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FROM HECTARES TO TAILOR-MADE SOLUTIONS FOR RISK MITIGATION

Annual project report 2018-2019

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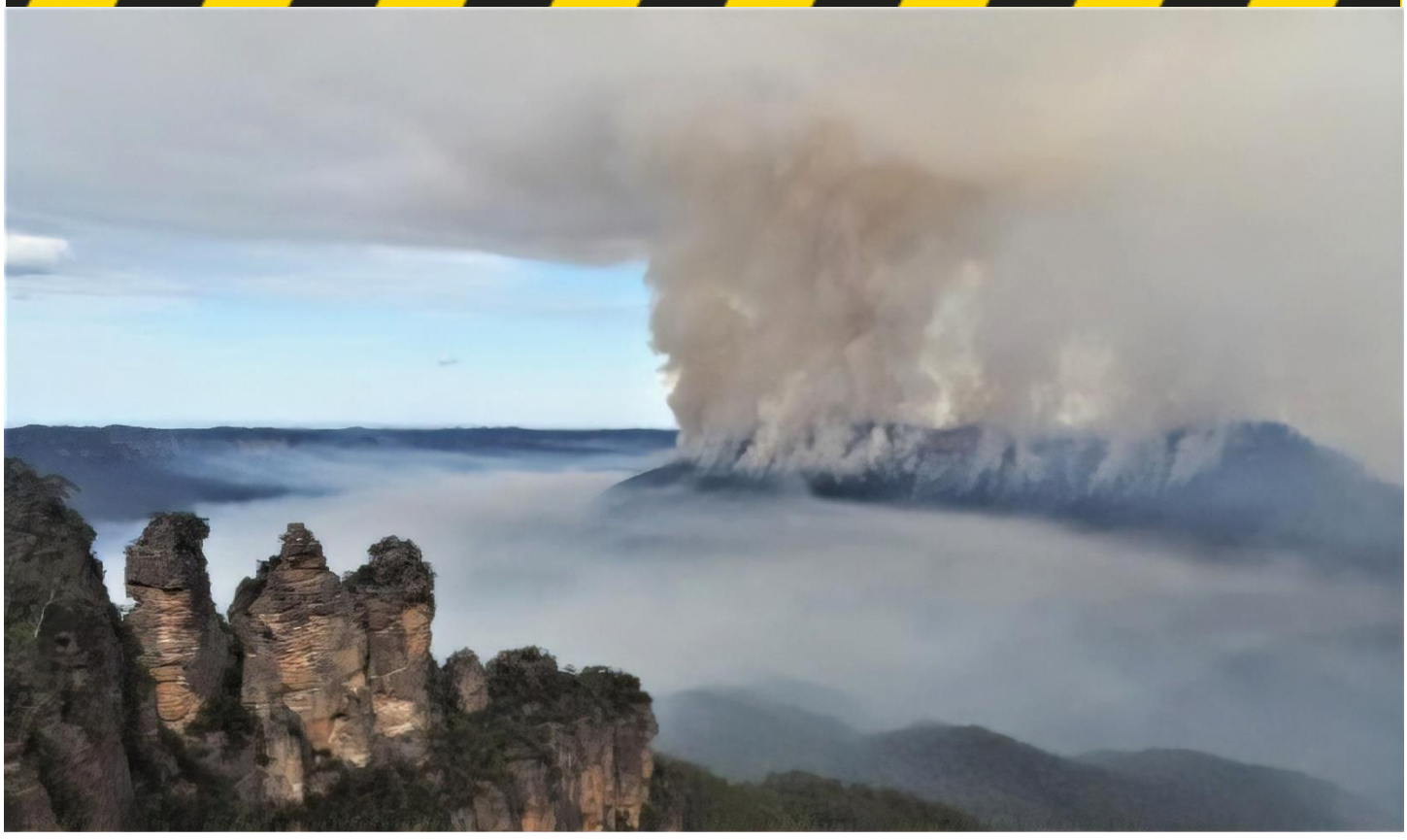

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Cover: Prescribed burn at Mt Solitary in May 2018. Credit: Beth Koperberg

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ACKNOWLEDGMENTS

We would like to acknowledge all our end user representatives and their agencies, in no particular order: the former NSW Office of Environment and Heritage, NSW National Parks and Wildlife Service, NSW Rural Fire Service, Victorian Department of Environment, Land, Water and Planning, South Australian Department of Environment and Water, ACT Parks and Conservation Service, Tasmania Fire Service. Thank you also to the broader community of end users who have engaged with the project in various ways. We are especially grateful to Naomi Stephens and Felipe Aires, our End User representatives from the NSW Office of Environment and Heritage, for providing an insight into the project's progress from a stakeholder perspective for this Annual Report. Finally, thanks to the host institutions of the project team: the University of Wollongong, Western Sydney University and the University of Melbourne.

EXECUTIVE SUMMARY

We are pleased to present the 2018-2019 Annual Report for the Bushfire and Natural Hazards CRC project, "*From hectares to tailor-made solutions for risk mitigation: systems to deliver effective prescribed burning across Australian ecosystems*". The project aims to provide critical support to agency decision makers across southern Australia by undertaking a systematic investigation of the drivers of prescribed burning effectiveness across the region.

This report describes the background, research approach and key milestones since the previous Annual Report in 2017-2018. The report focuses on the research outputs informing the development of the Prescribed Fire Atlas. The project has now delivered a rich, layered dataset capable of addressing nuanced questions about the quantitative risk reduction available through prescribed burning for multiple management values in varying landscapes.

The project is now entering its final phase as we complete climate change and cost-effectiveness analyses and launch the Prescribed Burning Atlas in 2019-2020. The Prescribed Burning Atlas will provide geographically based summary of risk for decision makers in an accessible, user friendly format. Our project is unique in placing the design and delivery of this utilisation output at the heart of the project. Active involvement of end users throughout 2020 and beyond will be crucial in ensuring uptake and translation into outcomes for end users and the communities they serve.

END-USER PROJECT IMPACT STATEMENT

Felipe Aires, *Fire and Incident Management Branch, NSW National Parks and Wildlife Service, NSW*

It's expected that this project will trigger a significant change in the way fire management agencies deliver their hazard reduction programs and proposed fuel management activities.

The methods and analysis used in this project give us the ability to quantify bushfire risk and cost to life and property as well as environmental impacts and infrastructure damage under a range of different scenarios. This project will support agencies to make more robust evidence-based decisions, tailoring their burning programs and optimizing burning strategies for wildfire risk mitigation.

The Atlas will strengthen the narrative that there isn't is a single prescribed burning strategy to achieve optimal risk reduction across all values and landscapes. The reduction in risk as result from prescribed fires is dependent on management actions that should take in consideration local variation in landscapes and vegetation communities as shown by the patterns that emerged from this research.

There is scope for the Prescribed Fire Atlas to support end users beyond its core ability to identify optimal prescribed burning strategies tailored to local conditions and management objectives. Possible uses include supporting education of and communication with stakeholders both within agencies (e.g. operations staff, senior executive, media staff) and outside them (e.g. land managers, electricty companies, the insurance industry, Aboriginal Land Councils and Corporations, Treasury, school students, general community).

INTRODUCTION

The Bushfire and Natural Hazards CRC project, "*From hectares to tailor-made solutions for risk mitigation: systems to deliver effective prescribed burning across Australian ecosystems*", aims to systematically investigate drivers of prescribed burning effectiveness across southern Australia in order to provide critical support to agency decision makers across the region.

In order to deliver on this overarching goal, the project will need to:

- compare the performance of different prescribed burning strategies in reducing risk to multiple values;
- derive fire regime characteristics and risk solutions for individual bioregions;
- provide results for current conditions and climate change scenarios, and
- organise results in an accessible interface, tailored to agency needs and amenable to updates.

A number of complementary project streams have been designed to meet these project objectives:

1. Fire spread simulations in case study landscapes, designed to sample variation in climate, population and land-use across southern Australia (Years 1-2);
2. Empirical analyses of prescribed burning effects on area burned, severity and other direct impacts of fire (Years 1-2);
3. Risk estimation for case study landscapes (Years 2-3);
4. Multi-criteria decision analysis to investigate trade-offs between key values and cost-benefit (Years 2-3);
5. Modelling of climate change effects on ignitions, fuel, fire regimes and risk (Years 2-4);
6. Data, models, software, testing and launch of the Prescribed Fire Atlas (Years 3-5).

In the 2017-2018 financial year, the project focus was on large-scale risk estimation based on extensive simulation outputs from earlier years. The 2018-2019 year has seen significant progress in designing how the multi-layered dataset arising from these analyses will be incorporated into the Prescribed Fire Atlas and forms part of this report.

Other areas of achievement for the 2017-18 financial year include completion of modelling of climate change effects on ignitions, fuels and fire regimes, analysis of trade-offs between key values. Significant progress was made on the modelling of climate change effects on risks to key values and analyses of the cost-effectiveness of differing prescribed burning strategies.

The project is heading into its final phase, as climate change and cost-effectiveness analyses are completed and the Prescribed Burning Atlas is launched, initially as a prototype and then formally following end user feedback. The Atlas will be the vehicle which will enable key research findings to be utilised by the end user community.

BACKGROUND

Prescribed burning in Australia, currently stands at a cross roads. The 2009 Victorian Bushfires Royal Commission recommended an annual treatment target of 5% of public land in Victoria. Subsequently, concerns have been formally raised (e.g. Bushfires Royal Commission Implementation Monitor 2013 Annual Report) that such an area-based target may not deliver the most effective levels of risk reduction for people and property in Victoria. Concurrently, some other States have adopted such a prescribed burning target, but formal attempts to evaluate its effects on risk to people, property and environmental values across different jurisdictions are lacking. Such extrapolation of the 2009 BFRC recommendation pre-supposes that there is a "one-size fits all" solution to the problem. While many agencies are moving toward planning systems supposedly based on risk assessment, knowledge of the best way to use prescribed fire to reduce risk to key values is generally lacking.

General principles need to be developed about how to apply a risk-based approach across widely varying environments, human communities and combinations of key management values. In essence, the use of prescribed fire for risk mitigation involves understanding how risk to any particular management value will respond to variations in the spatial location and rates of treatment. Managers and policy-makers need to know how these fundamental elements of prescribed burning can be tailor-made to suit the environmental and human context of their local jurisdictions. A variety of fundamental problems need to be overcome in order to deliver effective, tailor-made prescribed burning solutions across different Australian environments.

The Bushfire and Natural Hazards CRC project "*From hectares to tailor-made solutions: systems to deliver effective prescribed burning across Australian ecosystems*" is designed to address these challenges.

RESEARCH APPROACH

The development of data, models and software for the Prescribed Fire Atlas formed a major part of our research effort in 2017-18. Other areas included modelling climate change effects, multi-criteria decision analysis and cost-effectiveness analysis.

DEVELOPMENT OF THE PRESCRIBED FIRE ATLAS

The project output is layered, allowing for multiple levels of interrogation and interpretation (Figure 1). High level summaries allow comparison of different prescribed burning treatment rates and locations for different values (Figures 2 and 3). Care must be taken in interpreting these values, as different landscapes have different levels of treatable vegetation, different levels of interface and landscape, and different layouts and exposure to wildfire risk for various management values. Examples of raw data and underlying data can be found in previous Annual Reports for this project. An example of additional analysis is investigation of some of the drivers of these results across the entire set of case study landscapes (Figure 4). A major workshop to get end user feedback on the development of the Prescribed Fire Atlas was held in March 2019 (See Utilisation and Impacts below). Some Atlas concepts are shown in Figures 5 and 6.

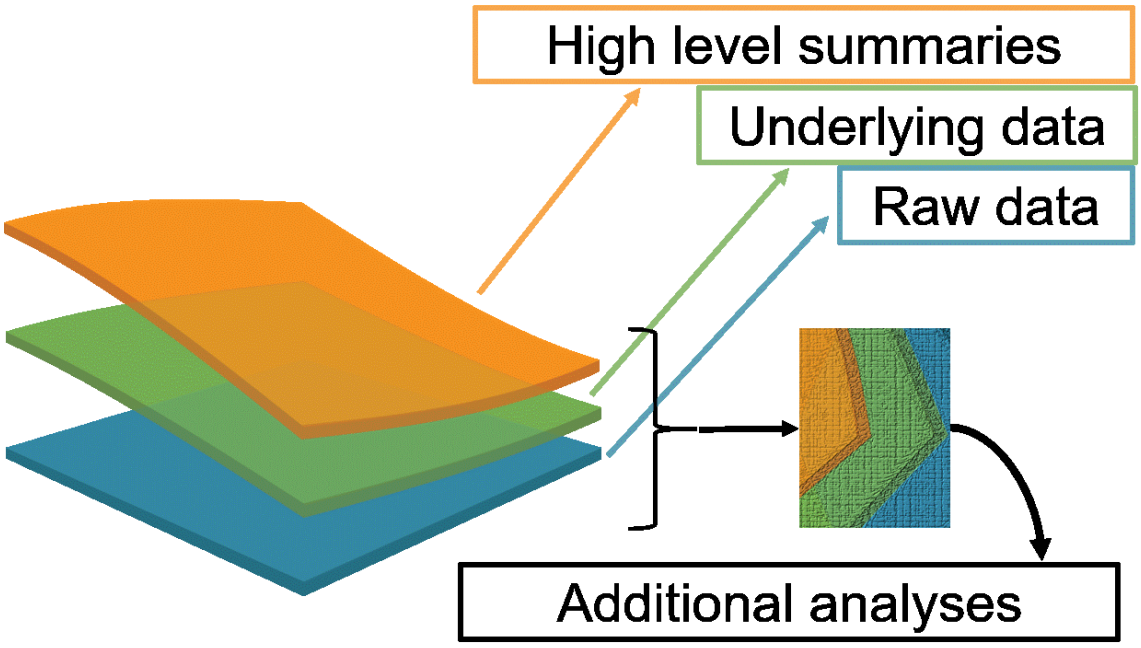

FIGURE 1 LAYERED NATURE OF PROJECT OUTPUT

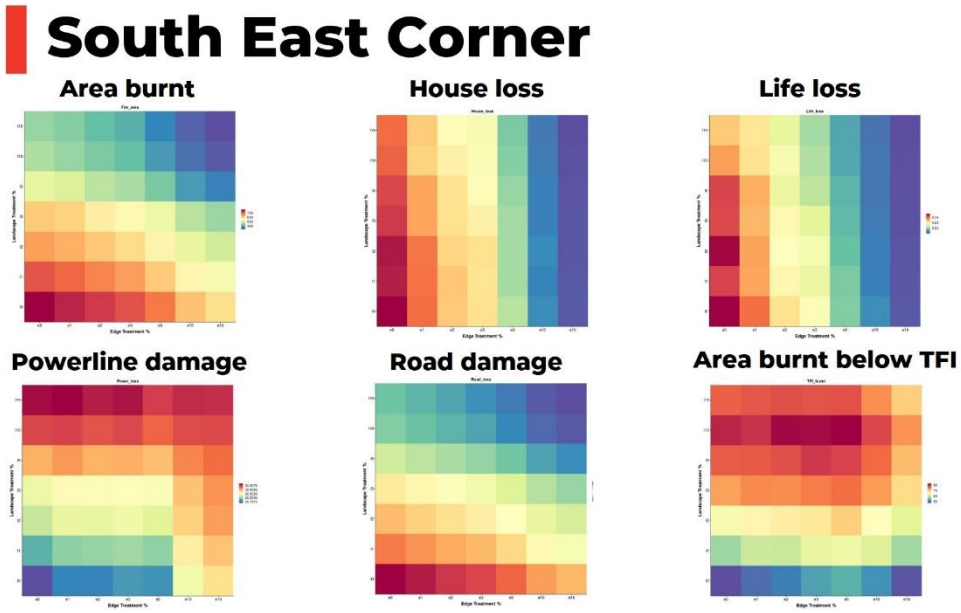

FIGURE 2 HIGH LEVEL SUMMARIES – SOUTH EAST CORNER (NSW) STUDY LANDSCAPE. EACH PLOT SHOWS THE TRAJECTORY OF RISK REDUCTION/INCREASE FOR A GIVEN MANAGEMENT VALUE IN RESPONSE TO CHANGING RATES (0 TO 15%) AND LOCATIONS (EDGE ON X AXIS; LANDSCAPE ON Y AXIS) OF PRESCRIBED BURNING TREATMENT.

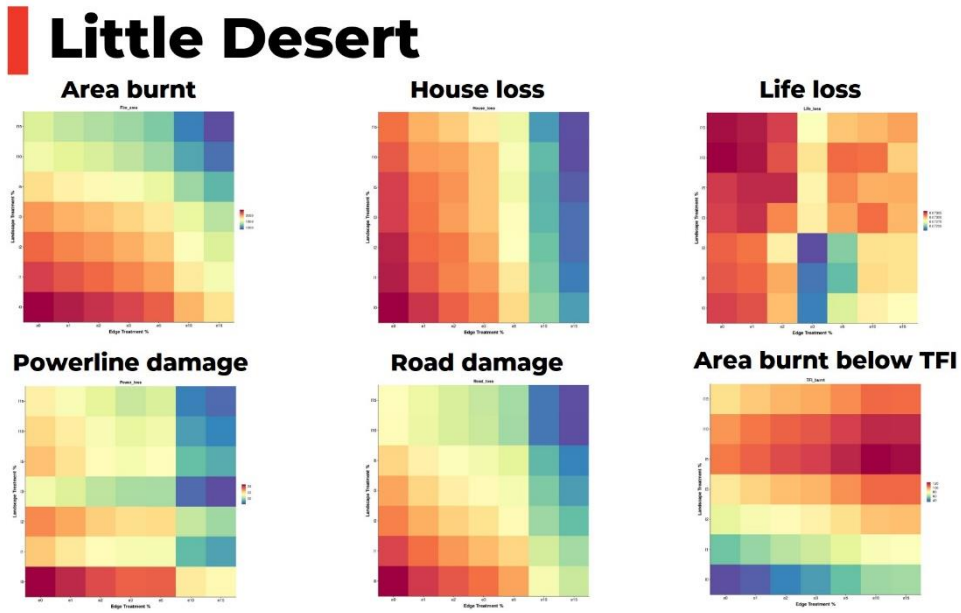

FIGURE 3 HIGH LEVEL SUMMARIES – LITTLE DESERT (VIC) STUDY LANDSCAPE. EACH PLOT SHOWS THE TRAJECTORY OF RISK REDUCTION/INCREASE FOR A GIVEN MANAGEMENT VALUE IN RESPONSE TO CHANGING RATES (0 TO 15%) AND LOCATIONS (EDGE ON X AXIS; LANDSCAPE ON Y AXIS) OF PRESCRIBED BURNING TREATMENT.

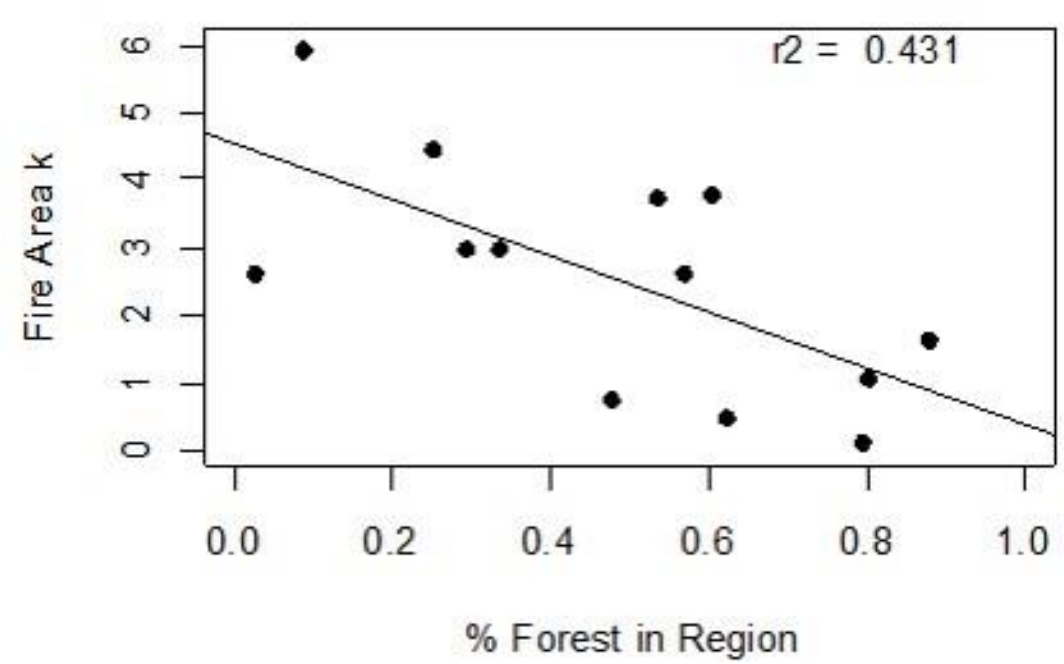

FIGURE 4 RELATIONSHIP BETWEEN FOREST COVER AND K, A PARAMETER DESCRIBING THE STRENGTH OF THE RELATIONSHIP BETWEEN AREA BURNT AND PRESCRIBED BURNING TREATMENT. AT LOW K VALUES FIRE SIZE IS REDUCED MORE STRONGLY IN RESPONSE TO TREATMENT, WITH THIS OCCURRING MORE OFTEN IN FORESTED AREAS.

FIGURE 5 PRESCRIBED FIRE ATLAS CONCEPT. FRONT PAGE OF INTERACTIVE WEBSITE.

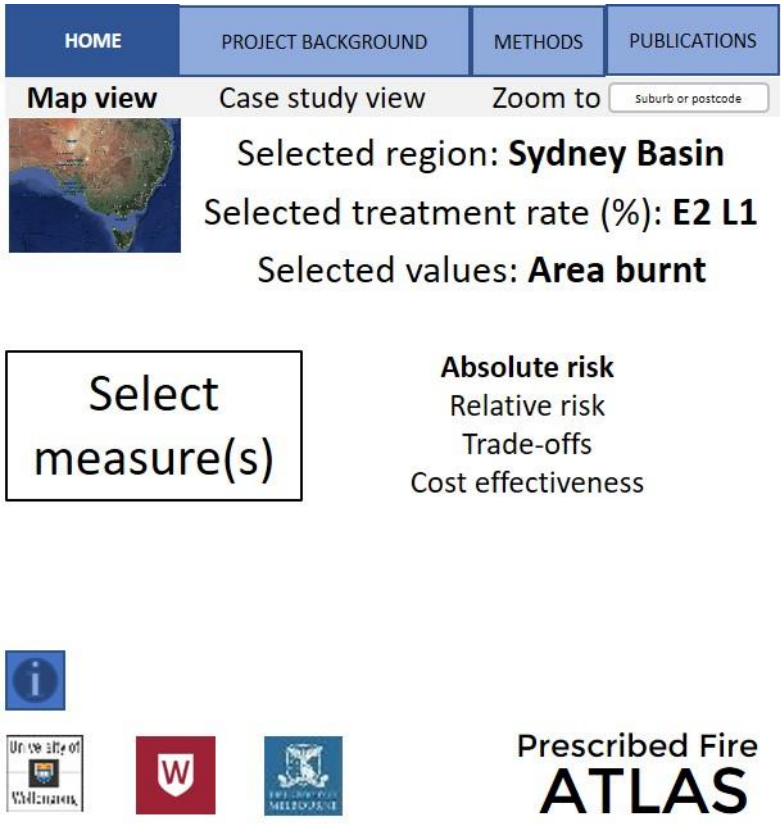

FIGURE 6 PRESCRIBED FIRE ATLAS CONCEPT. PAGE SHOWING SEQUENCE OF USER DECISIONS TO EXPLORE DATA.

ANALYSIS OF CLIMATE CHANGE EFFECTS ON IGNITION AND FUEL MOISTURE

Ignitions and fuel moisture are critical factors in controlling wildfire incidence, along with weather conditions and the presence of sufficient and continuous fuel. Previous studies have repeatedly shown that wildfire ignition probability from most sources increases under more dangerous fire weather conditions (e.g. Penman et al. 2013). Climate change therefore provides a direct link to wildfire ignition, through the effect of any alterations in the frequency, duration and intensity of fire weather conditions. Studies have also shown that dead fine fuel moisture can be reliably estimated from surface weather conditions (Resco de Dios et al. 2015; Nolan et al. 2016), providing another link between climate change projections and a key driver of wildfire risk.

MULTI-CRITERIA DECISION ANALYSIS

Differing prescribed burning strategies are likely to result in different levels of risk reduction to different management values, necessitating an approach for weighing up trade-offs. Multi-criteria decision analysis (MCDA) is a way of

investigating such trade-offs, and can incorporate tools such as Pareto Surfaces, Robust Decision Making and Mutually Acceptable Outcomes (Driscoll et al. 2016). For this project, the MCDA was undertaken using Bayesian Decision Networks. Methods were developed, refined and applied to the 15 case study landscapes.

COST-EFFECTIVENESS ANALYSIS

A critical extension of existing work examining risks to multiple values is the incorporation of financial information. By assigning costs to individual values, as well as the activity of prescribed burning itself, and applying existing project methodologies surrounding risk estimation and multi-criteria decision analysis, the project will deliver estimates of the cost-effectiveness of different prescribed burning strategies across the study landscapes. Cost estimates will be drawn from published literature.

KEY MILESTONES

In the 2018-2019 year we worked towards many milestones, but the key project areas that were completed this year were modelling of climate change effects and multi-criteria decision analysis to investigate trade-offs between values.

ANALYSIS OF CLIMATE CHANGE EFFECTS ON IGNITION AND FUEL MOISTURE

Manuscript(s) based on this study are yet to be accepted for publication in a peer reviewed journal. Therefore, we are only able to provide a summary of key aspects in this Annual Report.

For both studies, climate change effects information was drawn from an objectively designed regional climate model ensemble (Evans et al. 2014).

For ignitions, climate model output was used to calculate fire weather conditions, which were assigned to changes in the frequency of major fire weather categories across the study area. These changes were then applied to existing ignition models within the overall project methodology to evaluate the influence of climate change on wildfire ignition probability.

For fuel moisture, climate model output was also used to calculate changes in dead fine fuel moisture, including the frequency of exceeding critical thresholds associated with step changes in fire activity.

Both studies found the potential for significant increases in wildfire risk from ignitions and fuel moisture under climate change in southeast Australia. However, there were complex spatial and seasonal patterns, with some areas projected to experience only moderate or little change.

MULTI-CRITERIA DECISION ANALYSIS

Manuscript(s) based on this study are yet to be accepted for publication in a peer reviewed journal. Therefore, we are only able to provide a summary of key aspects in this Annual Report.

This study followed the approach of Driscoll et al. (2016). The study area comprised 11 case study landscapes across southern Australia. Trade-offs were examined for area burnt, lives lost, property loss, length of road and powerline damaged and area burnt below minimum tolerable fire interval. The primary tool for MCDA is Bayesian Decision Networks, applying results of fire behaviour simulations and risk estimation as previously delivered through this project.

There was a complex pattern of trade-offs between key impacts (area burnt) and management values across the study area. Case study results broadly cluster into landscapes with a significant proportion of forest and/or interface, and those in more remote and sparsely populated areas.

These results do not support the hypothesis that there is a single prescribed burning strategy that achieves the optimum risk reduction across all values and landscapes. Nevertheless, the presence of patterns across key values and landscape types suggests the possibility of applying targeted strategies to optimise risk reduction at a regional scale.

UTILISATION AND IMPACT

In this project, utilisation is not a separate activity to the research; rather, the project is structured in a way that multiple streams in the early part of the project converge in a single stream in the final phase of the project: the Prescribed Fire Atlas. Utilisation outputs therefore will track the development of the Atlas. Significant work has been undertaken on the Atlas, with a prototype due in September 2019, followed by launch and release in early 2020.

END USER WORKSHOP FOR PRESCRIBED FIRE ATLAS DEVELOPMENT

A major end user workshop to inform development of the Prescribed Fire Atlas was held in March 2019. Portions of a summary for end users are reproduced below.

Workshop attendees

Donald McDonald (NSW National Parks and Wildlife Service), Felipe Aires (NSW National Parks and Wildlife Service), David McKenna (SA Department of Environment, Water and Natural Resources), Louise Mendel (TAS Tasmanian Fire Service), Adam Leavesley (ACT Parks and Conservation Service), Claire Beale (ACT Parks and Conservation Service), Melissa O'Halloran (NSW Rural Fire Service), Simon Heemstra (NSW Rural Fire Service), John Bates (BNHCRC), Ross Bradstock (UOW), Owen Price (UOW), Hamish Clarke (UOW & WSU), Trent Penman (UniMelb), Brett Cirulis (UniMelb), Matthias Boer (WSU), Josh Whittaker (UOW).

Project overview

The research team started the day with an overview of the project. This included some of the background, history and motivations from Ross, the key results and the layered nature of the project outputs from Hamish and Owen, the main research methods from Brett and Trent and finally a sketch of what the Atlas might look like to get participants thinking.

Breakout groups

We then handed over to Josh Whittaker who facilitated a series of breakout discussions on key questions about the Atlas. Here are the highlights:

Which outputs and analyses are most important?

- Users were interested in all of the available outputs and analyses, with specifics depending in large part on the user and their intended audience. Life and property were universal priorities, but there was also strong support for measures of environmental impacts and infrastructure

damage. There was keen interest in both relative and absolute measures of risk and cost.

What should the Atlas look like?

- There was active discussion of what the 'front page' of the Atlas might look like, with some voting for a map of Australia, and others suggesting buttons allowing users to drill into data, reports, methods and things like that. There was strong support for a variety of map-based products, including key biophysical information about the study region and case study landscapes.
- There was discussion about the possibility of 'canned' reports available 'off the shelf', which users in a hurry could grab for particular regions or values of interest. Users also discussed the various ways in which they might interrogate the Atlas, starting the strategies and investigating resultant risk and cost, or starting with desired risk levels or available budgets and examining available options.
- There was agreement on the need to provide clear advice and guidance on the project, its definitions of risk, and caveats etc.
- There was considerable discussion of how the Atlas might allow the exploration of results and implications for areas outside case study regions. A number of both qualitative and quantitative approaches were canvassed, with the research team set to actively explore these soon.

How will the Atlas be used and by whom?

- A long list of potential end users was discussed, ranging from state and regional fire planners to high level decision makers, from NGOs and conservation organisations to communications specialists, from land councils and land corporations to electricity and insurance companies, private land managers and the general public.
- There was a strong desire to make the Atlas public, while potentially allowing for different users or levels of access.
- There was recognition of the strong educational potential of the Atlas, for internal users ranging from operations to planning and policy, as well as external users and the general public.
- The need to consider how the Atlas fits in with and complements other agency tools was stressed, as was the thorny issue of how it will be hosted and maintained, with some promising options on the horizon.

What else might the Atlas include?

- There was a discussion of a range of additional data, analyses and complementary material that could help add value to the Atlas. This

included interest in trade-off analyses, the inclusion of topographic factors in interpolation and case study comparisons, and various additional values that are not currently in the project such as water quality, smoke, carbon emissions, intangible values and area burnt within tolerable fire intervals above threshold intensity.

- There was a discussion of how data protocols, methods, journal articles and validation may contribute to building the confidence and trust of users.

NEXT STEPS

Cost effectiveness and climate change (risk to multiple values) analyses are due to be completed by December 2019. The major focus of the project team for this year is completion of the Prescribed Fire Atlas including data, models and software. A prototype is due for completion in September 2019, with the final version ready in December 2020. A national workshop to launch and foster utilisation of the Atlas is due in May 2020, with the overall project winding up in June 2020. Continued use and maintenance of the Atlas beyond June 2020 will be an active area of focus for the project team and end user group this year, with the aim of ensuring utilisation by the end user community well beyond the life of the project.

PUBLICATIONS LIST

PEER REVIEWED JOURNAL ARTICLES

1 Cirulis B, Clarke H, Boer M, Penman T, Price O, Bradstock R (2019) Quantification of inter-regional differences in risk mitigation from prescribed burning across multiple management values. International Journal of Wildland Fire. https://doi.org/10.1071/WF18135

2 Clarke H, Gibson R, Cirulis B, Bradstock RA, Penman TD (2019) Developing and testing models of the drivers of anthropogenic and lightning-caused wildfire ignitions in south-eastern Australia. Journal of Environmental Management, 235, 34-41. https://doi.org/10.1016/j.jenvman.2019.01.055

3 Clarke H, Tran B, Boer MM, Price O, Kenny B, Bradstock R (2019) Climate change effects on the frequency, seasonality and interannual variability of suitable prescribed burning weather conditions in south-eastern Australia. Agricultural and Forest Meteorology, 271, 148-157. https://doi.org/10.1016/j.agrformet.2019.03.005

CONFERENCE PAPERS

1 Boer M, Resco De Dios V, Nolan R, Di Guiseppe F, Clarke H, Bradstock R (2018) Forecasting forest flammability. Ecological Society of Australia 2018 Annual Conference, Brisbane.

2 Boer M, Clarke H, Nolan R, Resco de Dios V, Bradstock R (2019) Future global climatology of critical forest flammability events. European Geosciences Union 2019 Annual Conference, Vienna

3 Bradstock R, Boer MM, Clarke H, Cirulis B, Price O, Penman T (2019) How much does it cost to save a life or a house? The comparative cost-effectiveness of alternative prescribed burning strategies. 6th International Fire Behaviour and Fuels Conference, Sydney.

4 Clarke H, Tran B, Boer MM, Price O, Kenny B and Bradstock R (2019) Goldilocks and global warming: climate change effects on the weather envelope for conducting prescribed burning. AMOS-ICTMO 2019 Annual Conference, Darwin.

5 Clarke H, Tran B, Boer MM, Price O, Kenny B and Bradstock R (2019) Goldilocks and global warming: how will climate change affect prescribed burning weather conditions in south-eastern Australia? 6th International Fire Behaviour and Fuels Conference, Sydney.

6 Clarke H, Price O, Cirulis B, Penman T, Boer MM, Bradstock R (2019) From code to crown: comparing the drivers of simulated and observed wildfire severity. 6th International Fire Behaviour and Fuels Conference, Sydney. * Judge's award for best conference poster *

TEAM MEMBERS

RESEARCH TEAM

Senior Professor Ross Bradstock is a leading, widely cited researcher in fire ecology with over 110 journal papers and book chapters and 6 books on fire ecology, biodiversity and management, plus more than thirty major scientific reports and policy documents. Recent invited research collaborations include Australian Government (Department of climate Change and Energy Efficiency) and NCCARF reviews on impact of climate change on fire regimes, fuels, biodiversity and fire management (2008-2012), ARC Network for Vegetation Function Working Groups (2007-2010), USGS Natural Hazards Program (2009-2013), ACEAS Pyrogeography Working Group on fire and climate change (2011-12). Recent invited international conference presentations include, INTECOL (2009), AGU (2010), MEDECOS 2011, EGU (2012). He leads a multidisciplinary research team that is dedicated to the development of a quantitative understanding of risks posed by landscape fires to multiple values and the way such risks may be altered through cost-effective management and global change. Major funding sources for his team and other collaborations include ARC, NSW Environmental Trusts, NSW Government, CSIRO, Bushfire CRC, USGS and the European Union.

Associate Professor Matthias Boer (Hawkesbury Institute for the Environment, University of Western Sydney) is a physical geographer/landscape ecologist with over 15 years of relevant experience in environmental research in Europe and Australia using a broad suite of field methods, remote sensing techniques and spatial modelling approaches. Dr. Boer recently moved from The University of Western Australia to his current position. His cross-disciplinary research on dryland ecohydrology and landscape ecology of fire-prone environments is strongly management-oriented and has been supported by funding from European Framework Programmes, Tropical Savannas CRC, Bushfire CRC, Australian Research Council and the mining industry (Worsley Alumina). Dr. Boer is an invited member of the ARC-NZ Research Network on Vegetation Function (2008), the Australian Centre for Ecological Analysis and Synthesis (2011), and the National Climate Change Research Facility (NCCARF) –Terrestrial Biodiversity Network (2012). Dr. Boer has published in international high-impact journals on relevant topics, including water balance modelling, remote sensing of vegetation status and fire severity, fire-climate relations, and prescribed burning.

Associate Professor Trent Penman (Department of Forest and Ecosystem Science, University of Melbourne) is a fire scientist with over 10 years of experience in environmental research in Australia. Between 2001 and 2010, Dr Penman worked with Forests NSW and NSW Department of Primary Industries examining the impact and efficiency of varying fire management approaches using a range of field methods, remote sensing techniques and spatial modelling approaches. Much of this work was supported by the Bushfire CRC. In this role, Dr Penman was a member of the Forest Industry Research Working Group 7 – Fire, and the Bushfire Ecological Reference Group (NSW RFS). From February 2011 until May 2014, he was employed as a bushfire risk modeller at the CERMB, University of Wollongong with funding from the NSW Rural Fire Service. This research is strongly

management focused in developing methods to quantify how fire management can reduce risk to property and life. Dr Penman has a strong publication record with over 50 papers in the peer reviewed literature including several papers on remote sensing methods, spatial modelling, wildfire and prescribed fire.

Dr Owen Price is a Senior Research Fellow at the Centre for Environmental Risk Management of Bushfire at the University of Wollongong. After undergraduate and postgraduate study in the UK and three years working at Cambridge University, he emigrated to Australia and accepted a position as a research scientist for the Northern Territory Conservation Commission in 1992. He worked on a range of landscape conservation project for 15 years, highlights of which included writing the NT's first regional conservation plan, working on country with a variety of landholders and leading projects on habitat fragmentation and rainforest conservation. During this time he developed an interest in fire ecology. In 2007 he moved to the University of Wollongong to work as a Bushfire Risk Modeller. Here, he has researched a wide range of empirical topics related to evaluating the effectiveness of bushfire risk management strategies. This includes pioneering work on prescribed burning evaluation, drivers of fire severity and house loss. He has published over 85 publications, of which 54 are papers in international journals (21 as first author). He is an expert in landscape ecology, Geographic Information Systems, spatial and statistical analysis, data management and computer programming.

Dr Hamish Clarke is a Research Fellow in a joint position shared between the Centre for Environmental Risk Management of Bushfire at the University of Wollongong and the Hawkesbury Institute for the Environment at Western Sydney University. Hamish previously worked in the Climate and Atmospheric Science Branch of the NSW Office of Environment and Heritage, in various roles including coordinator of the state's regional climate change impact assessment science program. Hamish did his PhD part-time at the Climate Change Research Centre at the University of NSW. He studies the impact of climate change on bush fire risk and the effectiveness of prescribed burning at wildfire risk mitigation. He is committed to public interest science and collaborative, multidisciplinary approaches that engage end users from project conception to completion and beyond. Hamish is a Research Fellow in the Earth System Governance Project, a Member of the IUCN Commission on Ecosystem Management (CEM) Oceania Working Group, an Ex-Oficio Committee Member of the Future Earth Australia Steering Committee and Deputy Chair of the Australian Academy of Science Early- and Mid-Career Researcher Forum. The EMCR Forum aims to secure the future of Australian science by representing and advocating for researchers up to 15 years post-PhD.

Mr Brett Cirulis is a Research Assistant in the Department of Forest and Ecosystem Science, University of Melbourne. Brett works supporting the research of the Department's fire group, including data analysis and undertaking fieldwork, report writing and fire simulation. Brett completed the Masters of Forest and Ecosystem Science in 2013. The focus of Brett's work up until 2016 was related to the research and development of the PHOENIX RapidFire bushfire characterisation model. In particular, the improvement of the fuel inputs through the development of a state-wide fuel classification model. His work is now focused on further model development as well as performing simulation based

risk analysis for the Bushfire Natural Hazard CRC and DEWLP/INFFER prescribed burning projects.

END-USERS

Naomi Stephens, NSW National Parks and Wildlife Service, (former) Office of Environment and Heritage

Felipe Aires, NSW National Parks and Wildlife Service, (former) Office of Environment and Heritage

Elizabeth Ashman, Department of Environment, Land, Water and Planning (Victoria)

Louise Mendel, Tasmania Fire Service

Mike Wouters, Department of Environment and Water (South Australia)

Mellissa O'Halloran, NSW Rural Fire Service

Adam Leavesley, ACT Parks and Conservation Service

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