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Home Destruction Examination

Grass Valley Fire

Lake Arrowhead, CA

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San Bernardino National Forest

Report Submitted to

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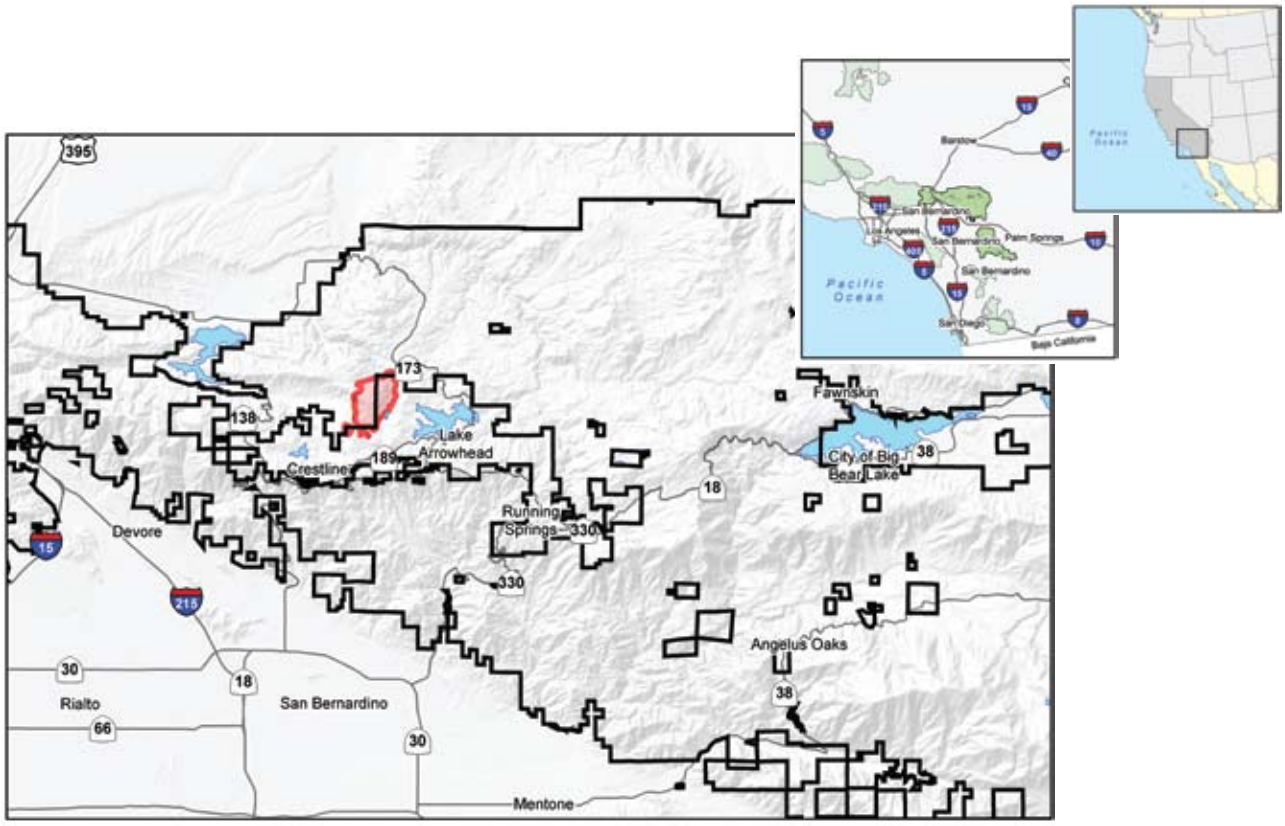
Vicinity Map of the Grass Valley Fire



Executive Summary

The Grass Valley Fire started October 22, 2007 at approximately 0508, one-mile west of Lake Arrowhead in the San Bernardino Mountains. Fuel and weather conditions were extreme due to drought, dry Santa Ana winds, and chaparral and conifer vegetation on steep terrain. The fire proceeded south through the Grass Valley drainage one-mile before impacting an area of dense residential development (~0930), initially showering the northern edge with firebrands and igniting several homes and residential vegetation. Burning homes and the surrounding vegetation ignited adjacent homes initiating a "domino effect" of home destruction without the wildfire as a major factor. By the end of the day, 199 homes were destroyed or damaged.

This report documents the sequence of events and factors contributing to the residential destruction associated with the Grass Valley Fire. The examination was requested by the U.S. Forest Service, Pacific Southwest Region Fire Director, in association with the report on fuel treatment effects. We assessed how home vulnerability and ignition exposure contributed to home destruction. Specifically, we examined the relationship (if any) between the wildfire as an ignition source and home destruction.

Our post-burn examination revealed that the residential destruction did not result from a high intensity wildfire engulfing homes. With minor exception (6 homes), the wildfire primarily initiated residential burning from firebrands igniting homes directly and/or producing spot fires that spread through surface fuels to homes. Once initiated, home destruction largely resulted from local residential fire conditions. The ignition vulnerable homes (e.g., flammable wood roofing, surface fuels in contact with wood siding, heavy pine litter in roof gutters), burning in close proximity to one another continued the fire spread through the residential area without the wildfire as a factor.

Key Findings

◊ 199 homes were destroyed or damaged during the Grass Valley Fire.

◊ Although torching and crowning occurred during the Grass Valley Fire, the wildfire did not spread as a continuously crowning, high intensity fire.

◊ The majority of destroyed and damaged homes ignited between 0930 and 1700.

◊ With minor exception (six homes), high intensity wildfire was not a direct factor in igniting homes.

◊ Of the 199 destroyed and damaged homes, 193 ignited in two principal ways:

1. from fire largely spreading through surface fuels within the residential area that contacted homes and/or from firebrands generated by burning vegetation and/or

2. from thermal exposures directly related to burning residences (from structure flames and firebrands).

◊ Firefighters were overwhelmed in their attempt to prevent the residential fire spread due to multiple homes burning simultaneously. However, more homes would have burned without their intervention.

◊ The Grass Valley residential fire disaster was principally the result of high home ignition potential. The wildfire initiated the residential burning, but burning homes predominantly continued the fire spread to other homes without the wildfire as a significant factor.

Introduction

The Grass Valley Fire started on October 22 at about 0508, one-mile west of Lake Arrowhead. Relative humidity was 10% and winds were north and northeast at 18 mph gusting to 27 (per Rock Camp Remote Automated Weather Station [RAWS]; one-half-mile to the northeast). Overstory vegetation consisted of ponderosa pine (*Pinus ponderosa*), Coulter pine (*Pinus coulteri*), and black oak (*Quercus kelloggii*), with a brush understory (e.g., manzanita [*Arctostaphylos spp*]). Surface litter consisted of conifer needles, oak leaves, and branch wood. Fire behavior varied from surface fire and occasional torching to slope-driven crown runs (particularly on south and southeast facing slopes) (Figure 1). The fire proceeded through the Grass Valley drainage, first impacting homes on the east flank (Brentwood Dr. near Edge Cliff Dr.) (~0915), followed by those approximately one-mile south from the origin on Windward Rd., Amador Ln., and Trinity Dr. (0930-1000). Figure 2 depicts the October 22nd fire progression overlaid with home destruction by parcel. The progression layer was developed from discussions with initial attack firefighters and corroborated with dispatch logs and eye-witness accounts from private citizens. The progression map is an *approximation* of when fire was first observed in an area. By the end of the day (10/22), 199 homes were fully or partially destroyed (per San Bernardino County's "confirmed damaged or destroyed structures list" [10/31/2007]) and the fire was estimated to be 950 acres.

Although reasonable to assume that the wildfire caused the initiation of the residential burning, without a residential fire examination it is not obvious how home destruction occurred and how much the wildfire contributed. Through our approach we determined how home ignitions *could not occur* and thereby identified significant factors that could contribute to home destruction. The result is an *estimated* categorical cause of home destruction and a determination of whether or not the wildfire contributed.

We used the **home ignition zone** (HIZ) concept (Cohen 2001) to guide the

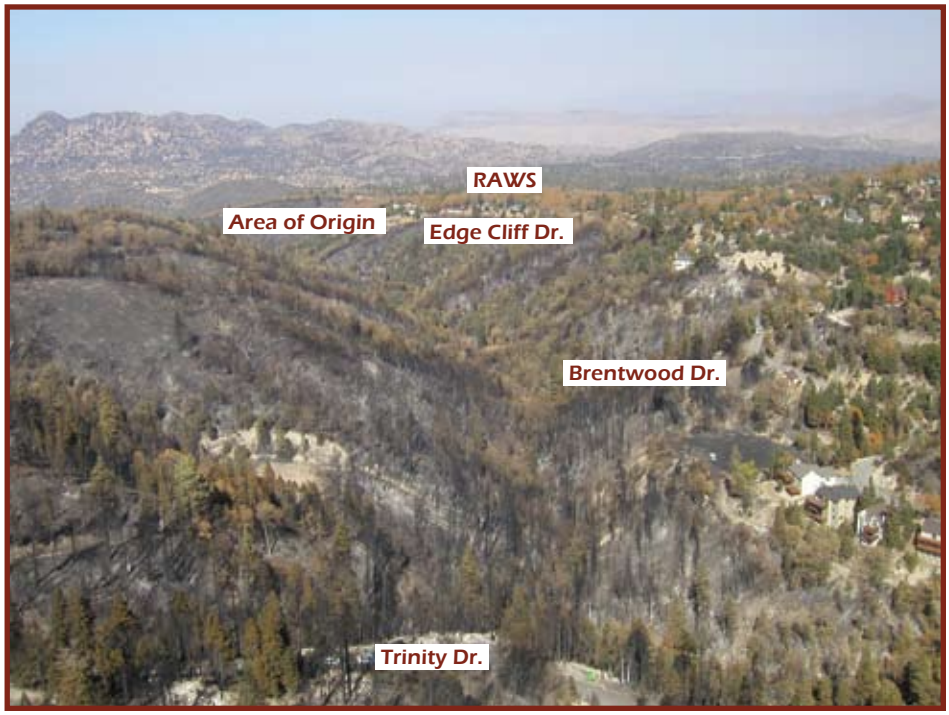


Figure 1. Aerial view of the Grass Valley drainage looking north toward the area of origin and Rock Creek RAWS.

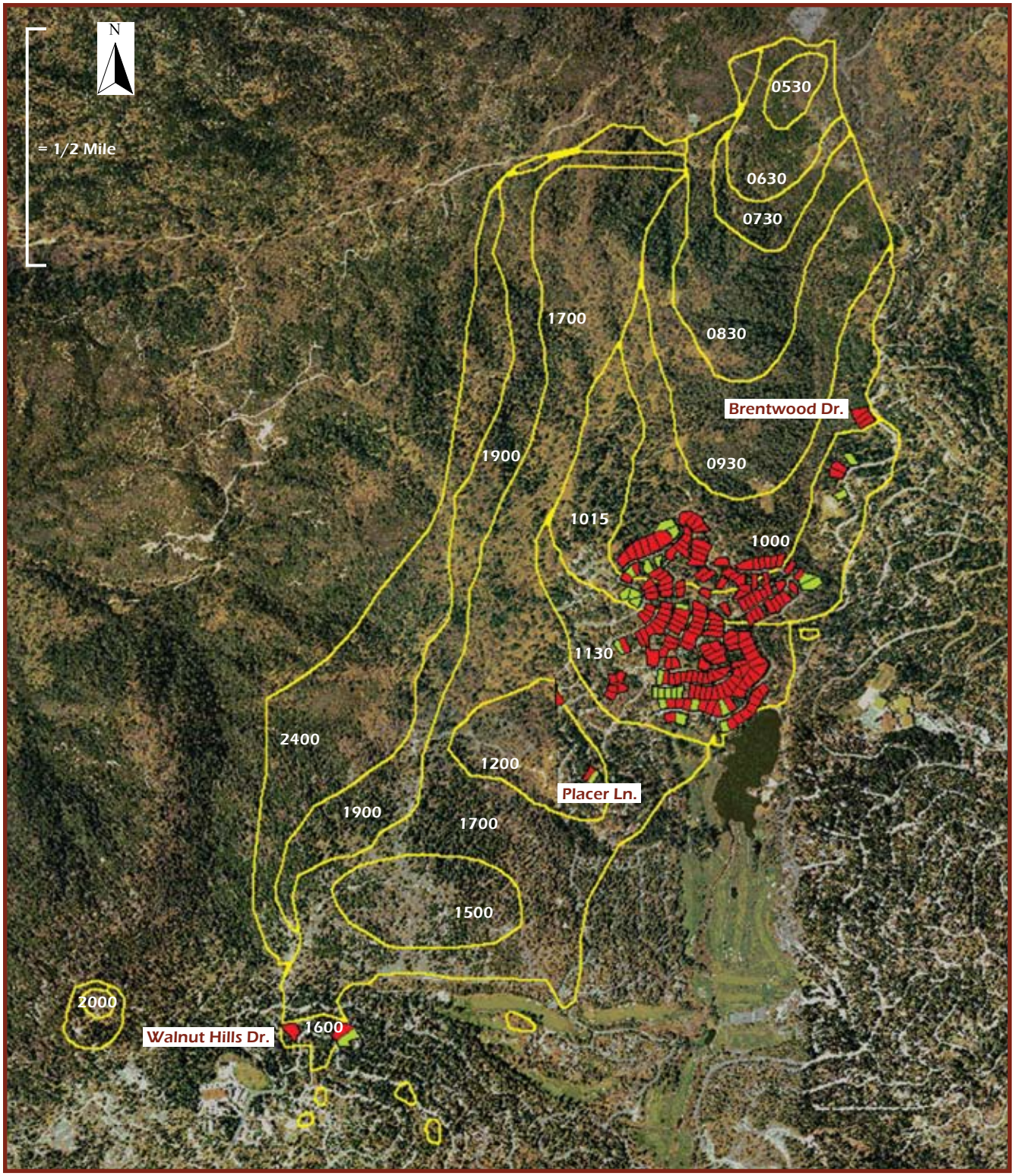


Figure 2. Aerial photo overlaid with the October 22nd Grass Valley Fire progression and the locations of destroyed homes. Homes that were completely destroyed are shown in red (174 homes); those that were partially damaged are in green (25 homes). (Aerial imagery by DigitalGlobe; parcel information by San Bernardino County)

evaluation of how home ignitions occurred. The home ignition zone is defined as those factors that principally determine a home's ignition potential during a wildfire. Research (Cohen and Wilson 1995; Cohen 2000a, b; Cohen and Stratton 2003; Cohen 2004) has determined that during extreme wildfire conditions, a home's characteristics (i.e., materials and design) in relation to the surrounding burning objects within 100 – 200 feet comprise the HIZ. The HIZ concept provides the framework for evaluating the likely ignition cause(s)—flames and/or firebrands. The HIZ approach became particularly useful for evaluating the ignition potential due to adjacent burning homes (i.e., significantly overlapping HIZs).

Road Familiarity

Figure 3 is an aerial view facing west, with the Grass Valley drainage to the right (north). The fire progressed to the south and into the subdivision. Roads typically run cross-slope and in near alignment with the morning winds on October 22nd. Brentwood Dr. near Edge Cliff Dr. is to the right and not in view. Figure 4 is a view from the southeast looking at destruction primarily on Brentwood Dr., Modoc Ln., and Merced Ln. Homes destroyed by surface fire and/or firebrand(s) on Del Norte Ln./Madera Ln. (group of five), 710 Sonoma Dr., Placer Ln., and Walnut Hills Dr. are not in view (to the left [southwest]).

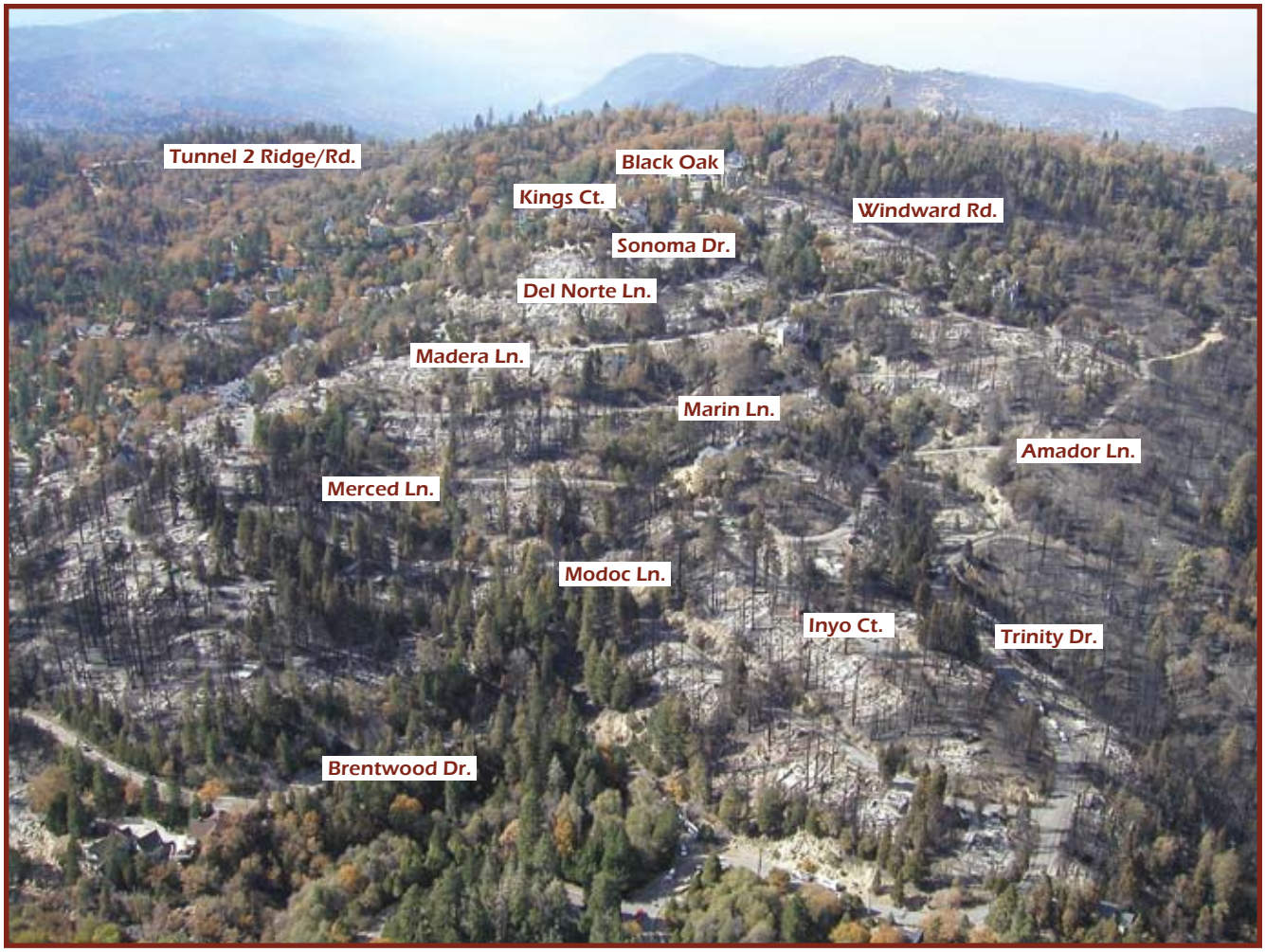


Figure 3. Aerial view of home destruction looking west.

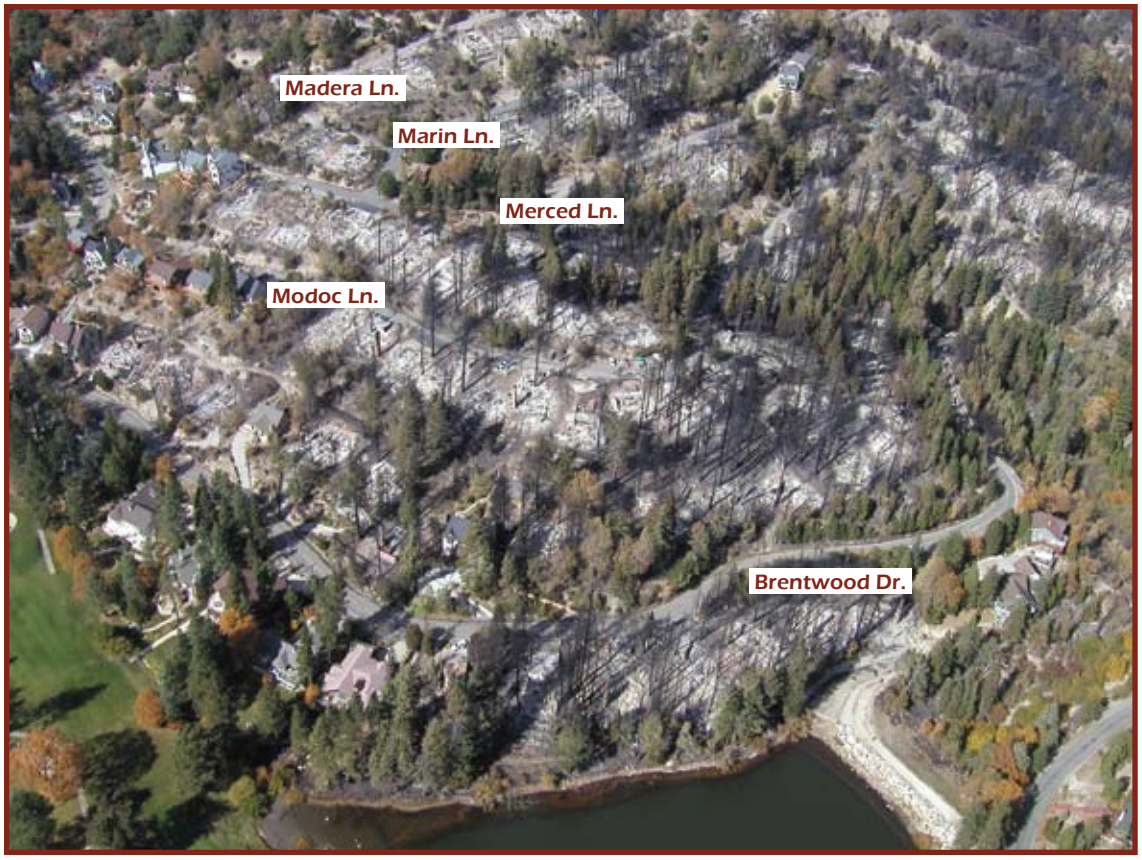


Figure 4. Aerial view of home destruction looking northwest. Grass Valley Lake is in the foreground and Lake Arrowhead Country Club is to the left.

Home Destruction Chronology

The following timeline documents home destruction in relation to the fire progression (see Figure 2). The exact time individual homes were destroyed is largely unknown. *The time intervals provide an estimate of when fire first reached a particular street, not when all home destruction occurred* (Figure 5). Our examination indicates that after the wildfire burned to the residential area, the burning homes primarily determined the fire spread—an *urban fire*. The home destruction chronology details (1) the area of destruction by street(s), (2) the approximate time when fire was observed in the area, (3) the resulting destruction (complete or partial—usually due to intervention), and (4) the primary ignition exposure (surface fire and/or firebrand(s), crown fire, house-to-house).

Figure 5. A home on Madera Ln. fully involved approximately seven hours after the wildfire impacted the area.
(Photo taken at 1819 by Don Kelsen, Los Angeles Times)

Brentwood Dr. (1204–1216)—near Edge Cliff Dr.

The east flank of the Grass Valley Fire progressed upslope and into homes located on Edge Cliff and Brentwood (See Figure 1). Fire intensity was moderate to high (shrub and single/group tree torching) (Figure 6).

0915–1000 Hrs.

Completely Burned		Partially Damaged	Total
3		0	
Surface Fire and/or Firebrand(s)	**Crown Fire**	**House-to-House**	
0	1	2	**3**

Figure 6. Aerial view of homes 1204, 1210, and 1216 off Brentwood Dr. The manzanita and oak canopies remain unconsumed near where conifers torched, suggesting a mixed intensity. The steep slopes (~40º), cross-slope winds, multi-level construction (e.g., four-story home to the left), and close home proximity promote house-to-house spread. This is an example of overlapping HIZs

Trinity Dr. (949–988) • Marin Ln. (939–1045) • Amador Ln. (26605–26695) • Windward Rd. (26609–26684)

Pushed by northerly winds gusting to 30 mph (per Rock Camp RAWS), the head of the Grass Valley Fire progressed southwest through the Grass Valley drainage and upslope into homes located on Windward (Figures 7-9), Amador (Figure 10), Marin (Figure 10), and Trinity (Figure 11).

Fire intensity was locally high due to burning shrub canopies and low to mid-height conifer branches, single/group tree torching, and localized crown fire runs. Homes on Windward were impacted first and predominantly exposed to firebrands; homes on Trinity were exposed to the highest flame intensities (Figure 12).

0930–1000 Hrs.

Completely Burned		Partially Damaged	Total
30		5	
Surface Fire and/or Firebrand(s)	**Crown Fire**	**House-to-House**	
17	5	13	**35**

Figure 7. Aerial view west of homes initially exposed to the wildfire from 0930 to 1000.

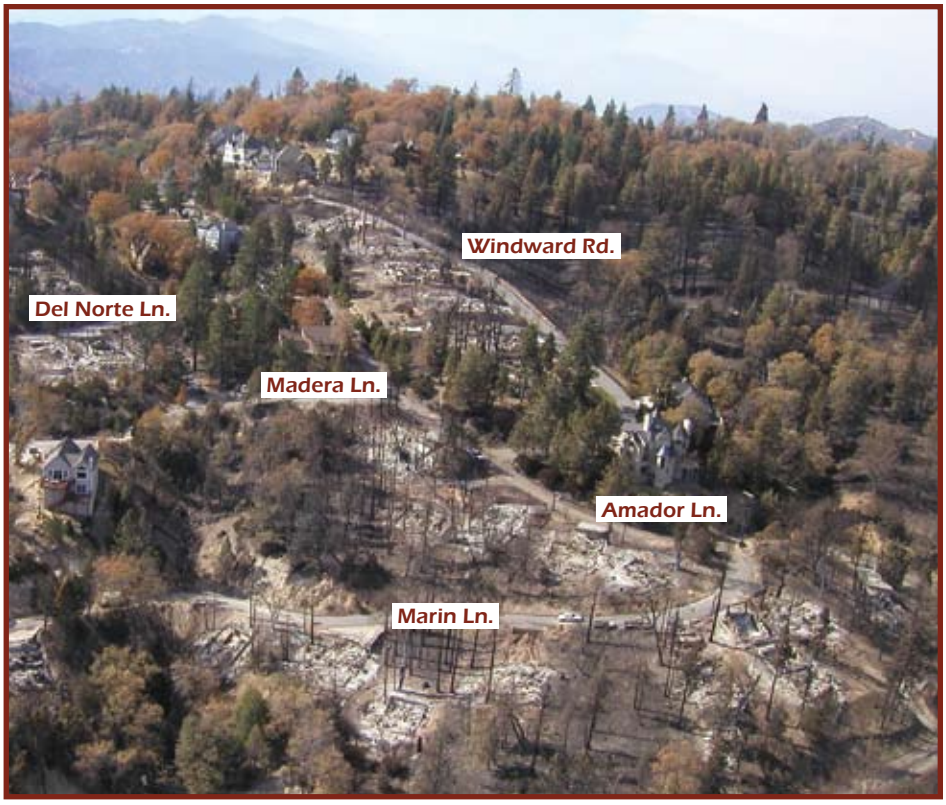


Figure 8. A "needle-frozen" ponderosa pine tree between Amador Ln. and Windward Rd. that indicates a northeast wind at the time of the fire and in alignment with Amador and Windward. Foliage is "frozen" as the heat from the fire is absorbed by the foliage that desiccates the needles but not to the point of combustion.

Figure 9. Aerial view of home destruction on Windward Rd. Note the unconsumed vegetation around the two homes in the lower left and directly across to the destroyed home (circled). These three homes were exposed to surface fire and/or firebrand(s). Once burning (circled), the house-to-house fire spread continued to neighboring homes. This is an example of a burning home well within a neighboring home's HIZ. (Photo by Tom Iraci)

Figure 10. An aerial view of home destruction looking south toward Lake Arrowhead Country Club.

Figure 11. A destroyed home on Trinity Dr. looking northeast across Grass Valley drainage; Brentwood Dr. is in the upper right. This photo shows the patchiness of aerial fuels exposed to high wildfire intensities.

Figure 12. View to the east, principally of five destroyed homes on Trinity Dr. (971-949). The high degree of consumption of tree and shrub foliage downslope from these homes likely indicates high intensity flame exposure.

Brentwood Dr. (1084 – 1126) • Trinity Dr. (925 – 941)

The east flank of the Grass Valley Fire progressed upslope into four homes on Brentwood (Figure 13) and southeast into homes on lower Trinity (Figure 14). Fire intensity was low (surface fire) to moderate (shrub and single tree torching).

0930–1015 Hrs.

Completely Burned		Partially Damaged	Total
4		4	
Surface Fire and/or Firebrand(s)	**Crown Fire**	**House-to-House**	
7	0	1	**8**

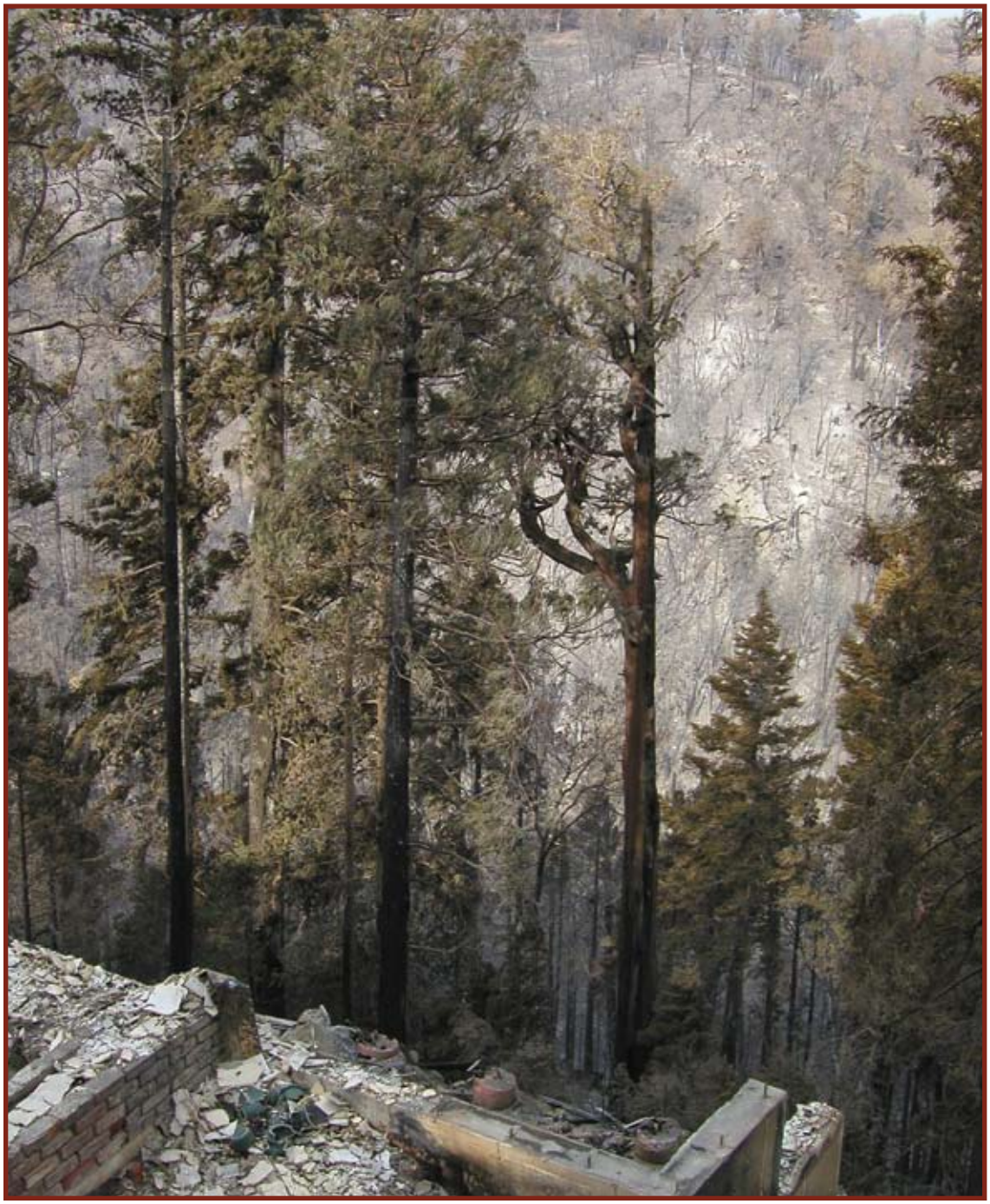


Figure 13. Destroyed home at 1114 Brentwood Dr. looking across Grass Valley drainage west. Note the unconsumed canopy indicating this home was destroyed by surface fire and/or directly ignited from firebrands.

Figure 14. Destroyed home at 933 and 941 Trinity Dr. The low hanging, unconsumed canopy suggests that these homes were ignited from a surface fire and/or directly from firebrands.

Modoc Ln. (26805–26895) • Inyo Ct. • Merced Ln. (26775–26786) • Marin Ln. (905–1045) • Madera Ln. (905–955) • Del Norte Ln. (905–965) • Sonoma Dr. (935–955) • Kings Ct.

At about 1030, the fire extended from Brentwood at the bottom of the slope to Kings Ct. at the top. *The wildfire transitioned to principally burning overlapping HIZs—an urban fire* (Figure 15). From this time on, home ignitions were due primarily to flames and firebrands from three or four-story homes burning 25-40 feet from neighboring homes. Winds were in close alignment with the cross-slope roads gusting to approximately 35 mph. Burning homes and their surrounding vegetation produced a shower of debris on adjacent homes and vegetation downwind. The steep terrain likely increased fire spread and firebrand production and lofting as well as the downhill cascade of collapsed burning debris (Figure 16). All of these factors result in a 'domino effect' of home destruction (Figures 17 and 18). Although there were significant tactical successes that stopped fire from spreading further along a street, the suppression forces were strategically overwhelmed, due to multiple homes burning simultaneously with little chance of preventing the disaster.

0945–1030 Hrs.

Completely Burned		Partially Damaged	Total
37		4	
Surface Fire and/or Firebrand(s)	Crown Fire	House-to-House	
19	0	22	**41**

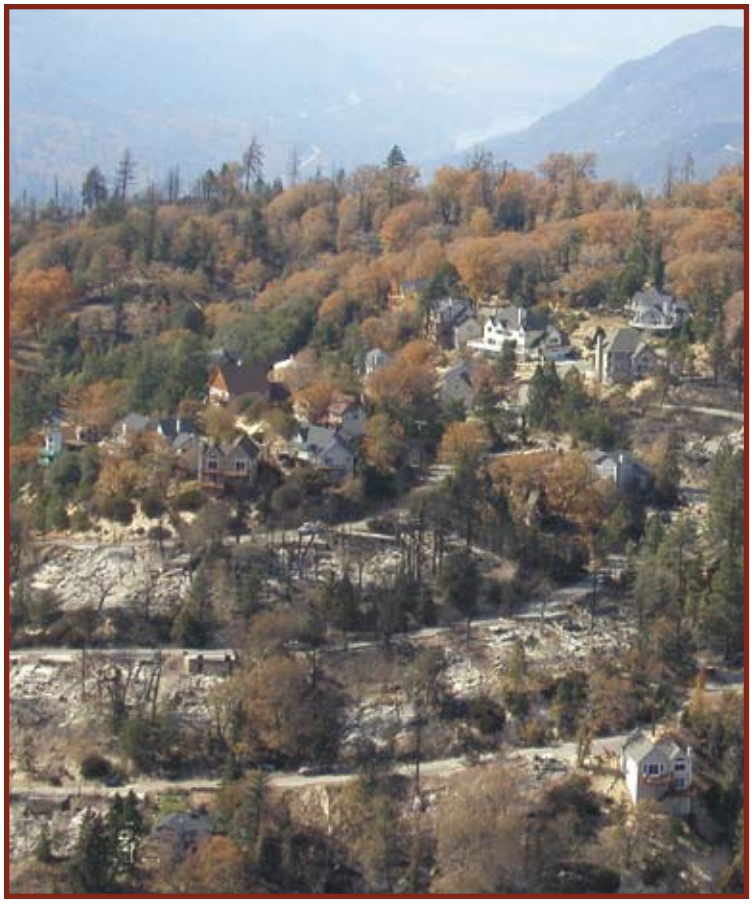


Figure 15. Home destruction on Madera Ln. (bottom), Del Norte Ln. (middle), and Sonoma Dr. (top). Note the abundance of unconsumed vegetation among the destroyed homes. Within the subdivision, the wildfire has now transitioned largely to an urban fire burning overlapping HIZs

Figure 16. Photo of 26787 Merced Ln. from Trinity Dr. Note the steep slope (35-40°) with the remaining debris from the collapsed home spread down the hill.

Figure 17. An aerial view of home destruction on Modoc Ln. (middle) and Inyo Ct. (top). Trinity Dr. is the road to the right (northeast) that wraps around the hill. Unconsumed tree canopies surround the home destruction. Burned canopies are over and between the destroyed homes. This indicates that the trees burned due to the burning homes, and the head fire that impacted Trinity Dr. from the north (arrow) did not continue into the subdivision. In this area, home destruction is primarily house-to-house. (Photo by Tom Iraci)

Figure 18. View of seven destroyed homes looking southwest on Inyo Ct. The burning homes primarily caused the tree canopy consumption.

Sonoma Dr. (899–915) • Del Norte Ln. (837–901) • Madera Ln. (770–895) • Marin Ln. (810–895) • Merced Ln. (26665–26765) • Modoc Ln. (26805–26895) • Brentwood Dr. (26805–26895)

Fires followed the hillside around to the southwest (Figure 19). Homes near the top of the hill (on Sonoma, Del Norte, and Madera) (Figures 20-22) and mid-slope (Marin) (Figure 23) were exposed first. Firebrands, possibly from 837 or 845 Del Norte, likely spotted across Madera and ignited a home(s) on Madera/Del Norte resulting in the eventual loss of five homes (Figure 24). At approximately 1100, the wind shifted north-northwesterly, spreading fire and burning debris downhill (southeast) to Merced, Modoc, and Brentwood (Figures 25-27).

1030–1130 Hrs.

Completely Burned		Partially Damaged	Total
95		10	
Surface Fire and/or Firebrand(s)	Crown Fire	House-to-House	
23	0	82	**105**

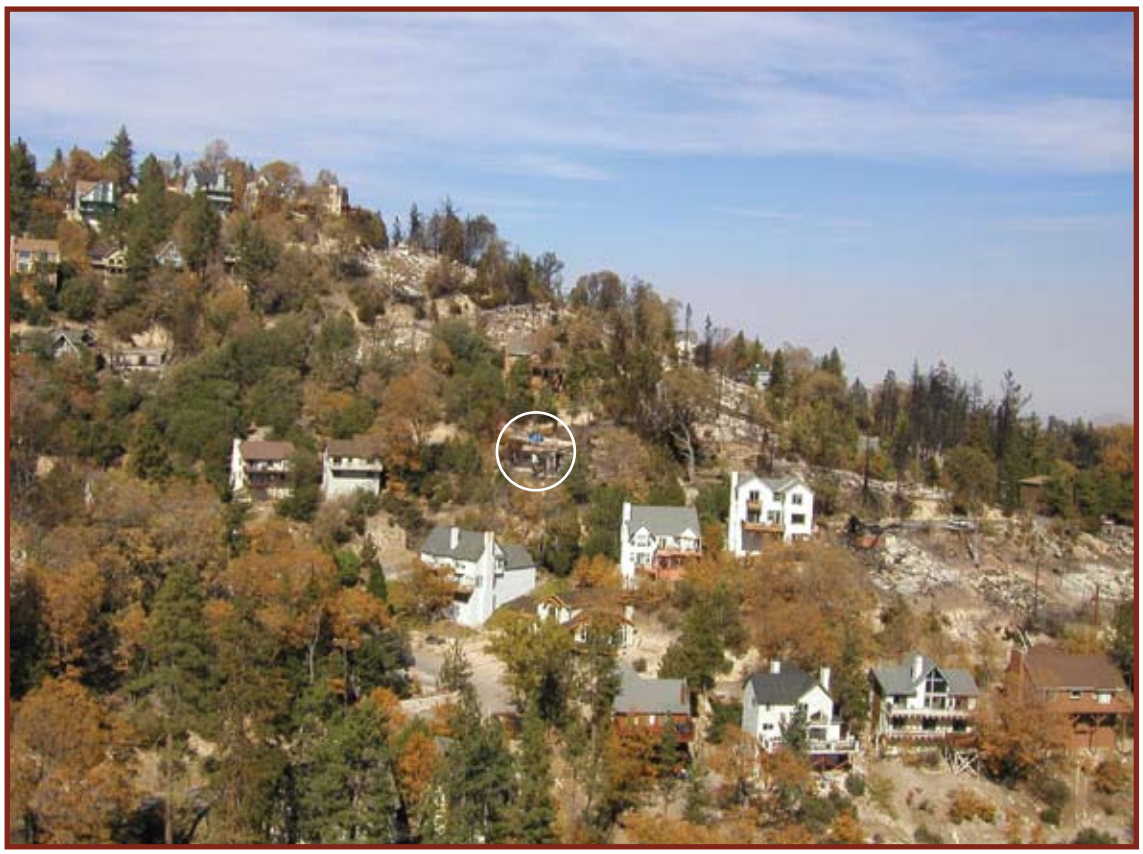


Figure 19. Photo of homes on Merced Ln. (1st row of homes) toward Kings Ct. (top of the hill). The destroyed home in the center of the photo (845 Del Norte Ln. [circled]) ignited from a surface fire and/or firebrand(s). Fire suppression stopped the house-to-house spread in this area due in part to the 'lee' effect the hill had on the northeast winds, the north-northeasterly wind shift at 1100, and the vacant parcels that reduced the house-to-house fire exposure.

Figure 20. Aerial view facing west with Madera Ln. at the bottom, Del Norte Ln. in the middle, and Sonoma Dr. just below the homes at the top of the hill (Kings Ct.). Note the unconsumed vegetation between the destroyed homes, particularly in the vacant parcels that were burned by surface fire (framed areas).

Figure 21. Destroyed homes at 899 and 905 Sonoma Dr. looking southwest through two vacant parcels that surface burned with an undamaged home (framed) in the background (875 Sonoma).

Figure 22. View of five destroyed homes on Madera Ln. looking south to Lake Arrowhead Country Club. The unconsumed tree canopies, in the middle-left of the photo, are in a vacant lot that surface burned.

Figure 23. A view to the northwest upslope from 810 Marin Ln. through four levels of home destruction. The unconsumed vegetation between rows of destroyed homes indicates that a high intensity vegetation fire did not spread through the residential area.

Figure 24. Aerial view looking down on five homes (circled) on Del Norte Ln. and Merced Ln. that were initially started by firebrands, possibly from burning homes or vegetation at 837 or 845 Del Norte (framed).

Figure 25. Four destroyed homes on Brentwood Dr. looking northwest. The home in the background is 850 Brentwood.

Figure 26. View looking west through seven destroyed homes on Merced Ln. to the white house at 26665.

Figure 27. Aerial view to the northwest of homes on Brentwood Dr. (bottom) and Modoc Ln. (center). Areas with blackened trees are a result of the homes burning the vegetation. At about 1100, the wind shifted north-northwesterly, spreading fire and firebrands downhill to the southeast.

Sonoma Dr. (710) • Placer Ln. (26530 and 26540)

A spot fire west of 700 Sonoma and east of Tunnel 2 Rd. grew to about 35 acres. A surface fire and/or firebrand(s) directly ignited 710 Sonoma (Figure 28). Firebrands, possibly from the five burned homes on Del Norte/Madera (see Figure 24), start a surface fire and/or directly ignited 26530 Placer resulting in destruction (Figures 29 and 30). The burning house caused minor exterior damage to the neighboring house at 26540.

1100–1200 Hrs.

Completely Burned		Partially Damaged	Total
2		1	
Surface Fire and/or Firebrand(s)	Crown Fire	House-to-House	
2	0	1	**3**

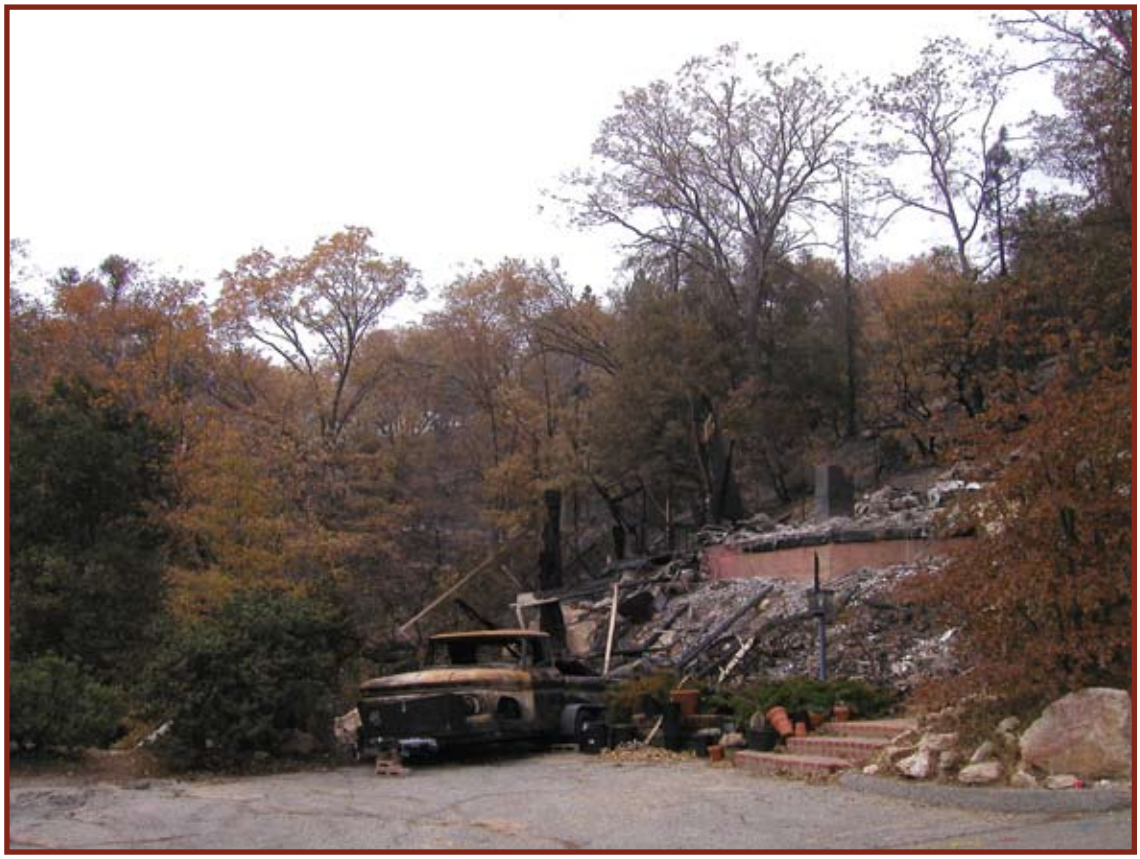


Figure 28. View of 710 Sonoma Dr. National Forest System lands are directly behind the destroyed home (west). The unconsumed vegetation surrounding the destroyed home indicates the likely cause was surface fire and/or firebrand(s). The neighboring house directly uphill survived (out of view to the right at 26516 Amador Ln.).

Figure 29. View of 26530 Placer Ln. This home ignited from surface fire and/or firebrands.

Figure 30. View from 26530 Placer Ln. (destroyed) to the north-west through three vacant parcels that burned with low intensity surface fire.

Walnut Hills Dr. (26088, 26142, 26150, and 26305)—near Fairway Dr.

Firebrands, possibly from an area of torching across the drainage from Walnut Hills Dr. (Tunnel 2 Ridge) (Figure 31), started several spot fires upslope of Fairway Dr. Surface fire and/or firebrand(s) destroyed 26142 (Figure 31); 26150 Walnut Hills (Figure 31) it was severely damaged on the sides exposed to 26142 (Figure 32). Surface fire and/or firebrand(s) destroyed 26088 (Figure 33); 26305 received minor exterior damage.

1600–1630 Hrs.

Completely Burned		Partially Damaged	Total
2		2	
Surface Fire and/or Firebrand(s)	Crown Fire	House-to-House	
3	0	1	**4**

Figure 31. Aerial view looking northwest up Walnut Hills Dr. to destroyed home at 26142 (circled) and damaged home at 26150 (framed). Tunnel 2 Ridge is directly across drainage and shows evidence of group tree torching.

Figure 32. Home at 26150 Walnut Hills Dr. Thermal exposure from the destroyed home at 26142 contributed to the vinyl sloughing off. Surface fire burned the vinyl siding and under-layment on the northwest side (left) and worked its way up the wall burning the wood siding. Blackened asphalt shingles in the roof valley (center top) are from accumulated needles that burned.

Figure 33. Aerial view looking southeast at 26088 Walnut Hills Dr. This destroyed home was ignited by a surface fire and/or firebrand(s). Note the steep slope, cascading debris field at the destroyed home site, and the unconsumed vegetation surrounding the destruction.

Home Destruction Totals

October 22, 2007 0500–2359 Hrs.

Completely Burned			Partially Damaged	Total
174			25	
Surface Fire and/or Firebrand(s)	Crown Fire	House-to-House		
71	6	122		**199**

Summary and Conclusion

The Grass Valley Fire largely spread within the Grass Valley drainage in surface fuels with brief high intensity runs up steep side slopes. The first homes that ignited were on the fire's east flank along Brentwood Dr. At nearly the same time, the head of the wildfire reached the northern edge of the residential area bordered by Trinity Dr., Amador Ln., and Windward Rd.

Our post-burn examination revealed that most of the destroyed homes had green or unconsumed vegetation bordering the area of destruction. Often the area of home destruction involved more than one house. This indicates that home ignitions did not result from high intensity fire spread through vegetation that engulfed homes. The home ignitions primarily occurred within the HIZ due to surface fire contacting the home, firebrands accumulating on the home, or an adjacent burning structure.

Home ignitions due to the wildfire were primarily from firebrands igniting homes directly and producing spot fires across roads in vegetation that could subsequently spread to homes. We identified only six homes where the high intensity wildfire continued into the home ignition zone and was close enough to ignite homes (one on Brentwood Dr. and five on Trinity Dr.).

The principal wildfire influence related to home ignition was the firebrand shower that produced simultaneous ignitions on houses and in vegetation across the northern edge of the community (i.e., firebrands across Trinity Dr., Windward Rd., and the northern extent of Amador Ln., Merced Ln., Marin Ln., and Madera Ln.). The fire progression (see Figure 2) into the northern portion of the community from 0930-1000, combined with unconsumed vegetation around destroyed homes, suggests numerous simultaneously burning homes due to firebrand ignitions. The wildfire became a residential fire where the wildlands became residential development at the northern end of the subdivision. Inside the residential development, the high intensity burning was principally associated with burning homes. The vegetated portions of the residential area (vacant lots and locations away from houses) largely burned with surface fire.

In general, the home destruction resulted from *residential fire characteristics*. The ignition vulnerable homes burning in close proximity to one another continued the fire spread through the residential area without the wildfire as a factor. This implies that similar fire destruction might occur without a wildfire. A house fire at an upwind location at the same time and under the same conditions as the wildfire could have resulted in significant fire spread within the community. Given the same high wind occurrence early in the morning, an electrical fire starting at the overhead utility attachment of an unoccupied home could totally involve the house before detection and a firefighter response. If

for example the house was on Inyo Ct., large conifers next to the burning house could have ignited. The intensely burning house and adjacent torching tree canopies could produce a shower of firebrands into the residential area resulting in more simultaneously burning houses. It is conceivable that numerous homes could have burned without a wildfire as was the case in the Ball-Euclid Fire in Anaheim, CA (April 21, 1982) and the Washoe Fire near Tahoe City, CA (August 19, 2007). These incidents remind us to focus attention on the principal factors that contribute to a wildland-urban fire disaster—the home ignition zone.

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