TEAM 3
FINAL REPORT

SIXTEENTH ACTUARIAL CASE COMPETITION SPRING 2022

Team 3 - General Analytics

I. Background

California Homeowner Catastrophe Insurance Company (CHCIC) is an insurance company based in California that provides property insurance for homeowners, business owners, and personal automobiles. CHCIC primarily offers its insurance products to property owners who are deemed to live in high catastrophe risk areas. The company has done well in all its years of operation due to a low volume of high catastrophe activities and more low catastrophe activities. However, in recent years, CHCIC has been taken aback financially due to the growing number of wildfires and high catastrophe activities around California. As of recently, the Dixie Wildfire in California has ravaged several properties and thus has hit CHCIC extremely hard. As Catastrophe Risk Management Team 3 at CHCIC, we are tasked by company executives to assess and analyze the impact of the Dixie fire on our customers and their properties.

II. Preliminary Analysis

Team 3 of CHCIC's will assess and analyze several key datasets in order to advise CHCIC on further actions to reduce their current financial strains. Given the dataset containing a list of the insured property in the area along with their respective addresses, location, characteristics, total insured value, and inspected damage from the wildfire, Team 3 will need to find a way to merge these various datasets into one combined dataset that provides further insights for CHCIC's executive board. Thus, the two main metrics we will be assessing in this analysis include the properties' total insured value (TIV) and the damage done to the properties by the wildfire.

To be more specific, Total Insured Value (TIV) is the value of property, inventory, equipment, and business income covered in an insurance policy. This is essentially the maximum dollar amount that CHCIC will pay out if an asset that it has insured is deemed a constructive or actual total loss. We used average TIV to demonstrate the overall level of insured amount for each property. Average TIV is important for rate making because rate is positively related to insured amount.

Damage is the proportion of a property that is damaged by the wildfire, which is calculated by Total Amount of Damage in dollar amount / TIV. To get a numerical value to the damage done, we made a mapping of damage done to buildings which was initially given in the dataset as a string format into a number ranging from 0 to 1: {'No Damage': 0, 'Affected (1-9%)': 0.1, 'Minor (10-25%)' : 0.2, 'Major (26-50%)': 0.4, 'Destroyed (>50%)': 0.75, 'Inaccessible': 1}. We used larger values to denote buildings with larger damages to serve the purpose of using dots with different shades to represent buildings with a variant amount of damage. Damage is an important measure of approximately how much the insured properties would be destroyed in the insured period.

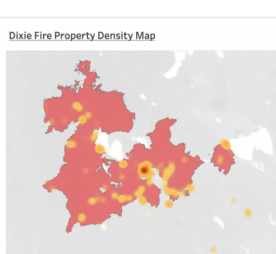
Utilizing TIV and Damage, we multiply the two and then find the average to get the Average Expected Loss (AEL), which is measured in dollar amount. In the rate-making process, an important principle for us is to ensure our designated rate to be above AEL so that we could secure the profits of CHCIC's product and alleviate the financial strains.

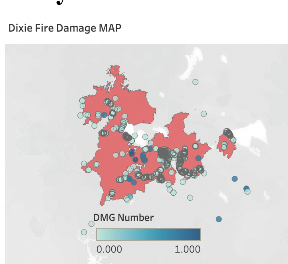
III. Methodology

The first thing Team 3 needed to do was to find a way to make it so the data we were given is interpretable. Team 3 was given the Dixie Properties Location dataset and the Dixie Damage dataset. The team had to find a way to join these two datasets but there was no column/series that existed between the two datasets to easily join on. For the Dixie Damage dataset, we were given the exact coordinates in the form of a geometry POINT object. However, we were only given the addresses in the form of a string for the Dixies Properties Location dataset. In order to join these two datasets, we geocoded the given addresses into coordinates by utilizing Google's Geocoder API through GeoPy. After we got the longitude and latitude of each individual address in the Dixie Properties Location dataset we then merged the two datasets using the nearest spatial join function through QGIS.

IV. Analysis

A. Spatial Analysis

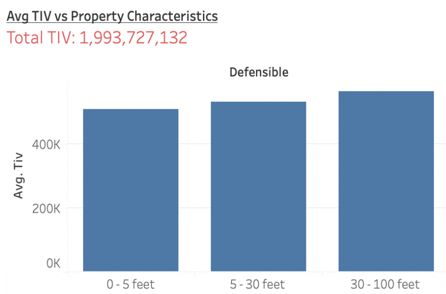


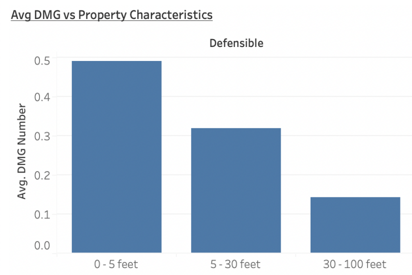


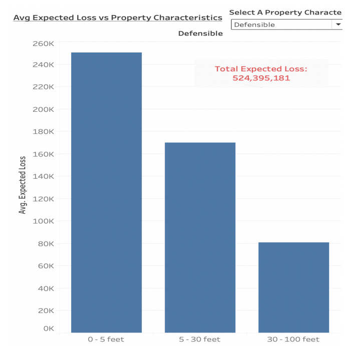
After overlaying the Dixie Fire perimeter on top of the merged POINT geometries on Tableau, we were able to get two maps showing the Dixie Fire perimeter along with property locations and the damage done to them. From the Dixie Fire Density map, we can see the locations that had the highest density of properties being shown by the dense red spot near the middle right of the fire perimeter. Similarly from the Dixie Fire Damage Map, we can see that many of the properties that were deemed to be 'Destroyed (>50%)' which is shown by the navy blue circles, are primarily located where there is a high density of properties. From this visualization, we can get an idea that high density property areas are positively correlated with the Dixie wildfire damages. This makes sense because we expect dense locations to easily spread the wildfire from one property to another.

B. Property Characteristics Analysis

Defensible



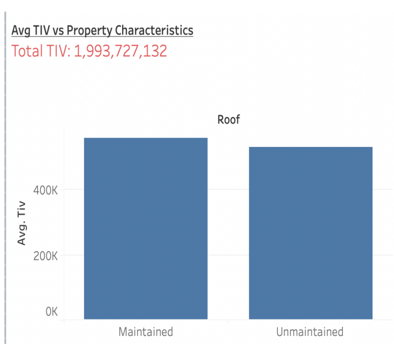


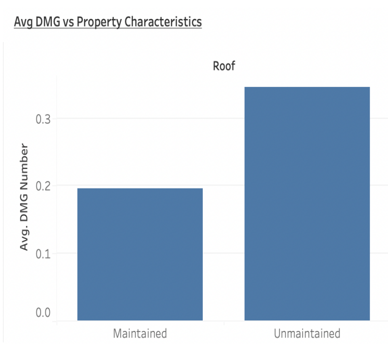


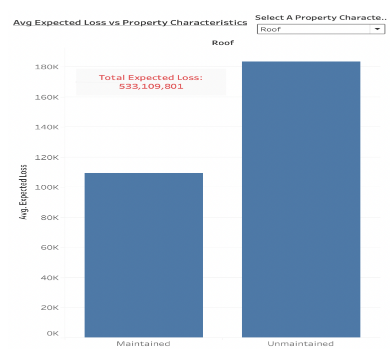
At a glance, we can see that a larger defensible space is typically correlated with a slightly higher insured value. This makes sense as owners of more valuable properties would be more inclined to give better protection towards their space as they have a lot more to lose. The average Total Insured Value (TIV) of a property with under a 5ft radius of defensible space is at 510,929, while the average TIV of a property with 30-100 ft defensible sits at 567,103, which is about an 11% increase. The TIV of properties in between 5 to 30 ft is about 533 thousand, which is about 4% higher than the value of the property with a defensible radius of under 5 feet.

Additionally, it is evident that an increase in the defensible radius leads to a remarkably lower damage, up to 4 times for defensibles above 30ft. Having a larger radius around a property makes it less likely that the space gets damaged, which is really intuitive. Even properties with a 5-30 ft defensible have an average damage score of 0.32 which compared to barely any defensible space (<5ft) that has a score of 0.5, is a substantial improvement. With both of these observations taken into account, it can be extracted that properties with almost no defensible pose an overall risk amount loss of $250,548, which is more than triple of that with a defensible of 30-100 feet.

Roof





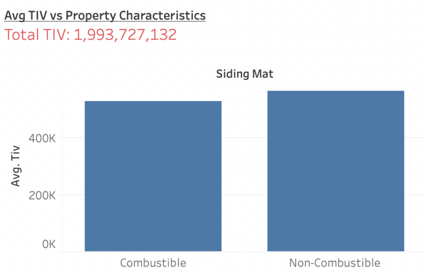


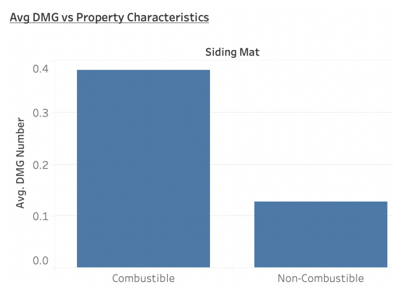
The roof property characteristic is split into two categories. Maintained and unmaintained. Maintenance of a property's roof is important as unmaintained roofs are more prone to collapse, leaks, and other safety issues. As seen in the bar graphs showing the average TIV for maintained and unmaintained roofs, we can see the average TIV to be about the same. This hints that roof maintenance status does not seem to play a part in the current insurance policy's calculation of TIV. Properties with maintained roofs have an average TIV of 558,487 while properties with unmaintained roofs have an average TIV of 531,690. Properties with maintained roofs have only a 4.91% higher average TIV compared to properties with unmaintained roofs. The total TIV is 1,993,727,132.

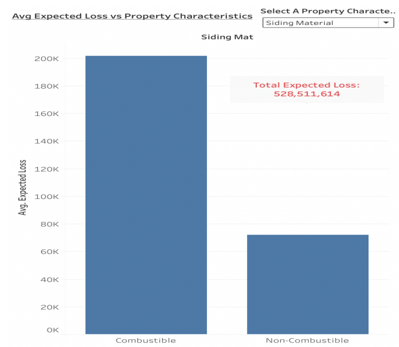
The difference between the average damage of properties with maintained roofs and unmaintained roofs is more profound. As we can see in the average damage bar graph, we can see that properties with maintained roofs have an average damage of 0.1959 (minor damage) which is 55.21%

higher than properties with unmaintained roofs which have an average damage of 0.3453 (major damage). As a result the bar graphs for average expected loss will be similarly shaped to our bar graphs for average damage. Properties with maintained roofs have an average expected loss of 109,387 and properties with unmaintained roofs have an average expected loss of 183,589. Properties with maintained roofs have a 50.21% higher average expected loss compared to properties with unmaintained roofs. These findings make sense because unmaintained roofs are usually more prone to damage. An unmaintained roof is also positively correlated with an unmaintained house. As a result, we would expect properties with unmaintained roofs to be more susceptible to wildfire damage and to have a higher average expected loss. The total expected loss for the roof property characteristic is 533,109,801 which is 26.73% of the total TIV.

Siding Material



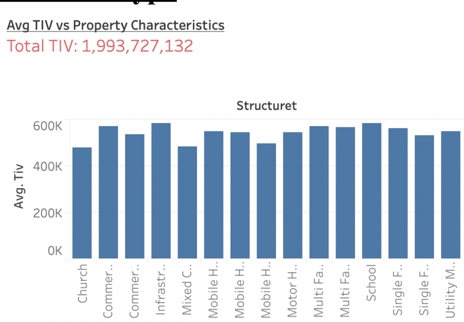


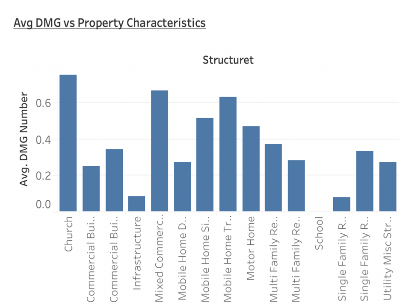


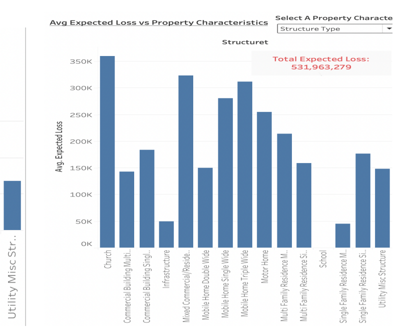
The siding material property characteristic is split into two categories. Combustible and non-combustible. Whether a property has combustible or non-combustible siding material is very important in its ability to withstand environmental hazards especially fires and wildfires. As seen in the bar graphs showing the average TIV for combustible and non-combustible siding material, we can see the average TIV to be about the same. This hints that siding material does not seem to play a part in the current insurance policy's calculation of TIV. Properties with combustible siding material have an average TIV of 529,374 while properties with non-combustible siding material have an average TIV of 565,473. Properties with non-combustible siding material have only a 6.59% higher average TIV compared to properties with unmaintained roofs. The total TIV is 1,993,727,132.

The difference between the average damage of properties with combustible and non-combustible siding material is more profound. As we can see in the average damage bar graph, we can see that properties with combustible siding material have an average damage of 0.3813 (major damage) which is 99.64% higher than properties with non-combustible siding material with an average damage of 0.1277 (minor damage). As a result the bar graphs for average expected loss will be similarly shaped to our bar graphs for average damage. Properties with combustible siding material have an average expected loss of 201,876 which is 94.62% higher than properties with non-combustible siding material with an average expected loss of 72,206. These findings make sense because properties with combustible siding are usually prone to fire damage. As a result, we would expect properties with combustible siding to be more susceptible to wildfire damage and to have a higher average expected loss. The total expected loss for the siding material property characteristic is 528,511,614 which is 26.50% of the total TIV.

Structure type



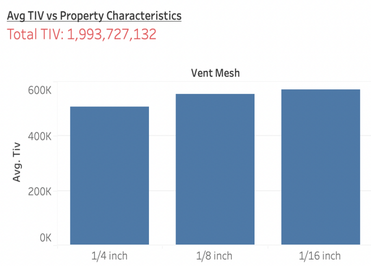


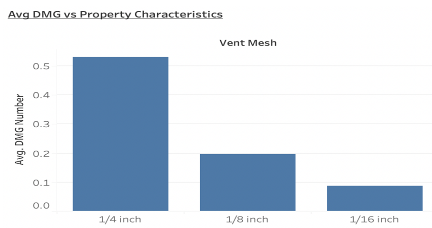


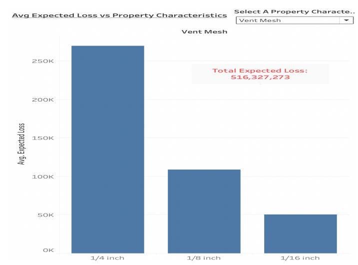
There are many different structure types in our dataset. Single Family Residence Single Story, Utility Misc Structure, Single Family Residence Multi Story, Commercial Building Single Story, Mobile Home Double Wide, Mobile Home Single Wide, Infrastructure, Motor Home, Multi Family Residence Single Story, Commercial Building Multi Story, Mobile Home Triple Wide, Mixed Commercial/Residential, Multi Family Residence Multi Story, School, and Church. Different structure types react differently to wildfires. We expect larger, more dense structure types to be better against wildfire damage. Because some structure types have too small sample sizes (>5% of the data) we will only look at the top 3 structure types that take up around 80% of our data: Single Family Residence Single Story, Utility Misc Structure, and Single Family Residence Multi Story. As seen in the bar graphs showing the average TIV for all three structure types to be about the same ranging from 530,000 to 560,000. The total TIV is 1,993,727,132.

As we can see in the average damage bar graph, we can see that smaller single story properties such as Single Family Residence Single Story and Utility Misc Structure have an average damage of 0.2712 and 0.3311 respectively (between minor and major damage), while larger properties like Single Family Residence Multi Story have an average damage of 0.0806 (affected damage). Smaller single stories have a 115.54% higher average damage compared to larger multi story properties. As a result the bar graphs for average expected loss will be similarly shaped to our bar graphs for average damage. Single Family Residence Single Story and Utility Misc Structure have an average expected loss of 176,483 and 148,553 respectively, while larger properties like Single Family Residence Multi Story have an average expected loss of 45,210. Smaller single stories have a 112.94% higher average damage compared to larger multi-story properties. These findings make sense because larger multi story properties should have more defense against wildfires due to its sheer size. As a result, these properties would also have a lower expected loss. The total expected loss for the structure type property characteristic is 531,963,279 which is 26.68% of the total TIV.

Vent Mesh







Our data contains properties with 3 types of Vent Meshes, that range from ¼ inch to ⅛ inch to 1/16 inches. We can observe that properties with a higher total insured value typically have smaller sized vent mesh. Properties with 1/16 inch vent meshes on average have a value of $571k, which ise 12% more valuable than the average insured value of a property with ¼ inch vent meshes. These measurements of inches represent the average diameter of the hole in the mesh.

We can also observe that the smaller sized vent meshes have a remarkably lower damage coefficient on average. Properties with a ¼ inch vent mesh have an average score of 0.53, while properties with a ⅛ inch vent mesh have a damage score of 0.1975, which is about a 62% decrease in expected damage. Properties with a 1/16 vent mesh have an even lower average damage score at 0.088, which is another 50% decrease. Similar to what was observed in the defensible, properties with larger total insured values happen to have the best type of protection which mitigates a high amount of damage. Properties with a ¼ inch vent mesh are expected to cost more than 5 times on average in comparison to properties with a 1/16 inch vent mesh. This is due to the fact that smaller holes prevent flammables like small sharples of amber from entering the property and starting a flame.

V. Recommendation

In response to our previous analysis, CHCIC should adjust its premiums according to the different risks of each property characteristic. By constructing a risk classification and rating factors, the future rate change will better reflect the risk exposure of each property. We set our base premium for a Single Family Residence Single Story with a 30-100 feet defensible, maintained rooftop, non-combustible sliding material, and ⅛ inch vent mesh. We decide to have 30-100 feet as the base defensible as currently, California law requires 100 feet of defensible space around any structure, building or to the property line. Moreover, it is clearly reasonable to select a maintained rooftop and non-combustible sliding material as the base levels as all policyholders have the responsibility to maintain their property to withstand wildfire. We choose Single Family Residence Single Story as the base structure type it has the greatest exposure and total insured value in the company, also being the median average damage and average expected losses among all structure types. We believe Single Family Residence Single Story would be an accurate and reliable basis in comparison to other structure types. Finally, we select 1/8 inch vent mesh as the base level as 1/8 inch and 1/16 inch vent meshes provide better protection from flame entry to the property. While the California Building Code only requires 1/4 inch vent mesh, it is said to be ineffective and should be replaced or retrofitted. Therefore, requiring policyholders to install 1/8 inch mesh vents would better protect their property and also reduce the expected loss of the company.

Defensible	Exposure	Expected Loss	Avg. Expected Loss	Indicated Relativity	Indicated Relativity to Base
30 - 100 feet	1878	151,586,716.87	80,717.10	0.56275	**1**
5 - 30 feet	905	154,079,916.79	170,254.05	1.18698	**2.1093**
0 - 5 feet	873	218,728,547.00	250,548.16	1.74678	**3.1040**
Total	3656	524,395,180.66	143,434.13	1.00000	**1.7770**

Vent Mesh	Exposure	Expected Loss	Avg. Expected Loss	Indicated Relativity	Indicated Relativity to Base
1/4 inch	1312	151,586,716.87	269,890.58	1.88163	**2.4717**
1/8 inch	746	154,079,916.79	109,190.09	0.76126	**1**
1/16 inch	1598	218,728,547.00	50,547.58	0.35241	**0.4629**
Total	3656	524,395,180.66	143,434.13	1.00000	**1.3136**

Roof	Exposure	Expected Loss	Avg. Expected Loss	Indicated Relativity	Indicated Relativity to Base
Maintained	1861	203,568,409.26	109,386.57	0.75016	**1**
Unmaintained	1795	329,541,391.91	183,588.52	1.25903	**1.6783**
Total	3656	533109801.2	145,817.78	1.00000	**1.3331**

Sliding Material	Exposure	Expected Loss	Avg. Expected Loss	Indicated Relativity	Indicated Relativity to Base
Non-Combustible	1616	116,685,438.34	72,206.34	0.49949	**1**
Combustible	2040	411,826,175.34	201,875.58	1.39648	**2.7958**
Total	3656	528511613.7	144,560.07	1.00000	**2.0020**

When constructing the risk classification and relativities, special consideration is given to structure type. We observe that some structure types have too small sample sizes (>5% of the data), therefore we decide to manually adjust the rate relativities for any structure type with less than 50 exposure, including Church, Mixed Commercial/Residential, Mobile Home Triple Wide, Multi Family Residence Multi Story, Multi Family Residence Single Story, and School. Since the figures of average damage and expected losses can be easily skewed by some particular data point, these past results do not accurately reflect future potential losses unless the sample size increases. Therefore, we adjust their rate relativities closer and converge to 1 which is the base level in order to avoid overcharging or undercharging premium and prevent potential adverse selection.

Structure	Exposure	Expected Loss	Avg. Expected Loss	Indicated Relativity	Indicated Relativity to Base	Adjusted Indicated Relativity to Base
Church	7	2,517,796.50	359,685.21	2.471992298	2.038070651	1.5
Commercial Building Multi Story	30	4,285,218.00	142,840.60	0.98169414	0.809372269	0.8094
Commercial Building Single Story	240	44,198,037.14	184,158.49	1.265657737	1.043490261	1.0435
Infrastructure	88	4,389,366.48	49,879.16	0.34280225	0.282628391	0.2826
Mixed Commercial/Residential	9	2,908,009.33	323,112.15	2.22063828	1.83083811	1.5
Mobile Home Double Wide	137	20,528,133.39	149,840.39	1.029801281	0.849034914	0.8490
Mobile Home Single Wide	126	35,380,563.43	280,798.12	1.929828557	1.591075728	1.5911
Mobile Home Triple Wide	25	7,806,057.84	312,242.31	2.145933622	1.769246748	1.5
Motor Home	72	18,355,548.75	254,938.18	1.752102116	1.444546532	1.4445
Multi Family Residence Multi Story	8	1,710,486.75	213,810.84	1.469448104	1.211508246	1
Multi Family Residence Single Story	32	5,093,434.41	159,169.83	1.093919302	0.901897965	1
School	8	0.00	0.00	0	0	0.5
Single Family Residence Multi Story	733	33,139,003.35	45,210.10	0.310713412	0.256172273	0.2562
Single Family Residence Single Story	1203	212,309,283.28	176,483.19	1.212908049	1	1
Utility Misc Structure	938	139,342,340.05	148,552.60	1.020950745	0.841737958	0.8417
Total	3656	531,963,278.70	145,504.18	1	0.824464806	0.8245