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ABSTRACT: Two fires burned in the same area in southern California under nearly similar weather conditions, 11 years apart. Yet the Inaja fire of 1956 was much more disastrous than the Pine Hills fire of 1967. The earlier fire claimed 11 lives, and covered an area five times larger than the 1967 fire. Differences in fuels, topography, fire behavior, fire-control action, and severity and duration of Santa Ana conditions help explain the differences in the size of the two fires.

RETRIEVAL TERMS: Inaja fire; Pine Hills fire; fire behavior; fire control; Santa Ana winds; comparative fire histories.

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Inaja Fire—1956,
Pine Hills Fire—1967...

similar, yet different

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Two wildfires burned in the same area of the Descanso Ranger District, Cleveland National Forest, in southern California under similar weather conditions. The fires occurred 11 years apart--the Inaja in 1956 and the Pine Hills in 1967 (fig. 1). By far the more disastrous, the 4-day Inaja fire burned over 43,904 acres within the Cleveland National Forest and adjoining land protected by the California Division of Forestry. And it claimed the lives of 11 firefighters in a flareup during its second day.¹ The Pine Hills fire started to the northeast of where the Inaja fire had begun. It burned some of the same ground previously scorched, but covered only 7,030 acres before being contained 2 days later.

Both fires occurred under Santa Ana conditions, with strong northeast winds causing the initial rapid fire spread to the southwest. If the origins of the fires were approximately the same and the weather conditions similar, why was one fire controlled at less than one-fifth the size of the other?

This note compares the conditions of weather, fuels, and topography and suggests some reasons for the different fire sizes.

Weather

Burning conditions throughout southern California were extremely severe in 1956. Rainfall had been below normal in the previous 4 years. On November 19, a high pressure cell moved into the Great Basin causing Santa Ana conditions to persist for the entire period of the Inaja fire. Five days later, on November 24, when the fire broke out, this same High was reinforced and became more intense. On November 25, high



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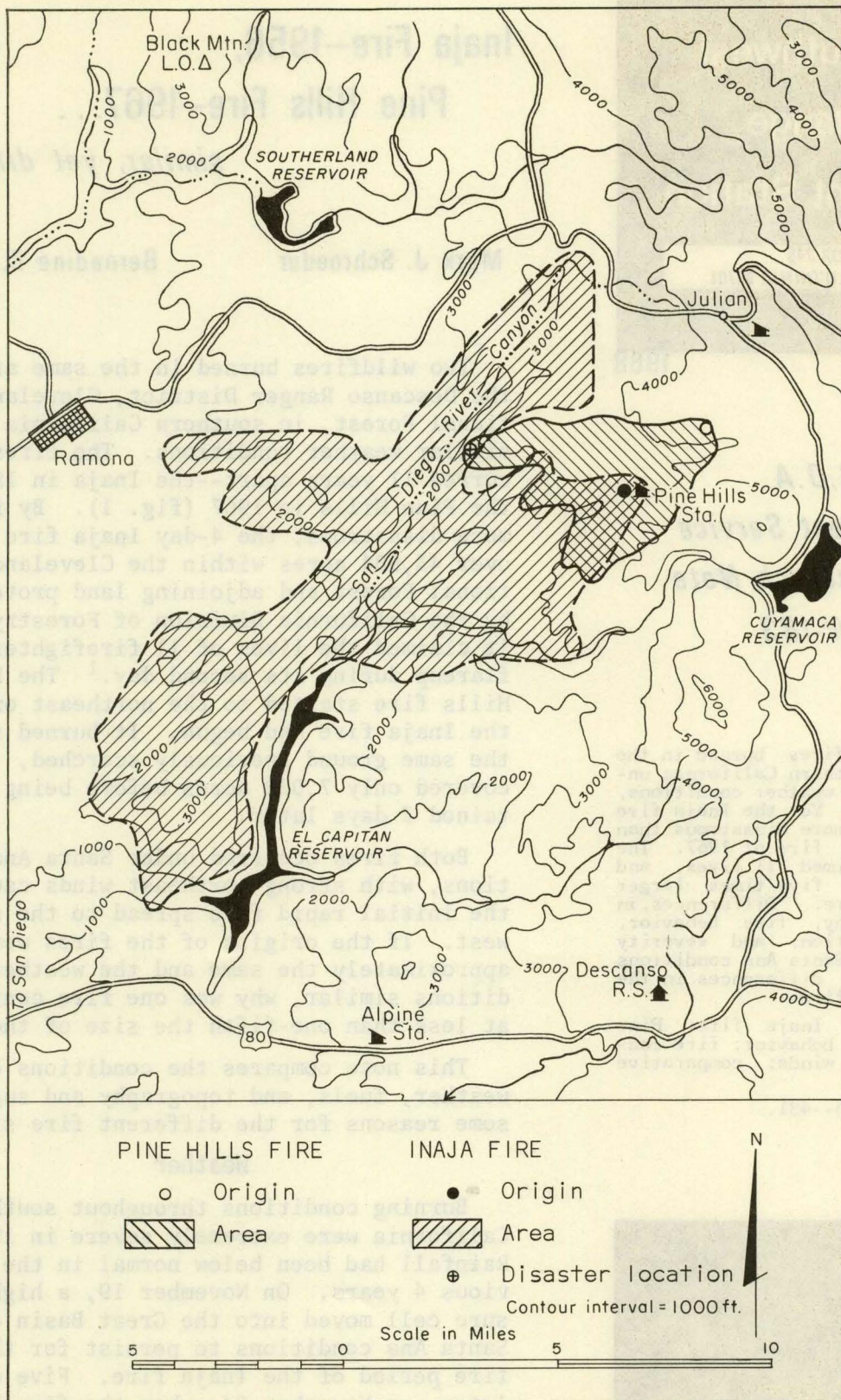


Figure 1.-Location map of the areas burned by the Inaja fire of November 24-28, 1956 and the Pine Hills fire of October 30-November 1, 1967 showing observation sites, Cleveland National Forest, southern California.

pressure covered much of the Great Basin with strong pressure gradient to the south and west. The pressure difference between San Diego and El Centro indicates the gradient affecting the winds near the fire area (table 1). The pressure difference became negative, that is, the gradient was from east to west, on November 19 and remained so throughout the period. It reached a peak negative value on the 21st and a second, lower peak on the 24th. The pressure difference between Los Angeles and Tonopah (the gradient between the edge of the Great Basin and the Coast) presents a broader view of the pressure distribution. It also became negative on the 19th and remained so throughout the period. Table 1 shows that the Los Angeles-Tonopah gradient also reached its peak negative value on the 21st and a second, lower peak on the 24th.

During a Santa Ana condition of any significance, there is a pressure difference of at least -7 millibars between Los Angeles and Tonopah. The weaker gradients on the 22nd and 23rd indicated that Santa Ana winds had slacked off temporarily.

The period beginning November 19 may be described as one of continuing Santa Ana winds, with a temporary weakening on November 22 and 23. This condition is borne out by daily weather observations from the Alpine Station (table 2). Other stations in the general area reported relative humidities of 6, 8, and 9 percent, and stick moistures were down to 1.5, 2, and 3 percent. One station (Julian) reported a windspeed of 45 m.p.h. on November 20. Undoubtedly, higher windspeeds occurred but were not recorded.

These weather conditions are further reflected in the high brush burning indexes for available stations (fig. 2). Burning indexes of 27 or higher are considered to be in the extreme category.

Fire-weather conditions were also severe in 1967 when the Pine Hills fire flared up the morning of October 30.

Rainfall the previous 10 years had averaged about 4 inches below normal per year, with the years 1957, 1958, and 1965 having above average precipitation. Rainfall reported since January 1967 had also been below normal. Weather stations in the Cleveland National Forest and surrounding areas averaged only about 2-1/2 inches of precipitation for the 5-month period of June 1 through October 31, 1967. The only station in the area to report any measurable precipitation in October 1967 was Ramona Spaulding, which had .02 inch.

The Santa Ana condition, existing at the time of the Pine Hills fire, began on October 29, 1967--1 day before the fire started. A surface high-pressure center from the Pacific moved into the Great Basin and remained there through the 31st. The Santa Ana condition ended November 1 when the High weakened considerably. The pressure difference between San Diego and El Centro (table 1) became negative on October 29, remained so on the 30th, and changed to positive on the 31st. Pressure difference between Los Angeles and Tonopah became negative on October 28 and remained negative throughout the Pine Hills fire, but it was strong only from October 29 until early November 1.

This Santa Ana period was brief and moderately intense. The daily fire-weather observations for the Alpine Station and Black Mountain (table 3) bear this out, although stick moisture readings did not reach less than 3 percent. Other stations in the area reported humidities down to 6 percent on October 30 and stick moistures down to 1.5 percent. However, at the Pine Hills Station, within the fire itself, winds were recorded at a steady 20 to 30 m.p.h. during the evening of October 30, with gusts to 40 and 50 m.p.h. and even as high as 60 m.p.h.

How far the surfacing Santa Ana winds extended downslope to the southwest is not known exactly, since

Table 1. - Pressure differences between San Diego and El Centro and between Los Angeles and Tonopah at the times of the Inaja and Pine Hills fires¹

Date	San Diego - El Centro				Los Angeles - Tonopah			
	Time				Time			
	0400	1000	1600	2200	0400	1000	1600	2200
1956:								
Nov. 18	+0.9	+0.4	+2.1	+3.5	- 3.0	+ 0.5	+ 1.3	- 4.6
Nov. 19	+1.2	-3.4	-4.5	-4.8	- 7.9	- 9.8	- 8.3	- 9.6
Nov. 20	-4.0	-3.5	-6.1	-2.0	-10.0	-10.6	- 8.2	- 7.5
Nov. 21	-7.4	-8.2	-4.8	-4.3	-12.7	-12.8	-13.7	-12.1
Nov. 22	-4.0	-4.1	-1.3	- .7	-12.2	-10.7	- 6.9	- 7.9
Nov. 23	- .3	-1.4	- .8	- .1	- 8.7	- 7.2	- 8.5	- 7.7
Nov. 24	-1.4	-3.3	-2.1	-2.6	- 9.9	-11.0	- 9.0	- 8.9
Nov. 25	-2.7	-3.2	-1.9	-1.2	- 6.9	- 8.2	- 8.0	- 7.9
Nov. 26	-1.0	-1.4	-2.2	-1.6	- 8.0	- 7.4	- 6.3	- 7.0
Nov. 27	- .3	-1.4	- .2	+ .7	- 3.6	- 3.7	- 7.8	- 6.2
Nov. 28	+ .3	-1.6	+1.3	-1.2	- 3.8	- 7.0	- 4.9	- 6.8
1967:								
Oct. 28	--	--	+7.2	+1.5	--	--	+ 1.5	- 4.8
Oct. 29	+2.1	-6.0	-3.4	-4.1	-10.2	-11.8	-11.9	-11.8
Oct. 30	-4.1	-5.4	-2.7	-1.7	-11.3	-11.3	- 8.8	-10.5
Oct. 31	-1.6	-1.3	+ .7	+1.3	-10.7	- 9.7	- 7.8	- 9.2
Nov. 1	+1.0	+ .7	+3.1	--	- 8.6	- 5.4	- 5.0	- 2.6
Nov. 2	+2.8	+2.7	+3.1	+2.0	- 2.0	- 3.0	- 4.4	- 5.9

¹A negative value means that the pressure is higher inland than along the coast.

Table 2. - Fire weather observations recorded at 1630 hours, at Alpine Station, California (elevation 2,024 ft.), at time of the Inaja fire, 1956

Date	Temperature		Relative humidity	Wind		Fuel-stick moisture	Estimated fine fuel moisture
	Maximum	1630		Direction	Speed		
	F.°	F.°	Percent		M.p.h.	Percent	Percent
November:							
18	78	66	28	W	4	3.5	5.0
19	67	56	20	NE	12	4.0	3.0
20	59	55	18	NE	13	3.0	3.0
21	75	69	8	NE	18	2.0	1.5
22	78	66	21	NW	3	1.5	4.0
23	75	67	18	N	3	3.0	3.0
24	77	72	12	NE	20	2.5	2.0
25	--	70	13	NE	15	2.5	2.5
26	--	74	12	NE	9	2.5	2.0
27	--	71	17	NW	3	3.0	3.0
28	--	67	22	NW	3	3.0	4.0

Table 3.--Fire weather observations recorded at 1330 P.s.t. at Alpine Station (elevation 2,024 ft.) and Black Mountain (4,055 ft.), California during the Pine Hills fire, 1967

ALPINE STATION						
Date	Temperature	Relative humidity	Wind		Fuel-Stick moisture	Estimated fine fuel moisture
			Direction	Speed		
	F.°	Percent		M.p.h.	Percent	Percent
Oct. 28	75	42	W	10	7.5	7.0
Oct. 29	77	10	NE	21	7.0	3.0
Oct. 30	77	7	NE	20	4.0	1.5
Oct. 31	82	22	W	8	4.0	4.0
Nov. 1	85	18	SW	12	4.0	3.0
Nov. 2	78	29	W	10	5.0	6.0

BLACK MOUNTAIN						
Oct. 28	68	42	W	15	5.5	7.0
Oct. 29	65	12	NE	34	5.0	3.0
Oct. 30	62	8	NE	38	3.0	1.5
Oct. 31	78	13	NE	9	4.0	2.5
Nov. 1	76	19	SW	11	4.0	3.0
Nov. 2	71	25	SW	13	4.5	4.0

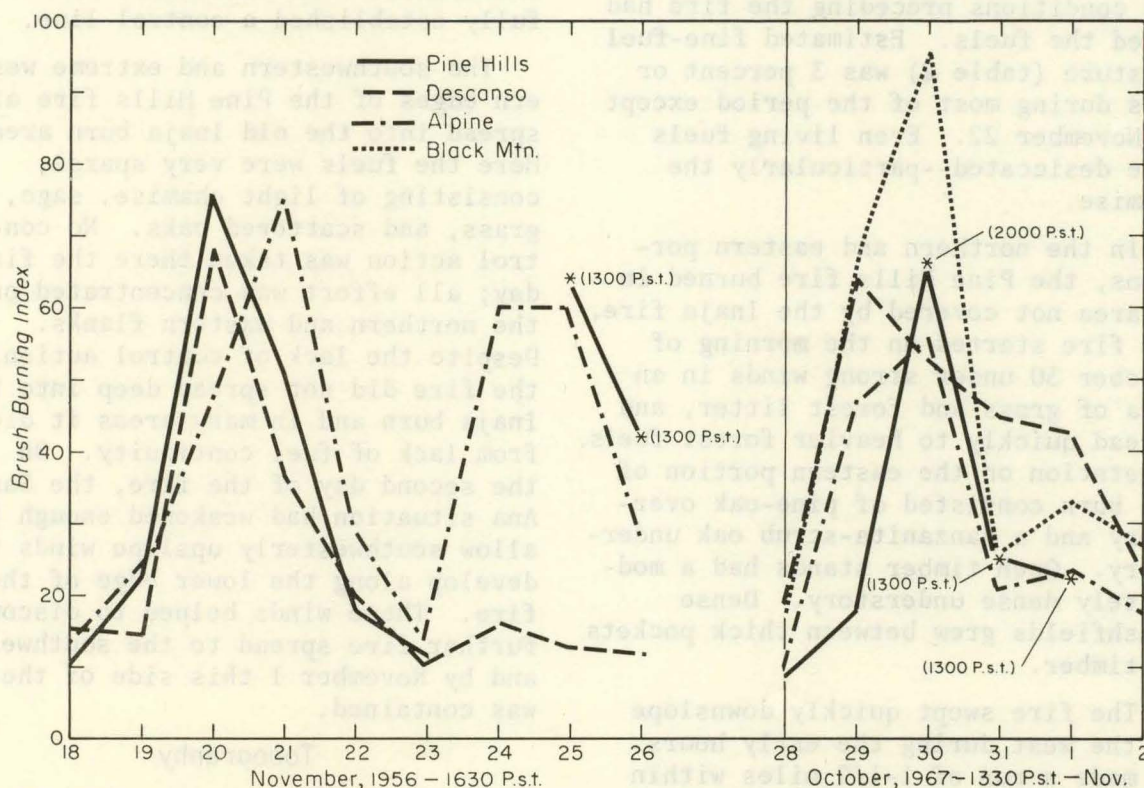


Figure 2.--Brush burning indexes for Pine Hills, Descanso, and Alpine according to the Wildland Fire Danger Rating System, during the Inaja Fire of 1956 and the Pine Hills Fire of 1967. Values of 27 or higher are in the extreme category. Asterisk indicates non-standard observations, that is, data recorded at different times or data recorded near the regular site instead of at the standard observation site because of evacuation.

the wind was not measured near the southwestern edge of the fire. However, another fire--the Pole fire--started about 1600 P.s.t. on October 30, 1967, about 3 miles southwest of the Pine Hills fire. Firefighters reported little wind in that area, therefore, the southwestward extent of the surfacing was somewhere between the Pine Hills Station and the Pole fire.

Fuels and Fire Behavior

The fuels in the area of the Inaja fire varied in density. They were light in grassy flats and moderately dense in woodland and brush areas. The Inaja fire started in a grassy area. The densest fuels were chamise in some of the canyons and draws. The total volume included a large amount of dead material. The long period of Santa Ana conditions preceding the fire had dried the fuels. Estimated fine-fuel moisture (table 2) was 3 percent or less during most of the period except on November 22. Even living fuels were desiccated--particularly the chamise.

In the northern and eastern portions, the Pine Hills fire burned in an area not covered by the Inaja fire. The fire started on the morning of October 30 under strong winds in an area of grass and forest litter, and spread quickly to heavier forest fuels. Vegetation on the eastern portion of the burn consisted of pine-oak overstory and a manzanita-scrub oak understory. Open timber stands had a moderately dense understory. Dense brushfields grew between thick pockets of timber.

The fire swept quickly downslope to the west during the early hours. It made a run of 1-1/2 miles within 25 minutes after ignition and crowned out in pockets of timber, burning hot and clean. Similar hot runs with crowning occurred near the Pine Hills Station during a period of strong winds in the evening. The fire

crowned out in timber again on the eastern edge the next day when upslope winds developed in the wind shadow of higher topography and carried the fire across the control line. A strong ground attack supported by air tanker drops of fire retardant controlled this slopover during the afternoon.

Vegetation on the northern portion of the Pine Hills fire consisted of woodland and grass types also untouched by the Inaja fire. These fuels were of considerably less density than the timber-brush areas in the eastern section. The fire spread rapidly toward the west on the first day until it reached the area of the Inaja burn, on the edge of the San Diego River Canyon. Meanwhile, along the northern edge of the fire, California Division of Forestry crews, aided by a favorable wind direction, successfully established a control line.

The southwestern and extreme western edges of the Pine Hills fire also spread into the old Inaja burn area. Here the fuels were very sparse, consisting of light chamise, sage, grass, and scattered oaks. No control action was taken there the first day; all effort was concentrated on the northern and eastern flanks. Despite the lack of control action, the fire did not spread deep into the Inaja burn and in many areas it died from lack of fuel continuity. On the second day of the fire, the Santa Ana situation had weakened enough to allow southwesterly upslope winds to develop along the lower edge of the fire. These winds helped to discourage further fire spread to the southwest, and by November 1 this side of the fire was contained.

Topography

The Inaja fire covered about 25,000 acres in the first 12 hours. The rapid spread carried the fire into and across the San Diego River Canyon, where the extremely steep sides made firefighting difficult and hazardous.

By contrast, the Pine Hills fire was fought in less steep topography. Bulldozers had little difficulty putting in fire lines. Only in the extreme northwest corner did the Pine Hills fire race into San Diego River Canyon. Minor flare-ups at the edge of the canyon on October 31 and November 1 were probably caused by the chimney effects of the steep terrain combined with upcanyon winds. Although the brush fuels were considerably lighter than in the Inaja burn, crews had some difficulty controlling the fire in this area.

Summary and Conclusions

Burning conditions in fine fuels were nearly identical at the start of both the Inaja and the Pine Hills fires. Because the area had been under the influence of Santa Ana conditions for nearly a week before the Inaja fire and only one day before the Pine Hills fire, however, medium-sized fuels were slightly drier at the start of the Inaja fire. Perhaps the most significant factor that influenced the final size of the Pine Hills fire was the fact that it ran into the Inaja burned area. As a result, the fire practically went out--especially after the Santa Ana winds let up.

A hard-hitting ground attack, closely coordinated with air tanker support, helped hold the slopover on the east side of the Pine Hills fire on October 31. Had this not been done, that side would have become

the most critical sector of the fire when the wind became southwesterly.

In summary, the following factors may account for the differences in the size of the two fires:

1. Fuels encountered in the southward spread were much more sparse in the Pine Hills fire than in the Inaja fire.
2. Topography in the Pine Hills fire generally was not as difficult for control operations.
3. The Inaja fire burned more days under Santa Ana conditions. Both were contained when the Santa Ana slackened.
4. By the end of the first day of the Inaja fire, the fire was larger and the open line more extensive, causing the subsequent control job to be much greater.
5. The Inaja fire was preceded by 6 days of continuous Santa Ana weather; the Pine Hills fire was preceded by only 1 day. This difference caused green fuels and some of the larger dead fuels to be slightly drier when the Inaja fire began.
6. Closely coordinated ground and aerial attack assured control of the east side of the Pine Hills fire before the wind changed direction.

FOOTNOTE

- ¹Countryman, Clive, Chandler, Craig, and Arnold, Keith. *Fire behavior 1930 to 2015 hours Inaja fire disaster*. Nov. 30, 1956 (Unpublished report on file at Forest Fire Laboratory, U.S. Forest Service, P.O. Box 5007, Riverside, Calif. 92507)

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