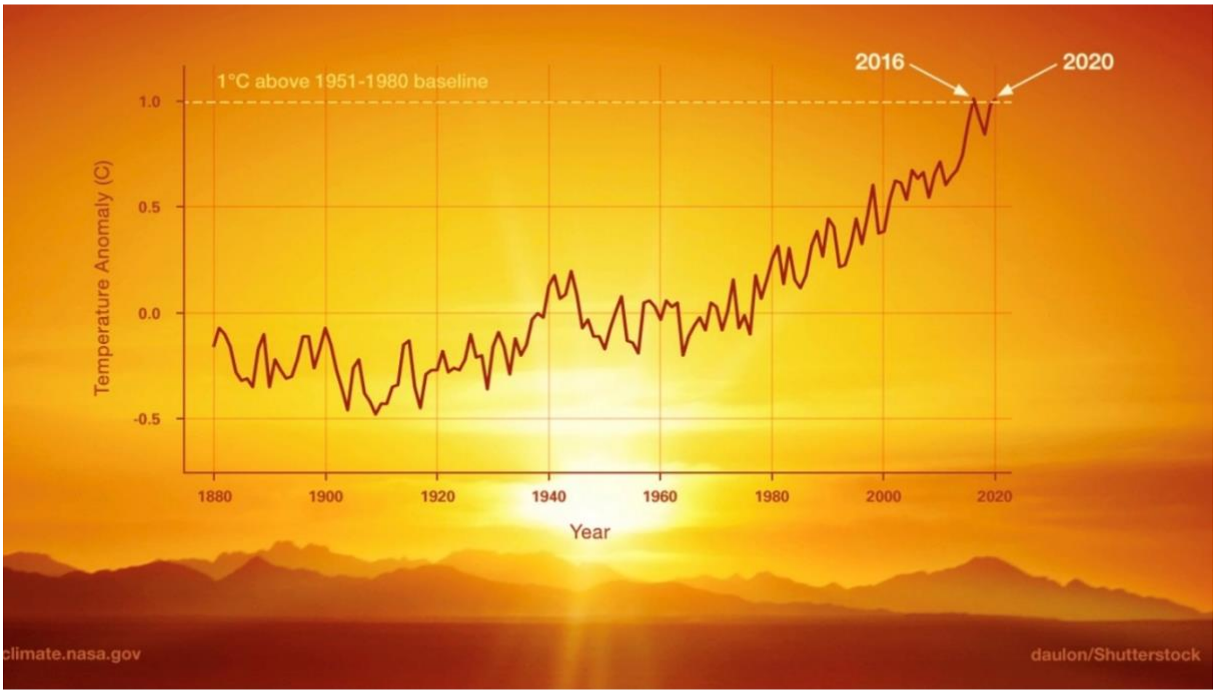
Climate Change and Forest Management for Bushfires

Setting the scene

In recent times there has been much said about the link between climate change and a predicted increase in large, uncontrollable and devastating bushfires. Let's try and understand what this means for bushfire management in Victoria.

Over millennia, the earth has experienced large regular swings in the global climate, from devastating droughts to ice ages. It is widely accepted that the earth is currently in a warming cycle and that the rate of warming is increasing, particularly over the past 100 years.



The change of global surface temperature 1800-2020.Source: NASA's Goddard Institute for Space Studies

Examples of the impact of climate change are evident in the alpine areas in SE Australia where the snow line has been slowly rising in altitude; in the southwest of WA where over the last 50 years the annual rainfall has fallen below the long-term average by about 30%; and in Tasmania where the incidence of lightning strikes has been increasing in the last 20 years.

The factors behind this warming cycle are not the subject of this article. What is discussed is how our changing climate will affect the frequency and intensity of bushfires, and what can be done to reduce their impacts now and into the future.

Factors affecting bushfire behaviour

The key factors which determine the behaviour and intensity of bushfires are:

- The amount and structural arrangement of the fuel;
- The moisture content of the fuel, which is determined by:
  - moisture in the atmosphere
  - antecedent rainfall
- Air temperature
- Wind strength
- Topography
- Soil dryness

There are interactions between all these factors, including weather events such as wind changes and temperature inversions.

A pyrocumulonimbus cloud rising over the Waroona fire in January 2016 (BOM image)

Large hot fires can produce pyrocumulonimbus (pyroCb) clouds in the form of convective columns resembling thunderstorms, which may be accompanied by strong and erratic inflow, potentially dangerous downbursts, and lightning strikes. These in turn can enhance fire spread rates and intensity, and cause sudden changes in fire spread direction and other anomalies.

Research has identified that an increased risk of pyrocumulonimbus has occurred over recent decades. The results also suggest that conditions for pyrocumulonimbus cloud formation may continue to become more dangerous into the future in southeast Australia.

Climate change impacts on bushfire suppression

1. An increase in average air temperature of 2.5°C

There is strong evidence that the average global air temperature will increase by at least 2.5°C by 2100. An increase in air temperature will lower the fuel moisture and cause fuel to dry out more readily. Using the McArthur Forest Fire Danger Meter which calculates suppression difficulty in a standard fuel bed type, under high fire danger conditions a 2.5°C increase in air temperature will increase suppression difficulty. By way of example with air temperature of 35°C, relative humidity 15%, wind speed 25 kmh, fuel load 15 tonnes/ha, drought factor 5, and ground slope 10°, an increase of 2.5°C in air temperature would increase suppression difficulty by around 9%. This increase is relatively similar across a range of drought factors (further discussed in point 2 below). The predicted increase of 2.5°C in air temperature will therefore have an impact on fire suppression, particularly at the higher fire danger levels.

Another consideration is that warmer overnight temperatures will also make fire suppression more difficult as fire agencies often rely upon cooler nighttime temperatures to undertake critical fire control works such as backburning.

2. Longer and more severe droughts

Emerging evidence indicates that we will experience a drought situation 70% of the time, which amongst other things, impact on soil dryness. The Macarthur Forest Fire Danger Meter uses the Keetch–Byram drought index (known as KBDI), along with days since rain and amount of rain to calculate drought factor. The KBDI is an estimate of the soil moisture deficit, which is the amount of water necessary to bring the soil moisture to its full capacity. A high soil moisture deficit means there is little water available for evaporation or plant transpiration. This occurs in conditions of extended drought and has significant effects on fire behaviour.

Using the same example as above and increasing the drought factor to 6, along with an increase of 2.5°C in air temperature, suppression difficulty would increase by around 27% under high fire danger conditions. Similar increases in suppression difficulty are also the case under very high fire danger conditions. This demonstrates the critical interaction of increasing temperature and more severe drought conditions on fire behavior.

3. Increase in forest fuel levels

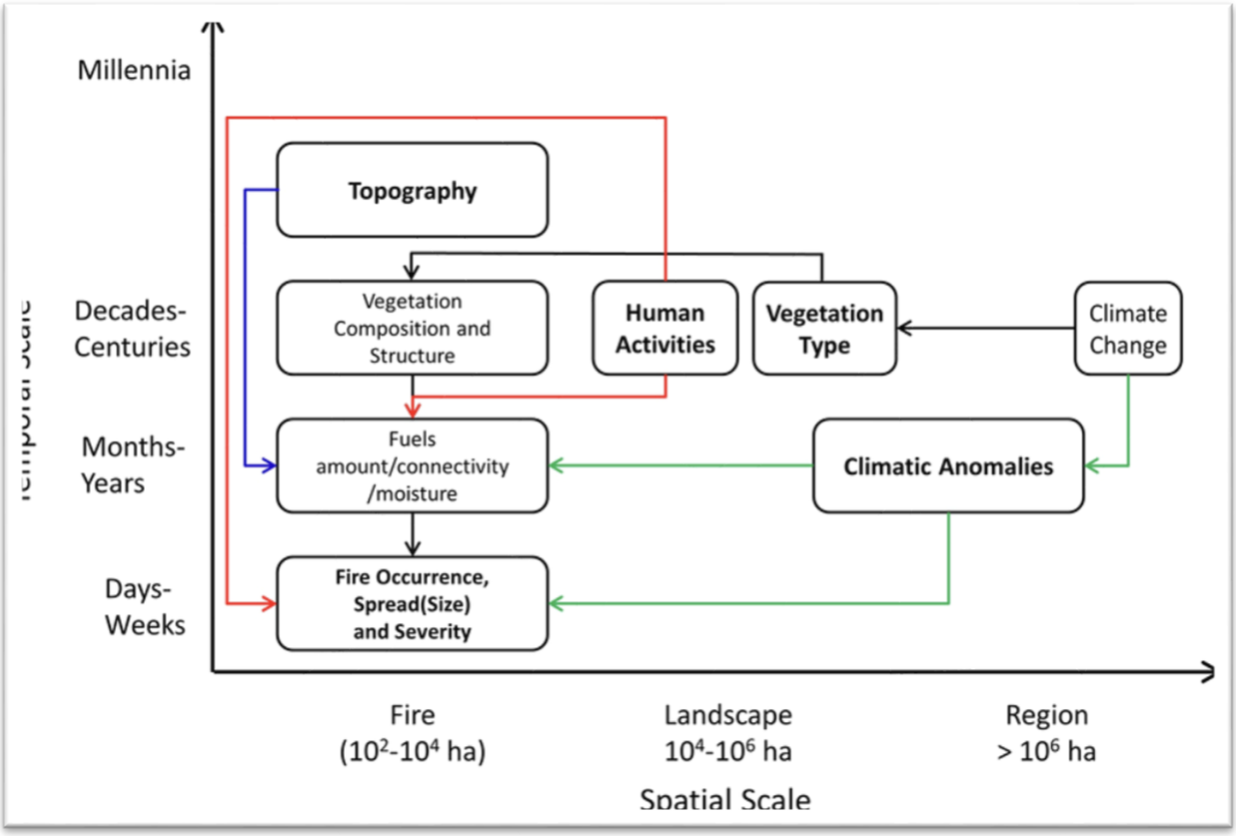
Fuel build-up depends on the rate of accretion (litter fall) and decomposition, and when this reaches an equilibrium. High rainfall during the warmer months increases decomposition rates and so surface fuel loads are generally low, for example in the rainforests and savannahs of northern Australia. In contrast in temperate Australia where rainfall is higher in winter, decomposition rates are low and so surface fuel loads can be very high, such as in Mountain ash forests.

Under the scenario of increasing temperature and less rainfall, fuel loads are likely to increase in the cool temperate forests which will increase flame height, spotting distance and rate of spread, all of which affect the ability to suppress fires. This has particular consequence for fire suppression in the foothill and sub-alpine forests in Victoria.

4. Decrease in fuel moisture levels

Prolonged drought and longer, hotter summers will reduce the moisture content of forest vegetation, leading to very low moisture contents in large fuels and removal of natural barriers such as swamps and moist green littoral areas along river and creek lines. Drier fuels will ignite more easily and will burn hotter once ignited, making fire control more difficult. Extinguishing large fuels (fallen trees and large branches) not only takes significant resources, but also their destruction has a significant impact on dependent forest fauna.

In northern Australia large areas of rainforest were impacted by bushfire during 2019/20, which is highly unusual. Rainforests have developed largely in the absence of fire, and so are becoming increasingly vulnerable with the drying out of surface fuels which predisposes them to a greater risk from bushfire.



Conceptual model of major factors affecting fire occurrence, size, and severity. Red lines: human influences; green lines: direct climate influences; black lines: indirect climate (vegetation) influences; blue lines: topographic influences. Bold text represents groups of variables included in the analysis. Non-bold text represents implicit relationships that were not directly analysed: Liu and Wimberley, 2015 Climatic and Landscape Influences on Fire Regimes from 1984 to 2010 in the Western United States, ResearchGate.

Impact on forest structure and forest fuels

The cessation of indigenous traditional burning across large parts of the Australian landscape has been a critical factor in transforming the structure of some of our forests, a process that started well before the impacts of climate change. This has been most dramatic in southern Australia where the understory of foothill forests and savannah woodlands has significantly changed. Historical records indicate that these forests and woodlands were more open with a predominantly grassy understory, however tree density has increased as well as the predominance of shrubs. This has been exacerbated by land management practices introduced by Europeans through the application of high intensity fire and grazing which have also reduced the extent of grasslands. As a result, fuel levels and therefore the fuel hazard, has increased significantly across these forested landscapes which further compounds any future effects from climate change.

Tree density and predicted increase in severity of drought is also another factor in foothill forests and savannah woodlands with the potential for widespread dieback further adding to the amount of fuel. These forests also tend to have fewer large trees and are less resilient to bushfires – there is a strong correlation between tree size and survivability from bushfires.

With the predicted increase in frequency and severity of bushfires further structural changes of our forests are likely to occur. The cumulative effects of frequent fires in fire sensitive ecosystems is likely to result in significant changes in species composition at a landscape scale. Mountain Ash and Alpine Ash dominated forests are particularly vulnerable as evidenced following the multiple large fires in Victoria since 2003. There is a very real risk that these forests will become dominated by wattles and shrubs, which will significantly impact on catchment and other environmental values. Forests which are currently fire resilient may also be impacted by more frequent and severe bushfires, and this is the subject of on-going research.

Climate change and forest fuel management

The only effective tool land management agencies have to reduce fuel hazards on the scale required to protect our communities, forests, soils, water and habitat from high intensity bushfires are planned burns. This is supported by an extensive body of scientific evidence that shows planned burns are effective, even under extreme fire weather conditions. Evidence given at the 2009 Victorian Bushfires Royal Commission showed that the spread of the Beechworth fire was retarded once it moved into an area that had been previously burnt. Had this not been the case then much of the Ovens Valley would have been impacted.

With climate change the predicted increases in air temperature, reduced fuel moistures, drier soils, and increase in fuel loads present significant challenges in implementing planned burns. Some of these challenges include an increased risk of fire escapes, unintended damage to the forest being treated (such as unacceptable levels of crown scorch and loss of hollow bearing trees), and increased danger from falling trees to those tasked with burning.

Planned burns in spring are likely to be more problematic with an increased risk of areas of unburned fuel and lower unburned layers reigniting as the fire weather becomes more dangerous during summer. Spring is also a time when the weather can be quite unstable. On the other hand, the changing climate with drier winter months may provide opportunities to extend the burning season post summer. Planned burns post summer have less risk because of the more stable weather and that it is getting cooler.

Over a number of decades there has been a gradual shift in policy by governments to reduce the extent of planned burning. This has been partly driven by risk aversion, and in Victoria most recently the policy of protecting built assets at the expense of protecting the environment at a landscape level. This has lead to increased fuel loads across much of the forested landscape.

What are the solutions?

Climate change is a fact and we will see more frequent and severe bushfires, and as such this presents a number of significant challenges to all Victorians. There are however strategies and actions which can be put in place to reduce the impacts of bushfires, and the occurrence of high intensity large scale bushfires.

First and foremost, land management agencies need to build the resilience of our forests. This means there has to be an increased effort in managing forest fuels across the broader landscape, and active management of forests to increase their survivability from bushfires. Some of the key actions would be to:

- Seek, acknowledge and apply indigenous traditional knowledge to the management of our forests – learn from the past.
- Actively manage forests to promote large trees – increase resilience.
- Implement planned burns at a landscape scale – strategically reduce fuels.
- Acknowledge that the protection of fire sensitive ecosystems means that we need to more actively apply fire to fire resilient ecosystems – protect the vulnerable.
- Ensure every effort is made to control bushfires quickly and safely – don't further compound the problem.
- Engage with and educate the broader community on the impacts of climate change on bushfires – gain community support.

This requires appropriate resourcing, a preparedness to critically review the current planned burning strategy, and acknowledgement that our forests need to be actively managed in partnership with traditional owners.

The consequences of not taking action are significant and inter-generational. Our forested public land provides incalculable environmental and socio-economic value to the Victorian community. Our high-quality water comes mainly from forested catchments. Our forests provide significant recreational value, both from a mental health perspective and economic benefit to rural businesses. Importantly our forests form the unique environmental fabric of Victoria, providing habitat to many and diverse species which we must protect as best as we can. Sitting on our hands is not an option.

Responding to the impact of climate change on bushfires through a triage approach is wasteful of resources and comes at an enormous economic and environmental cost. This approach will ultimately result in the demise of much of our unique and iconic flora and fauna. It is time to be proactive, immediate action is required – we in Victoria don't have the luxury of sitting on our hands waiting for a change in the current warming trend – we are at the tipping point.

Forest Fire Victoria will engage with land managers, government and the Victorian community to highlight the challenges facing bushfire management with climate change, and advocate for the adoption of appropriate strategies and actions.