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FROM HECTARES TO TAILOR-MADE SOLUTIONS FOR RISK MITIGATION

Systems to deliver effective prescribed burning across Australian ecosystems: annual project report 2017-18

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

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EXECUTIVE SUMMARY

We are pleased to present the 2017-2018 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 2016-2017 Annual Report. The report focuses on the analysis of fire spread simulations for two case study landscapes: the ACT and Tasmania. The analysis demonstrates that it is possible to investigate prescribed burning effectiveness at risk mitigation across a range of treatment levels, management values and landscapes, by placing them on a common baseline of risk.

We have done much of the hard work in running simulations, analysing results and integrating lessons learned from empirical analyses. We are now entering an exciting phase of the project as we complete climate change and cost-effectiveness analyses and then focus on development of the Prescribed Burning Atlas in 2018-2019 and beyond. 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 this phase of the project will be crucial in ensuring uptake and translation into outcomes for end users and the communities they serve.

END-USER STATEMENT

Naomi Stephens and Felipe Aires, *National Parks and Wildlife Service, Office of Environment and Heritage, NSW*

Bush Fire Management agencies need spatially explicit risk products, so that we can develop an environmentally sustainable fuel treatment program and plan long term bush fire suppression strategies for our areas of responsibility. By systematically evaluating the potential for wildfire risk mitigation with prescribed burning across broadly different fire prone landscapes, this project is increasing agencies' knowhow to make evidence based decisions.

One of the main challenges of using prescribed burning as a risk reduction tool is to decide where and how these fires will be introduced so the best cost-benefit for it can be achieved. This project is demonstrating that there are considerable variations in the rate of risk reduction achieved by prescribed burning to a variety of values in different areas. These results will allow managers to gauge their trade-offs and choose which tactics can be used for the best management options.

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 2016-2017 financial year, this project focus was on data acquisition, empirical analyses and the completion of a large number of fire spread simulations. The 2017-2018 year has seen significant progress on a number of fronts: not only have the simulations been completed, but we have undertaken a large-scale risk estimation based on simulation outputs. The results of this analysis form the bulk of this report.

Other areas of achievement for the 2017-18 financial year include empirical analyses on fire severity and ignitions, work on multi-criteria decision analysis of trade-offs between management values, as well as modelling of how climate change effects on ignitions, fuels and fire regimes.

The project is well placed to transition to the next phase, concentrating on completing work on climate change effects and delivering the cost-effectiveness stream. 2018-2019 also sees the formal commencement of work on the Prescribed Burning Atlas. While work has already begun on the Atlas, the onset of project milestones related to this work package signifies a ramp up in effort. The Atlas will be the vehicle which will enable key research findings to be utilised by the end user community. Therefore, an intensive period of stakeholder engagement will take place in 2018-2019, leading to the Atlas release and project completion in 2020.

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

A large scale set of fire behaviour simulations formed the major part of our research effort in 2017-18. Other areas included empirical analyses, modelling climate change effects and multi-criteria decision analysis.

FIRE SPREAD SIMULATIONS

A large number of fire spread simulations were carried out using the PHOENIX RapidFire model. Case study landscapes were selected to sample variation in human and natural systems across southern Australia. Fires were modelled under a range of weather conditions, at 1,000 high probability ignition points per landscape. A range of fuel treatments were investigated: edge vs landscape treatment, and overall treatment levels of 0, 1, 2, 3, 5 10 and 15% p.a. Close to 1,000,000 simulations were carried out in each case study landscape. A full description of the simulations can be found in the 2016-2017 Annual Report.

RISK ESTIMATION

The fire spread simulations were used as input for risk estimation. Wildfire impacts on range of direct and indirect values were calculated, either directly from model output or by using asset loss functions, which relate model outputs to management values. These include area burnt, house loss, life loss, powerline loss, road loss and area burnt within minimum tolerable fire interval (TFI). A full description of the values and associated loss functions can be found in the 2016-2017 Annual Report.

In order to translate impact estimates into risk estimates, a Bayesian Decision Network model was used which incorporated the relative frequency of weather conditions at each case study landscape, as well as other influences in the network between model outputs and management values (Marcot et al. 2006). This allowed an estimate of the risk reduction afforded by prescribed burning, as well as the relative risk mitigation across different management values, allowing a comparison to be made between them.

EMPIRICAL ANALYSES

Research was carried out on drivers of fire severity in Victoria, South Australia and Tasmania. The research followed the general method of Storey et al. (2016), examining the relative influence of prescribed burning on crown fire, using a Generalised Linear Modelling approach.

Research was also carried out on the drivers of ignition in Victoria, including whether models developed in Victoria can be generalised to South Australia and Tasmania. A major part of the methodology was the use of MaxEnt species distribution modelling, which deals with presence only data such as ignitions (Phillips et al. 2006).

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 is being undertaken using Bayesian Decision Networks. Methods have been developed and refined and will be applied to the 15 case study landscapes.

KEY MILESTONES

In the 2017-2018 year, the project switched to the milestones of the extended project, which will run until 2019-2020. While we worked towards many milestones in 2017-2018, the key project areas that were completed this year were empirical analysis and risk estimation.

EMPIRICAL ANALYSES

Our analysis of the drivers of severity in southeast Australia found that fire weather conditions were regularly the most important variable in predicting crown fire, while topography and time since fire were also important. But while increasing fire danger almost always led to more crown fire, the effects of topography and time since fire were more complicated and varied. Our research suggests that a major challenge is to establish a robust baseline of fire severity, against which to understand future patterns in fire severity.

Our study on ignitions found that fire weather conditions play a major role in driving all kinds of ignition types in Victoria. Population density and distance to roads were strong markers of the likelihood of ignitions caused by people, such as arson and accidental ignitions. The models developed in Victoria mostly performed very well in South Australia.

RISK ESTIMATION

The risk estimation was based on the large scale fire behaviour simulations we undertook in case study regions across Southern Australia. Here we present results for two key regions: the ACT (Figure 1) and Tasmania (Figure 2). We found that regardless of weather conditions, prescribed burning tended to decrease impacts on key values such as area burnt, house and life loss, but that the amount of area burnt within minimum TFI increased. Conversely, stronger fire weather conditions were more important in altering impacts on these values than strong increases in treatment rate (e.g. area burnt in Tasmania, Figure 3). Risk did not respond uniformly to treatment, with a greater relative impact in the ACT for some values (area burnt, powerline loss and road loss) and a greater relative impact in Tasmania for others (house loss, life loss). Prescribed burning seemed to have similar effects on the relative increase in area burnt within TFI in each region. In general prescribed burning was not able to achieve a halving of risk for the values studied here in these two regions. This analysis gives us confidence that we are on track to deliver a systematic assessment of the potential to use prescribed burning to achieve wildfire risk mitigation across the varied landscapes of southern Australia.

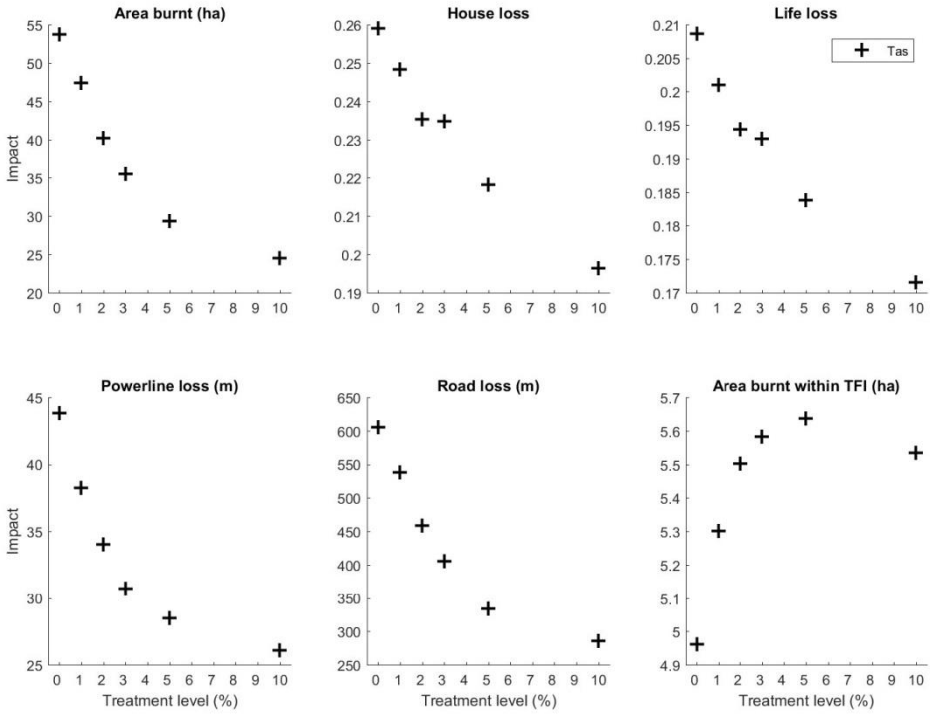

Figure 1 Effect of different rates of prescribed burning on simulated wildfire risk across key management values in the ACT case study landscape.

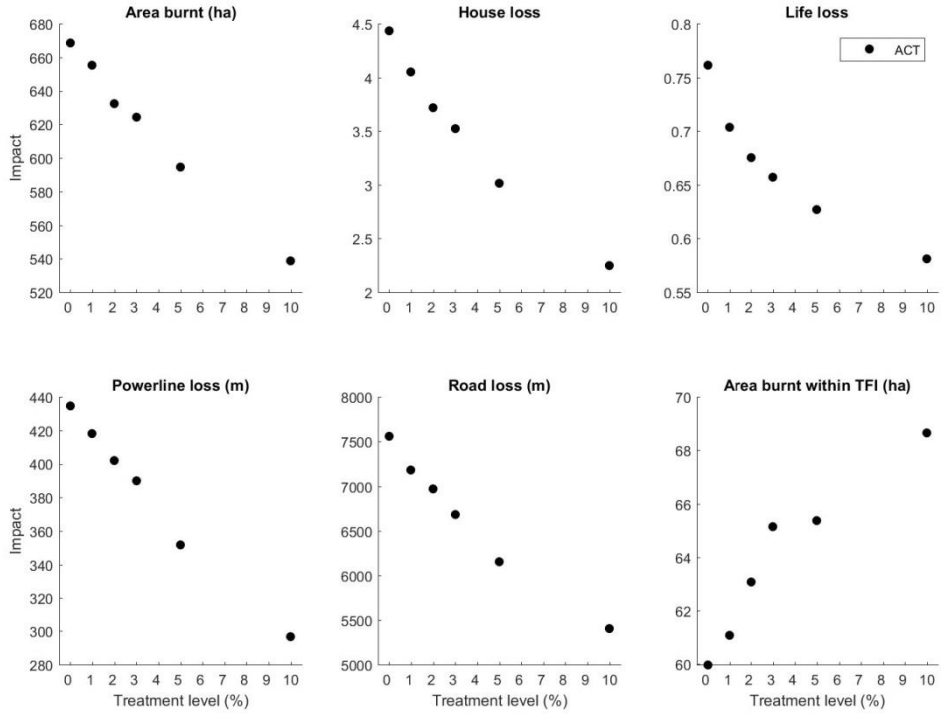

Figure 2 Effect of different rates of prescribed burning on simulated wildfire risk across key management values in Tasmania case study landscape.

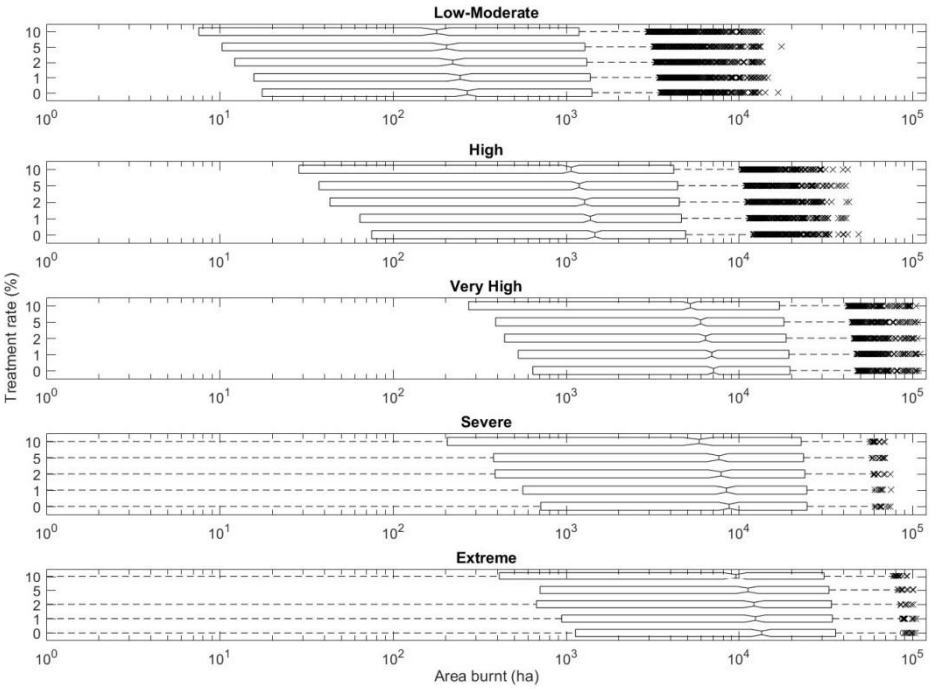

Figure 3 Effect of different rates of prescribed burning and different FFDI categories on simulated wildfire impacts on burnt area in Tasmania case study landscape.

UTILISATION OUTPUTS

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 Burning Atlas. Utilisation outputs therefore will track the development of the Prescribed Burning Atlas. Although work has informally begun on the Atlas, formal project milestones do not commence until September 2018, with the Atlas due for release and promulgation through a national workshop in mid-2020.

The development of the Atlas includes both functionality and design components. While project milestones focus on data, models and software to deliver the Atlas, we have incorporated extensive end user engagement, in particular through a Pilot workshop in late 2019, to ensure the Atlas meets the needs of end users.

PUBLICATIONS LIST

Clarke H, Gibson R, Cirulis B, Bradstock RA, Penman TD (submitted) Developing and testing models of the drivers of ignition in southeastern Australia. Journal of Environmental Management.

Cirulis B, Clarke H, Price O, Boer M, Penman T and Bradstock R (in prep) A systematic exploration of the potential for wildfire risk mitigation with prescribed burning. Environmental Modelling and Software.

TEAM MEMBERS

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.

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