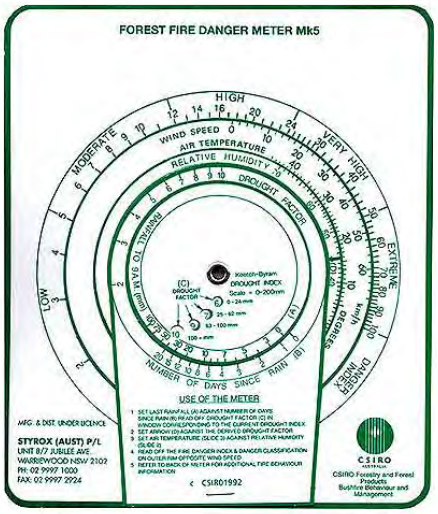
Climate Change and its effect on the Australian Bushfires

Eastern Australia : Sept 2019 – Jan 2020

The following graph uses the Forest Fire Danger Index (FFDI) to compare the changes of temperature to the changes of fuel in a forest fire in Australia.
The changes of temperature related to climate change is not the purpose of this discussion, but the increase in temperature, as indicated by Climate Change scientist, of a two degree change is used as a variable in the graph, for this comparison.

This FFDI index resulted, from a problem for fire-fighters in predicting fire behaviour and the solution was developed by CSIRO in research conducted by scientist A.R McArthur in the 1960-70s.

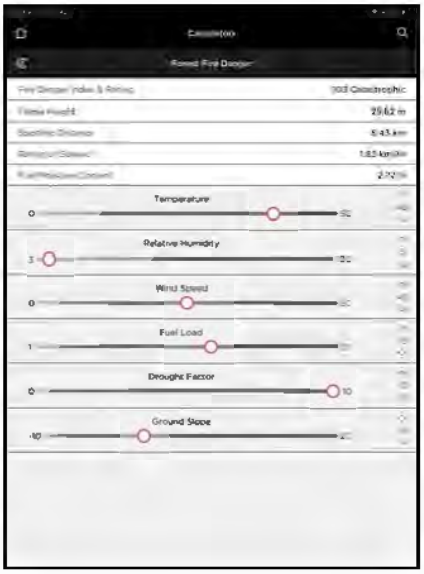
The resulting CSIRO research produced a scale 0 to 100, predicting the severity of a fire in all weather conditions. The scale was never designed to extend over one hundred. The last input was fuel, something that must be inputted at a particular location and due to its variability was an 'on ground measurement.



After the Victorian Fires of 2009 a new term was introduced for a FFDI of greater than one hundred. It was called 'Catastrophic" or Code Red (Victoria)

You could argue that this simple tool, a combination of weather and climate indicates that climate change has occurred as the number of100 plus FFDI days has increased. Whether man-made or not, is irrelevant in this paper

Over the years the Bureau of Meteorology (BOM) has assisted the NSW RFS in providing forecasts, that assists the inputs used in the FFDI formula.
The BOM in conjunction with the RFS now make FDI forecasts during the fire season for the different Fire Weather Zones within the State.



THE GRAPH(on Page 3)

The graph below, uses the FFDI and has variable inputs of weather and fuel loads.

Any person can check these figures using the RFS Pocketbook App or if you wish the Macarthur's original rotary slide rule. (FFDI Mark 2)

The graph deliberately uses two variables, Temperature and Fuel. The other inputs for the graph are fixed and deliberately set for a FFDI of 100. They are Humidity : 5 percent, Wind : 40 KPH, Drought Factor : 10 (maximum) and Slope : 0

Drought Factor

A variable factor that most people may not be familiar with, it is a simplified method of judging the environment including moisture content of soils and vegetation. Drought Factor is a range from 0 to 10. Ten being the worst, NSW, being in drought has been 10 for a number of years.

If the methodology of this comparison is questioned by indicating the drought is caused by climate change then this graph uses the extreme drought factor of 10 as a fixed factor.

The two variables with the graph are, temperature showing a 2 degrees increase due to climate change and fuel showing a scale from 10 to 25 tons per Hectare (t / Ha) On the graph the temperature rise of two degrees makes the FFDI rise to 110. and thus a Catastrophic day.

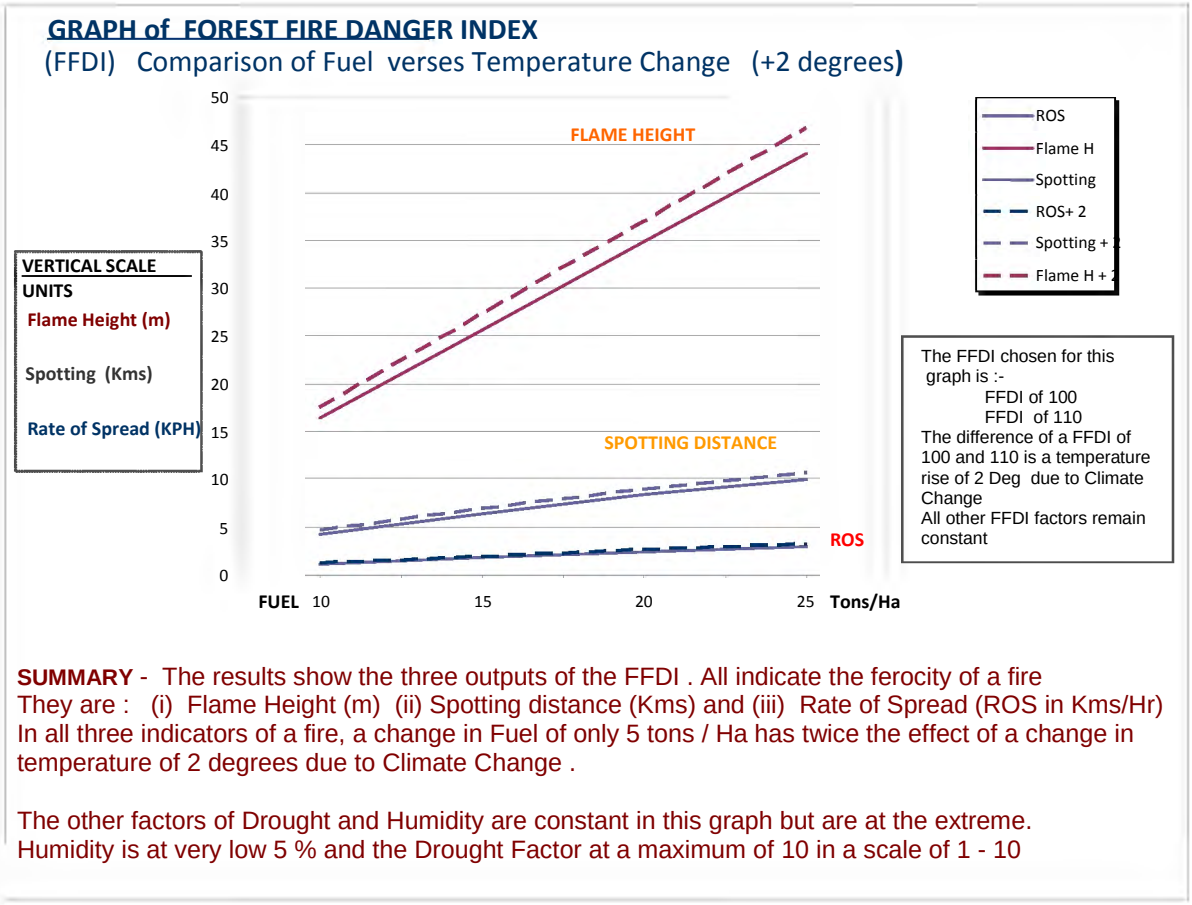
The fuel loading has no influence on the FFDI as it is not until the fuel calculation at a particular location, is added, that the severity of a fire will be known.

Fire-fighters use the FFDI and add the fuel loading then working out the three important indicators of how the fire will react.

These three factors are:-

Flame Height, measured in metres (m)
Spotting Distance, measured in Kilometres (Kms)
Rate of Spread (ROS) speed of fire measured in Kms per Hour (KPH)

The outputs of the graph shows these three factors and thus the severity of the fire, for both a temperature increase and also a fuel load increase



SUMMARY - The results show the three outputs of the FFDI . All indicate the ferocity of a fire
They are : (i) Flame Height (m) (ii) Spotting distance (Kms) and (iii) Rate of Spread (ROS in Kms/Hr)
In all three indicators of a fire, a change in Fuel of only 5 tons / Ha has twice the effect of a change in temperature of 2 degrees due to Climate Change .

The other factors of Drought and Humidity are constant in this graph but are at the extreme.
Humidity is at very low 5 % and the Drought Factor at a maximum of 10 in a scale of 1 - 10

Summary

The graph of the *Flame Height* output simply shows that a 2 degree increase in temperature, changed the Flame Height by 2 metres, but a *Fuel Load* increase of 5 tons per Hectare increases Flame Height by 9.2 metres

The other two fire indicators, Rate of Spread and Spotting show a similar relationship

Items to Note

1. Fuel loads over 25 t / Ha were reported during these fires with some reports indicating 45 – 50 tons per hectare as normal for some forests.
The FFDI fuel scale in the graph only goes to 25 t/Ha

2. Flame Heights, reported by fire fighter were also extremes with indications of twice the height of established trees (50 - 60 metres)

3. The rough rule of thumb for fire fighters is:- if the fuel litter on the floor of a forest is as deep as your thumb nail (1 cm), it is 5 tons per hectare.

Thus from the graph the temperature increase of 2 degrees at the 15 ton / Ha fuel loading means that 2mm of extra fuel over one Hectare is equal to this same temperature rise.

4. The coast of Queensland, NSW and Victoria experience extreme fires over the period from September 2019 till January 2020. These were all located in areas of high fuel loads.

5. Some observers will say that temperatures were higher than 42 degrees in these fire and this is true, but the graph outputs are a straight line, within the range of fuel loads and any higher temperature on any particular day will still have same ratio of temperature verses fuel

6. The temperature rise of 2 degrees is a forecast for 2030 and at preset the Observations are only one degree for 2020.

Observation

The coast of Queensland, NSW and Victoria experience extreme fires over the period from September 2019 till January 2020. These were all located in areas of high fuel loads mostly on the tablelands and coast hinterlands that has a large portion of government managed land.

These fires moved at below average speeds for weeks and months all waiting for that FFDI of 100 +, to come along. On these days the fire made extremely hot and fast *runs* and usually came out in populated areas creating the severe destruction to property and wildlife.

Once these fires became established the perimeter became too large and too difficult to patrol even under calm conditions. The fire continued, slowly moving through timbered areas waiting for the next FFDI of 100+

The two forest fires in the western part of NSW that occurred at the same period, were subject to the same drought, the same high temperatures and the same low humidity.

These fires were contained within days and weeks, not months.

The difference, the fuel load.

Pilliga	10/1/2020
Goonoo (pictured)	22/10/19

References

McArthur AG. Bushfires in Australia. CSIRO.; 1978.
(methodology of the Forest and Grasslands Fire Dangar Index)

Andrew Dowdy Climatological Variability of Fire Weather in Australia June 2017

Conclusion

Australians cannot influence the climate, but they can influence the fuel loads.

Attachment - Page showing Excel Graph in detail (Page 6)

Footnote

Below is an aerial photo showing the number of residence in the Bucketty Area, Great Northern Rd, in the Hawkesbury Area

These homes, built on 'dead end' roads are under 20 years old and are located on the eastern edge of a timbered National Park that extends from this valley, west to the Capertee Valley

The Gosper Fire started approx 50 kilometeres west of this location and is lucky to have escape this fire.

Easterly winds over a number of days, took this fire west to Lithgow and the high humidity at night, was the only reason this area was left untouched.

How can any fire Agency protect these homes.

CALCULATIONS USED FOR GRAPH ATTACHMENT to Bushfire Enquiry April 2020

Factors	Factors	Units				
Temp	Varable	Degrees C	40	40	40	40
RH	Fixed	Percentage	5	5	5	5
Wind	Fixed	KPH	40	40	40	40
DF	Fixed	0-10	10	10	10	10
Slope	Fixed	Degrees	0	0	0	0
FFDI	Output	Fire Dangar Index	103	103	103	103
ROS	Output	Rate of Spread (KPH)	1.2	1.85	2.46	3
Flame H	Output	Flame Height (m)	16.4	25.6	34.8	44
Spotting	Output	Spot Dist (Kms)	4.3	6.4	8.3	9.9
FUEL	Varable	T / Ha	10	15	20	25

2° Rise due to CC			
42	42	42	42
5	5	5	5
40	40	40	40
10	10	10	10
0	0	0	0
110	110	110	110
1.3	2	2.64	3.3
17.5	27.3	37	46.8
4.7	6.9	8.9	10.6
10	15	20	25

Differences from a 2° rise			
1.1	1.7	2.2	2.8
6.7%	6.6%	6.3%	6.4%
0.4	0.5	0.6	0.7
9.3%	7.8%	7.2%	7.1%

Equation of 40° C Line: **FH = -2 + 1.84 x Fuel**
(when Temp is 42 deg C and Fuel is between 10 and 27 T/Ha)

Temp	Fuel	FH: Flame Height	Fuel Incr	
40	**10**	16.4		
40	**15**	25.6	**Equation validation**	
40	**20**	34.8		
40	**25**	44		
40	10.60	17.5	6.0%	Is equiv
40	15.92	27.3	6.2%	to a 2°
40	21.20	37	6.0%	temp rise
40	26.52	46.8	6.1%	

Equation of 42° C Line: **FH = -2 + 1.953 x Fuel**
(when Temp is 42 deg C and Fuel is between 9 and 25 T/Ha)

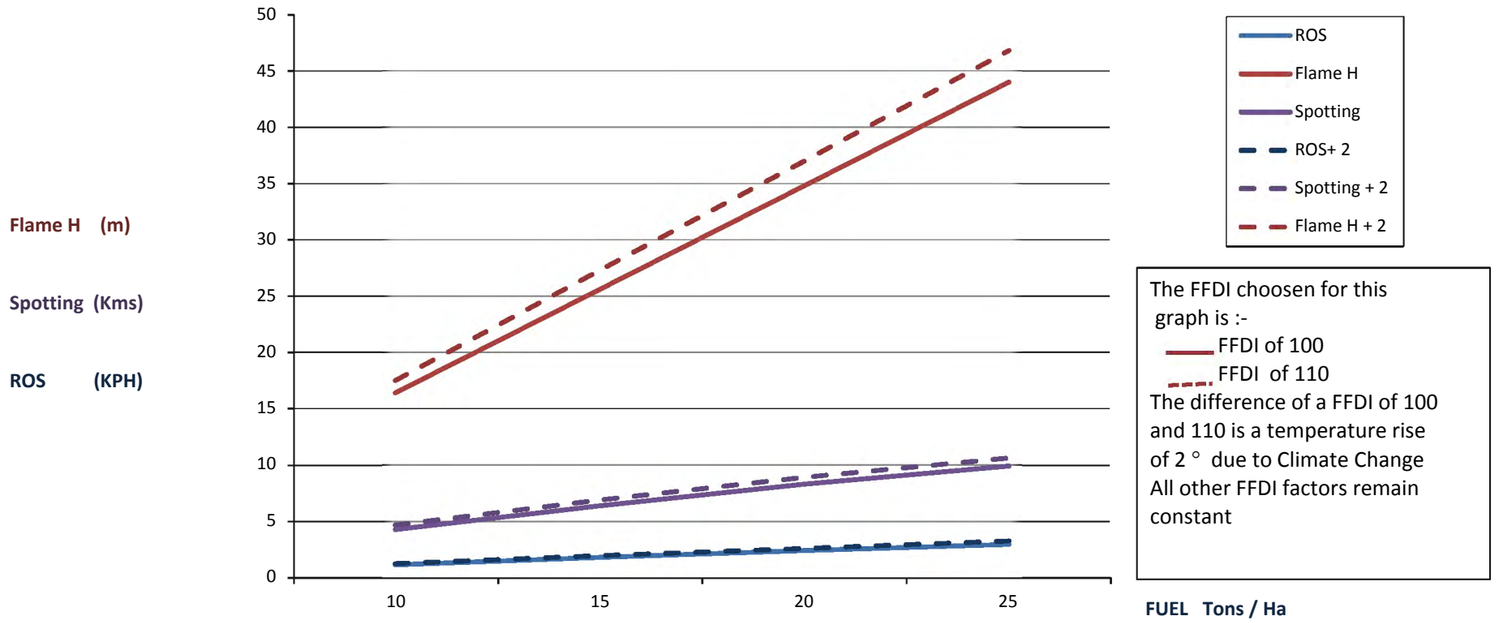
Temp	Fuel	FH: Flame Height	Fuel Red'n	
42	**10**	17.5		
42	**15**	27.3	**Equation validation**	
42	**20**	37.1		
42	**25**	46.8		
42	9.42	16.4	-5.8%	Reduction
42	14.13	25.6	-5.8%	required
42	18.84	34.8	-5.8%	to nullify
42	23.55	44.0	-5.8%	2° temp incr

Conclusion:

A two degree increase in temperature, from whatever cause, will increase the Forest Fire Danger Index (FFDI) from 100 to 110 and results in an increase in Flame height of 6.3 - 6.7%.

However, if the 2 degree increase in temperature, changed the FLAME HEIGHT by 2 metres, but a FUEL LOAD increase of 5 tons per Hectare increases FLAME HEIGHT by 9.2 metres (Remember 5 t/Ha is a thumbnail depth)
The other two fire indicators, Rate of Spread and Spotting show a same increase.

GRAPH of FOREST FIRE DANGER INDEX (FFDI) Comparision of Fuel with Climate Change (+2 degrees)



The FFDI choosen for this graph is :-
FFDI of 100
FFDI of 110
The difference of a FFDI of 100 and 110 is a temperature rise of 2 ° due to Climate Change
All other FFDI factors remain constant

The results show the three outputs of the FFDI They are Flame Height (m) Spotting distance (Kms) and Rate of Spread (ROS in Kms/Hr)
In all three indicators of the ferocity of a fire, a change in Fuel of only 5 tons / Ha has twice the effect of a change in temperature of 2 degrees due to Climate Change . The other factors of Drought and Humidity are constant in this graph but are also at the extreme.
That is Humidity at as very low 5 % and the Drought Factor at a maximun of 10 is a scale of 1 - 10