INDEPENDENT**BUSHFIRE**GROUP

2019-2020 NSW bushfires

Detailed Fire Studies

Summary & Introduction

Fire Studies Summary

The lessons learnt from these fire studies could be applied across all the bushfires:

- The importance of rapid and effective initial attack within 2-6 hours after detection and working overnight when fuel moisture and wind speeds can be favourable for safe ground crew operation.
- Applying effective fire containment strategies using a variety of options instead of over-reliance on backburning (in other words indirect attack).
- The high risk of backburn failures resulting from unfavourable drought fuel conditions, dead fine fuel moisture content and local wind conditions. The need to withdraw from operations when the proposed backburn is outside guidelines (eg RFS Fireground SOP #17, 1999, *see Section 3.3 - Suppression Strategies for Large Fires*).
- These fire studies also highlight the high risks associated with undertaking large scale backburns over kilometres; implementing tens of kilometres of fire containment lines either on one day or over several days and; the potential for backburn escapes due adverse high-severity fire weather conditions, especially during drought and heat-wave conditions.
- These issues and associated factors are discussed in detail in *Sections 2.1, 2.4, 3.1, 3.2, 3.3 and 3.9* of this report.

These fire studies show that backburning is not always the safest and most practical fire tactic when undertaken at a large scale on large bushfires without careful and due regard to local fire landscape conditions. As a local tactic done at the right time of the day and in the right period it can be an important containment option when carried out like a prescribed burn under mild fire weather conditions with due recognition to backburn escape risk factors. These factors include very low dead fine fuel moisture contents (3-10%), winds in excess of 15-20 km/h, unstable atmosphere, high Haines index and severe fire weather events within a 1-3 day period of the burn, often occasioned with significant wind changes across the fireground.

Some of the backburns conducted in the 2019-2020 fire season and those in previous fire seasons were carried out as a very high fire risk strategy. These carried the penalty of loss of property and post-traumatic stress in people affected, as well as a deep division in local communities about their merit or otherwise.

We especially highlight the need for integrated knowledge of fire landscapes, fuel types, ambient drought conditions and fire weather patterns both historical and during the suppression of a bushfire. Much of this detailed knowledge and experience has been lost in the fire agencies as a result of organisational restructures in the last 20 years.

Bees Nest Fire map and notes by Phil Zylstra. Half Penny Hill fire study by Dave Darlington. All other studies, analysis, reconstruction and mapping by Nick Gellie, with map design by Ian Charles and Nick Gellie.

Report Authors

Denise Allen

BSc Forestry

Denise Allen is a professional forester with over 39 years' experience in land management. Denise spent 15 years working for the Forest Department and the Department of Conservation and Land Management in Western Australia, nine of those years as District Manager Jarrahdale, just 60km south-east of the Perth CBD. There she was responsible for implementing broadscale aerial burns and fire suppression activities within close proximity to a large and vocal populous. Working for the NSW National Parks and Wildlife Service, Denise has had roles managing the fire management program at an Area, Region and Branch level. She assisted in establishing the Enhanced Bushfire Management Program on the north coast of NSW and has been involved in overseeing its implementation. Denise most recently acted as Manager of Booderee National Park, a park jointly managed by the local indigenous community of Wreck Bay and Parks Australia staff.

Ian Brown

OAM, BA Earth Sciences, National Fire Medal

Ian Brown worked in national park management for 20 years and was involved in over 100 fires in roles from crew member to Incident Controller. He was the planning leader for the 1994 Bell Range fire emergency in the Grose Valley (Blue Mountains National Park) and Deputy Incident Controller for the emergency declaration phase of the 1994 Gospers Mountain fire (Wollemi National Park). He worked on planning for the Northern Strategic Line in the Blue Mountains. He managed bushfire programs across the Blue Mountains park system and served on two district bushfire management committees. In recent years he has been an independent environmental consultant, maintaining a keen interest in bushfire issues.

Dave Darlington

BA Earth Sciences, DipEd, National Fire Medal

Dave Darlington is a retired NPWS Regional Manager from the Snowy Mountains. Dave helped to develop and refine the incident management system in the 1990s and was a key IMS instructor for NPWS. In the Snowy Mountains fires of 2002-03 he was the Section 44 incident controller continuously from mid-December 02 to March 03 (for which he was awarded Australia Day Citizen of the Year by Snowy River Shire Council). He has also managed numerous smaller incidents. He was the NPWS representative on several Bushfire Management Committees from the mid 90's until his retirement in 2013. Dave is an active member of the Jindabyne RFS Bushfire Brigade and is Brigade President. He assisted the Rural Fire Service to develop a Community Fire Protection Plan for some key rural residential estates in his Brigade area.

Introduction to Fire Studies

These fire studies from the 2019-2020 season use analysis, maps and text to illustrate some of the issues raised in this report. Weather data and graphics are included in some of the studies to assist understanding. The studies are 'first cut' analyses, offered as examples that can be improved with more information and work.

Several studies are from the Greater Blue Mountains area, as this region is well known to a number of authors of this report, and more information was available for these fires.

The studies have been prepared under several limitations, including time and not having access to the full range of analytical resources. Available data sources were used including satellite imagery, weather records and informants from the fireground. Some important inputs were not available, such as infrared fire linescans, incident mapping and Incident Action Plans. Other information not available for these studies include the amount and location of resources applied to various strategies and the pattern of aerial attack. Consequently, there may be errors in some details of these studies. The basic events are considered to be correct but could be refined with access to all relevant information.

The fires are presented in terms of factual events with some interpretation. The reasons for various decisions made on the fires, and the influences on those decisions, are mostly unknown. Speculation on these is avoided.

These studies demonstrate the potential for comprehensive post-fire analysis. Such work can identify successful and unsuccessful strategies, and the factors that made the difference. Conclusions can then inform future operations and improved suppression practices. Every major fire should be analysed in this way. By spending a tiny fraction of suppression costs on post-fire analysis, the impacts, trauma and costs of future fires could be reduced.

These studies can be broken into three large fires, with details of backburn escapes and containment problems on those fires, and two other fires as listed in *Figure FS1*. The locations of the fires are shown in this table. The analyses have been restricted to the Blue Mountains, Currowan and Half Penny Hill bushfires *(Figure FS2)* in the south and the Bees Nest bushfire in the north. There are many other case studies still to be investigated in the 2019-2020 bushfire season.

> ***NB:*** *It is recognised that these studies do not consider unknown factors that may have applied in some situations. Operations during the extraordinary 2019-2020 fire season were sometimes hampered by issues that constrained suppression options. These factors included smoke affecting aerial operations, inadequate fireground information and the limited supply of critical firefighting resources such as aircraft and RAF teams. Because it has not been possible to take these constraints into account, these studies should be taken as identifying potential alternative strategies and outcomes. Nevertheless, analysis such as in these fire studies is always valuable.*

No.	Bushfire	Issue	Perspective	Location	Period
1	Green Wattle Creek	Strategic containment	Whole fire	Southern Blue Mountains	05 – 16 Dec 2019
2	Green Wattle Creek- Seabrook Road escape	Backburn failure	Seabrook Road, Balmoral area	Eastern Nattai catchment	19 -20 Dec 2019
3	Gospers Mountain- South-west section	Strategic containment	South-west perimeters	Newnes Plateau and Wollangambe River catchments	07 Dec – 11 Dec 2109
4	Gospers Mountain- Newnes Plateau	Backburn failure	Glow Worm Tunnel Road	Northern Newnes Plateau	07-11 Dec 2019
5	Gospers Mountain- Mount Wilson escape	Backburn failure	Mount Wilson Road	Bells Line of Road at the intersection of Bowens Creek, Wollangambe, and Grose River catchments	14-16 Dec 2019
6	Mount Wilson Road (Grose)	Strategic containment	Southern perimeter	Grose Valley	21-31 Dec 2019
7	Currowan-Tianjara Complex – early stages	Early strategic containment	Currowan State Forest and Budawang National Park	Clyde River catchment	27 Nov – 1 Dec 2019
8	Currowan-Tianjara Complex – Milton-Conjola	Tactical containment and backburn failures	Conjola Park	Eastern escarpment of Milton precinct	27-31 Dec 2019
9	Currowan-Tianjara Complex – Clyde Mountain	Strategic containment	Kings Highway	Monga National Park and Buckenbowra River catchment	17-31 Dec 2019
10	Half Penny Hill	Initial attack	All fire	Byadbo area, Kosciuszko NP	27-28 Dec 2019
11	Bees Nest	Fire modelling and strategies	Moonmerri Creek	North of Dorrigo	Around 9 Sept 2019

Figure FS1: Locations, issues, perspectives and periods of fire studies

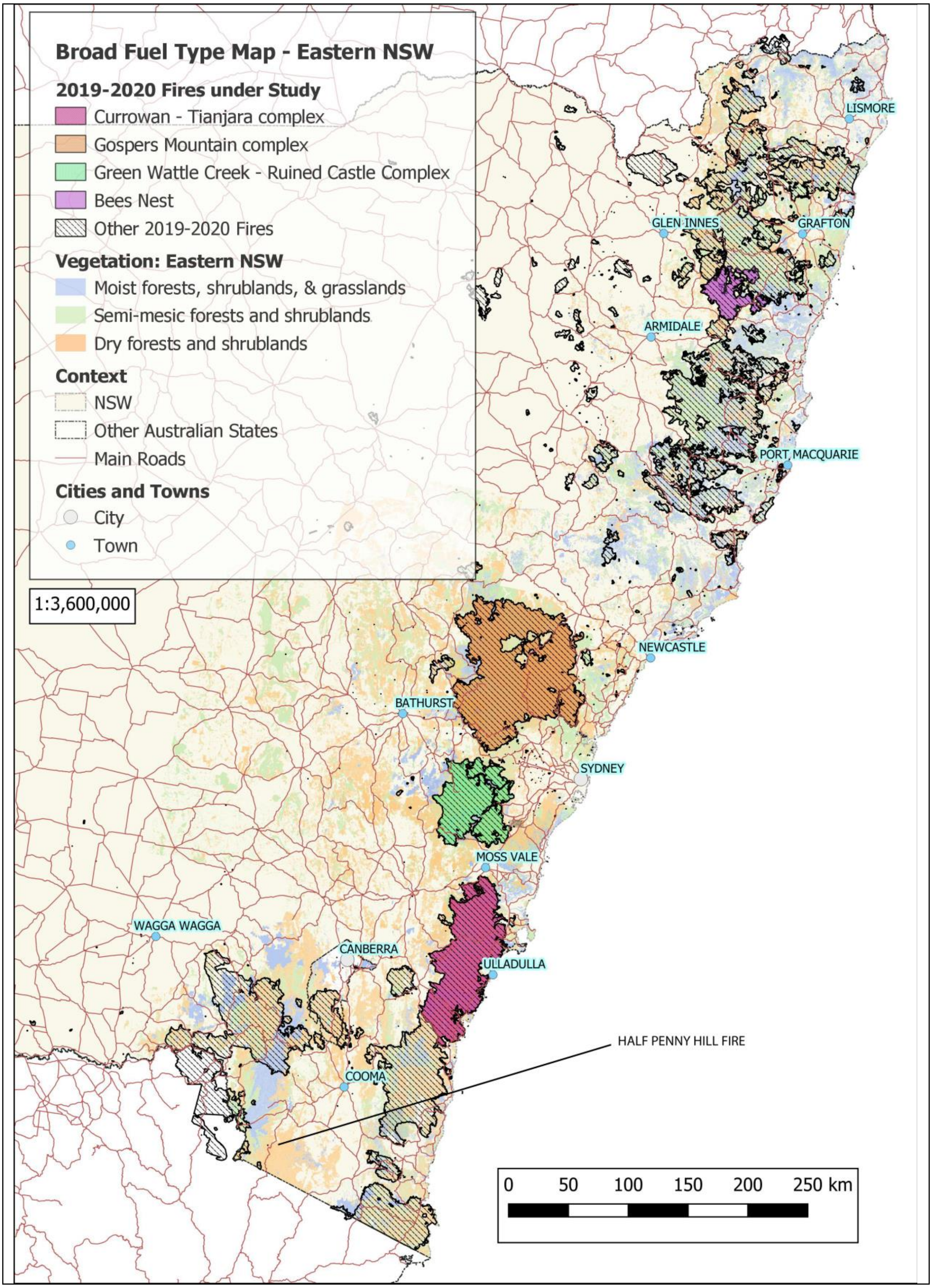


Figure FS2: General location and context of fire studies (vegetation/fuel type mapping by N Gellie)

Notes on fire weather analyses for these fire studies

In these analyses we use estimates of dead fine fuel moisture content (DFMC) and 10-m wind speeds from the nearest weather station as the primary raw indices of potential fire risk. These data can be used for determining whether a backburn is inside or outside management prescriptions. DFMC is derived from the simplified Matthew fuel moisture content equations published in the literature.

We also used the Noble at al equations for the Forest Fire Danger Index (FFDI) in our studies (1-9). In many cases, because of the high atmospheric instability, the drought-affected live and dead fuels did not reflect in many instances the extremely low live fuel moisture contents in these case studies. We have included the FFDI as a comparative index together with wind direction to provide context for the fire studies' analyses. The reason is the Drought Factor with a scale of 1-10 in the FFDI does not reflect the actual 'deep' drought conditions of low dead fuel contents in the coarse woody debris, tree or understorey bark (especially rough-barked tea-tree species) and live fuel moisture contents in the understorey and tree canopy.

Fire weather data was extracted from Weatherzone Pro and pasted into an Excel spreadsheet and the algorithms for DFMC, and FFDI were then added. Line graphs for the periods of each study were then generated to depict the trends for each of the fire weather variables.

Figure FS3 presents the weather stations used for each of the fire studies.

Seasonal drought trends for the three regions of eastern NSW

Drought plays a major role in making fire landscapes susceptible to large landscape fires and to extreme fire behaviour (Gellie 2009). For background in these fire studies, we use the Mount Soil Dryness Index which can be calibrated to a particular station or local area using catchment run-off data. In fact, Mount (1972) developed and calibrated his daily soil water balance model (DSWBM) on Lidsdale run-off data south of Wallerawang in central eastern NSW. It is widely accepted in Australia as an alternative to estimating soil water deficit (SWD) to Keetch-Byram Drought Index (KBDI) still in use in much of Australia.

We present below the trends in SWD, and modelled grass curing and tree canopy moisture content for three representative stations with complete temperature and rainfall records *(see Figure FS4)* in the three main fire-affected regions in eastern New South Wales. We could have analysed SWD to cover the full range of environments in each region. However, we had limited time to complete the extra work involved.

The modelled grass curing is derived from Roger Hosking's model (1981) of grassland curing index for grasslands near Braidwood. The modelled moisture content for trees is an interim model to describe the effect of severe drought on water stress in eucalypt leaves. Both models need further validation in different climate zones.

Detailed trend in SWD for the three regions is presented in *Figures FS5, FS6, FS7* over the period of reliable weather records. An inter-annual trend on a daily basis is presented in (a) and then (b) for the last two years up until May 2020.

In the last four years on the North Coast of NSW, there were three fire seasons in 2015-2016, 2018-2019, and 2019-2020 which had much higher SWD deficits than in comparable severe fire seasons in the past *(Figure FS8)*. The trends indicate that these droughts have become more frequent and intense in the last ten years, suggesting some possible changes in seasonal climate. For the Blue Mountains, the trends in seasonal SWD suggest that intense periods of drought are becoming more frequent mirroring the trends up the North Coast.

Based on the results presented in *Figure FS5*, the 2019-2020 fire season was comparable to 1979-80, 1982-83, 1990-91, 2001-02, 2013-14, 2015-16, 2017-2018. The 2005-6 and 2006-07 fire seasons belonged to a seasonal drought pattern that spanned two fire seasons. For the South Coast from Nowra to Batemans Bay, 2019-2020 came at the end of one of the most prolonged droughts and was comparable to the 2001-02 and 2002-03 and 1979/80-1982/83 sets of fire seasons. Unlike the Sydney Basin, recurrent drought is more of a feature of the Morton plateau and Budawang Ranges (Southern Highlands/South Coast) and can be prolonged over several fire seasons.

No.	Bushfire	Weather Station	Geographic Location	Lat / Long	Elevation (m)
1	Green Wattle Creek	Richmond AWS	Coastal lowlands	33.60°S 150.75°E	14
2	Green Wattle Creek-Seabrook Road escape	Richmond AWS	Northern Nattai	33.60°S 150.75°E	14
2		Moss Vale	Nattai Tablelands	34.55°S 150.37°E	680
3	Gospers Mountain-South-west section	Marrangaroo AWS	Newnes Plateau	33.43°S 150.11°E	961
4	Gospers Mountain-Newnes Plateau	Mount Boyce	Newnes Plateau, Grose Valley	33.64°S 150.28°E	1067
		Marrangaroo AWS	Newnes Plateau	33.43°S 150.11°E	961
5	Gospers Mountain-Mount Wilson escape	Marrangaroo AWS	Newnes Plateau	33.43°S 150.11°E	961
		Mount Boyce	Newnes Plateau, Grose Valley	33.64°S 150.28°E	1067
6	Grose (Mount Wilson Road)	Mount Boyce	Newnes Plateau, Grose Valley	33.64°S 150.28°E	1067
7	Currowan	Braidwood		35.36°S 150.47°E	7
		Ulladulla	Currowan Clyde River basin	35.36°S 150.47°E	5
		Ulladulla	Currowan Clyde River basin	35.36°S 150.47°E	5
9	Currowan-Tianjara Complex	Braidwood	South Coast Escarpment	35.71°S 150.17°E	7
		Moruya Airport	South Coastal Lowlands	35.91°S 150.08°E	10
10	Half Penny Hill	Nil – no weather data or analysis used			
11	Bees Nest	Nil – no weather data or analysis used			

Figure FS3: Details of weather stations used in study

No.	Region	Station	Elevation (metres above sea level)	Length of Record	Fires
1	North Coast	Pilot Head	0	1910 - 2020	Bees Nest
2	Blue Mountains	Bilpin	630	1971 - 2020	Gospers Mountain
3	South Coast	Braidwood	800	1971 0 2020	Currowan-Tianjara Complex

Figure FS4: Representative Weather Stations to estimate SWD by regions

In addition, the results for the three stations show that the deep drought period (SWD>140 mm) occurred one month earlier at Yamba Head (North Coast) during late October compared to Bilpin (Blue Mountains). The SWD for the Braidwood station (Monaro) had a much longer drought period than the other two stations in the Sydney Basin and in the North Coast starting well back in the 2017-2018 fire season. The exposed Morton plateau soils and heathy woodlands were therefore in much deeper state of moisture stress in the vegetation than the forest vegetation at the start of the fire season. Two years of below-average rainfall in the Nerriga area created a much more flammable fuel state than in the other two locations. The near-surface and understorey fuels in the heathlands and heathy woodlands became even more highly desiccated during the prolonged dry period from about mid-December onwards.

In the Blue Mountains understorey dieback from prolonged lack of rainfall in the peak summer period was prevalent in heathland, eucalypt dry shrubby forest and eucalypt semi-mesic forest in the upper Blue Mountains from early to mid-January 2020 *(see Figure FS8)*.

(a)

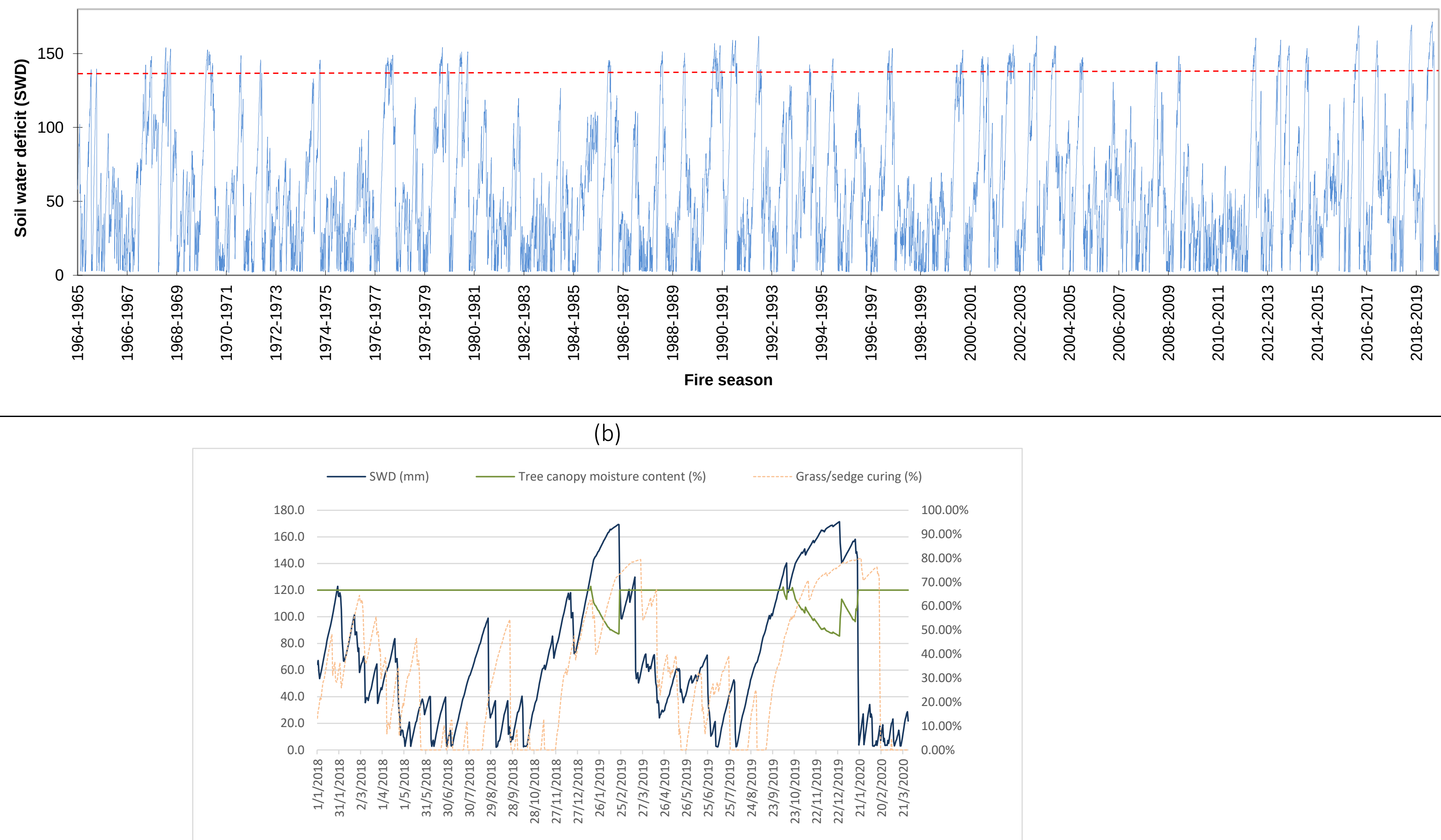
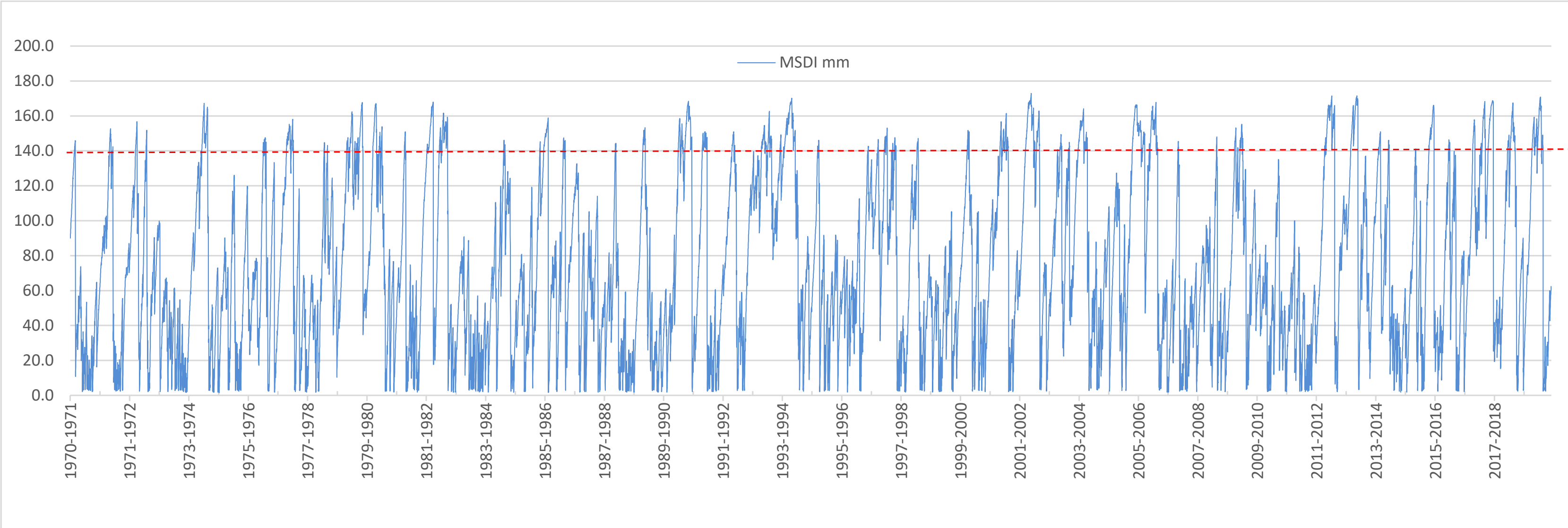


Figure FS5: (a) Trends in annual soil water deficit (SWD) in mm for Yamba head (North Coast) 1964-65 – 2018/2019 (b) Modelled trends in SWD< tree canopy moisture content, and grass/sedge curing 2017/18 – 2018/2019

(a)



(b)

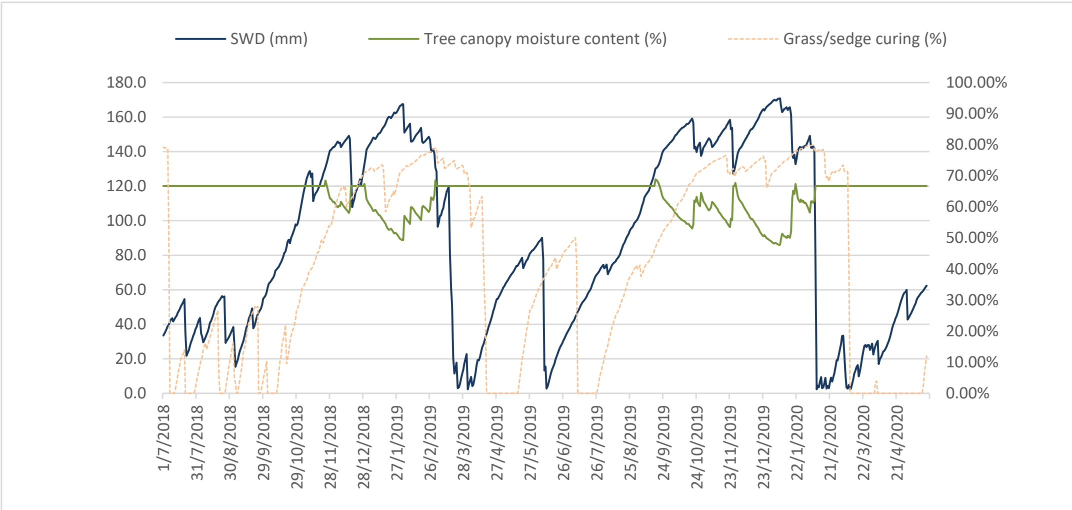
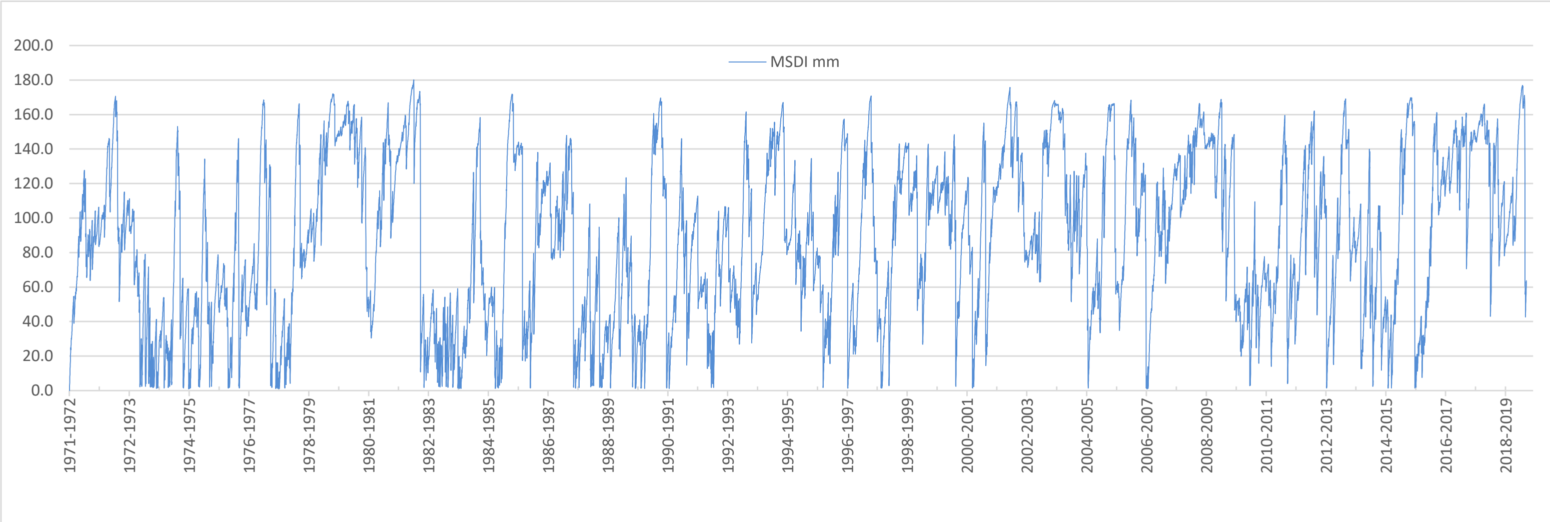


Figure FS6: (a) Trends in annual soil water deficit (SWD) in mm for Bilpin (Blue Mountains) 1970-71 – 2018/2019 (b) Modelled trends in SWD< tree canopy moisture content, and grass/sedge curing 2017/18 – 2018/2019

(a)



(b)

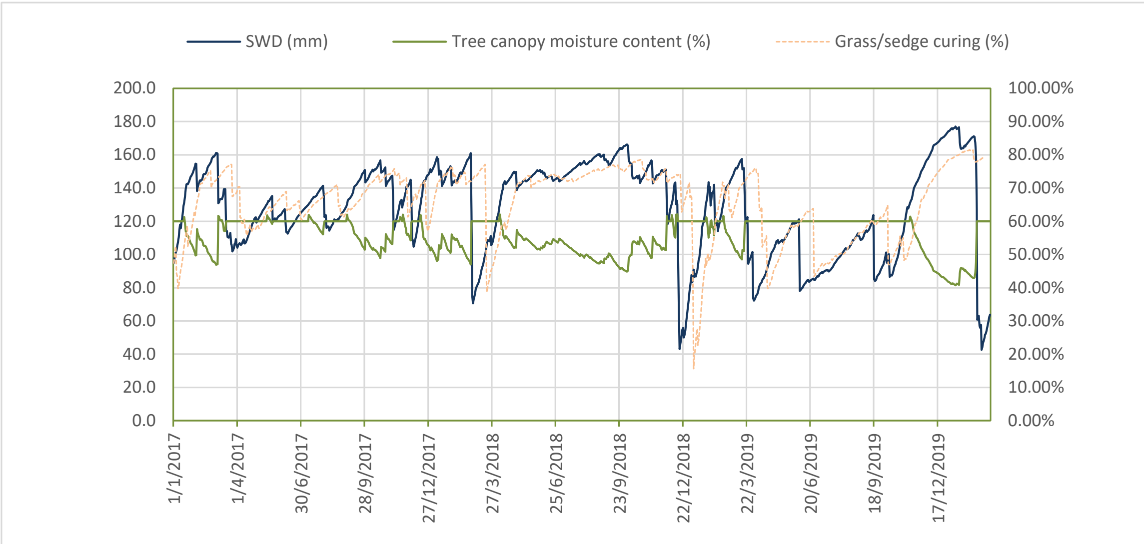


Figure FS7: (a) Trends in annual soil water deficit (SWD) in mm for Nerriga composite (South Coast) 1971-72 – 2018/2019 (b) Modelled trends in SWD< tree canopy moisture content, and grass/sedge curing 2017/18 – 2018/2019

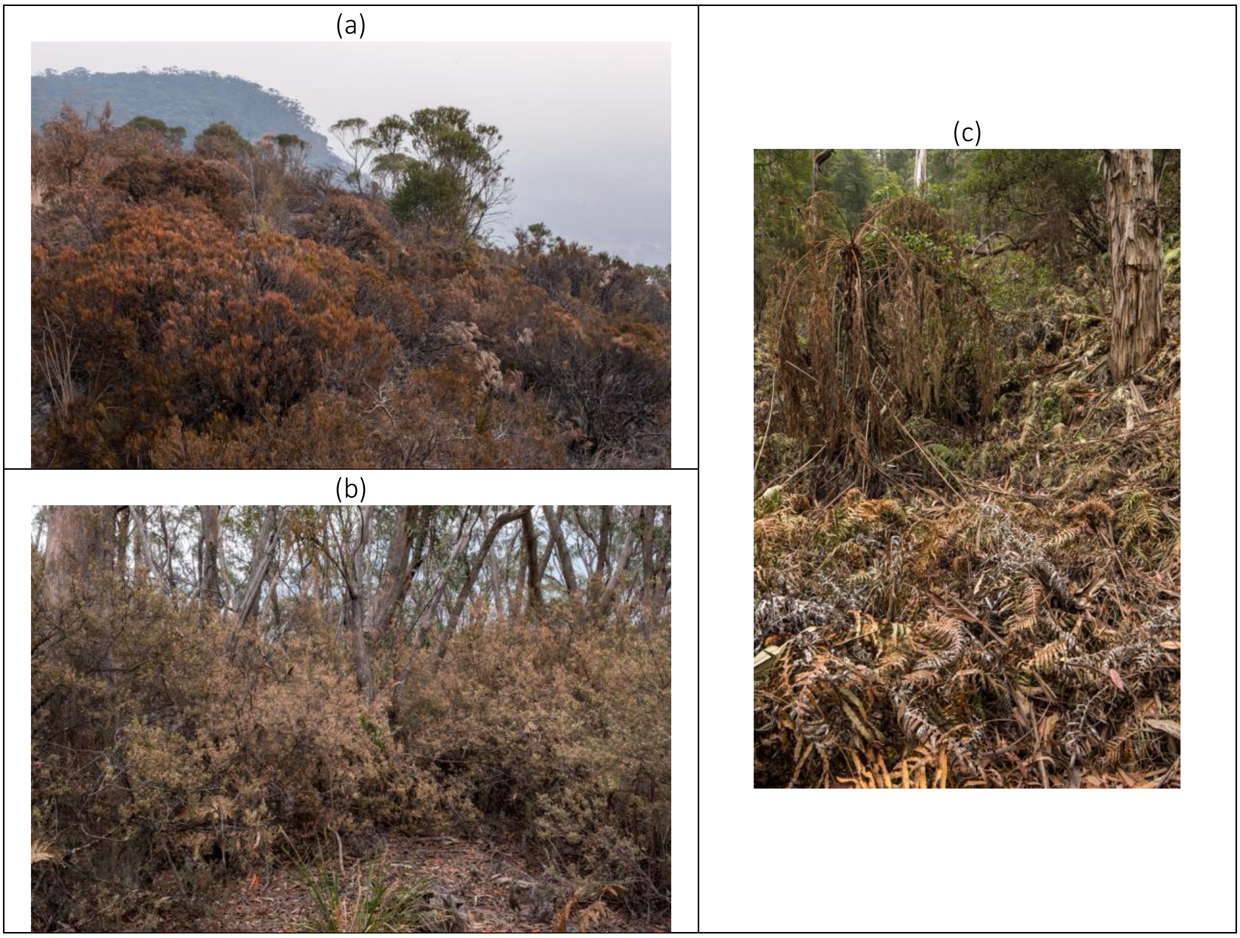


Figure FS8: Understorey dieback due to prolonged drought in (a) heathland at elevation c1040m (b) dry shrubby forest at elevation c1020m (c) semi-mesic eucalypt forest at elevation c750m, all at Mount Victoria (Blue Mountains) in late December 2019 (Photos: I. Brown).

Fire study authors

Nicholas Gellie

BSc Forestry, MPhil

Nicholas Gellie is a landscape ecologist and fire scientist with 37 years' experience in fire management, fire research, fire ecology, fire risk planning and vegetation mapping. He has an in-depth knowledge of landscape and bushfire processes in south-east Australia, having reconstructed over 100 major bushfires, including 2003, 2007 and 2009 (Black Saturday) in Victoria, 2003 in Canberra and 2019-2020 in NSW, as well as in Portugal and in California. He has undertaken many consultancies and published many scientific papers. He has worked extensively on fire behaviour analyses and the effectiveness of planned burning programs. He was a pioneer of community fire planning in NSW, has been involved in suppression strategies and aerial ignition for numerous wildfires and has planned and implemented many prescribed burns. From 2009 to 2014 he worked with Victoria's Department of Sustainability of Environment and the Bushfire CRC on analysing the Black Saturday fires. He was a key consultant to the House of Representatives Select Committee's inquiry into the 2003 Australian bushfires, *A Nation Charred*.

Philip Zylstra

B App Sc (Environmental Science), PhD (Mathematics in bushfire modelling)

Phil Zylstra is an Adjunct Associate Professor at Curtin University (WA) and an Honorary Fellow at the University of Wollongong. Phil worked in fire management across the Snowy Mountains from 2002-2012 and again in 2017, where he was one of NSW's first fire behaviour analysts. He combined management with research starting in 2004, to develop FRaME (Fire Research and Modelling Environment), which is the only peer-reviewed fire behaviour model in Australia for forests other than West Australian jarrah, the only existing model showing species' effects on fire behaviour, and the only model for first-order fire effects on wildlife. Phil now combines these mechanistic approaches with empirical analyses of fire history to understand what drives flammability in Australian forests, and what new thinking is needed to mitigate the increasing fire risk posed by climate change.

Dave Darlington

BA Earth Sciences, DipEd, National Fire Medal

Dave Darlington is a retired NPWS Regional Manager from the Snowy Mountains. Dave helped to develop and refine the incident management system in the 1990s and was a key IMS instructor for NPWS. In the Snowy Mountains fires of 2002-03 he was the Section 44 incident controller continuously from mid-December 02 to March 03 (for which he was awarded Australia Day Citizen of the Year by Snowy River Shire Council). He has also managed numerous smaller incidents. He was the NPWS representative on several Bushfire Management Committees from the mid 90's until his retirement in 2013. Dave is an active member of the Jindabyne RFS Bushfire Brigade and is Brigade President. He assisted the Rural Fire Service to develop a Community Fire Protection Plan for some key rural residential estates in his Brigade area.