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PREHISTORIC AND RECENT FIRE OCCURRENCE IN CALIFORNIA

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ABSTRACT

Fires have been a part of California wildlands prehistorically and continue today. They were started prehistorically by lightning and Native Americans. Recently, lightning has continued to be an important source of wildland fires, and accidental and arson fires are important ignition sources. Covering much of the State, we attempted to estimate how much area burned prehistorically, area burned recently under the regime of fire suppression, and how the fire regime characteristics have changed.

The area of California burned annually in prehistoric times, on the average, was estimated in two steps. First, the area of the state occupied by different vegetation types was obtained. Second, data from fire history studies or estimates of fire return intervals in the various types were used to estimate the area burned each year. Recent fire areas burned were obtained from Federal and State wildfire records, beginning in the early 1930's. The data are summarized in a moving five-year average.

Prehistorically, it is estimated that from 5.5 to over 19 million acres burned on the average each year, and data are presented for each vegetation group. Wildfire records show a decreasing trend in wildfire acreage until the late 1960's but an increasing trend since then, with more structures destroyed in the first half of the 1990's than in the previous seven decades. The difference in fire occurrence between prehistoric and recent times means a change in the four aspects of fire regimes -- period between fires, severity, seasonality, and dimensionality. Today there is less pyrodiversity, leading to a potential decrease in biodiversity.

INTRODUCTION

The purpose of the paper is to develop estimates of the burn areas of California for both prehistoric and recent times, and to consider the effects this has had on the biota and on wildfire trends today. Whereas total fire suppression had been the goal of land management and fire protection agencies for decades, there has been a gradual trend toward recognition of the role of fire in maintaining healthy ecosystems and in lowering the fuel loads. Today, agencies are looking more and more to reducing fuel loads through prescribed fire or other means and to using fire as a land management tool.

The prehistoric presence of fire in many of California's ecosystems has been documented extensively, through fire history studies and studies of Native American use of fire. There is little information on fire occurrence in the drier southeastern quarter of the state, and this area was left out of the analysis. Prehistoric fire information came from fire history studies and information on Native American use of fire. In some cases, educated guesses were used to estimate fire return interval.

Recent wildfire history from State and federal records indicate a decrease in acreage per year per 1,000 acres protected, until the late 1960's, but an increasing trend since that time. Increasing fuel loads are a major reason for the increase in area burned, as there has not been a consistent trend in the number of fire starts. The number of structures lost to interface fires has increased dramatically in the last three decades, and particularly in the 1990's, with more structures lost in the first six years of this decade than in the previous seven decades.

METHODS

Prehistoric Fire

Acreages in various vegetation types were taken from Barbour and Majors' 1977 summation of Kuchlers' 1964 vegetation map of California. The best information on fire history from different studies or information from various workers was used in estimating the period between fires. In some types, information from Native Americans or educated were needed to arrive at an estimate of fire return interval.

Often different methods were used by different workers in estimating the fire return interval (FRI), resulting in far different estimates of fire acreages. For example, in any vegetation type, workers might have used the ages of various aged cohorts in a stand, years between fire scars from a point source (single tree), or composite fire return interval taken from fire scars on several trees in a selected area (Dieterich 1980). Composite fire interval dates were often determined with crossdating using dendrochronological techniques. Studies sometimes gave only an average or median period between fires, whereas others gave ranges of periods between fires without further statistical analysis.

We have used or estimated the high and low medians for the period between fires for each type. Using the high and low end of the ranges would yield very high and low estimates of FRI's and of acreages burned. Where ranges, but no mean or median fire intervals were given, we estimated the median to be one-third of the way from the low interval to the high interval and rounded to the nearest year. The rationale for this is that fire intervals in most or all types are skewed toward the low intervals within the range (Finney and Martin 1989). Once a fire interval range from different studies or estimates was established, the high and low intervals were divided into the acreage in the vegetation type to arrive at the low and high estimates of acreages burned each year. These estimates were then summarized to obtain an estimate for California. Since the state consists of about 100 million acres, it is easy to convert acres to percent of the state land area. Little information was available from the desert types of southeastern California, which comprise about 26 million acres or 26 percent of the state, and these were left out of the estimates.

For the fire return interval information, we used the extensive listing in Skinner and Chang (1996) in addition to information cited here. (We have not repeated their citations in the interest of brevity). Information was obtained from Johnson and Smathers (1976), Olson and Martin (1981), Greenlee (1983), Rice (1983), Sugnet (1985), Finney and Martin (1989, 1992), Anderson (1993), Brown and Swetnam (1994), and Stephens (1996a, 1996b) as well as personal communications and knowledge.

Recent Fire History

Recent fire history in California was obtained from various USDA Forest Service (USFS) and California Department of Forestry and Fire Protection (CDF) documents. Over the years, reports on fire occurrence have been issued annually, although the format and data covered by the agencies varied over the years. We began with 1931 and continued through 1996. Over the years, the documents and the acres protected changed, sometimes drastically, although it has been relatively constant for the last several years. Data on structures and human lives lost came from the CDF guide by Imboden (1991) and later CDF reports.

RESULTS

Prehistoric Fire

Prehistoric fires varied greatly in their FRI, and the incidence of lightning and Native American fires were important factors in the variations (Table 1). FRI's were shortest in areas where lightning and Native American ignitions were combined. The shortest estimated FRI's were in the grass and oak dominated types, where not only was lightning often important, but also where Native Americans used fires to cultivate and ease the collection of the crop, such as grains or acorns.

In the Modoc Plateau, dominating much of the northeast corner of the state, lightning fires are common , resulting in around 40 fires per million acres per year (Johnson and Smathers 1976, Olson and Martin 1981). Native Americans contributed fires for management, hunting, and protection purposes. From photos of the 1873 Modoc Indian War, what is today a juniper /sagebrush/grass range was then primarily grass.

FRI in coast redwood was amazingly short. Whereas Jacobs, Cole and McBride (1985) came up with an average of 22 years, Finney and Martin (1989) and Brown and Swetnam (1994) arrived at a composite FRI of 8 to 12 years. In the wetter or cooler vegetation types, such as redwoods and associated types, lightning fires would have been far less common or have covered much less area, and Native American use of fire more importance than in the Sierra or eastside types. In northwestern California, Native Americans used fire extensively to improve fiber and acorn production (Michele Lee personal communication).

Recent Fire History

Wildfire Acreage

Recent fire history indicates a large decline in acreage burned until the late 1960's, but an increase in acreage burned per 1,000 acres protected since that time (Figure 1). In the last five years of the 1960's, about 2.9 acres burned per 1,000 acres protected. In contrast, in the first five years of the 1990's, about 6.7 acres burned per 1,000 acres protected, a figure about 2.3 times as high. In the figure, any year labeled is the average for that year and the previous four years. The figure, even though it is a moving 5-year average to smooth the line, indicates large jumps. These jumps are caused by high fire years, such as occurred in 1987 and 1996. Their effects on the moving average carries through for five years. Often the large fire years are years of high lightning fire occurrence, when multiple ignitions, sometimes numbering into the hundreds, immediately overwhelm the fire fighting resources.

Structure Loss

In addition to the increase in wildfire acreage, the number of structures destroyed by wildland fires has increased dramatically in the last three decades (Table 2). More structures were destroyed by wildfires in the first seven years of this decade than in the previous seven decades, including the disastrous 1923 Berkeley fire. Beginning with the 1960's, there has been an increasing loss of structures. The 1991 Oakland/Berkeley Tunnel Fire contributed greatly to the loss with 2103 structures and 2475 living units lost.

There may be multiple reasons contributing to the increased loss of structures. First is the generally increasing fuel hazard in all wildland areas. Thus wildifres in an area are less likely to be suppressed at a small size. Second is the increasing number of people living in wildland areas without the benefit of managing their surroundings. In the past, most people living in such situations were ranchers or farmers, aware of fire problems and often protected by their agricultural practices.

Loss of Human Life

Loss of human life has not displayed a trend in the last in the period of the 30's into the 90's, in spite of the great increase in structure loss. This is probably attributable to better communications and evacuation potential, particularly by the firefighting and law enforcement organizations. In comparison, no one was killed in the Berkeley Fire of 1923, the worst single interface fire structure loss until the 1991 Oakland/Berkeley Tunnel Fire.

One might argue that any loss of human life to wildfire is too much. However, it is far less than the loss of life in some of the disastrous wildfires of the 19th and early 20th centuries, when deaths in some of the large fires numbered in the hundreds, or the Tokyo earthquake and fire of 1923, where 69,000 people perished, mostly from fire (Martin and Sapsis 1995). The number lost in wildland interface fires is also far less than the human loss of life in dwelling and urban fires each year.

DISCUSSION

Prehistoric fire occurrence covered about 5.5 to 19 million acres (2.25 to 7.75 million hectares) each year in California, according to the estimates presented, or roughly 5.5 to 19 percent of the area of the state. If one considers that only three quarters of the State were considered in the estimates, then the figures represent 7.6 and 26.1 percent of the area studied. Although the lower figure seems reasonable, the higher figure seems quite high. Estimates made of the area burned may be in error for more than one reason. First, the study areas for individual fire histories might not have been representative of the entire vegetation type. Second, the estimates we used for FRI in some types may be low. Third, as studies are done to develop the composite FRI, all fires might not have covered the entire stand area. Regardless of the possible errors in the study, even using the lower figure for area burned per year, we have to conclude that a lot of California burned every year.

The recent fire history of California indicates a reduction in acres burned per 1,000 acres protected until the late 1960's, when the trend reversed itself. This is a pattern common to all other regions of the United States except for the South. Over the years, more money, equipment, and human resources were put into the effort to suppress wildfires, with apparent success. In the meantime, fuels were accumulating in the wildlands and vegetation changes were taking place. Eventually, the effect of suppression led to a point where fires occurring under severe fire weather conditions in the accumulated fuels were uncontrollable. Today, although most wildfires are still controlled at a small size by initial attack, some wildfires occurring under severe conditions are controlled after weather or fuel conditions change. These fires do most of the damage.

In addition to the recorded damage caused by this latter group of fires, there is a change in the biota, both caused by the lack of fire and the severe wildfires. Whereas the fire regimes before suppression had lower FRI's, burned in less fuel, often under moderate weather conditions, and were lighted during a fairly broad range of seasons. Today, the large, uncontrollable fires burn mostly under very severe weather conditions in high fuels loads. The season is usually quite narrow. The large, severe stand removal fires - - in contrast to stand replacement fires for species adapted to high severity fires - - are removing species adapted to short FRI's and fires burning in light fuels under moderate conditions.

The increased wildfire acreage is not restricted to California. Increased wildfire acreage in the last decades has been the norm in all regions of the United States except the Southeast (USDA Forest Service 1995). It is the Southeast where extensive prescribed burning is used for many purposes in wildland management, including fuels management.

Throughout California and most of the United States, not only has the wildfire acreage changed, but also the nature of the fires, bringing about changes in the nature of the fire regimes. Using fire return interval, seasonality, severity, and dimensionality to describe fire regimes (Martin and Sapsis 1992), we can see that most of these have been modified. The fires are now generally farther apart, allowing more accumulation of fuel and burn under more extreme fire conditions. Thus they burn with greater severity and size, and are more likely to occur in a narrow season of the year, the time when fire fighters are unable to suppress them. All these changes result in a narrowing of the pyrodiversity, with potentially a narrowing of biodiversity.

Our fire regimes have changed in fire return interval, season,, dimensions, and severity, reducing the pyrodiversity (Martin and Sapsis 1992). Rather than a range of FRI's from short to long, most areas covered by wildfires today are covered by long FRI's. The season has been narrowed. Dimensions have increased (Minnich 1983), making return of removed species more difficult and slower. Dimensionality has increased both spatially and temporally. Finally, more of the area covered by wildfires is burned severely, again narrowing the pyrodiversity. This can only narrow the biodiversity of both plants and animals.

Scientists and many land managers have recognized the problem of strict fire suppression going back to the early 1900's (Schiff 1962). Over the years, evidence has accumulated to support the use of fire for many purposes. Now, with increasing awareness of the extensive use of fire by Native Americans, and the increasing problems of controlling fires and protecting people and structures, fire protection agencies are changing to a fire management mode with prescribed fire and other fuel management methods. Some are quite well along in practicing prescribed burning; others are just now shifting emphasis.

As we move toward more prescribed fire, both the costs of doing so and the emissions are major problems. Fire suppression funds cannot be reduced for some time, until the effects of prescribed fire on fuels become widespread. Thus, funds for prescribed fire will be needed in addition to suppression funds. Looking for ways to reduce the costs is important, and approaching the problem with the "Florida" solution is one way (Wade and Brenner 1995). The State of Florida enacted a law, since copied by many other states, which basically says they will certify prescribed burners, approve prescribed burning plans , and assume responsibility if a properly conducted burn does damage. Weatherspoon and Skinner (1996) discuss strategies for dealing with fuels management throughout the Sierra Nevada area.

Smoke from fires is probably the single greatest problem in increasing the use of prescribed fire. No matter how well we manage smoke, there will be a tremendous amount. Dealing with a public that is demanding cleaner air will require extensive education and public relations, and still might not be successful.

SUMMARY

Estimates for the prehistoric areas of California burned per year are several times the areas burned today by wild and prescribed fires. The exclusion of fires from wildlands has led to extensive fuel buildup and large, damaging wildfires. Area and number of structures lost to wildfires each year has increased since the 1960's, and the nature of fire regimes has changed. For most of the area burned in wildfires, fire regimes have changed, with a resultant change in the biota. Agencies today are moving away from strict fire suppression policies toward fuel and fire management strategies. Costs of the management as well as the increased smoke from prescribed fires present major challenges to fire managers.

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Table 1. Summary of California vegetation types, acreages, and numbers from Barbour and Majors (1977) and estimates of fire return intervals and average annual acreages burned for California.

Vegetation Type	Number	Acres	Median Period Between Fires		Acres Burned per Year	
			Low	High	High	Low
Forest Types						
Spruce/Cedar/Hemlock	1	5,009	50	100	100	50
Cedar/Hemlock/D-fir	2	2,015,696	9	27	223,966	74,655
Mixed Conifer	5	13,641,010	5	16	2,728,202	852,563
[redacted]						
Red Fir	7	1,903,490	16	20	118,968	95,174
Lodgepole Pine/Subalpine	8	2,150,944	50	100	43,019	21,509
Pine-Cypress	9	123,226	25	25	4,929	4,929
Ponderosa/Shrub	10	1,695,108	5	16	339,022	105,944
Great Basin Pine	22	49,090	5	16	9,818	3,068
Juniper-Pinyon	23	2,463,517	5	16	492,703	153,970
[redacted]						
Total Forest Types		29,766,576			4,5596,225	1,523,694
Shrub Fuel Types						
Chaparral	33	8,500,585	15	30	566,706	283,353
Montane Chaparral	34	573,051	5	16	114,610	35,816
Coastal Sagebrush	35	2,473,535	5	20	494,707	123,677
Mosaic of 30 and 35		641,175	2	12	320,588	53,431
Total Shrub Fuel Types		12,188,346			1,496,611	496,277
Herbaceous Fuel Types						
California Oakwoods	30	9,554,518	2	8	4,777,259	1,194,315
Great Basin Sagebrush	38	1,851,394	5	12	370,279	154,283
Fescue-Oatgrass	47	878,711	5	12	175,742	73,226
California Steppe	48	13,222,242	2	8	6,611,121	1,652,780
Tule Marshes	49	1,859,409	5	12	371,882	154,951
Alpine Meadows	52	747,370	7	20	106,767	37,368
Sagebrush Steppe	55	3,245,951	5	12	649,190	270,496
Total Herbaceous Fuel		31,359,595			13,062,240	3,537,419
No Fire Records						
Saltbush-Greasewood	40	3,104,692				
Creosote Bush	41	16,355,988				
Creosote Bush-Bur Sage	42	5,330,774				
Paloverde-Cactus Shrub	43	1,052,930				
Desert Sparse Vegetation	46	115,211				
Total No Records		25,959,595				
Total All Vegetation		**99,274,112**			**19,155,076**	**5,557,390**

Table 2. Summary by decades of structures and human lives lost in wildland-based wildfires in California using data from Imboden (1991), CDF reports, and personal knowledge.

Decade	Structures Lost	Human Lives Lost
1920's	584	0
1930's	47	25
1940's	0	11
1950's	105	35
1960's	1,065	33
1970's	1,218	27
1980's	1,599	16
1990's	4,803 (through 1996)	27 (through 1991)
Totals	**9,421**	**174**

Figure 1. Recent wildfire acreage per 1,000 acres protected taken from CDF and USFS annual fire reports. Data points represent a running five year average with the date representing the last year entered. Data for 1987, 1988, and 1989 are USFS data only.