# The 2007 U.S. Wildfire Season

## Lessons from Southern California


RMS®  ImageCat, Inc.

# ACKNOWLEDGEMENTS


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# INTRODUCTION

Ronald T. Eguchi
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This joint Risk Management Solutions (RMS) and ImageCat report on the 2007 U.S. wildfire season represents an important milestone for wildfire loss estimation activities. It documents the unique way in which a new generation of advanced technologies and data fusion techniques—that proved invaluable amidst the chaos following Hurricane Katrina in 2005—were employed for wildfire losses in Southern California. In tandem with catastrophe model estimates and traditional ground reconnaissance, information extracted from remote sensing imagery provides a rapid, independent, and accurate record of damage and loss, offering increased confidence in the magnitude of loss in the early days of an event when claim statistics are not available.

During the course of the devastating 2007 California wildfire season, damage assessment teams at ImageCat collaborated with RMS to implement an innovative, advanced, technology-driven approach based on aerial reconnaissance and webcrawler technology to assess structural damage and produce independent estimates of loss. As one of the first damage assessment teams to deploy, ImageCat conducted aerial reconnaissance throughout affected areas and rapidly developed damage assessments, which were integrated with secondary sources such as tax assessor data to map damage and loss at a parcel level.

ImageCat determined that this combination of aerial reconnaissance and GPS-based video technology was the most effective means of capturing real-time damage information and the extent of damage caused by these fires. Whereas satellite imagery is normally the preferred data sensor, many of the affected areas were obscured by dense smoke for days and thus made it impossible for this imagery to be used to identify burnt structures. Thus, the webcrawler technology was deployed to capture alternative damage assessment information for validation purposes.

Regional factors played an important role in impeding or exacerbating the initial conditions of each fire. Some of the key regional factors included topography in relation to the prevailing Santa Ana winds, fire potential of vegetation landcover, configuration of urban developments, and fire suppression strategies such as aerial fire fighting and land-based equipment. Past experience with other natural disasters has shown that many of these factors can be quantified beforehand using a variety of technologies, including remote sensing and geographic information systems (GIS). In addition, data fusion helped to collate pre-fire information on each structure so the size and value of structures could be established even when very little was left standing after the fire.

At ImageCat, our mission is to "support the global risk and disaster management needs of today, using the technologies of tomorrow." While risk is a fact of life, the extent to which risk impacts us now and in the future is a function of the effectiveness with which we manage and mitigate it. Traditional techniques and emergent technologies, such as satellite and aerial remote sensing, GIS, and GPS-referenced streaming video, serve to manage and mitigate risk. It is our hope that as we develop a better understanding of the factors that lead to increased wildfire risk we also implement measures that will effectively mitigate and control this risk in the future. ■

Robert Muir-Wood
Chief Risk Officer
Risk Management Solutions

Catastrophic fire led to the founding of the first insurance company in late 17th century London. The conflagration that destroyed the heart of the city of Hamburg in 1843 triggered the creation of the world's first reinsurance company in Germany. In the 20th century, outside of losses due to war, the greatest property losses resulted from the catastrophic fires that followed earthquakes in San Francisco in 1906 and in Tokyo in 1923. While fire risk in cities has been significantly reduced, as more and more people choose to live on the fringes of the wildlands, the risk to property from catastrophic wildfires at the wildland-urban interface continues to rise. In some regions, such as the western U.S., a combination of growth-stimulating wetter winters, and hotter, dryer summers has further increased the potential for catastrophic fire outbreaks.

The 2007 California fires were a striking reminder of the potential for wildland fires to escape their normal bounds. An outbreak of near hurricane-force Santa Ana winds in southern California, supercharged fires, and simultaneous wildfire outbreaks stretched the available fire suppression resources. For hours to days, the fires blazed uncontained. The majority of the largest fires were finally extinguished only by a change in the wind direction that blew the fire back on itself. For the 2007 California wildfires, the hazard was as much the persistent high winds as the spark or match that first lit the flames.

Catastrophic fires are characterized by a series of non-linearities—in the way that multiple fires are triggered under the same weather conditions, that fires grow out of control, that the fire suppression systems become overwhelmed. The 2007 fires showed how, driven by a fierce, dry wind, fires can escape out of high fire susceptibility areas and continue to burn deep into low-risk populated areas. In modeling the risk of catastrophic fires at RMS, it is additionally important to consider fires even larger than those yet witnessed—including fires driven out of the wildland deeper into the fringes of the cities, where the density of wood frame housing can be high enough to provide its own fuel load.

The collaboration between Risk Management Solutions (RMS) and ImageCat, a pioneer in disaster aerial reconnaissance technologies, has allowed us to gain a deeper understanding of what defines the burnt area. How can one relate the perimeter of the fire to the high-resolution geography of the loss, including better predicting where structures survived inside the burnt area? In the aftermath of Southern California fires, there were twenty times as many insurance claims as structures consumed by the fire, a reminder that the loss from wildfire includes additional living expenses (ALE) payments for mandatory evacuations, as well as damage from burning embers and smoke.

As expansion of building continues into the wildlands, and as climate change increasingly exacerbates weather conditions, producing wetter winters and more extreme droughts, the preconditions for catastrophic fires in California continue to increase. ■

# EXECUTIVE SUMMARY

The 2007 U.S. wildfire season will be long remembered for its severity and extent. More than 85,500 fires across the country burned over 9.3 million acres of land. With $1.8 billion spent on fighting wildfires and a potential $2.5 billion in insured losses in California alone, the season ranks as one of the costliest wildland fire seasons in recent memory.

Southern California was especially hard hit, with over 3,000 structures destroyed in the October 2007 outbreak. The extreme nature of the wildfire outbreak resulted from the combination of several factors. The dry winter and summer months of 2007 allowed the fire fuel, consisting mainly of chaparral, to become abnormally dry and extremely susceptible to wildfires. From October 21 through October 24, the Santa Ana winds blew across the region, with gusts reaching hurricane force over a wide area. As a result, 23 separate fires consumed close to 520,000 acres of land. More than half a million people were evacuated throughout the region.

Risk Management Solutions (RMS) teamed with ImageCat to survey the damage from the Southern California outbreak. Over the course of two weeks, as the outbreak became contained, ImageCat flew four aerial reconnaissance missions over the most significantly affected areas and then merged their processed images with tax assessor data and other sources. The result was a geocoded database of locations and square footage of destroyed structures, along with refined fire perimeters showing the areas of greatest impact. These datasets have provided unique insights into the fires, both in terms of the characteristics of the fires and their impact on the built environment.

The widespread property destruction serves as a reminder of the importance of the management and mitigation of wildfire risk. Some measures traditionally used to mitigate the impacts of wildfires on structures were effective during the 2007 wildfire season. For example, residential structures with defensible spaces or non-burnable roof and cladding were less likely to burn and to ignite neighboring structures. However, the strong winds caused embers and smoke to travel great distances, damaging many other structures along the wildland-urban interface (WUI). While insured losses were primarily due to burnt residential structures and their contents, other claims included smoke damage, additional living expenses (ALE) due to the mandatory evacuation, burned automobiles, and a limited number of commercial structures. Government-issued fire perimeters proved limited in their usefulness to describe the extent of damage, as some structures within fire perimeters did not burn while other structures outside official fire extents sustained smoke damage and incurred ALE costs due to the mandatory evacuation.

The detailed, high-resolution RMS® Wildfire Hazard Data illustrated that the burnt structures from the 2007 California wildfire season fell into one of two categories. First, a large portion of the structures burned in the Angora, Grass Valley, Harris, and Slide fires were historically more at risk, being located at or within close proximity to the wildland-urban interface, or surrounded by highly burnable surface fuels. In contrast, structures destroyed in certain areas of the Poomacha, Rice, and Witch fires were located in historically lower risk areas. The Santa Ana winds in combination with the large quantities of highly burnable surface fuels caused the fires to spread into regions which, in a typical year, would not have burned due to fire suppression efforts.

The challenge of managing wildfire risk will only be exacerbated by changing climatic conditions. Various climate modeling studies have shown that future wildfires are likely to burn more acres of land in the western U.S. than they do today. With more widespread and potentially deadly wildfires expected in the future, solutions to manage and mitigate this risk are essential. As leaders in our field, RMS remains committed to the continual research of improved approaches to modeling the changing landscape of wildfire risk.

*Destroyed residential structure along the wildland-urban interface as a result of the Witch Fire in San Diego County in 2007 (Source: RMS)*

# 1 THE U.S. WILDFIRE PROBLEM

Wildfires are unplanned wildland fires caused by lightning, human intention or carelessness, or by prescribed fire projects that escape control. From 2001 through 2006, lightning caused close to 28 million acres to burn in the U.S., with another 14 million acres destroyed by arson or human carelessness. Over the past ten years, on average, six million acres of land are destroyed by fire every year in the U.S., causing tens to hundreds of millions of dollars in property and environmental losses. Less frequently, catastrophic wildfires can result in billions of dollars in losses, as observed in recent years—such as in California in 2007.

In 2007, over 3,000 structures burned in Southern California. Wildfire risk in the U.S. is expected to increase in the future as rapid demographic development on the intersection of the wildland-urban interface (WUI) escalates. The expansion of the WUI, defined as the area where human developments meet or intermingle with undeveloped wildland, creates an ever-expanding environment in which fire can readily move between structural and vegetation fuels, and increases the likelihood that wildfires will threaten people and their properties.

## 1.1 Historical Fire Insurance Coverage

The first American fire insurers modeled themselves after the British insurance companies that were established following the Great Fire of London in 1666, which destroyed over 13,000 structures. Coverage for property loss remained geographically localized in urban centers from the 18th century into the 19th century until a conflagration destroyed parts of the New York business district in 1835. As 23 of the 26 local fire insurance companies went bankrupt, the industry realized they needed to diversify their risk across the U.S. In the mid- to late-1800s, national residential insurers managed their risk by mapping the structures that they covered. Lacking the sophisticated geographic information systems (GIS) software of today, they used tacks on a wall-hung map to indicate their concentration of exposure. This crude technique served insurers well and limited their risk.

*Harris Fire burning on Mount Miguel in San Diego County on October 23, 2007 at 2:30 a.m. PDT*

Abundant claims data from the many small urban fires each year, and from catastrophic events such as the 1871 Great Chicago Fire and the 1906 San Francisco Earthquake and Fire, which respectively burned 18,000 and 28,000 structures, fueled the growth of an American fire insurance industry in the 20th century. However, the statistical techniques traditionally used by actuaries for estimating future losses stemming from fire insurance policies in urban environments—which rely on a wealth of available claims data—are insufficient for estimating future losses from catastrophic wildfire events bordering metropolitan areas or in rural areas. An abundance of historical data simply does not exist.

Today, the increased demand for housing creates an ever-changing landscape of properties in both urban and suburban settings, further limiting the usefulness of the historical loss data that does exist, as it cannot be easily extrapolated to estimate the economic impact of disasters. Increased demand influences property values, as well as the costs of repair and replacement. Building materials and design and construction practices change along with building codes. As with other natural catastrophes, sophisticated modeling techniques are required to fully assess and quantify the risk from catastrophic wildfire events.

## 1.2 Forty Years of Wildfire Losses

While there are historic wildfire losses in the U.S.—most notably the 1881 Michigan "Thumb Fire" and the 1923 Berkeley Fire, which burned 3,000 and close to 590 structures, respectively—the most catastrophic U.S. wildfire losses have occurred since the 1960s. Today, property insurance for losses due to fire is covered under standard residential property coverage. According to the Property Claim Services (PCS) unit of the Insurance Services Office (ISO), which maintains a comprehensive database of insurance payments in the U.S. due to wildfires and other catastrophes, there have been a total of 19 catastrophic (Cat) events resulting from wildfires since 1961. A Cat event is defined as an event incurring insured losses of greater than $25 million, as well as having a significant impact on insurers and policyholders. With the exception of three events (the 1985 Florida, the 2000 New Mexico Cerro Grande, and the 2002

| Fire Name | Year | County | Structures Destroyed |
|---|---|---|---|
| Cedar | 2003 | San Diego | 4,847 |
| Oakland Hills | 1991 | Alameda | 2,900 |
| Witch | 2007 | San Diego | 1,650 |
| Old | 2003 | San Bernardino | 1,003 |
| Jones | 1999 | Shasta | 954 |
| Paint | 1990 | Santa Barbara | 641 |
| Fountain | 1992 | Shasta | 636 |
| City of Berkeley | 1923 | Alameda | 584 |
| Bel Air | 1961 | Los Angeles | 484 |
| Laguna Fire | 1993 | Orange | 441 |

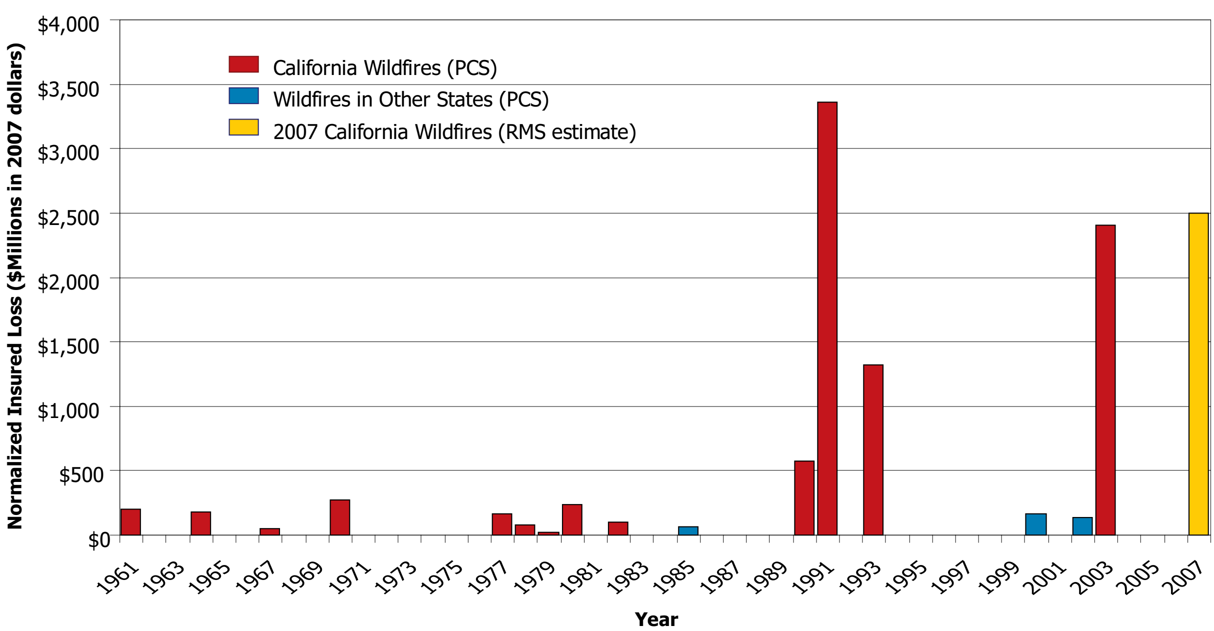
*Top ten California fires by structures destroyed (Source: California Department of Forestry and Fire Protection)*

Arizona Rodeo-Chediski fires), all catastrophic insured wildfire losses have occurred in California.

The year 2000 marked a turning point in catastrophic losses due to wildfires, as 2000—at the time—was considered the worst fire season since 1910. The magnitude of the fires in 2000 was attributed to extreme weather conditions and a recent severe drought combined with the effects of almost a century of aggressive fire suppression, which contributed to unhealthy forests that were susceptible to large fires. Following the 2000 fire season, the federal government issued a National Fire Plan (Healthy Forests and Rangelands, 2000). It recommended how best to respond to fires, ensure sufficient firefighting resources, and reduce the impacts of fires on rural communities. This plan instigated changes in suppression strategies and the development of defensible spaces for reducing fire risk to properties. Unfortunately, this plan has had no significant impact on wildfire losses over the past seven fire seasons, with 2007 marking the fourth consecutive year that fires consumed more than 12,500 square miles (32,400 square km).

The state of California is especially at risk from wildfires. According to the California Department of Forestry and Fire Protection, over $105 billion of property is located in areas of high wildfire risk. Moreover, while on average, California contains less than 10% of the burnt areas in the U.S., about 70% of the insured losses are from properties in Southern California. Specifically, the Southern California counties between Santa Barbara County and San Diego County contain close to 60% of the population of the state and have been particularly hard hit by wildfires, including the late October 2007 fires.

The relative importance of wildfire risk to California insurers will continue to grow. Although the current contribution of wildfires to total U.S. average annual losses from all natural disasters is less than 5%, according to PCS, losses from the 1991 Oakland Hills Fire, the 2003 Cedar and Old fires, and the 2007 Witch Fire rank among the top fifty insured losses. With many residential insurers transferring their earthquake risk to the California Earthquake Authority (CEA), wildfire has become a primary catastrophe risk for these carriers, especially in terms of large losses at short return periods. Furthermore, if one considers the past ten years of California wildfire history, close to 1,350 structures have burned on average each year with an associated estimated insured annual loss of approximately $490 million—nearly twice the long-term average. If recent history provides any indication of the future, this figure will most likely increase due to exposure concentrations within the wildland-urban interface. ■




*Insured wildfire losses from 1961 to 2007 (normalized to 2007 dollars), based on historical Property Claims Service (PCS) data and a 2007 estimate from Risk Management Solutions (RMS)*

# 2 THE 2007 WILDFIRE SEASON

With persistent rainfall deficits and severe-to-extreme drought conditions across much of the U.S., climatic conditions during 2007 were conducive to fire development. Throughout the year, FEMA reported over sixty disaster declarations resulting from wildland fires in the U.S. According to the National Interagency Fire Center (NIFC), as of December 2007, more than 85,500 fires across the country had burned over 9.3 million acres of land (NIFC, 2007). Throughout the season, the federal government spent more than $1.8 billion fighting wildfires, making 2007 the second costliest wildfire season on record. And while a number of fires occurred in areas of low residential and commercial exposure (such as forests and national parks), at the peak of the fire season, close to 20,000 people were assigned to fire suppression or support.

The fire season got off to an early start in April with fires burning in the southeastern states of Georgia and Florida. The Georgia Bay Complex Fire lasted several months, consuming approximately 565,000 acres across both states. According to the NIFC, this fire was the region's biggest wildfire since 1898, when three million acres of land burned across South Carolina. The Georgia Forestry Commission (GFC) calculated that the Georgia Bay Complex Fire resulted in the consumption of the greatest amounts of forestland and timber ever recorded in this region, with an estimated $60 million of privately owned timber lost to fire (GFC, 2007). Despite the vast area that burned, only 18 homes were destroyed and no lives were lost. Fires additionally impacted the Okefenokee National Wildlife Refuge, which spans the border between Georgia and Florida. By the time fires tapered off across the region, more than one million acres had burned across Georgia and Florida.

## 2.1 The Angora Fire

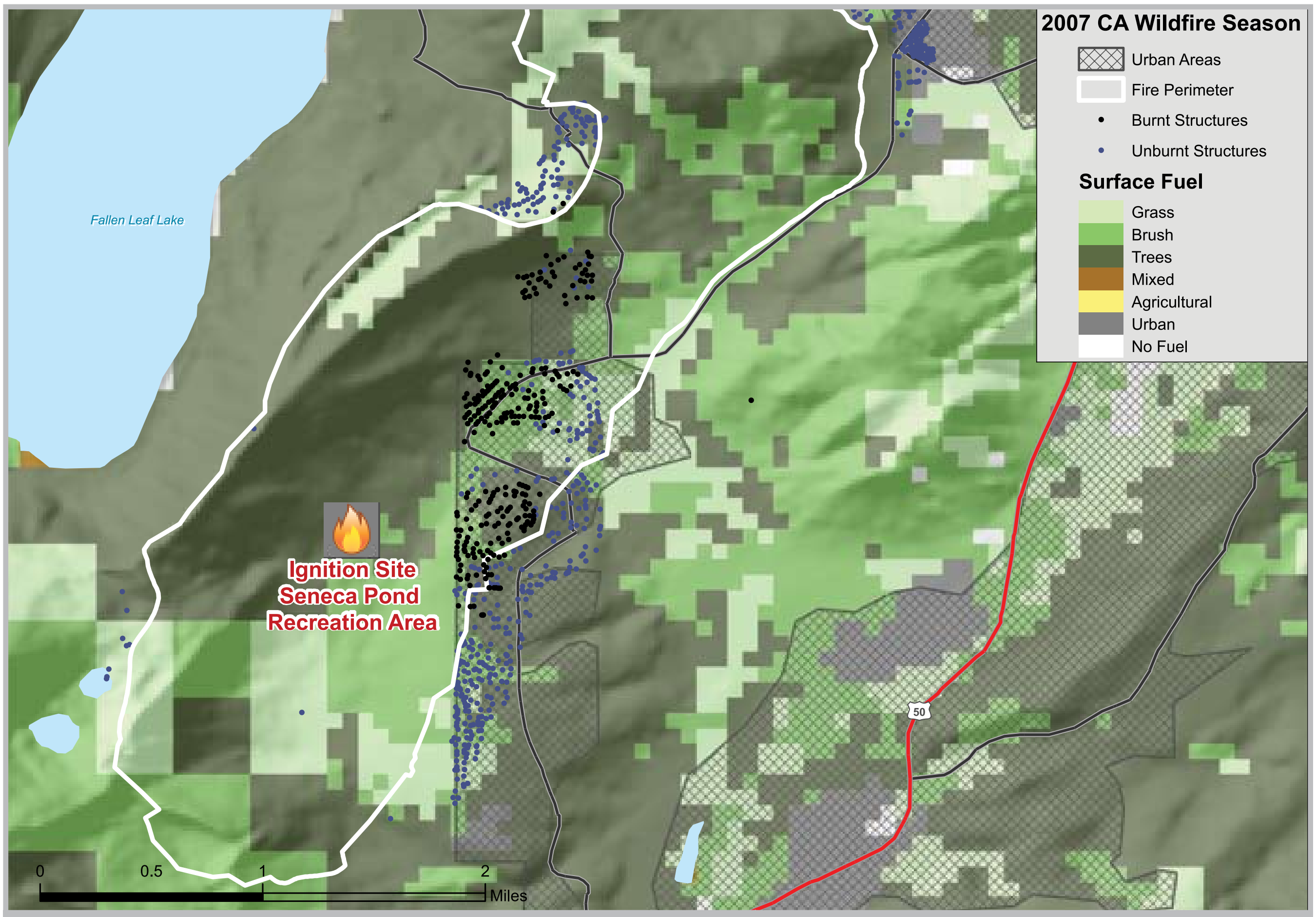
In June, the fire season was relatively calm as weather conditions improved. However, on Sunday, June 24, the Angora Fire began near Lake Tahoe, California, at the popular Seneca Pond recreation area. The fire, which was sparked by an untended campfire, burned approximately 3,100 acres over the span of three days, fueled by the surrounding dense forest. Moving across heavy timber


*Significant wildfires across the United States in 2007, highlighting the Murphy Complex Fire in Nevada and Idaho, the Milford Flat Fire in Utah, and the Georgia Bay Complex Fire in Georgia and Florida* and rugged terrain, the fire burnt over 300 structures but fortunately was contained before spreading to a more densely populated region.

The Angora Fire was a prime example of a canopy or crown fire, which advances from treetop to treetop across a forest independent of the fire on the surface of the ground. This type of fire spreads rapidly with strong winds, blowing burning embers into the air, threatening the surrounding region. Over the course of the first day, the fire spread rapidly with wind gusts measuring up to 35 mph (56 km/hr). Weather conditions improved on Monday when the strong winds that were prevalent on Sunday eased, reducing the probability of spread into South Lake Tahoe. The fire continued to burn along the slopes to the south of Lake Tahoe and a state of emergency was declared in El Dorado County.

However, on Tuesday, June 26, the fire jumped defense lines and embers were blown across the fireline, starting new spot fires in communities southwest of South Lake Tahoe. Many homes were consumed quickly with high spatial correlation between burnt structures. There were mandatory evacuations in place for residents south of Highway 89—which runs through South Lake Tahoe and was a critical line of defense in containing the fire—and volunteer evacuations to the north of the highway. Around 2,000 people were evacuated over the course of the event. Lake Tahoe is an area that is highly dependent on recreational tourism and there were fears that the fire could cause long-term economic consequences. Throughout the summer of 2007, local merchants estimated that sales were off by 10% to 20% from the year before. In addition, the revenue from Nevada casinos was down over 7% from 2006, as reported by the Nevada Gaming Control Board. Other

*The Angora Fire burning near Lake Tahoe, California on June 25, 2007*




*Map showing the ignition site, fire perimeter, surface fuels, and burnt structures during the Angora Fire in June 2007. The majority of the burnt structures are in the timber areas due to the rapid spread of the fire in the tree canopies.*

long-term consequences include the increased risk of landslides and mudslides due to the removal of large areas of vegetation.

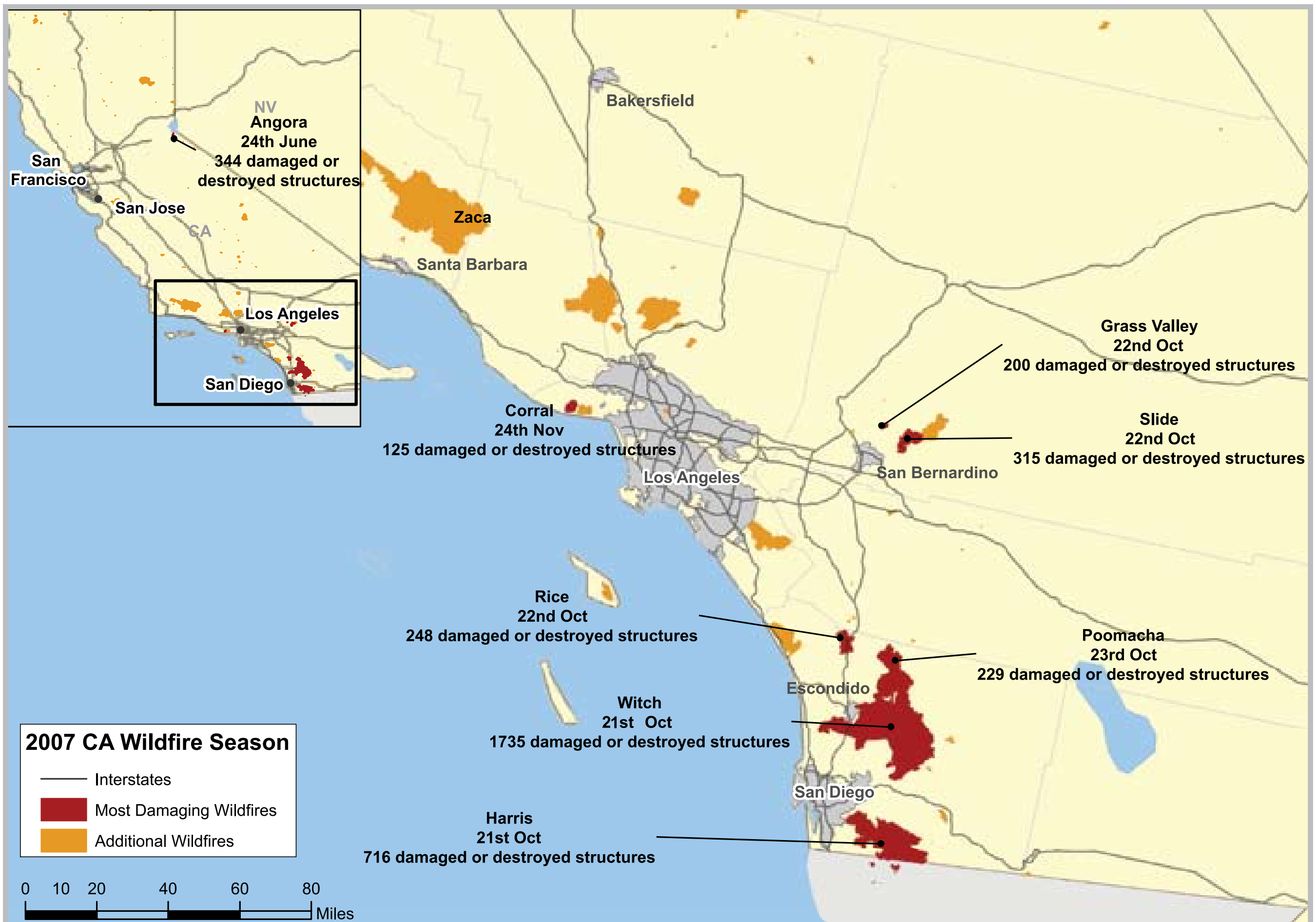
## 2.2 Notable Western U.S. Fires

The fire season worsened in July before moving onto more fuel-laden areas in Montana, as well as the Sierras, Cascades, and Rocky Mountains. Areas within the Great Basin were particularly hard hit, including Nevada, Utah, and Idaho. The Milford Flat Fire, which was started by lightning on July 6, grew to become Utah's largest wildfire in state history. The Murphy Complex Fire, a conflagration of six fires that burned together, destroyed over 650,000 acres in Nevada and Idaho. With a total of 2 million acres destroyed by fire, Idaho attained the dubious distinction of having the most area burned during the 2007 wildfire season. In Arizona, a state usually hard hit by wildfires, the 2007 season was relatively quiet, despite the state-wide drought.

To the west in the state of California, on July 4, the Zaca Fire in Santa Barbara County became the second largest wildfire in state history, consuming close to 250,000 acres. It burned a large stretch of chaparral, a plant community consisting mainly of densely-grown, drought-resistant, and fire-prone shrubs that is particularly common in California. Fortunately, it did not get too close to any urban areas. Unfortunately, this was not the case in the autumn, when wildfires hit the Southern California region, destroying many properties as fires spread.

## 2.3 The Southern California Outbreak

October fires in California are not unusual, as the month generally marks the peak of fire activity. In fact, the most notorious historical California wildfires have occurred in October—namely the 1991 Oakland Hills Fire and the 2003 Cedar and Old fires. The 2007 Southern California fires started on October 20, with some fires lasting over two weeks. Over 20 fires began within a few days of each other, and at the outbreak's peak, 23 separate wildfires were active. The large number of fires and the distances between them strained the resources of the fire suppression crews, and a few of the fires became extremely destructive—in particular the Witch Fire, which burned close to 200,000 acres. In all, the fires consumed approximately 520,000 acres of land, causing widespread property destruction and resulting in several fatalities. There were mandatory evacuations

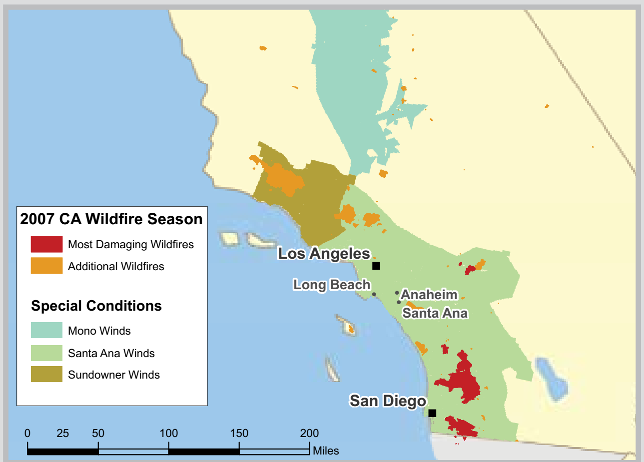



*The 2007 California wildfires, highlighting the most damaging wildfires in Southern California, including the Corral, Grass Valley, Harris, Poomacha, Rice, Slide, and Witch fires, and the Angora Fire in Northern California (inset)*

## The Santa Ana Winds

During the autumn season in California, there is a tendency for a strong pressure gradient to form in the atmosphere due to an inland high-pressure system coming into contact with an offshore low-pressure system. The result is a heated air mass with high offshore winds and low humidity. This weather is known locally as the Santa Ana winds in Southern California and the Diablo winds in Northern California. These winds impact hundreds of miles along the coastal mountains of California.

The Santa Ana winds derive their name from the Santa Ana Canyon on the edge of Los Angeles, where the northeasterly winds can blow with exceptional speed. The winds form when dry air from the high desert plateau of the Great Basin to the east comes into contact with the low pressure off the coast of Southern California. As the air descends, compressional heating warms it further, drying it out even more. Typical wind speeds are around 40 mph (64 km/hr) with gusts of up to 60 mph (97 km/hr). Sea breezes, which typically blow onshore daily, can help moderate the Santa Ana winds.




*Map showing the 2007 California wildfires with the prevailing winds, including the Santa Ana winds across a large portion of Southern California*

The Santa Ana winds are notorious for spreading wildfires, as was seen during the 2003 and 2007 events in Southern California.

across many parts of San Diego County during the main outbreak in October and all evacuations were finally lifted on October 31 at 11:00 a.m. PDT. The 24th and final fire of the season in Southern California, the Corral Fire, began in Malibu on November 24 and lasted three days. In December 2007, Insurance Commissioner Steve Poizner reported that California insurers had received over 33,000 claims and at least 1,500 of the reported claims were known to be total losses, with an estimated insurance industry exposure of more than $1.6 billion.

The extreme nature of the wildfire outbreak resulted from a combination of several factors. First, these catastrophic fires occurred under extreme weather conditions with a high "Energy Release Component" (ERC), which is a measure of fuel dryness. Southern California had not been subject to a particularly wet winter, and the summer of 2007 was very hot and dry. The dry winter and summer months allowed the fire fuel—vegetation mainly consisting of chaparral and shrub—to become abnormally dry and therefore extremely susceptible to wildfires. Moreover, these types of vegetation are the least resistant to fire, while wet grass is considered most resistant to wildfire spread.

Second, the meteorological conditions prior to and during the fires acted as a major driving force for explosive fire development, rapid spread, and long duration. Between October 21 and October 24, the weather in Southern California was dominated by very strong Santa Ana winds. Although these winds are common in October, the winds of October 2007 were particularly severe, with gusts reaching hurricane force (85 mph or 138 km/hr) over a wide area. Finally, in combination with the very strong winds, temperatures in Southern California were high, measuring between 92ºF and 97ºF inland (33ºC and 36ºC) with relative humidity levels between 10% and 15%.

The very strong Santa Ana winds, which lasted for four days, helped to spread fires over large areas in Southern California and showered structures with firebrands or embers that were transported by winds deep into dense suburban areas. As winds shifted, the fires continued, causing ashes to fall as far away as Del Mar on the coast of Southern California.

*Burnt residential structure following the Witch Fire in San Diego County. As fire suppression crews fought to save the sourrounding homes, this home burned to the ground. (Source: RMS)*

### *2.3.1 San Diego County: Witch and Poomacha Fires*

Of the 24 fires that occurred between October 20 and November 30, 2007, the most devastating were the Witch and Poomacha fires, which merged together in late October. These fires burnt a total of 250,000 acres and close to 1,900 structures, a majority of which were residential properties—some with very high value. The Witch Fire itself ranks third—behind the 2003 Cedar Fire and the 1991 Oakland Hills Fire—in number of properties destroyed.

The Witch Fire began on Sunday, October 21 in Witch Creek Canyon in eastern San Diego County, spreading rapidly to the west due to the strong Santa Ana winds. It is assumed that power lines downed by the Santa Ana winds initiated the fire, with sustained winds of 35 mph (56 km/hr) and gusts up to 60 mph (97 km/hr). Visibility was obscured due to the blowing ash and smoke from the fire. Many thousands of residents received evacuation instructions through the "Reverse 911" system, an automated system that calls all telephone numbers within a certain area, delivering a recorded message to inform residents of an emergency. The calls began in the early afternoon of October 21 and progressed in bands westward as the fire moved in that direction.

The Witch Fire merged with the Poomacha Fire, which was burning to the north, on Tuesday, October 23. Caused by a structure fire on the La Jolla Indian Reservation, the Poomacha Fire burned close to 50,000 acres, which in conjunction with the close to 200,000 acres burned by the Witch Fire, became the largest insured loss from the wildfire outbreak across Southern California in 2007. As of January 2008, PCS reported 13,000 residential and 3,000 commercial claims with a total estimated insured loss of $1.1 billion. This loss is approximately 60% of the total estimated insured losses from all 24 fires. A large proportion of the claims were related to cleanup efforts and time element losses due to disruption from the fires themselves, including from the mandatory evacuation of more than half a million people.

### *2.3.2 San Diego County: Rice and Harris Fires*

The next most destructive conflagrations in the outbreak, the Rice and the Harris fires, also occurred in San Diego County. While the insured losses from the fires were comparable, the fires themselves were quite different. The Harris Fire was the second largest fire to occur in October 2007, burning over 90,000 acres in a sparsely populated and inaccessible region in the southernmost part of the county. The Harris Fire was also the deadliest of the conflagrations in Southern California, with five reported civilian deaths, as well as over twenty civilian and forty fire fighter injuries.

The Rice Fire, on the other hand, was a much smaller fire that burned in a predominantly agricultural area in the northwestern part of San Diego County. While less than 10,000 acres burned, the impacted region

| Fire | County | Fire Start Date | Burned Acres | Destroyed Buildings | Damaged Buildings |
|---|---|---|---|---|---|
| Ranch | Los Angeles | 10/20/2007 | 58,401 | 10 | 2 |
| Canyon | Los Angeles | 10/21/2007 | 4,521 | 8 | 14 |
| Buckweed | Los Angeles | 10/21/2007 | 38,356 | 63 | 30 |
| Sedgwick | Santa Barbara | 10/21/2007 | 710 | 0 | 0 |
| Harris | San Diego | 10/21/2007 | 90,440 | 459 | 257 |
| Witch | San Diego | 10/21/2007 | 197,990 | 1,650 | 85 |
| Santiago | Orange | 10/21/2007 | 28,400 | 24 | 20 |
| McCoy | San Diego | 10/21/2007 | 353 | 2 | 0 |
| Nightsky | Ventura | 10/21/2007 | 35 | 0 | 0 |
| Roca | Riverside | 10/21/2007 | 270 | 1 | 0 |
| Cajon | San Bernardino | 10/22/2007 | 250 | 0 | 0 |
| Coronado Hills | San Diego | 10/22/2007 | 300 | 0 | 0 |
| Grass Valley | San Bernardino | 10/22/2007 | 1,247 | 178 | 22 |
| Magic | Los Angeles | 10/22/2007 | 2,824 | 0 | 0 |
| Rice | San Diego | 10/22/2007 | 9,472 | 248 | 0 |
| Rosa | Riverside | 10/22/2007 | 411 | 2 | 0 |
| Slide | San Bernardino | 10/22/2007 | 12,759 | 272 | 43 |
| Walker | San Bernardino | 10/22/2007 | 160 | 0 | 0 |
| Horno/Ammo | San Diego | 10/23/2007 | 21,084 | 0 | 0 |
| Martin | San Bernardino | 10/23/2007 | 123 | 0 | 1 |
| Meadowridge | Los Angeles | 10/23/2007 | 40 | 0 | 0 |
| Poomacha | San Diego | 10/23/2007 | 49,410 | 217 | 12 |
| Wilcox | San Diego | 10/23/2007 | 13 | 0 | 0 |
| Corral/Malibu | Los Angeles | 11/24/2007 | 4,901 | 80 | 45 |

*The 24 fires of the Southern California outbreak with fire start dates, number of burned acres, and destroyed and damaged buildings (Sources: California Department of Forestry and Fire Protection and Wildland Fire and Incident Information System)*

*Destroyed mobile homes in the Valley Oaks Mobile Home Park following the Rice Fire in San Diego County (Source: ImageCat)*

was much more densely populated than the region burned in the Harris Fire. One particularly hard hit residential neighborhood was the Valley Oaks Mobile Home Park, where one-half of the manufactured homes were destroyed.

### *2.3.3 San Bernardino County: Slide and Grass Valley Fires*

The Slide and Grass Valley fires both began on October 22 in San Bernardino County and grew to become the two most damaging fires in the county. The conflagrations burned within 5 miles (8 km) of each other, separated by an area burnt in the 2003 Old Fire. Relatively small in size, both blazes were characterized by timber fuel that burned more intensely and resulted in highly correlated losses. For example, over 170 of the structures that were destroyed in the Grass Valley Fire were within one-half mile (0.8 km) of each other.

### *2.3.4 Orange County: Santiago Fire*

Orange County was largely spared the effects of the wildfire outbreak with the notable exception of the Santiago Fire. This fire began on October 21 and was quickly attributed to arson, with fires set to maximize losses within the burnt area. While fewer than twenty residential structures burned, most of the properties were large, expensive homes. The Santiago Fire also proved to be one of the most difficult to bring under control, with full containment achieved close to twenty days later on November 9.

### *2.3.5 Los Angeles County: Canyon, Buckweed, and Corral Fires*

The Canyon Fire in Los Angeles County was one of the first fires in the Southern California wildfire outbreak. While relatively small in size, it received extensive media coverage due to the burning of high-value residential properties in Malibu and the evacuation of Hollywood celebrities. One notable property loss was Castle Kashan, a hilltop mansion that was listed for sale at $17 million earlier in the year.

In addition to numerous small fires, another notable blaze in Los Angeles County was the Buckweed Fire. This conflagration burned in excess of 35,000 acres in the northwestern part of the county and resulted in nominal property losses in comparison to some of the other events. Over sixty buildings burned in the Buckweed Fire, but two-thirds of these structures were outbuildings.

The Corral Fire started on November 24, three weeks after the majority of the October fire outbreak had been contained. It burned an area of Malibu less than two miles to the west of the Canyon Fire. The Corral Fire burned approximately the same number of acres as the Canyon Fire, but damaged or destroyed 135 structures before it was contained. Like the Canyon Fire, the high values of homes in this area resulted in losses disproportionate to the size of the fire. ■

*The burnt wildland-urban interface following the Witch Fire in San Diego County, illustrating the low correlation of loss among residential structures (Source: ImageCat)*

*Residential neighborhood surrounded by burnt wildland following the Witch Fire in San Diego County, illustrating the high correlation of loss among homes near canopy coverage (Source: ImageCat)*

# 3 IMPACTS AND LESSONS LEARNED

Following the Angora Fire near Lake Tahoe in June and the outbreak of wildfires in Southern California in October, RMS performed ground reconnaissance to ascertain the extent of the property damage and the key triggers prevalent for fire spread. As the fires of the late October outbreak became contained, RMS also commissioned ImageCat to provide aerial reconnaissance of the affected areas in Southern California. Over the course of two weeks, ImageCat flew four missions over the most significantly affected areas and then merged their processed images with tax assessor data and other sources. The result was a geocoded database of locations and square footage of the destroyed structures, along with refined fire perimeters showing the areas of greatest impact. These datasets have provided unique insights into the fires, both in terms of the characteristics of the fires and their impact on the built environment.

## 3.1 Damage Patterns

Measures traditionally used to mitigate the impacts of wildfires on structures were effective during the 2007 California wildfire season. Residential structures with defensible spaces or non-burnable roof and cladding were less likely to burn and to ignite neighboring structures. The presence of well-watered green vegetation also reduced the risk of a structure to burn, as was evident in the lesser damage in agricultural areas within the Rice Fire and around some high-value homes with large lawns.

As strong winds drove fires into suburban areas, structures were burned by firebrands generated by other burning structures, as particularly seen in the Angora Fire. The contribution of embers and firebrands took on increased importance in the Southern California fires as well. The Santa Ana winds provided a means for firebrands to travel great distances, well in excess of the recommendations for defensible space around a structure.

There was a high spatial correlation of burnt structures close to crown fires—fires that spread from treetop to treetop, traveling enormously fast on windy days. In areas affected by crown fires, as observed in the Angora, Grass Valley, and Rice fires, many structures within a given block burned. In contrast, there was a low spatial correlation of burnt structures close to surface fires, which burn ground vegetation. These fires are very dangerous if they spread under high wind conditions within close proximity to structures. While fewer structures within a given block burn, the fire can spread over a very large area. This behavior was observed in certain areas of the Witch Fire.

*High concentration of loss among residential structures in mountainous terrain and surrounded by timber fuels following the Grass Valley Fire in San Bernardino County (Source: ImageCat)*

| Fire | Mean Insured Loss ($Millions) |
|---|---|
| Buckweed | $8 |
| Canyon | $25 |
| Harris | $125 |
| Santiago | $16 |
| Witch | $1,080 |
| Grass Valley | $135 |
| Rice | $165 |
| Slide | $105 |
| Poomacha | $18 |
| Corral | $100 |
| Other | $23 |
| TOTAL | $1,800 |

*Estimated insured losses for the 24 fires of the Southern California outbreak*

From aerial flight surveys, it was determined that approximately 30% of the areas with burnt structures could be classified as urban areas along the wildland-urban interface, with the remaining 70% classified as rural or agricultural lands. In addition, the fire perimeters defined by government officials do not provide an exact definition of the areas that have effectively burned. For example, approximately 50% of the area within the fire perimeter of the Rice Fire was classified as unburned, as described in the Burned Area Emergency Response report (BAER, 2007) and observed through aerial and ground reconnaissance.

## 3.2 Insured Loss Estimates

RMS and ImageCat also collaborated on an updated insured loss estimate from the fires based on the aerial reconnaissance efforts. This includes an estimate for all of the significant blazes in Southern California in 2007. As all insurance claims are not settled yet, in February 2008, RMS estimates that insured losses for all 24 fires in the Southern California outbreak range from approximately $1.5 billion to $2.2 billion with a mean of $1.8 billion. The Witch Fire was by far the largest loss, comprising 60% of the total loss estimate. In addition, 85% of the total loss is attributable to property damage in San Diego County. If the Angora Fire in Northern California is included in the loss estimate, insured losses for all wildfires across California in 2007 could reach up to $2.5 billion.

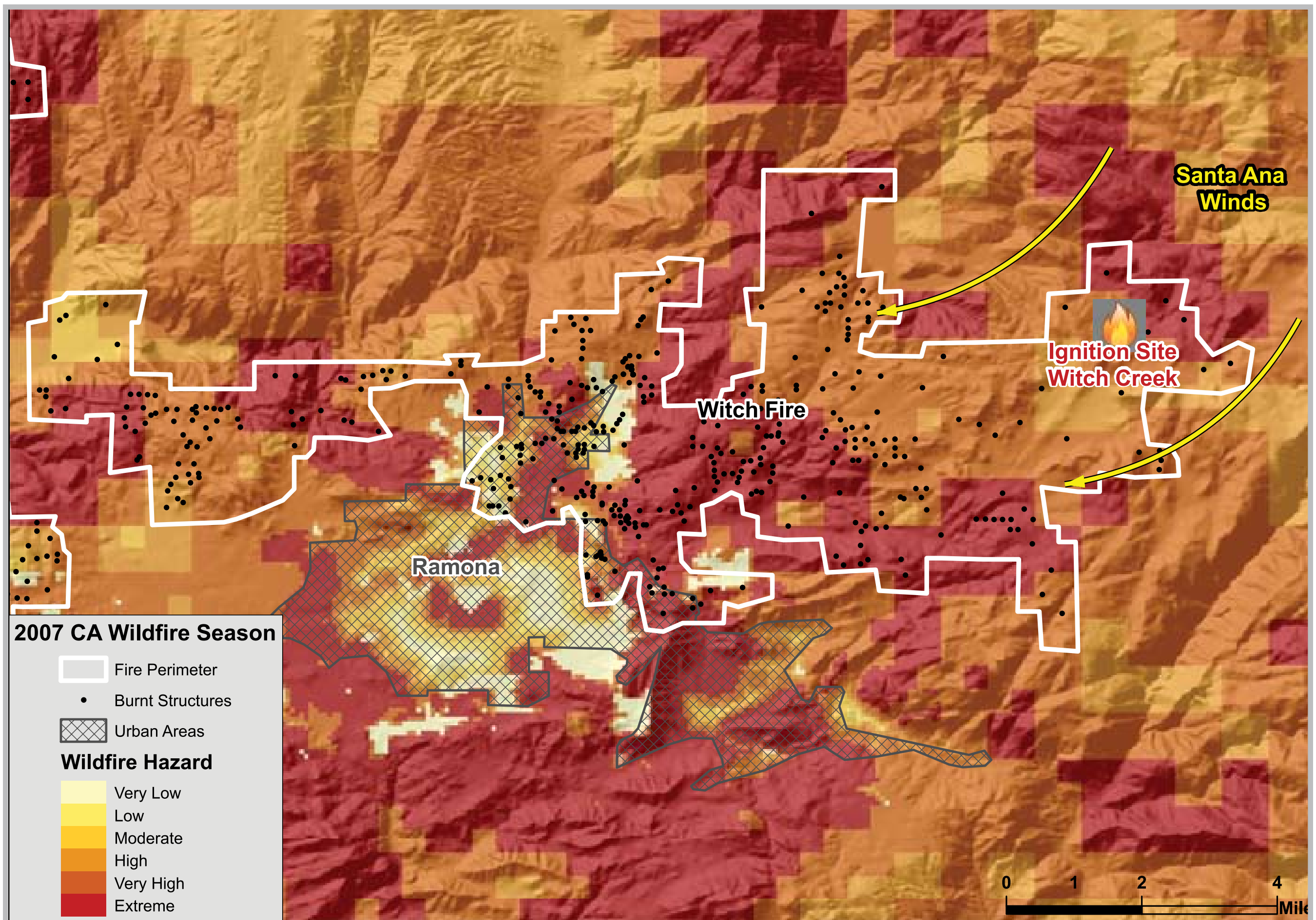
The majority of loss is due to destroyed or partially burned residential structures and their associated contents. Total loss estimates also include claims from smoke damage, additional living expenses (ALE) due to the mandatory evacuation, burned automobiles, and a limited number of burned commercial structures. In addition, the high value of burnt homes in certain areas resulted in losses disproportionate to the size of the fire, as seen in the Canyon and Corral fires.

The ratio of the number of insurance claims due to structural damage to the total number of claims was low, as there were many more claims for smoke damage and ALE than claims for destroyed homes. When a home burned, it typically burned to the ground as fire fighters fought to save as many of the neighboring homes as possible. For those structures left standing, smoke damage was a function of the wind direction and proximity to the burning fuel. The cost to clean an average home could reach on the order of tens of thousands of dollars, including cleaning soot and ash from inside and outside the home. There were also reports of damage to air conditioning units due to soot from the wildfires. Typical ALE claims were less than $1,000, but most residential insurance claims had some component of ALE as part of the loss.

Reports from residential insurers with significant market share in Southern California indicate that the losses from the fire outbreak constituted a sizeable portion of the catastrophe loss posted for the year. One insurer reported that the losses were over two-thirds of the catastrophe losses for the fourth quarter of 2007; another company disclosed that the losses were over 25% of its 2007 annual catastrophe loss.

## 3.3 RMS® Wildfire Hazard Data

The RMS® Wildfire Hazard Data, developed jointly by RMS and Sanborn and first released in 2006, incorporates a number of key attributes that describe a location's vulnerability to wildfire risk. To assess vulnerability and speed of wildfire spread, surface fuels in the area of interest are classified into categories, including vegetation fuels or burnable surfaces such as grassland, shrub or chaparral, and timber or trees, as well as non-burnable surfaces classed as urban, agricultural, water, or barren. Regional historical data is incorporated to provide the average wildfire ignition occurrence rate within a certain perimeter from the location of interest. Special climate conditions that can influence a location's risk, such as the presence of Santa Ana or Diablo winds, are identified. Finally, RMS includes information on the accessibility of a location, which estimates the response time of land-based fire suppression equipment and personnel to reach a location, considering the local terrain, road access, and other travel limitations.




*The fire perimeter and burnt structures of the Witch Fire, as defined by the ImageCat aerial reconnaissance, overlaid on the RMS® Wildfire Hazard Data, showing the areas of highest risk in relation to the areas with the most damage. The Santa Ana winds caused the fire to spread into some "low" risk areas.*

Three probabilistic measures of risk are calculated from this information: wildfire threat, wildfire susceptibility, and wildfire hazard. Wildfire threat is the annual likelihood of a fire igniting or propagating into the area. Wildfire susceptibility is the annual likelihood that a structure will burn, given that a nearby fire has occurred (i.e., the wildfire threat). Calculations are based upon the magnitude and intensity of a fire, the proximity to the wildland-urban interface (WUI), special weather conditions, and the type of surface and canopy fuels. Areas are designated as having "very low," "low," "moderate," "high," "very high," or "extreme" susceptibility to wildfire risk. Finally, considering both wildfire threat and susceptibility, the wildfire hazard represents the annual likelihood of loss. Wildfire susceptibility and hazard are particularly useful for insurance underwriting, but can additionally be used to estimate total exposures at risk.

### *3.3.1 Application to the Southern California Outbreak*

RMS analyzed the Angora Fire in Northern California and the 2007 Southern California outbreak using the RMS® Wildfire Hazard Data, demonstrating the usefulness of the data in managing wildfire risk. In particular, surface fuels were classified and susceptibility designations were calculated within the fire perimeters of the most damaging fires.

Utilizing the spatial data of surface fuels within the Southern California region, burnable and non-burnable surfaces were identified within the fire perimeters of the major wildfires in the outbreak. On average, 90% of the area within the fire perimeters can be classified as vegetation fuels—the majority of which is chaparral, a highly burnable surface fuel. The remaining 10% of the area is covered by agricultural lands (5%), urban regions (4%), and water (1%). Moreover, areas within fire perimeters containing timber or canopy coverage were identified, as these features are useful indicators of risk. In areas with canopy coverage, a damaged building is typically surrounded by other damaged buildings. In areas with low or no canopy coverage, stand-alone damaged buildings are more common.

Some fire perimeters had more vegetation fuels, as seen in the Grass Valley, Poomacha, and Slide fires, where over 95% of the area was covered by burnable vegetation fuels, 30% of which could classified as timber fuels. Other regions, such as those impacted by the Witch and Rice fires, had lower amounts of burnable fuels, as the

| Fire | Very Low | Low | Moderate | High | Very High | Extreme | Moderate to Extreme | High to Extreme |
|---|---|---|---|---|---|---|---|---|
| Angora, Grass Valley, Harris, and Slide Fires | 0% | 0% | 27% | 56% | 11% | 6% | 100% | 73% |
| Poomacha, Rice, and Witch Fires | 6% | 21% | 54% | 9% | 3% | 7% | 73% | 20% |

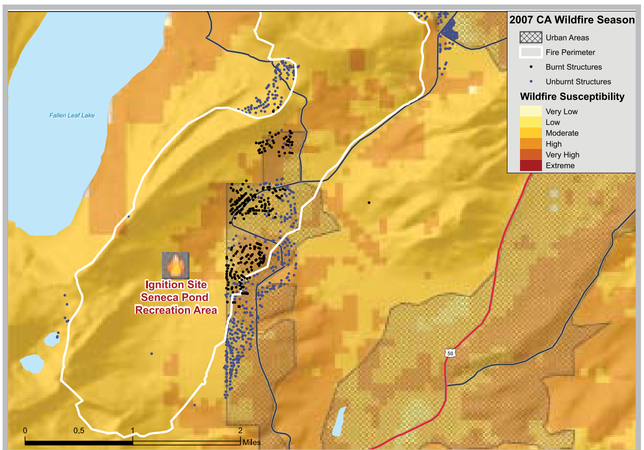
*Percentage of burnt structures falling into the wildfire susceptibility zones designated "very low," "low," "moderate," "high," "very high," and "extreme" in the RMS® Wildfire Hazard Data. There were more burnt structures in high-risk areas in the Angora, Grass Valley, Harris, and Slide fires than in the Poomacha, Rice, and Witch fires of the 2007 California wildfire season.*

the presence of plant nurseries caused certain areas to have a relatively large moisture content and, therefore, a lower propensity to burn.

All burnt structures identified through aerial reconnaissance efforts were additionally mapped to a wildfire susceptibility zone. On average, over 80% of the burnt structures in the Angora, Grass Valley, Harris, Poomacha, Rice, Slide, and Witch fires fell within the "moderate" to "extreme" wildfire susceptibility zones. For individual fires, such as the Grass Valley Fire, 99% of the burnt structures were within the "high" wildfire susceptibility zone.

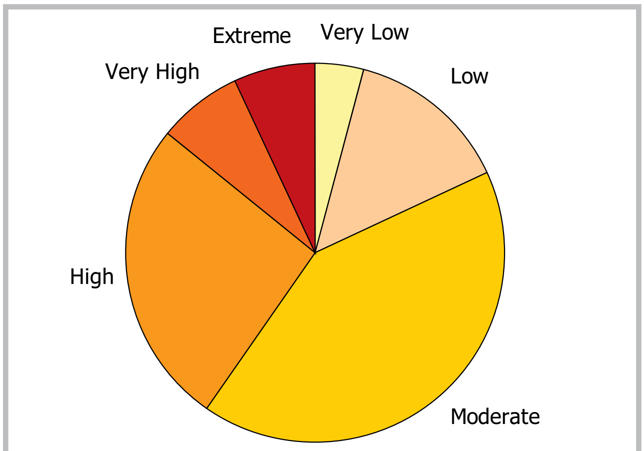
Moreover, the 2007 fire season illustrated that burnt structures tend to fall into one of two categories. First, structures that are at or within close proximity to the wildland-urban interface or are surrounded by highly burnable surface fuels are historically more at risk from damage. Burnt structures in the Angora, Grass Valley, Harris, and Slide fires fell into these high-risk areas and thus mapped to the "moderate," "high," "very high," or "extreme" wildfire susceptibility zones.

In contrast, the exceptional weather and climatic conditions caused structures to burn in certain regions of the Poomacha, Rice, and Witch fires that are historically low-risk areas. The strong Santa Ana winds in combination with the very dry summer season resulted in large quantities of highly burnable surface fuels. These conditions caused rapidly moving fires to spread into areas which, in a typical year, would not have burned due to fire suppression efforts. Therefore, close to 30% of the burnt structures in these fires fell within the "very low" or "low" wildfire susceptibility zones.




*The Angora Fire's ignition site, fire perimeter, and burnt structures overlaid on wildfire susceptibility zones of the RMS® Wildfire Hazard Data, showing "moderate" to "high" susceptibility in areas with burnt structures.*

The detailed, high-resolution RMS® Wildfire Hazard Data provides information that is invaluable to the successful underwriting of wildfire risk. The analysis presented here illustrates the importance of having the relevant wildfire threat, susceptibility, and hazard data offered by RMS to help differentiate between otherwise similar locations along the wildland-urban interface. ■



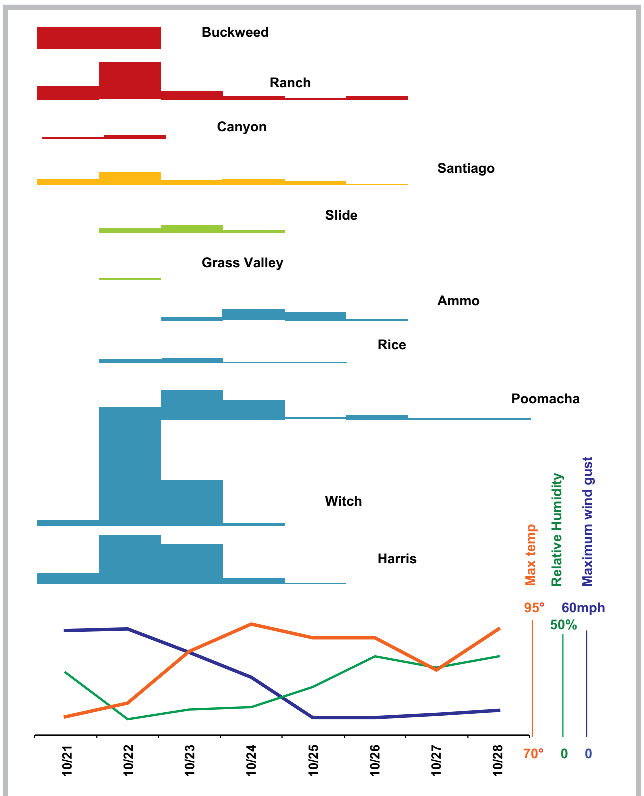

*Average percentage of burnt structures falling into the six wildfire susceptibility zones of the RMS® Wildfire Hazard Data, with the majority of structures in the "moderate" to "extreme" wildfire susceptibility zone.*

# 4 MANAGING WILDFIRE RISK

The 2007 U.S. wildfire season provided a harsh reminder of the destructive potential of wildfires and the increasing risk of damage as housing developments continue to spread into wildland terrain. Several lessons for understanding and managing this risk in the future should be highlighted, including the importance of local conditions and the extent of a wildfire's footprint, as well as future climatic conditions.

## 4.1 Local Conditions

A range of different local conditions can influence the characteristics of a fire, including the rate of spread and the correlation of burnt structures once a fire has occurred. The main drivers of fire propagation are the weather conditions, the type of surface fuel, and to a lesser extent, the local topography. As witnessed in the Southern California outbreak, the Santa Ana winds played an important role in the spread of the Witch and Poomacha fires, resulting in the eventual merging of the two blazes.




*Estimated acreage burned each day during the Southern California wildfire outbreak from October 21 through October 28 in relation to the daily local weather conditions, including maximum temperature, relative humidity, and maximum wind gust. Fires in Los Angeles County (red), Orange County (yellow), San Bernardino County (green), and San Diego County (blue) greater than 10,000 acres or with significant losses are shown.*

During the Witch Fire, the Santa Ana winds fanned the flames and transported the embers in a westerly direction from the ignition site toward the town of Ramona with the majority of burnt structures near the ignition site located in the "high" to "extreme" risk susceptibility zones in the RMS® Wildfire Hazard Data. Other burnt structures closer to Ramona were located in the "very low" to "moderate" susceptibility zones. In contrast, areas immediately to the north and east, although at high risk, remained relatively untouched due to the direction of the Santa Ana winds. If the winds had continued, it is likely that the fires in San Diego County would have spread farther, endangering more lives and property, including the outskirts of the city of San Diego.

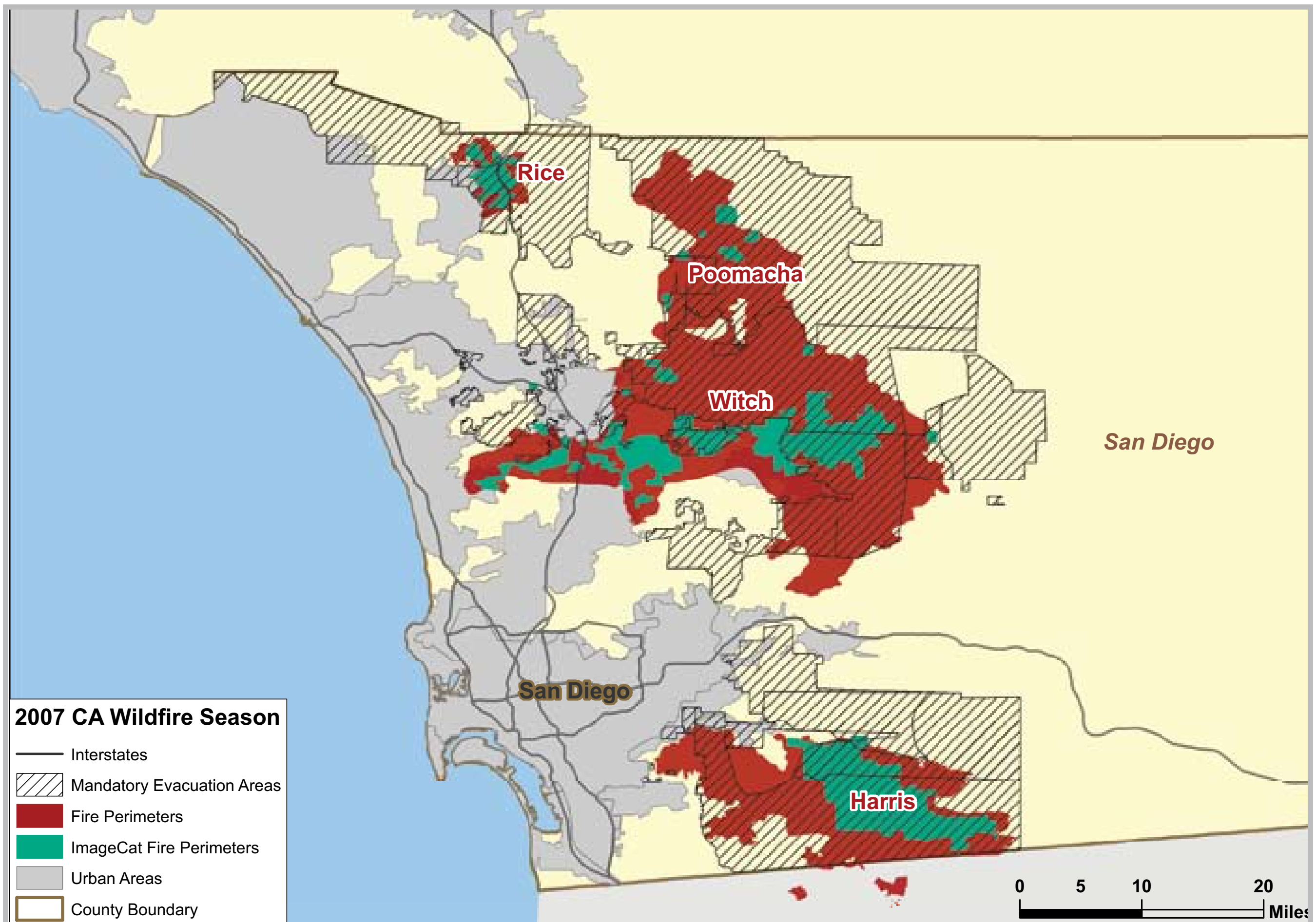
Strong winds were also experienced during the Angora Fire. When coupled with the dense forestry, they resulted in the rapid spread of the fire, which traveled 4 miles (6.4 km) in three hours and burned 250 residential structures. The density of trees and steep slopes meant that, once the canopy of one tree was engulfed by flames, the fire quickly spread to the surrounding trees. The high wind speeds also carried firebrands of burning branches significant distances, jumping defense lines in some instances. The U.S. Department of Forestry reported that firebreaks one-half mile (0.8 km) wide would have been needed to prevent the ignition of spot fires.

Areas that burned in Southern California in 2007 could potentially burn again in the near future. Approximately 39,700 and 14,500 acres of the Witch Fire overlapped with areas burned in the 2003 Cedar Fire and the 2003 Paradise Fire, respectively. The time of recovery for various surface fuels range from one year for grass to three to five years for chaparral to more than twenty years for trees that have completely burned.

However, the 2007 season saw fires that spread very fast and only scorched bushes and tree vegetation, and thus recovery in these areas will likely be faster, especially when aided by the large amounts of rain that fell in early 2008. January 2008 was a particularly wet month in Southern California, sparking the re-growth of surface fuels, but also increasing the potential for imminent mudslides.

## 4.2 Wildfire Footprint

During and following a wildfire event, fire perimeters published by the U.S. Forest Service, the U.S. Geological Survey, and other agencies provide valuable information




*Extent of mandatory evacuation areas, government-issued fire perimeters, and fire perimeters calculated by ImageCat in San Diego County for the most damaging fires following the 2007 California wildfire season*

on the fire's extent to assist fire suppression teams. As fire fighters use their available resources to prevent a wildfire from spreading into residential neighborhoods or other concentrations of structures, these government-issued perimeters are essential. However, these perimeters do not give an exact boundary of the extent of the losses for insurance purposes.

While the fire perimeters provide a rapid means to evaluate the impacted exposure and determine the general area to deploy claims adjustors, some structures within the fire perimeter will not burn and some structures outside the perimeter will sustain damage. Reconnaissance efforts following the Witch and Rice fires showed that several areas within the fire perimeters experienced minimal burning of the vegetation. The high winds caused the fires to spread rapidly via embers, moving on before igniting all structures within a neighborhood and causing structural property loss.

Property losses outside a fire's official perimeter can be caused by smoke from the fire, and can also result from mandatory evacuations. Smoke and soot blown westward due to the Santa Ana winds impacted homes outside the fire perimeter in Southern California, causing nonstructural damage to roofs, air conditioning systems, and contents within the residence. The mandatory evacuation of over half a million people resulted in numerous claims for additional living expenses (ALE). While reports indicate that insurers were responsive to residential claims, coverage for mandatory evacuations is not well-defined in all policies. Specific endorsements for coverage due to government-mandated evacuations can fill this gap and avoid confusion in the future.

## 4.3 Climate Change

As wildfire ignition and propagation is dependent upon weather and climatic conditions, any future changes in weather patterns and mean climate are of concern to the management of wildfire risk.

Studies conducted over the past several decades have shown a direct link between climate change and warmer temperatures. Most climate models predict the greatest warming at high latitudes, and longer and hotter summers. Several studies tracking wildfire trends over the past century find that fire frequency and area burned are significantly correlated with local air temperature. Westerling et al. (2006) show that warmer temperatures appear to be increasing the duration and intensity of the

## An Eyewitness Account of the Witch Fire: The Mandatory Evacuation and Insurance Claim Process

One homeowner in California, whose home lay on the west end of Ramona near the Poway border, within the fire perimeter, received her "Reverse 911" call at 10:00 p.m. PDT on Sunday, October 21, approximately ten hours after the Witch Fire began. The evacuation had begun earlier in the day and proceeded by sectors, starting with those residences closest to where the wildfire was expected to spread. Unfortunately, there was only one egress road (Highway 67) to evacuate residents to the west, which was backed up with traffic for miles eastward toward Main Street in Ramona. Following the event, fire officials indicated that it was fortunate that the fire changed direction and narrowly missed the downtown area of Ramona, which could have overtaken evacuees in their cars and caused a catastrophic loss of life and property.

While it was safe to return home on Thursday, October 24, Ramona's water system was still out of service. As a result, the mandatory evacuation was extended until water could be restored on Saturday, October 27. The water was non-potable until Tuesday, October 30. Fortunately, this homeowner's insurance company set up a central emergency claims center in San Diego to process claims in a timely manner. Her claim was initiated after the evacuation, once her family returned home and assessed the magnitude of damage. The insurer paid for additional living expenses (ALE) associated with the mandatory evacuation. Her home did not burn as a result of the fire, so the primary damage was due to smoke and ash. The insurance company paid for cleaning both the inside and outside of the home. Some neighbors with high deductibles did not claim the smoke damage and cleaned their homes themselves.

*Hot spots smoldered for several days after the homeowner returned from evacuation. This helicopter is dumping a bucket of water about one-quarter mile (0.4 km) away.*

wildfire season in the western U.S. Since 1986, longer, warmer summers have resulted in a fourfold increase of major wildfires and a sixfold increase in the area of forest burned, compared to the period from 1970 to 1986.

Moreover, the 2007 wildfire season in California was exacerbated by the ongoing drought in the state. Years of severe and prolonged drought in the western U.S. are regularly accompanied by active wildfire seasons. Projections of future climate conditions, conducted by nineteen different climate modeling groups around the world and using different climate models, show widespread agreement that the southwestern U.S.—and the subtropics in general—are going to become increasingly arid as a consequence of rising greenhouse gases (Seager et al., 2007). According to these models, the transition to a more arid climate in the southwestern U.S becomes marked early this century.

There are also a number of climate modeling studies that have directly assessed the impact of climate change on future wildfire activity. For example, studies undertaken by the Fire and Environmental Research Applications Team (FERA) of the U.S. Forest Service indicate that, over the coming century, wildfires will most likely burn over twice as much land in the western U.S. as they do today. Some studies have also suggested that global warming temperatures can potentially shift whole ecosystems, causing vegetation fuels to become more dense in some regions. Denser vegetation leads to higher fuel loads and larger wildfires.

Finally, while a changing climate is likely to impact fire activity, predicting future fire outcomes is complicated by the complex interaction of climate with suppression, changing land use, and other factors. Risk Management Solutions continues to monitor the latest research in wildfire activity and climate change as part of a wider RMS strategy to understand the impact of climate change and variability on the occurrence and nature of extreme events. ■

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