostoma, Ceanothus,* and *Arctostaphylos,* that dominates many sites at low to middle elevations throughout California, and into Arizona and Mexico as well (Barbour and Major 1990, Rundel and Vankat 1989). Notable for its intense fire behavior, chaparral has been classified as an intermediate fire-return interval system (FRI of 20–100 years) that typically burns in stand-replacing crown fires. Much of the chaparral occurs on steep topography, with slopes exceeding 100% not uncommon. Concern over fire management in these ecosystems is often driven by the proximity of many chaparral areas to major population centers and the tendency of chaparral fires to cause tremendous property damage and impacts on air quality, water quality, recreational opportunities, animal habitat, erosion, and sedimentation (Spittler 1995).

It is primarily the desire to lessen the societal impacts of chaparral fires that is the driving force behind fire suppression and fire management in many chap-

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arral ecosystems. There is considerable controversy over the effects of fire suppression in chaparral ecosystems and about the most appropriate ways of minimizing the negative impacts of fires, such as flooding, mudslides, and residential home destruction, while preserving healthy ecosystems. We will examine many assumptions and conclusions concerning fire in chaparral in light of existing and new data and propose alternative management schemes.

HISTORICAL FIRE REGIMES IN CHAPARRAL

Dendrological data on historical fire regimes in chaparral before this century are sparse or nonexistent because above-ground stems are generally burned or killed in fires. However, we believe that sufficient information exists to draw some inferences about past fire regimes and how they might have been affected by changing ignition and suppression patterns. Byrne et al. (1977) and Byrne (1978) examined charcoal deposits in cores of varved sediments from the Santa Barbara Channel to try to reconstruct historical large-scale fire patterns on the Los Padres National Forest. In a calibration core covering the years 1931 to 1970, for which good fire records exist, they found good correlations between years of high charcoal inputs and large fires in the front range of the Santa Lucia Mountains, and weaker correlations (delayed by a year) with occurrence of large fires in drainages farther from the coast. They used these relationships to analyze a core that covered about 150 years in the 16th and 17th centuries, and concluded that, over the period of the cores, there had been a large fire about every 20 to 40 years. As the entire area would not have burned in each of these fires, this might translate into a fire-return interval of somewhere around 50 to 150 years. Minnich's (1989) estimate of a current 70-year fire-return interval, which is based on mapped fire perimeters from 1920 to 1971 for chaparral sites in San Diego County, does not seem inconsistent with this.

Some have postulated that fire suppression has drastically altered chaparral fire regimes (Minnich 1983, 1987, 1989, Minnich and Dezzani 1991). It is postulated that effective initial attack has eliminated the fuel-reducing influence of long-term, small fires resulting in brief, large conflagrations that burn more area than occurred historically. We do not find supporting evidence for this hypothesis in chaparral. Since fire suppression was not widely effective until probably the 1930's or later, resulting increases in fire-return intervals (decreases in area burned), or changes in fire size or seasonality, should produce visible trends over the course of this century. Radke et al. (1982) reported on areas burned by decade for the Santa Monica Mountains from 1919–1980. They show a pattern of alternating decades of high and low areas burned (lows of 4,000 to 10,000 hectares for the decades ending in 1930, 1950, and 1970; highs of 20,000 to 26,000 hectares for the decades ending in 1940, 1960, and 1980), but no long-term trend in area burned is visible.

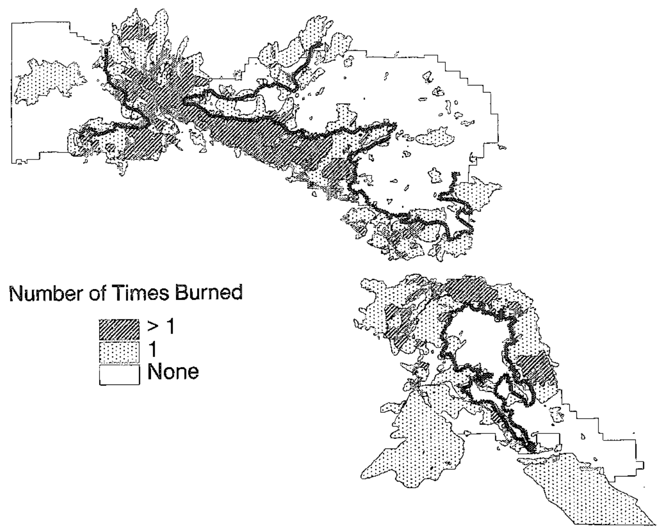


Fig. 1. Fires between 1911 and 1980 in the chaparral zone of the San Bernardino Mountains portion of the San Bernardino National Forest. Areas that burned once during the time period are shown in dots. Areas that burned more than once are cross-hatched. The heavy black line denotes the upper boundary of the chaparral zone.

The San Bernardino National Forest shows a similar pattern. From 1911 to 1980, about 85% of the chaparral area in the San Bernardino Mountains was burned (Figure 1), some of it as many as three times (data on file at San Bernardino National Forest). At this rate, it will take about 80 years for all of the chaparral in the San Bernardino Mountains to burn at least once; again, an average fire-return interval of about 50–70 years does not seem unreasonable. If we look at maps of fire areas by decade for the entire San Bernardino National Forest, where the fire data are dominated by chaparral fires (Figure 2), no clear patterns emerge of areas burned or of fire size. While these maps do not show individual fire boundaries, by and large, in a decadal time frame, individual fires show up as discrete patches. Furthermore, it appears quite clear that large fires were common in the 1910's through 1930's, just as they are today. The major evidence of changing fire regimes in the San Bernardino Mountains is the relatively high fire frequency in a zone that corresponds to the railway line and freeway across Cajon Pass (Figure 1). We attribute this to increased ignition frequency, primarily associated with the railroad and highways that cross the pass in this area. Minnich (1983) also documented extremely high ignition rates and acreages burned at Camp Pendleton Marine Base, largely as a result of military munitions exercises. Between 1972 and 1980, 46.8% of Camp Pendleton burned (Minnich 1983). This is over six times the percentage of area burned for other chaparral and coastal sage sites in southern California during the same period and would translate into a local fire-return interval of 19 years for that period. Data from the San Bernardino National Forest illustrate that little change in number of mapped fires has occurred since the 1930's (Figure 3a). During the same period, regional population and access to remote areas have increased.

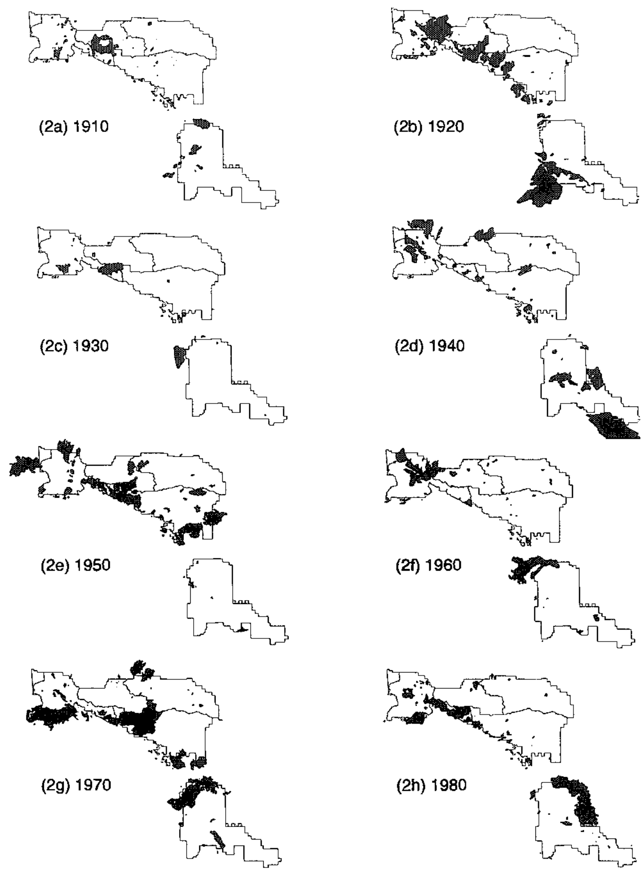


Fig. 2. Areas burned by decade for the San Bernardino Mountains and San Jacinto Mountains portions of the San Bernardino National Forest. Dark areas are actual fire perimeters.

Parallelling the changing ignition load has been a huge growth in fire suppression activities, beginning with mobilization of large numbers of ground crews in the 1930's and expanded to include use of aerial fire suppression in the 1950's (Cermak 1996). In the balance between these opposing changes, there is no evidence of trend in the annual area burned (Figure 3b) between 1910 and the present, as we would expect if fire suppression had been successful in altering average fire-return intervals. The major obvious change appears to be a decrease in average fire size (Figure 3 c,d) in the later half of this century. This would be expected as a result of the success of fire suppression at controlling most fires at very small sizes, and provides little insight into the patterns of the large fires that burn the majority of the area. Fire size class distribution by decade, reported by Minnich (1983), for the southern California region shows no evident trends in fire size or in numbers of fires for fires greater than 40 hectares over the period 1911–1980 (Figure 4a, b), supporting the hypothesis that the decrease in fire size is driven primarily by larger numbers of very small fires.

Most of the area burned in southern California chaparral is in the fall months (e.g., Radke et al. 1982). This coincides with periods of high offshore winds (Schroeder et al. 1964), known as either Santa Anas or Sundowners, depending on the location. While Santa Ana winds can occur in essentially any month but August, the greatest frequency and duration is in the fall months, from September to December, with a peak in October through December (Schroeder et al. 1964, Weide 1968). The frequency and intensity of Santa Ana winds decreases from north to south in southern California (B. Meisner, personal communication). If Santa Ana winds are the primary cause of large chaparral fires, we would expect the occurrence of large fires to decrease southward through southern California and into Baja California.

Under natural conditions, lightning would have been the primary ignition source for chaparral fires. Minnich (1988) summarized lightning ignition data for the San Bernardino Mountains over a 15-year period, and found the greatest frequency of ignitions in July (average of 19/year) and August (27/year). However, it was not uncommon for significant numbers of ignitions to also occur in September (5/year) and October (2/year), and occasional ignitions were reported even in November and December. While lightning fires in July and August are generally kept to fairly small sizes by fire suppression, under natural conditions some of these fires would likely have held over in canyons, tree stumps, etc. for several weeks or months and provided ignition sources for wind-driven fires in the fall months (Minnich 1987). Minnich (1987) documented a pattern such as this for three fires in the Mount Wilson area during the late 1800's (1896, 1898, 1900). These fires ignited in late July and late August and burned for several months, with periods of smoldering or slow progression alternating with aggressive runs when weather became hot or windy.

While most fires in chaparral are currently caused by human ignitions (an average of 72% of all fires on the San Bernardino National Forest are human-caused), a significant percent are caused by lightning. Keeley (1982), for example, reported that 19% of the lightning-caused fires in California were in chaparral during the 1970's. It appears likely that human ignitions in the fall may simply have replaced held over unsuppressed lightning ignitions in summer as the primary mechanism for generating ignition sources during periods of high fire hazard. Even though most of the acreage in southern California chaparral is now burned in human-caused fires, it is unlikely that there has been a large shift in the seasonality of the large fires that burn most of the acreage. Based on Strauss et al. (1989), the largest 10% of the fires in southern California burn over 90% of the acreage. These large fires typically are associated with severe fire weather conditions that prevent effective suppression. Minnich (1983) estimated that, between 1972 and 1980, over 70% of the area burned in southern California chaparral was burned after September 1. Large burned areas were almost always associated with high winds. Even mature chaparral (especially the broad-leaved mixed chaparral types) is relatively nonflammable except under conditions of very low fuel moisture or high winds (Philpot 1977).

At this point we find no evidence that fire suppression has significantly altered landscape-level fire

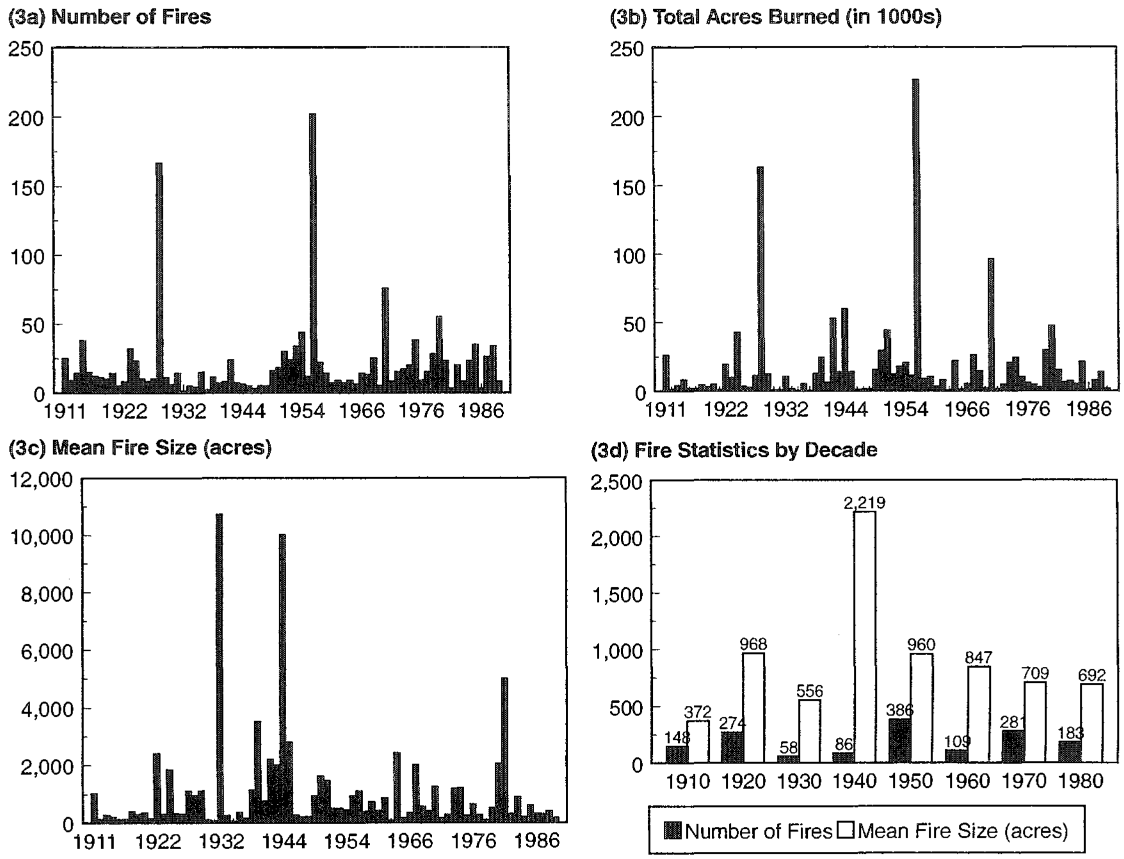


Fig. 3. Annual number of fires (3a), acres burned (3b), mean fire size (3c); and number of fires and mean fire size by decade (3d) for the San Bernardino National Forest from 1910–1990.

regimes in southern California chaparral. Suppression appears, in fact, to have been an essential factor in maintaining something approximating historical fire regimes in the face of increased ignition loads. This conclusion runs counter to the hypothesis of Minnich (1995) that fire regimes in southern California chaparral are largely fuel-driven, rather than ignition-driven. In areas of very high ignition loads (e.g., Cajon Pass, Camp Pendleton), fire frequency seems to be substantially higher than in other areas, supports the idea that fire-return interval would be to a large extent ignition-driven in the absence of active fire suppression. Fires at Camp Pendleton and Cajon Pass are actively suppressed. Therefore, we do not expect that there have been negative ecosystem impacts from fire suppression in chaparral. On the contrary, it is more likely that there would have been negative impacts in the absence of active fire suppression as a result of greatly decreased fire-return intervals.

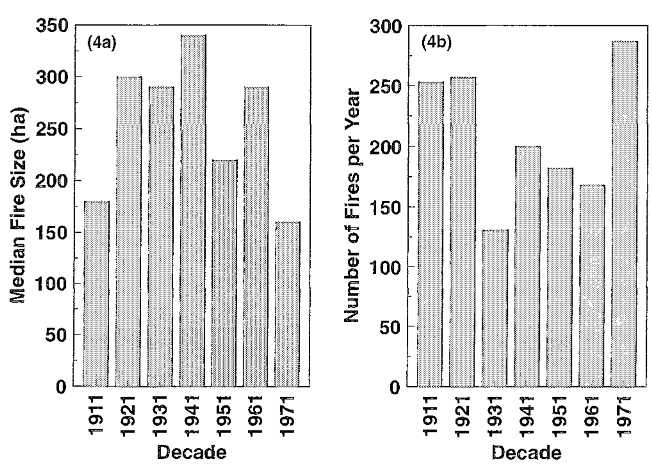


Fig. 4. Median fire size (4a) and average annual number of fires (4b) by decade for the four southern California national forests. Only fires greater than 40 hectares are included. Data based on Minnich (1983). Median and mean fire size were estimated by recreating an empirical distribution from Minnich's (1983) data which were separated into fire size classes.

FUEL DEVELOPMENT IN CHAPARRAL

Patterns of fuel accumulation and flammability in chaparral must also be considered in the context of fire management. General trends are for fuels to increase after fire (Figure 5) and perhaps for the rate of increase in biomass to begin to level out after 20 to 40 years. However, it is important to note the great variability in biomass of mature stands and in rates of fuel accumulation. As chaparral stands mature, it has generally been held that there is a gradual increase in dead fuels (about 1% per year) that is a major cause of increasing flammability (Green 1981, Rothermel and Philpot 1973). This assumption has been incorporated

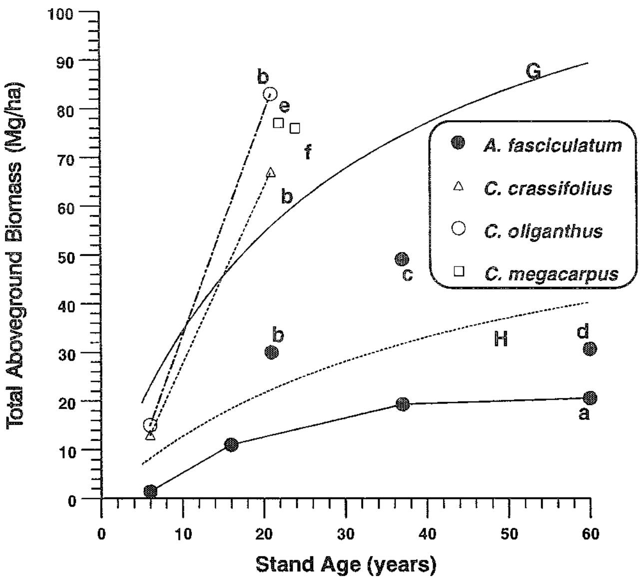


Fig. 5. Biomass accumulation in southern California chaparral as related to stand age. Sources for data: a. Rundel and Parsons (1979); b. Riggan et al. (1988); c. Specht (1969); d. Stohlgren et al. (1984); e. Schlesinger and Gill (1980); f. Gray (1982); g, h. Rothermel and Philpot (1973), fuel models for mixed chaparral and chamise chaparral, respectively.

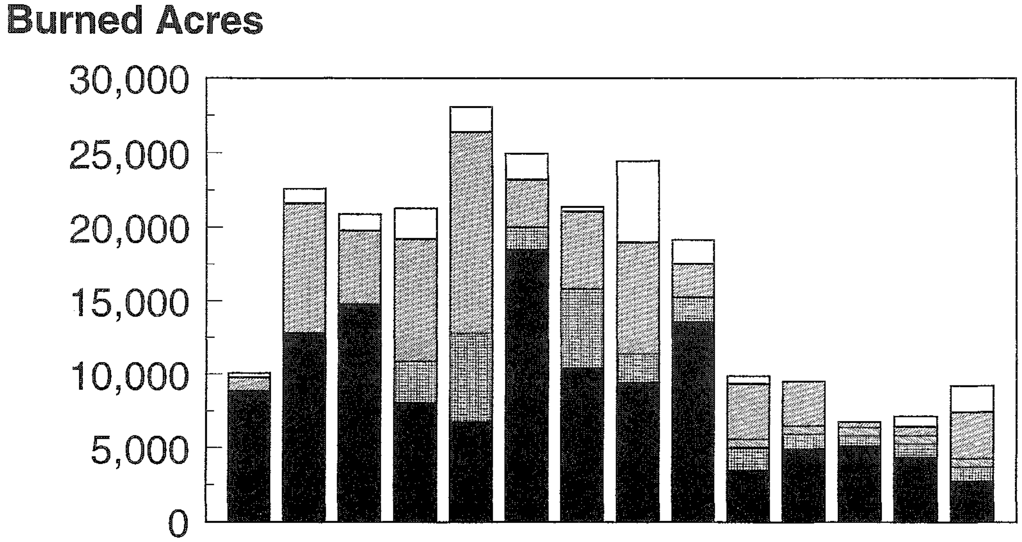
into the basic fuel models for chaparral used to predict fire behavior, and has been a basis for chaparral management strategies (Philpot 1974, Cohen 1986). More recent research, however, has cast doubt on this general model. Paysen and Cohen (1990) found no general age-dependent regional relationships for accumulation of dead material in chamise chaparral. In fact, resampling of one stand at 33 and 55 years showed no significant changes either in percent dead or in fuel size class distribution. Percent dead of stands 31 to 55 years old ranged from 25 to 30%. Evidence points to a likely overprediction of percent dead in this model for many older stands. Studies throughout southern California (Hardy et al. 1996, Riggan et al. 1988) have occasionally found percent dead values up to about 45% but, at least for stands 21 to 35 years of age, extremely high within and between site variability is common, with typical values of 5 to 35% for both chamise and *Ceanothus*-dominated sites (e.g. Paysen and Cohen 1990, Riggan et al. 1988). Montygierd-Loyba and Keeley (1987) also report high vigor and small amounts of dead material for old stands of mixed chaparral in the Santa Monica Mountains.

While wind is recognized as an important factor contributing to fire spread (Wilson 1962), the factors that govern fire spread in chaparral and other live fuels are not well understood (Cohen et al. 1995, Martin and Sapsis 1987, Weise et al. 1991, Weise and Biging 1997). Clearly, as fuel accumulates, we expect an increase in intensity and spread rate of chaparral fires (Philpot 1977), however, it is important to note that under conditions of high winds and low fuel moisture, both fire spread model outputs and documentation from individual fires show that chaparral stands of any age can burn. Dunn (1989) investigated the fire records for San Diego County from 1940–1984, and found that in 11.6% of fires greater than 400 hectares, at least 400 hectares of chaparral that burned were less than 20 years old. In 59% of these 17 fires, over 30% of the area burned was in young age classes (average of 14 years old). In 18% of these fires, over 70% of the area was in young fuels (average age 15 years). The age of young fuels burned ranged from 5 to 20 years. These fires typically occurred under southwest flow or Santa Ana conditions, and therefore would have been associated with hot weather and/or high winds. Although this is admittedly a biased sample, it illustrates that young fuels will burn quite readily under high hazard conditions. And most large fires are under conditions of high wind that favor fire spread through all age classes. Frontal attack on wind-driven fires in chaparral is not particularly effective or safe. However, moderate fire intensity associated with lower age class fuels provides better access for crews and other ground-based suppression actions. The most careful analysis we have found in the literature is an analysis of the factors that determined the fire boundary in different areas of the perimeter of the 1985 Wheeler fire (Dunn and Piirto 1987). They concluded that 47% of the boundary was established by burnout operations (most of which were either from roads or existing fuelbreaks), 14% was due to fuel type changes, 9% to obstructions, 11% to weather changes (areas affected by marine air), and 10% to direct attack. They also observed that the fire burned around an earlier (1984) burn, but that neighboring burns that had occurred 10 years previously appeared to have no effect on fire perimeter. This analysis points up the value of a fuelbreak system (including roads) in providing access for burnout operations and other defensive actions in chaparral wildfires. Dunn and Piirto (1987) speculate that if there had been a fuel break system in the central area of the fire, it might have been kept to a considerably smaller size.

While large fire size and occurrence in chaparral do not appear to have changed in this century of fire suppression, property damage, costs of sediment management, impacts on water quality and other negative societal impacts from chaparral fires are still unacceptably high. There is still the issue of how to best manage fire size and intensity to minimize negative social and economic impacts (including the costs of fire suppression!). Furthermore, it is important to recognize that even if large fires are natural they may not necessarily be desirable from a societal point of view. Some management of fire size and distribution across the landscape, within the natural range of variability for chaparral, is desirable to minimize negative societal impacts while maintaining healthy ecosystems.

STRATEGIES FOR FIRE MANAGEMENT IN CHAPARRAL

Current forest plans for the four southern California national forests (Los Padres, Angeles, San Bernardino, Cleveland) emphasize the use of extensive pre-



	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
State VMP	8,900	12,873	14,808	8,090	6,813	18,549	10,451	9,485	13,548	3,463	4,935	5,154	4,375	2,778
Angeles				2,836	6,040	1,516	5,435	1,980	1,755	1,590	1,020	714	932	953
Cleveland										574	574	574	574	574
Los Padres	923	8,780	5,006	8,315	13,555	3,170	5,212	7,552	2,260	3,760	3,005	330	600	3,162
San Bernardino	282	961	1,075	2,069	1,672	1,725	308	5,460	1,600	514	0	0	678	1,791

Fig. 6. Areas treated with prescribed fire for the four southern California national forests and the California Department of Forestry Vegetation Management Program (VMP) 1981–1994. Data unavailable for Cleveland NF prior to 1990 and for Angeles NF prior to 1984. Data compiled from National Forest and California Department of Forestry sources.

scribed fire to divide the fuel matrix into a mosaic of age classes in an attempt to manage the size of fires in chaparral (USDA Forest Service undated a, 1987, 1988, undated b). These plans typically call for rotational burning of chaparral on a 20- to 50-year fire-return interval. The current forest plans call for a target of burning an average of about 53,000 acres (20,000 hectares) per year on the four southern California national forests. This strategy has two inherent assumptions: 1) that a small-scale mosaic will control the size of large fires by fuel reduction in local areas, and 2) that rotational burning on a 20- to 50-year return interval can be accomplished. It is also assumed that a small-scale mosaic may minimize soil damage and reduce resource impacts by keeping large percentages of a watershed vegetated.

While an age-class mosaic could be effective at moderating fire intensity in young stands, and for making fires more amenable to control, especially under moderate burning conditions and on the flanks of a fire, it is important to recognize that a high-intensity fire will typically burn through any age class of vegetation. And, as discussed earlier, these are the fires that burn most of the acreage. Control is often associated with changes in weather, in conjunction with changes in fuel type or successful burnouts. However, such fires can burn easily through stands even 5–10 years old (Dunn 1989, Dunn and Piirto 1987) and most anecdotal accounts of effectiveness of age-class boundaries in stopping or diverting wind-driven chaparral fires relate to stands less than 5 years old. If we wish to maintain the diversity of natural chaparral ecosystems and wildlife habitats, and minimize long-term erosion, it is obviously not practical or desirable to maintain everything in these very young age classes. There is ample evidence that increases in fire frequency of this magnitude can have potentially major effects on vegetation composition and structure, and may tend to seriously degrade vegetation toward more flammable types (Zedler et al. 1983).

Even if mosaic burning could accomplish the desired fire management objectives without causing negative ecological impacts, there is considerable doubt about the feasibility of implementing use of prescribed fire on such a large scale. To accomplish these types of goals, current forest plans have proposed annual treatment areas of 25,000 acres (12,000 hectares) on the Los Padres, 18,000 acres (9,000 hectares) on the Angeles, 5,500 acres (2,500 hectares) on the San Bernardino, and 7,500 acres on the Cleveland (USDA Forest Service undated a, 1987, 1988, undated b). Figure 6 shows the available data on prescribed burning for these forests from 1981 to 1994.

While prescribed fire programs on the Angeles, Los Padres, and San Bernardino National Forests averaged 13,300 acres per year from 1984–1988 (29% of the acreage proposed in forest plans), since 1989 these acreages have dropped off dramatically to an average of 4,000 acres per year (1989–1994; 9% of proposed acreage). Even with increased funding for fuel management activities, there is little reason to believe that prescribed fire activity levels could ever be sufficient to achieve a landscape-level mosaic of the type envisioned when the current forest plans were drafted. Based on the estimated average cost of $250/acre for prescribed burning on California national forests (Bell et al. 1995), the cost of burning 50,000 acres/year in southern California alone might be as high as 12.5 million dollars!

Many things make it difficult to realize these goals (Bakken 1995, Pierpont 1995, Nehoda 1995, Williams 1995), and several of these constraints are expected to get worse over time:

- Smoke management/air quality/water quality and other environmental concerns;
- Concerns over the risks of burning (e.g., loss of structures) in the wildland-urban interface;
- Equipment and manpower resource conflicts with fire suppression (prescribed fire activities are low priority if wildfires are burning);
- Lack of adequate trained personnel;
- Risk-aversion on the part of fire-management personnel and organizations, due to perceived lack of institutional support, fear of lawsuits, inexperience, and other factors;
- Budget constraints;
- Public opposition (especially to burning during the active fire season, to risks of wildland-urban interface fires, to potential adverse effects on wildlife, and to smoke intrusions).

The net result of these constraints is that there is nowhere near enough area burned to accomplish the objectives of establishing a landscape mosaic. Furthermore, recent internal reports have emphasized the need for adopting new strategies for fire and fuel management in the wildland-urban interface (Federal Wildland Fire Management Policy and Program Review 1995, USDA Forest Service 1995).

RECOMMENDATIONS

In light of the above information, we propose a strategic approach to fuel and fire management in chaparral, with three major objectives:

1. To contain wildland fires strategically within easily defended boundaries;
2. To maintain a chaparral fire regime that fosters healthy, sustainable ecosystems in wildland areas;
3. To separate urban interface areas from natural fuel complexes, both to protect urban interface areas from wildland fires and to protect wildlands from fire starts in the urban interface.

For these purposes, landscape mosaics are impractical, unnecessary, and probably not particularly effective. We basically recommend shifting the management focus away from pure mosaic burning toward development (and rejuvenation) of strategically placed fuel management zones. We envision a program with two major components: 1) strategically placed dynamic fuel management zones in wildland areas to provide access for attacking fires (burning out, retardant drops, etc.) by providing areas of reduced fuel load and fire intensity, and 2) intensive fire risk management zones (developed in cooperation and with shared responsibility with local agencies and landowners) around high value areas, such as in the wildland-urban interface or areas of particular fire sensitivity in the wildlands. With this modified approach, the approach shifts from burning every hectare of chaparral on a rotational basis to strategically burning portions of the chaparral area.

The fuel management zones are envisioned as fairly broad areas that take advantage of natural features and human-constructed barriers such as roads, that would be managed using rotational burning, site conversion, and other fuel modification techniques, to maintain temporally and spatially dynamic areas of reduced fuel within the fuel management zone. One can envision these reduced fuel areas as fuel breaks that are moved around the landscape over time rather than fixed on ridge tops. These reduced fuel areas would provide areas of access for ground and aerial fire suppression forces as well as burnout or other fireline construction when fires occurred. Within the watershed areas defined by these dynamic fuel break belts, natural and accidental human ignitions would be the major mechanism for fire starts, although prescribed fires might also be used in these areas under certain circumstances (e.g., if fire hazard was increased by episodes of dieback, if ignitions were not occurring under appropriate conditions and at appropriate intervals, or if there were specific wildlife or sediment management needs). Fire suppression would remain active to ensure that fire-return intervals were not shortened excessively in areas of high ignition loads and to ensure that most of the area was still burned during the normal fire season. Each watershed zone would have a prescription defining clearly the conditions under which fires would be allowed to burn, and under which conditions, and with what strategies (e.g., confine, contain, use of burning out), they would be suppressed. In recognition that mosaic prescribed burning is an unrealistic approach, southern California national forests have already begun moving in this direction. An excellent example is the fire and landscape planning approach that is being developed and implemented on the San Jacinto District of the San Bernardino National Forest. This approach is similar to that proposed by Hanes (1971).

In the immediate wildland-urban interface, we believe that a different and often more intensive approach is often necessary. Management in this zone must have two objectives: both to prevent ignitions from populated areas from adversely impacting natural resources of the wildlands and to prevent fires that start on wildlands from causing property destruction and loss of life. In this zone, any approach to management will necessarily involve a diversity of stakeholders. Many aspects of the solution will be the responsibility of local landowners and of local governments, rather than of land management agencies. Through exercise of this joint responsibility, the goal should be to use a combination of intensive fuel management zones (on both public and private land as appropriate) with zoning codes and various community actions and policies to minimize potential fire intensity around structures. Additional goals include fire safe homes, adequately designed and staffed community fire protection systems, appropriate agreements for interagency cooperation and initial attack responsibilities, public and agency personnel knowledgeable of interface fire hazards, prevention, and mitigation. An effort to develop a model urban-wildland interface fire code is currently underway (International Fire Code Institute 1995). These steps are prerequisites to the ability to structure planning and response systems so that agencies such as the Forest Service can maintain their focus on resource protection and management in balance with the need to protect life and property.

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