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Is Arson Associated with Severe Fire Weather in Southern California?

Romain Mees

Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, Riverside, California 92507 USA
Tel. 714-276-6523; Fax 714-276-6426

Abstract. Under severe fire weather conditions arson is believed to be the primary cause of large wildland fires in southern California. Wildland fire suppression personnel and the public use the the expression "This weather brings out the arsonists" to indicate their awareness of the high potential for large arson-caused fires under these conditions. To determine the accuracy of this statement, fire occurrence and weather data were analyzed for four southern California National Forests for a 10-year period (1975-1984). The results showed that the proportion of arson and non-arson person-caused fires remained the same under most fire-danger conditions; however, a much higher percentage of arson fires became large fires when fire danger was severe. Furthermore, the timing of the arsonist contributed to the frequent occurrence of large arson fires.

The data presented here refute the idea that most arson fires occur under severe weather conditions and—at the same time—validate the utility of maintaining arson prevention programs during most weather conditions.

Keywords: Arson; Fire weather; Wildland fires.

Introduction

During severe fire weather conditions fires set by arsonists tend to burn large acreages in southern California, and the number of fires set appears to be larger. For this reason fire prevention and suppression personnel go on alert under these conditions. Previous studies of wildland arson fires (Bradshaw anduff, 1985; Utz and Forst, 1978; Hansbrough, 1961) have not examined the relationship between fire danger as measured by the National Fire-Danger Rating System (NFDRS) indices and the occurrence of arson.

To investigate the association between arson-set fires and fire danger, I examined USDA Forest Service fire and daily weather records from four National Forests (Angeles, Los Padres, Cleveland, and San Bernardino) located in southern California for the period 1975 to 1984. About 85% of all fires on these Forests are person-caused, and of these, 21% are arson.

This paper reports the results of a study that tested three hypotheses: (1) arson wildfires are (contrary to the opinion of most wildland fire suppression personnel) almost equally likely to occur under most fire danger ratings as measured by one of the NFDRS indices; (2) when fire danger is severe, a larger proportion of the arson-caused fires become large fires; and (3) the timing of the arsonist provides some evidence for the high percentage of large fires among arson-caused fires.

The daily weather observations and fire data for the study period constitute a complete census of all fires in southern California for the 10 years. I was interested in descriptive statistics rather than in questions of statistical inference. Fire management, fire weather, fuel loading, and fire occurrence vary from year-to-year and are never repeated. This variability and independence between fire seasons leads to great differences in fire occurrence, size, and fire management. Therefore, the conclusions and fire management implications drawn from this analysis may not apply to the next 10-year period (1985-1994).

For this study a fire was designated as a large fire if at least 100 personnel were employed to suppress it, and it reached a minimum size of 40.46 hectares.

Methods

The four National Forests studied are located within the same fire climate region (Schroeder et al, 1964)—all are closely located geographically and can be described by the same wildland fuel model. Burned area and the maximum number of personnel used for each fire were obtained from computerized USDA Forest Service fire reports (Form 5100-29). Daily weather observations for

Table 1. Arson and non-arson person-caused fires by 10 equal burning index (BI) percentile classes. The ratio of arson to non-arson fires by BI class is given. The left end-point is included in each class interval.

District BI percentile class	Person-caused Fires		Ratio	Total number of fires
	Arson	Non-arson		
0-10%	50	362	.14	412
10-20%	52	360	.14	412
20-30%	62	350	.18	412
30-40%	77	335	.23	412
40-50%	76	336	.23	412
50-60%	68	344	.20	412
60-70%	87	325	.27	412
70-80%	76	336	.23	412
80-90%	79	333	.24	412
90-100%	90	322	.28	412

the years 1975 to 1984 were available for each of the four National Forests.

One weather station was selected to represent all fires within each Ranger District and to provide the best available history of local weather observations. Computation of the fire danger indices within NFDRS requires the selection of a fuel model to represent the predominant fuel type. Fuel model B (mature, heavy, dense brush) was used to calculate the burning index (BI) for all fires within all four National Forests. The BI is a common measure of daily fire danger (Deeming et al. 1978). This highly variable daily index has proven to be an acceptable measure of fire danger, especially under severe conditions (Mees and Bednar, 1989).

The focus of this work was primarily large fires, which were not always contained on the day they were reported. For each fire, daily BI values were computed for 7 consecutive days: the day the fire was reported, 3 days after it, and 3 days before it. The 3 days after the day the fire was reported were included to describe the weather during the containment phase of the average large fire. The 3 days before the report day were included to indicate the weather leading up to all fires, large or small. If one of the seven consecutive BI values was missing, a BI based on the larger of the two neighboring values was used. The remaining value was used if one of the neighbors was missing, and the fire was eliminated from the data base if no neighbors existed.

The average BI for the 7 days was used as an overall measure of fire danger for each fire within a Ranger District. All fires during the 10-year period occurring within a District were ranked by their 7-day average BI. The fires were then grouped into 10 equal (10%) BI quantile classes for each District, which were used to compare the proportion of arson versus non-arson person-caused fires.

Weather stations within the same National Forest may be under the primary influence of either desert or coastal climates, resulting in large variations in fire danger from District to District. A Forest-wide percentile for the BI was calculated by averaging the District percentiles for all fires within the 10-year period. These Forest-wide percentiles for the BI were ranked and grouped into 10 equal BI quantile classes, using all fires in the 10-year period within the same Forest. Districts for which no average 7-day BI existed were excluded from the 7-day average percentile BI for the Forest. A Forest-wide percentile ranking based on the average of the District percentiles is not subject to the extreme differences in local climatology and may provide a better estimate of Forest-wide fire danger.

The 7-day BI sequence for each fire, based on a weather station located within the District where the fire occurred, was also used to determine if the BI of the fourth day (the day the fire was reported) was greater than the median BI of the 7 days. The expected proportion of fires for which the fourth day BI exceeds the median is 3/7=.428, if the BI of the fourth day is truly random. The difference in proportions for arson and non-arson fires for which this is true provides a measure of the arsonists' intentions (timing) and may have affected the size of the fires during the 10-year period.

Results

A total of 732 arson and 3452 non-arson person-caused fires for the 10-year period produced an overall ratio of approximately .21 for all Districts (Table 1). For fires with a 7-day District average BI below the 30th percentile, the ratio was lower than .21. Above the 30th percentile the ratio ranged from .20 to .28 (Table 1). A daily BI below the 30th percentile is considered equivalent to low fire danger.

When the District 7-day average BI was at the 60th percentile or higher, 7.2% of the arson fires became large: 100%*(4+7+7+7)/(87+76+79+90)(Tables 1 and 2). Of non-arson fires 1.9% became large:100%*(7+10+4+8)/

Table 2. Large arson and non-arson person-caused fires for 10 equal burning index (BI) percentile classes, by District- and Forest-wide 7-day average BI. The left end-point is included in each class interval.

BI percentile class	District BI Number of large fires		Forest-wide BI Number of large fires	
	Arson	Non-arson	Arson	Non-arson
0-10%	1	4	0	0
10-20%	0	6	0	2
20-30%	2	9	0	6
30-40%	1	7	2	10
40-50%	1	7	1	12
50-60%	1	7	4	6
60-70%	4	7	4	13
70-80%	7	10	8	11
80-90%	7	4	6	4
90-100%	7	8	6	3

(325+336+333+322). The ratio of these two percentages is almost 4 to 1, and is based on the District 7-day average BI rankings. Forest-wide BI's result in a 3 to 1 ratio: 100%*(24/362)=6.6% for arson fires versus 100%*(31/1365)=2.27% for non-arson fires.

The total number of large arson and non-arson fires based on the District BI was less than the total based on the Forest-wide average BI because some of the fires were eliminated in the District calculation due to a lack of weather observations (Table 2). The Forest-wide average was based on the available weather data within each District, and if one District was missing weather data the Forest-wide average was computed without the missing District.

When the 7-day average BI was greater than the 60th percentile, 50% to 60% of the arson fires exceeded the median BI of the seven daily values. For non-arson fires the percentage was near the expected 42.8% (Table 3).

Table 3. The percentage of arson and non-arson fires for which the burning index (BI) on the fire report day exceeds the median BI of the 7 days, by District BI percentile class. The left end-point is included in each class interval.

District BI percentile class	Arson fires	Non-arson fires
	(percent)	
0-10%	24	39
10-20%	48	40
20-30%	48	56
30-40%	49	51
40-50%	51	48
50-60%	41	46
60-70%	50	43
70-80%	59	43
80-90%	52	42
90-100%	51	44

The 7-day average 90th percentiles for the BI at each of the 18 weather stations (Districts) studied were as follows: 64, 60, 64, 150, 60, 85, 130, 59, 90, 62, 66, 73, 83, 148, 134, 130, 116, and 148. Weather stations with a 90th BI percentile that is less than 100 are located such that they are primarily under the influence of a coastal climate. Values above 100 represent weather stations primarily under the influence of a desert climate and represent, in order of occurrence, the Valyermo District (BI=150) on the Angeles National Forest, the Palomar District (BI=130) on the Cleveland National Forest, and the five Districts (BI = 148, 134, 130, 116, and 148) on the San Bernardino National Forest.

Discussion

The Forest Service fire reports form a large data set containing many confounding and interrelated variables, and the methods of collection can lead to data of questionable reliability. Fire reports are often completed several days after fires are controlled. Gross discrepancies occur between recorded values for acreage burned and the maximum number of personnel used. The fire reports also provide a value for the BI on the day the fire was reported. However, after computing a BI using the NFDRS, the person filling out the fire report was encouraged to enter a subjective value based on their view of the situation. Therefore, verification of the computed values for the BI based on historical weather data was impossible.

About 400 out of a possible original 4573 fires had to be eliminated because of a lack of weather data. Most of those eliminated were large fires, the fires of interest. Local weather observations were often nonexistent on the days large fires were reported and contained. Although fire personnel are intensely occupied during

these periods, recording weather observations would be helpful.

Improved fire and weather records during the course of especially large fires are a prerequisite before additional studies, such as in fire suppression and multiple fire situations, can contribute to wildland fire management.

The District 7-day average ranking may contain both low and high daily BI readings, which is reflected by the occurrence of some large fires below the 30th percentile (Table 2).

The Forest-wide 7-day average tends to concentrate the large fires nearer the 50th percentile (Table 2). Both the District and Forest-wide BI classifications show that the percentage of large fires among arson fires during more severe weather conditions is much larger.

The timing of arson is such that the daily BI tends to favor large fires (Table 3). The BI on the day of occurrence is one of the top three values of the seven daily values surrounding the fire from 50% to almost 60% of the time. Other variables such as suppression effort and fuels may be involved, but the data to evaluate these does not exist.

The ratio of arson to non-arson fires is almost constant when the 7-day average BI is above the 60th percentile. The proportion of arson fires that become large fires above the 60th percentile is remarkably high. Since both arson and non-arson fires were started under similar fire danger conditions, other factors such as the arsonist's timing, selection of fuel and location must be considered.

Fire occurrence and weather data for four southern California National Forests support the three hypotheses studied. First, for a 7-day average BI in excess of the 30th percentile, arson was just as frequent during periods of low or high fire danger. Second, when the District BI was at or above the 60th percentile, arson tended to produce large fires at four times the rate that non-arson fires became large. Third, the arsonist's selection of a day with a high fire-danger rating during the 7-day period may partially explain why so many of these fires became large.

Management Implications

The Forest Service fire report data base and the weather records used in this study are loaded with missing and contradictory data. Federal and State agencies have not realized the importance of filing reliable and accurate fire and weather data. Fire management is an unpredictable business. It is often a case of decision-making under conditions of extreme uncertainty. As long as agencies do not improve the quality of this all-important data, the benefits of research and the applicability of historical data to fire management will remain questionable.

Fire management personnel and the public at large continue to believe that the arsonist is primarily active during periods of severe fire danger. Current prevention measures tend to be designed to prevent arson and to meet the arsonist during these times. Targeting the arsonist at almost all levels of fire danger may help identify and discourage some of these individuals.

Since arson fires set under more severe fire danger conditions appear more likely to become large fires, arsonists probably target fuels or locations or both where fires are more likely to start and spread. Furthermore, because arsonists tend to select days with relatively high BI, the timing of these fires has to be included in any further analysis of arson fires.

Arson prevention is difficult since the perpetrators try to hide their actions. Controlling information about severe conditions, such as not issuing special fire warnings, would probably do little to deter arson occurrence since many other sources of the same information exist (personal observation, word of mouth, mass media weather reports). Incarcerated arsonists reported that an increased chance of apprehension would more likely have deterred their incendiary actions than increases of length or severity of sentence (Bradshaw and Huff, 1985). Effective prevention of arson would require enhanced patrols and detection, indicating a higher probability of arsonists getting caught.

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