

Process Book

Visualizing US Wildfires in 2020

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<https://github.com/reepoi/data-vis-2020-fires>

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1. Project Proposal

1.1 Background and Motivation

Our project team has a mutual interest in creating a visualization involving natural disasters. We talked to a data scientist with the Pacific Northwest National Lab who works with natural disasters, and he recommended visualizing the current wildfire season because it was so significant. Troy is a graduate student in a lab that works with wildfires, so we have additional resources to inform our project. Taos is from California, one of the most impacted states from wildfires.

The 2020 US wildfire season has been one of the most destructive seasons on record. As of October 29th, 2020, over 13 million acres of land have been burned and suppression costs are over \$3 billion ([National Interagency Fire Center 2020](#)). The previous record was 10.1 million acres in 2015, and since records began in 1960, the top 5 have all been since the turn of the century ([Congressional Research Service 2020](#)). Climate change is known to have a negative impact on forest resilience, or the ability of forests to recover post-fire ([Stevens-Rumann et al. 2018](#)), and climate change is expected to amplify in the coming decades potentially resulting in even more destructive fires.

A study by [Abatzoglou & Williams \(2016\)](#) found that warmer temperatures and an increased vapor pressure deficit, or the amount of moisture in the air compared to how much moisture the air can hold, has caused increased fuel aridity, or a measure of the lack of moisture, which can make fires burn more and last longer. They estimate that climate change has contributed to an additional 10.2 million acres of forest fires from 1984 through 2015 which is an equivalent area to the states of Maryland and Delaware combined. Therefore, it is important for the public to be aware of this rising issue, especially for those who are not impacted by wildfires.

1.2 Project Objectives

What is the visualization trying to answer?

- Show the extent and damage of the 2020 wildfire season, which was the worst on record

- Make the data feel tangible; give the viewer visual references to show just how bad the damage is.
- That the 2020 wildfire season is not an outlier; wildfires have gotten worse recently
 - It won't be our goal to attribute wildfire growth to a single factor (that's more complicated and is a combination of factors like climate change, management, etc), but to show that it is a trend.

What are our learning goals?

- How to draw an interactive map, which could involve a custom D3 map or a JavaScript library such as Leaflet.
- How to tell a story with a map.
- What data is appropriate to be displayed on a map and what is not.
- How to balance the amount of information shown in a visualization, the amount of interactivity (learning curve), and 'cool' effects.
- How to find the appropriate information for the visualization. Especially for geographic data; the choice of point vs polygon data will change the direction of the design.

1.3 Data

We will use active fire data from the National Interagency Fire Center (NIFC). For the 2020 wildfire season map, we will use the current fire boundary polygons that include the name of the fire and the mapping method. We will enrich the polygon data using the data from the current wildfire statistics PDF which includes point location information. The PDF includes data that could be used in additional diagrams (optional features). In part 2 of our visualization, we will utilize the historical wildfire statistics data to show trends in wildfires over the past 30+ years. We also have data for contributors to wildfire growth, such as drought and above normal temperatures.

- [Current Fire Boundaries \(Polygons\)](#)
- [Current Wildfire Statistics \(PDF\)](#)
- [Archived Wildfire Boundaries \(Polygons\)](#)
- [Historical Wildfire Statistics \(HTML Table\)](#)
- [Top 20 largest California wildfires \(PDF\)](#)
- [Historical data for climate extremes](#)

1.4 Data Processing

- Polygon data
 - We will need to clean the polygon data before loading it into our code. There are many attributes for each polygon that are not needed for our work, and each fire may have several polygons. We'll need to simplify the data for our needs by removing unnecessary attributes and combining polygons to encompass a single fire. There may also be polygons for small, insignificant fires, so we will need to remove these to reduce clutter on the map. This data processing will likely take place in a geographic information system (GIS) like ArcGIS Pro. The data is currently stored in a file geodatabase, so we'll then need to convert this data into a GeoJSON file. ArcGIS Pro provides a [built-in tool](#) for converting file geodatabase features into GeoJSON format.

- Text data
 - We're having trouble locating the original data for some of the historical statistical data from the National Interagency Fire Center, so we'll have to scrape the information from the web or PDF file. We tested a web scraping tool online (PDF to Excel converter) and it works reasonably well to reformat the data. We'll still need to spend some time reformatting the file, doing a quality check, and getting it ready for a CSV data load into D3.
- Data Enrichment
 - The polygon data includes the spatial extent of each fire while the text data contains much of the information we want to attribute to each fire. Within the text data, there is included information for the fires' center point (latitude and longitude), so these data can be converted to point data on a map. We can use ArcGIS Pro to [spatially join](#) the point data to the fire boundary polygons. We can then export the joined and cleaned data to a GeoJSON file.

1.5 Visualization Design

At the top of our design, we'll show a simple scorecard to show the total number of acres burned, the total suppression cost, and total deaths. The rest of the visualization design consists of two components. The first part of the visualization will include a map showing the fires of the 2020 wildfire season along with a coordinated view showing additional data such as acres burned, fatalities, structures destroyed, and fire suppression costs. This view will also include storytelling where the viewer can click next or back and see facts about this wildfire season. When clicked, the map will pan and zoom to the extent of the subject but the user will still be able to pan the map if they please. Some topics for the storytelling include the largest fire, a comparison of the largest fire to a known place (i.e. projecting the fire polygon centered over Salt Lake City), the fire with the highest suppression cost, and the fire with the most fatalities. Within these views, the user can also select other fires from the coordinated view (bar chart) or select different fires as they pan the map. The map will also include a tooltip. The encodings are points with a location on a map (zoomed out), polygons on a map (zoomed in), and length (bar chart). The points will remain static in size but be coded by color according to the dataset selected (yellow to orange to red, consistent with what a user would expect for fire) and will only be encoded by size and location (polygon) when zoomed, since it will be in focus and specific information will be displayed in the coordinated view.

The second part of our design will show how wildfires have gotten worse during recent history. We will display various charts including the total area burned per year since 1983, the top 20 wildfires in California, 4 of which from 2020 that are in the top 5, and other statistics. There will also be optional features included in this portion, depending on how much time we have, including showing other trends in data that may be contributors to the increase in wildfires (high temperatures, droughts, etc), and another map that overlays all of the fire perimeters in the 1960s (first layer) and 2010s (second layer) in California, to show how more area is burning now than before. As it stands, this part of the design will include the length and position encoding for points, lines, and bars. We will avoid color here unless it is used to distinguish unique values.

Final Design (described above)

[View full-res visualization design](#)

Prototype Designs

[Map view with state focus](#)

- This design incorporates a single map view with a coordinated bar chart alongside the map.
- The data is encoded with location, size/shape, and length. Location on the map is important for wildfire boundaries because it gives context to what was affected. Shape will allow the viewer to directly see how big the fire is. However, for comparison purposes, we added a bar chart (length) so that the user can see which fire was the largest.
- The interactivity includes the ability to select a state or a fire within the state. On click, the map will auto-zoom and pan to the fire/state extent.
- The data displayed will change according to the zoom level. Point data will be displayed for the fires when zoomed out while polygon data will be displayed when zoomed in. This change in encoding is important because when zoomed out, it may be impossible to see or select smaller fires, so a scalable point is more appropriate.
- An animation slider is included for the year.
- The Next/Back buttons will highlight major events of the season.

[Map view with individual fire focus](#)

- This design is similar to the above but will focus more on specific fires than the states. The encoding remains the same.
- The coordinated view will show sorted information for acreage burned, structures destroyed, fatalities, cost, etc. The fire can be selected from the map or bar chart. The data will change according to the story position, but the user can explore the map at any point in the story.

[Map with fire overview, storytelling, animation](#)

- This is a sample design of main visualization. A US map with red spikes indicating wildfires at the corresponding locations. Each spike's height specifies how severe the fire is (by acres or by number of active days).
 - Hovering on each spike will toggle a display box of brief information about the fire
 - Double click on the spike will toggle a zoom into that state and display the fire as an area of effect (polygons in geoJSON), and a display box to give more details about the fire
 - **Why the spikes?** I was inspired by this visualization:
<https://www.nytimes.com/interactive/2020/10/15/us/coronavirus-cases-us-surge.html>
Which is very eye-catching and I think the spikes can tell how serious wildfires are by the states.
 - **Why not the spikes?** We've discussed that with too many fires to visualize, there will be spikes overlapping each other, which can be an annoying issue to select them one-by-one

- There are also a slider to see cumulative fires by date starting in 2020 and a story-telling text box that lets the user navigate around the visualizations we want to show them. As a user experience practice the arrows at left and right side should do the same function as the text box's back and next buttons.
 - For the story-telling box, I was inspired by the 3D visualization we had in class (about the yearly yield and long-term predictions), it would be great to tell a story in that box along with navigating through multiple views/visualizations.

[Choropleth map with state and county view](#)

- The goal of this design is to show a quick overview of the United States relative to fires and then provide more detail on demand.
- Some states have many fires so having icons for individual fires when viewing the country as a whole can get crowded. The choropleth United States map is colored darker when there are more fires, and lighter when there are fewer.
- The choropleth view removes the viewer's ability to find information about smaller regions within states and individual fires. To maintain this information access, the viewer can click on a state to view a choropleth map of the state's counties; further, they can click on a county to finally view the individual fires as polygons.
- The viewer can click on individual fire polygons to view information about that fire with an adjustable context: comparing to other fires in the county, other fires in the state, other fires in the country.
- Some states are similar relative to fire damage while others are very different. To help the viewer see how their selected region (state, county, or fire) compares, a 'Similar Regions' section will be displayed.

1.6 Must-Have Features

- Map to visualize the wildfires in the U.S. during 2020
- Coordinated view along with the map:
 - Bar charts alongside the map
- The ability to pan and zoom the map
- A tool-tip for the map.
- Storytelling within the map that updates the coordinated view, highlights certain fires, and adds additional context about the fire. This should be implemented with next and back buttons and the map will pan and zoom upon clicking these buttons
- Charts in a second section showing how fires have been getting worse in recent years
- A well-designed website to showcase the visualization - simple, clean, and not distracting from the data

1.7 Optional Features

- A base map (Leaflet), as opposed to plain state outlines and city labels.
- More charts to show trends in other factors that contribute to wildfires
 - Weather/climate-based: temperatures, droughts, etc
 - Fire causes (human, lightning, powerlines, etc)
- A map that shows the extent of fires in the 1960s compared to the 2010s; two layers drawn on the map.

- The website is fully adaptive to changing window size and mobile devices
- Include state-level information, i.e. summarize the fire season for California, Oregon, etc and allow the user to click the state and update the coordinated view to see that state's information.

1.8 Project Schedule

Note that delegated duties are likely to evolve as we progress in our project.

Date	Description
Mon, Nov 2	<ul style="list-style-type: none"> • Initial design finalized (Troy) • Project proposal submitted (All) • Website functions finalized (Huy) • The basic framework of the website established (Huy) • Start building the U.S. map (Taos)
Thurs, Nov 5 (Project Feedback)	<ul style="list-style-type: none"> • Project Peer Feedback (All) • Data processed (Troy)
Mon, Nov 9	<ul style="list-style-type: none"> • Implemented a Leaflet and button zoom/pan function (Taos) • Added data to the map (Taos) • Historical fire data views (charts) created (Troy)
Sun, Nov 15	<ul style="list-style-type: none"> • Project Milestone (All) • Add coordinated views
Mon, Nov 23	<ul style="list-style-type: none"> • Documentation (All) • Debugging (All) • Styling and refining website design (All) • Any other catch up (All)
Mon, Nov 30	<ul style="list-style-type: none"> • Finalize project and have a meeting for final tweaks (All)
Wed, Dec 2	<ul style="list-style-type: none"> • Project Due

2. Related Work

2.1 Examples

Fire Weather and Avalanche Center Web App

<https://www.fireweatheravalanche.org/fire/>

The Fire Weather and Avalanche Center map displays a large variety of data and is more of a web application. It's messy, but it displays many of the data that may be available for our project.

Incident Information System (InciWeb) Web App

<https://inciweb.nwcg.gov/>

InciWeb shows very similar data to what we want to use in our map view, except the fire point data are only for current fires, not all fires for this year. It also follows a similar behavior to our idea to only display polygon data when zoomed in.

New York Times Fire Tracker

<https://www.nytimes.com/interactive/2020/us/fires-map-tracker.html>

The NYT Fire Tracker displays previously burned areas, areas burned recently (past 7 days), and areas actively burning (past 24 hours). They also have an air quality map with color encoded point data.

Our World in Data

<https://ourworldindata.org/natural-disasters#us-wildfires>

There are several bar charts that show the number of fires, the number of acres burned, and the number of acres burned per fire. We have access to this same data, so we'll likely use a similar chart to show historical trends for wildfires.

Esri ArcGIS StoryMap

<https://storymaps.esri.com/stories/usa-wildfires/>

Esri, the makers of ArcGIS, created an interactive StoryMap that displays major fires from 2020. There is a coordinated view that shows a timeline, this view updates according to which fires are in the map extent. The fires are displayed in a heatmap style where larger fires are encoded by larger circles. The data includes the fire name, acres burned, and percent contained.

New York Times Interactive Story

<https://www.nytimes.com/interactive/2020/09/24/climate/fires-worst-year-california-oregon-washington.html>

This NYT story titled "Record wildfires on the west coast are capping a disastrous decade" features an eye-catching visualization of major fires burning. The visual shows several satellite images and animates fires burning, encoded by orange dots. It's a beautiful visualization but it does not give the user any usable information. The story goes on to show several simple charts about how fires have been getting worse with time.

NBC News Fire Extent Comparison

<https://www.nbcnews.com/news/us-news/map-compare-west-coast-wildfires-2020-n1240011>

This visualization projects a fire extent over a user-input location. There is also text showing how large the fire is, and how much larger the fire is than the location. There is a dropdown box that allows the user to select which fire to project on the map. This visual is very impactful to show the user just how large the fires are, especially for those who don't live in a region where fires occur. This is something we're considering borrowing as a part of our storytelling.

National Geographic Burn Area Comparison

<https://www.nationalgeographic.com/science/2020/09/western-wildfires-have-now-burned-area-bigger-than-new-jersey/>

This visualization compares the total area burned in California, Oregon, and Washington to common places, like a tennis court, a track, Central Park, Manhattan, and the state of New Jersey.

3. Project Peer Feedback Session

Classmates Giving Feedback: Joachim Meyer, Abishek Krishnan

3.1 General Questions

- Are the objectives interesting to the target audience?
 - Yes, as a fire educational website, to show a map and a static number allows the user to get the full picture of where and how much area was burned.
- Is the scope of the project appropriate? If not, suggest improvements.
 - Yes, it gives enough information for the user but not too much to overwhelm them
- Is the split between optional and must-have features appropriate? Why?
 - Yes, there are many possible extensions to the visualization, but they aren't completely necessary to the story/data. These optional features are more of 'wow' factor items than showing meaningful data.
- Is the visualization innovative? Creative? Why?
 - Yes, the visualization has several avenues for storytelling, from navigating current fires, to viewing the history, to exploring causes.
- Does the visualization scale to the used dataset? Could it handle larger but similar datasets?
 - This may be the main challenge of this project - there is a lot of data but it needs to be balanced to show the data while not throwing many large datasets at the user. The current visualization design should scale well, but larger polygon datasets will need to be reduced in size (reduce vertices, or load subsets at one time).
- Is the project plan detailed enough? Is a path to the final project clear?
 - Yes, there is a path to the must-have features and the optional features are only added if time allows.
- Is an interesting story told?
 - Yes, the visualization guides the user through the story with direct navigation and gives interesting facts and meaningful data.

3.2 Visual Encoding

- Does the visualization follow the principles used in class?
 - Yes, the visualization shows the data and only the data. Design is clean and uses proper encodings.
- What is the primary visual encoding? Does it match the most important aspect of the data?
 - Location and size are two of the primary encodings, as well as length and position for any additional charts or views. Since the fire data is location specific,

it makes sense to put this data on a map.

- What other visual variables are used? Are they effective?
 - Color will be used to encode the active metric (acres, cost, etc). The color scheme is graduated. This seems to be effective when used on a map.
- Is color sensibly used? If not, suggest improvements.
 - The color scale is graduated and follows a yellow to red scheme that seems fitting for a visualization about fire. The color encoding is good for getting a general idea of where the worst fires are. This seems to be the best encoding for this, as the other option is 3D.

3.3 Interaction and Animation

- Is the interaction meaningful? If not, suggest improvements.
 - Yes, the main interactions are panning and zooming and selections. The viewer is able to select either coordinated view and the map updates to that feature. This is pretty intuitive and interesting.
- If multiple views, are they coordinated? If not, would it be meaningful?
 - There are multiple views where the map view is the center piece, the left are charts, and the right is selection information. The chart coordinated with the map gives the viewer an idea of how the selected fire compares to other fires.
- Is there any animation planned? Is it clear? Is it intuitive?
 - Yes, at least for the map. The storytelling will jump to specific areas of interest, and an animation will provide context.

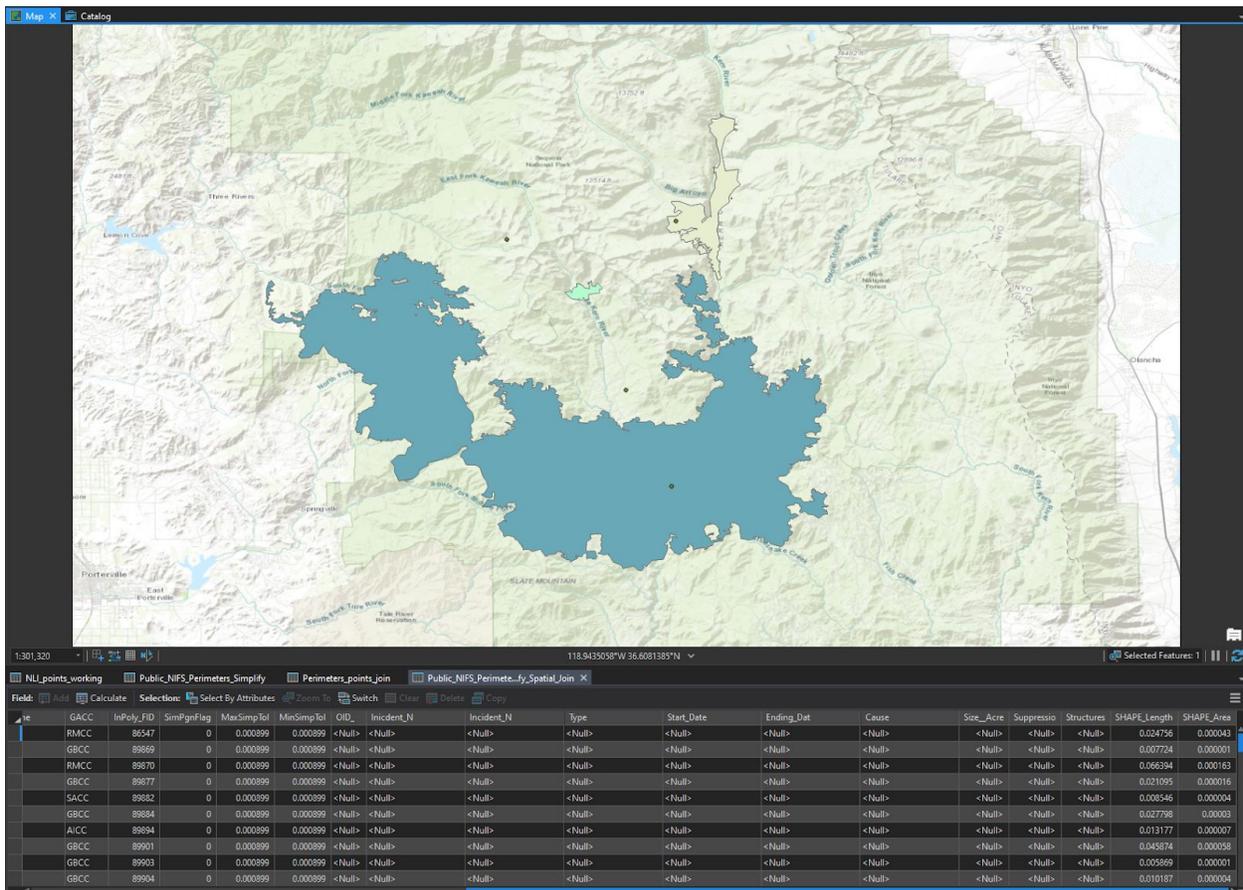
Other comments:

Add copyright information to map

4. Data Processing

We decided the best way to display our data was to use a combination of point and polygon data. We found direct sources for this data, however, they were compiled by different institutions and, while the essential information was the same (name, size, acres, etc), the locations and organization of the data was different. In an ideal situation, the point and polygon data could be joined based on primary keys or a combination of foreign keys. In this case, the point and polygon layers only shared names in common, but many were not exact matches. Some data named the fire complex while others named the individual fires. This leads to another problem; in some cases, the polygon data grouped some fires as a complex while the point data had several individual points that are part of that complex. To address these issues, we had to manipulate the data. Our thinking was to first enrich the polygon data with the point data. We accomplished this by spatially joining (if the point intersects the polygon, the point data is joined to the polygon data). There were some mismatches in location, so there were some cases where we had to move the point data to fall within the polygon after we confirmed they were the same fire and the data (acres lost) matched. Once the data were joined, we removed the original point data and created new points centered in the middle of each polygon. In the end,

the point and polygon data contain the same information except the point data will be shown when zoomed out and the polygon data when zoomed in.



A screen capture showing polygon and point data in a California forest. In some cases, points did not correspond to polygons, and some small polygons did not have point data.

Due to the data inconsistency, we will add a disclaimer to the project that the data within the map view does not include every single fire. The map view is intended to show the user major fires only. Summary statistics will include all of the data. It also must be noted that the 2020 wildfire season was not complete at the conception of this project, so this visualization is representative of most, but not all, of the 2020 wildfire season.

5. Data Ambiguity

5.1 Summary

Over the course of this project, we've had difficulty searching for data. Not that we could not find data; this was not an issue, but that the quality of the data and its format was questionable. Since we are covering the 2020 wildfire season, there was no expectation that we would have all of the data, not to mention scientific quality data. The main goal of this project was to show

the extent of the 2020 wildfire season and historical trends. Our analysis has shown that there are not more fires, instead fires are increasing in size and total area burned is increasing. The data we have will accurately portray this. At the same time, we want to have as accurate of data as possible. Fortunately, we were able to contact a Bureau of Land Management (BLM) Public Affairs Specialist who is affiliated with the National Interagency Fire Center (NIFC). She provided us with excellent insights on the datasets we're using for our project. This will allow us to accurately display our data with the proper disclaimers, and has opened communication for us to improve or update our visualization after this class ends if our team wishes to pursue this. We also found the discussion interesting and worth adding to our process book, included below.

5.2 Conversation with the NIFC

Troy 11/10/20:

"I am creating a visualization about the 2020 wildfire season and am gathering statistics from the NIFC. I found the National Large Incident YTD Report for specific fires on the GACC website and the fire info page on the NIFC website.

The Large Incident Report lists the cumulative area burned as 13.5 million acres while the NIFC fire info page lists 8.7 million acres burned. I would like to know, what are the differences between these figures? Why is one significantly larger than the other?"

BLM/NIFC Employee 11/12/20:

"I was asked to respond to your recent inquiry about the difference in total year to date acres burned from the two reports you were viewing. I forwarded your question to our Intelligence desk at the National Interagency Coordination Center. They develop the Incident Management Situation Report (IMSR) where the numbers come from for the National Fire News reports. They provided a little background in our fire reporting systems which may help explain why the data is different.

The IMSR is pulled from Fire and Aviation Management Web Applications (FAMWEB), which generates reports from the fire reporting systems federal agencies use (from where the GACC is also generating it's report). The IMSR is based on what is inputted into the Incident Situation Report (SIT-209). The SIT-209 is used to collect intelligence information related to the wildland fire management incidents and resources. SIT collects daily fire activity and initial/extended attack resource information during the active fire season for the local dispatch office. 209 is used to collect and store ICS-209 large Incident Summary information. This intelligence information is used to support the decision making process related to wildland fire resource placement and use.

The SIT-209 program is an Interagency FAMWEB application with two distinct functions. The 'SIT' side of the application captures Fires and Acres burned by protecting and ownership agencies as well as a mechanism to report prescribed fire statistics. This data is entered by dispatchers manually at local dispatch centers throughout the country. These statistics are

meant for fire managers at the local, geographic and national level and are not official statistics for any federal, state or local fire entity.

The '209' side of the application is a situational document meant to capture incident specific data for large or locally significant wildland fires and all risk emergencies. The 209 captures over 50 data elements that are entered either by the local dispatch center or incident personnel that captures incident size, complexity, critical resource needs, weather, projected activity, etc... The situational nature of this document does not reflect fire reporting for a given incident (even after the incident is contained and the 209 is finalized).

Utilizing summary report data from multiple 209's within the 209 application will result in erroneous data as many incidents are complexed or merged into other incidents and double reporting is frequent. An example of this would be on November 12 2020, where summing all acreage burned in the 209 application exceeds 13 million acres while statistically only 8.7 million acres have actually burned nationally.

Therefore, this data is not used for official agency statistics, only for a snapshot into situational awareness for that time. All final reporting is supposed to be completed by the end of the calendar year when we can confirm actual fire numbers and fire acres within each agency's reporting systems. With that said, some fires may not be out by the end of the year, so incident reporting continues into the next year.

I hope this makes sense. That was a very long explanation as to why the numbers don't match."

Troy 11/12/20:

"Thank you for the very thoughtful and informative response. This makes sense and lines up with my expectation for preliminary data while the season is still active. I've been developing my visualization with the understanding that the data is not of scientific quality. I'm using the wildfire perimeter data available from the NIFC as the primary visual and have enriched this polygon data with suppression costs and structures destroyed from the IMSR.

I have two more questions:

Once the season has completed and the data has been reviewed, is there a primary source where this data is made available? By this, I mean will final data for each named fire incident be published somewhere as either point or polygon data, or in a text report?

Does the duplication of records also apply to the total fire suppression cost which is currently listed as ~ \$3.4 billion? If so, is there an unofficial total for 2020 so far?"

BLM/NIFC Employee 11/13/20:

"NIFC doesn't maintain records for every individual fire. Final fire reporting information is held at the agencies responsible for managing the fires. With that said, the information you are looking for should be available in the fire reporting system once fire reports are finalized and vetted which is generally by the end of January.

This year, however, is going to be a little tricky as several agencies have moved to a new fire reporting system named InFORM, Interagency Fire Occurrence Reporting Modules. Since

InFORM is still in the development phases, I have not heard how/where final report data will be stored or how to access it. We do have some data analysts that can pull data, if needed, so keep in touch for that.

As far as suppression costs, the totals currently in the reporting system are estimated and there could be some duplication as well. Costs are tricky, too, as NIFC only tracks federal costs nationally as a whole, not individual fires. The agency who is responsible for managing the fire would track the actual costs at the local regional level and should include all costs federal, state and local. The estimated costs in the reporting system are inputted by the dispatch or incident personnel responsible for the fire (as with the other information), so they would be estimated based on resources used.

For FY2020, nationally the Department of Interior has spent \$510 million while the US Forest Service has spent close to \$1.8 billion. Again, that does not include state and local costs.

I know CalFire reports their costs of their website for the state of California. Other states may have something similar for their Forestry Divisions, but you may have to do some searching.

I will check with the U.S. Fire Administration and National Association for State Foresters representatives here, to see if they have totals for state and local costs. Or if there is somewhere you could find those.

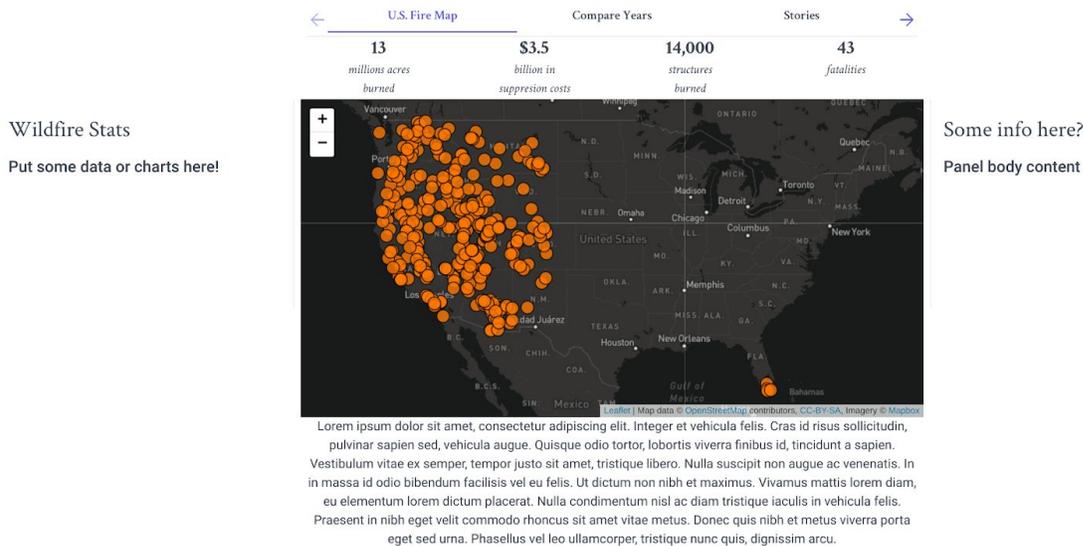
Sorry I wasn't able to give you a complete answer. Wildfires are multijurisdictional with a lot of moving parts and they can be complicated.

As far as the reporting, stay in touch. I will find out more as the year comes to an end."

6. November 10th Project Update

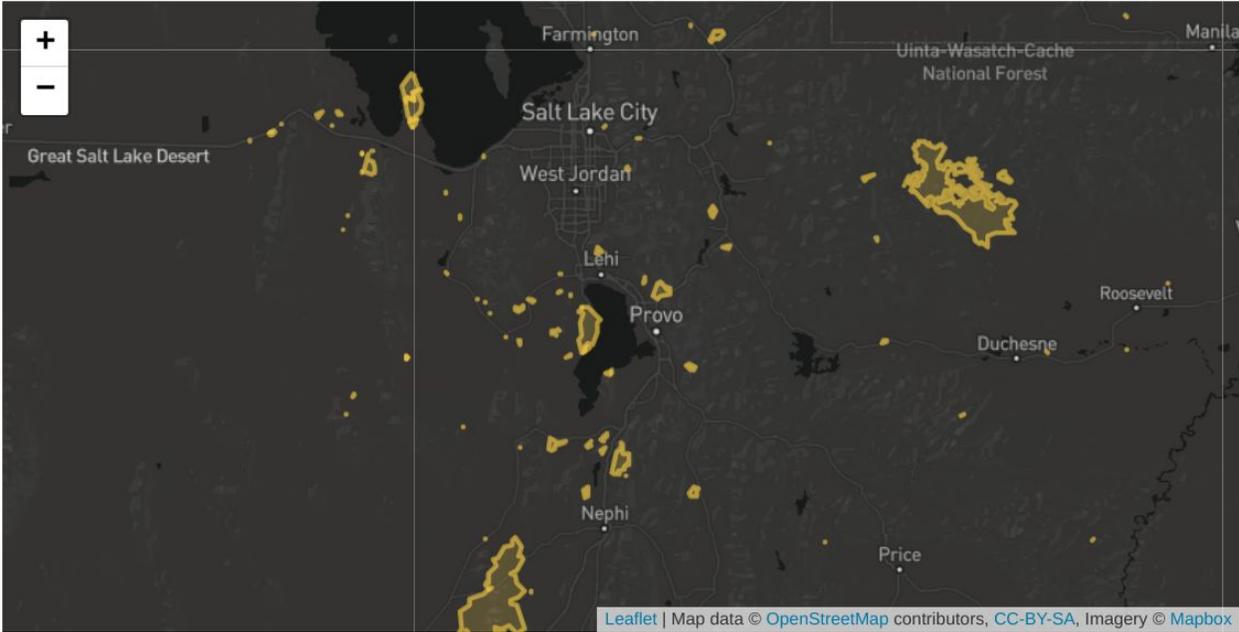
6.1 Progress Update

Our team met on November 10th to discuss our initial progress with the visualization. At this point, we've finalized the point and polygon wildfire datasets, implemented the web page structure, and added the map with data to the page.



The visualization upon first load.

We are on schedule at the moment and haven't had any major issues so far. In the current implementation, fire points are displayed when the map is zoomed out. The user can either zoom in or click on a fire point and the map will zoom to an extent where fire polygons (perimeters) are now visible, centered at the clicked point. Now, the user can click a specific fire polygon to zoom further. Since it may be difficult to select a specific point when fully zoomed out, we see the two step zoom behavior as desirable and more user friendly. Polygons also change color when hovered. The website structure consists of 4 panels and 3 tabs. The left panel displays statistics and charts, the right panel displays fire information, the main panel shows the map view, and the bottom panel shows text information. The tabs will update the views. In the compare years view, we intend to plot fires from the 1960s to fires in the 2010s on the same map (California only, they have reliable data). The third tab is where we may add charts with historical data, such as a bar chart showing the acres burned per year nationwide since 1983, when reliable records began for wildfires.



A point near Salt Lake City was clicked; the map zooms to show the wildfire perimeters in that area.



The East Fork fire, in the Uinta Mountain Range, was clicked and the map zooms to show its perimeter.

6.2 Next Steps

6.2.1 Map View

Much of the map view has been implemented, but there are several tweaks that can improve the user experience.

- Add custom icons for the point data. Instead of orange dots, add fire symbols (such as the favicon for the website) and color them according to fire size. We're thinking of creating a scale that adjusts the opacity (100% is the largest fire, 50% is the smallest fire). Ideally, we would use a color scale, but that may require us to hardcode a range since we're using a custom icon. For example, we would need to create icons for each: red (1,000,000 - 250,000 acres), red-orange (250,000-100,000 acres), orange (100,000-50,000 acres), yellow-orange (50,000-10,000 acres), and yellow (<10,000 acres). We may need to experiment with our options to figure out which is best. The opacity option may create issues with overlapping points.
 - The Beautify Icons Leaflet plugin may solve these issues. There is potential that we can apply a color scale to Font Awesome icons. [L.BeautifyMarkers](#).
- When a fire polygon is selected the polygon remains colored differently than the other polygons.
- When a fire point is hovered, it changes color. We would need to use a color that is distinguishable from our color scale. Light blue is a common color used in mapping programs.
- Add a widget to reset the zoom extent. Built-in function to Leaflet. [L.zoomhome](#).
- Add a search widget so users can search for a fire. Built-in Leaflet function. [L.search](#).
- Add a minimap widget so the user can get additional context when zoomed into a polygon. Built-in Leaflet function. [L.minimap](#).

6.2.2 Coordinated View

We haven't implemented the coordinated view at this stage. We're still thinking of displaying bar charts showing the top fires where the selected fire gets updated to the top of the bar chart so the user can compare it to other fires. We hope to complete a prototype of this before the milestone.

6.2.3 Fire Information View

We intend for the tooltip to display only basic information, such as the fire name. The rest of the information will be contained in the fire information view (right panel) such as the number of acres, structures destroyed, suppression cost, fatalities, etc. This is not implemented yet and we hope to prototype this before the milestone.

6.2.4 Text (bottom) View

The bottom view will be a simple text paragraph that gives the user a short summary of the data.

6.2.5 Compare Years Tab

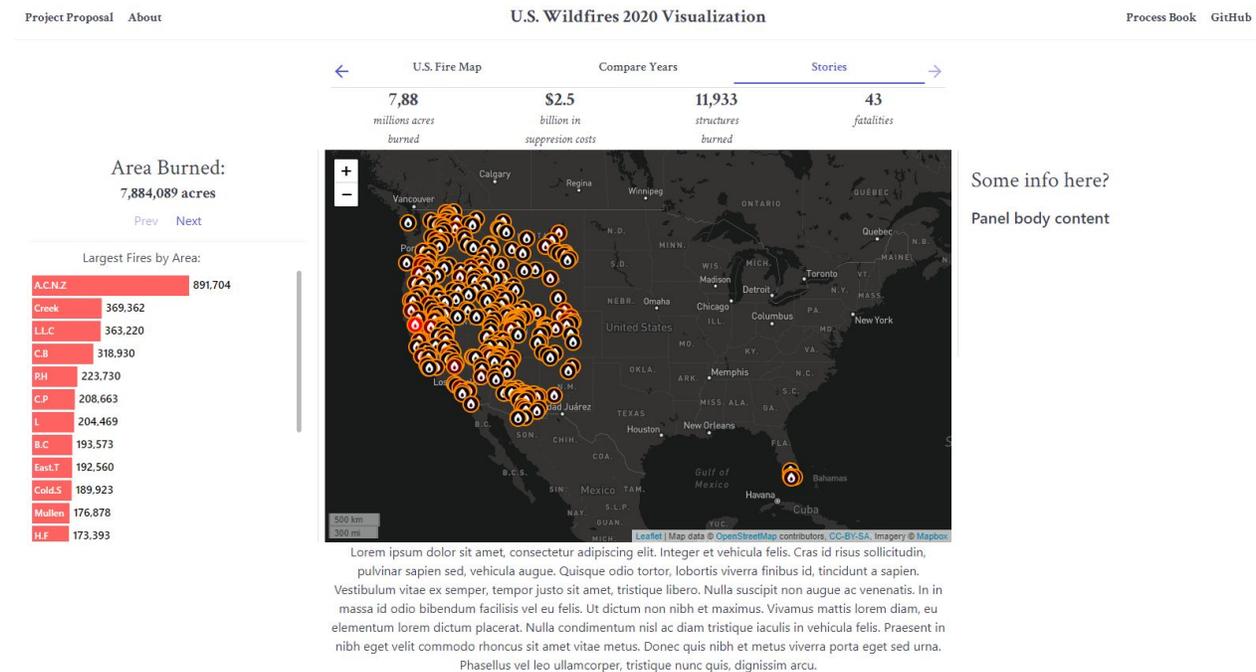
At this meeting we decided that the 'Compare Years' tab would show a map view with the fires from the 1960s and 2010s in California, shown on the same map. These layers will be added with a set opacity so the user can see both fires where they overlap as well as see if multiple fires occurred in the same location (this is common). This data is made available by [CalFire](#).

This component was inspired by [this visualization by Capradio](#). In our visual, we want to make it easier to compare past years to current years. Capradio's visual has a continuous scale making it difficult to know which year the polygons are.

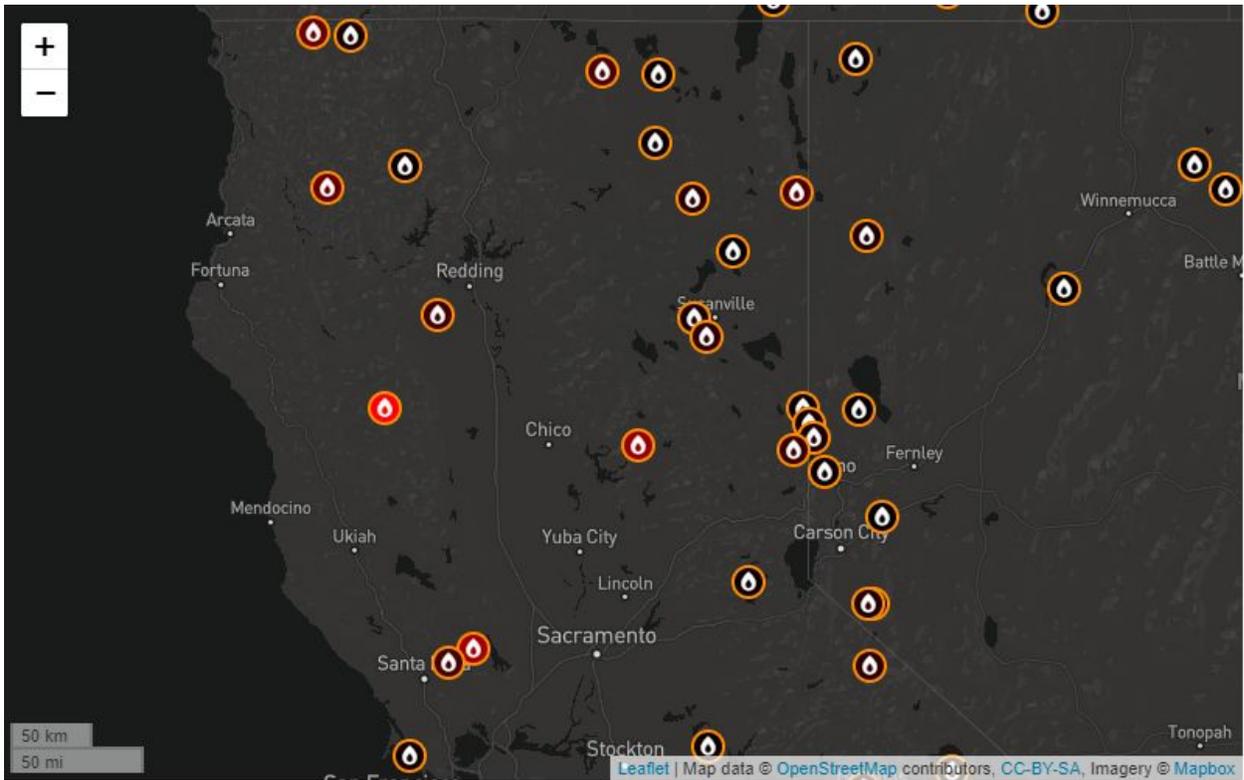
7. Project Milestone

7.1 Progress Update - November 15, 2020

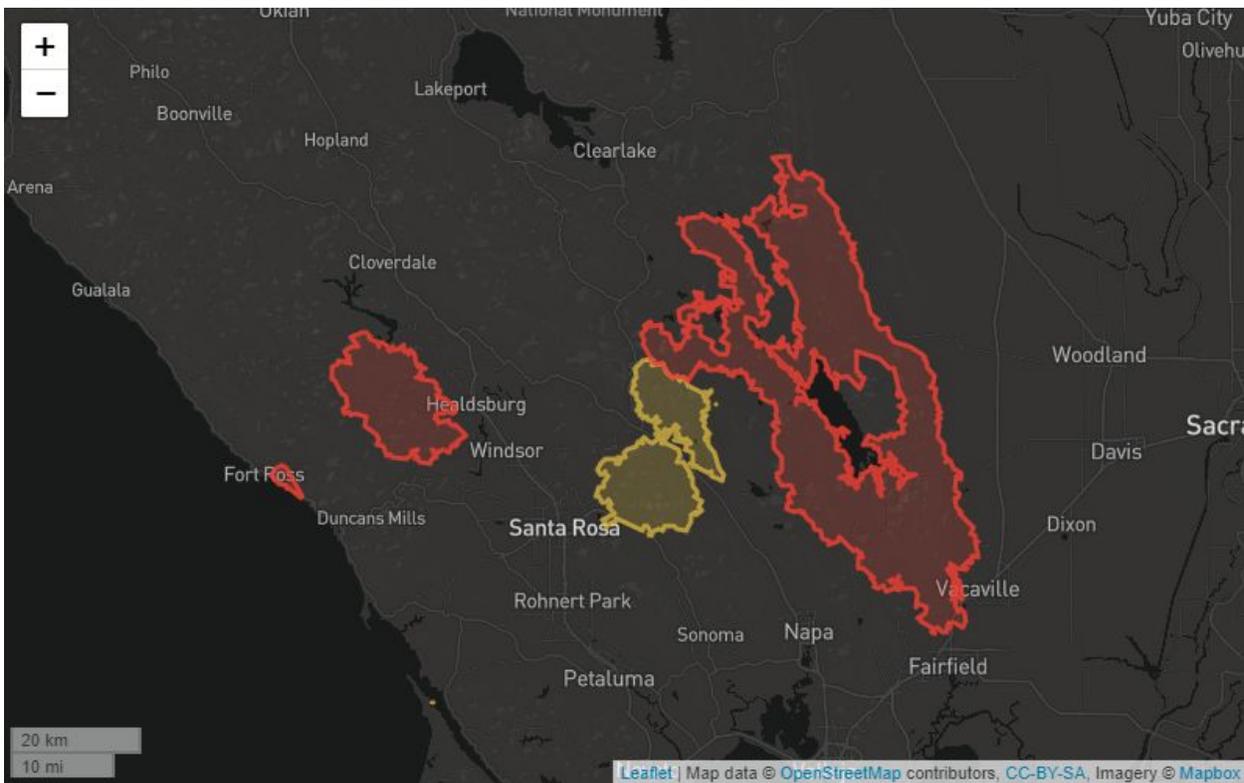
Since our meeting on November 10th, we've made good progress towards our goals. We now have bar charts for acres burned, structures destroyed, and suppression costs. These bars also have tooltips that show the fire name and all fire information. Since there are many fires, we made the div containing the bar chart scrollable. At the moment, we're only displaying the top 20 fires, but we can increase this to show all fires with data. With the fire data implemented, we also fixed the scorecards to be accurate to the data. In the map view, we've updated the point symbols with fire icons and implemented a color scale that is black for low acreage and red for high acreage. A tooltip displays the fire name and acres burned on hover and a map scale (bottom-left) was added. Finally, fire polygons are now selectable, we just need to add events to this selection.



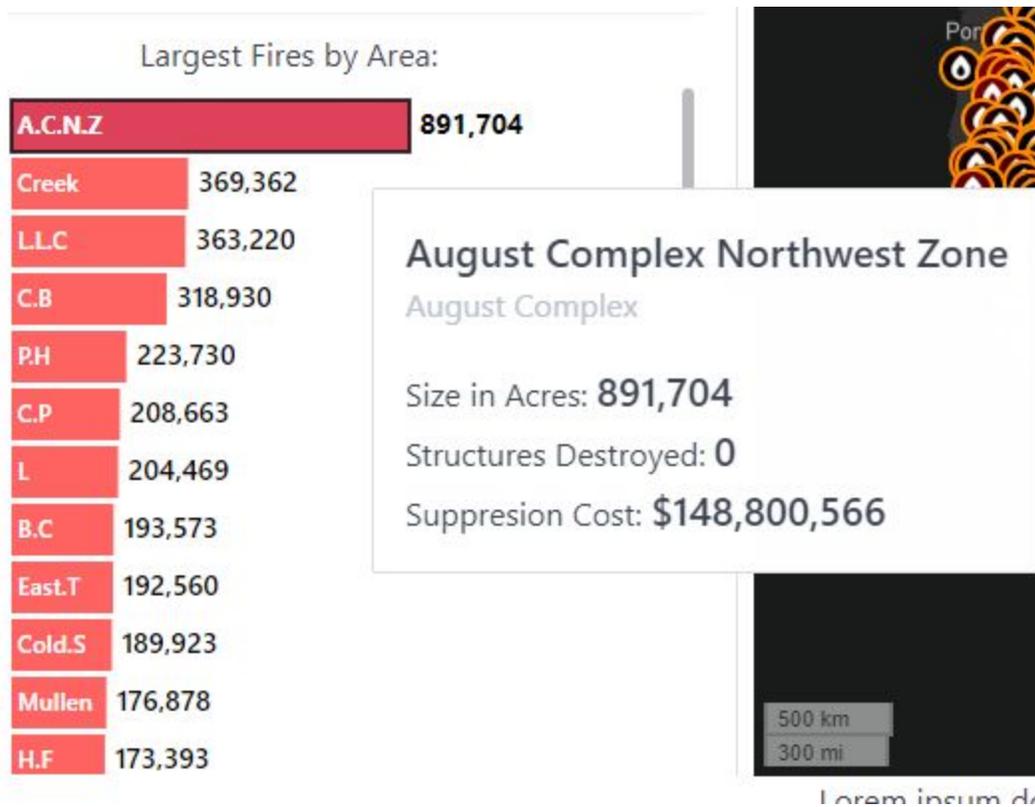
The visualization on first view.



The new map symbols and color scale.



A fire polygon is selected (red).



The tooltip hover over a bar.

We also prepared the data for the historical data comparison. We retrieved data from [CalFire](#), polygon data of wildfire perimeters since 1889. We decided to use climate periods (30 years) and compare the current climate period (1990-2019) to the previous one (1960-1989). By using climate periods, the data will be more meaningful as shorter periods may be influenced by short-term weather patterns like the El Nino Southern Oscillation (ENSO). ENSO can shift California's climate every 3-6 years. With 60 years of data, this dataset was very large, over 88 MB. We had to simplify the polygon vertices and remove fires under 250 acres to reduce its size to 10 MB. For the purposes of this visualization, which is to simply show the whole state of California and a comparison of fires in these two periods, this will not impact our design.

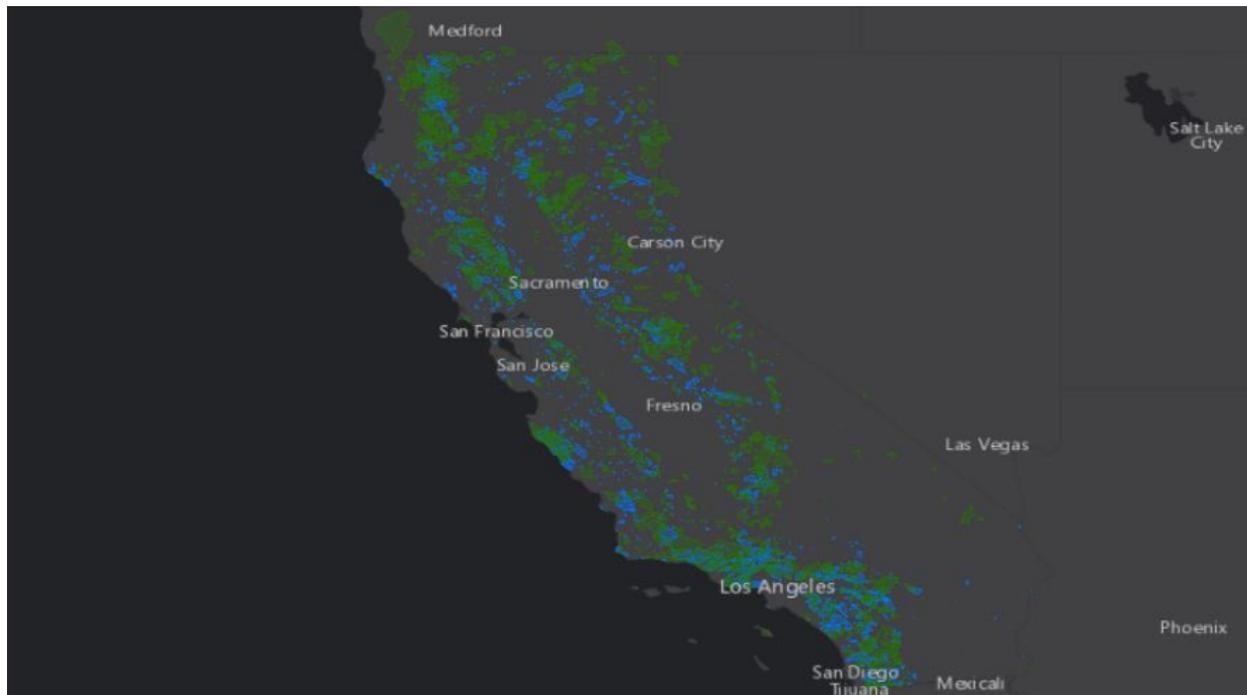
We also found an [article](#) where the authors spoke to the data source about what exactly this wildfire data is. From the article:

“Cal Fire says that their dataset — which runs from 1878 to 2019 as of May 2020 — is the most complete dataset of California wildfire perimeters before 1950. However, the pre-1950 information shown here is incomplete and should not be used for further analysis.

As of September 2020, Cal Fire had found that its dataset is missing 483 notable fires. The agency is currently looking into how they can find some of these large missing fires, and hopes to include them in a future update. This in no way invalidates this dataset, according to Cal Fire.

Cal Fire's data on this map shows timber fires that burned more than 10 acres, brush fires that burned more than 50 acres and grass fires that burned more than 300 acres.

This map shows the perimeters of Cal Fire and the U.S. Geological Survey's recorded wildfires, but it should be noted that not everything within a wildfire perimeter has burned. This means that the areas shown here do not necessarily represent burned areas."



A screenshot from ArcGIS Pro showing the historical fire data where blue is 1960-1989 and green is 1990-2019.

Now that our main data files have been loaded in, we can evaluate how well the page loads and renders. The polygon geoJSON files remain large (for the web, at least), despite our efforts to reduce file sizes. We kept this in mind when designing the website. The first dataset to be displayed is the point data, by far the smallest file at 146 KB. The user then must zoom in to see the next file, the 2020 wildfire polygons, weighing in at 3.27 MB. By the time the user can zoom in on the map, these should be loaded. Finally, the historical wildfire perimeter data is the largest, at 9.91 MB, but these data are behind the second view. Unless the user quickly tabs over to this view, it will definitely be loaded before viewing. Therefore, our data use is of low concern. We ran a test on [webpagetest.org](https://www.webpagetest.org) that confirmed our ideas. The point data were downloaded in 16 ms, 2020 perimeter data in 1669 ms, and the historical perimeter data in 5728 ms.

Request Details												
#	Resource	Content Type	Request Start	DNS Lookup	Initial Connection	SSL Negotiation	Time to First Byte	Content Download	Bytes Downloaded	Certificates	Error/Status Code	IP
32	https://reepoi.github.io/F_Perimeters.geojson	application/geo+json	2.856 s	-	-	-	130 ms	1669 ms	972.8 KB	-	200	185.199.109.153
34	https://reepoi.github.io/ta/WF_Points.geojson	application/geo+json	4.57 s	-	-	-	62 ms	16 ms	25.5 KB	-	200	185.199.109.153
35	https://reepoi.github.io/fire_history.geojson	application/geo+json	4.655 s	-	-	-	407 ms	5728 ms	3,341.0 KB	-	200	185.199.109.153

A table from wepagetest.org showing load times of the geoJSON files.

7.2 Next Steps

7.2.1 Map View

The map view is inching closer towards completion. We have some minor tweaks to make. The color scale may need to be updated, as of right now, only the largest fires are colored because fires like the August Complex are so much bigger than others. We will also continue adding map components, especially the zoom home widget, but potentially a minimap and search box, depending on how much work these take to implement.

7.2.2 Coordinated View

A major component of our visualization will be the coordination of the bar chart and the map polygons. When a polygon is clicked, we'd like to display additional information, as well as add it to the top of the bar chart so it can be compared to other fires. We also discussed potentially adding additional information on the right panel such as the cause of the fire, and we could also make that update according to what is in the map view (if zoomed to Utah, only Utah fires are shown). If we used something like fire cause, it would be a part of a whole chart.

7.2.3 Compare Years Tab

Since the last meeting, we only processed, uploaded, and logged the data in our script. Little has changed for our next steps.

7.3 Meeting with Jeff - November 18th, 2020

There were no major suggestions at the meeting; our team is currently on track to produce a meaningful and pleasing visualization. One minor critique was the color scale, which we were considering altering in a previous meeting. In our color scale, we could exclude the August Complex fire, which has a much higher value than other fires, especially for acres burned. We also could color the bar charts to match the point data color scale. This may be useful for the user so they know that the bars do correspond with the points. Finally, a legend can also help. There is a built in Leaflet legend, but we could also create our own div. We also discussed our next steps - these largely correspond to section 7.2.

<p>Wed, Nov 18 (Post-Milestone tasks)</p>	<ul style="list-style-type: none"> ● Specific Tasks for everyone ● Map to Bar Chart highlight (Huy) ● Bar Chart to Map Link (Taos, Huy) ● Tab changes content(Huy)
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	<ul style="list-style-type: none"> • Add processed data files (Troy)
Fri, Nov 20	<ul style="list-style-type: none"> • Start populating `Compare Years` Tab (Troy, Taos) • Add filtering by causes for bar chart (Huy)
Sat, Nov 21	<ul style="list-style-type: none"> • Add Story-telling for `fire map` (Huy)
Sun, Nov 22	<ul style="list-style-type: none"> • Clicked bar chart linked (Taos)
Mon, Nov 23	<ul style="list-style-type: none"> • Fire map coordinated views done (Huy, Taos)
Wed, Nov 25	<ul style="list-style-type: none"> • Finishing `fire map` content with all story-telling and navigation (Huy) (actual Fri Nov 27) • Making About Page (Troy)
Thurs, Nov 26	<ul style="list-style-type: none"> • Add National WildFires data (Troy)
Fri, Nov 27	<ul style="list-style-type: none"> • Complete `CA Years` Tab Visualization and Story (Troy, Taos)
Sun, Nov 29	<ul style="list-style-type: none"> • Draw National Wildfires Scatterplot (Huy) • Add Intro for National Wildfires tab (Troy) • Finish Process Book (Troy)
Mon, Nov 30	<ul style="list-style-type: none"> • Finalize project and have a meeting for final tweaks (All) • Project Video done (Troy) • Final Product Release (All)
Wed, Dec 2	<ul style="list-style-type: none"> • Project Due

8. November 23rd Project Update

8.1 Progress Update

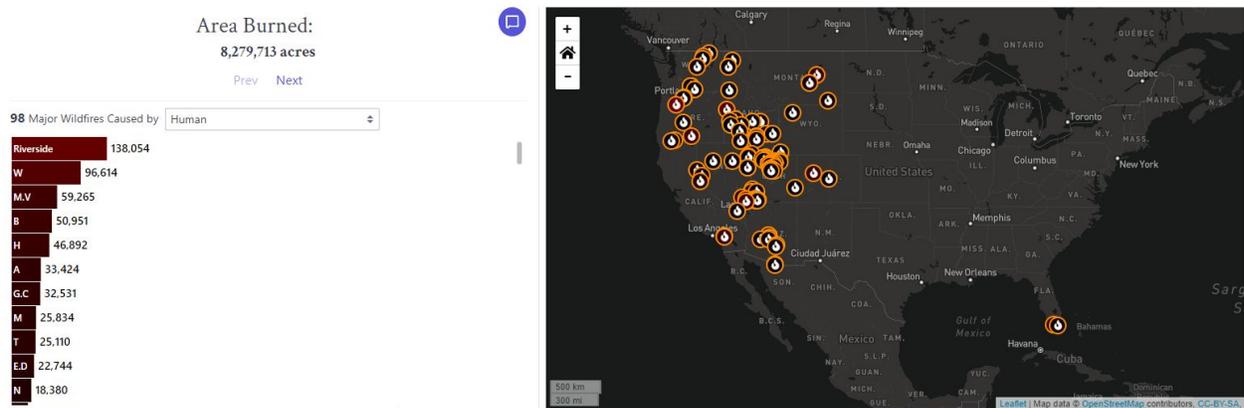
- Updated dataset to fix errors.
- Added rankings in the bar chart tooltip.
- Linked bar chart click selection to the map selection; the map zooms to the selected feature when the bar chart is clicked.
- When changing datasets, the polygon and bar stays selected and the map pop-up updates.
- All fires are displayed in the bar chart; a scroll bar allows the user to explore.

- In the Compare Years tab, the map has been created, the data loaded, and the polygons styled.
- Removed the right pane from the US Fire Map view.
- Added filtering for the wildfire cause. The user can select from a dropdown box.
- Added zoom home

8.2 Next Steps

With only 9 more days left and about a week until we want to record our project video, we are finalizing our final steps for completion.

- In the US Fires Map tab, add storytelling
- In the Compare Years tab, add a geoJSON file with California's counties and statistics with the amount of acres burned in the two climate periods, 1960-1989 and 1990-2019.
- Add a part-of-a-whole chart (potentially a donut chart) to show how the two climate periods compare. At first load, the visualization will show statistics for the entire state of California and the user can then select counties to see statistics for that county (comparison of climate periods, total land burned in the county).
- Add simple scatter plots for historical data.



The data can now be filtered by wildfire cause.



The California historical wildfire data has been implemented with a map view and donut chart.

8. November 28th Project Update

8.1 Progress Update

- Added a help button that shows the user how to navigate the visualization
- Added paragraph text for the US fire map and California Wildfire History
- Added a county label in the California area burned donut chart
- Changed the wording from area burned to area impacted to reflect the data more accurately
- Added animations to the donut chart
- Added highlighting of the hovered slice of the donut in the donut chart
- Added top 20 wildfires in California chart that shows the top 20 fires by area and their year. These are color coded the same as the periods on the map, and 2020 is also added and highlighted.
- Added an About page to show and explain our data sources, as well as display our project team members

8.2 Next Steps

- Fix Promise error when <https://reepoi.github.io/data-vis-2020-fires/> loads (only happens when there is not tag at the end of link (like #fire-map))
- Add ranking in the tooltip of top 20 fires
- Add another step or two in the help button to show how to filter by wildfire cause
- Add scatterplot with line to the stories tab ('stories' name will change)
- Add a footer

← U.S. Fire Map California Wildfire History Stories →

The 2020 wildfire season was another record breaker in the US

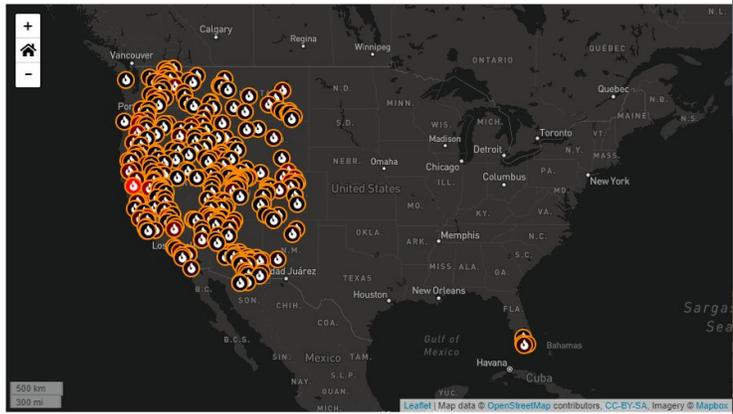
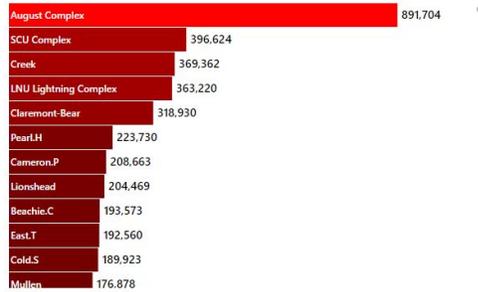
As of October 27th, the estimated area burned is 8.28 million acres which is 127% of the 10-year average of 6.54 million acres (NIFC). California was particularly hard hit, accounting for about half of the area burned and shattering records, including the August Complex fire which is pushing a million acres alone. The visual below shows major fires across the United States, their causes, the area burned, suppression cost, and structures destroyed. This is not an off-year, while the number of fires is not increasing, the sizes of fires are. As the climate warms and dries, wildfires are likely to continue increasing in size (Abatzoglou & Williams 2016).

8.28 millions acres burned	\$2.65 billion in suppression costs	16,116 structures burned	46 fatalities
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Area Burned:
8,279,713 acres

Prev Next

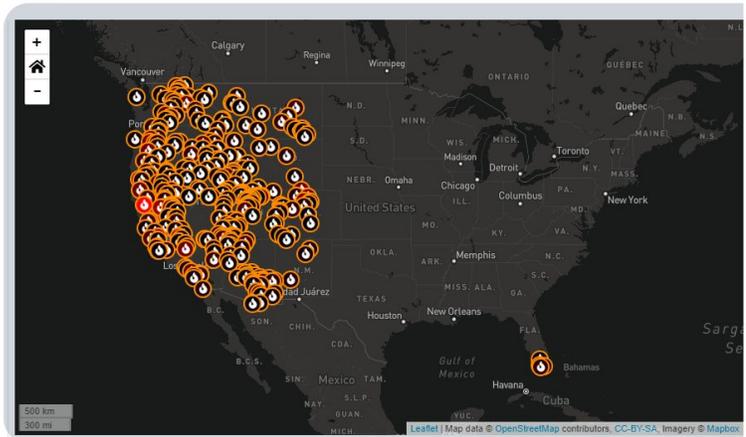
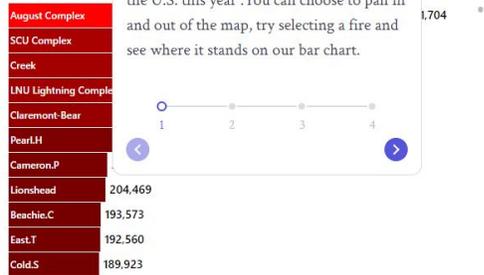
341 Major Wildfires Caused by All



The main 2020 US Wildfire map visualization is nearly complete.

Area Burned:
8,279,713 acres

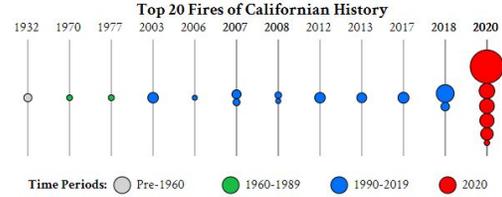
341 Major Wildfires



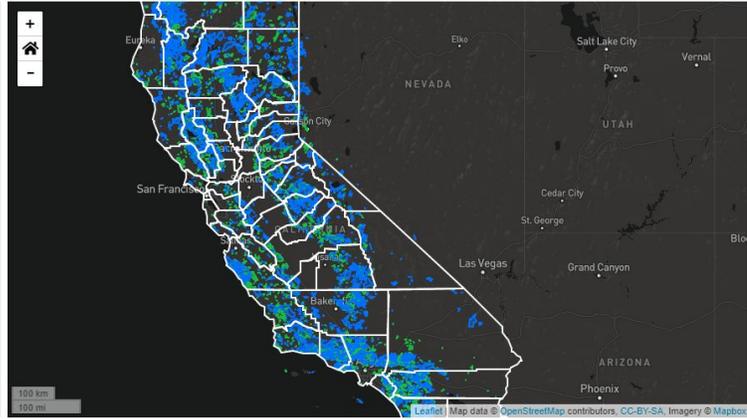
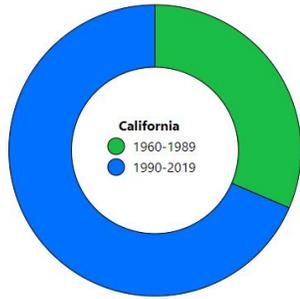
The main visualization now includes a help/information button to guide the user.

Comparing the past two climate periods in California

A climate period is typically defined as a 30 year period to measure average weather. It is important to consider long-term trends because certain events, like the El Niño-Southern Oscillation, can cause major shifts in weather patterns in 3-7 year periods, and therefore influence the number of wildfires. Cal Fire, California's fire agency, keeps comprehensive wildfire records dating as far back as 1878. The visualization below shows fires aggregated into two periods, 1960-1989 and 1990-2019. For the State of California, the period of 1990-2019 has had **2.18x more area impacted by wildfires** compared to 1960-1989. Most counties have seen a significant increase in area impacted in the recent climate period.



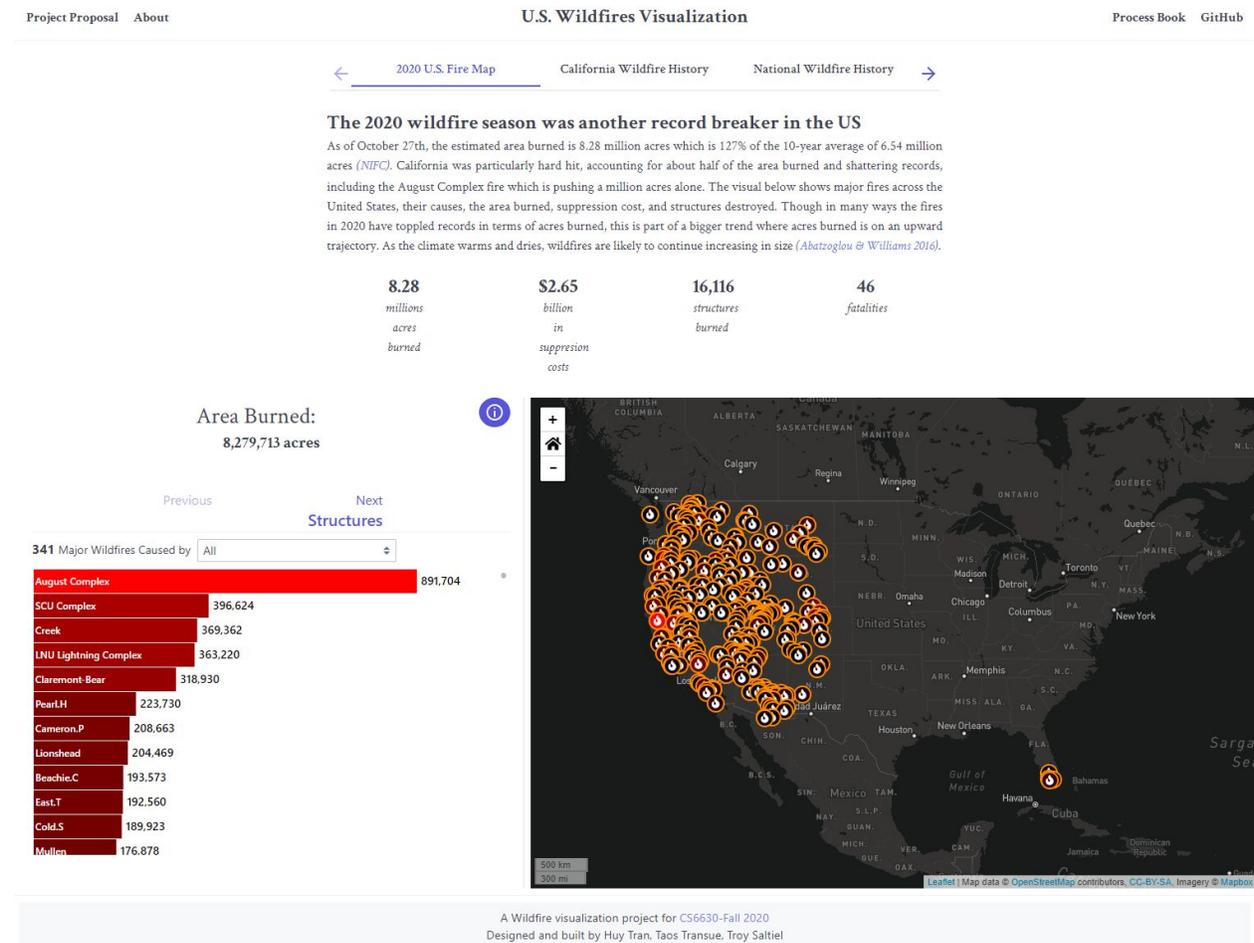
Ratio of Area Impacted Per Period:
1960-1989 vs. 1990-2019



The California Wildfire History visual is also near completing, with some very minor adjustments to come.

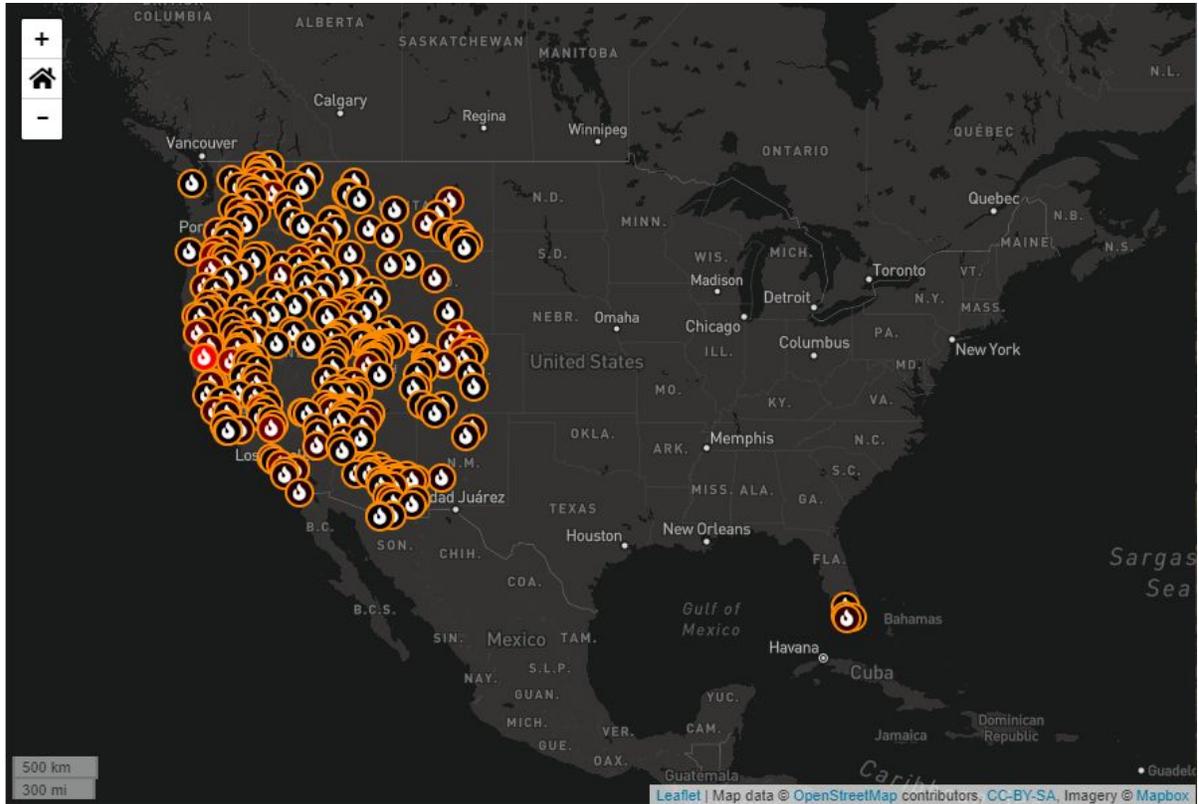
9. Project Completion

9.1 US Wildfires 2020



The first load of the visualization which begins with the 2020 US wildfire map.

The visualization begins with the 2020 US wildfire map that contains 3 content areas: text/scorecards, map, and bar chart. The paragraph text introduces the story and the scorecards are intended to give a quick glance at impactful information that summarizes the wildfire season. The map and bar chart content are coordinated, so selections made on the map also select the bar chart item and vice versa.



The wildfire map at first load, which shows point data.

The 2020 wildfire map shows point data encoded with color (black to red) by the data selection (acres burned, structures destroyed, and suppression cost). We chose black to hold a fire theme since red is usually associated with fire. With this encoding, the most significant fires stick out, which is what our team was aiming for.



The wildfire map zoomed in beyond 50 km.

Beyond 50 km, the point data is no longer displayed and polygon data takes its place. The attributes of each data set are exactly the same and the points and polygons are linked. Originally, only polygon data was to be shown, but we decided to use points when zoomed out because it's difficult to see polygon data at that extent.



A polygon is selected.

Polygon data can be selected directly, or the coordinated point data can be clicked and selected. If a point is selected, the map will pan and zoom to the coordinated polygon according to the polygon's spatial extent (the map zooms to fit the polygon). Point selection can also be used as a way to quickly zoom to an area, like the Salt Lake Valley, when zoomed out to the full United States.

Area Burned:
8,279,713 acres

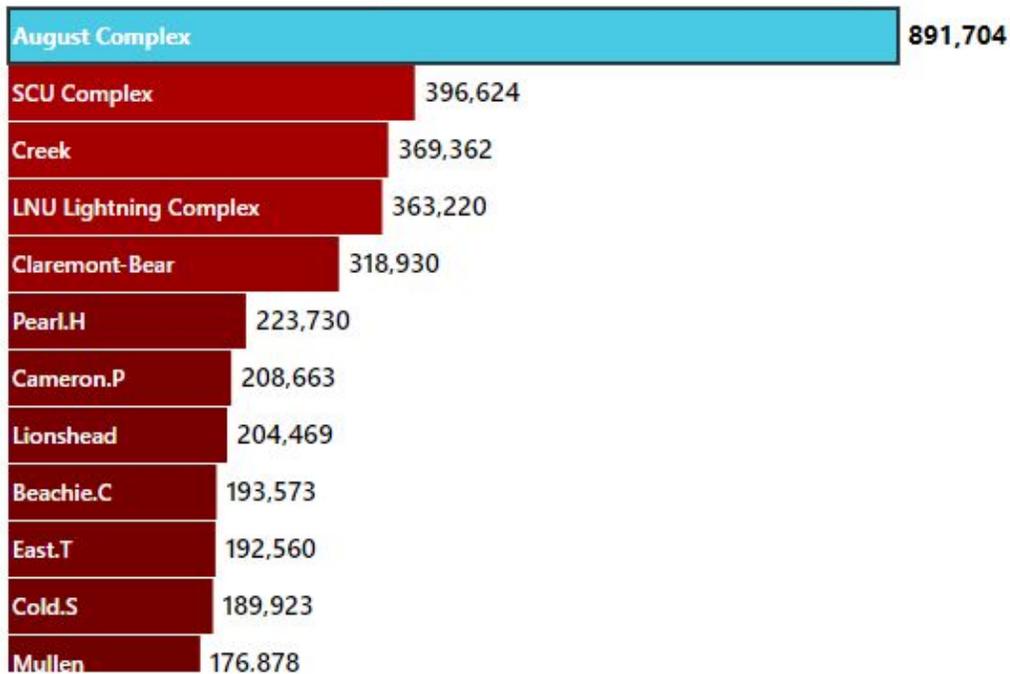


Previous

Next

Structures

341 Major Wildfires Caused by



The bar chart with a selection made on the August Complex fire.

If a user selects a point or polygon in the map, the corresponding bar will also be selected. This works in reverse, too; if a bar is selected, the corresponding polygon will be selected and the map will pan and zoom to its location. The bar chart is labelled with the fire name and the data label (area burned, structures destroyed, and suppression cost). The bars follow the same color scale as the map points, and dually serve as the legend for the map color encoding.

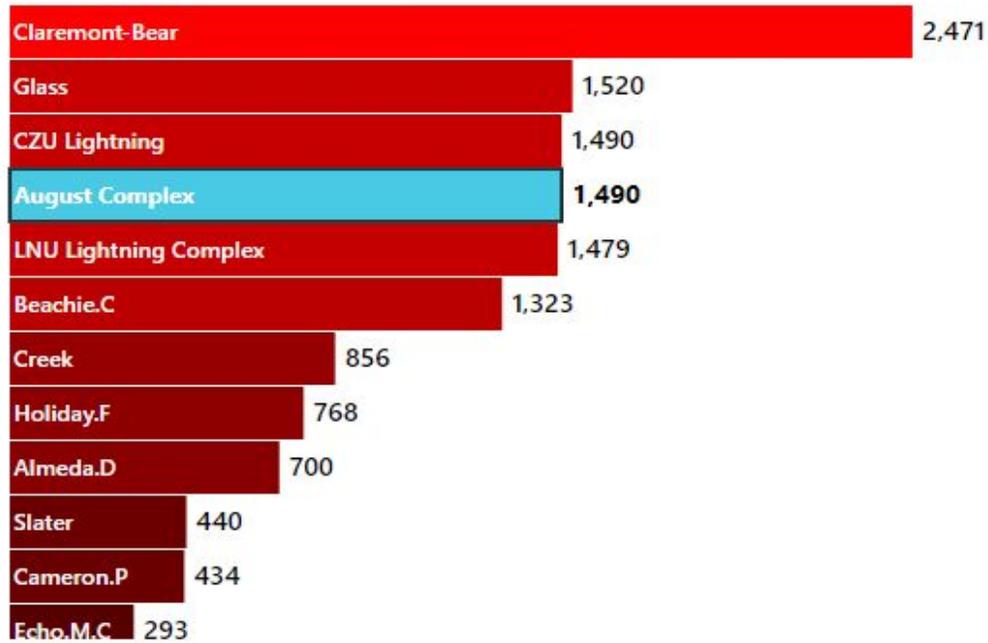
Structures Destroyed: 16,116



Previous
Area Burned

Next
Cost

341 Major Wildfires Caused by



The bar chart with the same selection as above, but with Structures Destroyed chosen.

Within the bar chart, the user can click previous or next to change the dataset (these are labelled with what dataset is previous or next). The bar chart will transition to reflect the new data and the previously made selection will remain.

Structures Destroyed: 16,116



Previous
Area Burned

Next
Cost

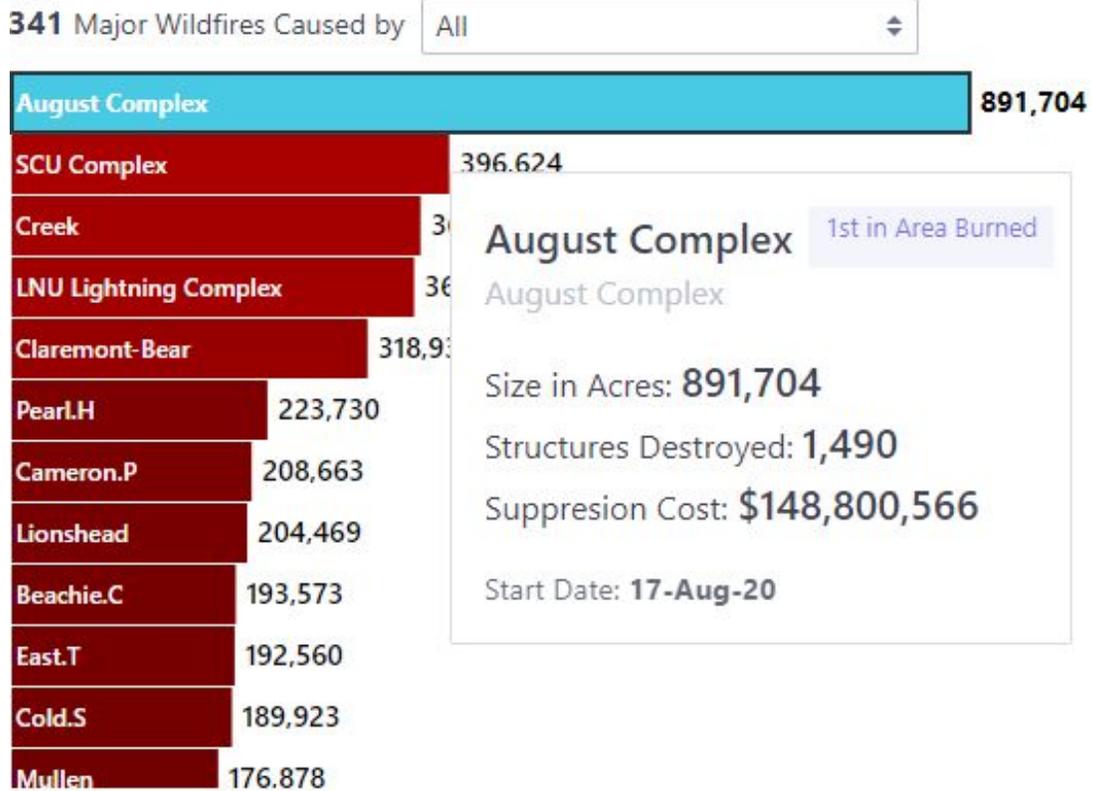
August Complex is not in current filter or it is a fire we don't have enough data ×

98 Major Wildfires Caused by

Almeda.D	700
Rivers	139
N	43
M.	36
W	34
H	24
E.	20
A	13
C.	11
B.	11
V.	7
A	5

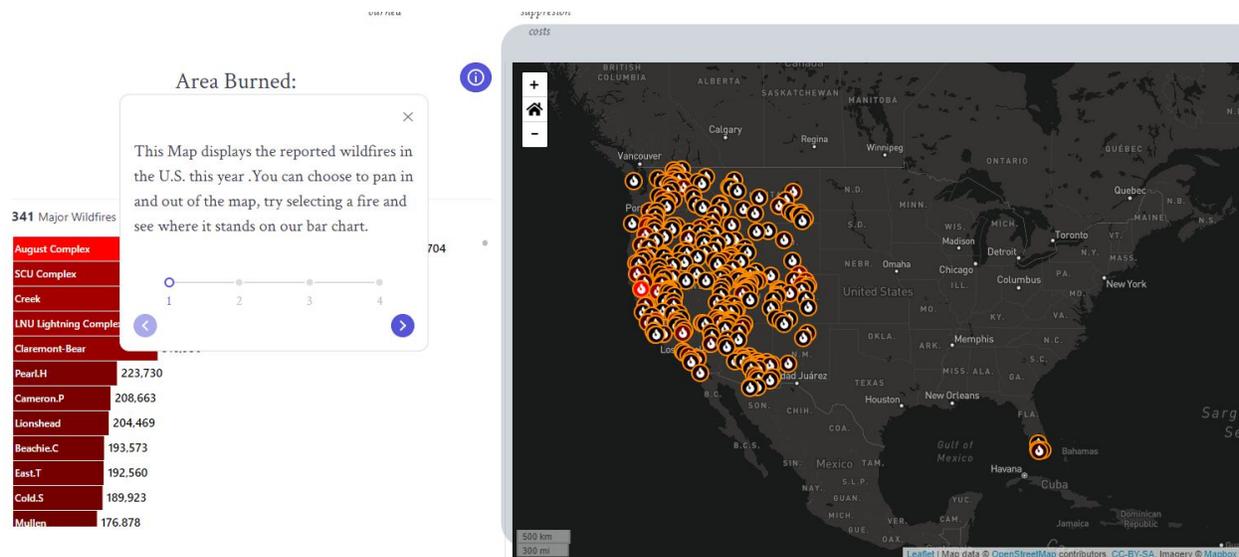
The dataset filtered by cause. If the selection is not in the filter, a message is displayed.

The dataset can also be filtered by cause, which includes human, lightning, and undetermined. If the current selection is not in the filter, a message will be displayed. Again, the selection from before is retained, including if the selection is not in the filter (the selection will appear again if the selection becomes in the filter).



The tooltip for the bar chart.

The bars can be hovered to show additional information about the fire. At the top, the name and complex name (in gray, if it exists) are on the left, while the rank of the fire is shown on the right. All three attributes are shown in the middle, and the start date of the fire is shown at the bottom.

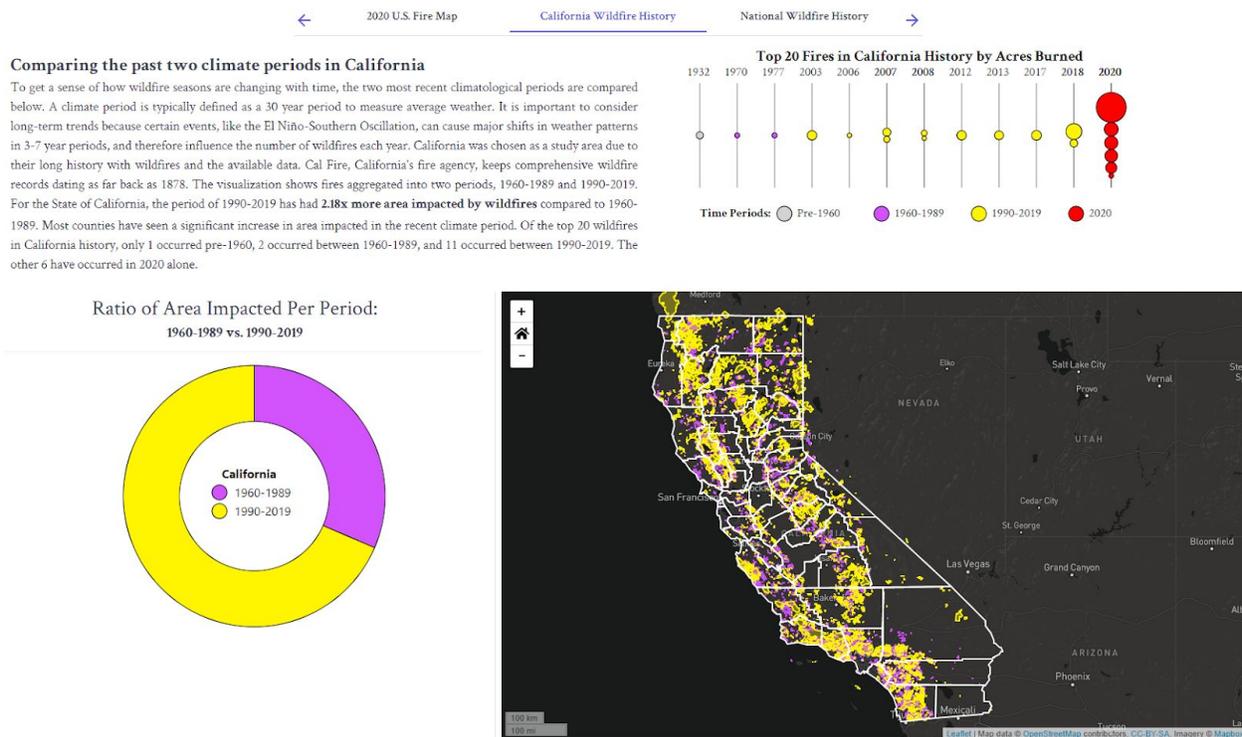


A help icon can be selected to aid the user in navigation.

A help button is placed to the left of the map encoded with a universally known “information” symbol. Once clicked, several parts of the visualization are highlighted and explained. In step 3, it also updates the map to select the August Complex, as an example, and in step 4, it updates the data sets showing the user that the data can be changed and the selection remains.

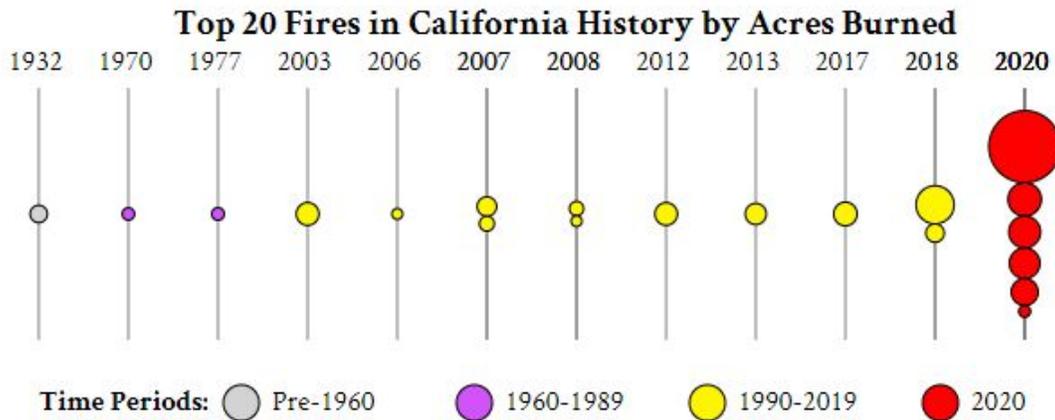
9.2 California Wildfire History

The California Wildfire History page is organized into 4 sections: a text explanation, a bubble chart with the top 20 wildfires in history, a map with the fire perimeters, and a donut chart that plots the area burned for each climate period. The intention of this page is to show that the area burned in California has significantly increased and that individual fires are becoming larger.



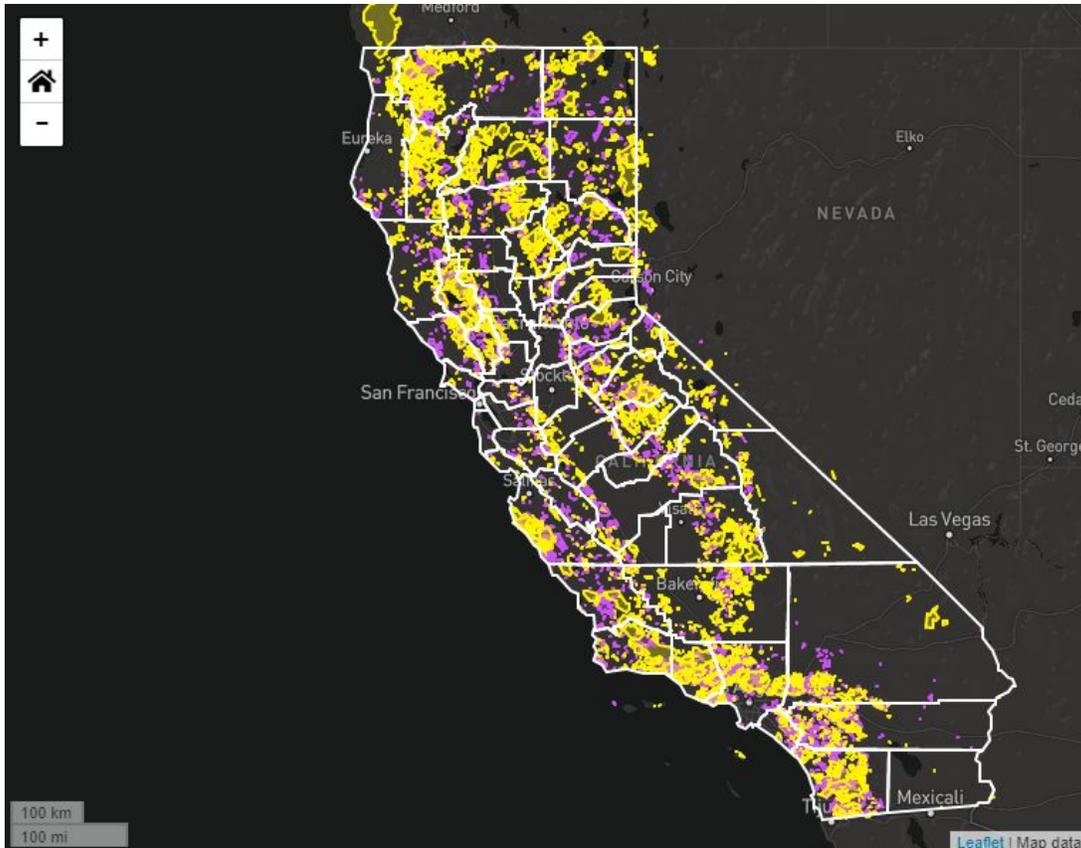
The completed California Wildfire History Page.

The top 20 California fires chart organizes the top 20 wildfires in California history by year and their time period. While 2020 is not included in the map below (data is not ready yet), it is included and highlighted here because it is significant information. The circles are encoded by time period, and the tooltip shows the fire’s name, it’s rank, the total acres burned, and the year it occurred.



The top 20 California wildfires chart and the tooltip.

The map view shows the counties in California, which are selectable, and wildfire perimeter data organized into two colors: yellow is 1990-2019 and purple is 1960-1989. We chose these colors to avoid color blindness incompatibility. The user can freely zoom or select a county to zoom to that county. A tooltip that shows the total acres burned for each county is included, and the zoom home functionality was ported from the other map.

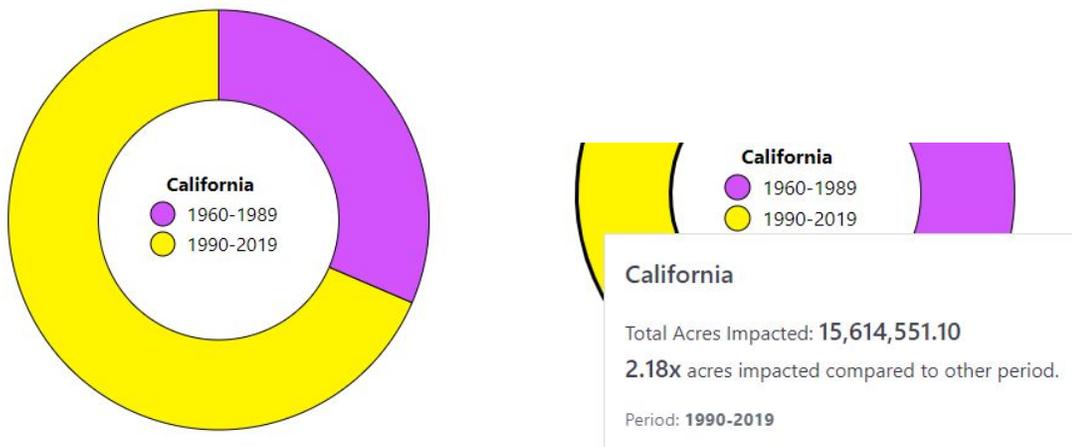


A map of California with counties and wildfire polygons organized by climate period.

The donut chart is initialized with the area impacted per climate period for the entire state of California. A tooltip shows the total acres impacted and a comparison to the other period.

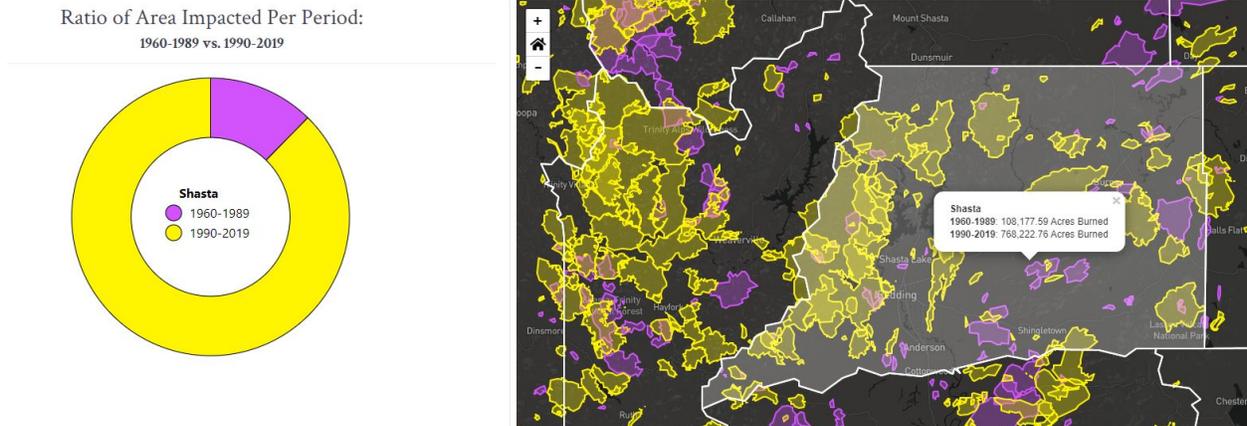
Ratio of Area Impacted Per Period:

1960-1989 vs. 1990-2019



The donut chart and tooltip displaying data.

The donut chart and map view are coordinated. When a county is clicked, the map zooms to its extent and the chart updates.



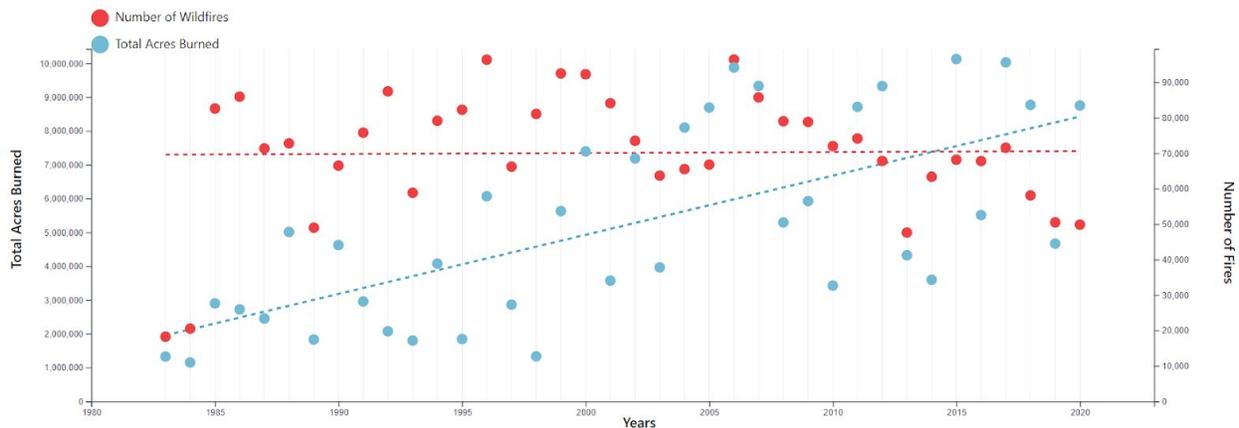
The map view and donut chart are coordinated when the user clicks a county.

9.3 National Wildfire History

Since we only have two attributes, the number of fires and acres burned on the national wildfire history data, we made a scatterplot that encodes two different colors and two y axes for the visualization. Our intent here is to conclude our story with a straightforward dataset that fully answers the question our story posed - that area burned is increasing with time and the area burned per fire is also increasing.

The trend of larger wildfires extends beyond California, nationally

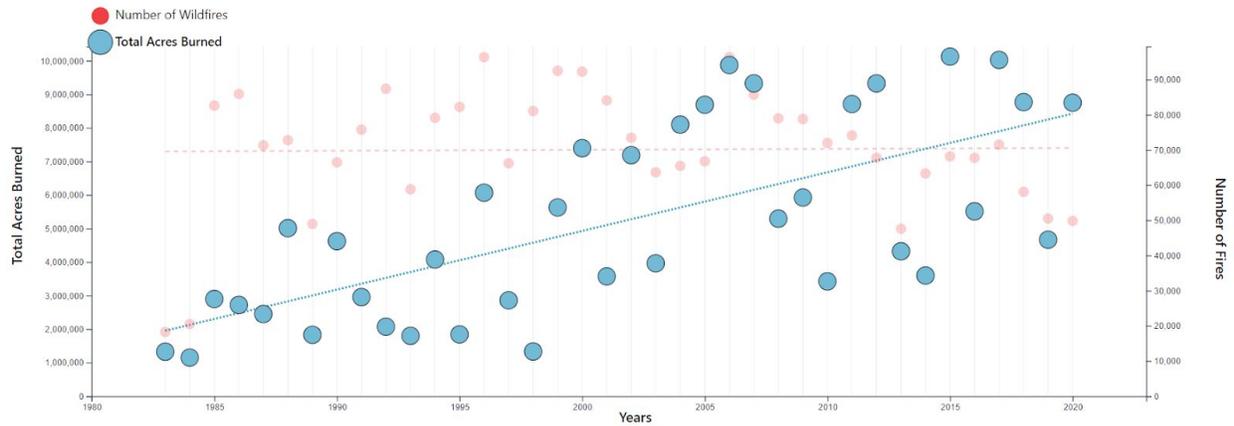
The National Interagency Fire Center (NIFC) keeps records of the acres burned on US wildlands. Since 1983, which is the year the NIFC began confirming these records, the number of fires has not increased, but the area burned has increased year-over-year. As with California's wildfires, there is a national trend of larger fires. On average throughout the period of 1983 to 2020, the area burned increases by about 175,000 acres each year while there is no trend in the number of fires. It is clear that wildfires are becoming a larger problem with time in the United States.



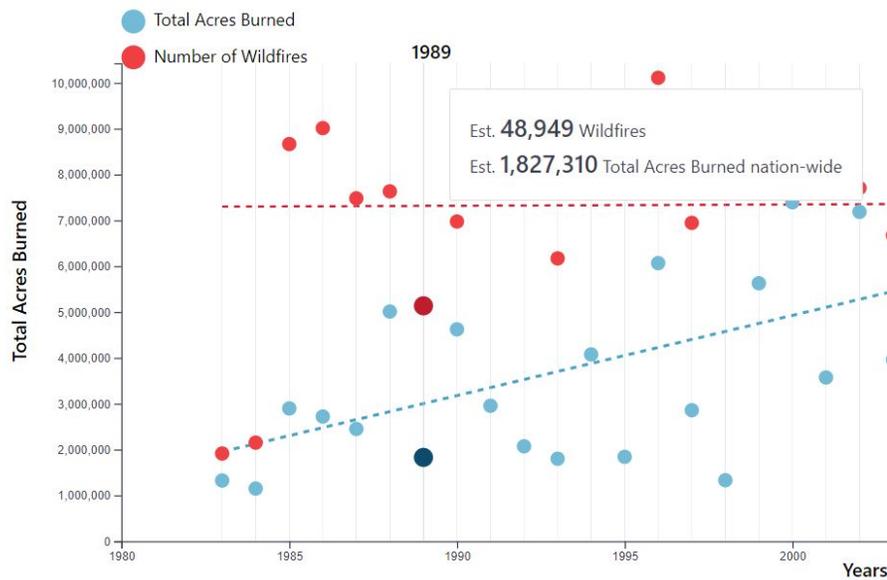
A scatterplot showing nation-wide area burned and wildfire counts (1983-2020)

There are also trend lines for both attributes. This serves to emphasize the fact that while the number of fires has no trend, the total acres burned has been steadily increasing throughout the decades.

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The user can click on the legend to highlight the trendline and the corresponding bubbles.



Years can be hovered to view the specific data for each attribute.

10. Project Evaluation

There has been recent news about wildfire seasons becoming worse, but it has been unknown to our team what extent fires are becoming worse. One of the major findings from our data visualization is that the number of wildfires has no trend, but the amount of acres burned and

the size of the biggest fires is increasing. These are trends that are documented and studied, but by visualizing the data, the trends become obvious and we were able to further understand the data.

Our original project question aimed to answer ‘how bad was the 2020 US wildfire season’, but was later expanded to also answer whether or not there are trends in historical wildfire data. For the first question, measuring the 2020 US wildfire season, we answered the question by showing all of the data and allowing the user to explore and draw their own conclusions. The text scorecards at the top serve to give a simple answer - “this is how bad the season was”, but the user could then focus on topics of interests such as viewing fires in their own state, filtering by different causes, and comparing the impacts of fires (acres burned, suppression costs, structures destroyed). Our intention was to convince the user that the 2020 season was bad, then extend the question to ask how this year compared to other years. We explored this in two ways - focusing on California, which is known for bad wildfires and also has great documentation, and showing national trends in a simple way (scatterplot). The California visualization gives two avenues to help answer the question. First is the top 20 fires, which shows that the majority of these huge fires were recent. The second is the comparison of area burned by climate period, which shows that area burned has doubled in the most recent 30 year period. Finally, we complete the argument that wildfires are increasing in size by showing a simple scatterplot with a trendline to show that the number of fires is not increasing, but the area burned is. With these two visualizations, the second question is clearly answered.

We are happy with how much functionality we were able to incorporate into our visualizations. In the 2020 US Wildfires Visualization we could add additional features to the map, such as a minimap view that shows a larger scale map when zoomed in, and a search function that allows the user to search for a specific fire or location. In the California Wildfire History visualization, it would have been great to plot the 2020 wildfires alongside the 30 year periods and in the donut chart, to show how significant of a fire year 2020 was for California. This also would have improved flow in this visualization because we display data for 2020 in the top 20 wildfires chart but not in the map. We could have added another visual to this page like a line chart that shows the cumulative area burned with time, and perhaps bars showing the area burned for each individual year. Finally, we could have simplified the California visualization by displaying the donut charts directly on the map for each county, though it’s unknown how effective this implementation would have been. For the last page, the national wildfire history, we intended to keep this visual simple to act as an impactful and straightforward conclusion to the story.