Understanding Fire Regimes in the Santa Ana Mountains and Laguna Coast

With a Special Feature Covering Water Quality Impacts

MELANIE SCHLOTTERBECK

Coal Fire 2012.

MITCH RIDDER, COURTESY OF LAGUNA BEACH INDEPENDENT

Laguna Fire 2015.

Friends of Harbors, Beaches, and Parks

Friends of Harbors, Beaches and Parks

Friends of Harbors, Beaches and Parks (FHBP) is a non-profit organization founded in 1997. FHBP's mission is "to promote, protect, and enhance the harbors, beaches, parks, trails, open spaces, natural preserves, and historic sites in Orange County."

Since 2000, FHBP has united conservation and community voices throughout Orange County through its Green Vision Project. Currently more than 80 organizations support the effort to increase the funding for parks, water quality, and open spaces in the region. One of the first tasks of the Coalition was to map conservation target lands. Known as the Green Vision Map, this map lays out the knowledge and efforts of the Coalition to preserve important landscapes.

The next major accomplishment of the Coalition was negotiating a comprehensive mitigation program. OCTA's Renewed Measure M includes approximately $243.5 million (in 2005 dollars) or 5% of the freeway program to mitigate habitat impacts from freeway projects. The transportation sales tax measure was approved by a two-thirds majority of voters in 2006. The measure included funds to acquire, restore, and manage lands. This landscape level approach, with streamlined permitting, is a departure from the earlier piecemeal or project-by-project approach. With this funding, important acquisitions have begun to fill in the gaps in conservation in the County.

While it is important to conserve important landscapes, fires that burn too frequently are changing the natural resource values of those natural lands and making them more prone to burn in the future. To understand the fire regimes for previously unstudied areas, FHBP launched a Fire and Water Quality Study to determine the baseline conditions and the change in fire frequency over 100 years, as well as make recommendations on fire prevention.

The health of our natural lands is directly linked to fire frequency. This report completes the last two areas of Orange County in need of study.

To Get a Copy of This Study

This Fire and Water Quality Study can be downloaded for free from Friends of Harbors, Beaches, and Parks website at: *www.FHBP.org*.

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Abstract

Fire studies conducted in 2009 and 2012 by the Irvine Ranch Conservancy and Hills For Everyone respectively provided in-depth information about the Irvine Ranch lands and Chino Hills State Park, but these studies left two significant fire impacted areas in Orange County out: the Santa Ana Mountains and Laguna Coast. Friends of Harbors, Beaches and Parks (FHBP) thought it important to add to the repository of information about wildfires and ignition points by reviewing 100 years of fire data in these two additional areas. While wildfires have an historic role in an ecosystem, the acres burned and frequency of fires has increased because of humans mainly and then exacerbated by climate change and unusual weather patterns. This report outlines the findings for both the Santa Ana Mountains and Laguna Coast.

Data, collected mainly from fire agencies, allowed FHBP to review fire perimeters, points of origin, and fire causes. Additional information was gathered on fire seasonality and weather conditions. Overlaying the data allowed us to create a fire frequency layer. A brief look at the impacts of fire on water quality is also included in the study. Finally, this report outlines several recommendations for residents, decision makers, jurisdictions, fire, transportation and natural resource agencies that have the potential to reduce fire ignitions. Education and outreach will be key to achieving these reductions, but land use planning plays a critical role too.

In short, portions of the Santa Ana Mountains, and to some extent areas in the Laguna Coast, are burning more frequently than the natural fire regime. Fires are consistently starting along roadways, which provide unimpeded access to the natural lands. Fire ingitions and increased fire frequency are found along the 241 Toll Road and Santiago Canyon Road (SR 18) in the Santa Ana Mountains and along Laguna Canyon Road (Highway 133) in the Laguna Coast.

Introduction

California is in its fourth year of an historic drought. In fact, as this report is being finalized nearly 20 fires are burning throughout the state—the majority in Northern California.[1] Governor Brown stated in a recent interview, "We have a real challenge in California. Unlike the East, where climate change seems to be adding more storms, here in California and the Southwest it's more dryness. We've got more dryness, less moisture and more devastating fires. So more to come. It is very serious."[2] In fact, a quick look at CalFire's yearly statistics shows that more fires are burning each year and more habitat is being consumed in the process.[3]

Table 1. CalFire's Annual Fire Statistics

Interval	Number of Fires	Acreage Burned
January 1 - August 1, 2015	4,201	100,000
January 1 - August 1, 2014	2,945	87,767
5 Year Interval (Average)	2,729	48,153

More fires also equate to more fire suppression costs. CalFire data indicates that over the last 36 years the costs to fight wildland fires on a yearly basis have increased tremendously. In 1979-1980 the cost were $11.9 million, last year 2013-2014 they were $240 million. This means the increase is twenty-fold in three and a half decades.[4] According to Climate Progress, "fighting wildfires also comes with a large price tag, with an average of $1.13 billion spent on wildfire suppression each year. With climate change, that price could increase to $62.5 billion annually by 2050."[5] The increase in fires and costs has also been seen in Southern California.

BUREAU OF LAND MANAGEMENT VIA WIKIMEDIA COMMONS

California wildfires are growing in size, frequency, and cost.

Two large local fires, one in 2007 and the other in 2008, prompted increased concern for, and attention to, large wildland fires in Orange County. Concern stemmed not only from the increase in houses located in wildland areas, which are more prone to burn due to location, but also the impact of frequent fires on the habitat lands. Studies conducted by the Irvine Ranch Conservancy and Hills For Everyone resulted in a better understanding of where, why, and how frequently fires are burning. In the case of the Irvine Ranch Conservancy, its study focused on the preserved Irvine Ranch lands, now a part of OC Parks.[6] This study is not available for public download, but was shared for the benefit of our research. The Hills For Everyone's study focused primarily on lands in and near Chino Hills State Park.[7] While these two studies were extremely beneficial to understanding Orange County's fire regime, sizable

Map 1. The Irvine Ranch Conservancy Study Area is shown in as a green polygon, while the pink polygon is the Hills For Everyone Study Area.

areas of protected lands within the County were not included in these studies.
Friends of Harbors, Beaches and Parks (FHBP) undertook a study of the last two large remaining natural areas in the County not yet studied to understand the where, why, and how of fires in those important areas. Specifically, the Santa Ana Mountains encompassing the Cleveland National Forest and surrounding foothills in Orange and Riverside Counties, as well as the Laguna Coast, were each evaluated for their fire history. While fires are a natural part of Southern California's ecosystem, fire scientists and land conservationists are finding that our natural lands are burning too frequently to sustain a healthy and resilient ecosystem.[8]

This study focused on capturing data from a variety of sources, combining it into one geographic information system (GIS) database for the Santa Ana Mountains and Laguna Coast. A water quality component was researched as well. The goal here was to understand the impacts of wildfires on watersheds and water quality. Details about both the fires and water quality will be relayed in this report.

> *"To live in California is to live with fire. In dry years, the state burns. In wet years, when spring rains produce explosive growth of flammable native brush and grasses, the state burns."*[9]

The Setting

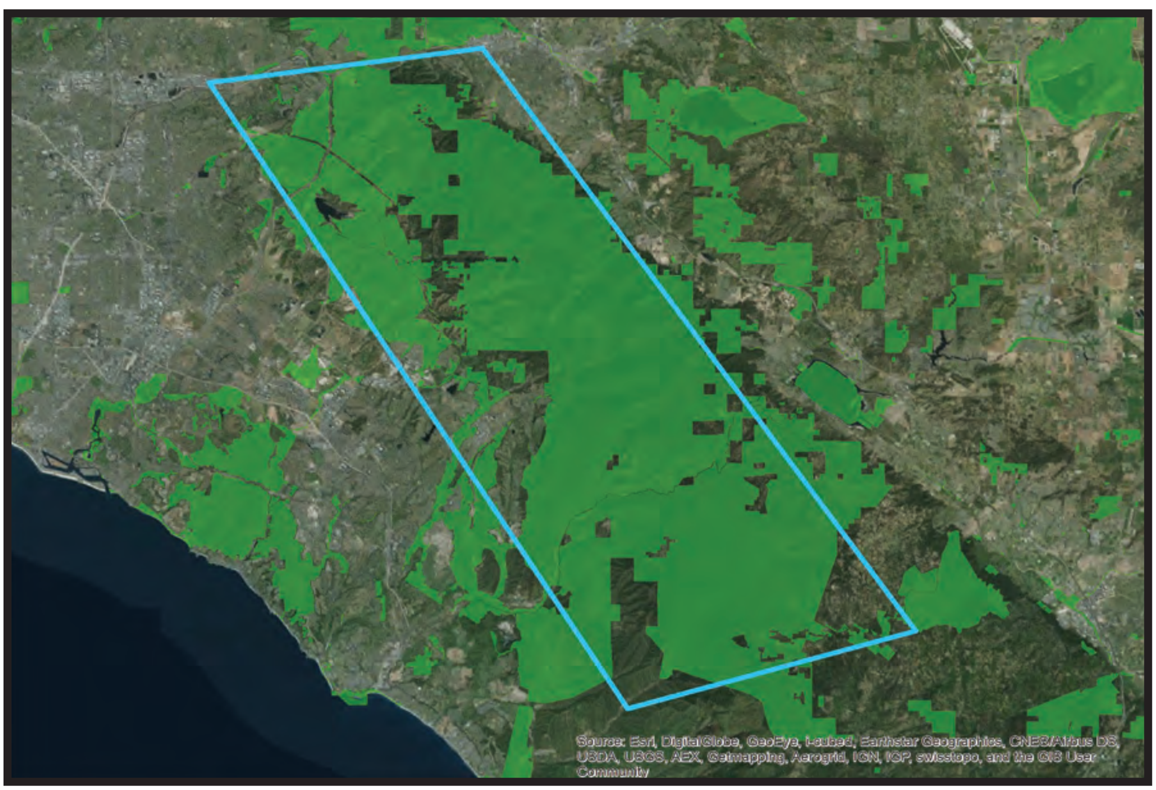
Santa Ana Mountains

The Santa Ana Mountains and foothills span Orange, Riverside, and San Diego Counties and include nearly 250,000 acres[10, 11] that create a backbone of protected lands along county lines. Within the Santa Ana Mountains is the Trabuco District of the Cleveland National Forest. This is the northern most district of the Cleveland and within its congressional boundary the majority of lands are protected, though not all.

ROBIN EVERETT

The Santa Ana Mountains have dense chaparral throughout the Trabuco District.

The geography in this study generally included the Trabuco District of the Cleveland National Forest and portions of Orange County and Riverside County foothills. There are also several smaller privately protected areas such as Audubon California's Starr Ranch Sanctuary and publicly protected Orange County Transportation Authority's Trabuco Canyon and Silverado Canyon Preserves. The entire study area includes the forest and the foothills totaling about 235,000 acres.



Map 2. The protected areas in and nearby to the Santa Ana Mountains Study Area are shown in green.

The United States Forest Service is the largest landowner in the Santa Ana Mountains. Its mission is simply "[Care] for the Land and [Serve] People."[12] The Trabuco District is bounded on the north by the 91 Freeway; to its west are contiguous lands protected under the OC Parks banner; to the south is Camp Pendleton; and to the east it is bounded by the 15 Freeway. Within the Forest there is the San Mateo Wilderness area that allows for hiking and equestrian use but not mountain biking. The only paved road that actually bisects the Santa Ana Mountains is Ortega Highway (Highway 74) which connects Orange County in San Juan Capistrano to Riverside County in Lake Elsinore.


PATRICK MITCHELL

Morrell Canyon in the Cleveland National Forest.

The original human inhabitants of the forest included mainly the coastal Native Americans in the 1500s. Not until the mid-1700s did the area finally attract some outside interest.[13] Early reports indicate the Native Americans did some brush burning, but the larger impact was ranching and cattle grazing. It was during the ranching days that the native scrub and grasslands were replaced by invasive plants from Asia and Europe. Several well-known explorers traversed this mountain range in the mid-1700s, including the Portolá expedition, led by Gaspar de Portolá and joined by Juan Crespí, Francisco Gómez, and Pedro Fages.[14]

While there was a version of the "Gold Rush" in the Cleveland, it was mainly contained to the southern districts in San Diego County. One item of notable history, according to the U.S. Forest Service, was that brush fires were frequent and would often burn uncontrolled for weeks at a time.[15] These fires had significant impacts on coastal towns, like San Diego, and to local watersheds. It was at this point the California Forestry Commission realized the need for a Forest Reserve in 1886. Part of the overarching goal in a Forest Reserve designation was the prevention of major fires.[16]


CHAY PETERSON

The Trabuco District of the Cleveland National Forest.

Through the Forest Reserve Act of 1891, Californians began demanding Forest Reserves be created to protect their watersheds. The Cleveland National Forest became one of the first in this new system and included the 50,000 acre Trabuco Cañon Forest Reserve created in 1893 by President Harrison. By 1899, this Reserve had more than doubled in size as a response to petitions sent to the government by local residents.[17] This designation was changed from Forest Reserve to National Forest in 1907. That same year, President

Theodore Roosevelt made extensive additions to the Trabuco District and shortly thereafter all three Districts (Trabuco, Palomar, and Descanso) were combined into one National Forest—the Cleveland National Forest. Its current size, including all three districts, is about 424,000 acres of National Forest. For the purposes of this study only the Trabuco District was evaluated for its fire history.

The Santa Ana Mountains are known for their extensive chaparral communities and coastal sage scrub. There are areas with rocky outcroppings, waterfalls, and natural springs. Golden eagles, prairie falcons, and red-tailed hawks are known to inhabit these mountains, as well as mountain lions, bobcats, mule deer, and the elusive ring-tailed cat.

Laguna Coast

It wasn't an act of Congress or a Presidential Decree that created the protected lands along the Laguna Coast. Instead, non-profit conservation organizations have worked for decades to protect lands there working closely with property owners and agencies.[18] The three largest landowners in that area are Orange County Parks, California State Parks, and City of Irvine. Through a network of conserved land, more than 22,000 acres are set aside for permanent conservation. The parks are bounded on the south by the coastal towns of Laguna Beach and Corona Del Mar, as well as the Pacific Ocean. On the north, east, and west are the more urban areas of the cities of Irvine, Aliso Viejo, Laguna Niguel, and Newport Beach. The historic Laguna Canyon Road (Highway 133) bisects these natural lands north-south, while the Transportation Corridor Agency's Toll Road (Highway 73) bisects the lands trending east-west.

Map 3. The protected areas in and nearby to the Laguna Coast Study Area are shown in green.

Some of the early history includes the same Native American tribes found in the Cleveland including the Acajchemem (Juaneño Mission) and the Tongva (Gabrieleño Mission). In fact, several of the same European explorers mentioned above also visited the Laguna Coast lands during their expeditions in the mid-1700s. During the incorporation of land grants, this area was used for sheep and cattle activities. By the 1900s land ownerships had changed and by the mid-1960s portions of the land were included in the nearby cities such as Laguna Hills, Laguna Niguel, and Aliso Viejo.[19]

MELANIE SCHLOTTERBECK

The Aliso Canyon area of Laguna Coast.

During that same time frame, organizations like Laguna Greenbelt worked to create a "greenbelt" of protected parkland around Laguna Beach. The public supported this greenbelt concept so much that they agreed to tax themselves to buy important parcels of land. Comprised of numerous contiguous protected land ownerships, the Laguna Coast now boasts Orange County's largest protected coastal area. There are four main owners of these lands: the State of California, County of Orange, and Cities of Irvine and Laguna Beach. The lands include Laguna Coast Wilderness Park, Bommer-Shady Canyon Open Space (Irvine Open Space – South), Crystal Cove State Park, James Dilley Preserve, and the Aliso-Wood Canyons Wilderness Park. The preservation effort continues to this day.[20, 21]

Laguna Coast Wilderness Park and Crystal Cove State Park are part of a statewide Natural Community Conservation Plan (NCCP) and Habitat Conservation Plan (HCP) which was designed to protect specific threatened and endangered species such as the California Gnatcatcher and Orange-throated Whiptail.

One unique feature of the Irvine Ranch lands, which are also part of the Central-Coastal NCCP/HCP, is the U.S. Department of the Interior designated 37,000 acres of land as a National Natural Landmark in 2006. This designation brings with it an acknowledgment of the exceptional natural resource values on these lands. Included in this designation are the coastal lands of Laguna Coast Wilderness Park, Crystal Cove State Park, the Bommer-Shady Canyon Open Space Areas, and the inland foothill lands of the historic Irvine Ranch north of the 241 Toll Road and adjacent to the

AMY LITTON

The diverse ecosystems of the Laguna Coast.

Santa Ana Mountains and foothills.[22] The Laguna Coast study area includes over 39,000 acres.

The network of preserved lands along the Laguna Coast includes some of the last remaining undeveloped coastal canyons in Southern California. Rocky outcroppings are interspersed among the oak and sycamore woodlands, coastal sage scrub, native valley grassland, and maritime chaparral. Visitors can also enjoy multiple riparian habitats, including: willow, oak, and sycamores.[23] Deer, coyotes, and bobcats are species seen throughout the hillside ecosystem.

The Study

Similar to the fire study efforts led by the Irvine Ranch Conservancy and Hills For Everyone, this study by FHBP attempts to quantify and understand where and why wildland fires are starting in the Santa Ana Mountains and Laguna Coast. Details about our approach are included in the next section. We focused on a time period of 1914 – 2014. Interestingly during the writing of our study multiple fires occurred in both Study Areas. They were not included since our timeframe ended with the 2014 calendar year.

There were four goals for this study. Using the available data:

1. Document the fire perimeters, points of origin, causes, and weather conditions for each fire that burned within the two Study Areas (Santa Ana Mountains and Laguna Coast);
2. Analyze the results of the research and determine any fire-prone areas that needed particular attention;
3. Determine how fires impact the watershed and water quality (post-burn); and
4. Provide general recommendations for residents and agencies to reduce the number of fires and impacts associated with wildland fires, and concurrently protect homes, people, and parkland from unnaturally frequent fires.

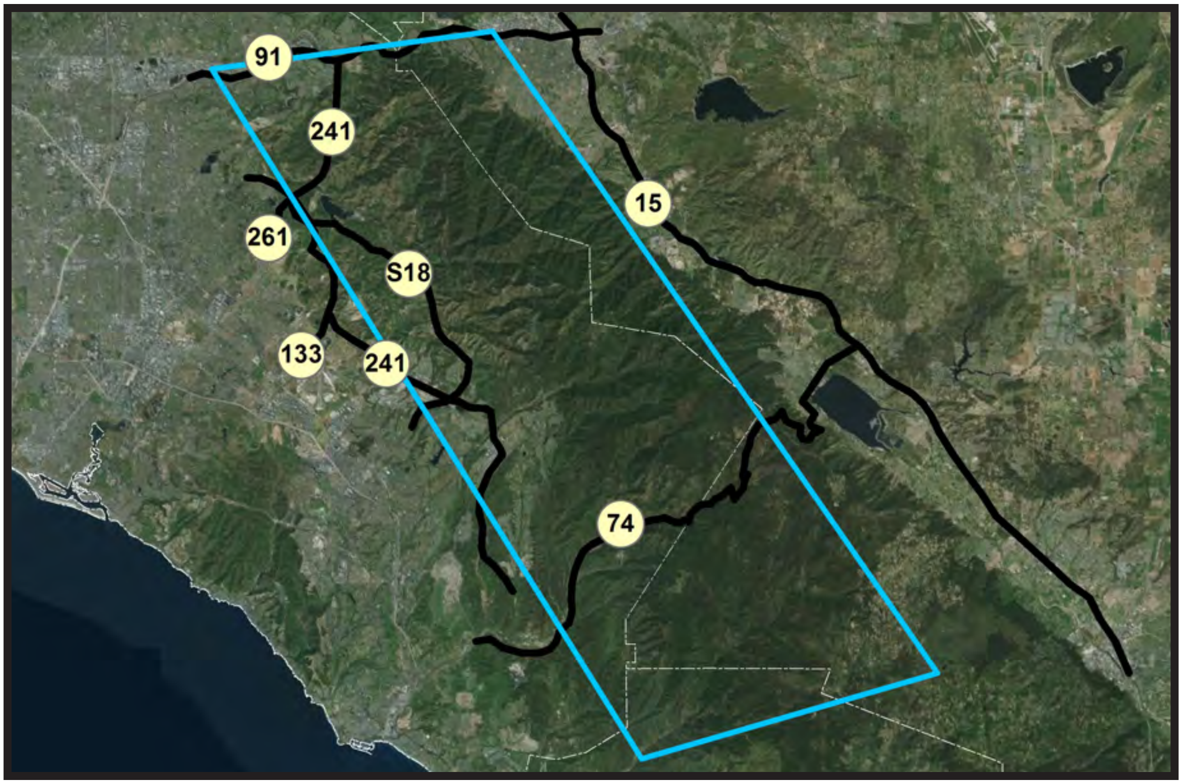
The study has resulted in a digital history of 186 fires that have burned over the last 100 years (1914 to 2014). There are two Study Areas: the Santa Ana Mountains and the Laguna Coast—the last remaining unstudied areas for wildland fire history in Orange County.


MELANIE SCHLOTTERBECK

Audubon Starr Ranch in the southern Cleveland.

The Santa Ana Mountains Study Area includes lands generally bounded on the north by the 91 Freeway, the east by the 15 Freeway, the south by Camp Pendleton and the west by the Santiago Canyon Road and the 241 Toll Road. The area studied includes all of the Trabuco District of the Cleveland National Forest, but other lands were included due to the proximity, such as:

- Chino Hills State Park (owned by California Department of Parks and Recreation)



Map 4. The Santa Ana Mountains Study Area is shown in blue with major highways labeled.

- Tecate Cypress Reserve (owned by California Department of Fish and Wildlife)
- Orange County Transportation Authority Preserves
- Audubon Starr Ranch Sanctuary
- Several OC Parks (Irvine Ranch, Caspers, Limestone & Whiting, O'Neill, and Santiago Oaks)

Numerous private ownerships in Orange and Riverside County abut these protected lands and were also included due to proximity.

The Laguna Coast Study Area includes lands generally bounded on the north by the 405 Freeway, on the east by the Cities of Aliso Viejo and Laguna Woods, on the south by Pacific Coast Highway (Highway 1), and on the west by MacArthur Blvd. The region studied includes Laguna Coast Wilderness Park, Crystal Cove State Park, Laguna Laurel Ecological Reserve, the Dilley Preserve, Aliso and Wood Canyons Wilderness Park, City of Irvine Open Space (South) and William Mason Regional Park.

Numerous private ownerships around the Laguna Coast abut these protected lands and were also included due to proximity.

Map 5. The Laguna Coast Study Area is shown in blue with major highways labeled.

There are important terms used throughout this study and their meaning is useful to understand:

- **Cause:** The confirmed or unconfirmed source of the wildland fire's ignition.
- **Fire Perimeter:** The farthest geographical extent, also known as the outer boundary, of a fire. *Note: Not all areas within the perimeter necessarily burned.*
- **Fire Frequency:** The number of times a specific geographic region has burned. This is similar to how population density is displayed, the darker the color the more frequently the area has burned.
- **Natural Fire Regime:** The general classification of the role fire would play in the natural environment in the absence of modern human intervention.
- **Point of Origin:** The approximate or exact location where the wildland fire ignited within the Study Area.
- **Study Area:** The geographic bounds of this study, which generally encompasses publicly protected natural lands with some overlap of private lands.
- **Wildland-Urban Interface (WUI):** The boundary between developed regions and the natural wildland areas.

Information Sources & GIS Analysis

The digital data for this study was found from two sources. First, data was obtained for free through the California Department of Forestry and Fire Protection's (CalFire) online digital data sets. Second, data was purchased from the Orange County Fire Authority (OCFA) via a Public Records Act Request. The data obtained came in the form of shapefiles (digital data sets). To further understand the data set, various newspapers, such as the OC Register, LA Times, Inland Valley Tribune, were reviewed to add to the data. No new information was obtained from the newspaper search. One personal communication with a local resident yielded a point of origin and fire cause. We attempted to get data from Laguna Beach Fire Department, but we learned it had the same data as OCFA.

FHBP used the ArcMap 10.1, a geographic information system (GIS) program, to assimilate the fire data. To enable wide distribution, the files were exported from ArcMap for use in Google Earth. These datasets are available on the FHBP website: *www.FHBP.org*.

Through this research, FHBP was able to piece together a digital dataset that outlines where known fires burned and where, and in some cases why, the fires started. Not all fires that burned in the Study Areas were formally documented in this study. The fire agencies didn't necessarily document all fires and with missing information those incidents were not included in the study. Therefore, some fires were not included due to lack of adequate data. That said, the historic record of digital data that now exists due to this study is more comprehensive than it was prior to the study.

Fire Regime

According to recent fire science, the natural fire regime for Southern California's chaparral and coastal sage scrub is between 30 and 150 years.[24] This means that in order to allow the plants adequate time to regenerate, resprout, and store enough energy to grow/reproduce again fires happening more frequently than 30 to 150 years disrupts this cycle and has negative impacts on the plant communities. In short, the more frequently a fire burns a specific geography, the less chance these plant communities have to adequately recover. When the plants cannot recover quickly, it allows opportunistic non-native plants to replace native plant communities. These invasive plants are often non-native grasses—which grow faster, dry out earlier, and spread fire faster.[25] Non-natives tend to exacerbate the fire cycle.

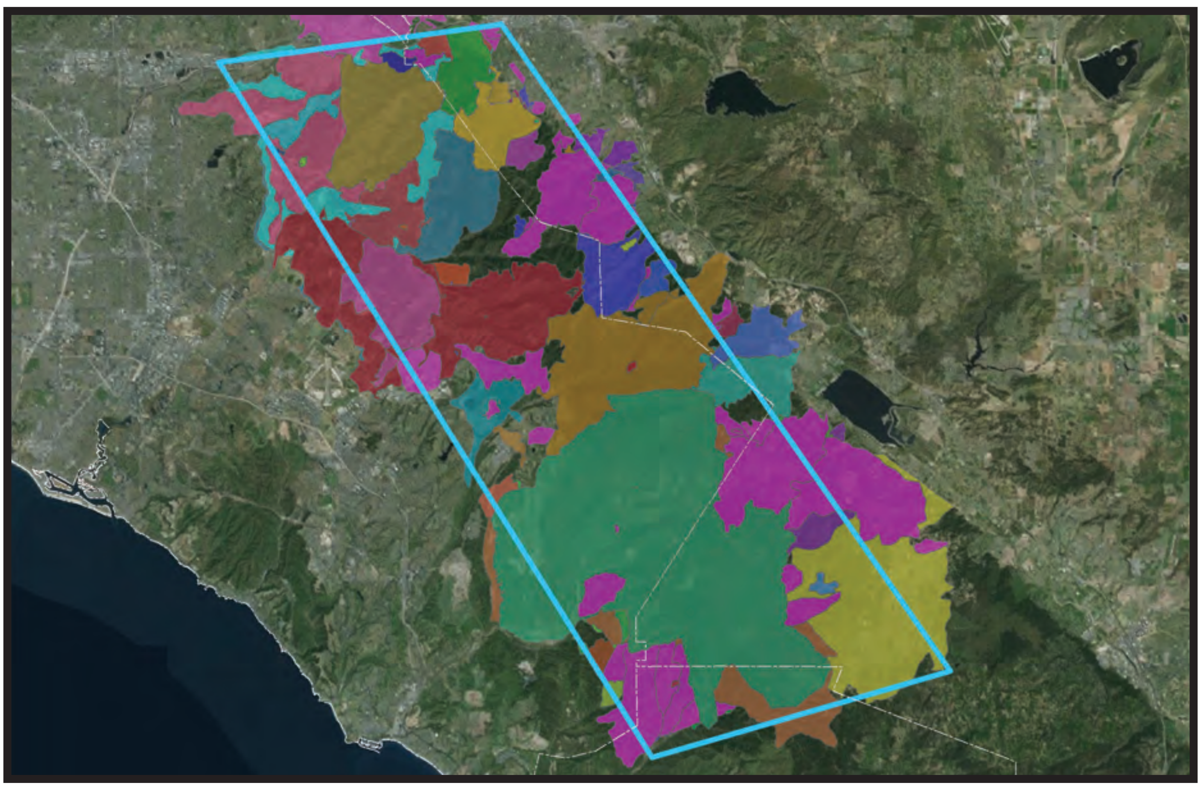
CELIA KUTCHER

Habitat lands that burn too frequently can't regenerate fast enough.

With this in mind, and with the records available from CalFire and OCFA, FHBP was able to analyze the fire regime (both natural and human-caused) for fires in the Santa Ana Mountains and Laguna Coast spanning 100 years. Going back to 1914, it seems there was only one recorded natural (non-human caused) fire in the two study areas. The cause was a lightning strike in the Santa Ana Mountains in 2009. This fire burned 142 acres. It fits with the natural fire regime for this area. The balance of the fires was most likely caused by humans accidentally or intentionally. We know this because our region does not generally experience weather patterns that produce lightning strikes. In addition, a fairly significant portion of the fires can be directly attributed to human activity (cars, arson, camping, shooting, etc.).

Santa Ana Mountains

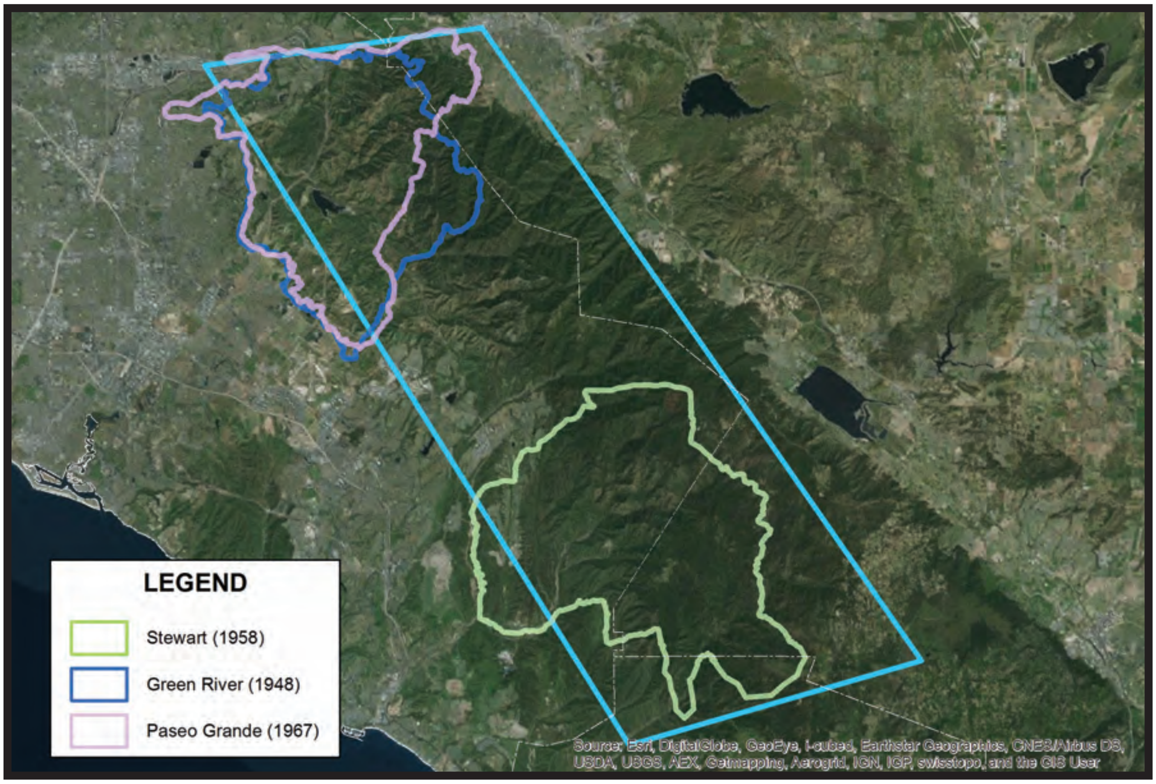
Within the Santa Ana Mountains study area 144 separate fire perimeters were found. Of the 144, we know the point of origin for 21 of them. The smallest fire is less than one acre and the largest is over 69,400 acres.



Map 6. The Santa Ana Mountains Study Area includes 144 separate fire perimeters—each one a different color.

The three largest fires from the study include:

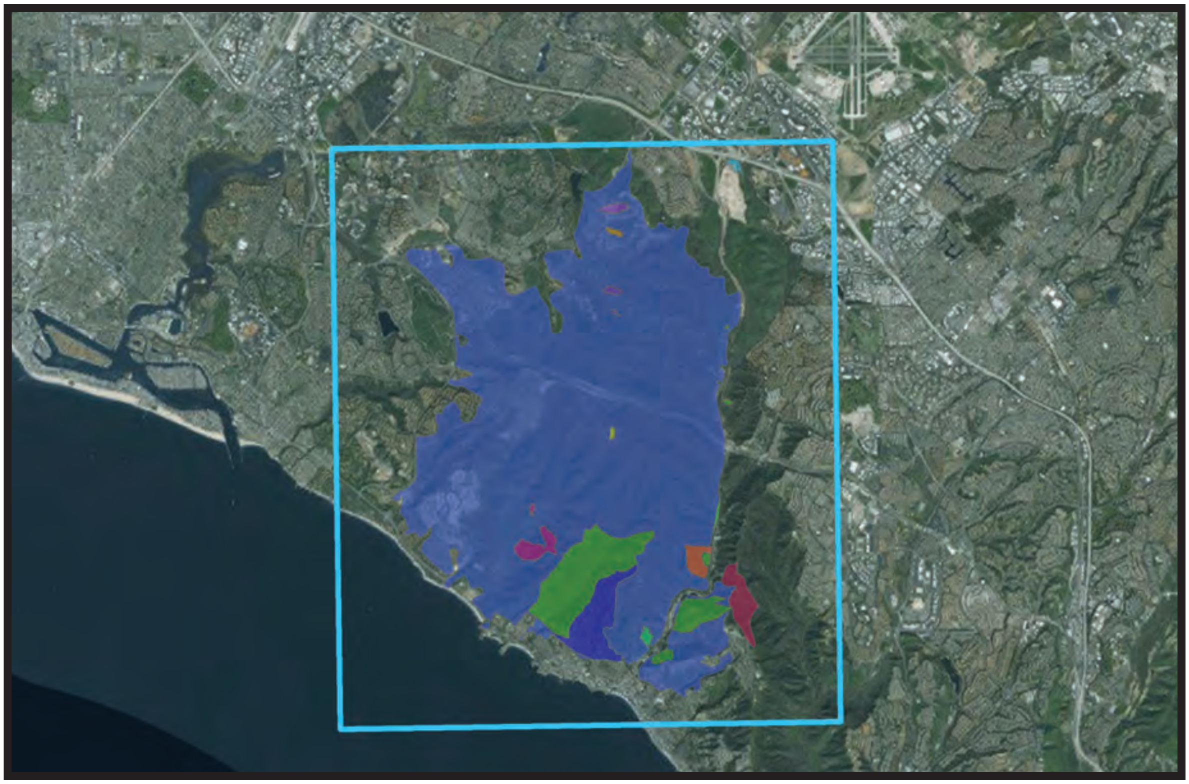
- Stewart (1958) at 69,444 acres
- Green River (1948) at 53,078 acres
- Paseo Grande (1967) at 51,075 acres



Map 7. The three largest fires are shown on this map of the Santa Ana Mountains Study Area.

Laguna Coast

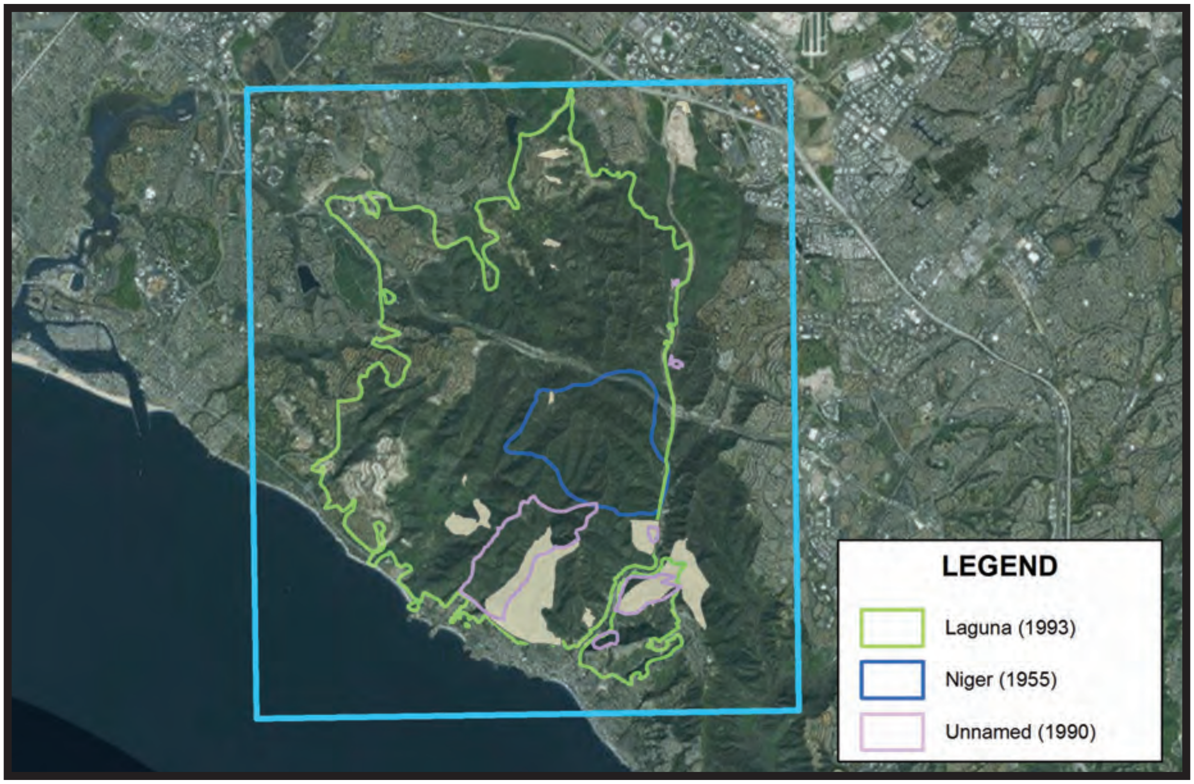
Within the Laguna Coast study area 21 separate fire perimeters were found. Of the 21, we know the point of origin for seven of them. The smallest fire is less than an acre and the largest is over 14,330 acres.



Map 8. The Laguna Coast Study Area includes 21 separate fire perimeters—each one a different color.

The three largest fires from the study include:

- Laguna Fire (1993) at 14,336 acres
- Niger Fire (1955) at 1,606 acres
- An Unnamed Fire (1990) at 720 acres



Map 9. The three largest fires are shown on this map of the Laguna Coast Study Area.

Fire Points of Origin

Santa Ana Mountains

Thirty-eight fire points of origin were obtained during the study on the Santa Ana Mountains. Twenty-one of them have matching fire perimeters. The smallest fire is less than one acre and the largest is over 30,000 acres. Roadways have the highest occurrence of ignition points, especially along the 241 Toll Road, Santiago Canyon Road (S18), and Ortega Highway (SR 74).

Map 10. Every recorded point of origin in the Santa Ana Mountains Study Area is show with a flame icon.

Laguna Coast

Eight fire points of origin were obtained during the study on the Laguna Coast. Six of them have matching fire perimeters. The smallest fire is less than one acre and the largest is over 14,300 acres. Again,the main roadway (Laguna Canyon Road, Highway 133) is the main fire ignition location.

Map 11. Every recorded point of origin in the Laguna Coast Study Area is show with a flame icon.

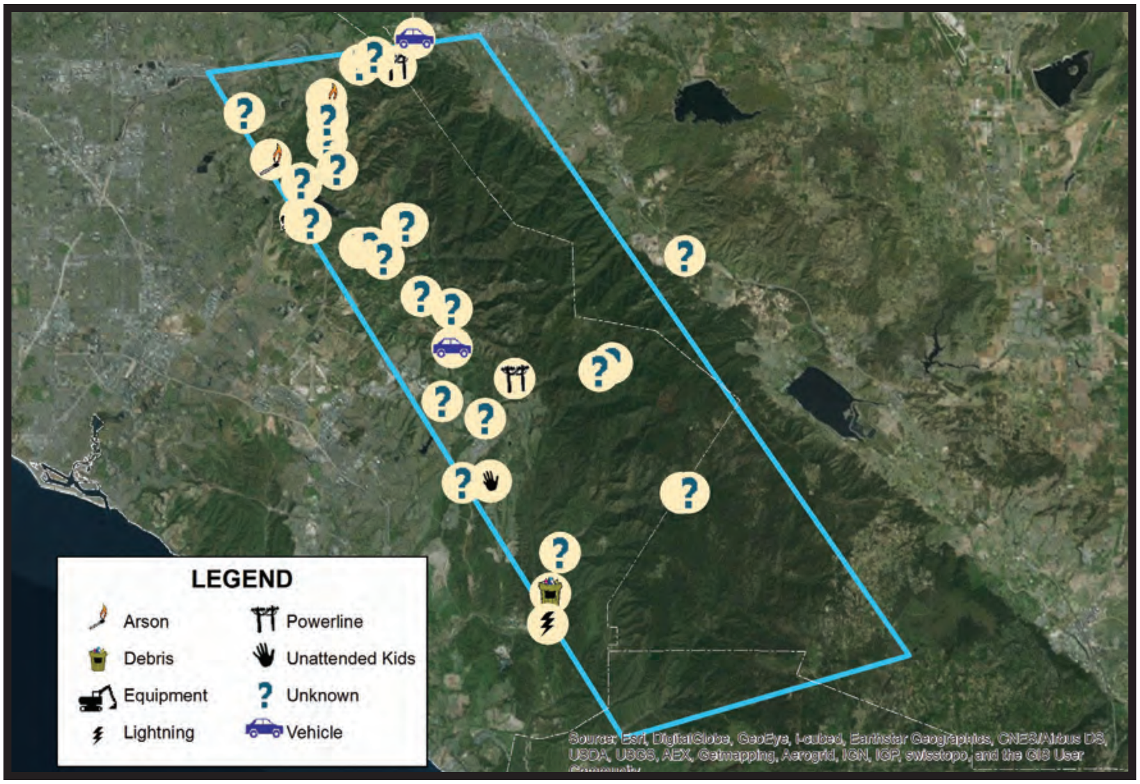
Fire Causes

Santa Ana Mountains

In reviewing the data on the Santa Ana Mountains, we found 35 fires had a known cause, while 129 had an unknown cause.

Map 12. Every known fire cause is shown in the Santa Ana Mountains Study Area with a colored flame. Unknown causes are shown in grey.

The fire causes have been separated by cause to create the next map.



Map 13. Icons were generated for each known cause for a fire's point of origin as shown in the Santa Ana Mountains Study Area. Unknown causes are shown with a question mark.

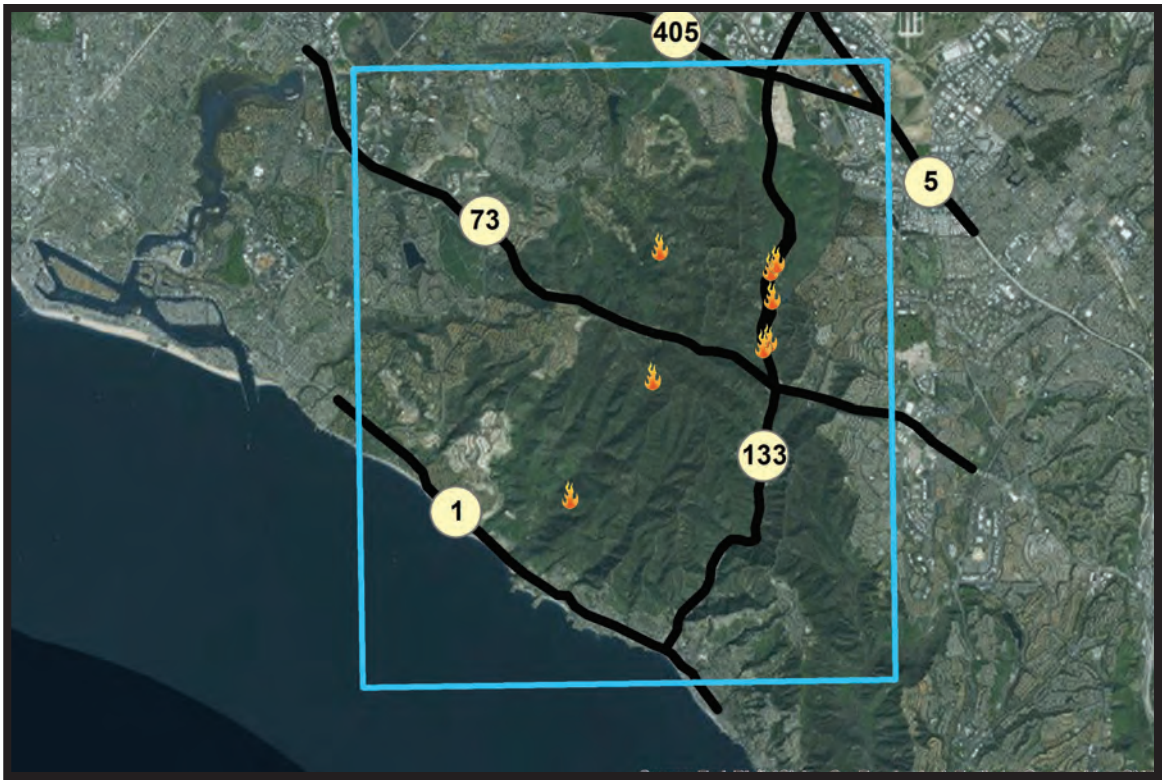
To provide a more comprehensive view, the table below includes known and unknown causes of wildland fires using data from the fire perimeter and point of origin layers.

Table 2. The types of fires burning in the Santa Ana Mountains.

Cause	Number of Fires	Acreage Burned
Aircraft	1	10
Arson	11	61,802
Campfire	3	94
Debris	3	142
Equipment	3	480
Fire Arms	1	69,444
Lightning	1	142
Metal	1	959
Misc.	16	92,270
Playing with Fire	3	200
Powerlines	2	2234*
Prescribed Burn	1	10,591
Unknown	113	389,794*
Vehicle	5	31,028
TOTAL:	**164**	**659,190**

Laguna Coast

In reviewing the data on the Laguna Coast, we found 8 fires had a known cause, while 14 had an unknown cause. The types of fires are broken down as follows:



Map 14. Every known fire cause is shown in the Laguna Coast Study Area with a colored flame. Unknown causes are shown in grey.

The fire causes have been separated by cause to create the next map.

Map 15. Icons were generated for each known cause for a fire's point of origin as shown in the Laguna Coast Study Area. Unknown causes are shown with a question mark.

To provide a more comprehensive view, the table below includes known and unknown causes of wildland fires using data from the fire perimeter and point of origin layers.

Table 3. The types of fires burning in the Laguna Coast.

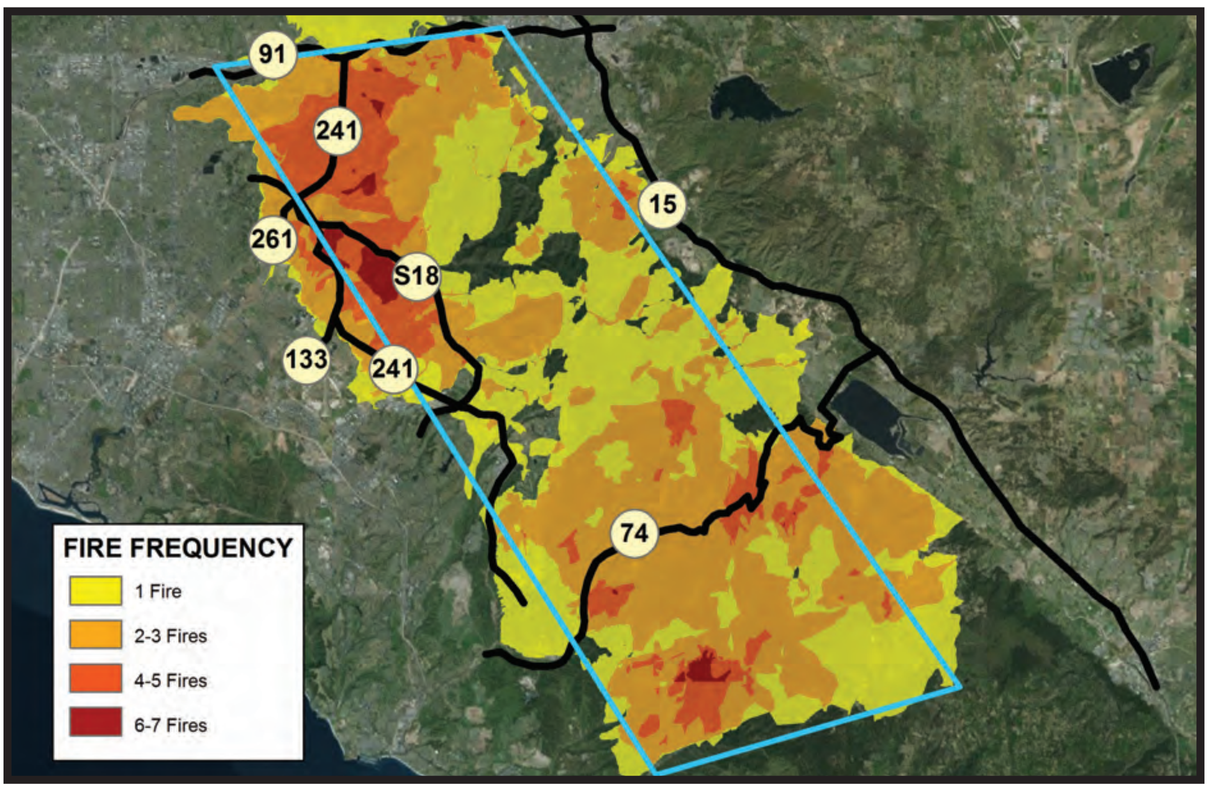
Cause	Number of Fires	Acreage Burned
Arson	3	14,433
Equipment	1	84
Powerline	3	33
Smoking	1	3
Unknown	14	3,462*
TOTAL:	**22**	**18,016**

Fire Frequency

Using a technique similar to those that show population density, by overlapping all the fire perimeters, the fire frequency in the Study Areas can be determined. The lightest color on the map indicates that area only burned once. The darkest color on the map, a maroon color, indicates the area burned seven times. When one looks at the fire frequency, there are obvious hot spot locations that have burned repeatedly and where attention should be focused on prevention.

Santa Ana Mountains

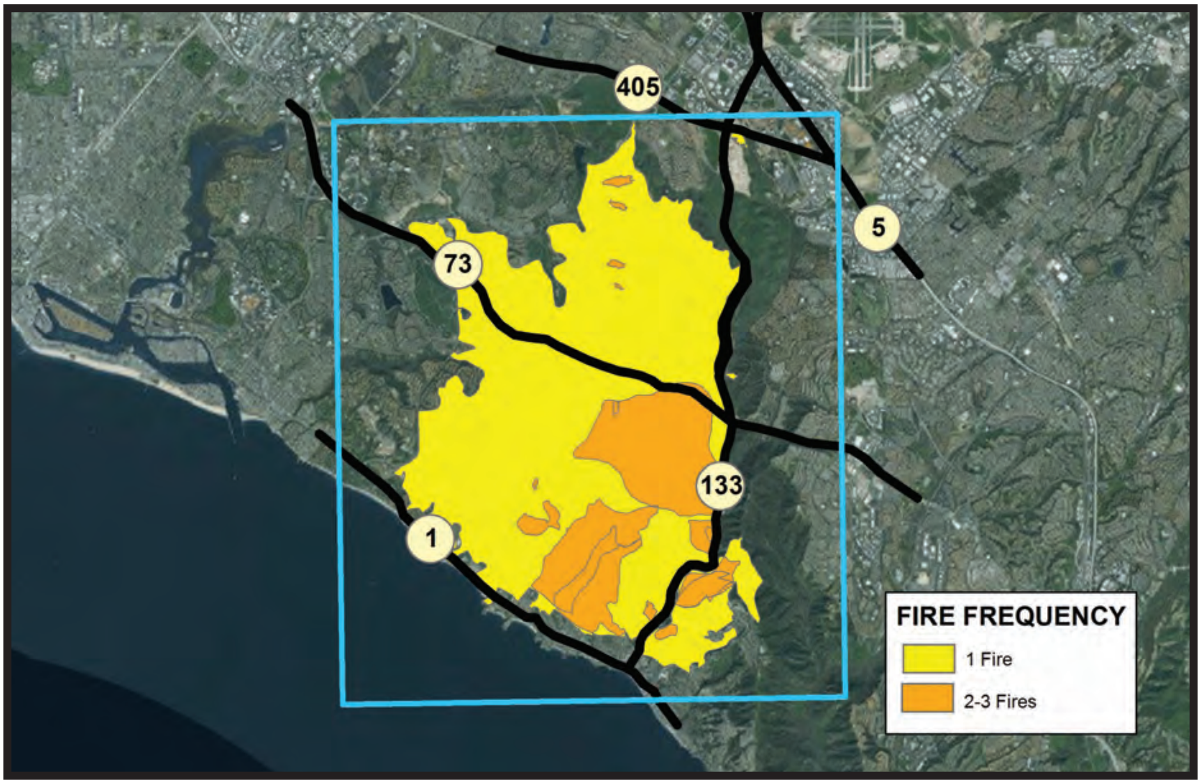
The data show that there are three areas in the Santa Ana Mountains that have burned frequently—along the 241 Toll Road, Santiago Canyon Road, and Ortega Highway (Highway 74). The areas that are prone to burning most frequently are the roadway edges. There is one exception to this. A small area of land within the Trabuco District's San Mateo Wilderness has an extensive fire history, but has limited access due to its remote location. All of the fire causes in the Wilderness are unknown, except one. FHBP will provide general recommendations to reduce the fire frequency in these known hotspots.



Map 16. This map demonstrates the fire frequency in the Santa Ana Mountains Study Area. The lighter the color the fewer the fires, the darker the color the more fires have burned that area.

Laguna Coast

The data show that there are no extreme hotspots in the Laguna Coast as they relate to fire frequency. Only a few areas have even burned multiple times, based on the data in our possession. Again, general recommendations to reduce the fire frequency will be provided toward the end of this report. Though there are fewer fires in this Study Area, the places most prone to burning are the roadway edges.



Map 17. This map demonstrates the fire frequency in the Laguna Coast Study Area. The lighter the color the fewer the fires, the darker the color the more fires have burned that area.

Fire & Weather Patterns

Under normal circumstances, the prevailing wind for Orange County is a westerly onshore flow. This is when the majority of fires occur. However, the most devastating fires burn when the Santa Ana winds (which come from the north and east) occur. These winds bring hot and dry conditions to the region—exacerbating the fires under these windy conditions. Research indicates that most fires, 97%, are contained shortly after they start.[26] It is the fires in the 3% category that get out of hand quickly and spread at an alarming rate.

The relative humidity and temperature both play a significant role in reducing the fuel moisture in the vegetation, especially the fine dead fuel (such as annual grasses and mustard). When high pressure systems sit above the high desert (Mojave and Great Basin) and low pressure systems are off the coast, that phenomenon creates foehn winds, known locally as Santa Ana winds. These winds then blow from the south side of the high pressure system toward the coast (the low pressure system). The relative humidity with feohn winds tends to be 10-20%.[27] Relative humidity is the ratio between the moisture in the air and the amount of moisture needed to saturate the air. Relative humidity is then a function of both moisture and temperature. Vegetation can dry out quickly and be depleted of significant moisture during Santa Ana Wind conditions. The larger vegetation (sycamores, oaks, etc.) don't dry out as quickly due to their size, whereas a blade of grass (finer fuel) dries out very quickly.

FHBP included in this study some research on weather patterns and seasonality of fires. The Weather Underground website was used to collect the data, using Silverado, CA as the nearest location for the Santa Ana Mountains and Laguna Beach, CA for the Laguna Coast. Accurate Weather data was not available prior to 1977.

Santa Ana Mountains

Table 4. The weather averages for fires in the Santa Ana Mountains.

<table>
<tr><th colspan="3">Weather Features on Fire Days</th></tr>
<tr><td>Average Temperature was:
(Data was available for 61 fires)</td><td colspan="2">83 °F</td></tr>
<tr><td>Average Relative Humidity was:
(Data was available for 35 fires)</td><td colspan="2">53%</td></tr>
<tr><td>Average Wind Speed was:
(Data was available for 35 fires)</td><td colspan="2">6 mph</td></tr>
<tr><td>Average Wind Gusts were:
(Data was available for 29 fires)</td><td colspan="2">27 mph</td></tr>
<tr><td rowspan="4">Wind Direction was:
(The direction the wind originates from)
(Data was available for 36 fires)</td><td>North (N, NE, NW)</td><td>4</td></tr>
<tr><td>East (E, ENE, ESE)</td><td>8</td></tr>
<tr><td>S (S, SE, SW)</td><td>2</td></tr>
<tr><td>West (W, WNW, WSW)</td><td>21</td></tr>
</table>

Laguna Coast

Table 5. The weather averages for fires in the Laguna Coast.

Weather Features on Fire Days		
Average Temperature was: *(Data was available for 14 fires)*	84 °F	
Average Relative Humidity was: *(Data was available for 4 fires)*	66%	
Average Wind Speed was: *(Data was available for 4 fires)*	3 mph	
Average Wind Gusts were: *(Data was available for 3 fires)*	22 mph	
Wind Direction was: *(The direction the wind originates from)* *(Data was available for 4 fires)*	North (N, NE, NW)	1
	East (E, ENE, ESE)	0
	S (S, SE, SW)	0
	West (W, WNW, WSW)	3

Fires & Seasonal Patterns

Santa Ana wind conditions occur mostly in the fall (October and November), while the majority of fires occur in the summer months (July, August, and September). Though no month is immune from fires, there is a clear correlation between fire occurrence and summer months and fire size (largest acreage) during Santa Ana wind events. There appears to be one anomaly—a large fire (69,000+ acres) in December 1958. Most December fires appear to average 1,000 acres. It is unclear why this fire was so large.

Santa Ana Mountains

Table 6. Fire statistics by month for the Santa Ana Mountains.

Month	Known Fires	Total Acreage Burned	Average Acreage Burned
January	7	2,096*	419** (5 fires)
February	4	27,411	6,853
March	1	1,618	1,618
April	1	Unknown*	Unknown**
May	7	6,412	916
June	15	17,760*	1,269** (14 fires)
July	20	20,788*	1,223** (17 fires)
August	14	19,676	1,405
September	17	17,109*	1,069** (16 fires)
October	13	190,467*	15,872** (12 fires)
November	11	104,899*	10,490** (10 fires)
December	5	73,445	14,689
Unknown	49	177,512	3,622
TOTAL:	164	659,193	4,954

** indicates some acreages are unknown and therefore the number is actually higher than shown.*

*** indicates acreages were averaged only where known fire acreages existed; if a fire acreage was unknown the fire was left out of the average.*

Laguna Coast

The Laguna Coast generally doesn't follow the same seasonal pattern as the Santa Ana Mountains with the exception of the large fire in October (likely Santa Ana winds). there are also significantly fewer fires over the same span of time to compare to the Santa Ana Mountains.

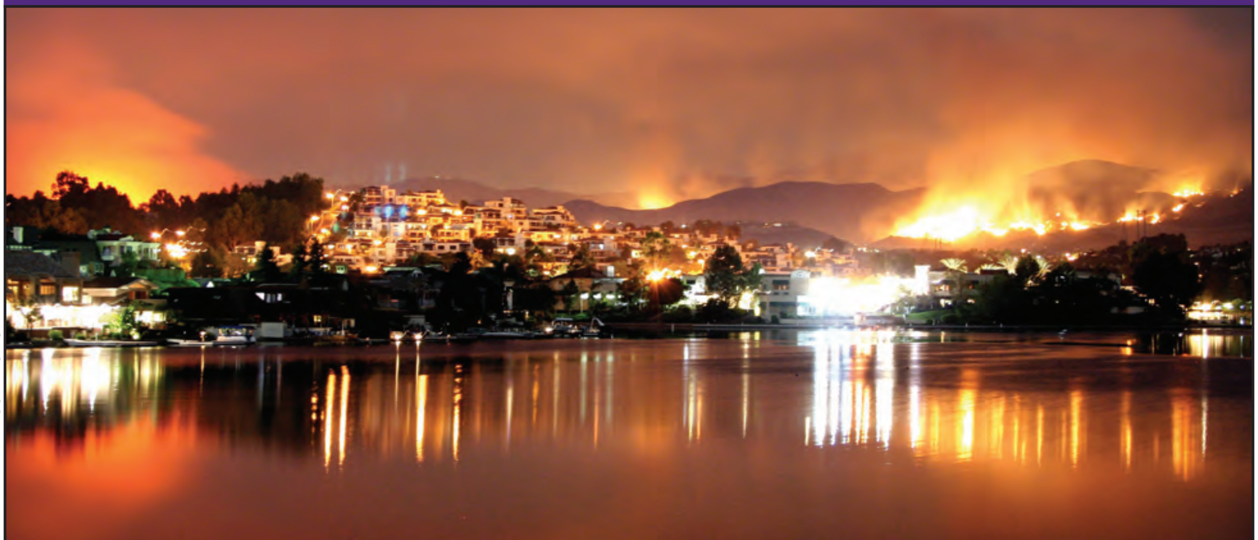
Table 7. Fire statistics by month for the Laguna Coast.

Month	Known Fires	Total Acreage Burned	Average Acreage Burned
January			
February	1	5	5
March	1	3	3
April			
May	2	13	6
June	2	83*	83**
July	2	169	85
August	5	128	26
September	4	1,977	494
October	2	14,365	7,182
November			
December	2	553	276
Unknown	1	720	720
TOTAL:	22	18,016	888

** indicates some acreages are unknown and therefore the number is actually higher than shown.*

*** indicates acreages were averaged only where known fire acreages existed; if a fire acreage was unknown the fire was left out of the average.*

Case Study: 2007 Santiago Fire



KEVIN LABIANCO FROM IRVINE, USA VIA WIKIMEDIA COMMONS

The Santiago Fire burned for 20 days in 2007. According to the Orange County Fire Authority's After Action Report for the Santiago Fire, 22 fires were burning at the same time impacting seven Southern California counties. While numerous homes were lost in other counties, especially San Diego, the Santiago Fire claimed 14 houses. With the multiple fires burning, hundreds of thousands of residents had to evacuate during the fire siege. At the time, with the mega-fires burning, it was the largest evacuation in California history with over 321,500 evacuees.

Santiago Fire Background

During Santa Ana wind conditions, with winds gusting from 50 to 85 miles per hour, an arsonist ignited a fire in the rural canyons of eastern Orange County. The point of origin was near the juncture of Santiago Canyon Road and Silverado Canyon Road. The low humidity coupled with the dry, gusty winds fueled the fire and greatly assisted its spread. In fact, according to the After Action Report, the fire spread three miles in less than 20 minutes.

RICHARD SMITH ORANGE COUNTY, USA VIA WIKIMEDIA COMMONS

The Santaigo Fire burning a densely vegetated hillside.

The bucolic canyons of eastern Orange County are home to an eclectic mix of residents. From families to hippies, horseback riders to ranchers, they reside in this area because of its historic feel and limited urban intrusions. Due to the nature of the foothills, there are several key roads leading off the main road—Santiago Canyon Road—entering into the various canyons (Silverado, Williams, Modjeska, etc.) These roads are narrow, winding, and provide the only escape routes for residents in the canyons to get to Santiago Canyon Road.


MELANIE SCHLOTTERBECK

Roads within the canyons are narrow, winding and often tree canopied increasing fire danger.

While many of the residents heed the good advice of public safety personnel by creating defensible space, keeping their homes better protected through brush clearance, ember proof vents, reduced fuel ignition opportunities in yards, etc.—no home is a good match for a wind-driven fire.

The majority of lands near these quiet enclaves are conserved as parkland in some form or another. For example, the historic Irvine Ranch lands generally follow Santiago Canyon Road on its western flank. To the east of Santiago Canyon Road is the Cleveland National Forest. Much of the land is protected in the form of the Trabuco Ranger District, there are numerous private inholdings within the Congressional boundary of the Forest.

Timeline

The Orange County Fire Authority received its first notification of a vegetation fire at 5:55 PM on Sunday, October 21, 2007. This was the second day of a red-flag warning. Just a few miles north of the fire's ignition point (at the Fremont station) wind speeds were recorded at 45-55 mph with gusts up to 85 mph. Since the fire began in the evening, the temperature was cooling down—a temperature of 68 degrees—but the relative humidity was in the single digits at 9%. OCFA notes the "burning conditions were very critical."[28]

Just 120 minutes after the fire started it already encompassed 5,000 acres. Within the first 16 hours, it had burned 15,000 acres. Though units responded immediately (within five minutes of the call) the high winds reduced their ability to stop the fire's fast spread. Due to the intensity and fast pace of this wind-driven fire, and the threat it made to structures, fire personnel provided a global direction called "Commanders Intent."


RICH GOMEZ

The Santiago Fire suddenly changed direction due to wind.

Map 18. This map shows the fire perimeter for the Santiago Fire and the multiple points of origin used by the arsonist to start the fire. At this scale, the points of origin nearly overlap.

This direction tells all units there are three priorities:
"1. Life safety for residents and firefighters
2. Protection of threatened structures most immediately at risk
3. Seek opportunities to make direct attack on the fire."[29]

Firefighters lit backfires to help control the direction of the blaze. Objectives for the fire's containment evolved as the fire's progression changed with the winds and topography. Some firefighters were assigned to protect interior canyon homes, while others were sent to exterior canyons to prevent the fire's spread into more urban areas at the mouth of the canyon. By Monday morning, OCFA's helicopters were on staggered shifts to provide direct aerial support to assist ground crews. However, pilots are limited to eight hours of flying per shift. Though ready to help, the helicopters were grounded pretty early in the firefight due to extreme wind conditions. When wind conditions improved, flights and therefore, water drops, resumed.

A sudden wind shift late Monday night, completely reversed the direction of the fire—giving it a new place to burn. Shifts in wind direction and even micro-climates are common in the Santa Ana Mountains based on geography, topography, etc. It wasn't until late that night that the first out-of-area firefighting resources arrived. The entire fire thus far had been fought by local (Orange County) mutual aid assistance. By Tuesday morning,

COLBY RUMBACK

Residents sift through the remnants of a canyon home.

additional aerial assistance was deployed and provided much needed assistance to ground crews.

One of the most complicating factors during this fire, is that many of the residents have horses and/or other livestock that were also in need of evacuation. A massive effort to get the animals out of harm's way meant trailers and equipment had to be brought in during the inferno. El Modena High School served as an evacuation center for some of the animals, as did El Toro High School. More than 200 animals were impounded and more than 100 were transported by Orange County Animal Care.[30]

All in all, more than 28,500 acres were burned with 42 structures damaged and 14 structures destroyed. Many residential areas and business also suffered smoke damage from the fire. The cost estimate to fight the fire was over $27.5 million. While no one died during the Santiago Fire, 139 civilians and 58 firefighters reported injuries.[31]

Predictable Disaster

While no one wants to endure a raging wildfire, disasters can be an opportunity for reflection, recognition, and recommendations. Hot, dry Santa Ana wind days make our communities and our natural lands extremely vulnerable. Communities situated in east-west trending terrain are most vulnerable since it coincides with the wind direction and accelerates the wind—a tunneling effect. Continuing to build houses at the WUI increases the risk for loss of life and property—especially in areas prone to wildfires.

HTTP://FLICKR.COM/PHOTOS/GRIDDLECAKES/
VIA WIKIMEDIA COMMONS

SANTIAGO FIRE AND AFTERMATH PHOTOS

RICHARD WMITH ORANGE COUNTY, USA VIA WIKIMEDIA COMMONS

LAURA*B VIA WIKIMEDIA COMMONS

BOB HUNT

HELEN DE LA MAZA

COLBY RUMBACK

RICH GOMEZ

RICH GOMEZ

RICH GOMEZ

Case Study: 1993 Laguna Fire

DEBRA CONKEY

The Laguna Fire burned for 12 hours in 1993 before it was considered contained. While firefighters did their best to "subdue the beast" the winds made it nearly impossible.[32] At the same time at least a dozen other wildfires burned throughout the Southland. These fires destroyed hundreds of homes and forced tens of thousands of people to evacuate.[33] Santa Ana wind conditions fueled the spread of this and the other fires, and encouraged its explosive speed requiring the entire town of Laguna to be evacuated—some 25,000 people.[34]

Laguna Fire Background

There was no After Action Report accessible for this fire to include in this study. The story of the Laguna Fire has been cobbled together with newspaper articles, blogs, and personal stories.

PROVIDED BY GENE FELDER

Firefighters worked to save homes in Laguna.

The fire first started, likely by an arsonist, between El Toro Road and the 405 Freeway on Wednesday, October 27, 1993.[35] Similar to the Santiago Fire of 2007, the Laguna Fire was fueled by the hot, dry Santa Ana winds. Gusts were reported up to 92 mph, which included sustained wind speeds at 40 mph. While the temperature was only 78 degrees, the humidity was in the single digits, around 6-7%.[36] Big brushfires had erupted in Thousand Oaks, Chatsworth, Villa Park, Malibu, and Altadena.[37] Reports indicate the flame lengths were approaching 200' high as the wildfire jumped Laguna Canyon Road. The fire was moving at a rate of 100 acres per minute.[38]

PROVIDED BY GENE FELDER

Evacuees heading south on Coast Highway.

Surrounded on the south and west by the Pacific Ocean, homes in Laguna Beach generally hug the coast and then extend up the hillsides. Laguna Beach is accessible by only two routes: Laguna Canyon Road (Highway 133) which runs north-south and Pacific Coast Highway (PCH/Highway 1) which runs northwest to southeast. They provide the only escape route for residents fleeing the City. Highway 133 was blocked due to the fire, leaving only PCH for an evacuation.

This coastal town is known for its wonderful beaches and summer festivals (Sawdust, Art-A-Fair, Pageant of the Masters, etc.). While there are numerous multi-million dollars homes, there is also an eclectic mix of older homes and beach cottages in Laguna Canyon proper. Many of the roads within Laguna are steep, narrow, and winding on ridgetops and in canyon bottoms. Evacuees were sent south on PCH, while fire personnel went north.[39] Traffic reports indicate intersections were at a standstill.

Due to the intense Santa Ana Winds there was little time to evacuate. Residents didn't realize how little time they actually had to get out of harm's way. Some stayed behind to defend their homes from the flames with nothing more than a garden hose. Since it was a school day, some parents realized that the fire was headed straight for El Morro School near Crystal Cove State Park. If it wasn't for the alert thinking of school personnel who called in the buses and evacuated the entire school[40] at the first signs of the fire, chaos would have ensued as parents attempted to rescue their children.

Timeline

The first reports of a 911 call came in at 11:50 AM on Wednesday, October 27, 1993. Since numerous other fires were burning throughout Southern California, air tankers had to be diverted from other fires. Anticipated arrival of aerial support was at 1:40 PM—an hour and a half after the request from the incident commander. Mutual aid began arriving from other jurisdictions, but due to the high winds the fire burned 1.25 miles of brush in 17 minutes.[41] The fire presented exploding fireballs "and cloak[ed] Laguna Beach in a sickening, hot cloud of ash and embers."[42]

According to a 10 year anniversary article in the LA Times, Mystic Hills had entire streets destroyed, including: 16 of the 24 homes on Tahiti Avenue, 18 of the 19 homes on Caribbean Way, and 46 of 47 homes on Skyline Drive. All of this destruction occurred in 45 minutes.[43] Homes in Canyon Acres, Emerald Bay, and El Morro were also lost. Mutual aid from other communities included 345 fire engines, 17 dozers, 30 aircraft, 11 hand crews, and a total of 1,968 fire personnel. At one point the command post was overrun with flames and had to be moved.[44] The fire jumped fire breaks and roads due to the strong winds.

Map 19. This map shows the fire perimeter for the Laguna Fire and the point of origin.

The Santa Ana winds stopped suddenly and it was this change in weather that stopped the onward progression of the fire from making its way to the ocean.[45] By mid-night on Thursday, October 28th, roughly 12 hours after the initial reports, the fire was considered contained.

While no one lost their life, the fire brought neighbors together and actually rebuilt a sense of community. One of the recurring themes is the fast spread of the fire. Though the fire could have begun five miles away, the Santa Ana wind conditions meant it was at your doorstep almost immediately.

All in all, the Laguna Fire burned 347 homes[46] and 17,000 acres of habitat with damage estimates exceeding $528 million. Lacking reliable data, we were unable to find if any injuries occurred as a result of this fire, but there was no loss of human life.

PROVIDED BY GENE FELDER

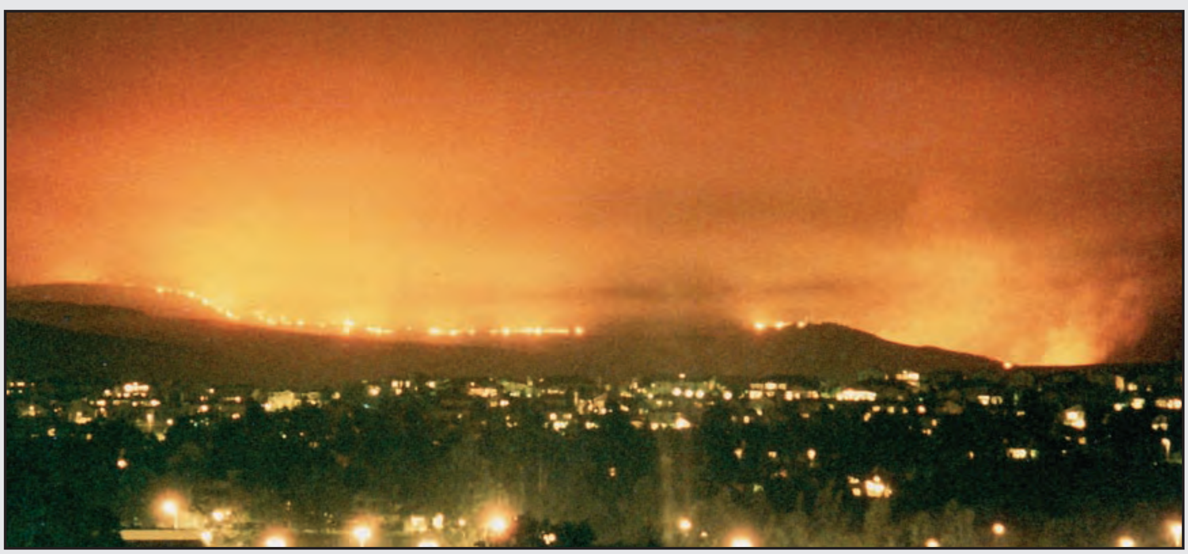
The fire spread so quickly dozens of homes were lost at the fire's onset.

Predictable Disaster

This fire occurred at a time when fire and building codes were very different. Many homes had wood shake roofs or wood siding,[47] which contributed to the enormous property loss. The flames in this fire reached 2000°F requiring fire personnel to abandon structure protection operations to ensure their own safety. Fires burning this hot take structures down in five minutes. When temperatures reach 400°F, items on the inside of homes, such as curtains, wallpaper, and bedding, begin to ignite even without direct flame contact. At 450°F wood studs spontaneously combust, or pyrolyze, and single-pane windows blow out from heat and ambient-pressure differences. Fire personnel report that many houses during this disaster were destroyed from the inside out.[48] The extensive loss of homes in this fire and others led to the significant changes in building and fire codes after 1993.

PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

Mystic Hills was hit hard by the Laguna Fire.



PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

LAGUNA FIRE AND AFTERMATH PHOTOS

PROVIDED BY GENE FELDER

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PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

MITCH RIDDER, COURTSEY OF LAGUNA BEACH INDEPENDENT

PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

PROVIDED BY GENE FELDER

Fire & Water Quality Impacts

In addition to looking at fire perimeters, points of origin, and fire frequency, we also investigated fire impacts to watersheds, including water quality. Under normal circumstances, a natural area will manage the precipitation it receives with subsurface and surface flows. Tree canopy, surface vegetation, leaf litter, etc. slow the movement and allow for more absorption. As long as infiltration into the soil exceeds the amount of precipitation, the subsurface flow will dominate.

© TRUDE HURD

Post-fire hillsides are prone to erosion.

When a fire removes vegetation the ability to deal with precipitation and retain moisture is reduced. Studies conducted by the University of Wyoming determined the volume of runoff can increase by 30% more than the year prior to the fire and erosion impacts from wildfires can be up to 100 miles from the burn site.[49]

Under ordinary circumstances subsurface flow plays an important role but following a fire, overland flow pathways predominate. The increase in runoff volume and velocity, combined with a decrease in the amount of time it takes for flows to concentrate, leads to erosion of the landscape, and hydromodification of receiving water bodies. This not only removes top soil, but can also serve to establish new channels for the water. What had been ephemeral pathways can become new permanent conduits. How much the runoff is altered depends on how it changed soil chemistry, the intensity of the fire, its duration, the terrain, the characteristics of the soil, and the nature of the precipitation. The runoff from these fires not only carries the remnants of the fire itself but the atmospheric deposition that occurred naturally prior to and during the fire.

JOEL ROBINSON

Water courses are impacted post-fire.

Fires change the hydrologic response of the land. These changes include higher runoff volumes, higher flow rates, and higher concentrations of total suspended solids.[50] These solids include regulated constituents. If the fire burns hot enough they can create hydrophobic soils which will accelerate runoff.

Forest fires promote the release of metals and nutrients found in the vegetation and soils, and these, in turn, are transported into streams during rain events. The fate of the metals and nutrients will determine the effect of the fire on water quality. For example, organic carbon and other elements like phosphorous and nitrogen can stimulate the growth of algae. This in turn could impact the odor and taste of water, as well as the vertebrates and invertebrates living in the water.[51] One of the first things to increase is pH (acidity or alkalinity), causing fish to die. There are also higher levels of nitrates in water post-burn. This has implications for areas that capture water in reservoirs. This observation may change how agencies need to react to water treatment.[52] Reservoirs are less prevalent in Southern California. Trace metals, like arsenic, lead, mercury, and copper, could impact human health in a variety of ways. Other chemicals like dioxins are even created in a fire.[53]

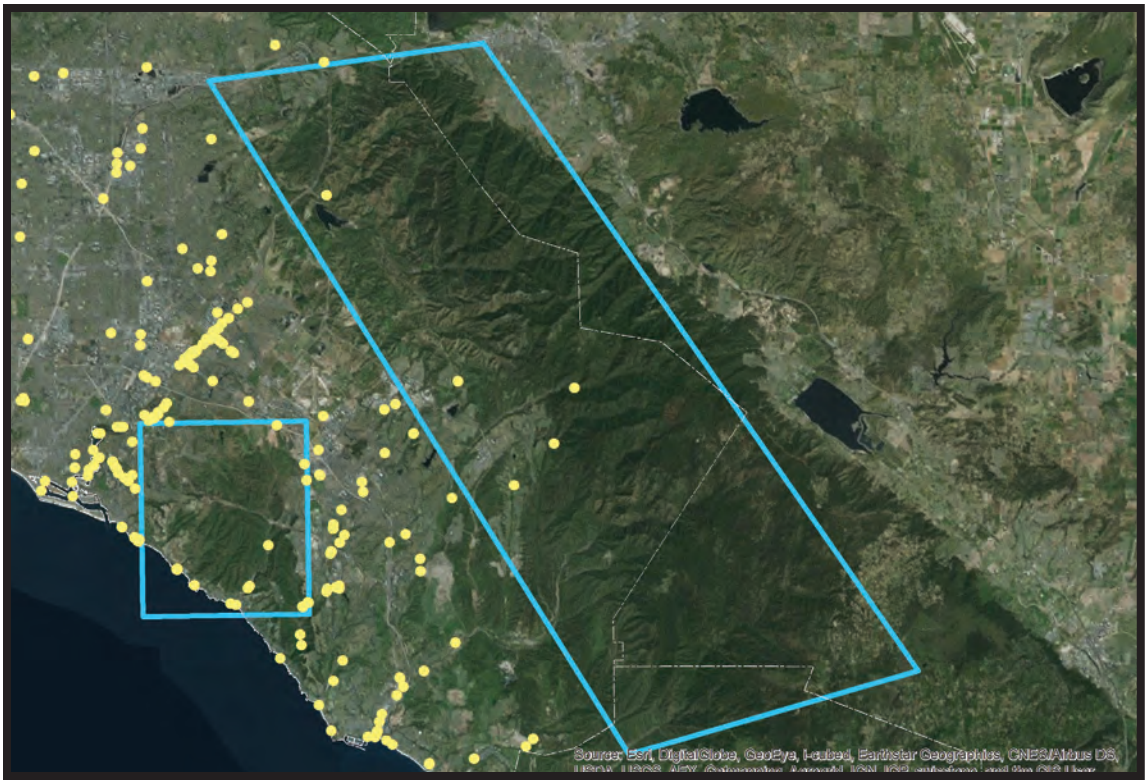

MELANIE SCHLOTTERBECK

The Stanislaus National Forest post-Rim Fire.

FHBP participated in a Society of American Foresters Conference in August 2014 to hear a presentation on the water quality effects of the Rim Fire.[54] The Rim Fire ignited when a bow hunter's campfire went out of control. The fire ultimately burned major portions of the Stanislaus National Forest and portions of Yosemite National Park. In its entirety the fire burned 400 square miles, destroyed 11 homes and dozens of outbuildings.[55] During a tour of the fire's destruction, speakers relayed the issues described above with hydrophobic soils, erosion, mudflows, etc. Unfortunately, due to the drought, the area within the fire perimeter had received so little precipitation in the year following the fire, that no direct link to the water quality could be made. In fact, 2-3 million people get their water from the reservoirs in these now-burned mountains and the water wasn't impacted at all because it never rained.[56] This is an interesting twist, in light of the extensive drought California currently faces. Should El Niño occur during the winter of 2015-2016, researchers may see the impacts from the Rim Fire happen until several years post-burn.

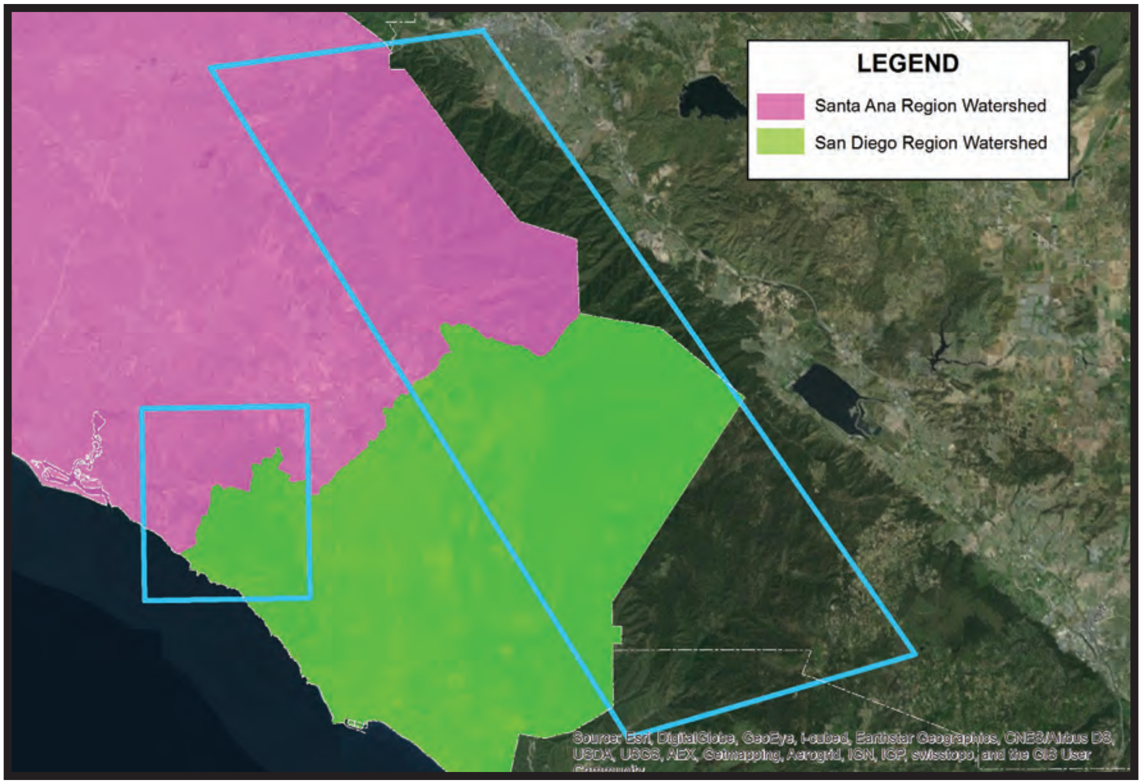
Information Sources & GIS Analysis

In addition to a literature review, we worked closely with the County of Orange Public Works Department (OC Public Works) to understand water quality impacts post-fire. The County has implemented a county-wide stormwater monitoring program on behalf of the Orange County Stormwater Program (a collaborative effort between the Orange County Flood Control District, the County of Orange, and 34 cities of Orange County) since the first municipal separate storm sewer system permits (MS4 Permits) for Orange County were issued in 1991.



Map 20. This map shows various water collection points throughout the County in relationship to the Study Areas.

From the online OC Environmental Resources Data Portal[57] and archived sample history, we reviewed the water quality monitoring data in Orange County's two Regional Water Board areas of jurisdiction: the Santa Ana Region (North and Central Orange County) and San Diego Region (South Orange County).

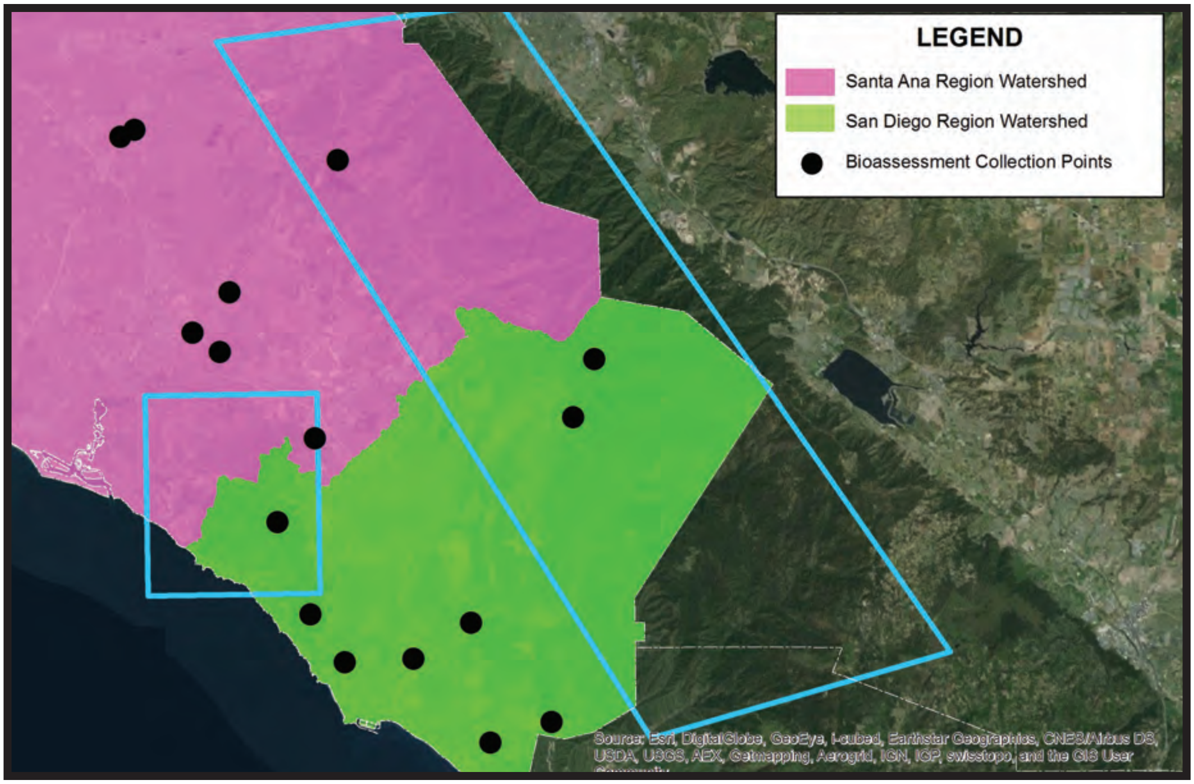


Map 21. This map shows the location of the Santa Ana Region Watershed and San Diego Region Watershed in relationship to the Study Areas.

Monitoring Programs

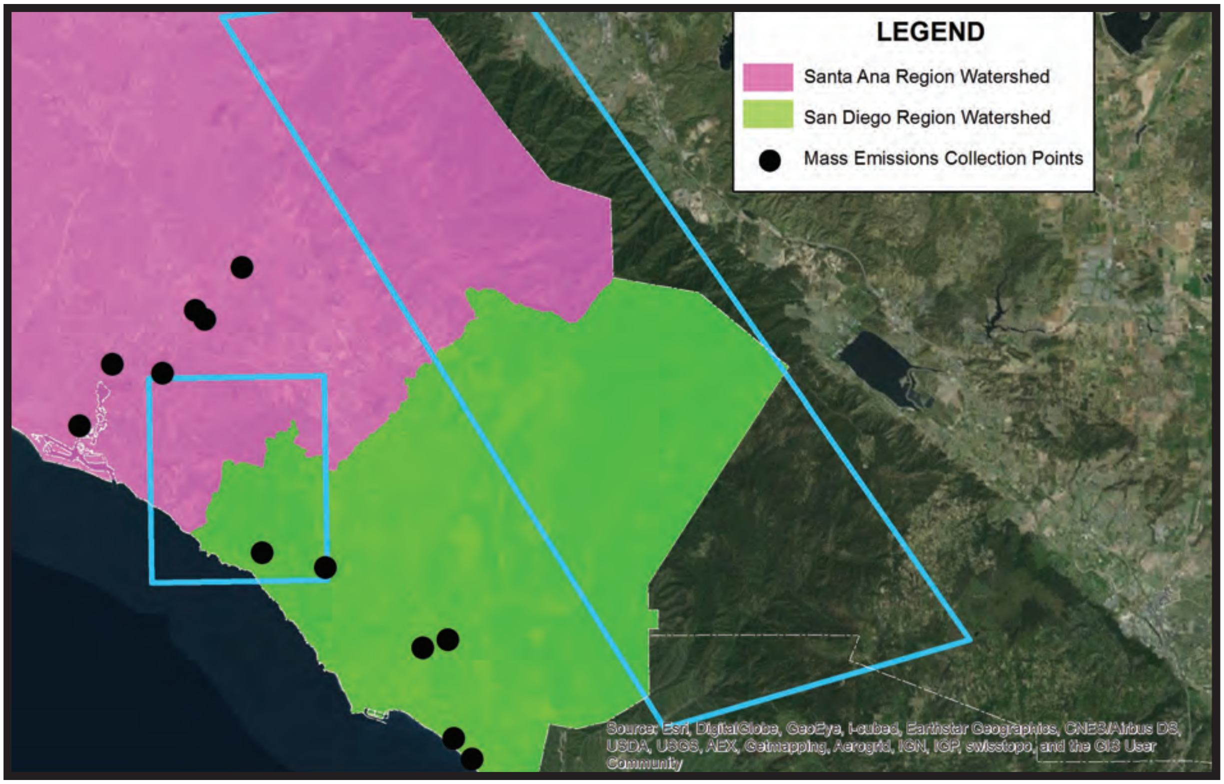
Based on the study of fires in the Santa Ana Mountains and Laguna Coast, we were looking at both regions of Orange County for potential information. County staff recommended a review of data from two elements of the county-wide stormwater monitoring program: bioassessment and mass emissions.

According to the County's 2013-14 Unified Annual Program Effectiveness Assessment: "Bioassessment monitoring is a means of assessing the quality of aquatic habitat by evaluating the assemblage of benthic macro-invertebrates (BMI)."[58] This assessment usually occurs during the late spring time, following the wet season, typically in May.[59] The bioassessment program involves aquatic chemistry, toxicity testing, bioassessment, and physical habitat assessment with the goal of providing multiple lines of evidence to characterize the conditions of freshwater habitat receiving waters. The chemical analyses typically include pH, total organic carbon, nitrate, organophosphate pesticides, copper, chromium, lead, selenium, and zinc among a suite of other items.[60]



Map 22. This map pinpoints the locations of the bioassessment collection points in relationship to both watersheds and both Study Areas.

The goals of the mass emissions monitoring program are to determine the impact of urban stormwater discharges on receiving waters, and determine changes in receiving water quality over time. Monitoring occurs during 2-3 storm events per year (an effort is always made to sample the first rain event of the wet season) at key receiving water locations in watersheds where stream gauge stations are also installed which measure flow. Time-weighted composite samples are collected for up to a 96-hour period, so an entire storm event can be characterized. The composite samples are analyzed for metals, nutrients, bacteria, and pesticides, as well as toxicity. Combined with the flow data from the stream gauges, pollutant loads can be calculated. Two dry weather events per year are also sampled at each mass emissions station so that wet weather pollutant loads can be compared to dry weather pollutant loads. Through the mass emissions data, OC Public Works is able to analyze trends to help answer questions such as: "Are receiving water conditions getting better or worse?" and "Are stormwater management actions working as intended?"[61]



Map 23. This map pinpoints the locations of the mass emissions collection points in relationship to both watersheds and both Study Areas.

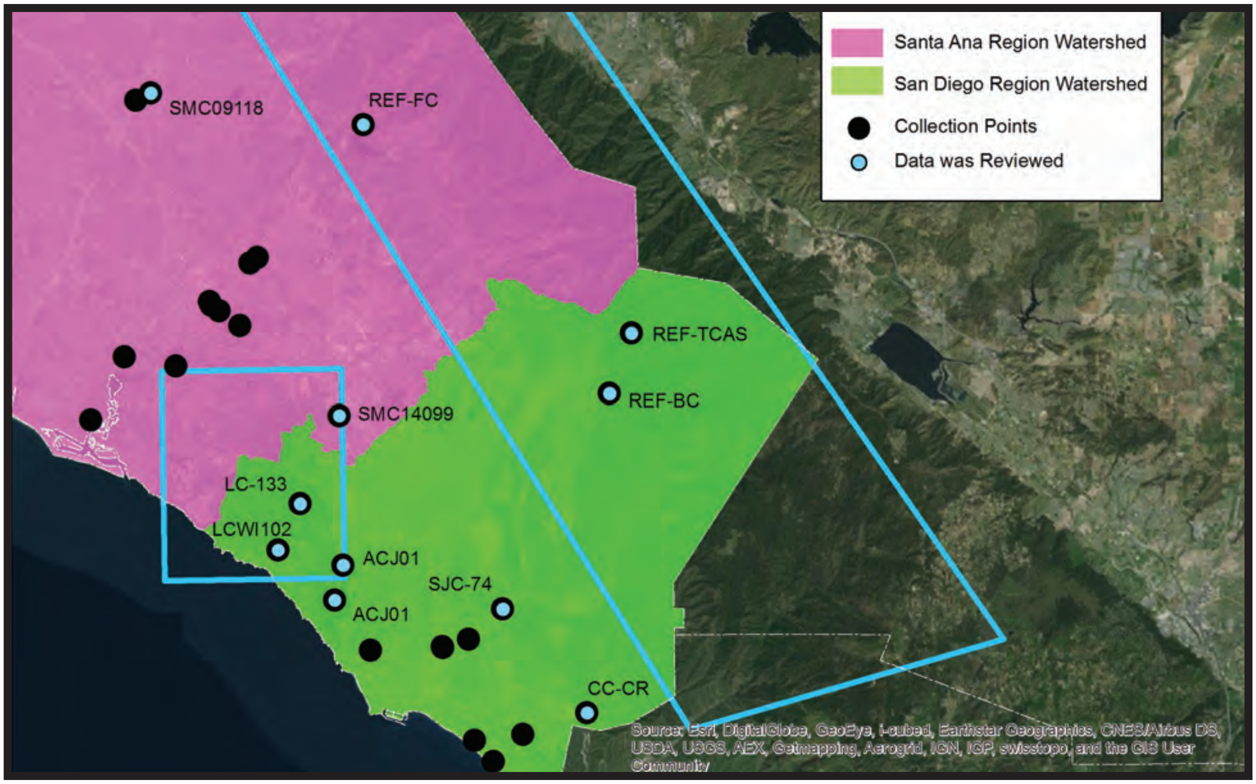
This information resulted in narrowing our search area down to six sampling points for the Santa Ana Mountains and five sampling points for Laguna. Bioassessment data was available for the Santa Ana Region of Orange County between 2005 – 2014 and beginning in 2001 to 2014 for the San Diego Region of Orange County. The mass emissions data was available for the Santa Ana Region 2004 – 2015 (Q1) and the same for the San Diego Region.

Table 8. The data collection information for the Santa Ana River and San Diego River Watersheds.

Data Collection Points	Stream Name	Region	Water shed	Monitoring Type	Santa Ana Mountains	Laguna Coast
ACJ01	Aliso Creek	San Diego	Aliso Creek	BA/ME		X
CC-CR	Cristianitos Creek	San Diego	San Clemente Coastal Streams	BA	X	
LC-133	Laguna Wash	San Diego	Laguna Coastal Streams	BA		X
LCWI102	Laguna Canyon Channel	San Diego	Laguna Coastal Streams	ME		X
REF-BC	Bell Creek	San Diego	San Juan Creek	BA	X	
REF-FC	Fremont Canyon Creek	San Diego	Santa Ana River	BA	X	
REF-TCAS	Trabuco Creek	San Diego	San Juan Creek	BA	X	
SJC-74	San Juan Creek	San Diego	San Juan Creek	BA	X	
SMC09118	Colllins Channel	Santa Ana	Santa Ana River	BA	X	
SMC14099	Canada Channel	Santa Ana	Newport Bay	BA		X

BA is bioassessment, while ME is mass emissions

Though we sifted through data from tens of thousands of samples for each monitoring point above, we were unable to find a direct correlation between water quality and a fire. While the fire likely had an impact on the watershed and water quality, the span of time between the data collection and the fire date was too great to draw any correlations (direct or indirect). This was likely a result of when the sample was collected, when the fire occurred and when the next sample was collected.



Map 24. This map shows the bioassessment and mass emissions point in relationship to both watersheds and both Study Areas.

Index of Biotic Integrity

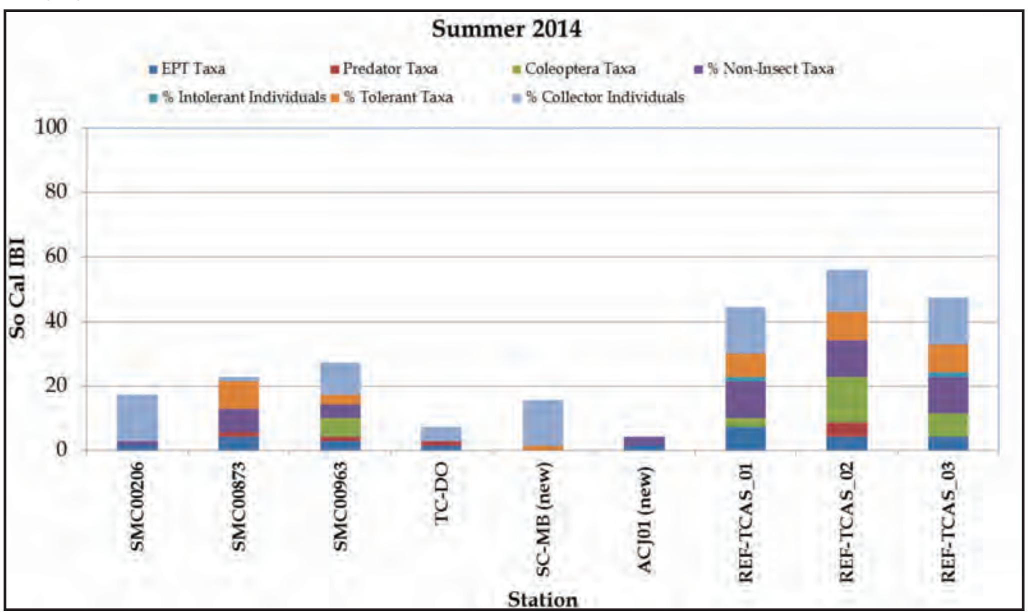
Another tool also available to us through the county-wide stormwater monitoring program implemented by OC Public Works is the Index of Biotic Integrity (IBI). We were able to find reference to the IBI score data in the 2013-14 Unified Program Effectiveness Assessment Report for the San Diego Region. The IBI score is a tool that was designed to help stormwater programs determine a link between anthropogenic influences and biological activity within receiving waters in urbanized areas. The score is calculated using data developed from biosurveys and scores from urban streams are compared to those that are considered to be reference streams (located in undeveloped areas). These scores allow researchers to determine the ecological complexity from statistical analysis. A well-constructed IBI score allows scientists to understand the issues, diagnose the watershed's program, define management approaches to remedy the situation and allow for retesting.[62] In the County's situation they used the bioassessments to determine the IBI score. "Each site is rated with an IBI score which is based on a statistical analysis of the distribution of organisms at a site. The scoring range is 0 to 100 with higher scores indicating a higher distribution of pollution-intolerant BMIs."[63] In other words, the higher the score the better the watershed condition is.

As with other areas of Southern California, Orange County's more urbanized and downstream sampling points average an IBI score in the very poor range, while more rural streams fair a bit better. In fact, most of the Orange County IBI scores rank in the "very poor" category, which is indicated by a score at or around 20. In this chart, the IBI scores from 2013-14 for the Santa Ana and San Diego Regions are included.[64]

JOEL ROBINSON

A stream in Upper Santiago Canyon.

Figure 1. This chart shows the IBI scores for the San Diego Region Watershed as reported in 2013-14.



2013-14 UNIFIED ANNUAL PROGRESS REPORT - SAN DIEGO REGION

Figure 2. This chart shows the IBI scores for the Santa Ana Region Watershed as reported in 2013-14.

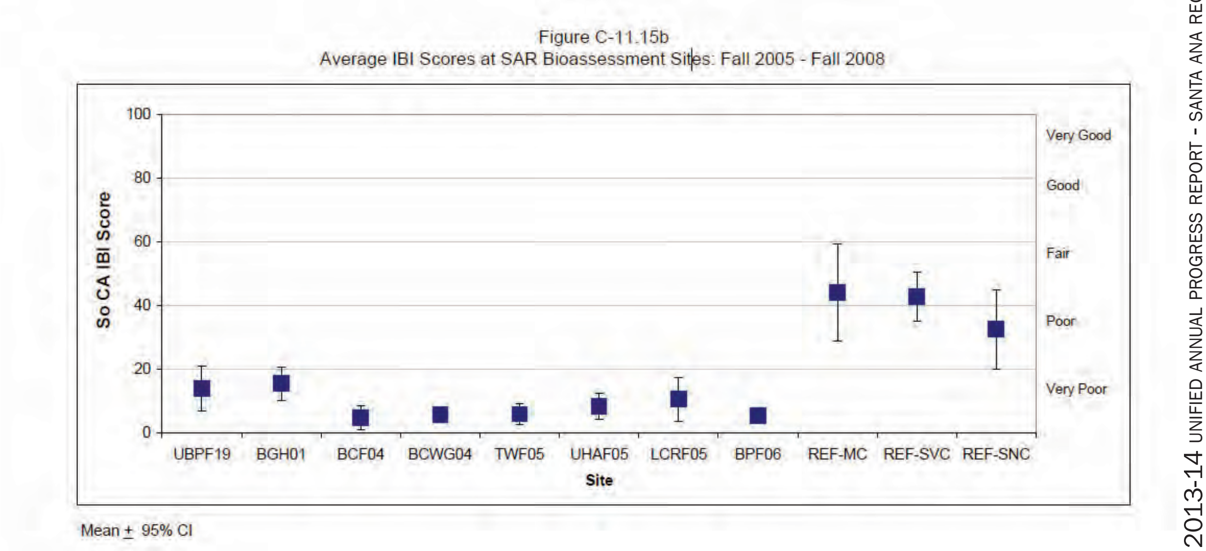
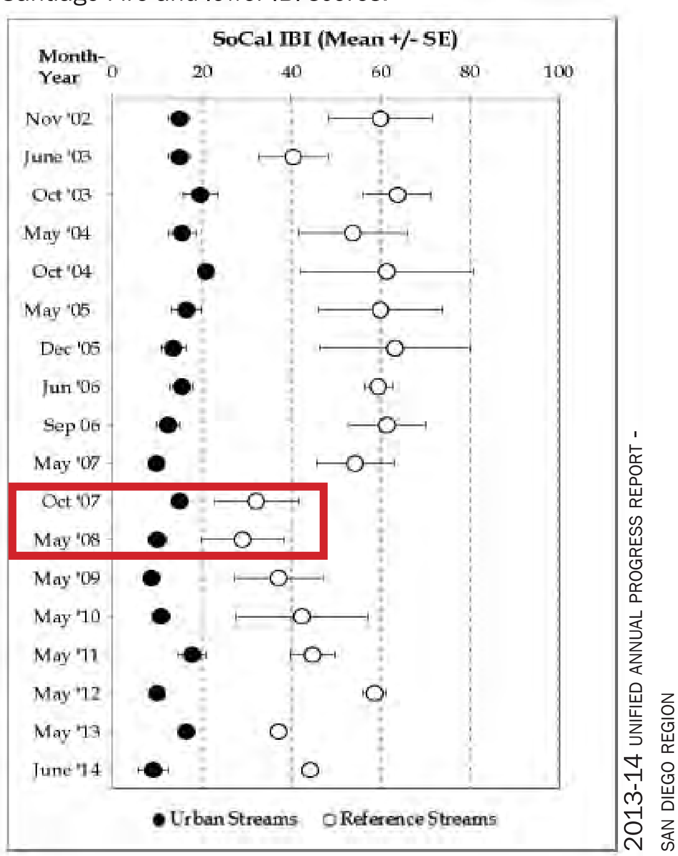


Figure 3. This chart shows the IBI scores for the San Diego Region and outlines the clear link between the Santiago Fire and lower IBI scores.



Santiago Fire
Oct. 2007

Portions of the Santa Ana Mountains are in both the Santa Ana and San Diego Regions. As reported in the San Diego Region 2013-14 Unified Program Effectiveness Assessment Report, a relationship between the sudden decline in the mean IBI scores immediately following the Santiago Fire of 2007 is apparent.

Note: The Laguna Canyon sampling site was moved in 2011 due to several factors. No data for this site is available after 2011.

A similar figure was not available for the Santa Ana Region. It can be reported that the Silverado sampling sites for this region had an IBI score of fair, much better than its urban counterparts at very poor.[65] While the approach of the county-wide stormwater monitoring program is to determine if and where problems exist, quantify the magnitude and extent of them, and identify the sources, it is rare that direct cause and effect relationships are made due to the complexity of the environment being monitored, and the extraordinary number of variables involved.[66]

While water quality had limited information, we know that air quality is impacted. Climate Central reviewed 11 of the largest fires in the last 12 years and found that in the majority of instances, the worst air quality days were those associated with the wildfire burning. In fact, "fires that burned within 50 to 100 miles of a city often resulted in air quality five to 15 times worse than normal."[67] And there was an increase in the number of hospital visits for respiratory related illnesses, with the biggest threat from fine particulate matter.

Recommendations

The data demonstrate that there are four general "hotspots" in the Santa Ana Mountains Study Area that show a propensity to burn: along the 241 Toll Road, Santiago Canyon Road, and Ortega Highway (Highway 74), and within the San Mateo Wilderness. For the Laguna Coast area it is along the Laguna Canyon Road between the 405 Freeway and the 73 Toll Road that the hotspot exists. Because of this information, FHBP has provided several suggestions for possible adoption by the US Forest Service, State Parks, OC Parks, Irvine Ranch Conservancy, regional non-profits, cities, decision makers, and/or transportation and fire agencies. We acknowledge that these recommendations may require an increase in expense and/or staffing. FHBP is able to provide outreach and education as well as information to the public and decision makers that may provide the impetus for implementing some or all of these recommendations. It is likely that recurring fire-fighting costs and damage to the habitats and homes far outweigh implementation costs.

CLAIRE SCHLOTTERBECK

Coal Canyon Fire (2002).

General

- To understand the details about wildland fires, fire agencies should determine, when possible, the exact cause and ignition location of a fire (arson, vehicle, fireworks, etc.).
- Enforcement of existing fire rules and regulations is essential if fires are to be reduced.
- Continue or create volunteer FireWatch programs and staff them on high fire danger days at high fire frequency locations to reduce ignitions.
- Educate homeowners and drivers, especially in the high fire frequency locations with the goal of fire reductions. For example, signage along roadways encouraging drivers to report suspicious behavior.
- Reduce fire frequency along roadways by reducing ignition opportunities. Brush clearance increases non-native plant growth and therefore increases fire ignition and spread. Weed mats have been successfully used along nearby Highway 71.
- Maintain buffers at the end of "chutes" (at the ends of canyons) by requiring homes to be clustered or moved beyond these areas as these homes are less defensible as the fires move up the canyon walls quickly.
- Include portable signage for residents and commuters to be cautious, alert and to report suspicious behavior.

MELANIE SCHLOTTERBECK

Weed mats installed along Hwy 71.

- Add new water quality stations in the upper watersheds and gather baseline information prior to fires occurring.
- Collect then analyze water quality samples post fire.
- Where appropriate de-energize problem powerlines during extreme Santa Ana Wind conditions and when it doesn't inhibit firefighting and overall public safety.
- Removal invasive exotic plants such as *Arundo donax* from the watershed.
- Decision makers should stop approving development projects in Very High and High Fire Hazard Severity Zones.


PROVIDED BY THERESA SEARS

Windy Ridge Fire (2007).

Santa Ana Mountains

- Focus fire reduction efforts along the hotspots areas.
- Harden the roadway edges along the 91, 241, 74 and Santiago Canyon Road. Hardening techniques can include vegetation removal, the addition of k-rail, and/or weed mats.
- Increase fire patrols or FireWatch presence on high fire danger days along the key roads.
- Work closely with residents to expand their understanding and personal responsibility to protect their property.
- Stop approval of new houses at the Wildland-Urban Interface and in Very High or High Wildfire Hazard Severity Zones.
- Continue to engage the Fire Safe Council to increase knowledge and understanding.
- Promote improved fire resistance and code upgrades for existing older canyon homes.

Laguna Coast

- Focus fire reduction efforts along the hotspots areas.
- Harden the roadway edges along the 133 between the 405 and the 73. Hardening techniques can include vegetation removal, the addition of k-rail, and/or weed mats.
- Utilize the parking areas and Nix Nature Center for information on fire prevention.
- Work closely with residents to expand their understanding and personal responsibility to protect their property.
- Consider creation of a FireWatch program in this area and/or a Fire Safe Council to engage residents.
- Promote improved fire resistance and code upgrades for existing older hillside homes.


PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

Laguna Fire (2012).

Conclusions

This study shows that portions of the Santa Ana Mountains and to a lesser extent portions of the Laguna Coast are burning more frequently than a healthy ecosystem can maintain. A natural fire frequency is one fire every 30 - 150 years. For the Santa Ana Mountains, there have been 164 fires in 100 years. For the Laguna Coast, there have been 22 fires in 100 years.


PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

Laguna Canyon Fire (2015).

Because we do not live in an area that has frequent lightning strikes, most of the fires that have started can be attributed (directly or indirectly) to humans. Only one of these fires, in the Santa Ana Mountains, has naturally occurred through a lightning strike. This would fit into the natural fire frequency. Instead, in the Santa Ana Mountains there is a fire burning roughly every seven months and a fire burning once every five years in the Laguna Coast.


PROVIDED BY LAGUNA BEACH FIRE DEPARTMENT

Fire trucks at every other house (2012).

While we have recorded one lightning strike, the acreage was 142 acres—relatively small. This sample size isn't large enough to determine if this is an average, maximum or minimum burn area for a lightning strike. In addition, weather conditions, water availability, fuel moisture, fuel load, and fire resources also play into how quickly a fire is contained.

For the Santa Ana Mountains, the average fire size for those started by humans or because of humans is 4,144 acres. By way of background, human caused fires tend to start along roadways, which are generally along canyon bottoms. Natural fires ignite along ridgetops where lightning strikes the ground. Fires that spread uphill do so at a higher rate of speed than those that burn downhill.

It appears based on the fire frequency that roadways, which provide access to natural lands, are a leading location of fire ignitions. It is clear the people have changed the natural fire regime. While some of the causes can be reduced by better managing vegetation along roadways, many of the causes are not known—which doesn't allow us to make recommendations on how to reduce ignitions since the cause is undetermined.

While the increase in fire frequency has an effect on the natural landscape—it also takes its toll on the residents. This study covered 1914 through 2014 yet while writing this report in 2015 three fires burned in the Study Areas. Residents must remain vigilant and be ready to evacuate with a moment's notice. So the toll isn't just ecologically and emotionally—it is also financial. All of these fires translate to an economic impact and have the great potential to damage or destroy homes and property.

As reported in the Hills For Everyone study, the habitats do not have enough time to recover from a fire before another burns it. This excerpt outlines the issue of type conversion from native plants to non-native plants:

"...increased fires mean a shift in the type and location of vegetation that normally could have recovered in a natural fire regime. When burned too frequently the native vegetation does not have enough time, and in some cases stored energy, to regenerate or become mature enough to produce seeds. This stress on the native vegetation allows non-native plants to dominate the landscape."


JOEL ROBINSON

Natural systems provide intrinsic values.

Natural lands have intrinsic value and ecological value, but those values aren't shared between agencies. For example, a fire agency viewing a natural landscape may see "fuel load," while a resource ecologist sees an intact habitat and watershed.

Maintaining intact watersheds and riparian corridors is essential to the health of the ecosystem and reduces the spread of wildfires. In other words, when streams and rivers have natural and native habitat—these areas provide a natural fire break. When streams and rivers are choked with non-native species—these plants actually help spread the fire.

Based on the fire history and potential for future development, especially in the Santa Ana Mountains, our decision makers should focus on the protection of existing communities rather than continuing to place new and future residents and homes in harm's way. Furthermore, it is each individual homeowner's responsibility to understand their geography, their escape route, and the ways their home can be penetrated by wildland fires or embers. Ensuring properly maintained defensible space is critical.

FHBP believes that to reduce this increased fire frequency, an emphasis needs to be placed on education and outreach by fire agencies and planning by our local jurisdictions. Furthermore, decision makers can protect life and property by no longer approving residential projects at the WUI.


GREG O'LAUGHLIN

Reduced fire frequency keeps people, property, and habitat safer.

Acknowledgments

Melanie Schlotterbeck is a conservation advocate specializing in natural resource protection in and around Orange County. Melanie is a technical consultant for numerous conservation-focused non-profits both locally and regionally, including FHBP. She has experience with GIS mapping, land conservation, research projects, and outreach. Some of her most recent efforts have led to the conservation of nearly 1,000 acres in the Santa Ana Mountains and Laguna Coast. Schlotterbeck earned her bachelor's degree in Environmental Geography and her Master of Science in Environmental Studies.

Claire Schlotterbeck, Melanie's mother, founded Chino Hills State Park and was the key researcher on water quality section for this project. Claire earned her bachelor's degree in Political Science from UCLA and a Master of Science from Purdue University.

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