NSW Bushfire Risk Management Research Hub

Tree mortality after bushfire

What we learned from Black Summer and other fires

Resprouting eucalypts dominate Australia's temperate forests, providing vital habitat and carbon storage. They resprout after complete defoliation due to drought, herbivory or fire. Many also produce a large crop of seedlings after fire. They are highly resilient, but there is wide variation reported in rates of mortality after fire.

Critical questions

Do mortality rates vary among species and, if so, why?

Do climate change and altered fire regimes affect resilience?

Does bark protect trees from fire?

Intense bushfire heat can kill dormant buds, preventing trees from recovering. Many fire-prone ecosystems have trees with thick bark, which protects dormant buds. In eucalypt forests, bark thickness and density can vary considerably, although this is not yet well characterised. In a study of seven eucalypts (including the closely related *Angophora* and *Corymbia*) and one Banksia species, the NSW Bushfire Risk Management Research Hub found:

- Small trees were most prone to resprouting failure after severe fire, due to their thinner bark, consistent with previous research.
- The size of trees prone to resprouting failure varied among species.
- For each species we identified the **critical diameter of stems** associated with resprouting failure. This value varied from 1–25 cm.
- Bark thickness and bark density explained 65% of this variability in the critical stem diameter.
- Species with thick bark and low bark density were most resistant to fire, i.e. had the lowest critical stem diameters.

Conclusion

Bark traits can indicate how well species will respond to fire.

What is a critical stem diameter?

- When it comes to resprouting after bushfire, each species has its own **critical stem diameter**.
- More than **half** the trees of this diameter are **unlikely to resprout**.
- Trees smaller than this diameter are even less likely to resprout.
- Trees larger than this diameter have an increasing chance of resprouting.

Species with thick bark, but low bark density, are most resistant to fire.

This stand of Inland scribbly gum (*Eucalyptus rossii*), in the Pilliga National Park, was burned in early 2018. It is pictured 18 months later showing poor recovery. The species' thin bark provided poor protection to dormant buds.

Dr Rachael Nolan inspects old-man banksia (*Banksia serrata*) in the Royal National Park in spring 2019. The area was burned 18 months earlier, but the species' thick bark protected dormant buds. INSET: The thick bark of *Banksia serrata* helps dormant buds resprout after bushfire.

Increasing bark thickness

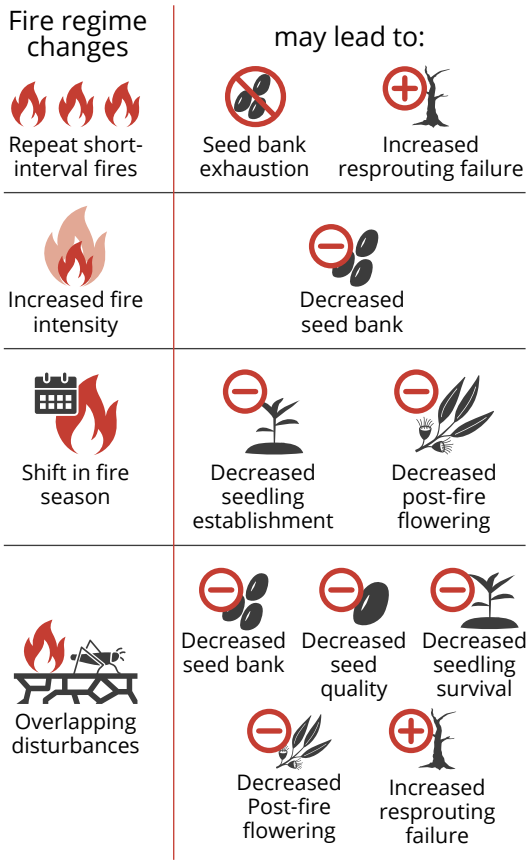
Decreasing bark density

Increasing resistance to post-fire mortality

Fire and climate change

- As the climate changes, more frequent fires are expected in south-east Australian forests.
- These fires are expected with more frequent, more intense and longer droughts and heatwaves.

► Download scientific article (https://doi.org/10.1111/pce.14176)



Conclusion

Our resprouting forests are likely to remain resilient to increased fire. However, when those fires coincide with severe drought and heat stress, they may not have the reserves to recover. 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.

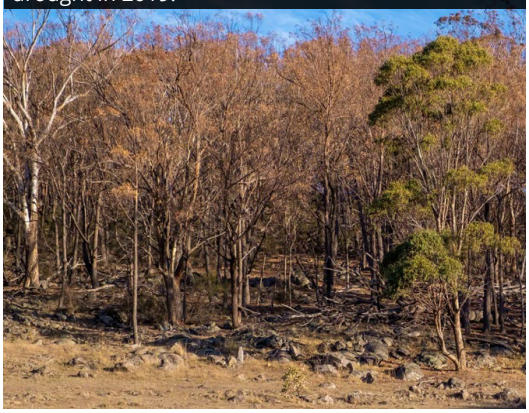
When fire follows drought

What were the implications of the severe drought and fires in 2019–20 for resprouting eucalypt forests?

Unprecedented drought had severely affected many ecosystems before they were burnt. Large tracts of forest turned brown as the canopy died back. In one of the worst-affected areas, in the New England Tablelands, we surveyed forests at the height of the drought (Nolan et al., 2021b). The Hub found:

- Smaller trees were generally more affected, most likely due to shallower roots, and less access to deeper soil moisture.
- Canopy die-back was due to the hydraulic system collapsing.
- After the rains, many trees showed signs of resprouting, but more work is needed to quantify how well these forests are recovering.

Forests in the New England Tablelands experienced canopy collapse due to the severe drought in 2019.

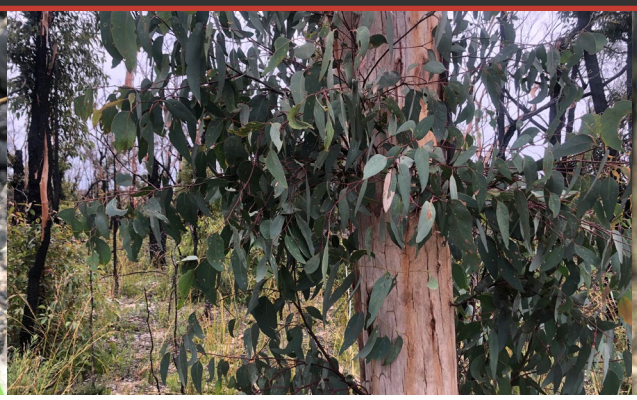


Unprecedented drought had severely affected many ecosystems before they were burnt

Conclusion

Smaller trees were more likely to be impacted by the drought.

Poor tree condition due to drought may change the critical stem diameter for species, leaving more trees vulnerable to fire.



One year after Black Summer

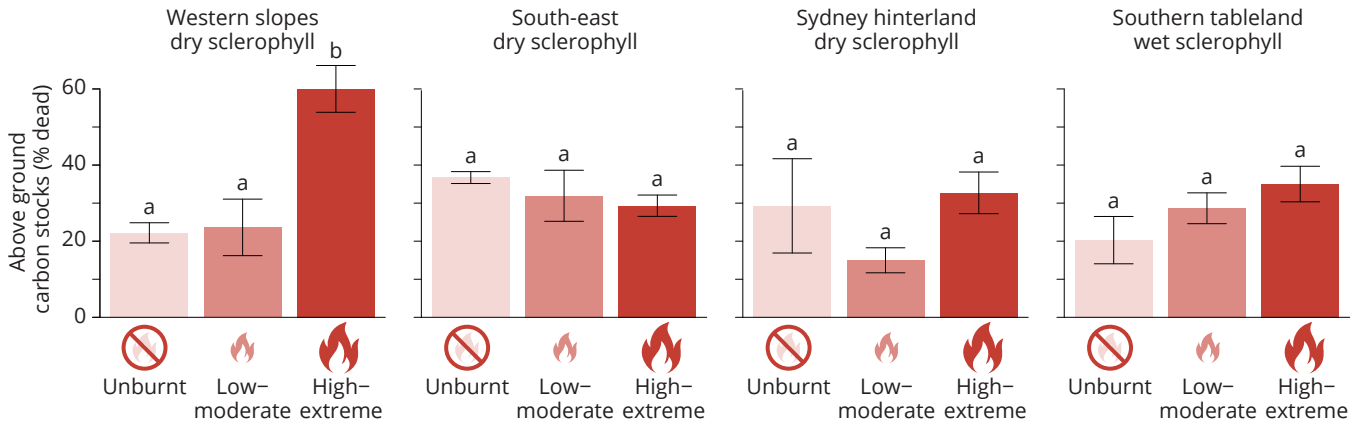
The Hub assessed how well NSW forests were recovering one year after the fires (Nolan et al., in review). We surveyed four types, including wet and dry sclerophyll forests, and found:

- Rates of tree mortality were higher in smaller trees and with increasing fire severity, as in previous studies.
- Three of the forest types appeared to be recovering well, with similar rates of mortality to previous studies.
- One forest type showed poor recovery, with 60% of above-ground carbon stocks dead
- Many of the trees showed signs of resprouting, but sawfly larvae ate the foliage, and the trees did not resprout again. It is difficult to determine why not, but this forest was in a lower rainfall zone and may have been more drought affected. Previous studies have shown drought affected forests are more vulnerable to insect infestations.

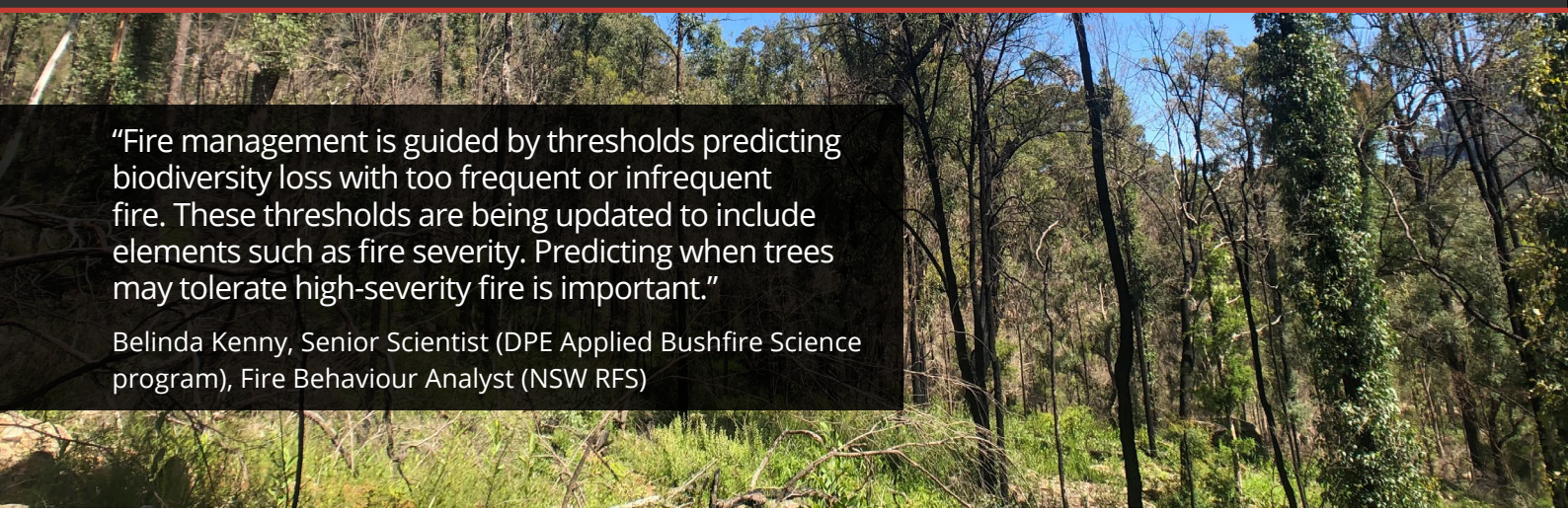
The forest above is recovering well after the Black Summer fires, with lots of epicormic regrowth on the stems. However, the forest below is not recovering well, with high rates of tree mortality.

Conclusion

Many, but not all, forests are recovering well. Longer-term studies are needed to assess how fire after drought affects recovery.



For Western slopes dry sclerophyll forest, the percentage of carbon stocks in dead biomass increased from 22% in unburnt forest to 60% in forest subject to canopy fire. Dead biomass will slowly decompose, releasing carbon into the atmosphere for years to come, leaving an ongoing legacy of the fires.



"Fire management is guided by thresholds predicting biodiversity loss with too frequent or infrequent fire. These thresholds are being updated to include elements such as fire severity. Predicting when trees may tolerate high-severity fire is important."

Belinda Kenny, Senior Scientist (DPE Applied Bushfire Science program), Fire Behaviour Analyst (NSW RFS)

Take-home messages

Many of NSW's eucalypt forests are highly resilient to fire, even when frequency increases. However, there is considerable variation in how well they recover. This is likely due to a combination of:

- characteristics of species, particularly bark traits
- size of the trees, which affects bark thickness, as well as access to deep soil moisture
- severity of pre-fire drought and heat stress
- biotic factors, such as insect infestation.

What now?

Longterm, the combined effects of repeat fires, under hotter, drier conditions, may lead to a gradual decline in the health of our forests, and an associated decrease in forest carbon stocks. The effects are unlikely to be uniform. Further research is required to assess which areas may be more at risk of post-fire mortality under climate change.

More information

fire.science@environment.nsw.gov.au

Associated articles

- The carbon cost of the 2019–20 Australian fires varies with fire severity and forest type (under review).
- Limits to post-fire vegetation recovery under climate change. (https://bit.ly/post-firevegetation)
- Hydraulic failure and tree size linked with canopy die-back in eucalypt forest during extreme drought. (https://bit.ly/hydraulic-fail)
- Bark attributes determine variation in fire resistance in resprouting tree species. (https://bit.ly/bark-attributes)

Researchers

Dr Rachael Nolan
Rachael.Nolan@westernsydney.edu.au

Professor Matthias Boer
M.Boer@westernsydney.edu.au

Belinda Medlyn
B.Medlyn@westernsydney.edu.au

Brendan Choat
B.Choat@westernsydney.edu.au

The **NSW Bushfire Risk Management Research Hub** (www.bushfirehub.org) is a partnership between researchers at the University of Wollongong, Western Sydney University, the University of NSW, the University of Tasmania, supported by the NSW Department of Planning and Environment and the NSW Rural Fire Service.

UNIVERSITY OF WOLLONGONG AUSTRALIA
UNSW SYDNEY
WESTERN SYDNEY UNIVERSITY
UNIVERSITY of TASMANIA
NSW GOVERNMENT