AN APPRAISAL OF CRITICAL FIRE WEATHER IN NORTHWESTERN CALIFORNIA

by

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A Thesis
Presented to

The Faculty of Humboldt State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

June, 1976

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ABSTRACT

Fire managers need to use burning index values that relate to specific levels of fire problems. A recent appraisal of critical fire weather in northwestern California indicates that some burning index values currently used in planning do not reflect the character of the fire problem. The study examined National Fire Danger Rating System burning indexes associated with 64 major fires (fires 300 acres or larger) burning during the months of June through October from 1955 to 1974. These fires occurred at lower burning indexes than are currently identified as severe by local fire managers. Critical level values for burning indexes in major and minor fuel model and slope class combinations were developed using data from the tires, and their frequency (%) of occurrence at 23 fire weather observation stations was identified. A review of fire occurrence in eight fire season climatic zones delineated showed the warm—dry zone had the highest major fire occurrence rate per unit area of all zones. Ninety two percent of the fires were associated with four major synoptic weather systems; (1) SubtropIcal High Aloft, (2) Great Basin High, (3) Meridonal Ridge (Southwest Flow), and 4) Pacific High (Postfrontal). The study presents data indicating a need to reevaluate criteria used to guide current fire management activities, particularly activities associated with burning index values.

ACKNOWLEDGEMENTS

This study was made possible through a cooperative aide agreement (No. 21—333) between the United States Forest Service, Pacific Southwest Forest and Range Experiment Station, Forest Fire Laboratory, Riverside, California and the Humboldt State University Foundation. I wish to express appreciation for this support.

Sincere gratitude is also extended to Dr. R. Brooks Sibley for his efforts in obtaining the funding for this project and for his confidence, advice, assistance, and time devoted in serving as the graduate committee chairman.

I would also like to thank the other members of my graduate committee, Drs. David A. Bryant and William H. Sise for their guidance and comments.

Special thanks are extended to William H. Henning and Melvin K. Hull of the National Weather Service, Eureka, California for their contribution as “technical advisors” for the project, and to R.J. Wilson of the Humboldt State University Computer Facility and the many research and administrative personnel throughout the United States Forest Service, California Division of Forestry and Bureau of Indian Affairs who provided comments, suggestions, data and encouragement.

Lastly, the most special thank you goes to my wife, Donna, who contributed unselfishly to the project over the past two years. Without her efforts this thesis would not have been a successful endeavor.

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INTRODUCTION

Fire management personnel are faced with economic, ecological and tactical decisions when implementing fire management activities. If fire managers are to make optimal decisions, they must understand how current and predicted synoptic scale weather influences fire weather and, thus, fire behavior.

The purpose of this study is to appraise critical fire weather in northwestern California. Fire weather can be defined as weather conditions which influence fire ignition and behavior, and man's ability to control fire (Brown and Davis 1973). These conditions are not restricted to the earth's surface, but extend to heights of *5* to 10 miles into the atmosphere. They are continually responding to synoptic scale weather systems which move in generally predictable paths across the United States and around the globe (Schroeder and Buck 1970).

Burning conditions also depend on fuels and topography. The interaction of weather conditions, fuels, and topography constitute fire environment (Countryman 1972). A wildfire is the product of this environment. There can be no large fires regardless of weather if there are no fuels. Likewise, burning conditions may be critical under even less severe fire weather because of the amount, concentration, type and arrangement of fuels (Schroeder 1969) or because of topographic conditions. Weather, though, is the most variable component of fire environment, changing rapidly in time and space (Countryman 1972).

Fire weather measurements are used to guide daily and longterm fire management activities (Lancaster l974). Measurements such as ambient air temperature, relative humidity, fuel moisture, wind speed and duration and amount of precipitation are integrated into a system of numerical scales which are designed to identify the severity of the fire problem on any single day. In 1954 there were eight different systems being used nationwide. These various systems have been reduced to one designated for nationwide application.

Studies relating to critical fire weather in northwestern California have been limited. The first major report dealing with synoptic scale weather systems and critical fire weather was developed by Schroeder et al. (1964). The continental United States was divided into 14 regions based on differences in climate and topography. Data from a network of 89 first-order weather observation stations which best represented the weather within each of the regions were used with the California Wildland Fire Danger Rating (CWFDR) System (Anonymous 1962) to compute fire load indexes. These indexes gave a relative measure of the total probable fire suppression job for the day. It was found that periods of critical fire weather in northern California, as indicated by a fire load index of 22 or greater, were associated with the occurrence of four principle synoptic scale weather systems. These were (1) Subtropical High Aloft, (2) Meridonal. Ridge (Southwest Flow), (3) Pacific High (Postfrontal) and 4) Great Basin High.

A study by Helm, Neal and Taylor (1973) focused on critical fire weather appraisal on a statewide basis. CWFDR System fire load indexes for fire danger rating areas were reviewed to identify the number of cases where an assumed critical fire load index of 28 was equaled or exceeded. The fire danger rating areas, which represented areas of similar climate and broad fuel types, were then placed into categories based on the average number of yearly occurrences of the critical index. The study concluded that incidences of critical fire weather in northwestern California averaged less than ten days per wildfire season.

The CWFDR System, which was a major component of previous fire weather studies, has been replaced by the National Fire Danger Rating (NFDR) System (Deeming et al. l974). Deeming (1972) indicated that important differences exist between the two systems. The differences are such that critical CWFDR System indexes identified in previous studies do not necessarily represent critical indexes in the NFDR System. This study and future fire weather studies, therefore, must be based on the national system.

Specific objectives of the study are to (1) identify dates and places of large fires (300 acres or larger) from 1955-1974 during the June 1 through October 31 fire season, (2) identify fire season climatic zones and locate large fire occurrence by zones,

(3) determine burning indexes associated with the fires, 4) determine critical levels of burning indexes and their frequency of’ occurrence, and (5) identify the synoptic scale weather systems associated with the fires

STUDY AREA

Location

The study area is located in northwestern California between latitude 40^0 00'N and 42^0 00'N and longitude 123°00'W and 124°30'W (Figure 1). The boundaries of the study area correspond with the boundaries of the Six Rivers National Forest, United States Forest Service; the Humboldt-Del Norte Ranger Unit of the California Division of' Forestry; and the Hoopa Indian Reservation, Bureau of Indian Affairs. The wildlands protected by these agencies amount to approximately 3,180,000 acres.

Area Description

Weather: A dominant factor influencing fire season climate in the study area is the position of the permanent Pacific High in the eastern Pacific Ocean. This anticyclone moves northward in the summer, effectively holding cyclonic storm tracks north of the study area. As a result, the area receives little or no precipitation during the summer. The scant summertime precipitation comes in the form of infrequent showers and/or thunderstorms.

All of the coastal areas are affected by the marine air mass from the Pacific Ocean. Berg and Lowery (1959), Coffin (1959), and Fosberg and Schroeder (1963) found that weather parameters used to compute fire danger are influenced by the marine air mass. The extent of marine air influence on the study area depends on

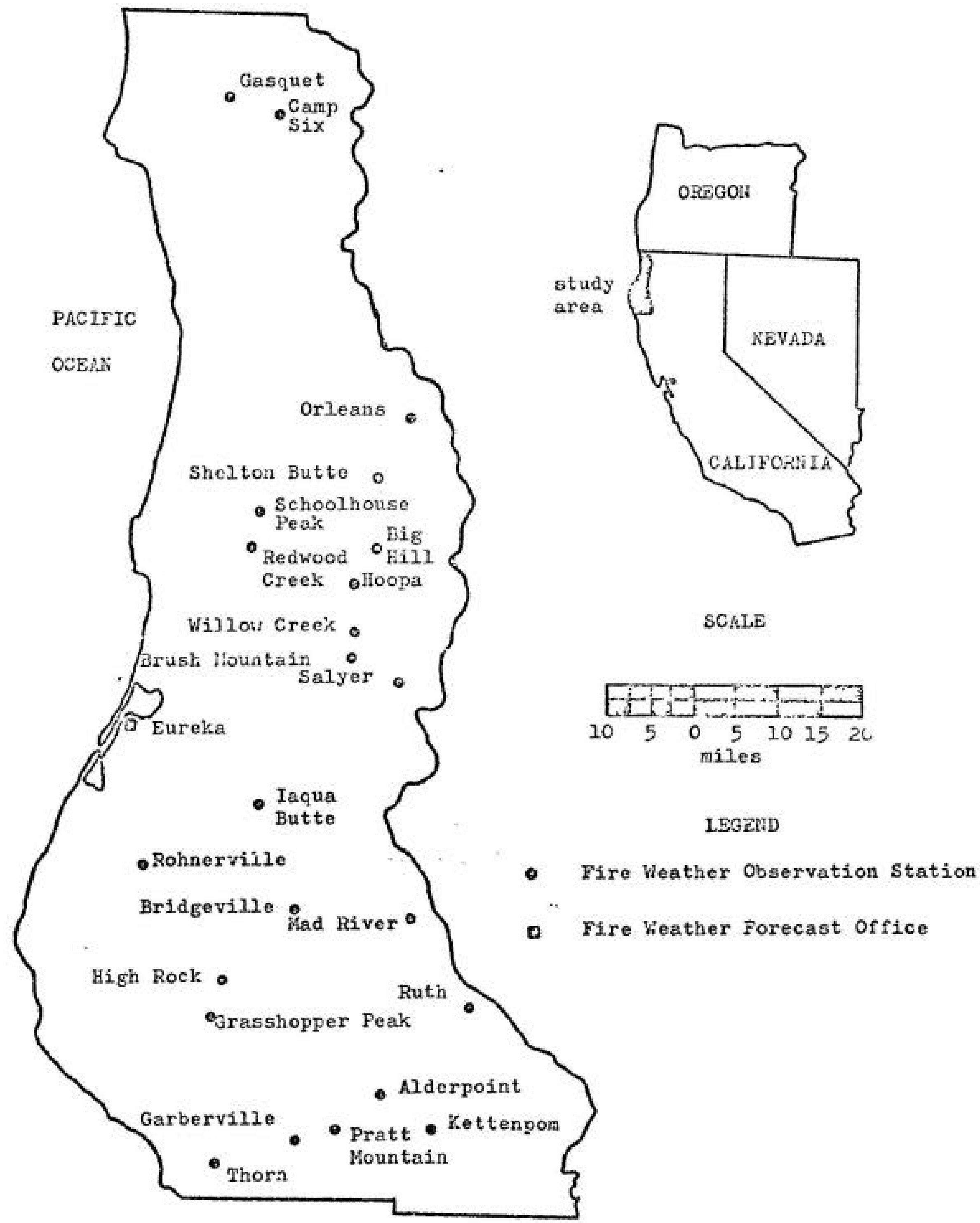

Figure 1. Location of the northwestern California fire weather study area.

the synoptic scale circulation pattern (Cramer and Lynott 1961, Fosberg and Schroeder 1966). Off-shore flow may prevent moist marine air from moving Inland-resulting in critical fire danger throughout the area (NOAA 1973). At other times, the marine layer may Influence only a narrow strip adjacent to the coast, leaving the inland area hot and dry. Under still other conditions, humid air may reach well into the study area through the major river drainages, and leave ridgetops above the marine layer hot and dry. The encroachment of marine air into the study area can produce strong, shifting winds, and also anomalous wind, temperature, and humidity patterns that affect the inception, behavior and control of wildfires In the area (Phillips and Schroeder 1967, Schroeder et al. 1967).

Fuels: High value redwood (Sequoia sempervirens) dominates the moist coastal valleys. Douglas-fir (Pseudotsuga menziesii), hardwoods such as madrone (Arbutus menziesii), tanoak (Lithocarpus densiflorus), and various oaks (Quercus spp.), plus various species of pine (Pinus spp.) are found on drier upper slopes and ridges. Timber harvesting operations have resulted in concentrations of flammable slash. Adjacent to timbered areas are large grassy openings covered with fine rapid burning fuels. The combination of high rainfall and moderate temperatures have resulted in a buildup of heavy fuel volumes (Schroeder and Buck 1970).

Vegetation cover types and fuel types in the study area have previously been classified using several systems (Weislander and Jensen l946, U.S. Forest Service. 1963, U.S Forest Service 1969). Such classification is not applicable to fuel models used in the NFDR System as fuel models are based on fuel amounts by class and arrangement rather than cover types (Deeming et al. l974). A fuel model is a simulated fuel complex for which all the fuel descriptors required for the solution of the mathematical fire spread model have been specified (Deeming et al. l974). Personal communications with the U.S. Forest Service (Riley 1975) and California Division of Forestry (Imboden 1975) indicate NFDR System Fuel Models C, D, and G are the best representations of fuels in the study area. Fuel Models A, B, and I are also applicable on a limited basis.

Topography: The study area is steep and rugged and many sections are inaccessible to vehicles. The area is composed of mountains, some small valleys, rivers, streams, and relatively small coastal plains. Elevation ranges from sea level at the coastline to above 6000 feet at points along the eastern boundary.

The combined effects of weather and fuels on fire ignitions, intensity and spread are strongly influenced by aspect, elevation, steepness of slope, position of the fire on the slope, shape of the country, and the existence of natural or man-made barriers. Although by definition topography is relatively static, the effect that topography has on fire behavior is dynamic and varies with the time of day and year.

Fire History: Evidence of specific historic fires has been presented by Show and Kotok (1925), Fritz (1931), and Barrett (1935). Agency fire records prior to 1940 are considered poor (Wallis, Bowden and Lent 1963), but an extensive review of northwestern California newspapers and various other documents covering about 100 years prior to the current study period indicated that large fires were not uncommon. The “fire seasons” of 1880, 1887, 1891, 1906, 1910, 1913, 1915, 1918, 1919, 1924, 1926, 1928, 1929, 1931, 1931+, 1935, 1936, 1938, 1939, 1941, 1944, l945, 1947, 1951, and 1952 were relatively severe. The substantial number of past severe years is a good indication that the area can develop a fire environment capable of producing large fires.

METHODS

Large Fire Occurrence

Dates and locations of all large fires were extracted from fire records maintained by the Six Rivers National Forest, U.S. Forest Service; Humboldt-Del Norte Ranger Unit, California Division of Forestry and Hoopa Indian Reservation, Bureau of Indian Affairs. Data for the Humboldt-Del Norte Ranger Unit were supplemented with information from the California Division of Forestry archives in Sacramento, California.

Fire Season Climatic Zones (Fire Climate Regions)

Various objective and semi-objective methods to delineate fire season climatic zones (fire climate regions) have been proposed (Trigg 1971, Fosberg and Furman 1973, and Furman 1974. The technique proposed by Trigg was utilized to define the areas of homogenous "fire season" climates in northwestern California. It was chosen because there was a greater number of stations and more data available for use with this method. A modification of Trigg's method was also applied. This modification utilized normal values for temperature and precipitation rather than actual temperature and precipitation values.

The input data for both methods, data sources, and the computer program FIREZONE developed to analyze the data were extracted from Gripp and Gripp (1976).

Burning Indexes

Fire weather observation records were obtained from sources extracted from Gripp and Grlpp (1976). Data presented in these records provided the information necessary to compute the NFDR System burning indexes for the large fires.

Fire weather stations used to portray each fire occurrence were chosen using proximity to the fire, fire season climatic zone and fire weather observation data availability. The station selection process also included information on local weather situations provided by the Fire Weather Forecaster, National Weather Service, Eureka, California.

The fire weather station observations taken closest to the time of fire start, along with the fuel model and slope class for each fire site, were used in conjunction with FIRDAT (Furman and Helfman 1973) to generate NFDR System burning indexes for the fire sites. Slope was designated by one of three class codes. Slope class “1” represented 0-20 percent slope, slope class “2” represented 21-40 percent slope and slope class “3” represented slope greater than 40 percent (Deeming et al. 1974). A modified version of FIRDAT was developed from Gripp and Gripp (1976).

Burning indexes generated for the fires in the different fuel model and slope classes were analyzed to determine median values of the burning index in each particular situation. This median value was then designated as the “critical index” for that particular fuel model and slope class. The fuel models most applicable to the study area, fuel models C, D, and G, were designated as the “major” fuel models and those with only limited application, fuel models A, B, and I, were designated as the “minor” fuel models.

If the particular fuel model for the fire site contained 100-hour timelag fuels (Fosberg 1971), weather data for four days prior to the fire were used along with the fire day observation to ensure that moisture content of this particular fuel class was adjusted to ambient environment (Helfman et al. 1975). If the fuel model contained only 1 and 10-hour timelag fuels (Fosberg and Deeming 1971), only the fire day observation was used in the generation of the burning index.

In cases where precipitation was recorded at a station within seven days preceding a large fire, the series of indexes generated for the fire using the data from the station where the precipitation was recorded was expanded to include the day or days of precipitation. The herbaceous fuel stage was considered to be 30 percent green for fires occurring before July 15 and 10 percent green for fires after then.

Distribution of NFDR System Burning Indexes

Analysis of the distribution of the burning indexes in all fuel model and slope class combinations was accomplished using FIRDAT and all available weather data, stored on magnetic tapes, for the study area. Gripp and Gripp (1976) reported amounts of fire weather observation data varied from one year of records per station to 17 years of records per station. To facilitate processing, the U.S. Forest Service stations were separated from the California Division of Forestry and Bureau of Indian Affairs stations.

An assumption concerning the "state of' the weather" was necessary to process fire weather data stored on magnetic tape prior to the use of the NFDR System and AFFIRMS (Helfrnan et al. l975). It was assumed that if there was measurable precipitation during the 24-hour observation period, the precipitation occurred at the time of observation and the "state of the weather" was coded as "5". In all other cases the "state of the weather" was coded as "0."

Synoptic Weather Systems

The synoptic scale weather systems associated with the occurrence of large fires were determined from the Daily Weather Map Series produced by the United States Department of Commerce. The synoptic systems were broken into two groups; “fire weather types” were used to identify surface weather patterns and “fire weather patterns” were used to identify the upper air (500 millibar) weather patterns. The individual fire weather patterns and types were defined using the classification system developed by Schroeder et al. (1964). The classification of the synoptic systems was accomplished under the direction and supervision of the National Weather Service, Eureka, California.

RESULTS

Fire Occurrence

A total of 64 large fires occurred during the study period (Figure 2). The U.S. Forest Service reported 12 fires and the California Division of Forestry reported 54. In two cases, the fires burned both Forest Service and Division of Forestry protected lands and were reported by both agencies. The Bureau of Indian Affairs reported no large fires in their management unit. The fires burned a total of approximately 115,000 acres.

Tabular displays of fire occurrence by month and year, and fuel model and slope class are presented in Table 1 and Table 2.

Fire Season Climatic Zones

Eight fire season climatic zones (fire climate regions) were designated within the study area (Figure 3). The data used in delineating the various fire season climatic zones were extracted from Gripp and Gripp (1976). A statistical comparison of the summary PEI and TEl values developed using Trigg's approach versus the modification to his method using the Chi-Square Test (a = .995) revealed no significant differences (Gripp and Gripp 1976).

Fire Occurrence by Climatic Zones

Large fires occurred in seven of the eight fire season climatic zones. A summary of large fire occurrence by fire season climatic zone is presented in Table 3.

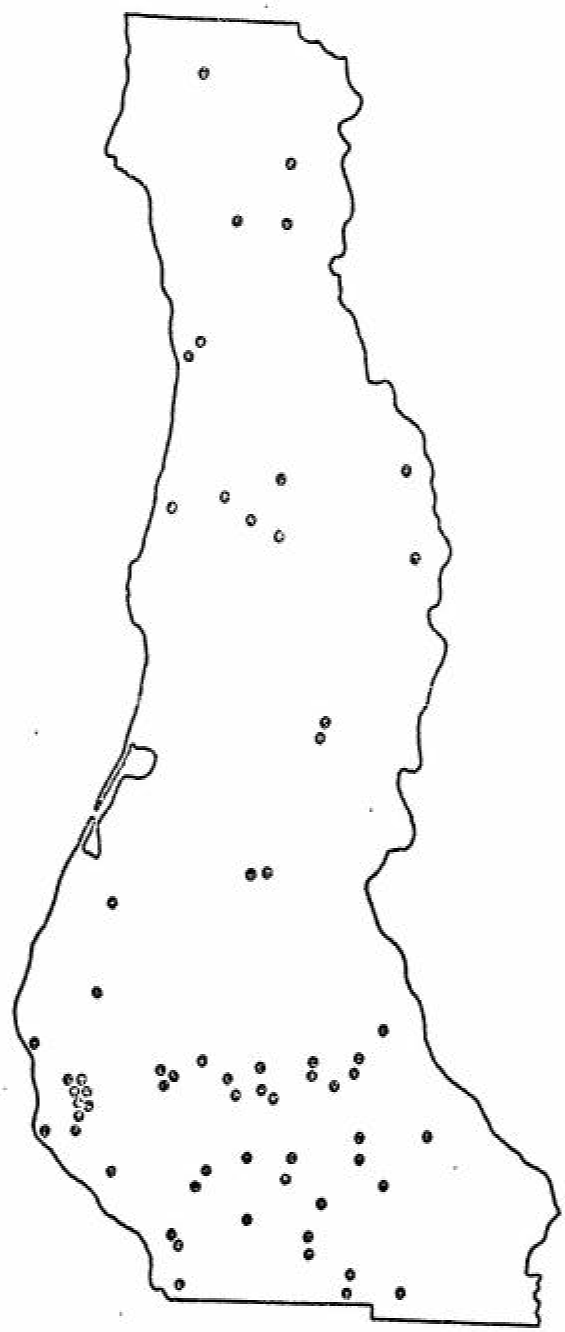

Figure 2. Sites of major fires in northwestern California. Each dot represents a fire of 300 acres or more in size during the period of June through October, 1955-1974.

Table 1. Large fires in northwestern California by month and year, 1955 thru 1974.

Year	Jun	Jul	Aug	Sep	Oct	Totals
55	2	0	1	5	0	8
56	0	0	0	2	1	3
57	0	0	0	3	0	3
58	0	0	2	7	0	9
59	1	6	7	0	1	15
60	0	1	0	0	1	2
61	0	0	2	0	1	3
62	0	0	0	0	0	0
63	0	1	0	0	0	1
64	0	0	1	2	1	4
65	0	0	0	1	1	2
66	0	0	0	0	0	0
67	0	0	0	1	0	1
68	0	0	2	0	0	2
69	0	0	0	0	0	0
70	0	0	0	2	2	4
71	0	0	0	0	0	0
72	0	0	0	1	0	1
73	0	0	0	2	0	2
74	0	1	0	3	0	4
Totals	3	9	15	29	8	64

Table 2. Large fires in northwestern California (1955-1974) by National Fire Danger Rating System fuel model and slope class combinations.

Slope Class	Fuel Models					
	A	B	C	D	G	I
1	1	0	2	0	1	0
2	1	4	10	9	14	1
3	0	5	0	4	11	1
Totals	2	9	12	13	26	2

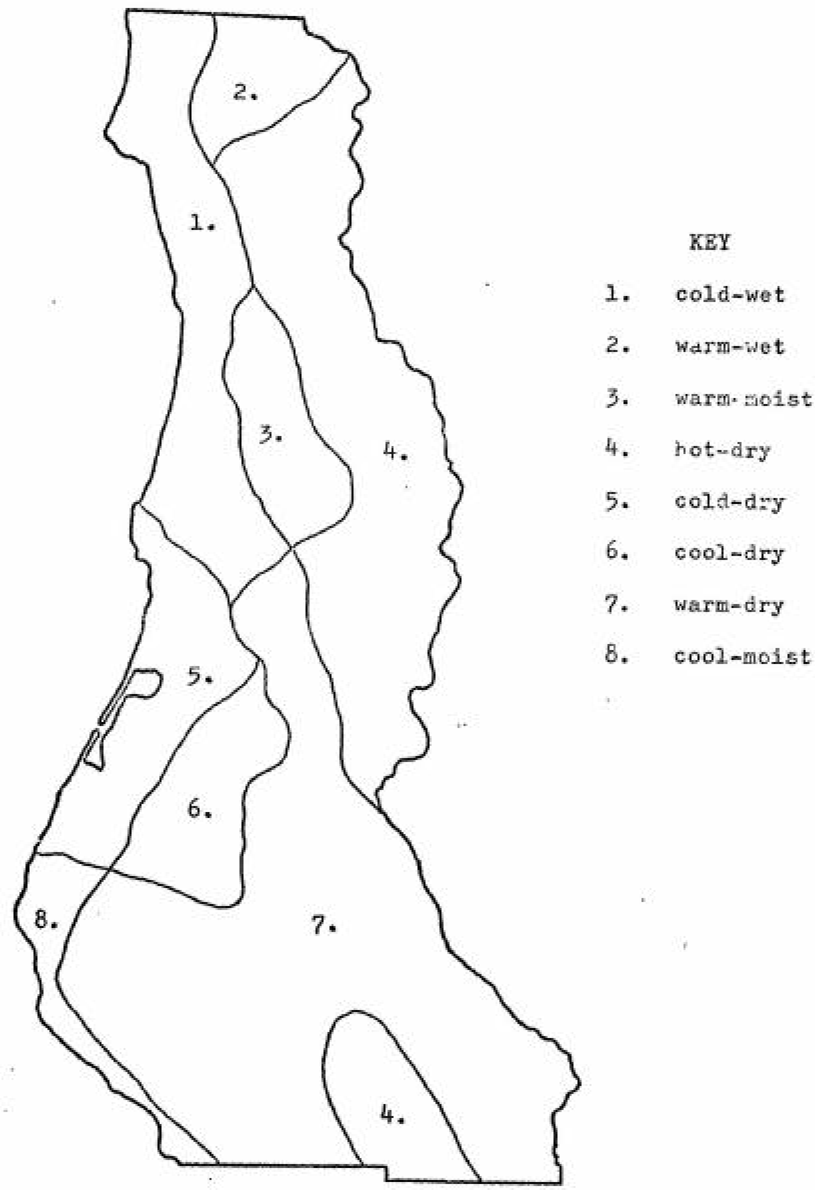

Figure 3. Fire season climatic zones in northwestern California.

Table 3. Large fire occurrence by fire season climatic zone in northwestern California, 1955-1974.

Zone	Number of Fires
warm-dry	38
hot-dry	14
cold-wet	5
cool-moist	3
warm-moist	2
warm-wet	1
cold-dry	1
cool-dry	0
Total	64

Large Fire Burning Indexes

The "critical levels" for burning indexes determined from large fires in the major and minor fuel model and slope class combinations varied from 17.2 to 41.7 percent of the theoretical maximum burning index possible in the various fuel models from the NFDR System. The maximum burning index values are: Model A, 12; Model B, 100; Model C, 41; Model D, 51; Model G, 58; and Model I, 90. The "critical burning index" values established for northwestern California are presented in Tables 4a and 4b. Caution should be used when interpreting "critical burning index" values established on only a limited number of fires and observations. The range of burning indexes and weighted critical of burning indexes for each major and minor fuel model are also included in Tables 4a and 4b. The weighted critical burning indexes of the major fuel models are Model C, 10; Model D, 16; Model G, 17 (Table 4a).

The burning Indexes for each fire situation, and pertinent statistical data were obtained from Gripp and Gripp (1976).

Frequency (%) of Occurrence of Critical Burning Indexes

The "critical burning index" values established in the study are equaled or exceeded on as many as 68.9 percent of the days during the fire season at some stations in the major fuel models (C, D, and G) and 81.8 percent of the days during the fire season in the minor fuel models (A, B, and I). The frequency (%) of occurrence in situations with limited data should be viewed with caution.

A summary, by fire weather observation station of the frequency (%) of occurrence of a burning index value equal to or greater than the established "critical level" for the major fuel model and slope class combinations is presented in Table 5, and the same information relative to

Table 4a. Summary of NFDR System burning index values for large fires in the major fuel model and slope classes for northwestern California, 1955-1974.

Fuel Model/ Slope Class	# of Fires	# of Obs	Range Min	Range Max	Mean	Standard Deviation	Critical Burning Index	Weighted Critical Burning Index
C1	2	5	7	23	13.6	6.7	10	10
C2	10	25	4	24	10.8	4.5	10	
D2	9	18	13	24	16.9	3.0	17	16
D3	4	8	8	17	13.6	3.0	14	
G1	1	1	10	10	10.0	...	10	
G2	14	30	5	35	17.6	6.8	16	17
G3	11	21	12	28	19.0	4.1	18	

Table 4b. Summary of NFDR System burning index values for large fires in the minor fuel model and slope classes for northwestern California, 1955-1974.

Fuel Model/ Slope Class	# of Fires	# of Obs	Range Min	Range Max	Mean	Standard Deviation	Critical Burning Index	Weighted Critical Burning Index
A1	1	1	5	5	5.0	...	5	5
A2	1	1	4	4	4.0	...	4	
B2	4	12	7	45	24.1	10.4	21	22
B3	5	12	11	33	22.9	5.7	22	
I2	1	1	35	35	35.0	...	35	23
I3	1	2	11	22	16.5	7.8	17	

the minor fuel model and slope class combinations is presented in Table 6. The summarized values are reviewed from Gripp and Gripp (1976).

Synoptic Weather Systems

The Pacific High (Postfrontal) type, Great Basin High type and Subtropical High Aloft pattern were associated with 57 of the 64 large fires. Table 7 summarizes the number of cases of large fires associated with the fire weather patterns and types in northwestern California. The fire weather patterns or types affecting large fires in each climatic zone are identified in Table 8

Table 5. Frequency (%) of occurrence of "critical burning indexes" in the major fuel model and slope class combinations at fire weather observation stations in northwestern California.

Station Number	Station Name	Number of Obs	Fuel Model and Slope Class Combinations and Their Critical Burning Index Values						
			C1(10)	C2(10)	D2(17)	D3(14)	G1(10)	G2(16)	G3(18)
040101	Camp Six	1733	30.1	31.0	15.0	37.7	75.9	37.4	28.9
040102	Gasquet	2497	33.5	34.5	16.4	39.3	75.1	38.5	29.2
040401	Alderpoint	140	0.3	0.4	....	1.4	26.5	1.0	0.4
040402	Big Hill	617	9.6	10.5	2.8	26.1	83.6	28.9	17.0
040403	Bridgeville	1349	25.3	27.1	4.1	30.7	79.3	31.2	18.1
040404	Brush Mtn	2233	40.6	42.0	27.5	52.0	82.1	51.6	42.9
040405	Garberville	153	9.2	9.5	3.3	18.0	68.6	20.9	13.7
040406	Grasshopper	1155	39.0	40.5	22.3	47.0	83.9	47.1	36.9
040407	High Rock	1830	17.0	18.4	2.2	19.5	72.1	19.7	10.2
040408	Hoopa	988	27.4	29.2	13.1	47.6	89.8	49.5	39.0
040409	Iaqua Butte	128	12.9	15.3	4.7	25.0	74.2	26.6	16.8
040410	Orleans	2013	17.9	19.4	10.4	34.9	80.0	38.3	29.5
040411	Pratt Mtn	1314	20.6	21.9	10.0	31.3	76.9	33.2	24.3
040412	Redwood Cr	480	11.9	12.9	2.5	16.2	75.3	17.4	10.0
040413	Schoolhouse Pk	1507	33.3	34.4	13.3	37.2	75.5	36.7	26.3
040414	Shelton Butte	1753	32.8	34.1	19.4	43.8	80.1	44.6	34.6
040415	Thorn	126	6.8	7.6	1.6	16.3	74.6	17.4	11.6
040419	Rohnerville	144	41.4	41.7	1.4	24.3	77.4	18.8	5.6
040420	Willow Creek	978	25.1	27.6	16.1	44.0	82.0	46.3	38.5
040505	Kettenpom	2082	29.8	31.5	21.0	48.2	85.2	49.7	40.7
040507	Mad River	2281	62.0	63.2	46.7	68.9	87.3	68.0	59.3
040508	Ruth	1482	45.4	47.8	32.5	60.9	92.1	63.2	53.7
040509	Salyer	1459	27.0	28.6	13.9	40.7	80.3	42.3	33.5

Table 6. Frequency (%) of occurrence of "critical burning indexes" in the minor fuel model and slope class combinations at fire weather observation stations in northwestern California.

Station Number	Station Name	Number of Observations	Fuel Model and Slope Class Combinations and the "Critical Burning Index" Values					
			A1(5)	A2(4)	B2(21)	B3(22)	I2(35)	I3(17)
040101	Camp Six	1738	3.5	21.8	53.6	51.5	7.0	75.4
040102	Gasquet	2497	2.5	21.8	56.7	46.1	6.0	74.2
040401	Alderpoint	140	0.0	0.4	2.1	2.8	0.0	30.7
040402	Big Hill	617	0.2	7.6	46.8	45.3	0.5	84.3
040403	Bridgeville	1349	0.7	21.4	55.3	52.8	1.2	78.7
040404	Brush Mtn	2233	3.1	25.1	65.9	64.3	15.4	81.7
040405	Garberville	153	0.0	6.9	30.1	28.5	0.0	69.9
040406	Grasshopper Pk	1155	10.0	29.0	64.3	62.5	12.5	84.2
040407	High Rock	1830	0.1	15.1	44.1	40.6	0.2	71.2
040408	Hoopa	988	0.3	19.0	64.2	62.6	3.7	90.6
040409	Iaqua Butte	128	0.0	8.2	40.6	37.4	1.6	74.2
040410	Orleans	2013	0.9	22.6	44.3	44.0	5.7	81.8
040411	Pratt Mtn	1314	1.1	15.2	46.5	44.7	5.2	77.4
040412	Redwood Cr	480	0.6	10.8	35.0	33.1	1.0	75.2
040413	Schoolhouse Pk	1507	3.8	24.4	59.5	56.5	4.8	74.2
040414	Shelton Butte	1753	2.7	22.1	59.5	56.5	9.2	80.1
040415	Thorn	126	0.0	5.5	27.8	25.3	0.0	79.4
040419	Rohnerville	144	4.9	31.0	66.0	65.2	0.0	75.2
040420	Willow Creek	978	0.8	27.7	53.4	53.2	6.6	83.6
040505	Kettenpom	2082	2.2	19.5	59.6	57.9	11.4	86.3
040507	Mad River	2281	19.7	43.1	81.8	80.1	31.7	89.8
040508	Ruth	1482	4.0	30.0	73.1	71.6	20.8	88.9
040509	Salyer	1459	1.4	20.4	54.6	53.0	7.8	80.7

Table 7. Synoptic weather systems associated with large fires in northwestern California, 1955-1974.

Fire Weather Pattern or Type		Number of Fires
Pacific High (Postfrontal) Type		24
Great Basin High Type		19
Subtropical High Aloft Pattern		14
Meridonal Ridge (Southwest Flow) Pattern		2
Northwest Canadian High Type		1
Miscellaneous		4
High Low Block	1	
Ridge Aloft	2	
Unclassified	1	
Totals		64

Table 8. Large fire occurrence by synoptic weather systems and fire season climatic zones in northwestern California, 1955-1974.

Climatic Zone	Pacific High	Great Basin High	Subtropical High Aloft	Med Rid SW Flow	NW Can High	Misc	Totals
	Synoptic Weather Systems						
warm-dry	13	13	6	1	1	4	38
hot-dry	6	1	6	1	0	0	14
cold-wet	2	2	1	0	0	0	5
cool-moist	2	1	0	0	0	0	3
warm-moist	0	1	1	0	0	0	2
cool-dry	0	1	0	0	0	0	1
warm-wet	1	0	0	0	0	0	1
cold-dry	0	0	0	0	0	0	0
Totals	24	19	14	2	1	4	64

DISCUSSION AND CONCLUSIONS

Large Fire Occurrence

The study indicates that large fires still occur in northwestern California. The overall number of large fires, however, has decreased. During the l955-l964 decade three times the number of fires occurred as during the 1965-l974 decade. Increased prevention efforts and improved suppression equipment and techniques, particularly aerial attack, probably account for most of this decrease.

September is the most dangerous large fire month with 45.3 percent of the large fires occurring during this time. August ranks second with 23.4 percent, then July with 14.1 percent and October with 12.5 percent. June ranks lowest with 4.7 percent.

Fire Season Climatic Zones and Fire Occurrence

The warm-dry fire season climatic zone had the largest number of' fire occurrences, 38 or 59.4 percent of the total fires. The hot-dry zone had the second greatest number of occurrences, 14 or 21.9 percent.

The size of' the fire season climatic zones ranged from 115,000 acres to 1,130,000 acres. One measure of the fire problem in the zones can be accomplished by examining the number of fires per unit area. This examination shows that the warm-dry climatic zone presents the greatest problem. The "occurrence factor for large fires in this zone was .34 fires per 10,000 acres. The cool-moist zone was next with.22 fires per 10,000 acres, and the hot-dry and warm-moist zones ranked third with .17 fires per 10,000 acres. The occurrence factor for the remaining areas were cold-wet, .12; warm-wet, .09; and cool-dry, .04. Based on fire histories, the cool-dry zone had an "occurrence factor" of 0.0. The "occurrence factor" in the cool-moist zone can probably be attributed to a high man-caused risk factor that exists in that particular area.

Burning Indexes and Large Fires

Study results indicate that large fires occur at much lower burning index values than those now recognized and identified as critical index levels by local fire managers. Burning indexes associated with large fires over the study period fluctuated in given fuel models, but no trend toward an increase or decrease in burning indexes was noted.

Burning index values of 18 or greater in fuel model D3 and 23 or greater in fuel models G2 and G3 are currently used to identify the threshold of critical fire weather conditions on the Six Rivers National Forest (Riley 1975). The California Division of Forestry is undecided on what constitutes a critical burning index value in their local management unit.

The critical burning index values established in the study are lower, and therefore, have a greater frequency (%) of occurrence than the values currently used to identify critical fire weather conditions in northwestern California. Table 5 shows that at Gasquet, for example, in a fuel model D and slope class 3 situation, fire managers could expect that 39.3 percent of the daily burning indexes would equal or exceed the “critical burning index” of 14; this is based on a review of 2497 daily fire weather records. Pratt mountain, in a C2 situation, could expect the “critical index value” of 10 to be equaled or exceeded on 21.9 percent of the days in the fire season, based on the analysis of 1314 daily fire weather observation records.

Caution should be exercised when interpreting the results from fuel model and slope class combinations or fire weather observation stations where there are only limited data. This includes the Al, A2, G1, I2 and I3 fuel model and slope class categories as well as Alderpoint, Garberville, Iaqua Butte, Thorn, and Rohnerville stations (Tables 5 and 6).

The weighted critical burning index values (weighted median values) from Tables 4a and 4b can also be used as a broadscale planning aid. Caution should be exercised when using these values as they can vary with their respective fuel model with differences in slope class.

Synoptic Weather Systems and Large Fires

Schroeder et al. (1964) concluded that the occurrence of large fires follows closely the pattern of high fire danger days and that high fire danger days are associated with certain synoptic scale weather systems. They also noted that these systems appear at times without producing high index values. In the study area, 59 incidences or 92.2 percent of the large fires were associated with the four major synoptic weather systems previously identified as being associated with critical fire weather in northwestern California. The Pacific High (Postfrontal) type accounted for 37.5 percent of the total occurrences, the Great Basin High type, 29.7 percent, the Subtropical High Aloft pattern, 21.9 percent and the Meridonal Ridge (Southwest Flow) accounted for only 3.1 percent of the occurrences.

A review of data on the numbers of occurrences of the Pacific High (Postfrontal) type, Great Basin High type, and the Subtropical High Aloft pattern at Mt. Shasta, Sacramento and Oakland (Hull, O'Dell, and Schroeder 1966) indicates that based on a 10-year average 50 to 55 days per fire season can be expected to fall under the influence of these three synoptic systems. The Subtropical High Aloft pattern can be expected 25 to 30 days per fire season, the Great Basin High type on 16 to 17 days and the Pacific High (Postfrontal) type can be expected 8 to 9 days per fire season.

These particular data also indicated July had the greatest occurrence of days associated with dangerous synoptic systems; an average of 14.2

days. August was second with 10.9 days, September had 10.6 days, October 8.5 days and June 7.9 days. The high number of July occurrences was due to a large number of cases of the Subtropical High Aloft pattern.

Projecting the yearly occurrence averages of the Pacific High (Postfrontal) type, Great Basin High type and the Subtropical High Aloft pattern over the study period reveals that the Pacific High (Postfrontal) type had the highest fire occurrence ratio; 24 fires on a probable 170 days of this type or 1.4 fires per 10 days of this particular fire weather type. The Great Basin High type recorded 19 fires on a probable 327 days for a ratio of 0.5 fires per 10 days of type occurrence and the Subtropical High Aloft pattern recorded only 14 fires on a probable 545 days for an occurrence ratio of 0.3 fires per 10 days. This analysis indicates that the Pacific High (Postfrontal) type is the “most dangerous” in northwestern California.

Study Implications

This study presents data that indicate a need to reevaluate the criteria currently used to guide local fire management planning. Burning index values, on which important tactical and logistical decisions are based, should accurately reflect local burning conditions. Other traditional fire management approaches such as fire prevention, presuppression and suppression, preattack, fuel management, and zoning and land use controls should also be reevaluated.

Prevention activities should be intensified during periods when “critical burning indexes”, as established in this study, are reached. The public should be educated to the fact that large fires are possible during periods of what is now considered moderate fire weather as well as during periods of acknowledged severe fire weather.

Fire suppression planning should be designed to allow for increased initial attack strength and rapid reinforcements during weather periods identified as conducive to the development of large fires. Intensive fuel modification, preattack and wildland zoning programs should be encouraged in areas where “critical burning indexes” are frequently reached.

The techniques used in this study to appraise fire weather and establish “critical burning index” levels in various fuel models can be applied in other areas. Fire reports are readily available at most fire planning unit headquarters. Data used to define areas of similar climate are also available and the calculations can be completed on scientific pocket calculators. Historic fire weather data and burning index values are available through the National Fire Weather Data Library (Furman and Brink 1975). Synoptic weather systems can be identified with the aid of the fire weather forecast unit servicing the particular management unit.

Synoptic weather systems and “critical burning indexes” are valuable tools for fire managers to use in appraising severity of local fire problems. A burning index alone does not always reflect the seriousness of a fire problem. When synoptic weather associated with large fires is evaluated along with “critical burning indexes” a realistic objective analysis of the local fire problem can be conducted.

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