Research Note | June 2025

Monitoring canopy dieback in NSW North Coast forests

This note summarises the development and testing of a new method to quantify and monitor canopy dieback in coastal NSW public forests, including national parks and state forests. This work was led by researchers from the Hawkesbury Institute for the Environment at Western Sydney University (WSU), in collaboration with remote sensing research scientists from NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW), as part of the Coastal Integrated Forestry Operations Approvals (IFOA) Monitoring Program.

A pilot study tested the method in eucalypt dominated forests of the NSW north coast affected by the severe early-season drought in September to October 2023. In these forests, there was a strong relationship between canopy dieback and ridges and north-facing slopes. These landscape features receive more sun and have lower soil moisture retention, which increases drought stress. Areas previously impacted by Bell Miner Associated Dieback (BMAD) had high levels of canopy dieback, but the area affected was small compared to other factors associated with canopy dieback (1.3 percent). Further analysis of the influence of land management practices on canopy dieback and testing in other forest regions is needed to support broader application of the method.

Details of the methods and data required are described in the report enabling reproduction of the analysis for other forests, with ground truthing. Spatial outputs from the pilot study showing dieback locations will be made available through the SEED portal. Future application of the method could be used to guide forest management decisions to manage dieback risk, for example avoiding cumulative impacts from disturbance such as prescribed fire and active management such as thinning.

Forests in the north coast region of NSW have experienced extremes in climate variability and disturbance in recent years. This includes widespread drought from 2017 to 2019, major fires in 2019-20, subsequent well above average rainfall in 2020 to 2022 and a localised 'flash drought' in September-October 2023.

Climate extremes are expected to become more frequent. The long-term forest fire research by Canadell et al (2021),[i] which assessed 90 years of ground-based data, identified that the area of forest burnt and fire frequency in Australia is increasing. Adapt NSW states that climate change is increasing temperatures and affecting rainfall and climate systems in NSW making drought conditions in southeast Australia worse.[ii]

With extreme climate events predicted to occur more frequently, an understanding of the spatial extent and drivers of canopy dieback is critical for future management of NSW forest ecosystems. The Coastal IFOA monitoring program seeks to answer the question "*To what extent are the [Coastal IFOA] conditions effectively managing the risk of new or existing areas subject to dieback?*"

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Western Sydney University was engaged to develop a repeatable, scientifically robust and low-cost method to monitor landscape-scale forest canopy dieback and test the method through a pilot study in the Coastal IFOA region.

Ridges and north-facing slopes were main factors associated with canopy dieback in pilot study area

The pilot study results demonstrated that canopy dieback was most extensive on ridges and north-facing slopes, where higher solar radiation and reduced soil moisture retention increased drought stress (Figure 1). South-facing slopes exhibited greater resilience. Exposed upper slopes were more likely to experience full canopy dieback, whereas lower-lying gullies, which retain more moisture, showed lower levels of canopy dieback. Further, relatively drier areas in the landscape were more susceptible to full dieback, while wetter areas were more likely to sustain partial canopy loss.

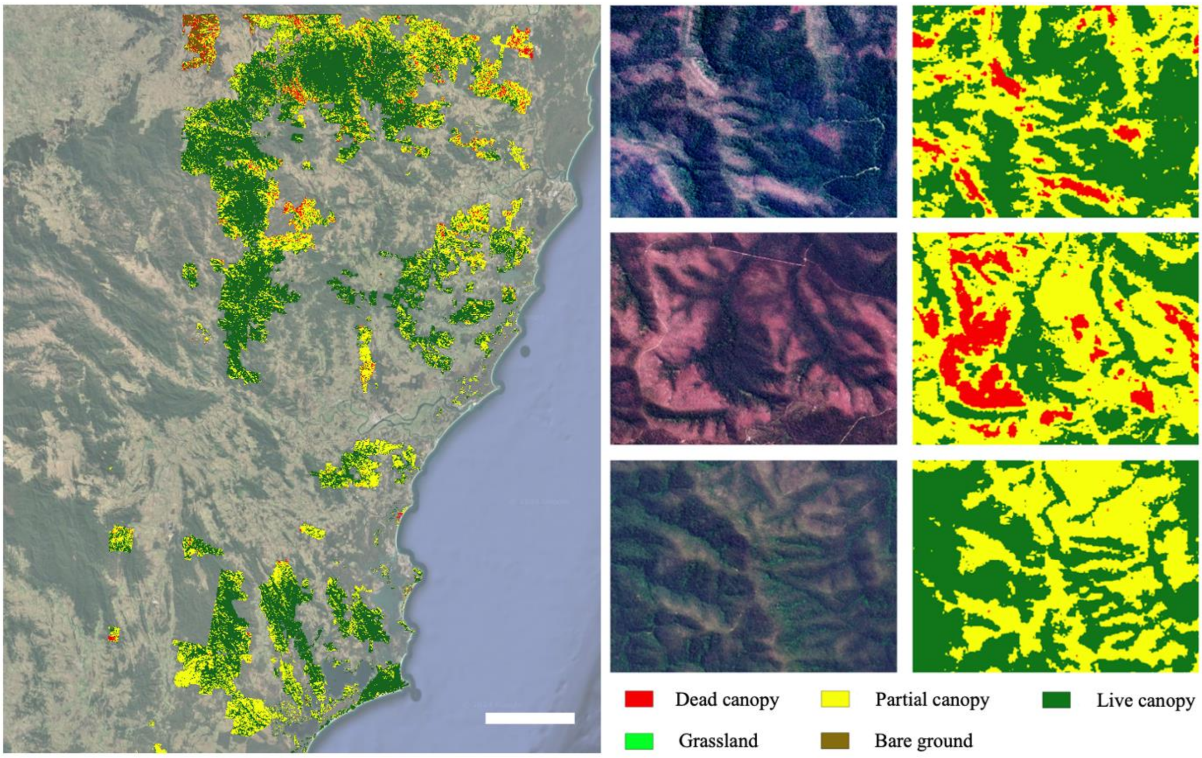


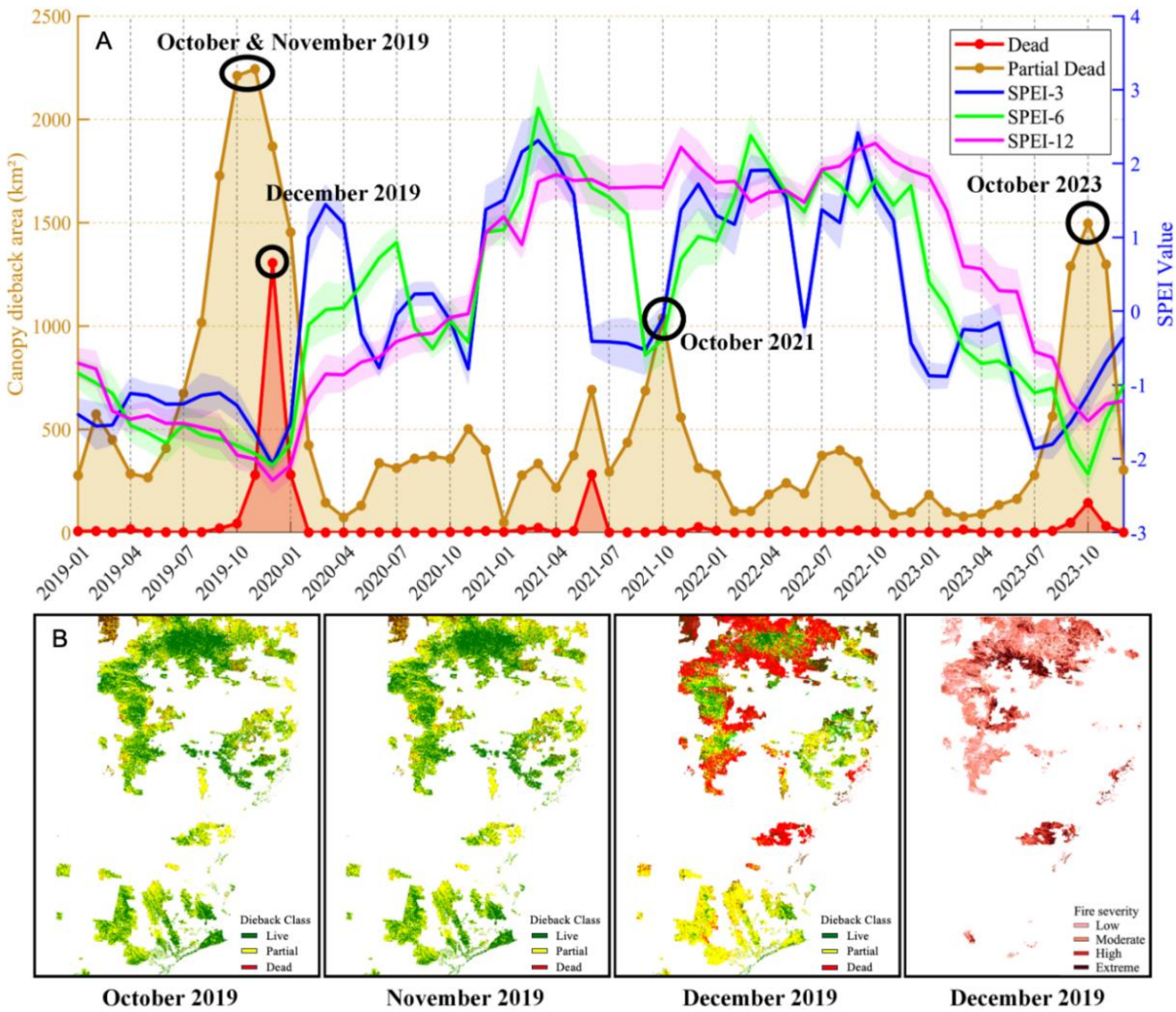
Figure 1: Canopy dieback severity mapping on public land at 10m spatial resolution showing dead canopy on ridges and north-facing slopes

Previous fire history also played a significant role in shaping dieback patterns. Areas that burned at high or extreme severity during the 2019-20 Black Summer fires were more likely to experience canopy dieback in the 2023 drought, suggesting a legacy effect from past disturbance.

National Parks and other protected areas outside State Forests had the highest probability of full canopy dieback. State Forests available for harvesting had the lowest probability of full canopy dieback, but highest probability of partial canopy dieback. Further analysis is needed to explore reasons for these differences, which could reflect forest types and site conditions or differences in management.

Areas previously impacted by Bell Miner Associated Dieback (BMAD) had high levels of canopy dieback (8% dead canopy, 45% partial dead canopy). However, the area affected by BMAD was small compared to other factors associated with canopy dieback (1.3 percent of the total area of canopy dieback in the pilot study area).

Figure 2 shows a time-series analysis from 2019 to 2023 revealing multiple peaks in canopy dieback, with the most significant occurring in late 2019, following the Black Summer fires, and in late 2023, during the most recent drought. The Standardized Precipitation Evapotranspiration Index (SPEI) shows the climatic water balance, with larger negative values indicating more severe drought conditions.



(A) Change in area (km²) of dead canopy and partial dead canopy between January 2019 and December 2023.
(B) Spatial variation is canopy dieback classes shown for three different months covering the period of the Black Summer drought and bushfires and subsequent recovery and fire extent and severity map (FESM) for the study area.
Note: The Standardized Precipitation Evapotranspiration Index (SPEI) calculated for 3-, 6- and 12-month periods is shown overlaying the change in canopy dieback areas.

Figure 2: Time-series and spatial mapping of canopy dieback for the study area

Although satellite imagery suggested some degree of canopy recovery after drought events, ground-based surveys confirmed that areas classified as dead canopy in 2023 contained a significantly higher proportion of dead trees one year later. Surveyed plots at the top of ridges showed the greatest tree mortality, while gully and south-facing slope plots showed better recovery. These findings suggest that while some forested areas may appear to be recovering in remote sensing data, on-ground assessment of the ecological impact is important and requires ongoing monitoring and further analysis.

Scientifically robust, repeatable method developed

The project developed a repeatable, scientifically robust and low-cost method to monitor landscape-scale forest canopy dieback and identify the principal drivers. The researchers used high-resolution PlanetScope satellite imagery to manually classify canopy conditions in areas affected by the 2023 flash drought into three categories: dead, partially dead, and live. This classification was then extended across the broader study area using publicly available Sentinel-2 satellite imagery and a machine learning approach. A further analysis was done to assess the influence of topography, fire history, and land management on canopy dieback patterns. The researchers also collected on-ground-data at selected sites to assess longer-term impacts on tree health for different classes of canopy dieback.

The study evaluated the performance of the canopy dieback detection method based on the Random Forest model and field survey-based validation for a pilot study region in the mid-North coast region of NSW. The Random Forest model achieved an accuracy of 94-96 percent in predicting the severity of canopy dieback in the test areas.

The report documents the data, approach and tools to reproduce the analysis. This could be used to apply the method to other forests at relatively low cost and analyse the influence of other land management and disturbance history, for example prescribed fire and harvesting, on canopy dieback. Output data from the pilot study will be made available through the SEED portal.

Limitations and future research

The method was tested for forests impacted by the 2023 flash drought in the mid-North coast region of NSW. The researchers recommend expanding canopy dieback mapping efforts across a broader region to improve early detection and response, as well as incorporating more detailed site-scale forest management data. They also recommend further refinement of tree-level monitoring incorporating LiDAR and high-resolution aerial imagery to track individual tree crown dynamics more accurately, and use of multi-seasonal training data. Future studies should expand ground surveys across a wider range of forest types and environmental conditions to refine predictive models and assess recovery trajectories over time.

This study provides a comprehensive methodology for mapping and monitoring canopy dieback and highlights the complex interactions between drought, fire history, and topographic factors. The results underscore the need for continued monitoring, predictive modelling, and adaptive forest management to mitigate the risks associated with climate-driven forest decline.

More information

This work is part of the monitoring forest structure and health strategy within the Coastal IFOA monitoring plan. The report detailing the project findings can be found on the Commission's website.

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i Canadell J, Meyer C P, Cook G D, Dowdy A, Briggs P R, Knauer J, Pepler A and Haverd V (2021) 'Multi-decadal increase of forest burned area in Australia is linked to climate change', *Nature Communications*, 12, 6921.

ii AdaptNSW (n.d.) Climate change impacts on drought, < https://www.climatechange.environment.nsw.gov.au/impacts-climate-change/weather-and-oceans/drought>