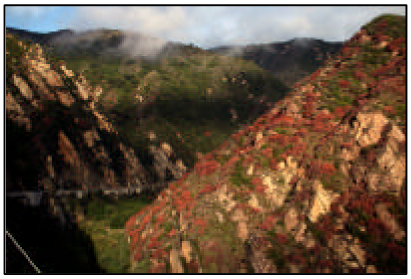
Proceedings of the 32nd Annual Southern California Botanists Symposium

Flora and Ecology of the Santa Monica Mountains





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Cover photographs, clockwise from upper left: Freezing damage, Malibu canyon – photo by Stephen Davis; *Calochortus albus* – photo by Tarja Sagar; lichen with *Dudleya verityi* seedling – photo by Tarja Sagar; Fire, Malibu bluff – photo by Stephen Davis; *Dudleya cymosa* – photo by Tarja Sagar

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Preface

The Santa Monica Mountains, with their rich flora and fauna, are a globally significant example of the diverse Mediterranean-climate ecosystem, designated as one of the world's biodiversity "hotspots." The threats to this biodiversity are great, including impending development, fragmentation, invasive species, increasing fire frequency, nitrogen deposition, altered hydrology, climate change, and the interacting and cascading effects of all of these factors. The 150,000-acre Santa Monica Mountains National Recreation Area, the nation's largest urban park, provides crucial open space in one of the United States' largest urban areas. In this network of city, county, state, federal, and private landholders, the conservation challenges are immense, while the opportunities for education and volunteerism provide hope.

These proceedings are the product of the Southern California Botanists' one-day annual symposium held at California State University, Fullerton, on October 28, 2006. It provides a valuable cross-section of both baseline floristic and ecological information, and it is our hope that it will be an important reference for the region.

Denise A. Knapp

Acknowledgments

Thank you to Kerry Knudsen, who had the brilliant idea to have a regionally-themed symposium focusing on the Santa Monica Mountains in 2006, and made the initial contacts with the National Park Service, Santa Monica Mountains National Recreation Area. John Tiszler was instrumental in coordinating the speakers and authors for this symposium and proceedings. The Southern California Botanists Board of Directors (see next page for list) contributes substantial time planning and orchestrating the annual symposium, and California State University, Fullerton allows the use of their facilities annually. Thank you also to the Catalina Island Conservancy for allowing the editor to work on this proceedings, which provides valuable information for Catalina Island as well.

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VEGETATION RESPONSE TO WILDFIRE AND FIRE HISTORY IN THE SANTA MONICA MOUNTAINS, CALIFORNIA

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ABSTRACT: The most significant local factors controlling vegetation distribution and plant diversity in the Santa Monica Mountains are wildfire and the extended summer dry period associated with a Mediterranean-type climate. Fire is an inevitable recurring event because of the combination of vegetation type, climate, topography and land use. Both the number of fires and the total amount of area burned is increasing in the Santa Monica Mountains and elsewhere in the mountain foothills surrounding urban southern California. Altered fire regimes are resulting in profound changes in vegetation assemblages and structure and, in the most extreme cases, vegetation-fire feedback cycles resulting in the extirpation of native shrub species and vegetation type conversion. We review the fire history of the Santa Monica Mountains and describe how altered fire regimes, plant life histories, and plant physiological traits interact to affect landscape-level vegetation patterns.

KEYWORDS: fire, chaparral, drought stress, type conversion, life history, sprouter, seeder, southern California, recruitment, survival

INTRODUCTION

The Santa Monica Mountains have one of the most extreme fire climates in the world and periodically burn in large, dramatic wildfires (NPS 2005). Approximately 13% of this fire-prone area is developed, with communities that are among the wealthiest in Los Angeles County and the state of California. Fires in this region are often extremely damaging and costly because of both wildfire suppression costs and property losses, and are usually considered to be major social disasters. In contrast, biologists have considered fire in the Santa Monica Mountains to be a normal event that maintains the vigor and diversity of its shrubland plant communities. Chaparral is the classic example of an auto-successional cycle where wildfire burns all of the aboveground vegetation and at the same time stimulates the regeneration of the same species that grew there previously from both the soil seed bank and resprouting shoots (Hanes 1971). The observed resilience of chaparral to fire has led to the sometimes uncritical acceptance of the idea that any fire, any time, and any where is good for chaparral. Plants are not adapted to fire per se, but to a specific fire regime defined by the range of variability in fire type, season, size, frequency, and intensity. When the parameters of the fire regime exceed their normal range species can be extirpated, causing shifts in community composition and structure to occur. We have used an 80-year fire history of the Santa Monica Mountains to define the parameters of the local fire regime and to examine how changes in fire patterns have affected landscape-level vegetation patterns.

Changes in vegetation patterns as the result of altered fire regime parameters can primarily be explained by plant life history type and associated plant physiological traits.

THE MODERN FIRE REGIME

Setting and Climate

The Santa Monica Mountains are 90,000 hectares of isolated Mediterranean habitat bounded on one side by the Pacific Ocean and surrounded on three sides by the urban sprawl of greater Los Angeles. These mountains are the most southwestern of the east-west trending Transverse Ranges of Southern California. They extend from the Oxnard plain eastward for approximately 45 miles to the Los Angeles River. The steep and rugged slopes on the south flank of the mountains are cut by long, V-shaped, deeply incised canyons that drain south to the ocean. On the north flank, short steep canyons descend to the San Fernando and Conejo Valleys at about 1,000 feet above sea level. The exception is Malibu Canyon, a deeply incised, antecedent drainage course, which bisects the range, draining the north slopes of the Santa Monica Mountains and the southern slopes of the Simi Hills.

The dominant vegetation types are chaparral (55%) and coastal sage scrub (20%) which are particularly good fire fuels because of their high density and continuity, small twig and stem size, and the large proportion of dead biomass. The average total live and dead fuel biomass is 17 Mg/ha in *Adenostoma* chaparral, 36 Mg/ha in *Ceanothus*-chaparral and 20.2 Mg/ha in coastal sage scrub (Ottmar et al. 2000). The average annual rainfall is 430 mm/year, and falls predominantly between November and March with an extended dry season from May to October. Seasonal föehn winds (Santa Anas), averaging 30-50 kph, occur mostly in the fall months at the end of the dry season and are often associated with high temperatures and low humidity. The Santa Ana winds, which blow predominantly from the north or northeast, are funneled through the north-south canyons of the mountains. By the middle of fall, live fuel moisture is critically low (~ 60%, Figure 1). This combination of vegetation and climate make the Santa Monica Mountains, and Southern California in general, one of the world’s most severe fire climates (Schroeder and others 1964). Digitized records of fires in the Santa Monica Mountains from 1925 to the present are maintained by the National Park Service. We have used these records to quantify the modern wildfire regime of the Santa Monica Mountains.

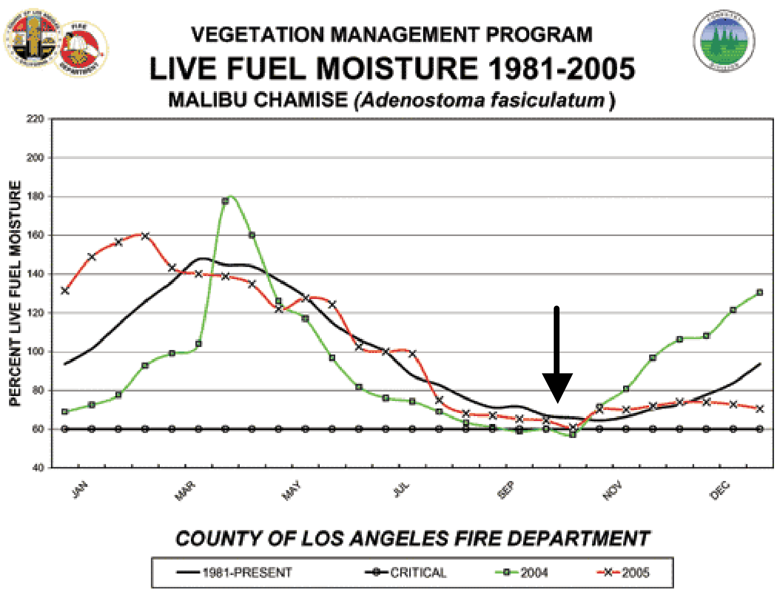
Fire Type

Fires in shrubland vegetation types such as chaparral and coastal sage scrub are high-intensity, stand-replacing crown fires. Type-converted shrublands with native shrubs growing in a non-native annual grassland matrix will experience a mixed fire type with cooler surface grass fires interspersed with high intensity canopy fires in native shrubs.

Fire Season

Föehn winds have been identified as the primary driver of the wildfire regime in southern and central California shrublands (Moritz 1997; Keeley and Fotheringham 2000). Although Santa Ana winds can occur in any month, they predominate from September to December (Figure 1B). The large fires in the Santa Monica Mountains coincide with this peak of Santa Ana activity when vegetation is dry and temperatures are high (Figure 1). Half of the area burned in the Santa Monica Mountains since 1925 burned in the month of October, while ninety percent burned between September and December (Figure 1C). A second small peak of Santa Ana wind activity

A.



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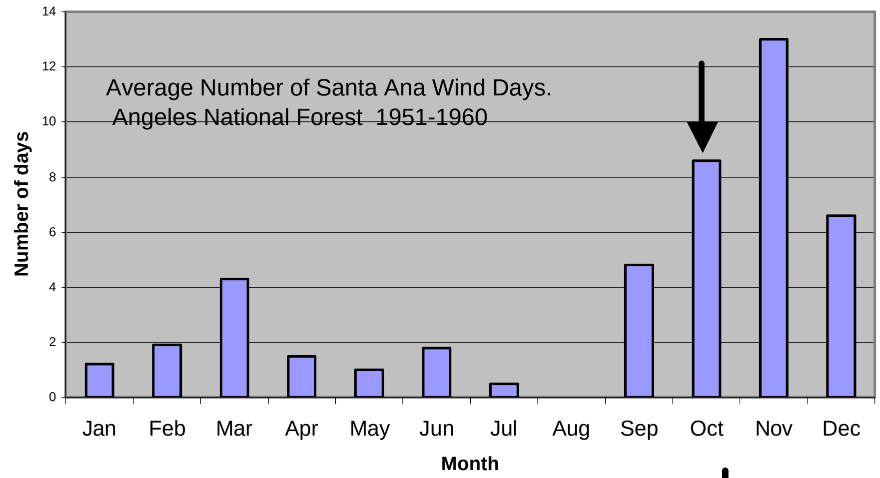

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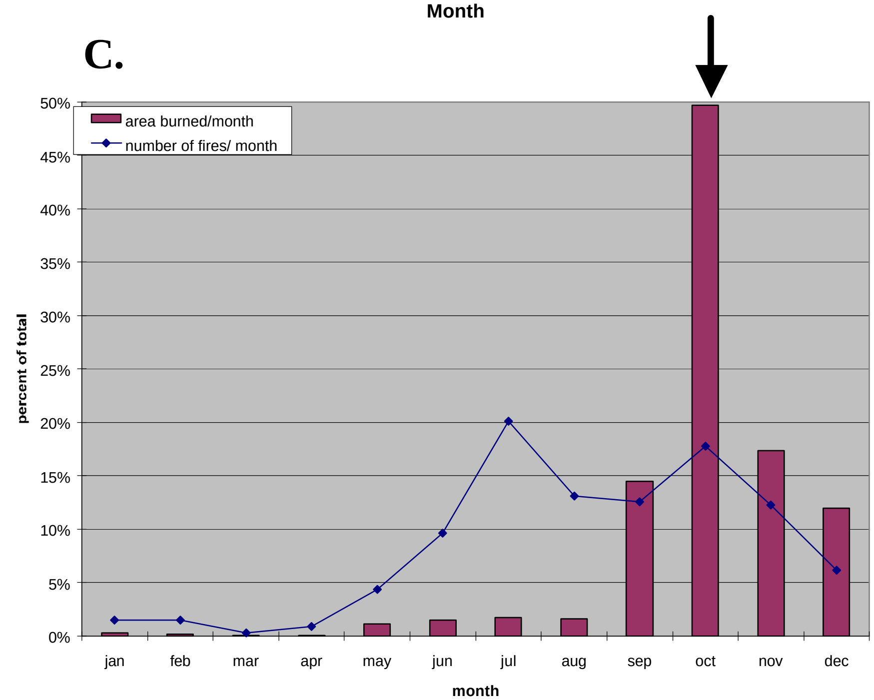

Figure 1.

A. Seasonal live fuel moisture, Malibu
B. Average number of Santa Ana wind days/month
C. Percentage of total area burned /month and
percentage of total number of fires per month

occurs in March, but this is usually a time of cool temperatures and high moisture and does not create the severe fire conditions that lead to large, uncontrolled fall wildfires.

Ignition Sources

Lightning ignited wildfires are extremely rare in the Santa Monica Mountains. Only two clusters of lightning started fires, 14 years apart, have been recorded in a 25-year fire ignition record (1981-2006). Of these fires, the largest was 600 acres, while the others were only 0.1-0.2 acres in size.

Native Americans occupied the Santa Monica Mountains for approximately 10,000 years before present and are known to have used fire as a cultural tool, but both the frequency and geographic extent of their fire use are unknown (cf. references by Keeley 2002, *Journal of Biogeography* 29:303-320; references by Kat Anderson 1999, *Human Ecology*, 27:79-113). Currently, ninety-eight percent of all fire starts are of human origin, with arson and arcing power lines responsible for the vast majority of the total area burned (NPS 2005).

Fire Size

Large fires (greater than 10,000 acres) are responsible for nearly all of the area burned in the Santa Monica Mountains. The largest 1% of fires has caused 25% of the total burned area and the largest 10% have caused 86% of the total burned area (Figure 2). Large fires have occurred throughout the fire record period (Figure 3). This is consistent with data from the rest of southern California, where the number of large fires has not increased since modern fire suppression began and therefore cannot be a function of increased fuel accumulation (Keeley et al. 1999). Although the wildfire size distribution in the Santa Monica Mountains has remained largely stable over time, the trend in average fire size has declined very slightly from 1925 to the present (Schoenberg et al 2003).

Fire Frequency and Fire Return Interval

Fire frequency is the number of fires within a given area in a specific period of time, while the *fire return interval* is the period of time between fires within a given area in a specific period of time. Fire frequency has increased in the Santa Monica Mountains over the last 75 years (Figure 4). The total area burned per decade has also generally increased (Figure 5). Both of these trends are attributed to increased ignitions due to urbanization and increased population size (Keeley and Fotheringham 2001).

The average between-fire interval for all natural areas in the Santa Monica Mountains from 1925 to 2001 was 32 years. This statistic expresses the average time between fires for any set of randomly determined locations in the area. The fire return interval within the Santa Monica Mountains is widely variable because there are both high fire frequency areas that have burned numerous times in the 80 years of record keeping and areas that have never burned in that period. This creates a complex mosaic of fire history across the landscape (Figure 6).

Fire Spread Patterns and Fire Frequency

Fire spread patterns are strongly influenced by topography and the direction of the prevailing winds during Santa Ana conditions. There is often an east-west spread as fires travel from north to south approaching the coast and are released from the confines of steep north-south mountain

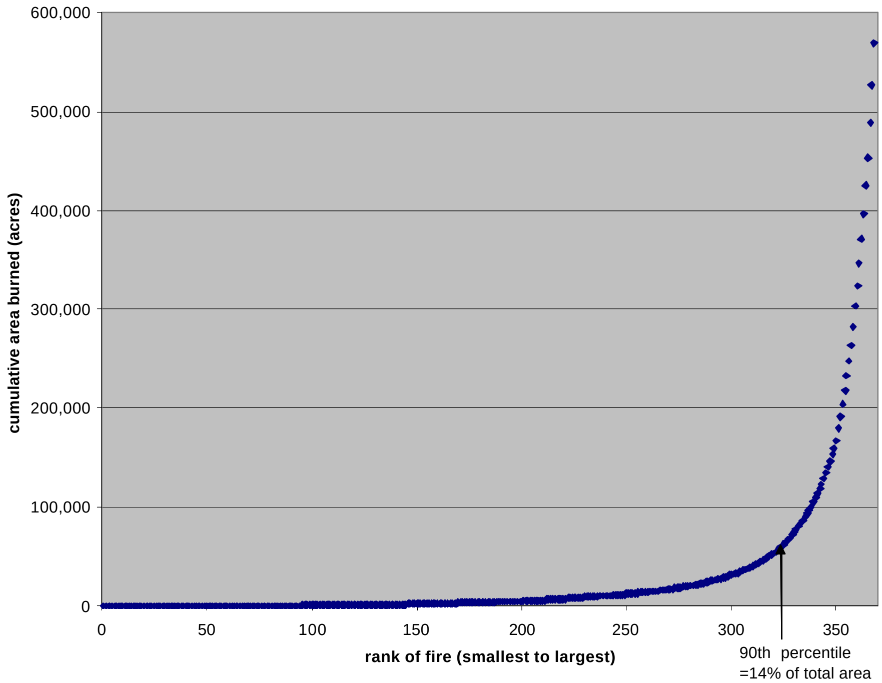

Figure 2. Rank ordered cumulative size distribution 1925-2003 (smallest to largest).

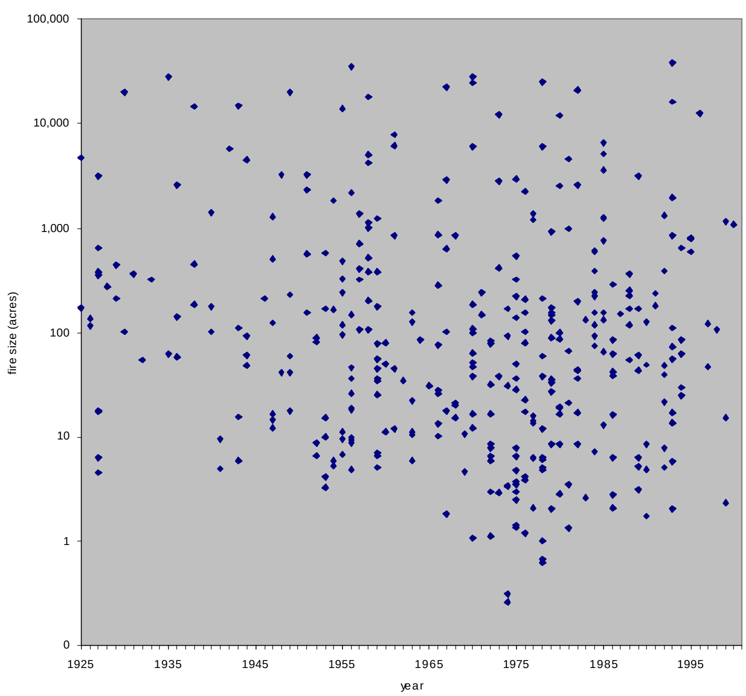

Figure 3. All fires by size and year.

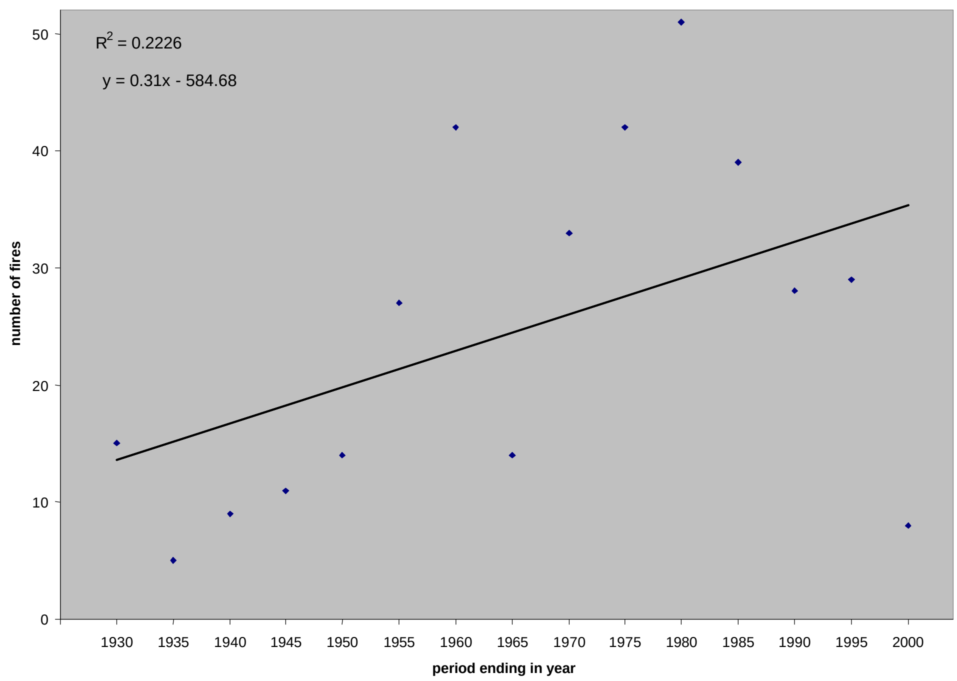

Figure 4. Number of fires 1925-2000.

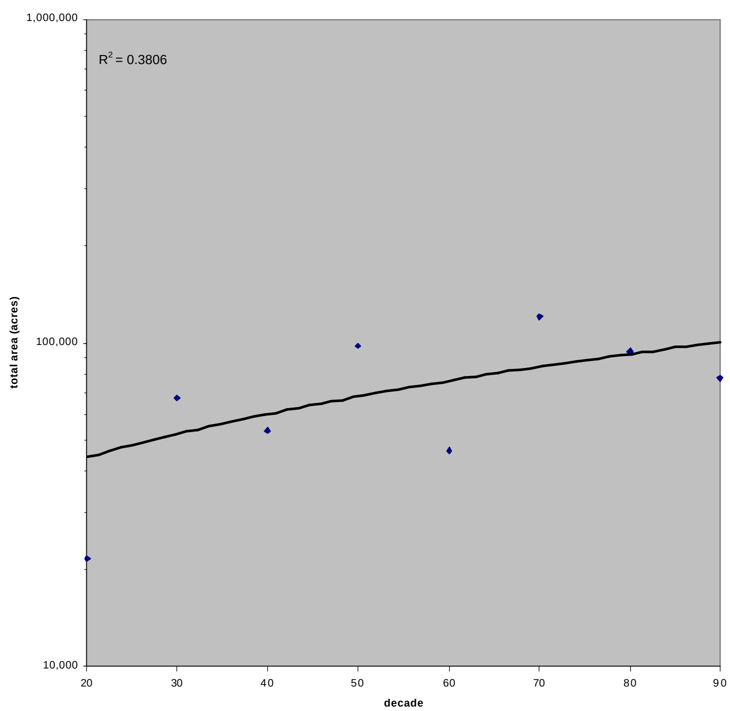

Figure 5. Total area burned 1925-2000.

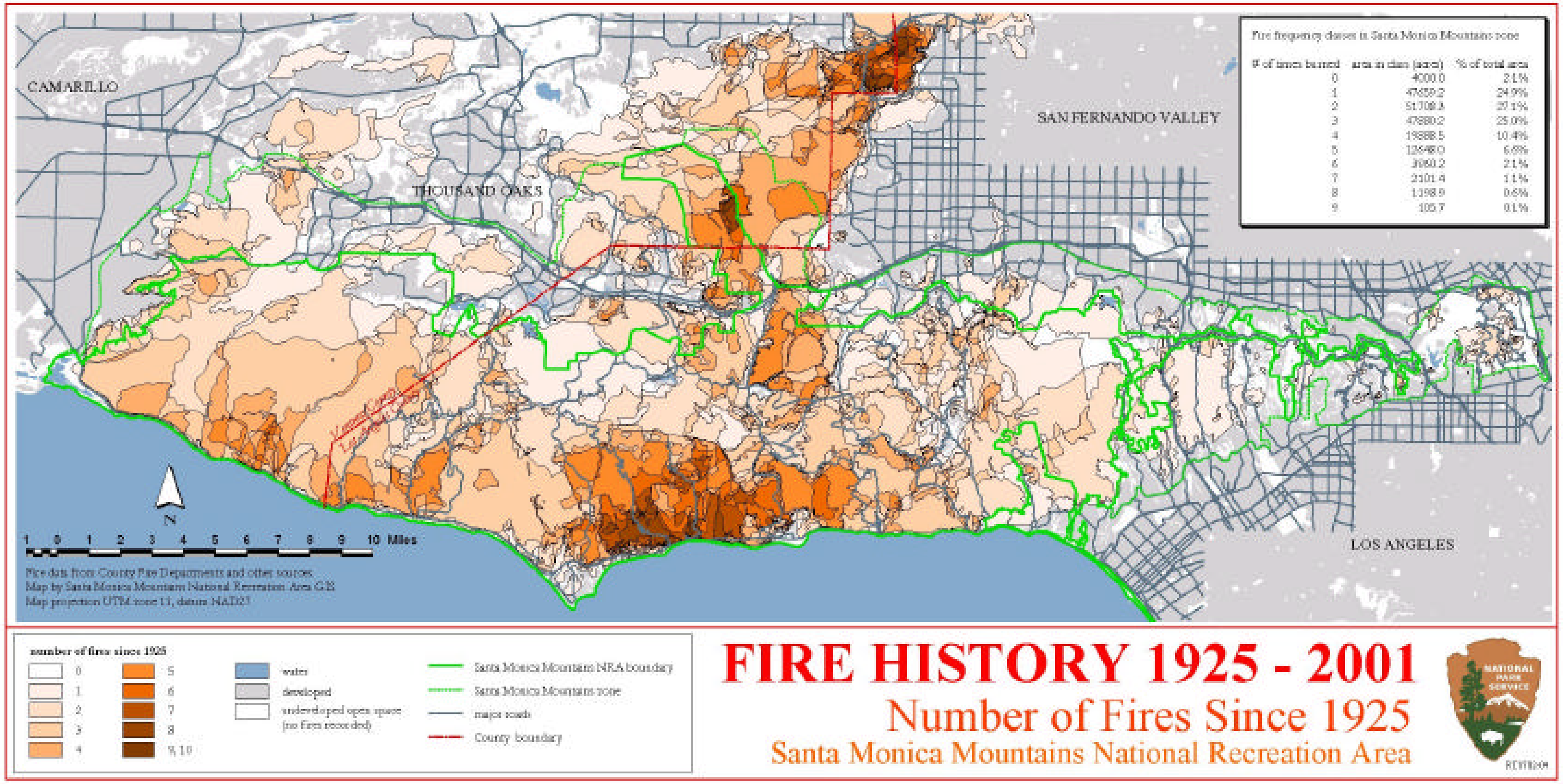

Figure 6. The complex mosaic of fire history in the Santa Monica Mountains.

canyons and unidirectional winds (Radtke et al.1982; Figure 7) The east-west spread of fires on the coastal slope may account for the increased fire frequency in this area, as different fires overlap (Figure 6).

Similarly, the high fire frequency corridor through the Malibu Canyon area may be partly a function of the break in the mountain range at Malibu Canyon and the increased wind speeds through this pass, making spread from inland fire starts to the coast more likely at this location.

Vegetation Age Classes

The time since the last fire is a good approximation of the age of the vegetation because many plants and regenerated plant parts will be exactly that old. Figure 8 shows a cumulative area curve for age classes based on time since fire in natural areas of the Santa Monica Mountains. Currently the vegetation is dominated by younger age classes: almost 30% of the vegetation is less than 13 years old, 40% is in the 20-30 year age class, and 25% is in the 30+ age class. Old growth chaparral occurs in only a few pockets that have experienced little or no fire and represents only a tiny fraction (<2%) of the total vegetation.

One consequence of large fires is that very large areas of the landscape are even-aged, creating large homogeneous age classes. Although the fire frequency map shows many overlapping fires in a complex mosaic pattern (Figure 6), the large fires typically overrun smaller fires, obliterating this mosaic and establishing large, even aged tracts (Figure 9).

VEGETATION RESPONSE TO FIRE

The stress of the summer dry period and disturbance by wildfire are two major factors that determine the community structure of chaparral in the Santa Monica Mountains. Postfire regeneration success depends on spring-germinating seedlings and postfire resprouts surviving the summer dry season in the first year after fire, a period of 4-6 months without rain (Davis 1989). The different modes of postfire regeneration are associated with suites of morphological and physiological features related to drought tolerance, because some species must survive the first summer as seedlings while others can draw upon established root systems.

It was recognized early in the study of the California flora that two different modes of reproduction, seeding and sprouting, occur following fire (Jepson 1916). Although terminology varies, the idea has been refined over time to recognize three functional modes of post-fire regeneration: *non-sprouters* (NS), species which are killed and regenerate only from seed, also called obligate seeders; *facultative sprouters*, species which regenerate partly from seed and partly from a percentage of the plant population which resprouts, also called facultative seeders; and *obligate sprouters*, which regenerate only from resprouts with no postfire seedling recruitment, also known as non-seeding sprouters (Wells 1969; Keeley and Zedler, 1978; Keeley et al. 1989; Keeley 1998). The facultative sprouters vary widely in their response and recruitment can occur predominately through seeding or sprouting, depending on species and/or population. A subgroup of the obligate sprouters are *functional sprouters*, species that both resprout and recruit seedlings, but whose seedlings all die in the first year postfire. In the Santa Monica Mountains, representative chaparral species for each functional type are *Ceanothus megacarpus*, *C. crassifolius, C. cuneatus, C. oliganthus,* and *Arctostaphylos glauca* (non-sprouters); C*eanothus spinosus, Arctostaphylos glandulosa, Adenostoma fasciculatum, A. sparsifolium,* and *Rhus ovata* (facultative sprouters); *Quercus berberidifolia, Prunus ilicifolia, Heteromeles arbutifolia, Rham-*

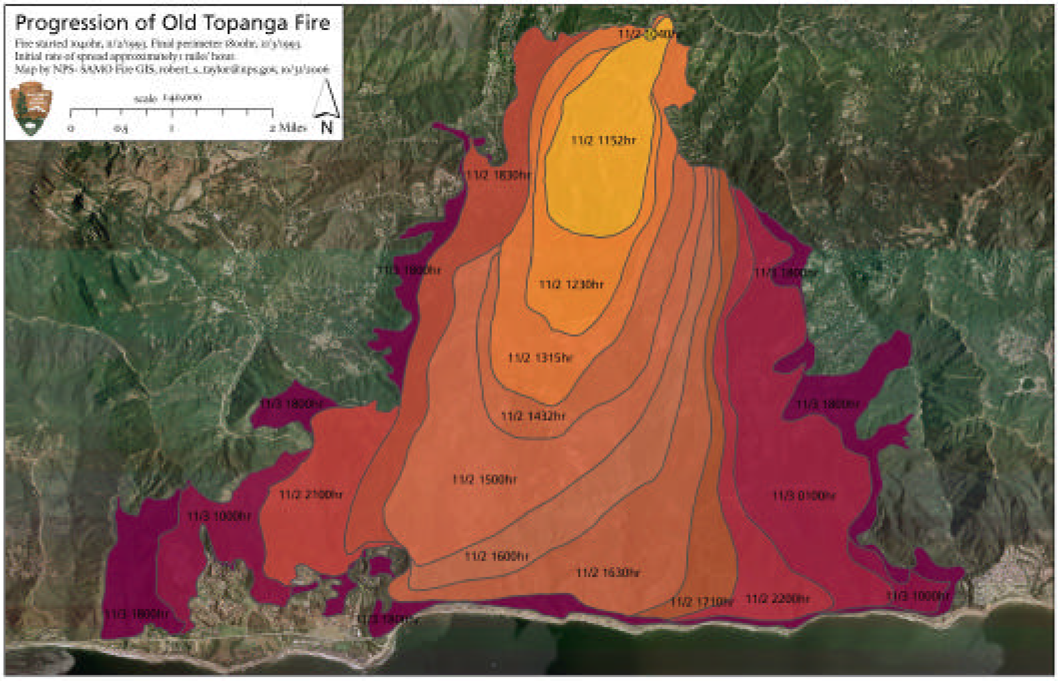

Figure 7. Fire spread patterns are strongly influenced by topography and the direction of the prevailing winds during Santa Ana conditions, as illustrated by the progression of the Old Topanga Fire.

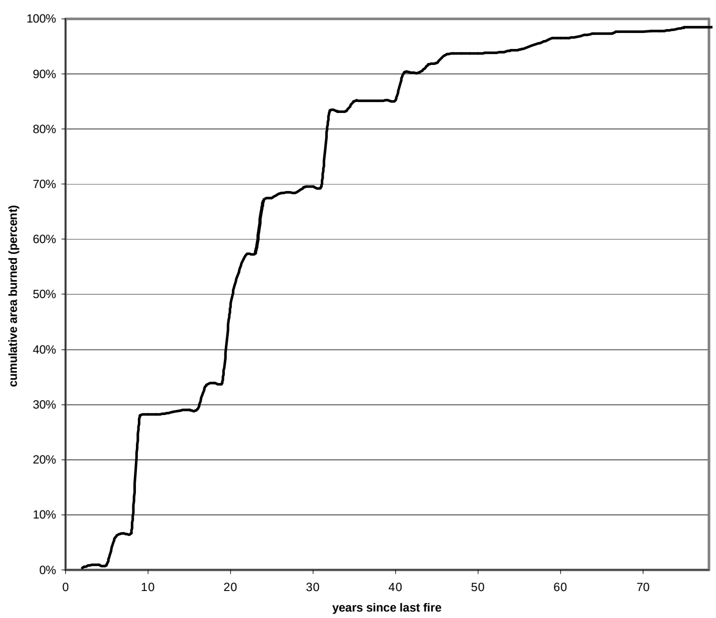

Figure 8. A cumulative area curve for age classes based on time since fire in natural areas of the Santa Monica Mountains.

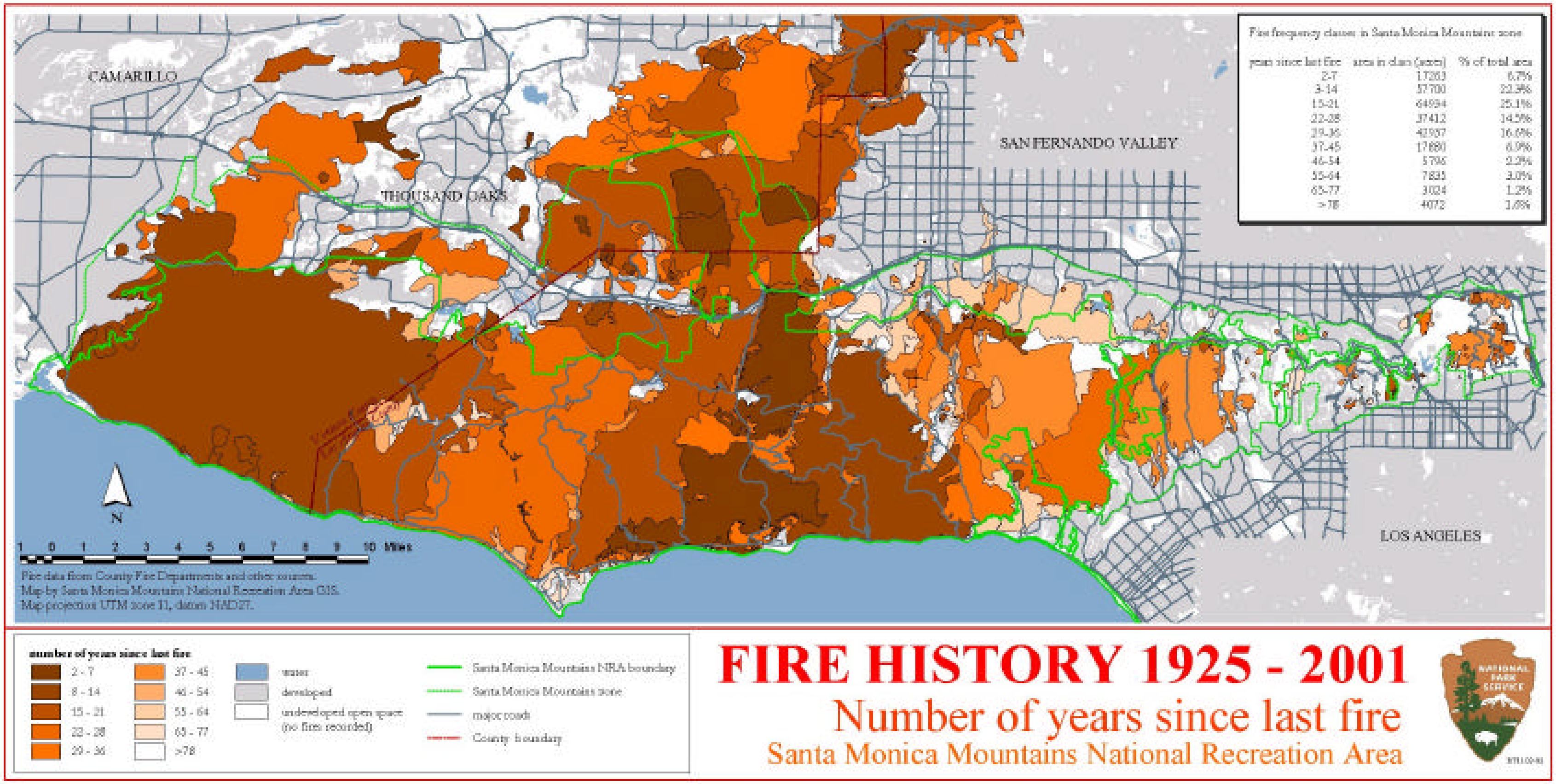

Figure 9. Large fires typically overrun smaller fires, obliterating this mosaic and establishing large, even aged tracts.

nus crocea, and *R. ilicifolia* (obligate sprouters); and *R. integrifolia* and *Malosma laurina* (functional sprouters).

Non-sprouting species are shallowly rooted and tolerate high levels of drought stress (Parsons et al 1981; Poole et al 1981; Davis et al. 1998; Jacobsen et al. 2005; Jacobsen et al. *In press*; Pratt et al. *In press*); obligate sprouters are more deeply rooted and reduce drought stress by tapping into deep soil moisture supplies (Poole and Miller 1981; Davis 1989). High seedling mortality occurs in all species in the first summer postfire, but there is a significant difference in survival rates between functional types caused by their differential drought tolerance. Seedlings from non-sprouters have a lower mortality than obligate sprouters and facultative sprouters (Figure 10, from Davis 1989). Seedlings of obligate sprouters die at much lower levels of water stress than non-sprouter seedlings (Oechel 1988; Davis et al. 1998). The profound impact of the physiological attributes of drought tolerance on post-fire population structure is exemplified by *Malosma laurina*. This species vigorously resprouts after fire (99% survival) while also producing an abundant postfire seedling crop (Frazer and Davis 1988, Thomas and Davis 1989). However, this extremely deep-rooted species has a low tolerance of water stress and virtually all seedlings die (99%) in the first summer following a fire (Thomas and Davis 1989; Saruwatari and Davis 1989). Because of its physiology, this species, which is a facultative seeder, behaves as a functional sprouter and is repopulated after fire almost exclusively through vegetative resprouting.

It is clear that an increased capacity to tolerate water stress in terms of resistance to xylem embolism, minimum seasonal water potential, maximum rooting depth, and the hydraulic transport efficiency of stem xylem is correlated to postfire reproductive mode and in part determines postfire resprout success as well as postfire seedling mortality (Figure 10; from Davis et al. 1998). The general geographic distribution of chaparral species is reflected in their relative levels of drought tolerance. The sprouting species of *Ceanothus* and *Arctostaphylos* are more important on mesic slopes and at higher elevations, while non-sprouters reach maximum abundance on south-facing slopes and ridgetops (Schlesinger et al. 1982; Keeley 1986; Nicholson 1993, in Keeley 2000). *Adenostoma*, *Ceanothus*, and *Arctostaphylos* predominate in the drier areas of the chaparral, but on more mesic sites other broad-leaved, evergreen, resprouting shrubs become dominant (Keeley 2000).

Natural variability in the fire regime interacts with varying regeneration strategies to maintain species diversity. However, if fire frequency exceeds a species' adaptive capabilities, postfire shrub regeneration will be reduced. Sensitivity to fire frequencies varies with regeneration strategies. Non-sprouters show the greatest sensitivity to short fire return intervals and may be eliminated by a single premature burn where insufficient time has passed to build up an adequate seed bank (Biswell 1989; Zedler 1995). Theoretically, non-sprouting species may also be at risk from extinction due to excessively long fire intervals that exceed the life span of both the adults and the seed bank. There is no evidence that long fire intervals are a real problem in California chaparral. One hundred and fifty year old stands of chaparral in the Sierra Nevada recovered as well as younger stands, although populations of the non-sprouter *Ceanothus cuneatus* were reduced (Keeley et al. 2005). In the Santa Monica Mountains, no plant communities are considered to be at risk from an excessively long fire-free period because only 1.6% of the vegetation is more than 77 years old (NPS 2005). Because of the high fire frequency in this region, risk to native plant communities from fire is associated with the potential for repeated fires and short fire return intervals, which exceed the capability of native shrubs to recover after fire (Zedler 1995).

Cm = *Ceanothus megacarpus*
NON-SPROUTER (NS)

Af = *Adenostoma fasciculatum*
As = *Adenostoma sparsifolium*
FACULTATIVE SPROUTERS (FS)

Ml = *Malosma laurina*
OBLIGATE SPROUTER (OS)

Data from Davis et al., 1998

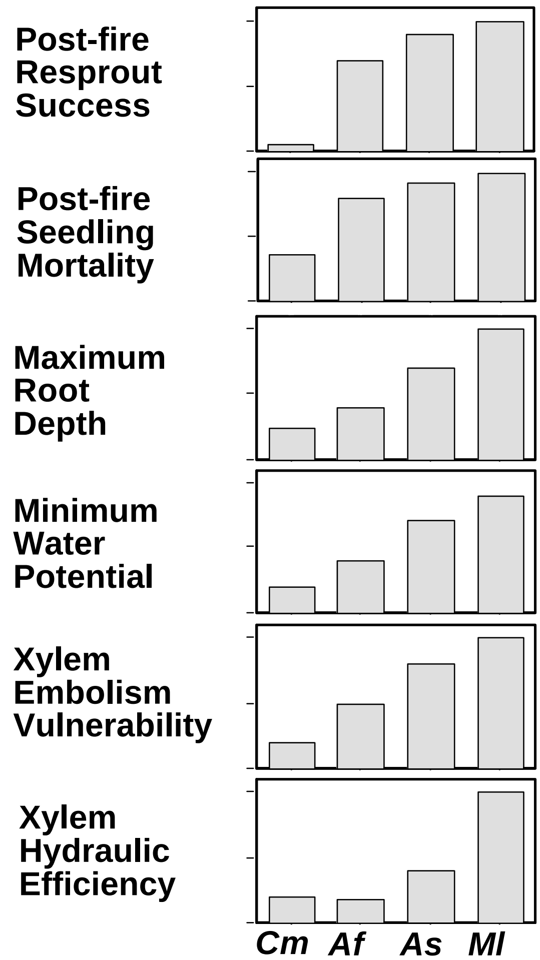

Figure 10. There is a significant difference in survival rates between functional types caused by their differential drought tolerance.Seedlings from non-sprouters have a lower mortality than obligate sprouters and facultative sprouters.

Vegetation Impacts of High Fire Frequency and Short Fire Return Intervals: The Pepperdine Longitudinal Study

In 1985 the Piuma Fire burned the Pepperdine University Biological Preserve, which had last burned in the 1970 Wright Fire. This fire provided the opportunity to study the interaction of drought tolerance and postfire recruitment demography (Figure 10, from Davis et al. 1998). Initial vegetation recovery followed the classic trajectory expected in chaparral, with abundant postfire native herbs in the first year, widespread resprouting (*Ceanothus spinosus*, *Malosma laurina*), and seedling recruitment (*Ceanothus megacarpus, C. spinosus, Malosma laurina*). Permanent plots were established to follow the long-term survival of the seedlings and resprouts. After seven years, *Ceanothus megacarpus* (non-sprouter) had 30% survivorship of its seedlings, while *C. spinosus* (facultative sprouter) had 60% survivorship of resprouts, but with a steady decline in seedling survivorship over 5 years to less than 5%. *Malosma laurina* had 98% resprout survivorship, but 99% seedling mortality at the end of the first year and 100% seedling mortality by year two postfire.

In 1993 the Old Topanga Fire burned the site again. With only eight years between fires, the recovery pattern was markedly different. Compared to the 1985 fire, the native herbaceous flora was significantly reduced while the annual non-native grasses increased (Figure 11). This effect on the herbaceous flora has been partly attributed to both higher non-native seed survival under the cooler fire conditions of an early fire and proximity to a non-native seed source such as trails or fuel breaks. *Ceanothus megacarpus* (non-sprouter) was completely eliminated from the site because eight years was insufficient time to reach flowering maturity and to build up a seed bank. *C. spinosus* (facultative sprouter) recruited an extremely reduced number of seedlings because those plants which resprouted after the previous fire were able to grow rapidly and reach reproductive maturity. By year two, all of those seedlings had died. The second fire caused additional mortality in the resprout population of *C. spinosus* and net survivorship declined to 40% three years postfire. *Malosma laurina* (obligate sprouter) resprouts recovered identically to the previous fire with >98% resprout survival. However, similar to *C. megacarpus,* there was no seedling recruitment after the second fire.

Finally, in 1996, the Calabasas Fire burned the site a third time, only three years after the Old Topanga Fire. With this fire the site was irrevocably changed. The native postfire herbs were largely replaced with non-native annual grasses. There were no seedlings of any of the three major shrub species. The *Ceanothus spinosus* resprout population was again reduced, this time to 30%. Based on mortality patterns from the previous two fires, that survivorship would be expected to continue to decline. Only *M. laurina,* with another >98 % resprout survival rate, maintained its pre-1985 population density.

The contrast between a typical stand of closed canopy mixed chaparral (A) and a high fire frequency site that has been type-converted to a non-native grassland dominated by a few resprouting native shrub species (B) is illustrated by the photos in Figure 12.

Impacts of Short Fire Return Intervals: Jacobsen Landscape Study

The Pepperdine longitudinal study demonstrates the impact of repeated short interval fires on plant community structure, especially the potential for extirpation of non-sprouters. An important question is whether the elimination of non-sprouting species has occurred at other sites where there have been short fire return intervals. Jacobsen et al (2004) compared sites throughout the Santa Monica Mountains with short fire return intervals (=six years) to matched control sites where the shortest fire return interval was =12 years. A point-quarter sampling method was used to measure chaparral shrubs in tandem with a canopy-coverage sampling method for exotic herbs and grasses. Sites that experienced a short fire interval (=six years) contained significantly fewer non-sprouting species and significantly more coastal sage scrub species than adjacent control sites ($p = 0.007$ for both; Figure 13). The relative densities of facultative or obligate sprouting species and non-native shrub species between short fire interval and control sites were not significantly different ($p > 0.05$; Figure 13). There was a strong correlation between the number of years of the shortest fire return interval and the percent loss in relative density of non-sprouting species relative to the control site ($r^2 = 0.94$, $p = 0.033$; Figure 14). A three-year fire interval resulted in complete extirpation, and a six- year interval resulted in an 85% reduction in density. The results were independent of the time since the critical fire interval, which occurred in the 1990’s, 1980’s, 1970’s and 1930’s. The failure of the non-sprouters to recolonize is consistent with the observation that non-sprouting shrubs have only limited dispersal ability and, once lost from an area, are extremely slow to recolonize from other established populations (Zedler and Zammit 1989).

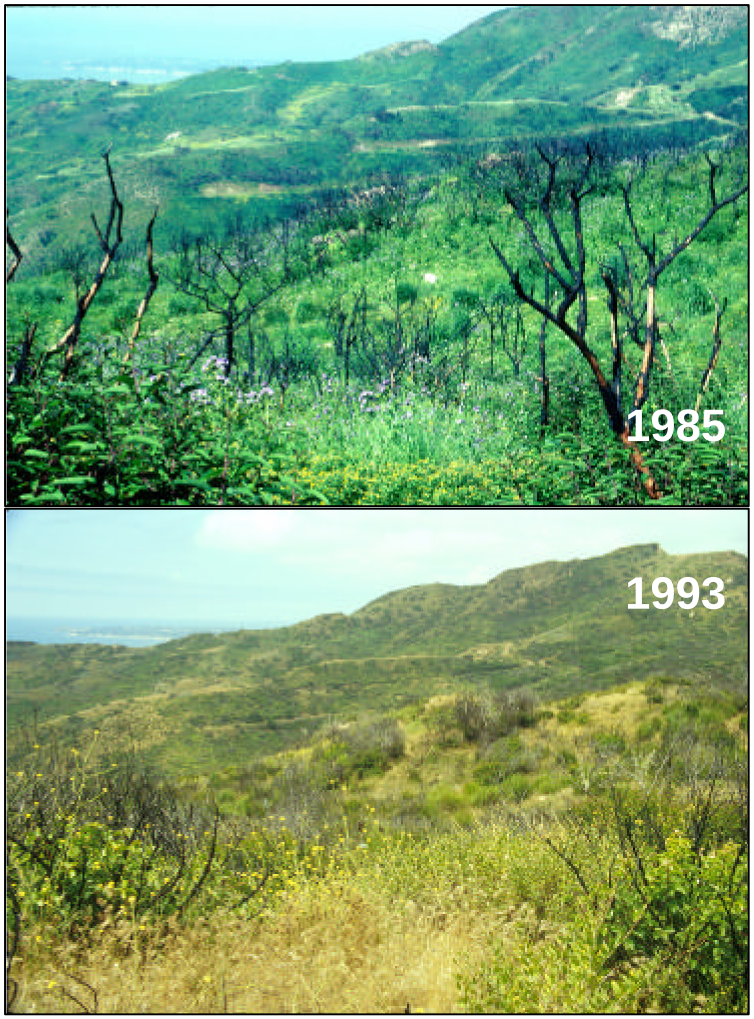

Figure 11. Compared to the 1985 fire, the native herbaceous flora was significantly reduced in the 1993 fire, only eight years later, while the annual non-native grasses increased.

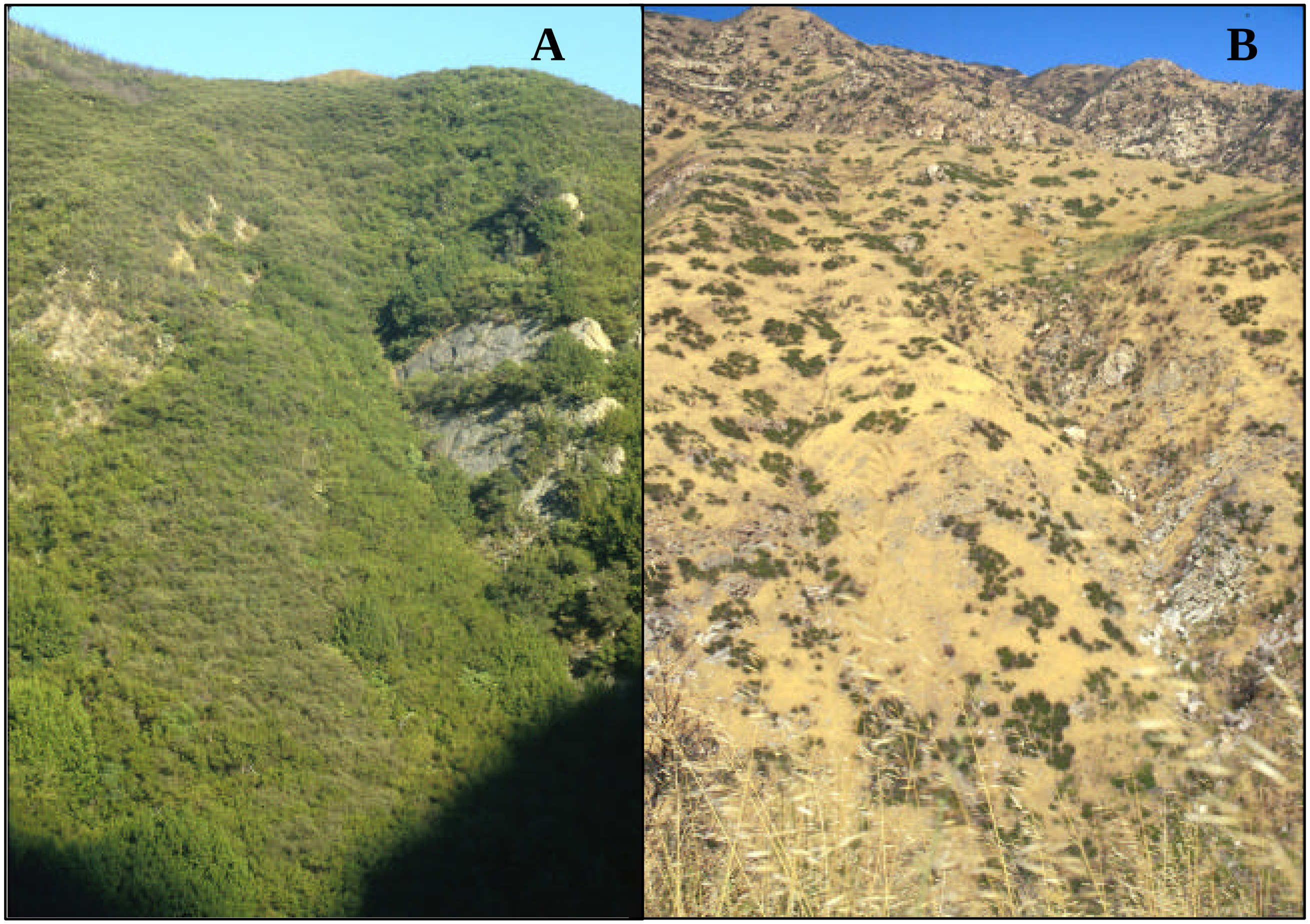

Figure 12. The contrast between a typical stand of closed canopy mixed chaparral (A) and a high fire frequency site that has been type-converted to a non-native grassland dominated by a few resprouting native shrub species (B) (Photos by Steve Davis, Pepperdine University).

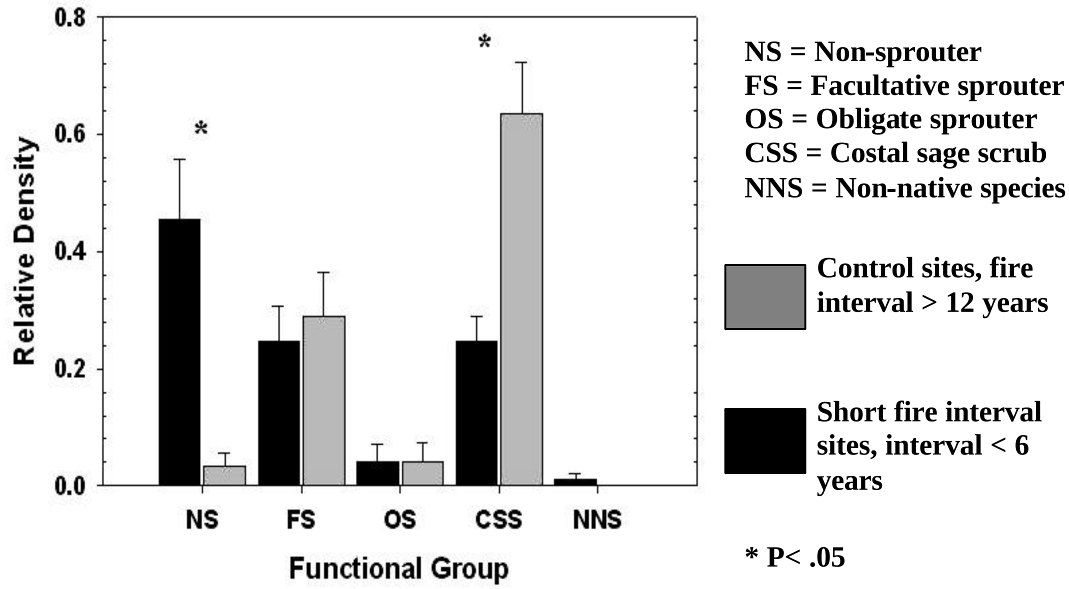

Figure 13. The relative densities of facultative or obligate sprouting species and non-native shrub species between short fire interval and control sites were not significantly different (p >0.05; Figure 10). Data from Jacobsen et al, 2004.

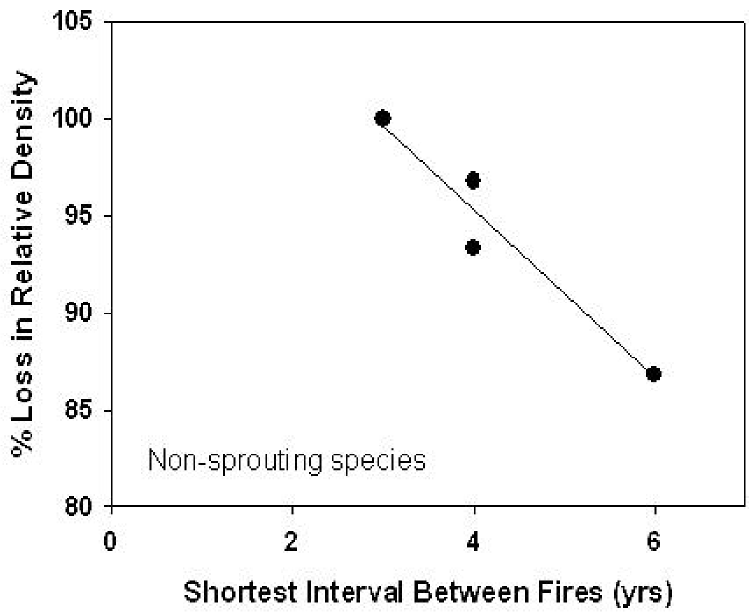

Figure 14. There is a strong correlation between the number of years of the shortest fire return interval and the percent loss in relative density of non-sprouting species relative to the control site ($r^2 = 0.94$, $p = 0.033$). Data from Jacobsen et al, 2004

While the extirpation of non-sprouting chaparral species is the most obvious effect of high fire frequencies and short fire return intervals, the effects on plant community structure are potentially much more pervasive. Although facultative seeders resprout after fire, mortality of lignotubers can be very high if fire returns prematurely (Zedler et al. 1983; Haidinger and Keeley 1993). Since a premature fire also kills seedlings that germinated in response to the previous fire, facultative seeders show only limited ability to persist under repeated disturbance. Obligate sprouters that show the greatest resilience under short fire return intervals (Zedler et al. 1983; Fabritius and Davis 2000) nevertheless may be severely impacted by sustained high-frequency fire regimes. Successful germination and recruitment of new individuals is correlated with the cooler, moister, low-light conditions and increased litter depth associated with the mature closed-canopy chaparral that develop over fire-free intervals of forty years or more (Lloret and Zedler 1991; Keeley 1992a & b; DeSimone 1995). If a short-interval fire regime is maintained, mature individuals and lignotubers that inevitably perish in fires will not be replaced, resulting in loss of resprouting populations over time (Zedler 1995). Finally, native annuals of the post fire herbaceous flora compete poorly and are eliminated where non-natives become dominant (Keeley 1981).

Type Conversion

The introduction of herbaceous exotics, particularly annual grasses, has fundamentally altered the fire ecology of southern California and plays a significant role in the conversion of shrublands to annual grasslands. Where fires are frequent, non-native herbaceous annual vegetation has been observed to increase and replace shrublands (Vogl 1977; Barro and Conard 1987; Haidinger and Keeley 1993; Beyers et al. 1994). This type conversion of shrubland to annual grassland has been widely observed in California (Keeley 1990; Keeler-Wolf 1995; Minnich and Dezzani 1998).

Annual grasses increase the fire frequency by changing the amount, distribution, and seasonal availability of fuels for fire (Giessow 1997). These grasses complete their life cycle early in the summer season, but do not easily decompose (D'Antonio and Vitousek 1992; O'Leary 1995). This results in a large amount of fine standing dead fuel that supports very rapid rates of fire spread under a broader range of weather conditions than chaparral (Barro and Conard 1987). Dry grasses have the lowest heat requirements for ignition and therefore have the longest fire season and highest fire frequency of any southern California vegetation type (Radtke 1983). Most importantly, the capacity of exotic herbaceous fuels to burn is little influenced by previous fire history. Herbaceous fuel build-up is sufficient to support fire return intervals of one or two years, a cycle that will eliminate shrub communities (Zedler et al. 1983; Nadkarni and Odion 1986; Minnich and Dezzani 1998).

Early fire return creates a positive feedback loop that leads to continued increases in fire frequency and dominance by non-native annuals (Figure 15; from Keeley 2006). When closed-canopy chaparral burns in normal 30-100 year intervals, the result is an intense canopy fire with low alien seed survivorship and strong native herb and shrub recovery. This will eventually return to closed canopy chaparral. If fire returns too early, then it will be of lower intensity and alien seed survivorship will be high (Moreno and Oechel 1991). Non-sprouting species would then be lost, resulting in degraded chaparral with more open canopy of native resprouters and a dense understory of native and non-native annuals and grasses. The altered vegetation is more conducive to another fire because of the high herbaceous fuel component. If repeat fires occur, they will lead to chaparral type conversion to non-native grassland with remnant resprouting shrubs and non-native annual grasses (Keeley 2006). In areas near fuel breaks, the amount of non-native cover in areas with three or more fires increased 25% over areas with one or no fires (Merriam et al 2006).

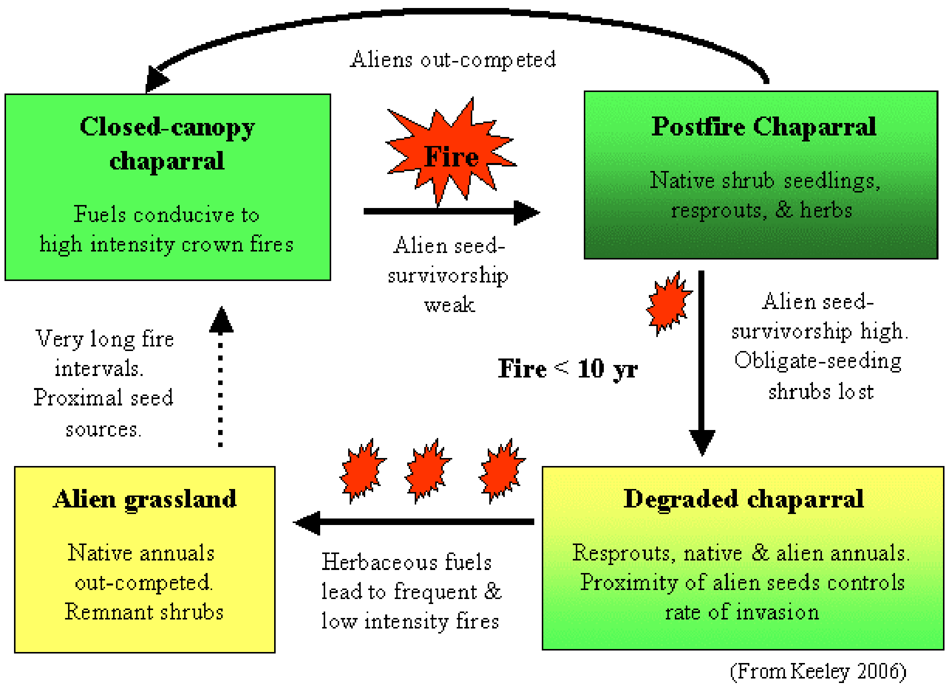

Figure 15. Natural fire cycle, 30-100 years.

Future Threats to Native Plant Communities

Many areas of the Santa Monica Mountains appear to have experienced some degree of fire-driven type conversion (Figure 16). NPS has calculated that 19% of the National Recreation Area has experienced a minimum fire return interval of less than six years, 25% has had minimum fire return intervals between 7-12 years, and the remainder has had a minimum fire interval of greater than 12 years. As population growth continues in the Santa Monica Mountains, urban development will increase the fire frequency and decrease the average fire return interval. Syphard et al. (2007) have modeled urban growth and fire disturbance to compare the relative impacts of altered fire regime and direct habitat loss to different functional plant groups: Coastal Sage Scrub (CSS), Non-Sprouting Chaparral Species (NS), and Obligate Sprouting Chaparral Species (OS). CSS and OS are most vulnerable to direct habitat loss, while NS are susceptible to both altered fire regimes and direct habitat loss. The cumulative effects of repeated fires may occur gradually as urban development expands across the landscape. With development there is likely to be a shift in the location of ignitions and fires, creating a lag time before the cumulative ecological effects of increased frequencies and shorter fire return intervals are observed.

CONCLUSIONS

The impacts of fire in chaparral have been misunderstood because of the habitat's apparent high resilience to fire and the inappropriate transfer of the forest model of the Ponderosa pine fire regime to chaparral fire management. The Santa Monica Mountains provide a model for how changes in the fire regime driven by urbanization and habitat fragmentation can alter native plant communities. The relationship of plant physiological traits to functional modes of post-fire regeneration provides a means to understand the future trajectory of our native plant communities in response to altered fire regimes.

Figure 16. An example of fire type conversion in the Santa Monica Mountains.

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