

Untangling the causes of tree dieback: Research priorities

Advice to the Environmental Trust

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Natural Resources Commission

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List of acronyms and abbreviations

The Commission	Natural Resources Commission
NSW	New South Wales
The Trust	NSW Environmental Trust

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Acknowledgment of Country

The Natural Resource Commission acknowledges and pays respect to all the Traditional Owners and their Nations. The Commission recognises and acknowledges that the Traditional Owners have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. We value and respect their knowledge of natural resource management and their contributions of earlier generations, including the Elders.

Table of Contents

1	Introduction	1
1.1	Next steps	1
2	Insights and issues	2
3	Recommended research priorities	4
3.1	Research theme 1: Investigating management interventions	4
3.2	Research theme 2: Investigating historical relationships	5
3.3	Research theme 3: Investigating species resilience and vulnerability	5
3.4	Research theme 4: Investigating soil factors	6
3.5	Criteria to select proposals	6

1 Introduction

The Environmental Trust (the Trust) has engaged the Natural Resources Commission (the Commission) to oversee the delivery of a research program to better understand the causes of eucalyptus dieback (dieback) in New South Wales (NSW).¹

This will:

- address knowledge gaps
- provide evidence to support policy and practice change for ecosystem management
- inform the effective management of risks to community values.

As a first step, the Trust has asked the Commission to advise on research priorities for the program. More detail on the Commission's role is provided in **Box 1**.

To develop this advice, the Commission:

- engaged leading researchers in dieback from Murdoch University to review the causes of dieback, identify knowledge gaps and advise on research priorities²
- sought feedback from policy and land management agencies on research priorities
- sought advice on research priorities from independent experts as part of a project steering group.

This paper outlines the Commission's advice.

- Chapter 2 discusses important insights and issues that informed the Commission's advice to the Trust on research priorities
- Chapter 3 presents the Commission's recommended research priorities.

1.1 Next steps

The Trust will consider the Commission's advice and develop a research investment stream for dieback that will be delivered over four years under the Trust's Contestable Research Grants Program (until May 2024).

Following this, the Trust will:

- publish a grant opportunity and call for an open expression of interest
- assess applications against eligibility criteria in consultation with the Commission
- announce successful grants.

¹ Dieback is a phenomenon that occurs globally in various tree species. In this report, 'dieback' refers specifically to dieback in eucalypt species, with a focus on occurrences in NSW.

² Matusick, G. and Fontaine, J. (2020) *Causes of large-scale eucalyptus tree dieback and mortality: research priorities. A report for the NSW Natural Resources Commission*. Terrestrial Ecology Research Group, Murdoch University, WA.

Box 1: The Commission's role

The Commission is tasked to:

- establish and independently chair a project steering group
- advise the Trust on research priorities
- monitor the progress of approved projects
- prepare a final synthesis report at end of program
- disseminate information, including an end-of-program public symposium.

The project steering group includes the Commission and Trust staff, and three independent experts:

Professor Giles Hardy (Murdoch University, Western Australia) - Giles is currently Director of the State Centre of Excellence on Climate Change, Woodland and Forest Health, and Director of the Centre for Phytophthora Science and Management.

Professor Ros Gleadow (Monash University, Victoria) - Ros is the Head of the Plant Ecophysiology Research Group, a Board Member of Eucalypts Australia, President-elect of the Global Plant Council and Past-President of the Australian Society of Plant Scientists.

Mr Bradley Moggridge (University of Canberra, ACT) - Brad is a PhD candidate at the Institute of Applied Ecology. He is a fellow of the Peter Cullen Trust Science to Policy Leadership Program. A Murri from the Kamilaroi Nation, Brad is a leader in linking western science and traditional knowledge in the management of the Australian landscape.

2 Insights and issues

The Commission asked researchers at Murdoch University to review and reference the scientific literature on dieback in NSW.³ This paper, and advice from the project steering group, highlighted several insights and issues that informed the Commission's final advice to the Trust on research priorities.

Dieback is a natural response of eucalyptus trees to changing environmental conditions and forms part of the compositional and structural dynamics of eucalypt forests. Dieback is only a problem under some circumstances. Eucalyptus are relatively resilient trees and use dieback to modify their growth in response to stressors both environmental and from pests and pathogens. Partial dieback is characteristic of Australian forest ecosystems and allows trees to adapt to an extremely variable environment. For example, trees may shed leaves, shoots and branches to reduce water stress in drought periods and recover when the drought breaks.

The resilience of eucalypt forests to stressors is provided by a combination of feedback loops which are complex interactions of biotic and abiotic factors across a range of spatial and temporal scales. The nature of these feedback loops can vary across different forest landscapes. For this reason, dieback events can differ across eucalyptus forests. Dieback becomes a problem when the resilience of a forest is eroded and when larger, more frequent or novel changes in forest conditions push forests past recovery thresholds. In these cases, trees experience a progressive decline in health and die, and seed germination is compromised.

³ Matusick, G. and Fontaine, J. (2020) *Causes of large-scale eucalyptus tree dieback and mortality: research priorities*. Report prepared for the Natural Resources Commission. Available at <https://www.nrc.nsw.gov.au/environmental-trust>

The extent, frequency and intensity of tree dieback is increasing globally, across Australia and within NSW. Evidence suggests that human factors such as land use change, fragmentation and changes to hydrology, fire regime or nutrient inputs are reducing the resilience of eucalyptus forests to events that cause dieback. Extreme climatic conditions, such as the drought experienced recently, increase the risk of dieback, and are projected to increase in the future. Climatic conditions outside the range which species are adapted to, may result in larger scale dieback events.

Such events pose a significant risk to ecosystem services that support community values such as biodiversity, water and timber resources, tourism, and cultural and spiritual values. Communities in NSW have expressed concern regarding increased dieback since widespread events in the 1950s and 1970s.

More recently, communities on the NSW North Coast are concerned about the impact of bell miner associated dieback.⁴ This type of dieback is listed as a key threatening process to biodiversity in NSW.⁵ There is also significant community concern around dieback events involving native weevils on the NSW Monaro plains⁶ and a native beetle in Kosciuszko National Park⁷. Communities in these regions and across Australia are recording dieback incidents through a national citizen science project.⁸ Reflecting these concerns, the Trust identified the issue of declining ecosystem health due to dieback as a priority in its biennial prospectus process.

Understanding the causes and management of severe and widespread dieback is challenging given the inherent complexity of ecological systems. External stressors are temporally and spatially dynamic and evidence of causal factors are often absent when studies commence as a result of delays in identifying symptoms, research funding and resources.

Developing practical solutions to manage dieback requires multi-disciplinary research that recognises the complex interactions and feedback processes, and extended timeframes associated with dieback. In some instances, management may need to strengthen or re-establish processes that enable forests to withstand future dieback events.

However, in other instances current or future disturbances may push forests past system thresholds from which they cannot recover. In these circumstances, land managers may need to directly intervene and actively transform forest ecosystems to those that are better adapted to changed disturbance regimes and continue to provide valued ecosystem services.

⁴ See for example, Waller, E. (2018) *Independent review of the report on progress with the implementation of the New South Wales Regional Forest Agreements for the second and third five-yearly reviews 2004-2014. A report the Commonwealth of Australia and State of New South Wales, to be tabled in Parliament.*

⁵ Listed under the NSW *Biodiversity Conservation Act 2016*

⁶ Murphy, S. (2018) 'Native weevil attacking ribbon gum trees in Monaro region of New South Wales', *ABC News*, 16 August. Available at: <https://www.abc.net.au/news/rural/2018-08-16/native-weevil-attacking-eucalyptus-trees-in-monaro-region-of-nsw/10004390>.

⁷ <https://themountainjournal.wordpress.com/2019/07/24/snow-gum-die-back-linked-to-climate-change/>

⁸ Nolan, R. (2020) 'Entire hillsides of trees turned brown this summer. Is it the start of ecosystem collapse?', *The Conversation*, March 9. Available at: <https://theconversation.com/entire-hillsides-of-trees-turned-brown-this-summer-is-it-the-start-of-ecosystem-collapse-126107>.

3 Recommended research priorities

To develop this advice, the Commission:

- engaged leading researchers in dieback from Murdoch University to review the causes of dieback, identify knowledge gaps and advise on research priorities⁹
- sought feedback from policy and land management agencies on research priorities
- sought advice on research priorities from independent experts as part of a project steering group.

Research priorities were then selected considering the following criteria:

- The research can readily translate into changes in policy and management practice.
- The research can address knowledge gaps in the current understanding of the dieback process.
- The research can support the accurate modelling of future events and impacts of dieback.
- The research can generate valuable information relatively quickly.
- The research can address community concerns.

3.1 Research theme 1: Investigating management interventions

This includes research on the effectiveness of management interventions to suppress dieback or interrupt trophic cascades. Managing dieback affected forests remains a challenge for forest managers on both public and private land. Management interventions are expensive and forest managers are seeking guidance on cost-effective approaches.

Management trials should be supported by good experimental design if they are to provide certainty to forest managers and be adopted. Well-designed management trials can also contribute to the identification of causal factors.

Research may focus on (but is not limited to):

- nutrient supplementation
- soil amendments
- environmental manipulation
- modification of the soil microbiome
- animal and plant control.

⁹ Matusick, G. and Fontaine, J. (2020) *Causes of large-scale eucalyptus tree dieback and mortality: research priorities. A report for the NSW Natural Resources Commission*. Terrestrial Ecology Research Group, Murdoch University, WA.

3.2 Research theme 2: Investigating historical relationships

This includes retrospective research that explores the temporal relationship between dieback events and potentially contributing environmental and biotic factors. Although retrospective analyses have limitations, particularly in the identification of biotic stressors, they are a relatively cost-effective and a quick way to effectively identify relationships between dieback events and environmental conditions.

Understanding these relationships can improve modelling the extent and impact of future dieback events. NSW has relatively complete records of historical landscape change to inform these studies and new techniques are improving dendrochronological studies for eucalyptus.

Research may include (but is not limited to):

- time series analysis of spatial data
- oral history and Indigenous knowledge of incidences of mass eucalyptus dieback
- dendrochronological analysis or other methods of measuring tree age
- climatic and fire record analysis (including Indigenous fire regimes).

3.3 Research theme 3: Investigating species resilience and vulnerability

Dieback effects eucalyptus species differentially, with some species being more vulnerable and others more resilient to dieback events. Understanding the functional attributes that drive these differences can help identify causal mechanisms, inform models of future projected impact, and inform management practice and conservation policy. Responding to dieback may require the adaptation of forest composition and structure.

Forest managers, and those that invest in environmental restoration require information to inform species selection. This theme focusses on research investigating the functional attributes of different eucalyptus species that makes them either more vulnerable or less susceptible to dieback.

Research may include (but is not limited to):

- comparative analysis of vulnerable and resilient eucalyptus species in mixed stands
- identification of the critical thresholds of key species to water and/or heat stress
- the cultural values of vulnerable or less susceptible eucalyptus species
- 'susceptibility to invertebrate pests
- susceptibility to pathogens.

3.4 Research theme 4: Investigating soil factors

This theme focusses on research that investigates the role of soil factors and processes in eucalyptus dieback.

Although soil and soil processes has been a focus of dieback research in other jurisdictions there is comparatively little research for NSW. Soil processes play an important role in forest landscapes. Root pathogens and declines in symbiotic mycorrhizal relationships have been proposed as key contributors to dieback. Advances in eDNA technology have improved the effectiveness of soil analyses to identify beneficial and pathogenic biota.

Research could focus on (but it not limited to):

- anthropogenic disturbance, for example compaction, drainage or loss of burrowing fauna
- soil pathogens, nematodes, viruses, bacteria and fungi
- nutrient and micronutrient availability
- role and impact of mammals as ‘soil engineers’
- soil biota and mycorrhiza
- allelopathy.

3.5 Criteria to select proposals

In addition to the research themes, the Commission identified the following criteria in relation to research design that the Trust could consider when selecting research proposals. To achieve the desired outcomes of the program:

- **Research projects should meet user needs** – research should be driven directly by the challenges faced by forest managers and policy makers. Proposals should demonstrate how research findings will be translated into changes in policy and management practice or support legislative responsibilities rather than only proposing further research.
- **Research projects should be interdisciplinary** – the complexity of dieback means that interdisciplinary approaches to research are more likely to provide useful insights compared with research that is restricted to individual fields of study.
- **Research projects should generate strong inference** – there should be a strong alignment between research objectives and experimental design. Similarly, research needs to be based on best practice and generate sufficient confidence and consensus to drive changes in policy and management practice.
- **Research projects should encourage collaboration** – research proposals should demonstrate how they are working collaboratively to meet the research objectives, including with forest managers, policy makers and researchers in related fields of study.
- **Research project should be linked to risk** – proposals should demonstrate how they address key risks to community values and ecosystem services.¹⁰

The Trust could also consider proposals that integrate one or more research themes more favourably.

¹⁰ Matusick, G. and Fontaine, J. (2020) provide a useful framework to illustrate the scale and severity of dieback events on the potential impacts on ecosystem services and community values.