NSW Bushfire Risk Management Research Hub

The trade-off: Optimising cost-effective HRBs to balance multiple aims

Identifying the optimal HRB strategy is challenging because we need to balance the risks to life, health, property and environmental values such as biodiversity and carbon. Importantly, the costs and benefits of HRB vary across regions. Simulation modelling is a way to explore many more strategies and conditions than could be trialled in practice.

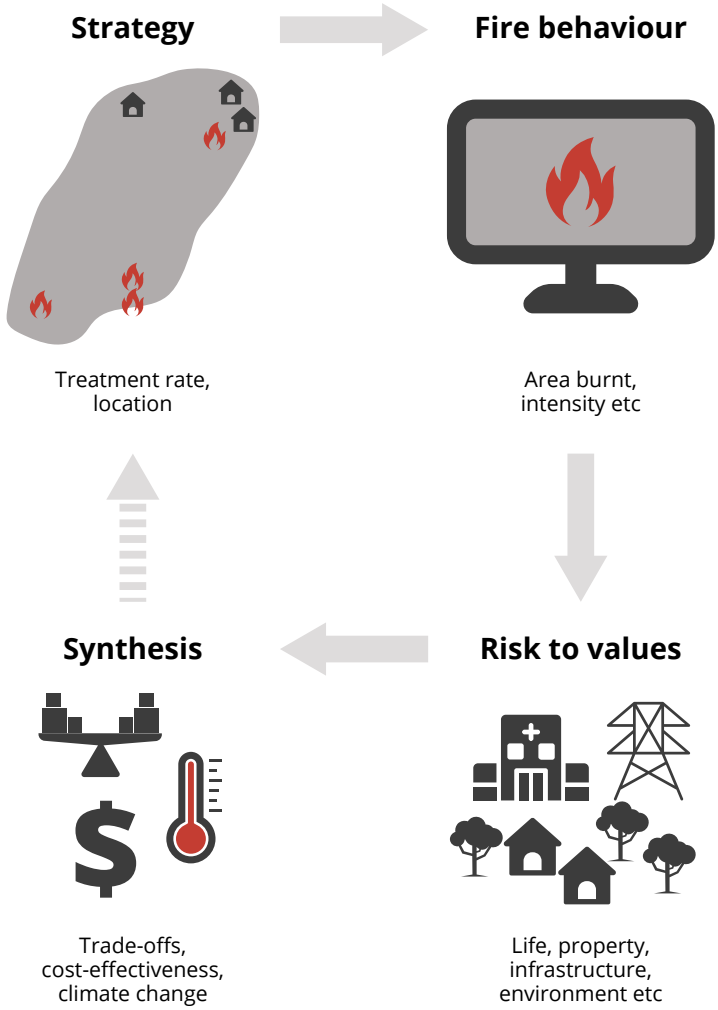
Photo: John Spencer, DPE

The 2019/20 bushfire season was extraordinary in many ways. Analysis suggests that hazard reduction burning (HRB) only reduced fire behaviour if it occurred in the previous two years. Analyses of previous seasons generally find a longer lasting effect. Even so, there were many instances where HRB helped firefighters, including in ways not obvious in GIS analyses.

Hazard Reduction Burns (HRBs) can be an effective risk mitigation tool, but they are not a silver bullet. There is no one-size-fits-all solution and tailoring HRBs to local conditions is a difficult task.

The NSW Bushfire Risk Management Research Hub built a risk modelling framework to examine how different rates and locations of HRB affected things we value. We created a virtual representation of 13 landscapes across NSW, running thousands of bushfire simulations in each and measuring the effects on life loss, house loss, infrastructure damage and the environment. We explored the cost-effectiveness of different strategies, factoring in bushfire effects and the costs of fuel treatment. We investigated risk in each landscape and compared risk between landscapes. We also tested new models from other Hub researchers for the health costs of smoke and the sensitivity of plants to fire seasonality.

A pathway to risk management



This image shows a fuel treatment strategy for a particular area, with a smaller HRB near a settlement in the north-east and a larger HRB in a more remote area in the south-west. Simulations test the effects of this strategy on bushfire behaviour and subsequent risks to values. This helps fire managers understand and compare the potential effects of different strategies and make the best decisions for their areas.

Hub researcher Dr Hamish Clarke compares the risk assessment method to an iceberg. Below the "surface", sits a vast amount of data, but how this data is synthesised will help fire managers weigh up decisions for their settings.

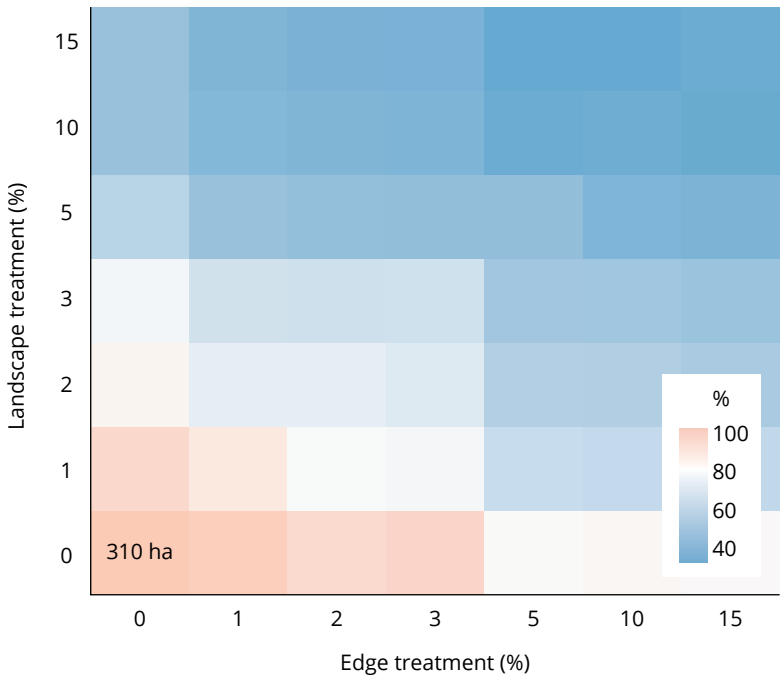
"We are trying to represent as many of the effects of bushfire and HRB as possible," Dr Clarke said.

"Our approach is designed to make these impacts – and trade-offs between them – clear, while allowing for new and improved models in the future."

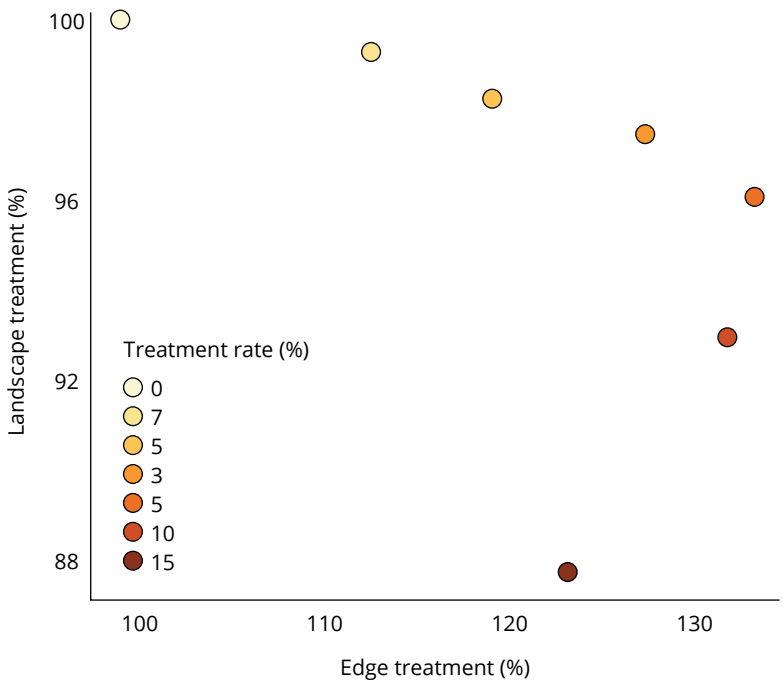
Chart A, above right, shows how different combinations of fuel treatment reduce the risk of bushfires. The vertical axis shows HRBs in the wider landscape, increasing from 0 to 15 per cent per year. The horizontal axis shows edge treatments, closer to people and assets, also from 0-15 per cent per year. As the scale of each treatment increases, the risk of area likely to be burned in a bushfire decreases (blue areas) compared to the risk when undertaking no or minimal treatment (pink areas).

Chart B shows a common trade-off in HRB, between property and environmental effects. As the treatment rate increases (darker colours), the risk of losing homes declines but, at the same time, there is increased risk of vegetation being burned sooner than its recommended minimum threshold. However, the trend is not uniform for all locations.

A. Residual risk - Area burnt by wildfire



B. Trade-offs



This work shows the potential for fire managers to work with Hub researchers on developing integrated risk assessments, encompassing trade-offs and a wide range of management values. Dr Clarke cautions there will be differences across landscapes and, in some cases, more HRBs might improve environmental outcomes.

"It's a way of framing the conversation that really puts risk at the heart of things because, ultimately, that's what matters," he said."Our work shows that sometimes where you burn matters more than how much you burn, and sometimes you can't avoid trade-offs."

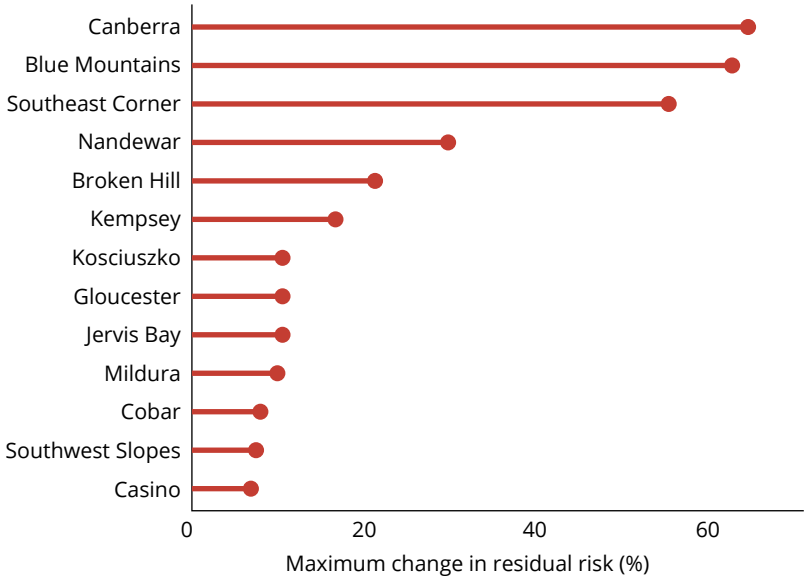
Dr Clarke said the risk assessment framework was "a decision support tool", rather than a set of absolute answers.

"It's about helping to think through issues and test assumptions about different management options," he said.

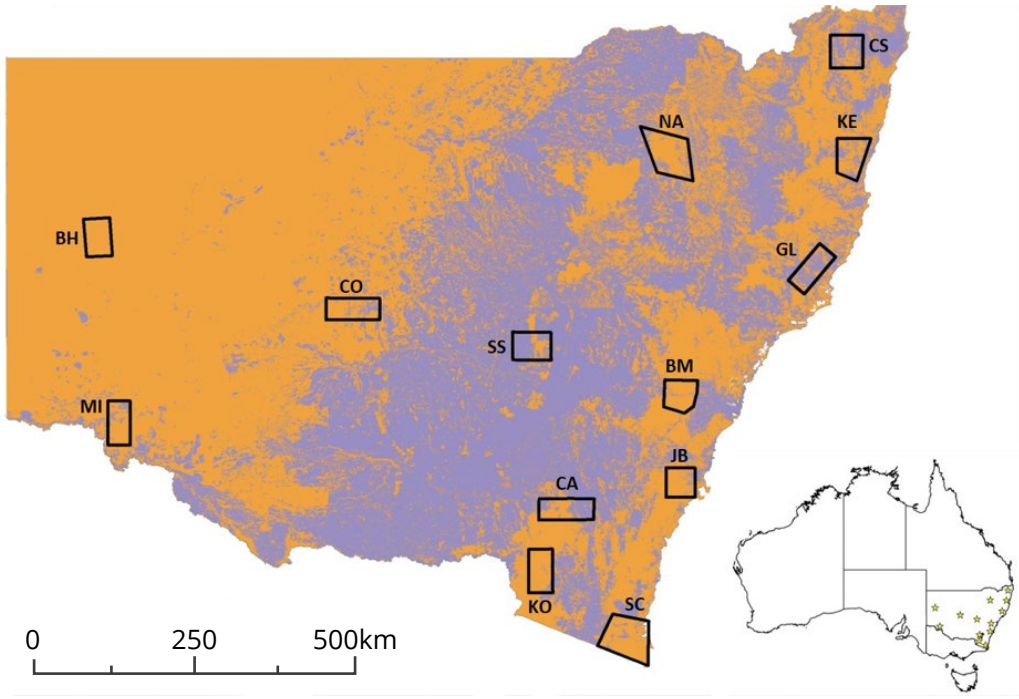
Bang for your burning buck?

Hub research reinforces there is no one solution that will work for every region in NSW or Australia. The chart and map below show different areas where fuel treatment effects were explored using bushfire simulations.

Sensitivity to treatment - area burnt by wildfire



The chart above shows the effects of HRBs on bushfire risk are by no means uniform around NSW. Areas such as Canberra and the Blue Mountains are predicted to experience a marked reduction in risk with increasing HRBs. However, increasing HRBs did not result in the same risk reduction in areas such as Cobar and Casino.



Bushfire simulations: Location and dominant land cover (orange = native vegetation, purple = cleared or modified vegetation) of thirteen case study landscapes in NSW, Australia: Broken Hill (BH), Mildura (MI), Cobar (CO), Southwestern Slopes (SW), Nandewar (NA), Canberra (CN), Kosciuszko (KO), Casino (CS), Kempsey (KE), Gloucester (GL), Blue Mountains (BM), Jervis Bay (JB), Southeast Corner (SC).

Dr Clarke said it was not about telling fire managers in one area to burn or not to burn.

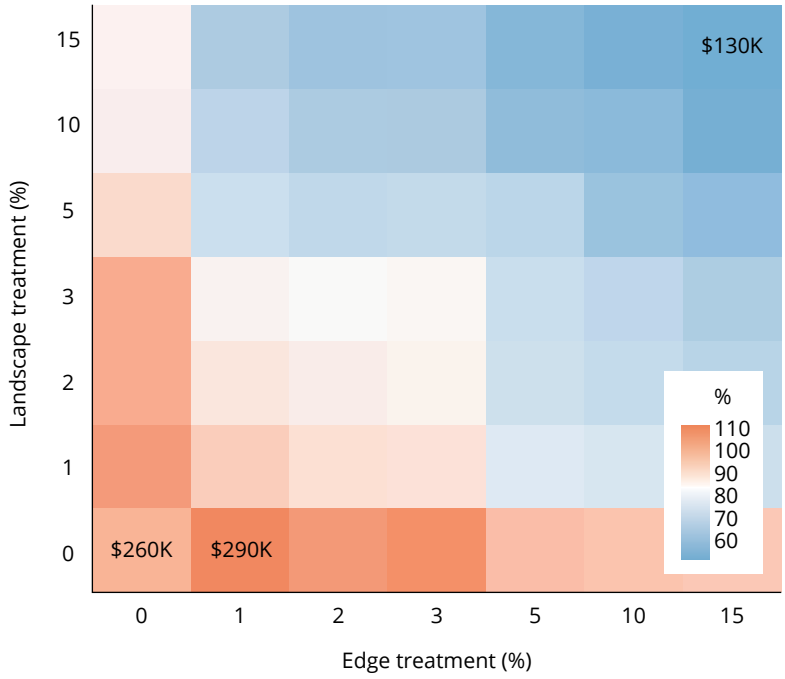
"It's about considering risks to all these different values and not necessarily expecting the same result if you apply the same strategy everywhere," he said.

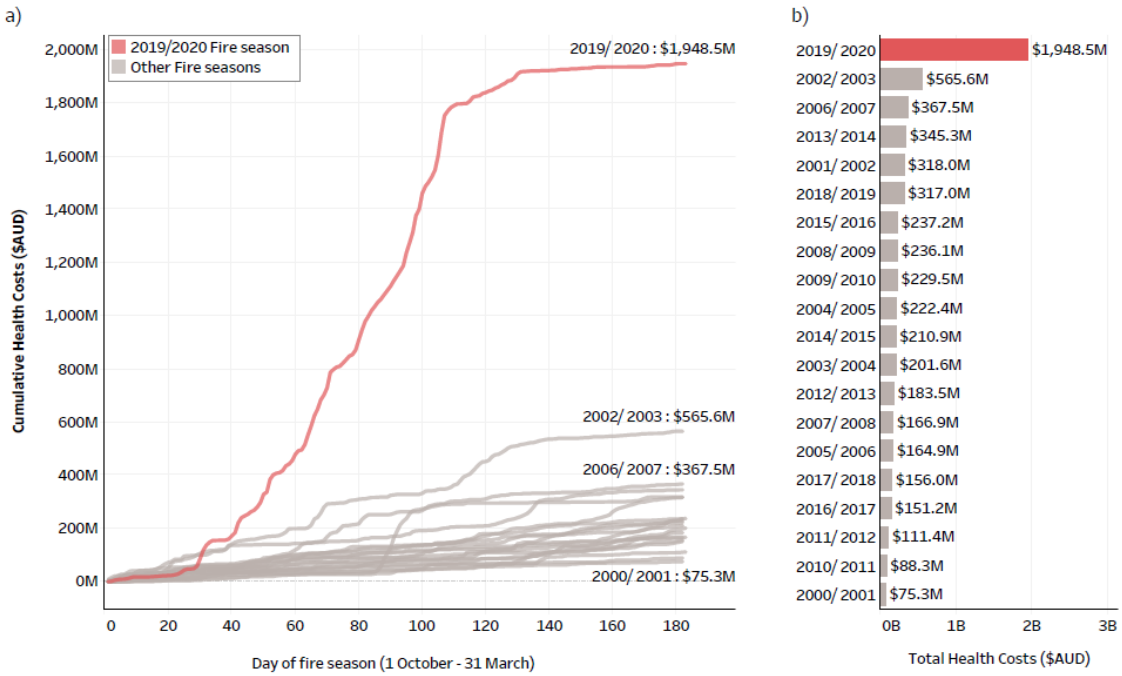
"That's why we've looked at a diverse mix of landscapes. We've tried to capture different vegetation types, climate zones, population density, land use."

Hub researchers have also considered factors such as how the health costs of smoke from bushfires are affected by different scales of treatments. The image above shows the likely results of combining edge and landscape HRBs in different proportions. As treatment rates increase, the risk of smoke health effects from bushfire declines. HRBs themselves produce smoke, meaning this is another trade-off that fire managers and communities must consider. Dr Clarke cautioned more research was required.

Hub research found the health burden of bushfire smoke in Australia is substantial and, in some cases, HRBs contribute significantly to this. This work underscores the importance of understanding the public health impacts of exposure to fire smoke, and the need to incorporate smoke impacts and smoke management into our practices and communications. Hub research helps fire managers better target their warnings when undertaking HRBs.

Wildfire smoke health costs
Blue Mountains



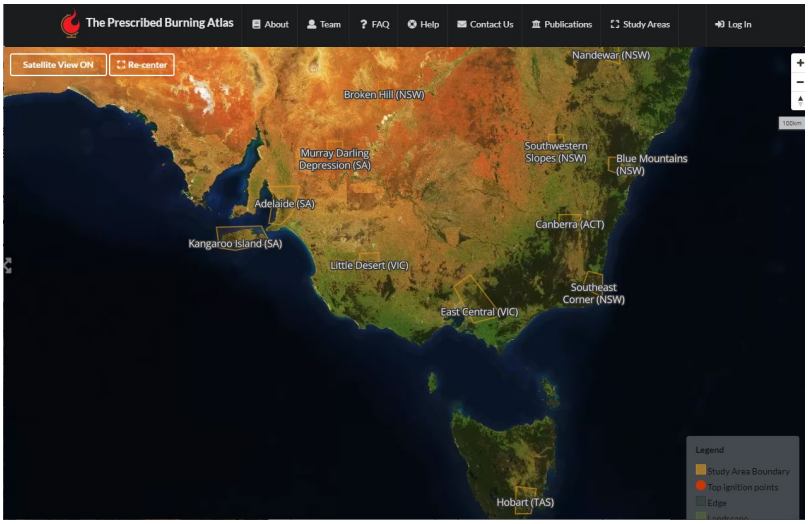


Johnston FH, Borchers-Arriagada N, Morgan GG, et al. Unprecedented health costs of smoke-related $PM_{2.5}$ from the 2019–20 Australian megafires. Nat Sustain 2020; 4: 42–47.

The Prescribed Burning Atlas

This Hub research follows on from a project supported by the Bushfire and Natural Hazards Cooperative Research Centre. Users can explore the results from that project in an online tool called the Prescribed Burning Atlas which covers multiple states and territories. This new Hub research builds on the Atlas, adding new landscapes, new values and new costs.

► prescribedburnatlas.science



Hub researchers Vanessa Cavanagh and Dr Kat Haynes have investigated the importance of cultural burning to Indigenous communities. Photo: Kat Haynes

Aboriginal cultural burning

Hub researchers have engaged with cultural burning practitioners to show the importance of supporting Aboriginal-led burning and understanding its importance for cultural renewal, resilience and wellbeing. The Hub seeks to help develop a respectful, equitable and evidence-based relationship between traditional practitioners and the prevailing fire management paradigm. Vanessa Cavanagh has researched the role of women in cultural burning and Dr Kat Haynes has investigated its links to community wellbeing.

Photo: Peter Taseski, DPE

Photo: Nick Cubbin, DPE

Climate change and HRBs

Climate change can affect the drivers of bushfire risk: fuel, fuel moisture, ignitions and weather. It is increasing the frequency of extreme weather conditions and changing the windows of suitable weather conditions for HRBs. It is already influencing bushfire behaviour and risks. Much bigger changes are projected if we do not take effective climate change action. Hub research has explored how the effectiveness of HRBs may change under a range of future climates.Dr Clarke said Hub research showed current rates of HRBs may decline in effectiveness as the climate changed.

"If we want to achieve what we are achieving at our current rates, we may need to do quite a lot more treatment, under the worst-case scenarios," he said.

The chart above shows current fuel treatment rates may not achieve the same risk mitigation in the future. Results depend on the climate change scenario. Best-case scenarios (blue dots) suggest little change will be required in treatment rate. Worst-case scenarios (orange dots), suggest considerable increases in treatment may be required to achieve the same risk reduction of current rates.

Maintaining current risk under climate change
Area burnt by wildfire

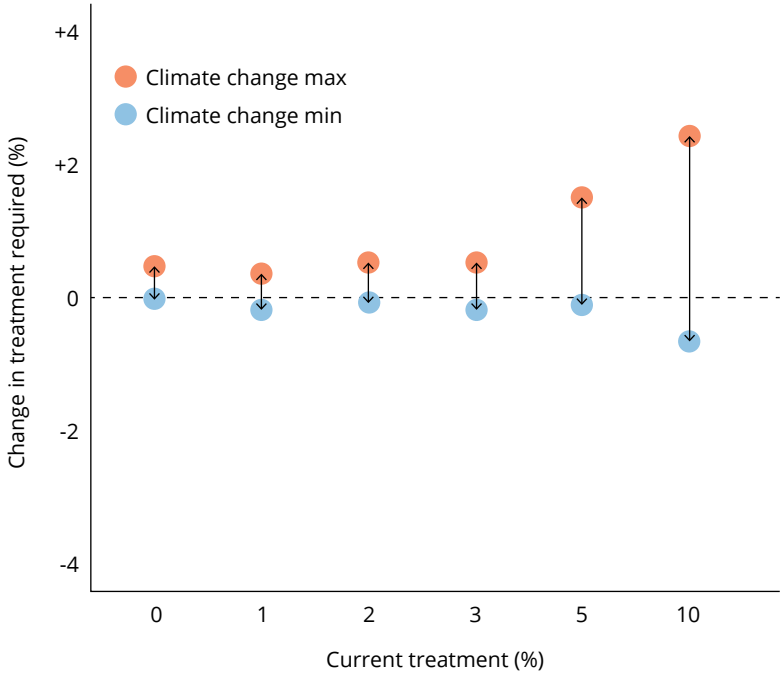


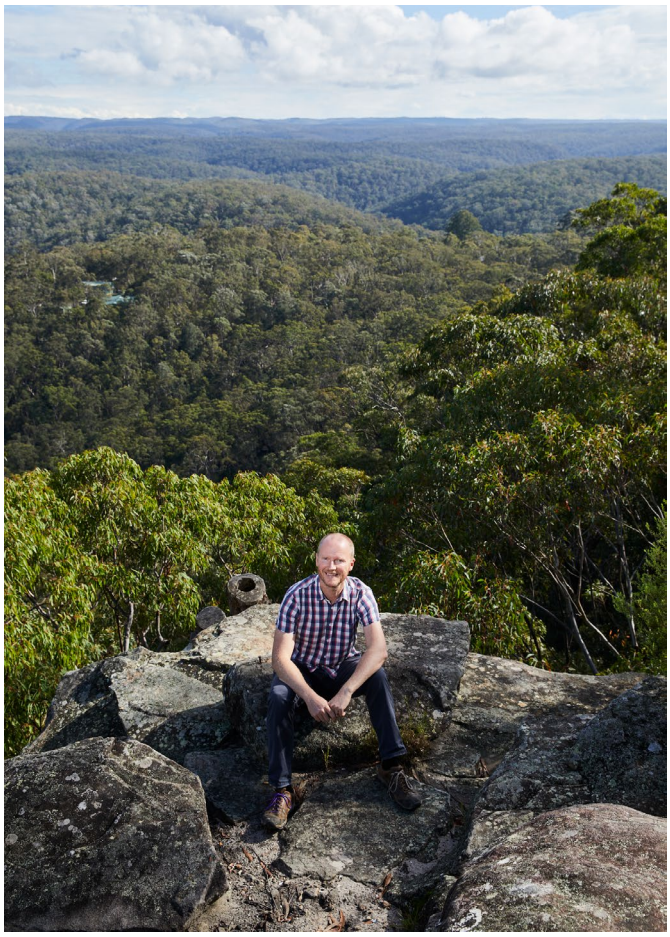
Photo: Peter Taseski, DPE

Protecting our biodiversity

Plants relying on post-fire recruitment are likely to be more vulnerable to climate change, with drought and heat stress likely to diminish the amount and quality of seed banks. One way to ameliorate the threats plants face from ongoing climate change is to manage in an informed way those species and ecological communities most at risk. Hub research has shown that considering the season in which fire occurs is important for some plant species. This can help fire managers balance biodiversity with timing of HRBs. In one landscape, it was found that changing the timing of HRBs led to complex changes in the risk of vegetation being burnt sooner than its minimum recommended threshold.

What's next?

Hub researchers are working closely with fire managers to communicate these findings and translate them into support for better decisions, for instance in NSW's bushfire risk planning. Models of smoke trade-offs, environmental impacts and the economic costs associated with different strategies continue to be improved.



Related articles

- Penman, T., Clarke, H., Cirulis, B., Boer, M., Price, O., & Bradstock, R. (2020). Cost-effective prescribed burning solutions vary between landscapes in eastern Australia. Frontiers in Forests and Global Change. https://doi.org/10.3389/ffgc.2020.00079
- Cirulis B, Clarke H, Boer M, Penman T, Price O and 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
- Borchers-Arriagada N, Bowman DMJS, Price O, Palmer AJ, Samson S, Clarke H, Sepulveda G, Johnston FH (2021) Smoke health costs change the calculus for wildfires fuel management. Lancet Planetary Health, 5, e608-19. https://doi.org/10.1016/S2542-5196(21)00198-4

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