Bushfire History in Victoria

Influence of bushfire weather severity and effectiveness of mitigation strategies on the bushfire damage toll

Part 2 Influence of weather severity and mitigation strategies on the bushfire damage toll, 1855 to Present

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September, 2018

Abstract
This study assembles long term data from 1855 to the present about annual bushfire season severity and annual damage toll over three policy eras to test three nominated theories:
It finds that Theory A applies to all policy eras - that bushfire season severity has a direct causal influence on annual damage potential. It finds that Theory B also applies to all policy eras - that bushfire protection strategies that mitigate damage potential have the capability to reduce the damage toll in proportion to their effectiveness. This was proven by the Stretton reforms. Theory C detected a worrying lapse of performance. In the first 45 years after the Stretton policy reforms, the percentage of serious damage toll years fell to 25% of all fire seasons, which was half the previous rate. But in the last 22 years, the percentage of serious damage toll years has reverted to 50% of all fire seasons, which is no improvement on the outcome of 100 years ago, despite the multi millions of dollars of investment in resources and equipment and the improvements in weather forecasting and technology. The outcome is an unacceptable deterioration that is worthy of urgent investigation and rectification.

Three mitigation influences are examined for effect on the frequency of damage toll years during higher severity years.
Government policy change: The 1945 Stretton reforms reduced damage toll by one third, but no reforms since.
Suppression capability: Capability to contain large fires in severe weather has not improved. This is of great concern because most of the high damage toll bushfires are in forested landscapes dotted with houses. The high tolls on Ash Wednesday and Black Saturday should have been acknowledged as symptoms of the limited capability of the suppression model in severe weather, yet it remains the government's only Plan A protective measure.
Control burning: There is no support for the theory that broad area burning has a mitigating effect on bushfire area burnt, even when the cumulative burnt area is as high as 20% of land area. There is no support for the theory that area burnt on public land has a mitigating effect on damage toll because the mitigating benefit of fuel reduction is dependent on its location rather than its size.

The case is made for long overdue policy reform, a Plan B policy that aims to prevent the life and house loss damage toll in severe weather with targeted application of passive and active defence measures before the bushfire strikes.

Introduction

In Part 1, three independent indicators of bushfire weather are derived from available Weather Bureau data for Melbourne weather station from 1855 to present. They correlate reasonably with bushfire behaviour influencers in a grass or forest fuel bed, and therefore should be useful indicators of bushfire threat.

They are then combined to calculate an objective measure of annual Seasonal Severity Level (SSL). Annual SSL is also expected to be a useful indicator of damage potential. As a professional, I have long regarded the annual Total Fire Ban count as a useful indicator of seasonal severity. Annual Seasonal Severity Level is tested against annual Total Fire Ban day records from 1945 to present and found to be reasonably consistent with a correlation coefficient of 0.5. Therefore, Seasonal Severity Level is hypothesised to be a useful indicator of damage potential.

The aim of Part 2 is to assess the influence of seasonal severity on the bushfire damage toll over three centuries and to examine the effect of mitigation efforts by community or government policy on reducing the damage toll.

Theory

This study tests three theories:
A *In absence of mitigation policies , Seasonal Severity Level is a direct influence on damage potential*, eg, a high annual damage toll is expected when annual Seasonal Severity Level is high, or conversely, a lower toll in a low severity season.
B *Effective bushfire protection strategies mitigate damage potential*, eg, the damage potential of given fire season severity determined by Theory A can be reduced by effective fire protection policies which can therefore lower the damage toll. If policies are not effective, the damage toll in a high severity season remains at Theory A levels.
Theories A and B lead to Theory C, a corollary theory of performance:
C *If bushfire protection performance is improving, the relative damage toll in a given seasonal severity will be declining.*

The theories can be interpreted in sequence as follows:

- seasonal severity level directly influences damage potential
- if damage potential is high, damage toll is high
- damage potential can be mitigated by effective fire protection policies
- if damage potential is lower after implementing mitigation measures, damage toll is lower

The correlation between Seasonal Severity Level and bushfire damage (potential or actual) is direct but blunt.
Direct:
SSL defines the environment for bushfire damage potential based on weather factors that influence bushfire behaviour.
The higher the SSL level, the higher number of severe weather days, eg, expressed as TFB days
More severe weather days means chance of ignition is higher and their spread rate is faster

More ignitions mean more fast fires occur simultaneously
Many fast running fires mean fire perimeters expand quickly
Fast spreading bushfires escape the control of fire fighters, and perimeter spread cannot be stopped by suppression until weather moderates.
The larger the perimeter, the more houses will be overrun per hour
The more houses overrun per hour means more chance of high house loss toll
Thus, a higher SSL means a higher chance of big house toll than a smaller SSL
Blunt:
A SSL applies to seasonal severity, whereas a severe bushfire occurs on a specific day when weather is severe. SSL really measures the potential number of severe weather days that might occur. Eg, a higher SSL year has more TFB's than a low SSL season.
B Two types of mitigation measures can reduce the chance of a big house toll whether SSL is high or low.

- Government protection policies (this paper discusses the Stretton reforms of 1945)
- House protection strategies (strategic bushfire-protection of house or township). [Local mitigation measures can reduce or even eliminate flame and ember threat by application of at least four protection options – managing separation distance between house and ignition source, flame location around the house and its height, ember vulnerability on the house and applying suppression intervention.]

Whatever the status of mitigation measures, the proportionality remains - a higher SSL means a higher chance of a many severe weather days, which mean a higher chance of severe bushfires, which means a bigger house toll than a smaller SSL.

Method

Two prerequisites for this study are long-term data about weather and damage toll records. Additional historic data allows us to separate this data into three government policy eras over three centuries. The data is then analysed to quantify the mitigating influence of policy, suppression and control burning on the damage toll, thereby testing support for Theories A, B and C.

Seasonal Severity Level Index

After verifying Total Fire Ban Days against Seasonal Severity Level Index, Part 1 concluded that the better match was SSL Method 1. See Part 1, Figure 8.

For the following analyses, **Highest** severity seasons are defined as SSL > 148. This figure is selected empirically because it captures the known major toll years. **High** severity seasons are defined as SSL 115 to 148. **Low** severity seasons are SSL< 114.

Relative (annual) damage toll

Red Eagle's Victoria's Bushfire History 1802 to Present compiles available sources of data about Victoria's recorded bushfire damage toll into a more complete set than has ever been available before. The record is far from complete and has been presented as a work in progress. Nineteenth century records rely primarily on newspaper reports because government agencies had no brief to keep or publish records. The reports focused on the settlement areas, not the vacant lands. Occasional royal commissions and government inquiries were helpful in adding to the record, but even the early royal commissions quoted newspaper sources.

Annual bushfire area data The most consistent and systematic set of records were published in Annual Reports by the Forests Commission and its successor for 100 years until the early 2000's, but they applied only to public land. Private property bushfire records were not kept by government before the CFA was formed in 1945 and have never been detailed since. At best, the major private property fires are reported, sometimes with detail, sometimes without.
The new era of coordinated fire agencies since 2009 has so far descended into a dearth of public reporting. We are now back to reliance on media reports and internet records. Good records are kept internally by the public land agency, but consistent and comprehensive data is no longer published as it was for a century. Parliament still has no requirement for accurate annual bushfire area data or even annual damage valuations on private property. This sadly means that, since the 1850's, Victoria's total annual bushfire areas listed in this study must be regarded as a best estimate, with unverifiable accuracy. Their application is restricted to qualitative comparisons.

For this analysis, "relative" is also the key word in for describing damage toll over three centuries. Firstly, the impact of damage is relative to each historical decade as Victoria's population expanded and consolidated. Secondly, historical records of damage toll are incomplete. For example, the newspaper records on the internet were silent on bushfire reporting in several high severity weather seasons, when bushfire activity would have occurred. The other confusion in our first 100 years or so was confusion caused by the annual occurrence of burn offs that were lit on private property or in the bush, and left to run unsuppressed. The post-Stretton era called them bushfires. The pre-Stretton era media called them bushfires when severe weather turned them into infernos.

The following objective classification of Relative Damage Toll will be used for this study from the 1850's to present. To enable visual comparison on charts, scores are allocated that are similar in scale to fire season severity levels:

Annual relative damage toll score

	Localities Many	Localities Few
Losses Major	300	200
Losses Moderate	200	100
Losses Minor	100	0
Losses not reported	0	0

Descriptions of relative damage toll scores

Relative damage toll scores	**Descriptions**
300 = **Major damage toll**	Typically, **major** losses in **multiple** areas, PLUS a very large area burnt
200 = **High damage toll**	Typically, **high** losses in **a few** areas OR and **medium** levels of loss in **multiple** areas, often a large area burnt
100 = **Low damage toll**	Typically, reports of **minor** damage in few areas OR many fires in multiple areas but reports of only **minor** damage, sometimes a large area burnt.
0 = **No damage reported**	**No reports of damage** in available source data in areas that have been burnt OR simply, no reports of damage in available source data.

In subsequent analyses, serious damage toll = damage toll scores of 200 and / or 300.

Figure 1 overlays charts of Seasonal Severity Level and Relative Damage Toll.

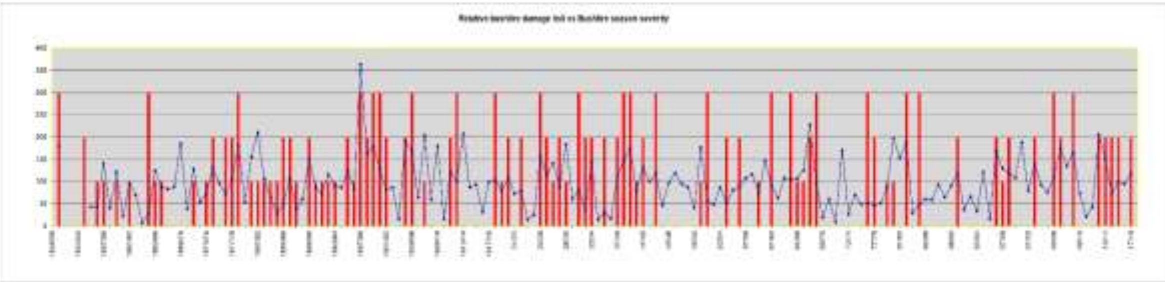

Figure 1 Seasonal Severity Level and Relative Damage Toll (red bars) charts from 1850/51 to present. Note: 1851 has been included as a best estimate because it was frequently quoted through the late 1800’s as a worst ever bushfire.

The damage scale is relative and therefore not suitable for quantitative comparison even when damage toll scores are identical. For example, 1983 and 2009 both had damage toll scores of 300, because both had a large area burnt and major losses in many areas. But quantitatively their tolls were very different, eg, 40 deaths, 2000 houses lost, in at least 3 major fire areas, $0.5B damage (current dollars) in 1983 compared to 173 deaths, 2000 houses lost in more than 10 major fire areas, $4B damage in 2009. Again, the 1897/98 bushfire was also a 300 score, but the damage was not systematically assessed at the time, and even if it was, the damage, trauma and disruption was relevant to the period, incomparable to today’s conditions. Nevertheless, a life loss and a house loss in those days was as devastating as a life loss and a house loss is today. Therefore, this study gives great weight to life and house loss. Unfortunately, (1) statisticians now confuse houses with buildings and structures and (2) many lives were lost in bushfires in the 1800’s, but went unreported. Accuracy in bushfire data remains elusive.

Three government policy eras

Figure 2 identifies three policy eras based on level of government interest and involvement in Victorian bushfires.

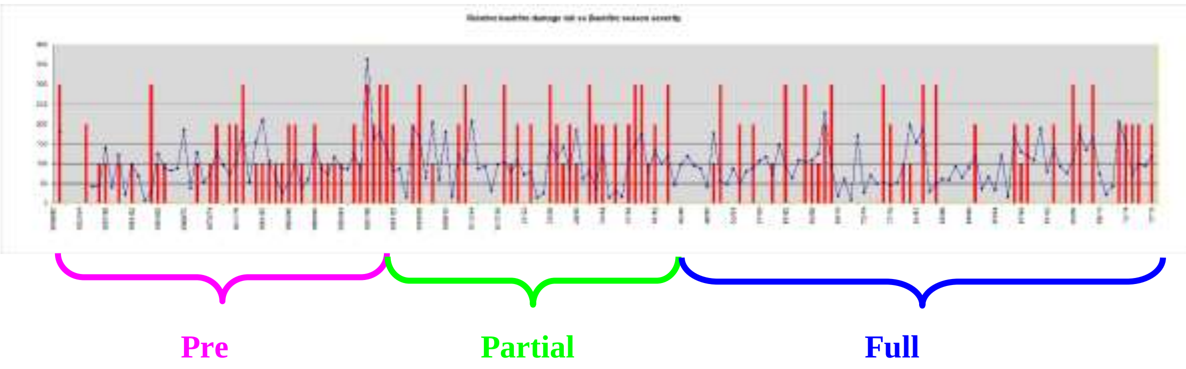

Figure 2 Three identifiable policy eras are based on level of government interest and involvement in Victorian bushfires. This chart visually shows a difference in number of damage toll years before and after the Stretton reforms of the mid 1940’s. Many gaps in the pre-Stretton era were due to data gaps rather than non-occurrence of a bushfire toll.

(1) Pre-government era (up to 1900)

This was the period when there was no active government involvement in bushfire suppression or prevention. Until 1910’s, there was no official state government involvement in bushfire issues, either in prevention, suppression, mitigation or rehabilitation, despite almost annual bushfire activity causing huge losses and setbacks to its citizens. If anything was done to combat the bushfire menace during this era, it was at the local community level, and it may or may not have been supported by the local shire. There was no mechanism or interest in collecting systematic bushfire statistics at government level.

Contemporary media sources consistently reveal burning off in summer was an annual event in the first 100 years, complete with public tolerance of fire escapes and let-the-fires-run. People in local communities tolerated the fires and minor damage to some extent because many were doing the same thing. They took precautions like burning off around their homesteads. The distinction between a bushfire and active burn off flame was blurred. Fires would run in the bush for weeks. Summers around settlements were typically smoky but when the wind sprang up, always catching them by surprise in the period before weather forecasting, the smouldering flames became multiple infernos that threatened damage. Their minds then became focused into determined community-centric self defence, and all hands battled with buckets and beaters to save their houses from the attacking bushfire.

(2) Era of partial government control (1900 – 1944)

In 1910's, the government appointed a forest management department, and in 1919, authorised the Forests Commission (FCV) to manage 16 million acres (6.4M ha) of crown land forest. FCV had a keen interest in protecting its timber assets from bushfires that came from private property and from bushfires lit by timber getters, graziers and miners on its forest reserves and other crown land. FCV introduced the concept of volunteer Bushfire Brigades into communities adjacent to the forests, and provided training, funding and coordination. FCV collected data and faithfully reported comprehensive raw bushfire statistics to Parliament annually. This tradition continued until the 1990's, soon after government abolished it and transferred its staff into a mega natural resources department.

(3) Era of state-wide government control (1945 – present)

This era can be called the post Stretton era, named after the Stretton Royal Commission in 1939. The government appointed the CFA in 1945 to register and oversee all country fire brigades on private property and the Forests Commission remained responsible for fires on crown land. It assumed control of Bushfire Brigades. This eventually allowed full state-wide coverage for fire suppression response on private property. Around that time, government introduced Stretton's policy changes and Figure 2 displays a noticeable performance improvement, ie, substantial reduction in damage toll years.

Three significant Stretton policy changes were (1) stop all running fires during summer and (2) prevent all unauthorised burning off during summer, and (3) prohibit and extinguish all fires on severe weather days [initially called Acute weather days, they became known as Total Fire Ban (TFB) days].

Traditionally, bushfire protection measures are conveniently assigned into four activity baskets – prevention, pre-suppression, mitigation and suppression. Stretton's Royal Commission-inspired policy changes are now examined from this perspective.

The first policy change category lies in the pre-suppression and suppression baskets. Its achievement required active firefighting by brigades and better coordination (= suppression), which required better pre-suppression supporting activity in communications, training, equipment, fire spotting, access, all aimed at detecting, turning out and controlling before the flames spread further.

The second and third policy change categories lie in the prevention basket – to prevent fire ignition in severe weather when fuel is bone dry and flames can run readily out of control and become unstoppable.

There was a fourth policy change that Stretton recommended, but was introduced gradually over the next few decades with unverifiable effect. It lies in the mitigation basket – fuel mitigation.

Quotes from Stretton's Royal Commission, Government of Victoria (1939):
Departments "should be obliged by law to clear margins of their lands wherever such margins are considered to be sources of fire danger to adjacent settlement. Their failure to do so should subject them to the same procedure and obligations as would apply in the case of other occupiers"
"Failure to clear Dangerous Areas - The local authority should have power to give notice to any occupier of land, whether public department or body or otherwise, to clear such of his or its land as might be in a dangerous condition. In default of compliance with such notice the local authority should have power to enter upon and clear such land and charge the cost thereof to the occupier; and in default of recovery, in the case of lands held on lease, to the owner. In default of recovery the cost should be made a charge on the land. Failure to comply with notice to clear should be made an offence at law".

To be effective against the damage toll on private property, protection measures such as control burning and fire breaks on public land have to be near settlements to protect the towns from fires and embers escaping from forested public land. In Stretton's time and for many years later, Forests Commission policy was the opposite. It applied control burning and fire breaks to protect its forest estate from private property fires, which had been an annual threat in previous decades. If Stretton's policy change was ever enacted effectively, its achievement was obscured within the broad-brush reported measure of "area burnt". A more useful indicator of "number of settlements protected" was not reported. This analysis will look for available alternative damage toll indicators, eg, house toll.

Results and Analysis

1 Damage toll performance due to Stretton reforms

In the 90-year pre-Stretton era, 17 years were at highest SSL (>148), 13 years were at high SSL (115 – 147) and 60 were at lower SSL (< 114).

- Of the 17 years of highest SSL, 82% (14/17) had high or major annual damage tolls.
- Of the 13 years of high SSL, 69% (9/13) had high or major annual damage tolls.
- Of the 60 years of lower SSL, 27% (16/60) had high or major annual damage tolls.

These findings provide good support for Theory A. Theory A says that that higher seasonal severity has higher damage potential and without mitigation, has higher damage toll. Theory A applies before the Stretton reforms because government-controlled fire protection measures were at negligible level. These findings show that higher SSL years had proportionately more serious damage toll years that lower SSL years.

Theory B suggests that applying fire protection strategies in a given seasonal severity level can reduce damage potential, therefore lower damage toll.

In the 73-year post-Stretton era, 13 years were at highest SSL (>148), 10 years were at high SSL (115 – 147) and 50 were at lower SSL (< 114).

- Of the 13 years of highest SSL, 54% (7/13) had high or major annual damage tolls.
- Of the 10 years of high SSL, 50% (5/10) had high or major annual damage tolls.
- Of the 50 years of lower SSL, 24% (12/50) had high or major annual damage tolls.

The comparisons between pre and post Stretton eras reveal strong support for Theory B. For each of the three Seasonal Severity Levels, application of the Stretton fire protection measures reduced the number of annual damage toll years substantially at higher SSL (>115) – 82% to 54% and 69% to 50%). This is reasonable proof that the damage toll can be reduced by appropriate bushfire protection measures. It shows that whilst higher seasonal severity has higher damage potential, appropriate mitigation can deliver a lower damage toll. This is also support for Theory C, ie, the measures were effective, eg, removal of a suite of bushfire causes that had been tolerated during Victorian summers for over 100 years.

These findings also provide good support for operation of Theory A within the post Stretton era. Higher SSL years have proportionately more serious damage toll years that lower SSL years. This finding suggests that higher seasonal severity has higher damage potential and with or without mitigation, has higher damage toll potential. Therefore, the scope of Theory A can be broadened from an era of negligible fire protection policy to any policy era.

Figure 3 now presents data from Figure 2 for the highest seasonal severity levels (SSL>148) to visually highlight the impact of the Stretton reforms.

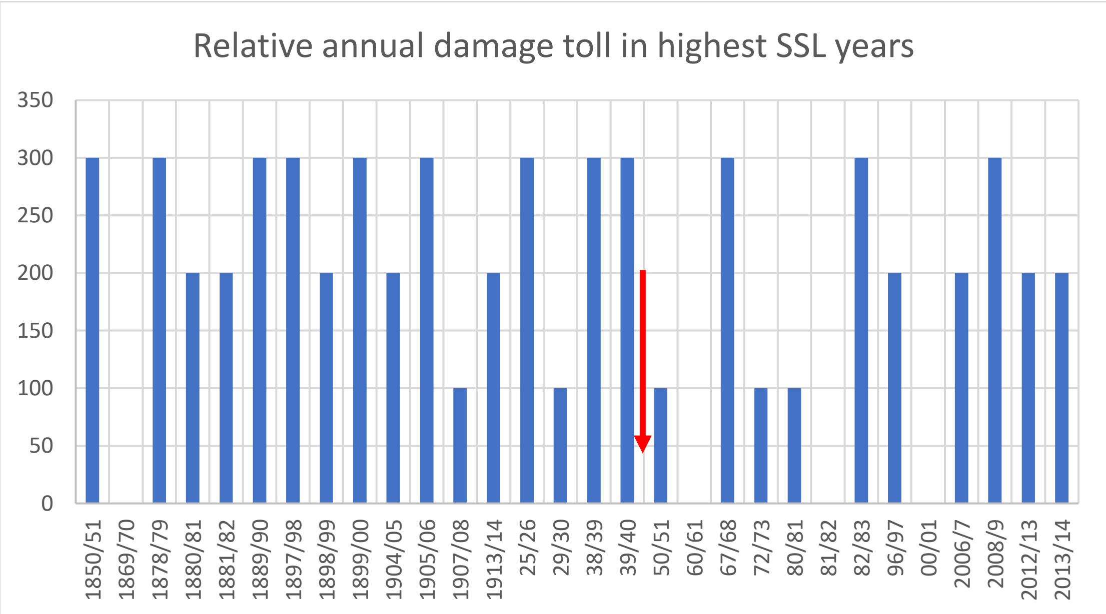

Figure 3 Relative annual damage toll in years of highest Seasonal Severity Level, SSL>148. Red arrow shows introduction of Stretton reforms.

Figure 3 shows that in the pre-Stretton era, 82% (14 / 17) of the highest SSL years had high or major annual damage tolls, but in the post Stretton era, 54% (7/13) had high or major annual damage tolls. This is a large difference and strong evidence of a damage toll reduction caused by effective fire protection measures like the Stretton Reforms.

Conclusion: Evidence in support for Theory A was found in both pre and post Stretton eras. This means damage potential is directly related to Seasonal Severity Level regardless of bushfire protection policy eras.

Evidence showed the Stretton reforms caused a Theory B response for three Seasonal Severity Levels. This means although damage potential is related to Seasonal Severity Level according to Theory A, damage toll can be mitigated by effective fire protection measures.

2 Damage toll performance during each policy era

Figures 4,5 and 6 present detailed data for the three identified policy eras of Figure 2.

Policy Era 1 Laissez faire era up to Royal Commission 1900

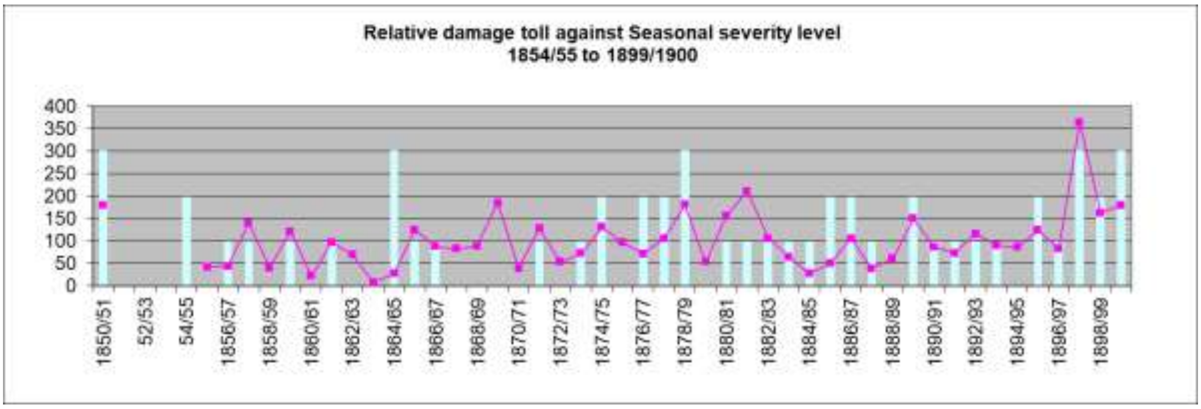

Figure 4 This 45+ year period has highest seasonal severity levels (>148) in 9 years (counting 1851), high seasonal levels (115 - 147) in 7 years and lower seasonal severity (<114) in 30 years

- Of the 9 highest severity seasons, at least* 8 have serious damage toll (>89%)
- Of the 7 high severity seasons, at least* 4 have serious damage toll (>57%)
- Of the 30 lower severity seasons, at least* 5 have serious damage toll (>17%)

* more are suspected, but data deficiency prevents confirmation.
Note: Serious damage toll = damage toll scores of 200 and/or 300.

Policy Era 2 Partial government involvement
Low level fire management on public land

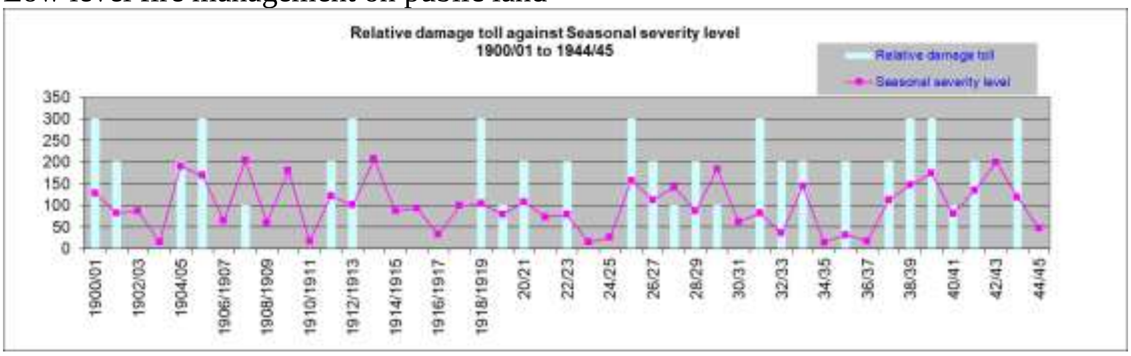

Figure 5 This 44 year period has highest seasonal severity levels (>148) in 8 years, high seasonal levels (115 - 147) in 6 years and lower seasonal severity (<114) in 30 years

- Of the 8 highest severity seasons, 6 have serious damage toll (75%)
- Of the 6 high severity seasons, 5 have serious damage toll (83%)
- Of the 30 lower severity seasons, 11 have serious damage toll (37%)

Note: Serious damage toll = damage toll scores of 200 and/or 300.

Policy Era 3 Post Stretton Royal Commission, full government control

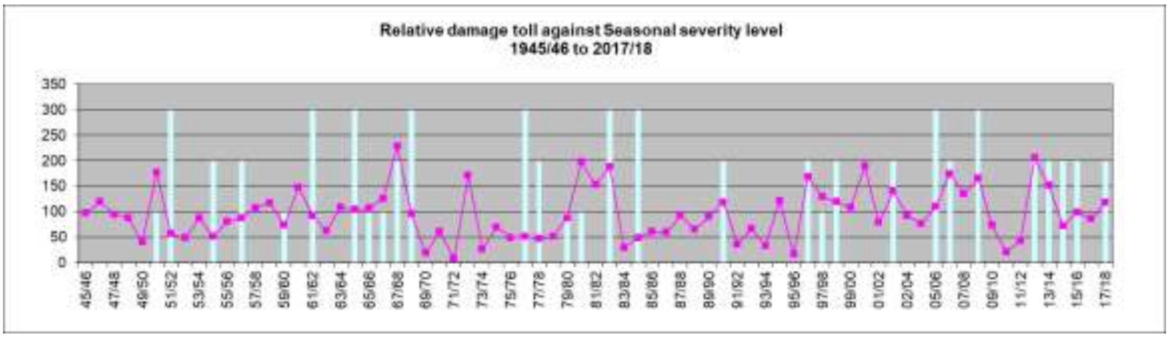

Figure 6 This 73 year period has highest seasonal severity levels (>148) in 13 years, high seasonal levels (115 - 147) in 10 years and lower seasonal severity (<114) in 50 years

- Of the 13 highest severity seasons, 7 have serious damage toll (54%)
- Of the 10 high severity seasons, 5 have serious damage toll (50%)
- Of the 50 lower severity seasons, 12 have serious damage toll (24%)

Note: Serious damage toll = damage toll scores of 200 and/or 300.

The Charts provide good support for Theory C, that "if bushfire protection performance is improving, the relative damage toll in a given seasonal severity should be declining"

2.1 Performance during higher Seasonal Severity years

A useful test of effectiveness of policies is the ability to reduce damage toll when exposed to worst case severity.

(1) Damage tolls in **highest** severity fire seasons

No. of highest SSL years (score > 148) Policy era		…when serious** damage toll years occur	
1855/56 to 1899/00	9	8	>89%
1900/01 to 1944/45	8	6	75%
1945/46 to 2017/18	13	7	54%

** Serious damage toll years = major damage toll years (300) + serious damage toll years (200)

During policy era 1, almost all (89%) the **highest** severity seasons generated serious damage toll years. There was a significant fall during policy era 2. Policy era 3 sees a substantial fall in damage toll years, coinciding with Stretton's improvements in bushfire protection performance.

(2) Damage tolls in **high** severity fire seasons

No of high and highest SSL years (score 115 - 147) Policy era		…when serious** damage toll years occur	
1855/56 to 1900/01	7	4	>57%
1900/01 to 1944/45	6	5	83%
1945/46 to 2017/18	10	5	50%

** Serious damage toll years = major damage toll years (300) + serious damage toll years (200)

Gaps in policy era 1 data probably explain why era 1 is not higher than era 2. Policy era 3 sees a substantial fall in damage toll years, again coinciding with Stretton's improvements in bushfire protection performance.

Conclusion No significant reduction in serious damage toll years occurred until policy era 3, which coincides with the application of the Stretton reforms. The reduction has been substantial at just over one third. Clearly, the policy changes were effective, but only up to a point. Whilst the reduction in damage toll years has been an excellent start, the proportion of serious damage toll years in the high and highest severity years remains high, at just over half. The findings provide evidence in support of Theory B that effective policy changes can improve bushfire protection performance in high severity weather.

2.2 Performance in Lower Seasonal Severity Years

The following Table compares the influence of low bushfire season severity on serious damage toll years during the three policy eras.

Damage tolls in **lower** severity fire seasons

No of lowest severity years (score < 114) Policy era		… when serious** damage toll years occur	
1855/56 to 1900/01	30	5	>16%
1900/01 to 1944/45	30	11	37%
1945/46 to 2017/18	50	12	24%

** Serious damage toll years = major damage toll years (300) + serious damage toll years (200)

Gaps in policy era 1 data probably explain why era 1 is not higher than era 2. Little more can be concluded other than stating that the percentage of serious toll years is less than occurred in the higher SSL years.

Conclusion: This is supportive albeit weak evidence for Theory A - that damage potential is less in lower severity weather.

Summary so far: Substantial reduction in damage toll years during the higher severity seasons has been due to the Stretton reforms, but the proportion of damage toll years in the high and highest severity years remains high at over half.

The data confirms that the Stretton policy changes improved community protection. This benefit was due to the removal of a suite of bushfire causes that had been tolerated during Victorian summers for over 100 years. The findings support Theory B, that effective fire protection policies in higher and lower seasonal severity level can reduce damage potential, therefore lowering damage toll.

These results show that improving community bushfire protection is possible, that the task has been started and beckons the next step driving the damage toll in higher severity seasons down further, well below half. Further reforms are needed to continue the reduction.

2.3 Worrying damage toll trends in the post Stretton era

Referring to Figure 6 above, the first 45 years of the post Stretton era shows there were half as many serious toll years as the previous 44 years, 11 vs 22. This improvement was within the primitive but improving era of bushfire protection equipment, stable management of forests and an increasingly skilled and equipped fire fighting force. This was an excellent outcome from Stretton's policy changes.

Era 2 44 years pre-Stretton ***22 serious damage toll years in 44 years***

- Of the 14 higher severity seasons (SSL > 115), 11 have serious damage toll
- Of the 30 lower severity seasons (SSL < 114), 11 have serious damage toll

Era 3 first 45 years post-Stretton ***11 serious damage toll years in 45 years***

- Of the 10 higher severity seasons (SSL > 115), 2 have serious damage toll
- Of the 35 lower severity seasons (SSL < 114), 9 have serious damage toll

Then there was then a decade of lower severity seasons from mid 80's to mid 90's before entering the past 22-year period, where damage toll rate rose back to era 2 rates.

Era 3 last 22 years ***11 serious damage toll years in 22 years***

- Of the 11 higher severity seasons (SSL > 115), 7 have serious damage toll
- Of the 11 lower severity seasons (SSL < 114), 4 have serious damage toll

Admittedly, the last 22 years had a high proportion of severe weather seasons, similar to the 17-year run from 1897 to 1913), which had 10 higher severity seasons in 17 years.

Eras 1 and 2 17 years (1897/8 to 1913/14) ***9 known serious damage tolls in 17 yrs***

- Of the 10 higher severity seasons (SSL > 115), 7 known have serious damage toll
- Of the 7 lower severity seasons (SSL < 114), 2 known have serious damage toll

The concern is that the percentage of damage toll years in the last 22 years (50% of all fire seasons) is no improvement on the outcome of 100 years ago, despite the multi millions of dollars of investment in resources and equipment and the improvements in weather forecasting and technology. The outcome is an unacceptable deterioration.

According to Theory C, if bushfire protection performance is improving, the relative damage toll in a given seasonal severity should be declining. The opposite is now observed. This lapse is worthy of urgent investigation because there are tangible reasons for a decline in performance that need addressing. The late 1990's coincides with the tragic deaths of five fire fighters followed by a disapproving inquiry that seemed to usher in a culture of higher caution and less aggressive fire suppression than in the past. Other coinciding factors at this time were departmental reorganisations affecting public land management and a significant loss of personnel with forest fire fighting experience.

Conclusion This lapse in performance is worthy of urgent investigation and correction.

3 Mitigation of damage toll performance due to suppression and control burning

This section analyses the impact of mitigation works on the ground, ie, suppression and control burning. It uses available data to test Theory B, that effective bushfire protection strategies are a mitigating influence on damage potential. Specifically, it asks does the data show the strategies are effective?

3.1 Suppression

Influence of suppression on area burnt

Area burnt by bushfires on a known land base can be used as a blunt measure of suppression performance or capability. The public land forest estate is one third of Victoria's land mass. It was managed by the Forests Commission for many decades, and has a long period of continuous comprehensive data about bushfires. This section tests Theory B and C as follows - if suppression capability has improved, less area will be burnt in years of a similar Seasonal Severity Level.

Has suppression performance on public land improved in high severity years?

This analysis uses bushfire area burnt per year as an indicator of bushfire suppression performance in forest fires on public land. It assumes the consistent goal of the organisation is to minimise area burnt by bushfires and a consistent capability to deliver that goal. If capability to deliver improves over the decades, area burnt by bushfires in a given seasonal severity should be reducing.

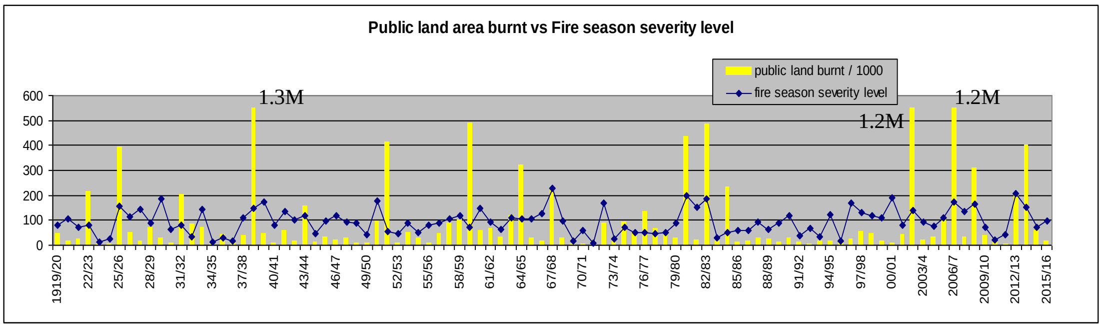

Figure 7 Public land burnt per year vs fire season severity level.
Three bushfire areas that exceed 1M ha are truncated at 550,000 ha for visual scale.

Data from Figure 7 is translocated to the following Table for years of higher severity (SSL > 115). It shows that just over half of high severity seasons before and after the Stretton reforms burnt more than 100,000 ha per year. This suggests no significant improvement. The pattern for larger burnt areas is very similar before and after, except the 2 – 400,000 ha category dropped substantially and the 400,000 to 1M ha category rose substantially.

	Severe seasons (score > 115)	**Total fire area > 100,000 ha**	100,000 to 200,000 ha burnt	200,000 to 400,000 ha burnt	400,000 to 1M ha burnt	>1M ha burnt
1919/20 to 1943/44	9 37% of years	5 55% of severe seasons	1 11% of severe seasons	3 33% of severe seasons	0 0%	1 11% of severe seasons
1944/45 to 2015/16	22 30% of years	13 60% of severe seasons	2 9%	5 23%	4 19%	2 9%

Since the Stretton reforms, the percentage of major and high severity fire seasons with large areas burnt is unchanged but there are more very large fire years than before the reforms. This is unexpected because substantial improvements have been made in pre-suppression and suppression technologies and skills. This suggests either capability to prevent spread of large fires has not improved, or policy priority to minimise area burnt has been relaxed.

Correlation between forest area burnt and Seasonal Severity Level

This section tests Theory A, ie, that public land forest area burnt increases as Seasonal Severity Level increases. Figure 8 plots forest area burnt each year against annual Seasonal Severity Level from 1919 to 2015/16.

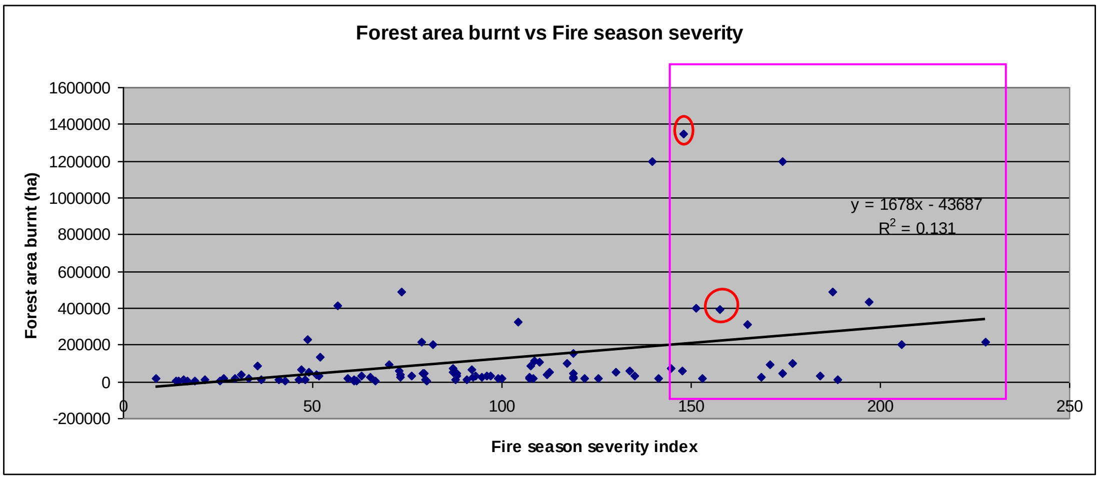

Figure 8 plots forest area burnt against Seasonal Severity Level from 1919 to present. The trend line rises but correlation coefficient is low, as confirmed by the scatter. The pink box indicates the highest severity level (> 148). The red circles mark the only two pre-Stretton bushfires above the trend line, the 1926 and 1939 bushfires. There are only two pre-Stretton bushfires below the trend line at SSL 174 and 184.

Figure 8 shows that for a given Seasonal Severity, there is an increasingly widening range of area burnt as SSL increases. There is also a rising trend line, whereby annual area burnt increases as Seasonal Severity Level increases. This is consistent with Theory A.

Figure 8 also shows that a given area burnt (eg, 300,000 ha) can occur over a wide range of seasonal severity, from Low to Highest. This shows that bushfire area is influenced by factors other than annual seasonal severity, and highlights the blunt predictive nature of SSL. For example, a low severity season may have only a few very severe weather days, and a large area can be burnt or a catastrophic damage toll can be inflicted on one of those days.

Implications for suppression capability in forested landscapes on private property
Suppression capability on forested public land can be an indicator of suppression capability on private property in forested landscapes because the same logistical difficulties are encountered – lack of access to fire edge by fire trucks due to terrain and tree cover, fire spread by leap frogging embers, fire grows too large before adequate resources arrive. Most of the high damage toll bushfires in Victoria's history have occurred in forested landscapes dotted with houses.

The concerning implication is that, as the decades pass by and the population grows, the area of forested-landscapes-with-houses also expands but suppression capability in severe bushfire seasons has failed to improve. Ash Wednesday and Black Saturday suppression failures should have been acknowledged as symptoms of the inadequacy of suppression as the primary protection tool of government in severe weather.

Suppression currently remains the government's Plan A priority defensive tool against the expanding bushfire in forested landscapes, but this analysis suggests it is a poor choice in higher severity weather. A strategic Plan B is required, for example, removing the bushfire's fuel to protect towns and settlements before the fire season.

It is therefore proposed that the limited capability of the suppression model as the Plan A response in high severity weather must be acknowledged and supplemented with an effective Plan B defence that puts mitigation measures in place before the bushfire strikes to protect lives and houses.

3.2 Control burning

Influence of area previously burnt on bushfire area on public land
This section tests the following variation on Theory B - that an increase in fuel reduced area causes a reduction in annual bushfire area burnt in higher severity fire seasons. The rationale is that the larger the area control burnt, the greater chance of a bushfire occurring within it or running into it.

Data for the study derives from Figure 9, which overlays Seasonal Severity Level onto area burnt by bushfires and control burns. Bushfire area and control burn area refer to public land, which is predominantly forested.

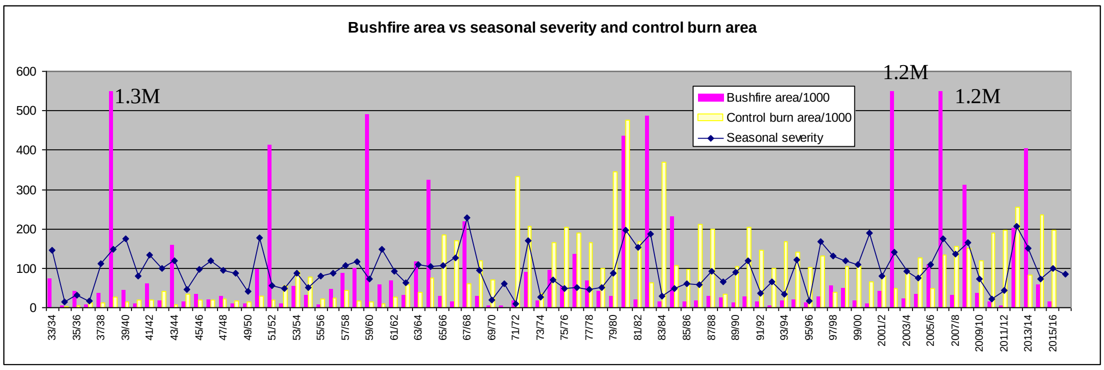

Figure 9 plots annual bushfire area on public land when Seasonal Severity Level is at higher levels (SSL > 115) against cumulative area burnt.
Three forest bushfire areas that exceed 1M ha are truncated at 550,000 ha for visual scale.

The study assumes that the mitigating effect of a burn is three years, meaning the cumulative area burnt is the sum of control burnt area and bushfire area for the three years before the bushfire year. Because bushfire occurrence is random, the study cannot assume that the cumulative burnt areas are in the right location to have a mitigating influence on the bushfire's behaviour, ie, will stop its spread or reduce flame height or ember generation.

Figure 10 plots area burnt by bushfire in higher severity fire seasons (when SSL > 115) against cumulative area burnt for the previous three years. Cumulative area burnt is the sum of bushfire area and control burning on public land for three years before the plotted bushfire season.

The independent variable in Figure 10 is cumulative area burnt without a location component. This means the data does not link bushfire location with cumulative areas burnt, and instead relies on random theory. For example, the public land estate is 7M ha. If the cumulative control burnt area was 500,000 ha, a randomly located bushfire has a 7% (0.5/7) probability of igniting in it, and a similar low percentage of being upwind of it and running into it.

According to Theory B, for a given Seasonal Severity Level, as cumulative burnt area increases, bushfire burnt area should decrease, meaning an inverse curve is expected. However, Figure 10 shows an imperceptible decline and a very low correlation coefficient. Why? The main assumption (the 3-year effect) seems reasonable. Data testing shows that if the 3-year effect is shortened to 1 or 2 or extended to 5 years, the trend line remains similar. The location issue is the major cause of the weak trend line. If the bushfire locations are random and the cumulative burnt area locations are random, the latter areas have only a random chance of providing protective benefit. This seems a reasonable explanation because a control burn provides effective protection to a town when its location is targeted, eg, near the town and on the danger side, in the expected path of the bushfire.

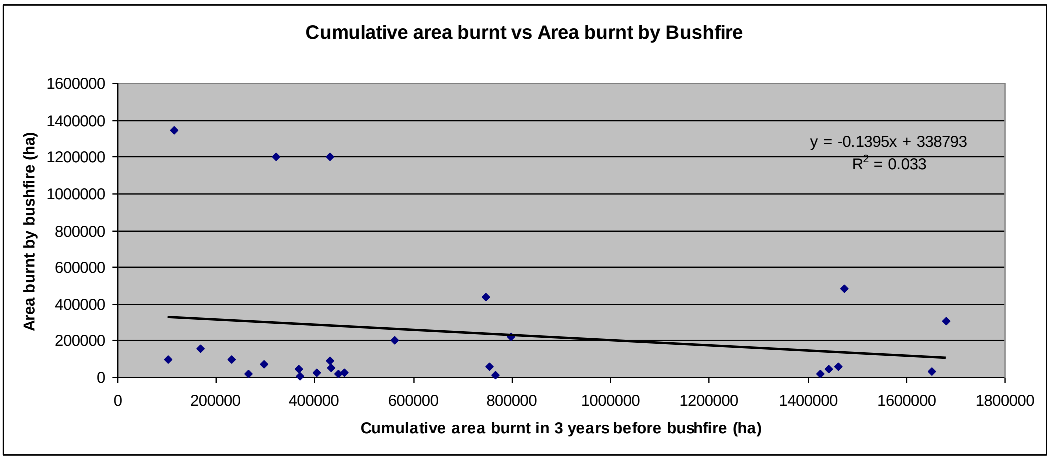

Figure 10 Data for bushfire seasons from 1934 to present where Seasonal Severity Level > 115. It plots bushfire area burnt on public land against cumulative area burnt on public land for the previous three years, ie, control burns plus bushfire area.

There are six data points of interest on Figure 10 that help explain the feint trend. They sit along the X-axis above 1.4M ha of cumulative burnt area, which is 20% of public land area.

- The data point of 32,000 ha of bushfire area when cumulative burnt area is 1.65M ha suggests a glimmer of support for the theory, but it in that year (2007/08), the bushfire area was in a different part of the state to the cumulative burns, and therefore, could not have had any influence.
- Two other points below the trend line are in 1939/40 and 1941/42. It is possible that the 1939 fires prevented some bushfire growth in those years on public land, due to the extent of the 1938/39 fire area, but corroborative records are not available.
- The final point below the trend line is 1981/82. The cumulative area burnt comprised two years of 3 - 400,000 ha of control burning in the eastern ranges and a similar area burnt in the western desert bushfires. It is possible that some bushfire growth was prevented on public land, but unlikely.
- The two points above the trend line are 1982/83 and 2008/09. The former year, which features the Ash Wednesday fires, burnt 486,000 ha of public land when the cumulative area burnt was 1.47M ha. The East Trentham fire ran into two substantial burnt areas, which limited the damage it caused. The Deans Marsh fire ran into Bass Strait as the NW wind kept blowing for several more hours. When the SW wind change hit the still burning fire, there was no barrier as it ran along the coastal forests causing massive life and house loss. The latter year, which features the Black Saturday fires, burnt 310,000 ha of public land when the cumulative area burnt was 1.68M ha. None of its fires ran into control burn areas of enough significance to prevent death and damage.

Other extremes in Figure 10 are the bushfire areas along the Y-axis above 1.2M ha. The 1938/39 Black Friday year bushfire burnt over 1.3M ha when multiple forest grazier fires and property burn offs joined up and burnt through inaccessible forest expanses. The 2002/3 and 2006/7 bushfires (both 1.2M ha) were in similar country, now reasonably well roaded, when a few lightning fires escaped the control of ample, well equipped fire fighters and burned for several weeks, eventually joining up. The spread of these bushfires was not prevented by previously burnt areas, 115,000, 320,000 and 430,000 ha respectively.

The feint trend line also means cumulative area burnt per se is a poor predictor of protection benefit. Supporters of larger control burn areas need to consider that the suppression-assisting effect of the control burnt area is very localised, eg, localised to upwind of the control line under attack, and to be effective might require the recently burnt area to be 40 to 60% of total area. For example, the entire 2M forest area in Western Australia was burnt on a five-year cycle during 1960's and 1970's to successfully reduce troublesome annual bushfire ravages to virtually zero. Effectiveness also requires that the control line is properly protected with appropriate infrastructure and manned with adequate resources when the running fire hits it.

Conclusion Figure 10 does not provide support for the theory that cumulative burnt area per se has a mitigating effect on bushfire area burnt, even when the burnt area is as high as 20% of public land area (1.4M ha). It confirms that the mitigating benefit of fuel reduction is dependent on its location rather than its size. The appropriate theory must be restated as follows: *Cumulative burnt area has a mitigating effect on bushfire area burnt in a given area when its location prevents a bushfire attack into that area.*

Influence of area previously burnt on damage toll

This section tests Theory B - that an increase in fuel reduced area on public land causes a reduction in damage toll years in high severity seasons. Data derives from Figure 11, which overlays Relative Annual Damage Toll with area burnt by bushfires and control burns. Bushfire area and control burn area refer to forested public land, whereas damage toll occurs on private property, often at a distance from public land.

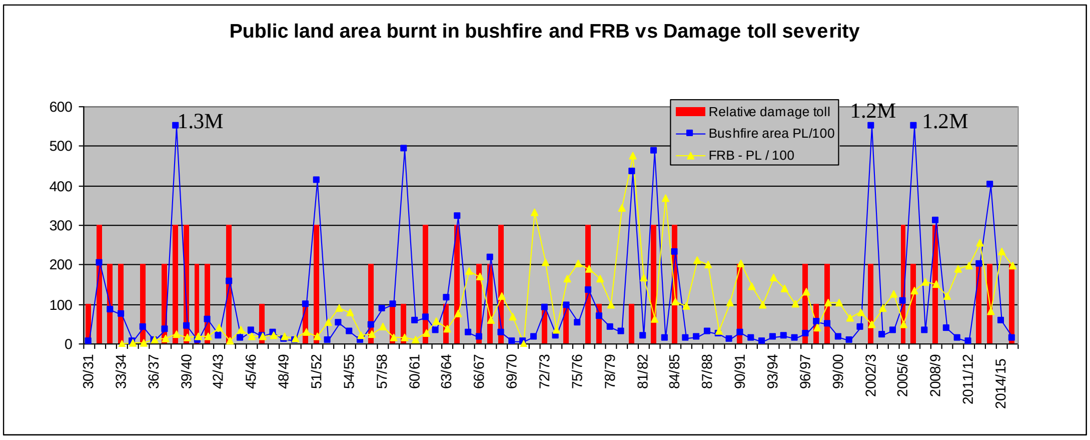

Figure 11 Three forest bushfire areas that exceeded 1M ha are truncated at 550,000 ha for visual scale.

The study assumes the mitigating effect of a burn is three years, meaning the cumulative area burnt is the sum of control burnt area and bushfire area for the three years before the bushfire year. According to Theory B, if cumulative burnt area causes a reduction in the relative damage toll, an inverse curve is expected as burnt area increases.

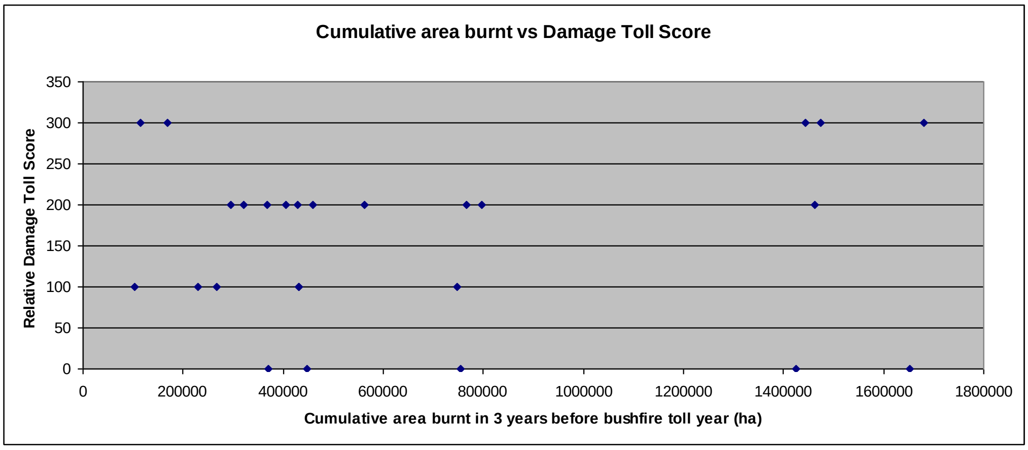

Figure 12 This chart plots cumulative area burnt on public land against relative annual damage toll on private property from 1930's to present.

Figure 12 shows no correlation between relative damage toll and cumulative burnt area because the source data is a mis-match from different land ownerships. Damage toll occurs on private property and the burnt area is on public land where there are no houses. There is no historic data about damage toll adjacent to public land. Basic fire behaviour theory suggests that fuel reduced areas can mitigate fire behaviour at the house site and upwind of it. Again. this means the mitigating benefit of fuel reduction is dependent on its location rather than its size.

Bushfire behaviour theory supports the application of control burning to protect a town. Evidence supporting the benefit of control burning is convincing. For example, the East Trentham fire mentioned above provides proof that two infernos stopped dead at previously burnt areas – one was a bushfire area burnt two weeks before, the other was a bushfire area burnt the year before. Serendipitous location was everything, because those two burnt areas prevented an otherwise certain catastrophe. Thus, evidence for the benefits of control burning exist, but the lessons have not been learnt by the government policy makers, nor yet converted into action.

What are the lessons? Protective measures must neutralise the local threats. To protect a town or protect a control line, the fuel reduced area must be upwind on the danger side and wide enough and recent enough to stop the flame, and there must be measures in place to extinguish the spot fires downwind.

Instead, governments continue to deploy ineffective measures. (http://www.delwp.vic.gov.au/__data/assets/pdf_file/0009/318879/DELWP0017_BushfireRiskProfiles_rebrand_v5.pdf
This latest risk management model in the government applies data about recently burnt areas on public land (control burns plus bushfires) in a model (Phoenix Rapidfire) to confer a residual risk on private property, measured as potential house loss numbers. They divide the state into regions and surprisingly claim that 10,000 ha burnt on the western part of the region, for example, confers a protective benefit by lowering residual risk to the whole region and indeed to the whole state. Clearly, the results of this study do not support the government's new approach.

Conclusion Figure 12 does not provide any support for the theory that cumulative burnt area per se has a mitigating effect on damage toll. This is because the mitigating benefit of fuel reduction is dependent on its location rather than its size. The appropriate theory must be restated as follows: *Cumulative burnt area has a mitigating effect on the damage toll in a given area when its location prevents a bushfire attack into that area.*

Discussion and Conclusion

This study assembles long term data from 1850's to the present about annual bushfire season severity and annual damage toll to test three nominated theories:

It finds that Theory A applied to all policy eras, whether government policies were active or inactive. Therefore, Theory A can be re-phrased as *Bushfire season severity has a direct causal influence on annual damage potential*

It finds that Theory B also applied to all policy eras, whether government policies were active or inactive. It can be re-stated as *Bushfire protection strategies that mitigate damage potential determined by Theory A have the capability to reduce the damage toll in proportion to their effectiveness.*

Eg, Applying the Stretton reforms reduced the proportion of serious damage toll years in higher severity seasons by one third.

Theory C has been useful. *If bushfire protection performance is improving, the annual damage toll in a given seasonal severity will be declining.*
It has revealed a worrying lapse of performance in high severity bushfire seasons. In the 45 years after the Stretton policy reforms, the percentage of serious damage toll years fell to 25% of all fire seasons, halving the rate seen in the previous 44 years. But in the last 22 years, the percentage of serious damage toll years has reverted to 50% of all fire seasons, which is no improvement on the outcome of 100 years ago, despite the multi millions of dollars of investment in resources and equipment and the improvements in weather forecasting and technology. The outcome is an unacceptable deterioration that is worthy of urgent investigation and rectification.

It is proposed that a recent cultural change in bushfire suppression response may be a contributory reason for this lapse, ie, more cautious and less aggressive.

Three mitigation influences are examined for effect on the frequency of damage toll years during higher severity years, government policy changes, suppression capability and control burning.

(1) Government policy changes
Before the Stretton reforms, almost all the **high and highest** severity seasons generated serious damage toll years. Since Stretton, about half of them do.
The source of this improvement was the removal of a suite of persistent bushfire causes that had been tolerated during Victorian summers for over 100 years.

Damage toll reduction since the reforms proves that the bushfire menace can be reduced substantially by policy reforms with effective protection measures. There have been no policy reforms since 1945. It is time for new reforms to reduce damage toll.

(2) Suppression capability in highest severity seasons
Area burnt by bushfires on a known land base can be used as a blunt measure of suppression performance or capability.
Theory C *If bushfire protection performance is improving, the annual area burnt in a given seasonal severity will be declining.*
Since the Stretton reforms, the same proportion of high severity fire seasons continue to burn large areas of public land as before, but the numbers of larger areas burnt has increased. This means capability to contain large fires has at best not improved.

Suppression capability in forested public land is proxy for suppression capability on private property in forested landscapes because the same logistical difficulties are encountered. It is therefore proposed that the limited capability of the suppression model as the Plan A response in high severity weather must be acknowledged and supplemented with an effective Plan B defence that puts mitigation measures in place before the bushfire strikes to protect lives and houses.

(3) Control burnt areas

Effect on public land area burnt The analysis tests a variation on Theory B - that an increase in fuel reduced area causes a reduction in annual bushfire area burnt in higher severity fire seasons. There is no support for the theory that cumulative burnt area per se has a mitigating effect on bushfire area burnt, even when the burnt area is as high as 20% of public land area (1.4M ha). The appropriate theory must be restated as follows: *Cumulative burnt area has a mitigating effect on bushfire area burnt in a given area when its location prevents a bushfire attack into that area.*

Effect on damage toll The analysis tests a variation on Theory B - that an increase in fuel reduced area on public land causes a reduction in damage toll years in high severity seasons. There is no support for the theory that cumulative burnt area per se has a mitigating effect on damage toll. This is because the mitigating benefit of fuel reduction is dependent on its location rather than its size. The appropriate theory must be restated as follows: *Cumulative burnt area has a mitigating effect on the damage toll in a given area when its location prevents a bushfire attack into that area.*

Direct and indirect evidence that strategic control burning reduces damage toll exists elsewhere, but the lessons have not been learnt by the government policy makers, nor yet converted into action. Reference is made to the latest risk management model in the government applies data about recently burnt areas on public land to confer a residual risk on private property. Clearly, the results of this study do not support the government's new approach.

Policy reform is overdue: There has been no policy reform in bushfire arena since 1945. It reduced the damage toll substantially. It is time for new reforms to reduce damage toll. This analysis presents some key findings:

- The suppression model cannot reduce annual forested area burnt in severe weather
- Protection by broad area control burns on public land does not reduce the damage toll
- Evidence exists elsewhere to show that targeted location of fuel reduction prevents damage toll
- Suppression is the government's Plan A measure for protection of the State against bushfires.
- Plan A suppression capability is limited in severe weather, and is ineffective in preventing damage toll
- Plan A suppression culture is now cautious and non-aggressive
- There is no government Plan B

The conclusion: The State needs to supplement the Plan A suppression model with a Plan B model to protect houses from bushfires in severe weather. If the capability of the Plan A model peaks at windy Fire Danger Index (FDI) 30, the Plan B model takes over to protect lives and houses at higher levels, up to maximum FDI.
We can assemble the above findings together into a bold new policy reform package whose aim is to eradicate the bushfire menace from Victoria.
There will be a Plan B model that aims to eliminate the damage toll in severe weather
Its aim is zero life loss and zero house loss

It will bushfire-protect each settlement and town against local threats using passive defence (eg, with fuel reduced areas) and active defence (eg, extinguish spot fires when small with upskilled self-defenders and coordinated spot fire swat teams).

The same Plan B principles that protect the house also protect the town. When the towns are protected, the region is protected. When the regions are protected, the state has eliminated the bushfire menace.

When government determines to protect the state from the bushfire menace and includes the people as a valuable resource (rather than evacuate them as a liability), we all protect our town, we all protect our region, we protect our site. This approach combines the skill and technology of policy era 3 government resources with the self-reliance and pioneering spirit of our policy era 1 forebears.