Improving Fire Hazard Assessment in South Lake Tahoe, CA*

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Because homeowners must be actively involved in fire hazard mitigation in the wildland/urban interface (WUI), private landscaping practices are closely regulated in high-fire-hazard areas in California (California Public Resources Code [PRC] 4291). PRC 4291 limits plant choice, density, and placement; regulates property maintenance practices; and requires at least 30 feet (9 m) of defensible space around homes (Cohen 1995; Foote and others 1991; Tran and others 1992).

Although compliance with PRC 4291 might increase fire safety, the policy does not recognize individual landscaping preferences or the impact of neighboring parcels on a homeowner's fire hazard potential. Property owners may resist firesafe regulations if compliance means a decrease in what they value in their landscapes (Abt and others 1991; Bailey 1991; Cortner 1991; Foote and others 1991; Hodgson 1993; Manfredo and others 1990; Smith and Rebori 2001; Winter and Fried 2000).

This article describes a fire hazard analysis conducted on private, developed lots in South Lake Tahoe, CA. In this WUI community, many developed lots are noncompliant with PRC 4291, although active agency outreach and public support of fuels reduction on undeveloped lots exists (Garrett 2002; Harcourt 2002). Fire hazard was assessed by using the National Fire Protection Association's Standard for Protection of Life and Property from Wildfire (NFPA 299); determining compliance with PRC 4291; and observing construction materials, irrigation practices, and the condition of neighboring properties.

People living in the wildland/urban interface have unique, individual values and preferences reflected in the landscapes they create and maintain around their homes.

Study Site

About 24,000 people live in South Lake Tahoe, which ranges in elevation from approximately 6,200 feet (1,900 m) to more than 7,000 feet (2,130 m). Historically, the Lake Tahoe Basin experienced low- and medium-intensity surface fires that occurred every 15 to 25 years. Rarely becoming stand-replacing events, these fires consumed mostly light surface fuels (Skinner and Chang 1996). Eighty-five years of fire suppression (Murphy and Knopp 2001), combined with prolonged drought and extensive tree mortality from insect infestations, have increased the area's highly flammable understory fuels.

The average January temperature for the basin is slightly below 32 °F (0 °C) and the average July temperature is approximately 60 °F (16 °C). The average annual precipitation is 29 inches (74 cm). Average annual snowfall ranges from 8 feet (2.5 m) to almost 350 inches (9 m). At lake level, there are an average of 70 to 100 frost-free days annually.

Methods

Sample sites were chosen from approximately 6,500 single-family residential parcels. The 102 parcels sampled were classified by low, medium, and high canopy cover and by low, medium, and high residential density. The vegetation and structural characteristics of each parcel were documented, measured, and mapped to the nearest 0.3 foot (0.1 m).

We divided the city into six neighborhoods based on observed differences in vegetation, lot size, and building characteristics. We refined the initial classification through statistical analysis for homogeneity in the defined neighborhoods. Neighborhood boundaries include areas with homes within city limits and exclude areas without homes, such as parks and golf courses. Major roads define the boundaries

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between adjacent neighborhoods.

Neighborhood 1 is the Tahoe Keys, characterized by wide streets; canals; large, new homes; exotic vegetation; and turf grass. None of the parcels in this neighborhood have any significant slope. Neighborhoods 2 through 5 all have small homes on small parcels. Native conifer species and an assortment of exotic shrubs and other plants dominate the vegetation, although species composition and structure differ among neighborhoods. Some parcels are slightly sloped. Neighborhood 2 is called the "Y" because it includes a large area surrounding the Y-shaped junction of Highways 50 and 89. Neighborhood 3, North Central, is located in that part of the city. Neighborhood 4 is the Sierra tract, and neighborhood 5 contains the Bijou and Tahoe tracts. Native conifer species dominate neighborhood 6, the Heavenly Ski Resort tract, which contains large, new homes on large lots. Slopes in this neighborhood are significant.

We conducted a fire hazard analysis on each parcel and then qualitatively compared the results to the fire hazard of neighboring parcels. We based the assessment predominantly on NFPA 299, which assigns a score for risk factors; and compliance with PRC 4291, which requires homeowners to prune dead branches, clear needles and other litter from roofs and gutters, cover vents with wire mesh, and clear tree branches for 10 feet (3 m) around chimney outlets. We also rated characteristics that contribute to the structural ignition potential, such as a wood roof, decks, and single-paned windows (Foote and others 1991; Quarles 2001; Quarles 2002; White 2000). High scores reflect a high fire hazard.

The combination of small lot size and landscape preferences can impede individual and community fire hazard mitigation.

We analyzed defensible space alone, maintenance alone, and a combination of the two for PRC 4291 compliance. We designated parcels as "noncompliant" if they had little or no defensible space and did not comply with one or more of PRC 4291's maintenance requirements. We considered wood decks hazardous if they were more than 1.5 feet (0.5 m) high and were either open or had flammable material stored underneath.

We classified parcels as small and under the direct influence of fire hazard from immediate neighbors if the distance between the house and the side boundaries of the parcel was less than 23 feet (7 m), if the difference between the total width of the parcel and the total width of the house was less than 45 feet (14 m), or if the difference between the total length of the parcel and the total length of the house was less than 45 feet (14 m). We considered large parcels independently of neighboring parcels.

We adjusted the fire hazard ratings for individual small parcels to include the fire hazard from the neighboring parcels. We rated small parcels with good defensible space and "better" maintenance the same

Controlling the Ecological Impact of Development

Management agencies and consortiums were developed in the Lake Tahoe Basin to mitigate the negative ecological impacts of the basin's growing population. Among the most visible are:

- ***The Tahoe Regional Planning Agency*** (TRPA), a powerful regulatory organization whose primary objective is to develop land use and management standards that maximize environmental health and mitigate negative environmental impacts from development (Murphy and Knopp 2000). Since the early 1970s, TRPA has prohibited development on environmentally sensitive parcels and has regulated private landowners' parcel management.
- ***The Forest Service's Lake Tahoe Basin Management Unit*** (LTBMU), which—alongside the California State Tahoe Conservancy—has compensated landowners for TRPA's restrictions on development by purchasing many private lots. The LTBMU also plays an active role in fuel management on the undeveloped urban lots owned by the Forest Service.
- ***Tahoe Re-Green***, an interagency consortium whose objective is to educate residents and help them reduce fire hazards by removing fuels on privately owned land.

for defensible space as medium or large parcels with moderate defensible space. Additionally, we rated small parcels with good defensible space and the "same" maintenance the same for defensible space as a medium or large parcel with good defensible space.

We assigned neighborhoods a mean fire hazard rating based on the fire hazards of the parcels sampled within the neighborhoods. Table 1 describes the point scoring system. The range of possible scores was 9 to 80 or greater, depending on the number of decks. Remember, high scores reflect a high fire hazard.

Results

Overall Fire Hazard Rating. The mean fire hazard rating was a relatively low 30, largely due to the city's wide, paved roads, the availability of water, and the presence of firefighting resources (table 2). Neighborhood 1 (Tahoe Keys) had the lowest fire hazard (24), whereas neighborhood 6 (Heavenly Ski Resort) had the highest (38). Neighborhoods 2 through 5 had mean ratings ranging from 28 to 30.

Lot Size. Mean lot size varies from 0.14 acres (0.06 ha) in the Sierra tract to 0.30 acres (0.12 ha) in Heavenly. The mean lot width is 72 feet (22 m). Lot sizes in the Sierra tract are smaller than those in any other neighborhood.

Compliance With PRC 4291. Most of the parcels have increased fire hazard ratings because they are partially or wholly noncompliant with PRC 4291. About 66 percent of the parcels are noncompliant with PRC 4291's requirements for maintenance and 75 percent have little or no defensible space. In total, 53 percent of the parcels are

Table 1—*Point scoring system for risk factors. Each parcel received a score depending on the degree of risk associated with each risk factor. The sum of the scores is a parcel's fire hazard rating. The higher the score, the higher the fire hazard.*

Risk factor	*Score*
Ingress/egress	1: two or more primary roads 3: one road, primary route 5: one way in/out
Primary road width	1: > 20 feet (6.1 m) 3: < 20 feet (6.1 m)
Accessibility	1: smooth road, < 5% grade 3: rough road, > 5% grade 5: other
Culdesacs	I: outside radius > 50 feet (15 m) 3: outside radius < 50 feet (15 m)
Turnarounds	3: dead end road is < 200 feet (60 m) 5: dead end road is > 200 feet (60 m)
Street signs	1: present (= 4 inches [10 cm] and reflect) 5: not present
Water	1: source < 20 minutes round trip 5: source 20–45 minutes round trip 10: source > 45 minutes round trip
Utilities	1: all underground 3: one above-, one underground 5: all aboveground
Maintenance	1: high 3: moderate 5: none
Defensible space	1: high (33+ feet [10+ m] treatment) 5: medium (10–23 feet [3–7 m] treatment) 10: no treatment
Roof materials	3: wood roof
Branches in chimney	2: branches within 6.6 feet [2 m] of chimney outlet
Irrigation	1: little or no irrigation
Vegetation	1: medium canopy cover 2: high canopy cover
Slope	1: 25–40% 2: > 40%
Wall materials	1: wood siding
Wall, eave, roof vents	2: some present without quarter-inch (6.35-mm) mesh cover
Predominant number of window panes	1: predominantly single-paned
Deck height	1: each deck with height > 1.6 feet (0.5 m)
Open space below deck	1: each deck with open space beneath
Storage of flammable materials under deck	1: each deck with storage of flammables beneath
Deck materials	1: each wooden deck
Parcel size	Adjustments made for small parcels
Relative maintenance	1: parcel is worse than neighbors 3: about the same 5: neighbors are worse than parcel

Table 2—*Fire hazard rating, noncompliance rates, and risk factors in South Lake Tahoe, CA, neighborhoods. Numbers (n) in parentheses below each neighborhood are the number of parcels sampled in that neighborhood. Mean fire hazard rating for each neighborhood is expressed as a number; all other values are percentages of the properties measured. "Total noncompliance" is noncompliance with both maintenance and defensible space codes.*

Risk factor	City total (n = 102)	Neighborhood					
		Tahoe Keys (n = 15)	Y (n = 22)	North Central (n = 13)	Sierra (n = 22)	Bijou/Tahoe (n = 21)	Heavenly (n = 9)
Mean fire hazard rating (standard deviation)	30 (6)	24 (5)	30 (4)	30 (6)	30 (6)	28 (5)	38 (7)
Maintenance noncompliance rate (%)	66	20	68	69	73	76	89
Indiv. defensible space noncompliance rate (%)	75	47	86	85	77	62	100
Indiv. total noncompliance rate (%)	53	7	59	62	64	48	89
Indiv. defensible space noncompliance rate, adj. for small parcels (%)	86	80	91	92	82	81	100
Indiv. total noncompliance rate, adj. for small parcels (%)	57	20	59	62	64	58	89
Irrigation (% of parcels with less than half irrigated)	52	13	45	69	59	58	78
Mean slope % (standard deviation)	2 (6)	0 (0)	0 (0)	0 (0)	1 (3)	0 (0)	15 (16)
Wood exterior (% of homes)	96	87	95	100	100	95	100
Wood roof (% of homes)	31	27	18	54	27	29	56
Single-paned windows (% of homes with more than half single-paned)	29	27	41	23	32	24	22
Deck hazard (% of homes)	67	60	68	77	73	48	89

noncompliant for both maintenance and defensible space. When considering the vegetation of neighboring parcels, 86 percent of the parcels are noncompliant for defensible space, whereas 57 percent are noncompliant for both maintenance and defensible space. Adjusting the defensible space rating to account for neighboring lots had the greatest effect on the defensible space compliance rates for the Tahoe Keys and Bijou/Tahoe tracts. Smaller changes were observed for the Y, North Central, and Sierra tracts, whereas there was no effect for the Heavenly tract.

Irrigation. More than half the parcels have irrigation on less than half the vegetation on the parcel. The vegetation in Tahoe Keys is well irrigated, whereas more than 75 percent of the parcels in Heavenly have little evidence of irrigation. Less than a third of the parcels in North Central are irrigated. Vegetation without irrigation in the other neighborhoods ranged from 45 percent to 59 percent.

Slope. Most of the parcels have little or no slope, except parcels in Heavenly, where the mean slope is 15 percent and the range is from 0 to 53 percent.

Wall Material. Ninety-six percent of the exterior walls in the homes sampled have shake, log, or wood siding. In Tahoe Keys, 13 percent of the homes are brick, stucco, or

stone, but 95 to 100 percent of the homes in the remaining neighborhoods have wood exteriors.

Roof Material. Thirty-one percent of the homes sampled have wood roofs. Neighborhoods where more than half the homes have wood roofs are North Central (54 percent) and Heavenly (56 percent). The fewest number of wood roofs is in the Y, where only 18 percent of the sampled homes have wood roofs.

Window Panes. More than half the windows are single-paned in 29 percent of the homes sampled. The highest percentage of homes that have predominantly single-paned windows is in the Y (41 percent), while the lowest percentage is in Heavenly (22 percent).

Decks. Sixty-seven percent of the homes sampled have decks. Deck construction and placement is particularly problematic in Heavenly, where slopes are the greatest. In that neighborhood, the fire hazard of only one of the nine homes sampled was unaffected by a deck. In Bijou/Tahoe, only 48 percent of the homes have a deck, whereas 60 to 77 percent of the homes in the remaining neighborhoods have a deck.

Discussion

The results of this study show that standard fire hazard rating in South Lake Tahoe will not provide managers and planners with enough information to implement an effective fire hazard mitigation program. Although the city's firefighting infrastructure is well developed, individual homeowners in the community rarely consider fire safety when choosing construction materials, type of property maintenance and landscaping, and defensible space. Many compliant small lots are affected by the fire hazard on neighboring noncompliant lots. Therefore, fire hazard ratings should consider the fire hazard created by neighboring vegetation and houses in areas dominated by small lots.

When developing a fire hazard rating system, each component should support fire management decisions, including identifying high-priority areas for treatment, noncompliant areas, and reasons for noncompliance. Each of the six neighborhoods in South Lake Tahoe has a unique profile that contributes to fire hazard at the neighborhood scale. Neighborhood profiles can be used to direct and focus management and homeowner education efforts. The obvious differences between the Tahoe Keys and Heavenly tracts, for example, provide managers with a clear set of objectives; however, there are also important, less obvious differences between the other neighborhoods. Data should be used to guide management decisions, including fuels reduction programs and outreach and education efforts that focus on the particular needs of each neighborhood.

In addition to education efforts regarding defensible space and maintenance, residents should learn about other fire hazards. Homeowners should understand the benefits of irrigation in raising the moisture content of vegetation and the relationship among drought stress, insect infestation, and fire hazard. Most homes in the South Lake Tahoe area have double-paned windows for better insulation against winter weather, but many residents are unaware of the fire protection that double-paned windows offer. Hazardous decks are a chronic problem for homes in the Heavenly tract, where most decks hang over steep slopes covered with surface fuels. In Heavenly, with its small lots and many seasonal residents, education on the importance of neighborhood-scale cooperation is critical.

In South Lake Tahoe and similar communities, fire hazard assessment that does not take homeowner practices and lot size into consideration is likely to underestimate an individual parcel's fire hazard. Defensible space and compliance with PRC 4291 are the most important factors in structure survivability, but the city's low fire hazard rating obscures the fact that three-quarters of the parcels are noncompliant with defensible space codes and two-thirds are noncompliant with maintenance codes. Also, the fire hazard on small lots may be underestimated due to the influence of neighboring parcels.

A more appropriate approach to fire hazard assessment in South Lake Tahoe is to assess parcels for compliance, lot size, construction materials, and irrigation. Analysis of compliance rates and homeowner choices will help to prioritize areas, provide a more accurate estimate of individual fire hazard, and support decisions to conduct outreach and education efforts.

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South Lake Tahoe is at high fire risk due to the reluctance of homeowners to provide defensible space, maintain and irrigate their property, and use firesafe construction materials.

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