Fire Incident Model for Cal Fire, California

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Introduction

This project focuses on modeling data from the CalFire website, https://www.fire.ca.gov/our-impact/statistics, to model and project fire incidents in the state of California.

Fire is an increasing issue affecting many communities today. This applies especially to the state of California. Through this model, we hope to show how quickly fire incidents have grown in California through recent years, and to help predict and project what future years might have in store for Cal Fire. Cal Fire is The Department of Forestry and Fire Protection for the state of California, a statement from their website reads as such, “CAL FIRE Serves and Safeguards the People and Protects the Property and Resources of California.” (CalFire)

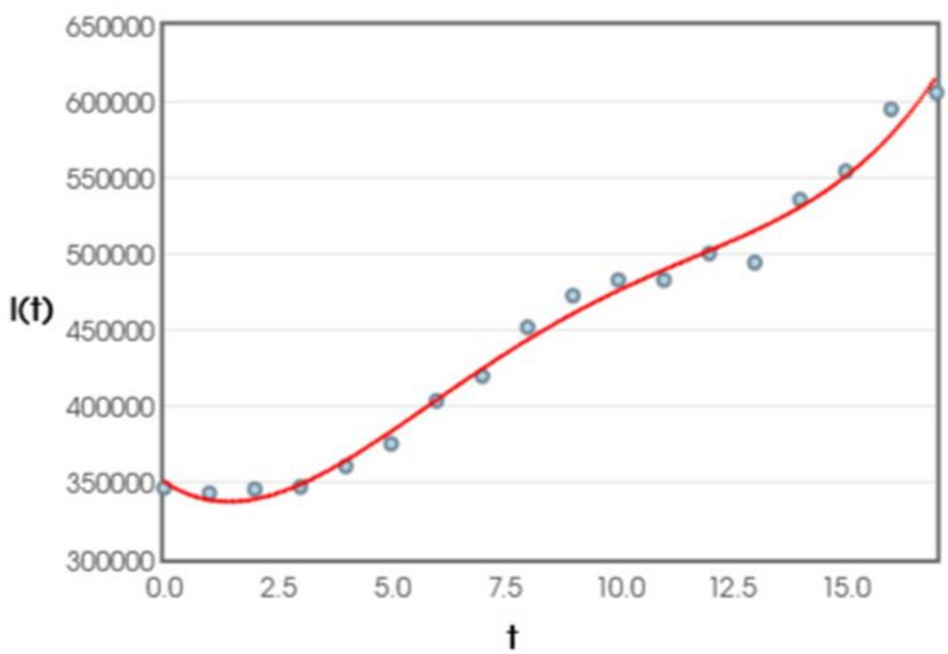
Photo Credit: Michael Darcy - https://verticalmag.com/features/raining-down-fire/

California is a large state, with the 5th largest economy in the world. A state this large and prosperous is home to many agricultural land and resources, National Parks, communities and cities, and forestry managed land. According to the National Interagency Fire Center, California leads the country with the most wildfires and the most acres burned.

The Cal Fire Model - Incident responses 2007-2023

This data was collected from the Cal Fire website. Through this site, the reader may find up-to-date statistics on California wildfires and CAL FIRE activities. This site uses both federal and state data to track the number of fires and acres burned in California, including data such as incident responses used for the model to be displayed. This data, as well as our graph, are displayed below.

I(t) = 2007-2024	Incidents per year
0	347045
1	343558
2	345998
3	347653
4	361142
5	375758
6	404048
7	420189
8	452014
9	472875
10	483116
11	483016
12	500518
13	494489
14	535819
15	554342
16	594971
17	605868



We found the best model, using online software, to be the Polynomial Regression Model.

The model,

$I(t) = 20.17 * t^4 - 707.49 * t^3 + 8266.96 * t^2 - 1973.45 * t + 351020.5$,

Assumes that t=0 corresponds the year 2007.

This model has an r^2 adj. equal to 0.99, indicating a good fit to the data relative to the number of model predictors.

Next, we will use this model to project the outcome for the year 2025. First, substitute 18 into x to find the projected number of incidents in 2025. We will round our answer to the nearest whole number of incidents.

$I(t) = 20.17 * 18^4 - 707.49 * 18^3 + 8266.96 * 18^2 - 1973.45 * 18 + 351020.5$

~ 669,000

Next, we will use the derivative of this model to find the growth rate of change for the year 2025.

$I'(t) = 80.68 * t^3 -2122.47 * t^2 +16533.92 * t – 19573.45$

$I'(t) = 80.68 * 18^3 -2122.47 * 18^2 +16533.92 * 18 – 19573.45$

~ 61,000

Here we see in 2025 that the rate of change is 61,000. These incidents per year mean that by the end of 2025, we estimate that the number of incidents in California will be increasing by about ~61,000 incidents per year.

Now, we will take a second derivative of our equation to find concavity and where the rate of change is increasing or decreasing.

$I''(t) = 242.04 * t^2 – 4244.94 * t + 16533.92$

Using the quadratic formula, we find the inflection points to be t = 5.84 and t = 11.70.

Then we will add these values to the year 2007.

2007 + 5.84 = 2012.84 rounded to = 2013   2007 + 11.70 = 2018.7 rounded to 2019

This indicates that there were shifts in wildfire incidents in the years of 2013 and 2019.

With these values though we will find the concavity of our curve. Finding a middle value between both points and using this to determine if our curve is concave down or concave up.

For the mean value between $5.8 < t < 11.70$, let's choose 8.

$5.8 < 8 < 11.70$, Now let's plug this into our second derivative to find the concavity.

$I''(8) = 242.04 * 8^2 - 4244.94 * 8 + 16533.92$

$\sim I''(8) = -1935.04$

Our negative value shows our curve is concave down between our inflection points of 2013 and 2019. So, between the 2013 and 2019 fire seasons, we saw a reduction in the rates of incidents each year.

Now we will choose a value above 11.70 to find the concavity of the graph after 2019.

I shall choose 13 for this value.

$I''(13) = 242.04 * 13^2 - 4244.94 * 13 + 16533.92$

$\sim I''(13) = 2254.46$

This value shows after the year 2019 we have a positive value equating to upward concavity. This indicates an acceleration in the rate of incidents beginning around the 2019 fire season. Since 2019, we have seen an increase in the rates of incidents per year.

Summary

Through this projection of incidents of fire in California, we can see an increasing number of fire incidents to be responded to. Numbers like this can help communities and workforce centered on fire control and suppression to plan and strategize the proper resources, equipment, and personnel needed to help with increasing fire incidents.

We hope that the model and its analysis can help individuals interested in fire research and fire management to understand and project future need that California will require to handle increasing incidents within the state. California is a large state that provides food and resources for communities far and wide. Helping to understand the need for fire response will help not just the forests and plains of California, but also communities with vital farmland.

The increasing frequency of wildfires, with regard to the state of California, also poses a significant threat to the communities of the state. These wildfires can result in devastating property loss. Homes, businesses, and other essential structures are at risk from these destructive fires. These fires not only destroy buildings but can also displace families and cause a future of economic struggles. For example, the wildfires of Los Angeles destroyed entire neighborhoods, reducing them to ash. The Palisades and Eaton fires being the most destructive burned 23,400 for Palisades, and 14,000 for Eaton. These fires also destroyed over 16,240 structures, not only that but 28 lives were taken. These losses are unfortunate, but important for understanding the impact of wildfire incidents. Studying these fire patterns can help all stakeholders towards protecting not only the landscape but the people who call California home.

References

California Department of Forestry and Fire Protection. “Current Year Statistics” CalFire, 2024 - https://www.fire.ca.gov/our-impact/statistics

CalFire. “Total Annual Incidents” December, 2023 - https://34c031f8-c9fd-4018-8c5a-4159cdff6b0d-cdn-endpoint.azureedge.net/-/media/calfire-website/images---misc/2023-total_annual_incidents.jpg?rev=cc38446a00044923b45989d028c399dc&hash=6E74FED028919C381CC6C94C349DF2A3

Li, Zhiyun, and William Yu. “Economic impact of the Los Angeles wildfires” PreventionWeb, 11 Feb. 2025, https://www.preventionweb.net/news/economic-impact-los-angeles-wildfires

Stats.Blue. “Software Suite” Stats.Blue. https://stats.blue/