What is the True Cost of Forest Fire Management on Public Land in Victoria?

What actions are required to increase transparency and accountability in reporting these costs in the public interest?

Barrie Dexter & Donald Macleod

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About the authors

Barrie Dexter. DipFor(Cres), BScFor(Melb), MScFor(Melb), FIFA. Over 60 years of experience in natural resource management including research and development in the silvics and silviculture of native and exotic forests, factors affecting bushfire behaviour, the planned use of fire, with experience that ranged from the fire-line to state level co-ordination and policy development and practice in management of state forests and national parks. Retired from the agency responsible for forest fire management on public land in 1989. A member of Forest Fire Vic. Inc. (2002-2008), an organisation which provides pro-bono independent expert opinion on forest fire management and subsequently, with colleagues, continues to substantively report and recommend changes aimed at returning Victoria to its former status as a premier forest fire manager on the State's public land.	**Donald Macleod** BE(Civil)(Melb), BA(ANU), DipTRP(Melb). Early experience was with the Victorian State Rivers and Water Supply Commission in irrigation design and later resource assessments, then River Murray Commission in long term system behaviours and daily river operations. Joined Maunsell Australia in 1973; a consulting career spanning 28 years; worked on water developments, environmental impact assessments and management plans, and freeway, port and rail projects in all Australian states and in 13 overseas countries. Managed Maunsell offices in four states and retired as Chairman of both the Australian operating and the shareholding boards. Environmental engineering consultant for Maunsell and later AECOM, 2001-2009. A keen bushwalker concerned about the increased prevalence and escalating damage caused by forest fires, Donald's extensive experience brings an independent and broad perspective for evaluating in the public interest, the true cost of fire management in Victoria's public forests.

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Executive Summary

(1) In Australia, the true cost of suppressing bush fires is never reported, nor, for that matter, is the cost of forest fire management on public land. "Fire management" covers the prevention, suppression, planned use of fire and damage and recovery from bushfire in the short and long term.

(2) By contrast, in the United States, these costs are regularly reported both on an annual national basis as well as through the detailed analyses for some individual fires.

(3) This concept paper has sought to present the best of the limited local data to produce preliminary estimates of personnel, plant and aircraft costs used in suppressing a major Australian fire. The fire selected was the 2003 Alpine fire in Victoria.

(4) The suppression cost component of forest fire management was chosen to:

- Identify their progressive escalation over the past several decades, now reaching unsustainable levels;
- Demonstrate the crucial need for forest fuel management in the landscape, and at the public/private land interface;
- Put in perspective that damage/destruction and recovery costs can typically be 2-3 times+ suppression costs - supported by indisputable evidence of the benefits of fuel management for:
  - Reducing risk to life, property, infrastructure and forest values and uses from high intensity bushfire;
  - Aiding fire suppression; and
  - Significantly reducing damage/destruction and costs of recovery in the short and long term.

(5) The available data proved to be incomplete due to variable quality of record keeping. Diligent searching has revealed occasional "snap shots" of daily personnel and plant but thankfully, detailed records of aircraft use.

(6) Plausible though conservative interpretations have produced daily numbers for the 59 day fire and current DELWP 2016/17 contract rates for personnel and plant were then used to generate current day costs estimates.

(7) While aircraft numbers were well known, charge rates needed to rely largely upon US figures. Apparently, in Australia, such data is not publically available being regarded as "commercial in confidence".

(8) This preliminary estimate shows a direct cost figure of A$152M and after including a multiplier (60%) to represent Governmental, Departmental and Regional overheads, just the cost to the Victorian economy of suppressing the 2003 Alpine fire could have been A$243M.

(9) These large figures are thus worthy of serious consideration by State government auditors, land managers and environmental regulators. They should be publically available and feature in agency annual reports to the Parliament as they have to some extent in the past.

(10) Presenting these huge costs will hopefully encourage authorities to diligently collect and analyse the true cost of forest fire management to improve performance, better inform the public and encourage pre-fire measures such as prescribed burning and other forms of fuel management to help:

- Protect and preserve life;
- Increase the safety of communities and fire-fighters;
- Aid fire suppression and reduce suppression costs;
- Reduce fire damage costs and important recovery costs.

All key parameters that should be included in Victoria's Strategic Control Priorities governing emergency response to bushfire.

(11) Such transparent reporting will also serve to inform citizens of the real cost of bushfires and remind The State Crisis and Resilience Council, relevant Departmental Secretaries and portfolio Ministers of the requirement for more effective and efficient bushfire prevention and suppression.

(12) The Inspector General for Emergency Management does not report on these costs in his annual reporting on performance and capability.

(13) Implementation of these strategies has been compromised with a long series of changes to the *Forests Act* 1958, failure to comprehensively report on the performance of bushfire management, a requirement identified in the Code of Practice for Bushfire Management on Public Land, the establishment of Emergency Management Victoria and the huge bureaucracy of a new industry now administering emergency management incidents including bushfire on forested public land.

(14) The paper finishes with a reiteration of earlier arguments to:

(i) restore forest fire management as a core priority of the responsible agency;
(ii) increase the amount of landscape-scale FRB and other forms of fuel management including at the public/private land interface and
(iii) aggressively attack fires in their early stages to keep them small with a key performance target of 90% < 5ha.

(15) Key elements include:

- A strong regional model(*) co-ordinated as required by a compact central administration; the lessons learned up to the mid 1980s;
- A permanent regionally-based workforce of 1800 – 2000 trained and accredited in forest fire fighting (fireground) and supplemented with project fire fighters (350-850) each fire season, in line with predicted severity of the bushfire season. They should be fully accredited for the fireground and managed by the lead authority responsible for forest fire management on public land;
- Amend the *Forests Act* 1958 to restore the requirement for clear financial and operational reporting to monitor effectiveness, efficiency and accountability in public administration, including forest fire management;
- Strengthen the independence and role of the Office of the IGEM by taking it out of the Department of Justice and placing it in the Department of Premier and Cabinet reporting directly to the Chair of the State Resilience Council.
- Include monitoring the costs of forest fire management on public land as one of the "outcome measures" of the IGEM's functions under Section 64(1)(a) of the *Emergency Management Act* 2013.

(16) Safeguarding citizens and protecting assets and values of forests from bushfire should always be a core duty of Government.

(*) *It is positive (Page 3, DELWP Annual Report 2015/16) that DELWP is currently strengthening its regional and district operating capacity and capability.*
This is the result of the then portfolio Minister commissioning an independent review (the Carter Report) into an escaped prescribed burn (the Lancefield-Cobaw fire, October 2015).
On the 19th November 2015, the Government announced it had accepted all 22 recommendations (see: http// delwp. Vic.gov.au/fire-and-emergencies/lancefield).
Some key extracts from the Carter Report:

* P6 " ... Planned burning in complex forested environments requires skills, knowledge and experience that can only be gained over many years in the field making training, development, monitoring and succession planning critical for the maintenance of a capable workforce into the future".
* P15 "... Over the last two years the number of individual public servants within the Department claiming Fireline Allowance has fallen indicating that there are fewer active operational fire staff than before".
* P27 "...while State, regional and district structures have been questioned regarding their adequacy and integration, the Investigation Team holds strongly to the view that fire management and planned burning on public land requires a strong and well integrated single agency able to bring to bear a diverse body of science, technical expertise, personnel, physical resources and infrastructure that also services broader land management functions and responsibilities. Fire management cannot be separated from land management activities..."

What remains disturbing in DELWP's 2015/16 and 2016/17 Annual Reports is:

- *the scant evidence of the requisite dedicated training required for forest fire management on public land;*
- *the slowness with which Carter's recommendations (October 2015) are being put in place, viz: "*On Tuesday 22 August 2017, the department announced a new business model for the Forest, Fire and Region group. As a result, improvements will be made to the organisational structure to better support the deliverable of the department's output for the group. The announcement does not impact the department's organisational structure and financial position at 30 June 2017. The changes and impacts will be considered for the 2017-18 financial year".

It remains to be seen how the new business model will lead to improved preparedness, capacity and capability in fire prevention and suppression, particularly in sever fire seasons and at what cost.

It is understood that less than 13% of DELWP's FTE regional and district staff, excluding project /seasonal fire fighters, have adequate training in all aspects of fire suppression on the fireground.

For future prospects, notwithstanding the Carter Report identified serious organisational and procedural shortcomings, it also found fire personnel co-operated with the inquiry and displayed a very professional outlook and dedication to their demanding work despite the many de-stabilizing re-organisations in recent years.

Introduction

(17) Authorities in Victoria (And Australia) do not publicly report details of expenditure on forest fire management (prevention, suppression, planned use of fire plus damage and recovery costs from bushfire on public land).

(18) There is strong evidence over several decades that much more attention should be paid to preventative measures and the benefits of aggressive first attack to bring forest fires under control quickly.

(19) The role of fuel reduction burning and other forms of fuel modification in the landscape and at the public/private land interface is greatly under-valued.

(20) DELWP (and current Government policy) no longer support a minimum 5% annual rolling hectare target for FRB on public land as recommended by the 2009 Victorian Bushfires Royal Commission; instead, claiming that reducing risk to that of 70% of maximum risk and measures of ecosystem resilience to fire are better parameters for defining optimal use of resources.
The IGEM concurred, but in doing so, issued a strong warning that such (nebulous) concepts require further development and are neither meaningful nor understood by threatened communities[1]. Detail on these matters is provided in Appendix 6.

(21) There are few Australian examples of benefit:cost analysis that demonstrate the benefits of FRB for:
- minimising risk;
- facilitating fire suppression;
- reducing damage/loss to life, property, infrastructure and the forest environment including water catchments/water quality and quantity[2].

For example:

- Bennetton et al 1997[3] demonstrated the importance of considering both bushfire prevention and suppression; *"for $1 of public resources allocated to the Fire Management Program, the State benefits by $22 in terms of assets not destroyed by wildfire".*
- RMIT Centre for Rural and Regional Development. Timber Towns Victoria (July 2003) [4].The Study *focussed on assessing the significant social and economic costs of the 2003 bushfires across the Gippsland and North East Regions (*of Victoria) *for both the short and medium terms. The study revealed that the bushfires are expected to have considerable direct and indirect effects on these regions for the long term (i.e. the next two to five years). In total the loss of income and production in the Shires of Alpine, East Gippsland, Indigo and Towong from the time of the fires to the present (May 2003) to be $121.1 million.* **[$167.27M in 2016]**
- Deloitte Access Economics (2013)[5] Building our Nation's resilience to Natural disasters – for the Australian Business Round Table for Disaster Resilience and Safer Communities – paper focuses on pre-disaster resilience measure to resist the impacts of natural disasters – comments attributed to Dr Chris Richardson, *"in Victoria bushfire mitigation aimed at reducing fuel loads could have a BCR of 3:1"* (in Australian Financial Review 21 06 13).

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1 Review of performance targets for bushfire fuel management on public land. Inspector-General for Emergency Management. April 2015. ISBN 978-1-925140-95-8 (pdf)

2 Note: The protection of water catchments from bushfire is well recognised and the impact of high intensity fire on water yield and water quality is comprehensively documented. The consequences for water hungry metropolis and high value irrigated agriculture are not widely understood. *"EXTENSION TO THE CASE FOR PRESCRIBED BURNING IN BUSHFIRE MANAGEMENT".*
A benefit:cost analysis to highlight some of these issues (including the additional impact of additional water supply penalties and fire suppression costs) is provided in Appendix 6.

3 An economic evaluation of bushfire prevention and suppression in Victoria. Working paper 9703: Julia Bennetton, Paul Cashin, Darren Jones and James Soligo – Performance Evaluation Division, Department of Natural Resources and Environment (Vic) June 1997 ISBN 0 7306 6711 1. Also in Australian Journal Of Agriculture and Resource Economics, $2:2 Pp 149-175

4 *"Socio-economic Impact of Bushfires in Rural and Local Communities and Local Government in Gippsland & North East Victoria"* RMIT Centre for Rural and Regional Development. Timber Towns Victoria (July 2003)

5 www2.deloitte.com/au/en/../building-australias-natural-disaster-resilience.html

- Think Long Term: The Costs and Benefits of Prescribed Burning in the South West of Western Australia: Non-peer reviewed research; proceedings from the Bushfire and Natural Hazards CRC and AFAC Conference Brisbane 30 August-1 September 2016. *'In countries like the US and Aus., fire suppression expenditure has approached record highs...*
  - *decades of fire exclusion and aggressive suppression that results in excessive fuel build-up.*
- *"Reframing Rural Fire Management"* Report of the Special Inquiry into the January 2016 Waroona Fire. Government of Western Australia – Mr M.C. Wauchope, Commissioner, Public Sector Commission. Special Inquirer Euan Ferguson AFSM 29 April 2016. *"Tragically, during the fire, two residents of Yarloop lost their lives. The fire burned a total area of 69,165 hectares comprising 31,985 hectares of public land. 181 properties were destroyed. At time of writing it is estimated that the cost of the fire, including the cost of suppression, losses, damage and recovery (including estimated insurance losses) totals approximately $155 million".* [Personal discussion with the author and further detail in Chapter 6 indicated these total costs could be much higher.]

(22) Deloitte Access Economics (2013)[6] estimated that annual economic cost of natural disasters would rise from $6 billion in 2012 to $12 billion by 2030 and $23 billion by 2050.
It also estimated that increased Australian Government expenditure (of around $250 million per year) would reduce these costs by more than 50% by 2050. DAE recommended increased identification and prioritisation of mitigation activities.

(23) Notwithstanding these clear strategic directions and a radical overhaul of its approach to emergency management implemented in 2014, Victoria has now adopted alternative criteria to those recommended by 2009 Victorian Bushfire Royal Commission for fuel reduction measures, on the recommendation of the Inspector-General for Emergency Management, viz. *"IGEM recommends a risk reduction target as the most effective form of performance target for bushfire fuel management on public land to protect life and property and guide investments for fuel reduction burning"*. This has resulted in preoccupation with process rather than outcome, and a large reduction in landscape-scale fuel reduction burning. Victoria continues to incur huge costs in fire suppression and recovery from bushfire on public land.

(24) During recent fire seasons, news broadcasts have been dominated by spectacular shots of large air tankers dropping fire retardant. While producing wonderful press releases and TV for various Ministers, to show the public action is being taken, this form of suppression of active forest fires in moderate to heavy fuel is very costly and often ineffective.
Never mentioned in the news coverage or Ministerial press releases is the very high cost of fire suppression operations.

(25) As in warfare, it is always well lead experienced 'boots on the ground' supported with the right equipment and appropriate use of aircraft that count.

(26) There are many examples illustrating these points in Victoria's bushfire history.

(27) This technical note presents one attempt at estimating the suppression cost of the 2003 Alpine fire in Victoria and notional values for other recent bushfires.

(28) he suppression cost component of forest fire management was chosen to:
- Identify their progressive escalation over the past several decades, now reaching unsustainable levels;
- Demonstrate the crucial need for forest fuel management in the landscape and at the public/private land interface;
- Put in perspective that damage/destruction and recovery costs can be typically 2-3 times+ suppression costs – indisputable evidence supported by positive outcomes of fuel management for:

[6] www2.deloitte.com/au/en/../building-australias-natural-disaster-resilience.html

- reducing risk to life, property, infrastructure and forest uses and values from high intensity bushfire;
- aiding fire suppression; and
- significantly reducing damage/destruction and costs of recovery in the short and long term.

(29) The following suppression cost estimates have gathered publicly available (but limited) data from a number of sources and applied experienced judgements to close gaps. Calculations are therefore forced to rely on surrogate costs that are arguably plausible and conservative to demonstrate the need in the public interest. It should be regarded as a first attempt.

(30) The capacity and capability to deliver effective and efficient forest fire management on public land is seriously compromised by:

- lack of experienced personnel including exclusion of skilled timber workers and their specialised equipment in over 90 percent of the forested estate;
- road and track closures and lack of maintenance;
- an inability/unwillingness to reduce fuels at a landscape-scale;
- not always directly attacking and containing fires when small, including at night; and
- an over-reliance on large fire-bombers to attempt to extinguish raging bushfire in the landscape.

(31) The ultimate purpose of this concept paper is to urge Parliament to make it mandatory for the agency responsible for forest fire management on public land to fully and clearly report on the costs, which appear to have risen astronomically in recent decades.

Rapidly escalating costs in overheads, particularly in fire suppression and recovery, in a climate where the benefits of prescribed burning (still the best defence for minimising risk, aiding bushfire suppression and reducing losses and recovery costs) is made increasingly problematical by over-sensitivity to OH&S and environmental concerns.

Suppression of bushfire – Australia

(32) The selected bibliography identifies references that present "snap shots" of the suppression effort devoted to some Australian (mostly Victorian) bushfires. Generally, these references do not provide details on costs of individual fires, but some provide an aggregate of costs for a particular fire season. In summary, they come from:

- Reports from land management and emergency management agencies and special inquiries including Royal Commissions (1939 and 2009 Vic) and the Ferguson (2016) report on the Waroona Fire (WA).
- Comparisons by experienced foresters of the suppression of past fires and recent fire management activities. "The Facts Behind the Fire" is the best example where a careful review contrasts between the major 1985 and 2003 fires in Victoria.
- Reviews of major fire operations such as those on the 2003 Alpine fires in Victoria.
- Occasional economic evaluation of bushfire prevention and suppression.

Data availability: unit costs

(33) Just as the total forest fire suppression costs are not reported, it is also difficult to determine the unit costs of fire fighting staff resources, the charges associated with say tankers and dozers and the high cost incurred with various small, medium and large fixed and rotary wing aircraft.

(34) In the following analysis, the unit costs have been assumed to be "direct or contract costs" only. However, an 'overhead multiplier' needs to be added to represent such non direct costs as 'departmental and head office'[7,8] and 'branch office' support, accounting and administration, HR activities, public communications, office rent and communications.

(35) Earlier work[9] with the then Rural Water Commission Design Branch reviews (1992 and the then NSW Water Resources Commission [1993]) suggests that a factor of 1.6 would be appropriate for a large Victorian Government authority.

Spreadsheet arrangement

(36) The paper uses two spreadsheets. Details can be found in Appendix 1. The first is a detailed daily estimate of the suppression cost of the 2003 Alpine Fire and the second, estimates of the suppression costs of a number of Victorian bushfires based on an extrapolation of the peak staff, plant and aircraft numbers recorded at the peak of involvement.

Assumed suppression costs: Personnel, Plant & Equipment, and Aircraft.

(37) The following unit costs were applied in both spreadsheets. The source and the rules covering their application can be found in Appendix 1.

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7 For example: Department of Justice – The Office of the Inspector General for Emergency Management, Emergency Management Victoria and EMV, the lead agency and supporting agencies.

8 State-wide Controller and Regional Controller/s and Incident Management Teams. The contrast between the 'old' and 'new' organisational arrangements is demonstrated in Appendix 6. A full examination would be revealing on overheads, but is beyond the scope of this report.

9 Organisational Reviews for the NSW Water Resources Commission (1993) to assist with the corporatisation of the long established internal design branches responsible for designs & project management

Assumed suppression costs: Personnel

Personnel: Direct Charge Rates 2016/17

Labour Rates	Hourly Charge (A$/hour)
Normal	40
Overtime	80
Standby	80
Double time & a half	100
Source: DELWP Labour and Plant Hire Rates, 2016/17.[10]	

Assumed suppression costs: Plant and Equipment

(38) Details can be found in Appendix 1.

Direct Plant & Equipment Charge Rates 2016/17

Plant and Equipment	Hourly Charge rate (A$/hour)
Dozer (D3)	140
Dozer (D9)	409
Total "specialised vehicles"	*200*
Grader	109
Skidder	100
Loader	100
4WDrives	43
Trailer	127
Water carriers	99
Water Carriers (20KL)	325
Source: DELWP Labour and Plant Hire Rates, 2016/17.[10]	

Assumed suppression costs: Aircraft

(39) Details can be found in Appendix 1.

Aircraft charge rates

Aircraft Type	Availability Charge/day	Deployment Charge/hour
Fire Bombers	A $30,000	A $1000
Light Helicopters	A $15,000	A $ 750
IRS Scanners	A $ 5,000	A $ 250
Heavy Helicopters	A $30,000	A $ 920
Medium Helicopters	A $15,000	A $ 830
FW Recce	A $ 4,000	A $ 170

It was only for aircraft that "availability" and "deployed" numbers were utilised. This was the basis of the contractual arrangements and could well have applied to much of the plant used to fight the fire. Unfortunately, no such split-up for other equipment was available.

To illustrate the order of the costs, individual costs for personnel, plant and aircraft for Day 25 of the fire are presented below.

[10] DELWP Rates Summary for fire suppression works. Valid From 1st November 2016 to 31st October 2017

Example of assumed suppression costs – 2003 Alpine fire, Day 25 of 59.

(40) Example, Day 25, 1 February 2003.

Area burnt so far	800,000ha (by Day 26, 880,000ha)	
Duration so far	25 days	
DAILY SUPPRESSION COSTS		
Personnel numbers (All sources)	4288	
Personnel cost for the day		$4,460,000
Plant totals (All equipment)	302	
Plant cost for the day		$ 210,000
Aircraft available	31	
Aircraft deployed	25	
Aircraft cost for the day		$ 645,000
Total direct cost for the day		$5,168,000

Summary of Suppression Costs : Day 1 – Day 59, 2003 Alpine fire.

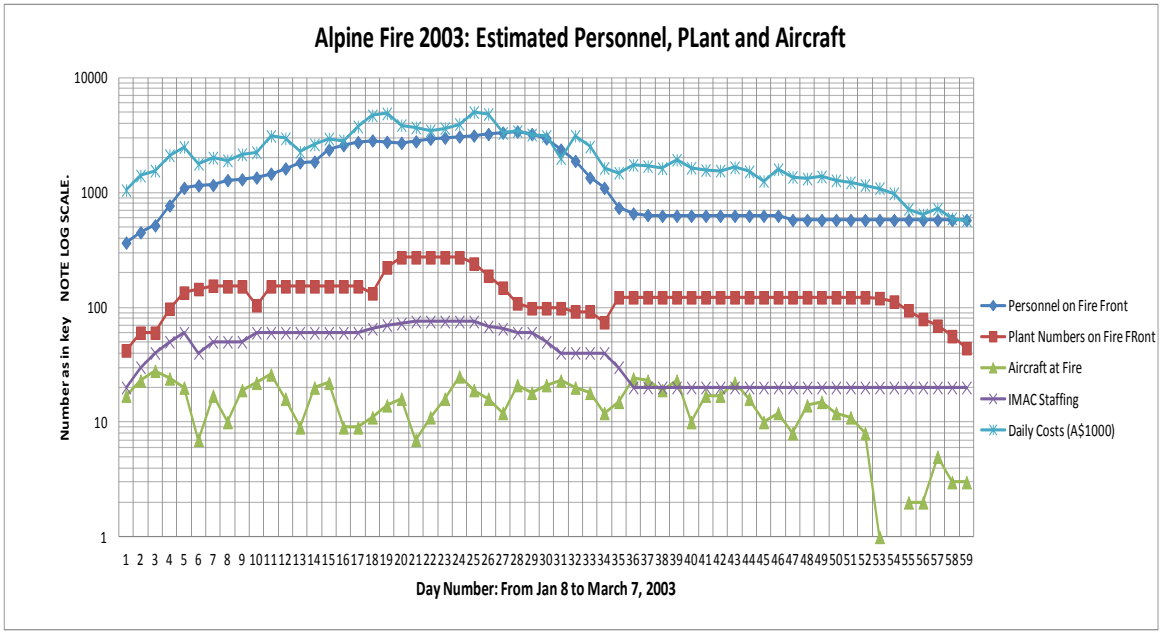
(41) The plot shows the estimated numbers of personnel, plant items and aircraft engaged over the 59 days of the Alpine fire. As these numbers vary from 10s for aircraft to 1000s for personnel and daily costs, the plot uses a logarithmic vertical scale.

(42) The summary table following the plot presents a comparison of area burnt, personnel, plant and aircraft numbers both at the peak and overall and the estimated suppression cost for the 2003 Alpine fire, both the initial attack over the first 9 days and for the 59 days.

(43) A second table compares these estimated costs with those from a similar major fire in January 1985.

(44) These costs are assumed to be "direct costs" or "contractual costs" and ignore the additional costs associated with Departmental and Governmental on-costs. The "overhead multiplier" used to adjust for these costs are described in the next section.

2003 Alpine Fire Suppression Summary: Plot



Suppression Summary: Direct Cost Numbers

2003 Victorian Alpine Fire	Days	Estimated Direct Costs (A$ - 2016)	Average daily cost. (A$/day)
Period			
Initial attack	9	Personnel $ 7,098,000 Plant $ 4,050,000 Aircraft $ 4,929,000 *Total $16,077,000*	Personnel $ 789,000 Plant $ 450,000 Aircraft $ 548,000 *Total $1,786,000*
Whole fire	59	Personnel $101,981,000 Plant $ 21,477,000 Aircraft $ 28,665,000 *Total $152,123,000*	Personnel $1,728,000 Plant $ 364,000 Aircraft $ 486,000 *Total $2,578,000*

Assumed suppression costs: Overhead multiplier

(45) Most landscape-scale fire operations have a significant centrally co-ordinated/managed/community information component and thus all the above field costs need to be increased to cover the overhead costs of 'head office', 'regional office' and local management and support. The factor adopted in this first instance was 1.6 (or 60% Head Office and Government overheads) representing a set of overhead costs at the lower end of likely expectations.

(46) It came from earlier work with the then Rural Water Commission Design Branch (1992) & the then NSW Water Resources Commission (1993)[11] which suggested that a factor of 1.6 would be appropriate for a large Melbourne or Sydney based Government authority.

(47) Certainly, all of these estimates could be queried but in the absence of any revealed data, they at least represent a reasonable starting point.

Suppression Summary: Total Cost Numbers with 1.6 Multiplier

2003 Victorian Alpine Fire	Days	Estimated Total Costs (A$ - 2016)	Average Total Daily Cost. (A$/day)
Period			
Initial attack	9	Personnel $11,357,000 Plant $ 6,480,000 Aircraft $7,886,000 *Total $25,723,000*	Personnel $1,262,000 Plant $ 720,000 Aircraft $ 877,000 *Total $2,859,000*
Whole fire	59	Personnel $163,169,000 Plant $ 34,363,000 Aircraft $ 45,864,000 *Total $,243,396,000*	Personnel $2,766,000 Plant $ 582,000 Aircraft $ 777,000 *Total $4,125,000*

The next table compares the statistics from a "similar" fire in 1985 with those from 2003. The 1985 fire was the subject of detailed analysis in the report "Facts behind the Fire"[12]. The comparison is based on "direct costs".

[11] Organisational Reviews for the Victorian Rural Water Commission (1992) & the NSW Water Resources Commission (1993) to assist with the corporatisation of the long established internal branches responsible for designs & project management.

[12] Dexter, B and A. Hodgson (2005) *The Facts Behind the Fire: A Scientific and Technical Review of the Circumstances Surrounding the 2003 Victorian Bushfire Crisis.* A Publication of Forest Fire Victoria. *forestfirevictoria.org.au* ISBN 0980314909

Summary Comparison: 1985 & 2003 Direct Costs

Feature	January 1985	January 2003	Jan/Feb/Mar 2003
Duration (Days)	14	9	59
Area burnt (ha)	150,000	34,000	1,150,000
Peak personnel (No)	3120	1350	4280
Peak plant (No)	475	255	350
Peak aircraft (No)	36	31	34
Total personnel days (No)	21,700	9,530	133,100
Total plant days (No)	3,330	2,180	8,560
Total aircraft days (No)	392	165	847
Estimated suppression cost	$42.0M	$16.1M	$152.1M
Suppression costs/area burnt	$280/ha	$473/ha	$132/ha

The Direct Cost comparison shows:

- When contained in a short time, suppression costs (and unit costs) can be high. BUT
- The approach incurs the least cost and results in the least damage.
- The 1985 approach, while dealing with similar fire conditions at the start, resulted in only 25% of the 2003 duration and limited damage to 13% of the final 1,090,000 ha burnt in 2003.
- The cost estimate comparison shows the 2003 effort cost an additional A$173M despite the quick attack in 1985 having nearly twice the unit rate (A$469/ha burnt vs A$223/ha).

Annual Suppression Costs: United States of America

(48) Annual fire fighting suppression costs[13] are available for mainland USA for the period 1985 to 2015. The statistics cover the:

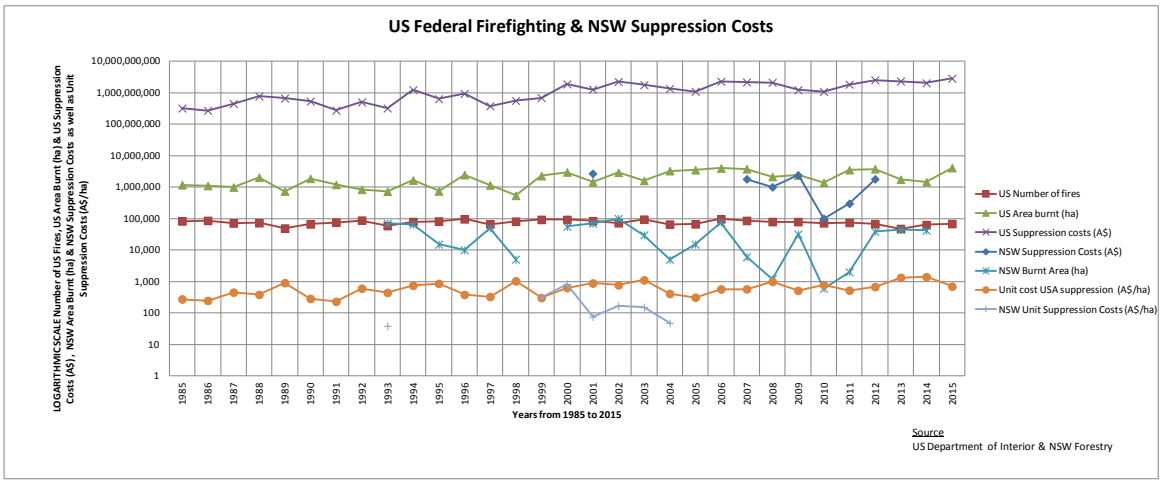
- Number of fires
- Area burnt
- Forest Service costs

(49) Department of Interior agency costs cover the Bureau of Indian Affairs, Bureau of Land Management, National Parks Service and US Fish and Wildlife Service.

(50) The annual returns are plotted below together with some limited data from two Australian States.

(51) Given that the annual totals are dominated by a few very large fires (one observer suggests that 94% of the annual cost comes from only 1.4% of the wild fires), it is impossible to identify any long term trend in either the area burnt or the cost of suppression.

USA long term annual burnt area



(52) While there may be a slight upward trend in the American burnt areas not reflected in the number of fires data, it is impossible to ascribe any long term trend. While conceding that it is but a crude measure, there is little or no trend in the USA Unit costs over the period. There is a small upward trend in the cost of suppression not surprisingly given the long time period and the increasing cost of personnel, plant and particularly, aircraft.

(53) The limited NSW annual data shows a variable burnt area (it varies by an order of magnitude over the period) although the unit costs appear to be similar to the American values.

USA Suppression Cost Case Studies

(54) The following recent detailed American data comes from the Western Forestry Leadership Coalition (WFLC) (2009)[14]. The paper acknowledges that while many agencies document suppression costs and rehabilitation costs (directly funded by federal programs), cost studies that provide detailed analyses of suppression costs associated with wildfire are (as in Australia) surprisingly few.

(55) WFLC has collected a number of case studies from western United States. A summary of this WFLC data now follows.

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13 Federal Fire Fighting Costs 1985 to 2015, Suppression costs only, US Department of the Interior & other related agencies.

14 True Cost of Wildfires in Western United States, (2009), lead author, Lisa Dale for the Western Forestry Leadership Coalition (WFLC).

(56) As before, the collected data can be found in the detailed paper but despite different data collection protocols, the American summary is able to list the important follow-on costs such as rehabilitation as well as estimates of both other direct and the very high indirect costs.

(57) In the following case studies, the areas burnt are small by recent Victorian and NSW experience.

Summary of data from Western Forestry Leadership Coalition Case Studies – Western USA (2009).

Fire Event	Area Burnt	Houses Destroyed	Suppression Costs	Rehabilitation Costs	Other Direct & Indirect Costs	Suppression cost/burnt area	Total Direct cost/burnt area
	(ha)	(no)	(US$M)	(US$M)	(US$M)	(A$/ha)	(A$M)
Canyon Ferry Complex	17,810	6	9.545	8.076	0.455	712	24
Cerro Grande	17,400	260	33.500	72.389	864.500	2567	1288
Hayman	55,849	132+	42.279	39.930	95.962	1011	236
Missionary Ridge	28,330	57+	37.715	8.623	103.061	1776	198
Rodeo Chedeski	176,450	490+	46.500	130.000	122.903	351	397
Old Grand Prix Padua	50,588	787	61.336	534.593	681.903	1615	1696

Victorian Suppression Costs

(58) In order to build a picture of likely suppression costs for major fires and as described in Appendix 1, the limited available Australian data was used in two ways.
For knowledge of peak resources, it was assumed that:
The peak resources were achieved at a linear rate from the start date of the fire to the date of the peak involvement. Likewise, the wind back assumed a linear drop from the peak day to the nominal finish of the fire event.

(59) The large spreadsheet with all the collected data can be made available as a CD.
As a summary, data in the following table show the duration, area burnt, staff resources and aircraft utilized together with preliminary direct cost estimates covering staff, equipment for the selected fires of:

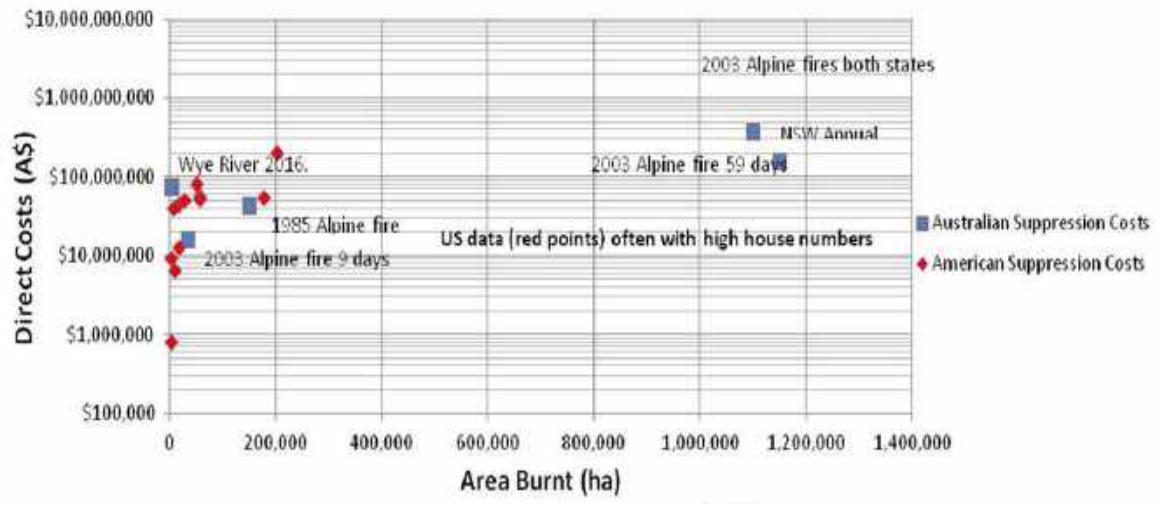
Wye River 2015/16
Harrietville 2013
2003 Victorian Alpine Fire January (9 days)
2003 Victorian Alpine Fire January/February/March (59 days)
1985 Victorian Alpine Fires
Black Friday 1939.

Estimated Fire Statistics Recent Victorian Fires

Fire Event	Activity	Area Burnt	Personnel on fires at peak	Aircraft Utilised	Estimated Direct Suppression Cost	Unit Suppression Cost
	(days)	(ha)			(A$M)2016	(A$/ha)2016
Wye River – Jamieson track 2015/16	34+	2,500	466	16	73.8	29,520
Harrietville 2013	55	37,000	400	?	100+	270
Black Saturday 2009	35	450,000	?	?	?	?
Alpine 2003, Jan	9	34,000	1782	19	15.8	466
Alpine 2003, Jan/Feb/Mar	59	1.15M	4,335	21	159.7	139
Alpine 1985	14	150,000	3119	36	42.9	286
1983 Ash Wednesday	Displan operated for 1 week. Mop up & make safe continued into March	122,032	16,000	25	Estimated cost to FCVic was 15M	123

These estimates are now combined with the USA data in the following chart.

Estimated Bushfire Suppression Costs



For smaller burnt areas, **the American and Victorian points form a reasonable cluster.**
The huge Victorian and NSW fires (burnt areas greater than 1,000,000 ha) sit as outliers on the plot.

Appendix 7. Extension to the Case for Prescribed Burning in Bushfire Management.

Donald Macleod
November 2017

Incorporating:

- water supply penalties and
- fire suppression costs

Contents

Executive summary

Deloitte Access Economics 2014

[1] Based on a seminal work by Deloitte Access Economics (DAE) in 2014 which evaluated a case study Benefit/Cost analysis for bush fire mitigation in the Blue Mountains region of New South Wales, a first attempt has been made to incorporate two features omitted from the DAE case namely; (1) the impact of bushfires on water supply and (2) the cost of bush fire suppression.

[2] The impact of bush fires on catchment hydrology and thus surface water supply has been well studied during the past decades and the important influences can be evaluated.

[3] The cost of bush fire suppression is a subject of which only a little data is ever revealed by the emergency authorities. They tend to rely upon the political adage that whatever the cost, society will bear the consequences provided no lives are lost and that 7pm news reports show great activity with air tankers over the fire ground and film showing the dropping of fire retardants

Absence of reported suppression costs from authorities

Suppression costs could well be high

[4] A preliminary analysis will show that the costs of fire suppression continue to escalate and, for example, could well have been many millions of dollars for the relatively small December 2015 Wye River fire.

5 These costs are often magnified as too many cases now occur of small fires being allowed to nominally reach containment lines, only for the lines to be breached and a major conflagration results. A preliminary analysis of suppression costs for some recent fires in eastern Australia produced figures which typically reach about A$1000/ha burnt.

Continuing lack of positive action on prescribed burning at a landscape scale.
Adding water supply & suppression costs improve the benefit/cost of fuel reduction burning (FRB)

6 These cases become more poignant when prescribed burning (a strong recommendation from recent Royal Commissions) is either ignored or played down by authorities nervous of say smoke nuisance in urban areas or unverifiable environmental damage along fire trails and burnt wildlife on the front pages of city newspapers.

7 The case for increased prescribed burning becomes even stronger when water supply and suppression costs are included.

Introduction

8 In May 2014, Deloitte Access Economics completed a paper(1) for the Australian Forest Products Association which presented a scoping study on a benefit/cost analysis of bushfire mitigation. This study in its day was ground breaking and has served as the basis for this short exercise to include extensions of the model to cover:

- **Water supply impacts**
- **Suppression costs**

Benefit cost model

9 The DAE model argued a convincing benefit/cost case for increases in prescribed burning as an effective tool in bushfire mitigation.

10 Their example considered the Blue Mountains bushfire record and determined average annual baseline costs following prescribed burning of 0.5% (at the time, the current level) and 5% of the area.

Economic costs in DAE/BTE model

* The average annual baseline costs included:
* Total economic cost:

11 DAE followed the approach established by the Bureau of Transport Economics (2001) in the report "Economic Costs of Natural Disasters in Australia"(1) (BTE is now known as the Bureau of Infrastructure, Transport and Regional Economics) by considering the following tangible, non-tangible, direct and indirect costs:

Tangible	Direct Damage To buildings	**Indirect** **Emergency response costs**
	Damage to infrastructure	Household costs
	Damage to crops & Livestock Damage to natural resources (e.g. timber)	Commercial costs Loss of production
Intangible	Death	Psychological
	Injury Personal items & memorabilia	Inconvenience and stress

The DAE study also included:

- PM 10 impacts, the health impacts of particulate emissions from bushfires.
- Carbon emission costs of bushfires.
- Fuel reduction costs including prescribed burning and mechanical removal

Model verification

[12] A careful review of the DAE report and clarifying questions sent to AFPA (and through them to DAE) failed to obtain answers to some minor discrepancies in the quoted baseline costs.

[13] Accordingly, the initial spreadsheet for this study adopted consistent and verifiable values which in turn produced final B/C figures very close to the earlier DAE numbers.

[14] Basic forest data and fire-fighting costs that led to an economic cost evaluation of the current Base Case now follows.

[15] The benefits and costs of any policy changes towards greater areas of prescribed burning (initially to 5% of national park area) come from differences between the above Base Case and the changed policy cases.

Basic data from DAE Model (1/2)

[16] The basic DAE parameters were:

• Average insured loss 2001 & 2013	A$157,200,000
• Average fire frequency	15 years
• Average insured loss say	A$10,500,000/year
• Average area burnt by bushfires each year	29,044ha
• Average annual loss per burnt ha	A$362/ha/year
• Average BTE economic cost multiplier	2.86
• Increase FRB from 0.5% to 5% offers:	
○ Area burnt each year	50% reduction
○ Carbon emissions	50% reduction
○ PM10 costs	50% reduction

Basic costs from DAE Model (2/2)

[17] The following basic costs applied by DAE were:

• Unit cost for Fuel Reduction Burning (FRB)	A$115/ha
• Carbon emissions costs from bushfires	A$1165/ha
• Mechanical removal of fuel & resale	A$300/ha
• Health cost from PM10 emitted during NSW fires	A$8,200,000
• Blue Mountains Council area	143,000ha
• Blue Mountains National Park	70%
• Current NSW FRB	0.5%

[18] **Base Case costs**

• FRB area	= 143,000ha X 70% X 0.5%	500.5ha
• Cost of FRB	= 500.5ha X A$115	A$ 57,558
• Average economic costs	= A$10,500,000 X 2.86	A$30,300,000
• Carbon emission costs	= A$1165 X 29,044ha	A$33,836,260
• Health costs from NSW		A$ 8,200,000
• Average annual baseline costs		A$72,393,818

[19] The above cost elements were then re-evaluated for the 5% FRB case and the difference between the two costs became the Net Benefit of the policy change, in this case, (A$ 72,393,818 less A$42,739,830) or A$29,383,988.

[20] The Marginal Benefits in turn became A$36,334,000 and Marginal Costs A$6,349,000 giving a high Benefit/Cost ratio of 5.7

Result of model verification

[21] Check of the Baseline Costs

Analysis	Blue Mountains Prescribed Burning Percentage	
	0.5% of NP area	5% of NP area
Deloitte Access Economics May 2014		
Base case costs	$ 72.315 M	
Net marginal benefits of policy		$40.59 M
Net marginal costs of policy		$6.808 M
Benefit costs ratio		6.0%
Macleod Spreadsheet April 2016		
Base case costs	$72.124 M	
Net marginal benefits of policy		$36.334 M
Net marginal costs of policy		$8.349 M
Benefit costs ratio		5.7%

Policy options 5% & 10% prescribed burning

[22] The complete spreadsheet for the Base Case comparison now follows. It covers the initial 0.5% and 5% FRB cases as well as a new policy change to 10% FRB. The reductions claimed for the 10% FRB case came from Dexter, December 2015, Personnel Communication on "Changes in fire Parameters of area burnt, carbon emissions and PM10 levels".

- The results of the marginal analyses are also shown.
- The marginal benefits come largely from the assumed reductions in economic costs together with reductions in PM10 and carbon costs.
- The marginal costs come from increases in the cost of prescribed burning and extra carbon emission costs.
- The benefit/cost ratio for the 5% case is a healthy 5.7 thereby supporting a strong economic case.

23 Detailed results: policy options

Feature	2015 Base Case	2020 Policy Change			A Further Policy Change		
Prescribed burning percentage	0.5%	5%			10%		
Area to be prescribed burnt (ha)	500.5	5,005			10,010		
Mechanical fuel removal (percentage of NP area)	0.0%	1.0%			2.0%		
Area Burnt each year (ha)	29,044	14,522			11,618		
	Base case Costs	Policy Change Costs	Marginal benefits	Marginal costs	Policy Change Costs	Marginal benefits	Marginal costs
Cost of prescribed burning ($)	$57,558	$575,575		-$518,018	$1,151,150		-$1,093,593
Net benefit of mechanical fuel removal & sale	0	$300,300	$300,300		$600,600	$600,600	
Average total economic cost ($)	$30,030,000	$15,015,000	$15,015,000		$12,012,000	$18,018,000	
Carbon emission costs	$33,836,260	$16,918,130	$16,918,130		$12,012,000	$21,824,260	
Extra carbon emissions from burning program increase	$0	$5,830,825		-$5,830,825	$11,661,650		-$11,661,650
PM 10 costs ($) from bushfires near Sydney	$8,200,000	$4,100,000	$4,100,000		$3,280,000	$4,920,000	
Total average annual baseline costs ($)	$72,123,818	$42,739,830			$40,717,400		
Net Benefits of Policy change ($/a)		$29,383,988			$31,406,418		
Total marginal benefits and costs ($/a)			$36,333,430	-$6,348,843		$33,701,210	-$12,755,243
Figures quoted in revised May 2014 DAE report			*$40,591,770*	*$6,808,443*			
DAE benefit/cost ratio			*6.0*				
Benefit/cost ratio			*5.7*			*2.6*	

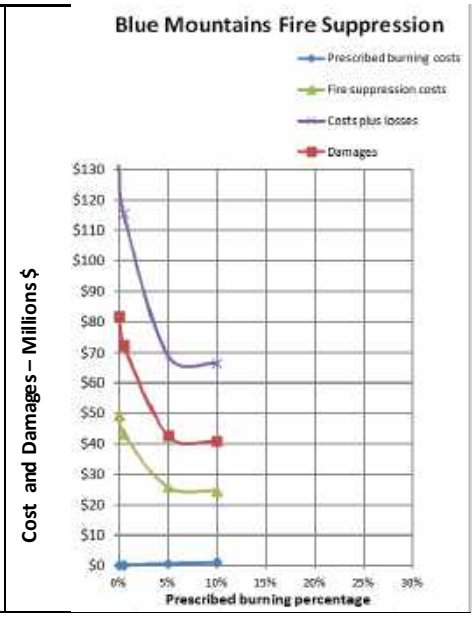
Conclusions from policy options analysis

24 Numbers from the Base Case and the two policy changes have been combined to show an approach to optimisation of the prescribed burning percentage. It follows the parameters used in a recent University of Western Australia[(2)] paper which adopted a minimisation of the "Cost plus Net Value Change" where suppression costs, damages, prescribed burning cost are combined.

25 The following figure summarises the numbers which shows that the 5% prescribed burning percentage is close to optimum.

Optimisation of policy options

SUMMARY BLUE MOUNTAINS FIRE SUPPRESSION		
Points for Plot	Prescribed Burning Percentage	$ Cost/a
Prescribed burning costs	0%	$0
	0.5%	$57,558
	5%	$575,575
	10%	$1,151,150
Economic Damages	0	$82,000,000
	0.5%	$72,123,818
	5%	$42,739,830
	10%	$40,717,400
Suppression costs	0%	$49,200,000
	0.5%	$43,274,291
	5%	$25,643,898
	10%	$24,430,440
Costs plus losses	0%	$131,200,000
	0.5%	$115,455,666
	5%	$68,959,303
	10%	$66,298,990



Introduction to water supply impacts: References

26 Three key references provide a basis for evaluating the likely impact on water supply following a major bush fire. They are:

- Bren[6], particularly Chapter 8, "Impacts of Burning on Catchment Hydrology and Management".
- Sinclair Knight Merz (2009)[7] a broad scale assessment of the impact of the 2003 and 2006/07 fires on River Murray flows.
- O'Shaughnessy (2005)[8], as Appendix 1.3.4 in reference[5] below entitled "Preliminary Assessment of the likely Effects on Long Term Streamflows due to the January 2003 Bush Fires in the Alpine Areas of Victoria.

Water supply impacts

27 All three references confirm that Mountain Ash forests demand a large proportion of local rainfall during a 100 year recovery period. The original O'Shaunassy analysis in "The Facts behind the Fire" suggested increased run-off for five years followed by 100 years of slow recovery.

28 The Mountain Ash conclusion is confirmed by the above SKM 2009 report. It studied the impact of the 2003 and 2005/6 fires on River Murray and Gippsland water resources.

Blue Mountains water supply impacts

29 For the Blue Mountains case, a modification of the SKM "Mixed Eucalypt" example was followed. It assumed extra run-off for years 1 to 7 and then losses as regrowth took over. For say a twenty year period, the initial gain was 23ML/ha and the loss 32ML/ha giving a balance of 8ML/ha over the twenty years and thus an annual loss of 0.4ML/ha/a.

30 Given that the Blue Mountains streams feed the Nepean River and are thus part of the present Sydney water resource and more importantly, the scarcity of alterative water supply sources, it was further assumed that this loss was made up through a desalination plant

running not at Sydney's high operating costs but at the lowest Australian cost of Perth's, A$1200/ML.

31 The results of adding a water supply penalty are shown in the following table for the earlier prescribed burning percentages of 0.5%, 5% and 10%. The water supply impact is highlighted in the table.

32 The Benefit/Cost ratios increased markedly for the two policy change options.

Feature	2015 Base Case	2020 Policy change			A Further Policy change		
Prescribed burning percentage	0.5%	5%			10%		
Area to be prescribed burnt - ha	500.5	5,005			10,050		
Mechanical fuel removal [% NP area]	0.0%	1.0%			2.0%		
	Base Case Costs	Policy Change Costs	Marginal Benefits	Marginal Costs	Policy Change Costs	Marginal Benefits	Marginal Costs
Cost of Prescribed burning ($)	57,553	575,575		-518,018	1,151,150		-1,093,593
Estimate of desal costs for water supply shortage($)	**13,941,120**	**6,970,560**	**6,970,560**		**5,576,448**	**8,364,572**	
Net benefit of mechanical fuel removal & Sale ($)	0	300,300	300,000		600,600	600,000	
Average total economic costs ($)	30,030,000	15,015,000	15,015,000		12,012,000	18,018,000	
Carbon emission costs ($)	33,836,260	16,918,130	16,918,130		12,012,000	21,824,260	
Extra carbon emissions from burning program increases	50	5,830,825		-5,830,825	11,661,650		-11,661,650
PM 10 costs ($) from bushfires near Sydney	8,200,000	4,100,000	4,100,000		3,280,000	4,920,000	
Total Average Annual Bushfire Costs ($)	**58,054,938**	**49,710,390**			**43,303,990**		
Net Benefits of Policy change ($/a)		**35,354,548**			**42,750,948**		
Total Marginal Benefits and Costs ($/a)			**43,303,990**	**-6,348,843**		**53,727,532**	**-12,755,243**
Benefit/Cost Ratio			**5.8**			**4.2**	

Australian suppression costs: Approach

The limited Australian suppression cost data can be summarised as:

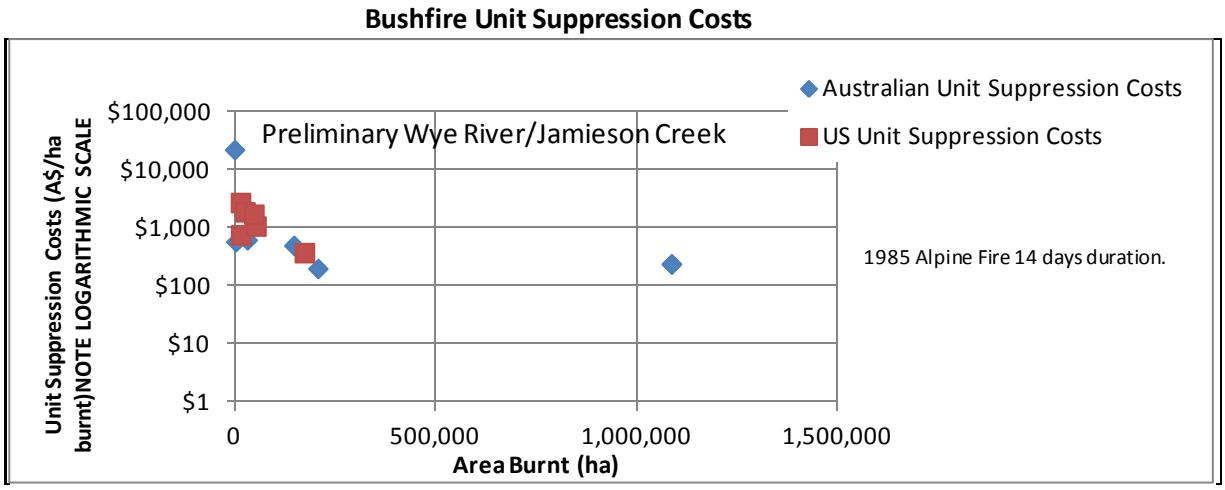
33 Preliminary estimates were developed from a detailed daily costing of the suppression of the 2003 Alpine Fire. The effort lasted 59 days and involved 1000's of fire fighters, 100's of specialised vehicles and 10s of dedicated aircraft. The final direct cost (in 2017 dollars) was thought to be A$152,000,000 and the cost to the Victorian economy a staggering A$223,000,000.

34 The real purpose of the reference was to encourage authorities to be more open with the high cost of forest fire suppression particularly in situations where prescribed burning (still the best defence for minimising fire losses) is made increasingly problematical by overly sensitive environmental concerns, lack of access due to abandoned fire trails and an inability to respond quickly in strength to keep fires small. The exclusion of timber workers within many forest reserves has also removed a valuable strike force.

Australian suppression costs (unit costs)

35 The daily analysis from 2003 was then combined with the limited available data from other Victorian fires to produce a set of crude "unit costs" (suppression costs/ha burnt) which were then compared with more comprehensive data from USA (YY).

36 The comparison is shown below.



Adding suppression costs to Blue Mountains benefit cost analysis

37 When the cost of suppression is added to the earlier water penalty spreadsheet, the case for prescribed burning is enhanced.

38 For our Blue Mountains case, the cost of suppression adds A$34M to the annual baseline cost then producing correspondingly large benefits when prescribed burning reduces the area burnt.

39 For the 5% prescribed burning case, the net benefits are now A$52M and for the 10% case, A$59M. The corresponding B/C ratios are 9.4 and 5.7. The detailed numbers are shown in the next table.

Benefit/Cost table with water & suppression costs added

	2015 Base Case	2020 Policy Change			A Further Policy Change		
Feature							
Prescribed burning percentage	0.5%	5.0%			10.0%		
Area to be prescribed burnt (ha)	500.5	5005			10010		
Mechanical fuel removal (percentage of NP area)	0	0.01			0.02		
Area burnt by bush fire each year (ha)	29,044	14,522			11,618		
	Base case Costs	Policy Change Costs	Mariginal benefits	Marginal costs	Policy Change Costs	Mariginal benefits	Marginal costs
Cost of prescribed burning ($)	$57,558	$575,575		-$518,018	$1,151,150		-$1,093,593
Estimate of desal costs from water suply shortage.	$13,941,120	$6,970,560	$6,970,560		$5,576,448	$8,364,672	
Net benefit of mechanical fuel removal & sale	$0	$300,300	$300,300		$600,600	$600,600	
Average total economic cost ($)	$30,030,000	$15,015,000	$15,015,000		$12,012,000	$18,018,000	
Carbon emmission costs ($)	$33,836,260	$16,918,130	$16,918,130		$12,012,000	$21,824,260	
Extra carbon emmissions from burning program increase	$0	$5,830,825		-$5,830,825	$11,661,650		-$11,661,650
PM 10 costs ($) from bush fires near Sydney	$8,200,000	$4,100,000	$4,100,000		$3,280,000	$4,920,000	
Suppression costs	$17,426,400	$8,713,200	$8,713,200		$6,970,560	$10,455,840	
Total average annual baseline costs ($)	$103,491,338	$58,423,590			$53,264,408		
Net Benefits of Policy Change ($/a)		$45,067,748			$50,226,930		
Total marginal benefits and costs ($/a)			$52,017,190	-$6,348,843		$64,183,372	-$12,755,243
Benefit/cost ratio			8.2			5.0	

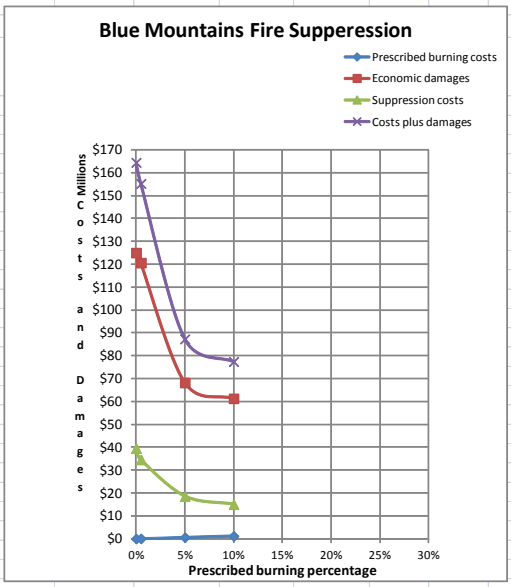
Conclusions from last benefit cost table

40 The "Benefit/Cost" ratio for the 5% prescribed burning percentage is now more than 8, a convincing result. The water supply penalty represents 13% of the total annual baseline costs and suppression costs 17%. Both clearly worthwhile additions to the analysis.

41 The "Cost plus Net Value Change" analysis for the addition of water supply penalties and suppression costs now follows. Compared to the initial analysis the optimum prescribed burning percentage is now trending toward 10% rather than the initial 5%. As before note the low cost of prescribed burning.

Last "Cost plus Net Value" table & plot

SUMMARY BLUE MOUNTAINS FIRE SUPPRESSION		
Points for Plot	Prescribed Burning Percentage	$ Cost/a
Prescribed burning costs	0%	$0
	0.5%	$57,558
	5%	$575,575
	10%	$1,151,150
Economic Damages	0	$125,000,000
Now includes a water supply penalty	0.5%	$120,627,298
	5%	$68,211,418
	10%	$61,280,552
Supression costs	0%	$39,470,796
	0.5%	$34,562,360
	5%	$18,501,028
	10%	$14,986,704
Costs plus losses	0%	$164,470,796
	0.5%	$155,247,215
	5%	$87,288,021
	10%	$77,418,406



Conclusions

42 Water supply penalties were acknowledged in the earlier DAE paper although not evaluated.

43 They are clearly a real costs of Australian bushfires particularly in southern Australia and thus worthy of inclusion in any economic assessment of management options.

44 It remains a sad indictment that authorities are happy with press releases extolling their air fleets rather than engaging in and perhaps resolving the currently "green dominated" anti prescribed burning debate.

45 Accordingly, suppression costs, traditionally hidden by fire fighting authorities, should be made public and always included in any economic assessment.

46 These detailed summaries of fire fighting efforts should cover field staff, head office management, equipment and aircraft hire and operations.

47 In most cases, the immediate costs such as evacuations of locals and follow on costs such as clearing dangerous timber should be part of the final picture together with damage and all recovery costs.

48 The case for prescribed burning in South East Australia is more than sound but requires the authorities to respond more forcibly to the recent encouragements arising from a number of inquiries and Royal Commissions.

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