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Team Disney Donut

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***Impact of climate change on bushfires in Australia***

### Why look into climate change and bushfires?

Climate change is a key issue around the world. The effects of climate change is keenly felt during bushfire season. In early 2020, Australians and the world saw the catastrophic result of bushfires across the state, in California and the Amazon Rainforest.

The most common assumption is that these catastrophic bushfires are caused by climate change. In turn, climate change is a result of rising temperatures, more emissions in our ozone layer, less rainfall, and less trees in the forest.

Guided by this, the Disney Donut Team set out to investigate two main questions:

* How has the climate impacted the occurrence of bushfires in Australia?
* How has climate change impacted the environment?

We expect to find, or our ‘***Hypothesis***’, is as follows:

|  |
| --- |
| 1. Climate change has increased the occurrence and severity of bushfires. 2. There is a relationship between bushfires, GHG, rainfall, temperature and deforestation. |

### Data cleaning and analysis

To ensure robustness of our analysis, the team sought to collect data that spans over 20 years. Data cleaning and analysis is undertaken manually using Microsoft Excel and VSCode.

Some of the data needed to undertake this analysis are often not in a useable format. For example, bushfire data is often presented as geo-spatial data, which has not been covered in the course yet and beyond the expertise of the team. Historical data on level of fuel load on forest floor, which would be a leading indicator on the likelihood of bushfires occurring, is only reported every 5 years.

The team had to be creative to find other proxies for climate change that can be used to undertake the climate change and bushfire analysis.

### Rainfall

The lack of rainfall is commonly assumed to contribute to draught and drier vegetation, which in turn, become fuel for bushfires.

First, we looked at average monthly Australian rainfall data obtained from the World Bank Climate Knowledge Portal. Calculating the average rainfall for all months in each year suggests that there has been a consistent and slightly positive trend in rainfall since 1990. See **Figure 1** below.

**Figure 1. Average monthly rainfall across Australia**

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Second, we looked at total yearly rainfall data for each Australian state obtained from the Australian Bureau of Meteorology. **Figure 2** shows that the total rainfall differs significantly for individual years. However, performing a linear regression for the individual states shows that total rainfall is consistent over a long-term period.

**Figure 2. Total rainfall for each Australian states and territories**

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### Greenhouse Gasses

Australia experiences extreme temperatures in summer, which is commonly attributed to more greenhouse gasses present in our atmosphere. Fire emergency departments around Australia are on high alert during summer and surrounding ‘fire season’, as the heat can spark a bushfire.

Data on greenhouses gasses was sourced from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), an Australian Government scientific research body, has been collecting monthly greenhouse gasses from the Cape Grim research station in Tasmania for over 40 years. Together with the stations at Mauna Loa in Hawaii and Alert in the Canadian Arctic, Cape Grim is one of three premier Baseline Air Pollution Stations in the World Meteorological Organization-Global Atmosphere Watch (WMO-GAW) network.

**Figure 3. Map of air pollution science stations around the world**

Map

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This report examined the three most abundant greenhouse gasses in the Earth’s atmosphere measured at Cape Grim: Carbon Dioxide (ppm) –  **CO2**; Methane (ppb) – **CH4**; and Nitrous Oxide (ppb) – **N2O**.[[1]](#footnote-1)

As shown in **Figure 4**, plotting the datasets over time show that the presence of all three gasses have increased in the atmosphere since 1990.

**Figure 4. Plot of CO2, CH4 and N2O**

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We explored the relationship between greenhouse gasses and temperature in the following section.

### Temperature

As discussed in the previous section, we examined temperature data as Australia experiences extreme temperatures in summer and lead to bushfires. Monthly Australian temperature data was obtained from the World Bank Climate Knowledge Portal. A monthly mean temperature was obtained and used to calculate the mean temperature for each year. Figure 5 demonstrates that there has been an upward trend in temperatures since 1990.

**Chart, scatter chart

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#### **Temperature and Greenhouse Gasses**

We asked the age old question: ‘Does an increase in the level of greenhouse gasses in our atmosphere have an influence on temperature?’

A regression analysis on recorded Australian temperatures and CO2 data over 30 years (from 1991 to 2020), shown in **Figure 6**, suggests that there is a moderate positive relationship (R-square = 0.4) between the two.

Therefore, a rise in greenhouse gasses does influence the rise of temperatures in Australia. However, other climate factors, such as cyclones, should also be considered.

Chart, scatter chart

Description automatically generated**Figure 6. CO2 emissions and temperature (1991-2016)**

### Deforestation

The data on deforestation was retrieved from the Australian Department of Agriculture, Water and Environment. The dataset contains only the forested area totals in million hectares per year between 1991-2016 with relatively minor variance. We extrapolated the last four years, i.e. 2017-2020, using the 5-year average annual increase starting in 2009.

We hypothesised that climate change would cause deforestation to rise. Therefore, we expected that the level total forested areas would worsen over time.

Plotted using Pandas, the forested areas deforestation data quickly showed that our hypothesis is untrue. The data showed that there was an initial decrease until around 2007. After this time period, the data shows that forested areas is rising as shown in **Figure 7** below.

Chart, line chart

Description automatically generated**Figure 7. Forest area (in million hectares) per year**

#### **Correlation coefficients**

We also hypothesised that deforestation has a relationship with the other proxies for climate change. In particular, with CO2 as it is stored in flora, with trees considered to be the biggest 'containers' for the CO2.

The table below summarises the results of the correlations coefficient test, which shows that there is a moderate positive relationship with the three greenhouse gasses considered in our study: CH4, CO2, N2O.

**Table 1. Correlation test result on deforestation**

|  |  |
| --- | --- |
| **Deforestation versus:** | **Correlation coefficients** |
| Burned area ha | 0.06 |
| **CH4** | **0.37** |
| **CO2** | **0.23** |
| **N2O** | **0.23** |
| **Total rainfall mean (states)** | **-0.18** |
| Average rainfall mean (AU) | 0.01 |
| Average temperature (AU) | -0.0002 |

Surprisingly, deforestation has a moderate negative relationship with the total mean rail fall in each state. The results suggests that as forested area increases by a million hectares, total rainfall decreases by 18%.

### Bushfires

Data on bushfire was taken from a number of sources.[[2]](#footnote-2) Throughout the data collection process, the team found that the data often is not consolidated because fire and emergency agencies would only publish data on bushfires for their region. Where data is consolidated, the data is in not in csv or excel format or is presented as geospatial data.

Proxies on the severity of bushfires was also difficult to source and determine. Most information published are on the total hectares or acres burnt, the number of fatalities, homes, buildings and properties destroyed and total number of cattle lost. The data on the economic value of bushfires, which could have represented the severity of bushfires, is few and far between which resulted in an unbalanced panel data.

In the end, the total hectares burnt is chosen as a proxy on the size and scale of bushfires and the number of bushfires in a year is chosen as a proxy for frequency.

First, we examined whether the changes in environmental factors (as a result of climate change) causes an increase in the occurrence of bushfires measured by the number of ‘major’ bushfires observed in a year.[[3]](#footnote-3)

A preliminary analysis on number of major bushfires per year shows that it is a weak relationship. Except for some outliers in 2007, 2011 and 2020, there does not seem to be an increase in the number of major bushfires.

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Description automatically generated**Figure 8. Number of major bushfires per year (1990 to 2020)**

**Figure 8** may show that there is no significant increasing trend, it still feels like Australians experience at least one major bushfire almost every year.

Examining the history of major bushfires (**Appendix A**), a large number of bushfires seem to have occurred over 20 years ago. Only a few major bushfires occurred in the last 20 years – these are the 2019-20 Australian bushfires that collectively destroyed almost 20 million hectares of forest land and threatened the biodiversity and conservation of Australia’s ecosystem. This observation suggests that regardless of temperatures rising, there will be a fire in our bushland!

#### **Bushfires and Rainfall**

We hypothesized that draught (caused back lack of rainfall) have a strong relationship with the frequency of fires and severity of bushfires measured at million hectares burnt.

When comparing the average rainfall for Australia to the burned bushfire area for each year, it was found that there was a negative relationship (R-squared value of -0.41) as shown in **Figure 9** below.

Chart, scatter chart

Description automatically generated**Figure 9. Average rainfall and burned area (in millions), 1991-2020 (with outliers)**

Removing this outlier showed us a little bit more variability and changed the R-squared value from -0.41 to -0.14 (**Figure 10**), but did not change the results from our previous analysis.

**Figure 10. Average rainfall and burned area (in millions), 1991-2020 (without outliers)**

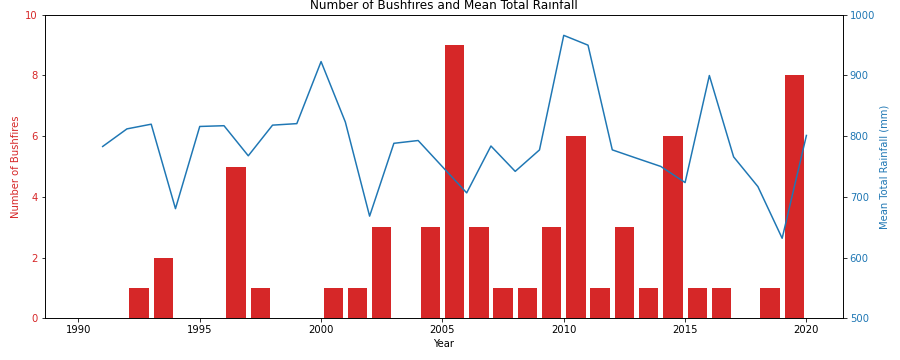
Chart, scatter chart

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The negative relationship observed could be because recorded rain levels occurred before bushfires started, or after the bushfire incident. Thus not providing respite to emergency services personnel during bushfires.

When we try to intersect the periods where Australia experienced major bushfires, we were able to glean that total rainfall would dip a couple of years prior. For example, in **Figure 11,** total rainfall fell sharply post 2015 to around 202; around the same time that Australia experienced one of the worst bushfires in history.

**Figure 11. Number of bushfires and mean total rainfall (1990-2020)**



### Further Research

Our analysis showed that the relationship between climate change and bushfires is complex. As shown with rainfall and bushfires, for example, the data does not support our hypothesis but this could partly be because of the datasets.

If the team had more time, we would undertake further research and analysis on other variables, such as:

* **Wind speed** – This affects the ability for fire and emergency services personnel to put out and contain fires. Finding a good source of data on this was a difficult task.
* **Other weather systems** – The presence of cyclones usually means that there is higher humidity. Combined with wind speed, it creates ideal conditions for fire to spread.
* **Geospatial data –** The locations of the fires (e.g. in bushland with minimal biodiversity) as a potential indicator of economic value loss.
* **Frequency of burn-offs during off-peak fire season** – The level of fuel load on the forest floor can affect the size and scale of bushfires. There are claims that the Government should undertake more prescribed burns to reduce the probability of bushfires.
* **Economic cost of bushfires** – This information was the most difficult to obtain as it is not published by Insurance Australia. While news outlets reports an estimated cost of bushfires, it may not reflect the “true” cost which includes the direct and indirect cost of experiencing a natural disaster. For example, the Perth Hills bushfires in February 2021 have burnt more than 10,000 hectares of land, destroyed approximately 80 houses and displaced thousands of residents. Analysts can estimate the economic value of land burn and houses destroyed, but the affects of being displaced or seeing your own house burn down is often not included in the total.

### References

Data for this report has been obtained from the following resources:

1. Temperature – Climate Knowledge Portal (World Bank)
2. Green House Gasses – CSRIO
3. Rainfall
4. Climate Knowledge Portal (World Bank)
5. Bureau of Meteorology (Australia)
6. Deforestation – Australian Department of Agriculture, Water and Environment
7. Bushfires – Wikipedia, Fire Departments website across Australia, Newspapers (CNN, BBC, ABC News).

# Appendix A. Major bushfires in the last 20 years (‘area burned ha’)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ranking** | **year** | **description** | **state** | **area burned ha** |
| 1 | 1975 | 1974-75 Australian bushfire season | Northern Territory | 45,000,000 |
| 2 | 1970 | 1969-70 Dry River-Victoria River fire | Northern Territory | 45,000,000 |
| 3 | 1968 | 1968-69 Killarney Top Springs bushfires | Northern Territory | 40,000,000 |
| 4 | 2002 | 2002 NT bushfires | Northern Territory | 38,000,000 |
| 5 | 1975 | 1974-75 Australian bushfire season | Western Australia | 29,000,000 |
| 6 | 1975 | 1974-75 Australian bushfire season | South Australia | 16,000,000 |
| 7 | 1975 | 1974-75 Australian bushfire season | Queensland | 7,300,000 |
| 8 | 2020 | 2019–20 Australian bushfire season (Black Summer) | Northern Territory | 6,800,000 |
| 9 | 2020 | 2019–20 Australian bushfire season (Black Summer) | New South Wales | 5,500,000 |
| 10 | 1851 | Black Thursday bushfires | Victoria | 5,000,000 |
| 11 | 1975 | 1974-75 Australian bushfire season | New South Wales | 4,500,000 |
| 12 | 1952 | 1951–52 bushfires | Victoria | 4,000,000 |
| 13 | 2020 | 2019–20 Australian bushfire season (Black Summer) | Queensland | 2,500,000 |
| 14 | 1985 | 1984 - 85 New South Wales bushfires | New South Wales | 2,484,000 |
| 15 | 2020 | 2019–20 Australian bushfire season (Black Summer) | Western Australia | 2,200,000 |
| 16 | 2003 | Tenterden | Western Australia | 2,110,000 |
| 17 | 1957 | 1957 Grose Valley bushfire, Blue Mountains | New South Wales | 2,000,000 |
| 18 | 1939 | Black Friday bushfires | Victoria | 2,000,000 |
| 19 | 1961 | 1961 Western Australian bushfires | Western Australia | 1,800,000 |
| 20 | 2020 | 2019–20 Australian bushfire season (Black Summer) | Victoria | 1,500,000 |

1. Ppm = parts per million; Ppb = parts per billion. [↑](#footnote-ref-1)
2. Wikipedia, newspapers (CNN, ABC), Australian Geographic, and many more. [↑](#footnote-ref-2)
3. For the purposes of this report, a major bushfire is a bushfire that have more than one of the following properties: destroyed more than 1 million hectares of land, destroyed buildings, caused loss of life and killed cattle. [↑](#footnote-ref-3)