Science for Saving Species

Research findings factsheet

Project 3.3.2

Threatened Species Recovery Hub

National Environmental Science Programme

Long term monitoring of ecosystem fragmentation and disturbance in Victorian Alpine Ash and Mountain Ash forests

In brief

Alpine Ash and Mountain Ash ecosystems in the Victorian Central Highlands provide essential ecological services and habitat for threatened species, but these forests are now under threat from a range of disturbances. We have been researching numerous aspects of these ecosystems for over 38 years, conducting repeated detailed ecological monitoring at over 180 sites. These sites have been subjected to a variety of fire and logging histories, and this has enabled us to examine the impacts and responses of plants, animals and soils to fire, post-fire salvage logging and clear-cut logging.

Our collective results show there has been a significant increase in disturbance to these forests over time. Only 1.16% of Mountain Ash, and 0.47% of Alpine Ash forest is old growth that has not been recently logged or burnt. Recurrent wildfire and logging have transformed the forest cover into widespread regrowth, with small patches of old growth forest. Arboreal marsupial site occupancy has declined significantly in response to site and landscape scale disturbances. The abundance of large old trees with hollows is also declining very rapidly, and these provide critical nesting habitat for arboreal marsupials.

Logging is making these forests more prone to high-severity wildfire. We found young, logged forest and regrowth forest, is generally more flammable than old growth forest, with older forest less likely to burn at high severity.

The recovery of these ecosystems after high-severity wildfire will decline if they are subjected to frequent disturbance. Anthropogenic disturbance to these forests needs to be reduced to conserve these forests and the forest-dependent threatened species dependent on these ecosystems. Crucially, existing hollow hearing trees need urgent protection. Mountain, and Alpine Ash forests need less fire if they are to recover, and areas of old growth forest need to be expanded to limit the risk of megafires.

A coupe burning after logging in the Victorian Central Highlands. Image David Blair

Australian National University

Background

Alpine Ash and Mountain Ash forests occur in the Victorian Central Highlands of south-eastern Australia and are collectively termed "montane" ash forests or "ash-type" forests. These forests are highly valued for wood production, ecological services, and the provision of habitat for threatened species including the Critically Endangered Leadbeater's possum (*Gymnobelideus leadbeateri*), and the Vulnerable greater glider (*Petauroides volans*).

Across these wetter forest types, fire is the main type of natural disturbance. These forests are well adapted to wildfires, which occur within a historical average fire-return period of 75–150 years. However, like other global forest ecosystems, Mountain Ash forests have experienced climatic changes and have been highly disturbed by multiple high-severity wildfires and clear-cut logging since the 1970s. Alpine Ash (*Eucalyptus delegatensis*) and Mountain Ash (*Eucalyptus regnans*) trees are typically killed by high-severity fire. The immature regrowth forests are highly vulnerable to high-severity wildfires for several decades after they have been regenerated from logging. When fires occur at short intervals (<~20 years) it prevents the development of sufficient seed stores that are critical to post-disturbance regeneration.

The structure and landscape composition of the Mountain Ash and Alpine Ash ecosystems in the Central Highlands of Victoria has been radically altered over the past century. Our research group has been examining the impact of both natural and anthropogenic disturbances in these forest ecosystems and landscapes since 1983.

Research aims

We have, and continue to, investigate the effects of disturbances on numerous aspects of Alpine Ash and Mountain Ash forest recovery. We have also been investigating the impacts of forest characteristics and disturbance regimes on arboreal marsupials, the plant community and the soil environment. Ultimately, we aim to improve the management and conservation of Alpine Ash and Mountain Ash ecosystems.

Leadbeaters possum. Image D. Lindenmayer and M Greer.

What we have done

We have been studying numerous aspects of the Mountain Ash and Alpine Ash ecosystems in the Victorian Central Highlands for over 38 years. We have established over 180 long term survey sites (Figure 1), which have been the focus of repeated, detailed ecological monitoring. These sites have been subjected to a variety of fire and logging histories, and this has enabled us to examine impacts and response at burned and unburned, and logged and unlogged sites. We have also been able to examine the impacts of post-fire salvage logging and clear-cut logging. Clear-cut logging, also known as clear-fell logging, is when most, or all the trees in an area are uniformly cut down. Post-fire salvage logging is the logging of trees after they have been burnt by wildfire.

An example, of one of the "natural experiments" we undertook, was to quantify the recovery of Alpine Ash and Mountain Ash forest vegetation over 11 years after high-severity wildfires in 2009. The 2009 fires burnt 21,132 ha of Mountain Ash forests and 7969 ha of Alpine Ash forests.

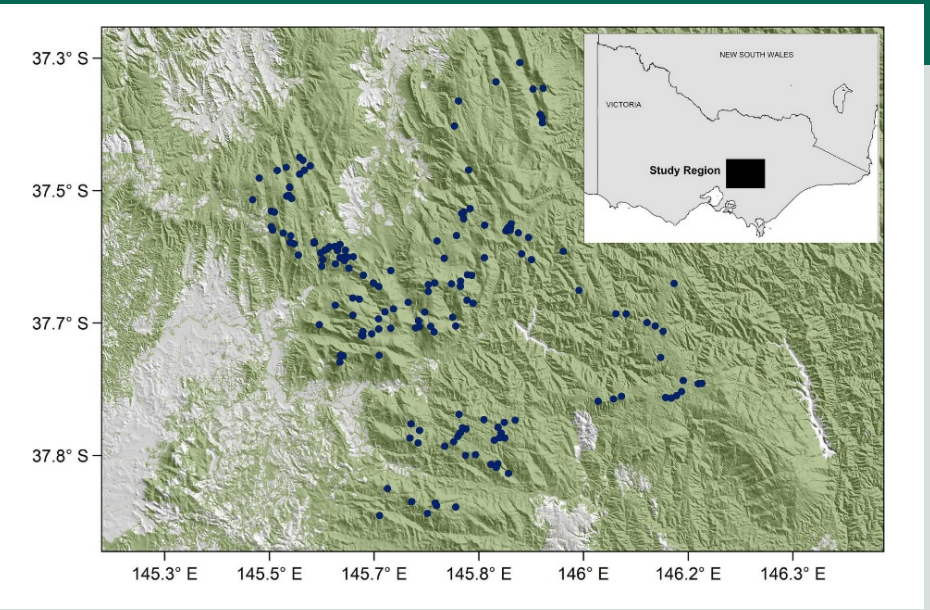

Figure 1: *The location of the study area in the Central Highlands of Victoria, south-eastern Australia. The black dots show the locations of field survey sites. Image: Lindenmayer, Blanchard, Blair, McBurney, Taylor, Scheele, Westgate, Robinson, and Foster (2021).*

Here we present part of our research findings on arboreal marsupials, vegetation age, composition and structure, plant recruitment, soil microbes and soil nutrient composition. In addition to collecting our own empirical data, we have also conducted spatial analyses and population viability analyses using spatial data from the Victorian Government.

Key findings

General changes in landscape cover with disturbance over time

There has been a significant increase in the amount of disturbance to these forests in the last decade. Most of the increase in disturbance is due to logging, with the last major fire in 2009. There is limited logging in the reserve areas which form part of a water catchment for Melbourne. We found that around 70% of Mountain Ash and 65% of Alpine Ash forest areas were either disturbed or within 200 m of a disturbed area. When we also considered future logging that will take part under the Timber Release Plan, these disturbance categories increased to 72% and 70%, respectively.

Spatial analysis shows that core areas of undisturbed Mountain Ash forest (>1000 ha) are becoming more isolated, with disturbed forest areas becoming closer together over time. This means that continued, and planned disturbance through logging will have an adverse effect on remaining undisturbed forest patches, which will become smaller and more dispersed across the landscape.

There has been a 77% decline in old growth across the forest estate in Victoria since 1995. In the central highlands area, only 1.16% of Mountain Ash forest is old growth that has not been recently logged or burnt. Historically, we estimate that there would have been 30-60% old growth forest in the landscape. Remaining Mountain Ash old growth forest is now distributed among 147 patches. For Alpine Ash, only 0.47% in the Central Highlands region is old growth. There is a strong positive relationship between the number of old trees and the age of the forest, and this has implications for animals that are strongly associated with old growth forest, such as many forest birds and the greater glider (see section on marsupials below).

Vegetation flammability

Climate change is one factor affecting vegetation flammability, but we found that logging also plays a significant role. The vegetation

Key findings (continued)

in young logged and regenerated forest (regrowth) is generally more flammable than in old growth forest due to having much finer stems and branches, and as the leafy canopy is much closer to the ground. The young forests also have more flammable species present including Acacias, shrubs and grasses (e.g. forest wire grass, *Tetrarrhena juncea*), and less low flammability species, like tree ferns and mature trees. For the first seven years after logging, there is a low risk of tree canopy fire, but when the forest reaches 8 to 40 years of age, we found there is a very high probability of canopy fire occurring. Fires that reach the tree canopy are very likely to kill trees and present a risk to many elements of the biota. From 40 years of age and on, the probability of canopy fire declines with increasing age of the forest.

Young post-logging regenerating forests create a fire risk for adjacent forest. These young forests are becoming more common as recurrent wildfire and logging have transformed the historical patterns of forest cover from widespread old-growth with small patches of regrowth embedded within it, to the opposite (widespread regrowth with small patches of old growth).

Plant responses to logging and fire disturbance

Overall, we have found that older forest is at lower risk of high severity fire. Our findings indicate that when high severity wildfires occur at the natural historical fire-return period of between 75 and 150 years, forest recovery between fires can be more advanced, and support a higher abundance and diversity of plant species, in comparison to younger or mixed aged forests, with shorter fire-return intervals.

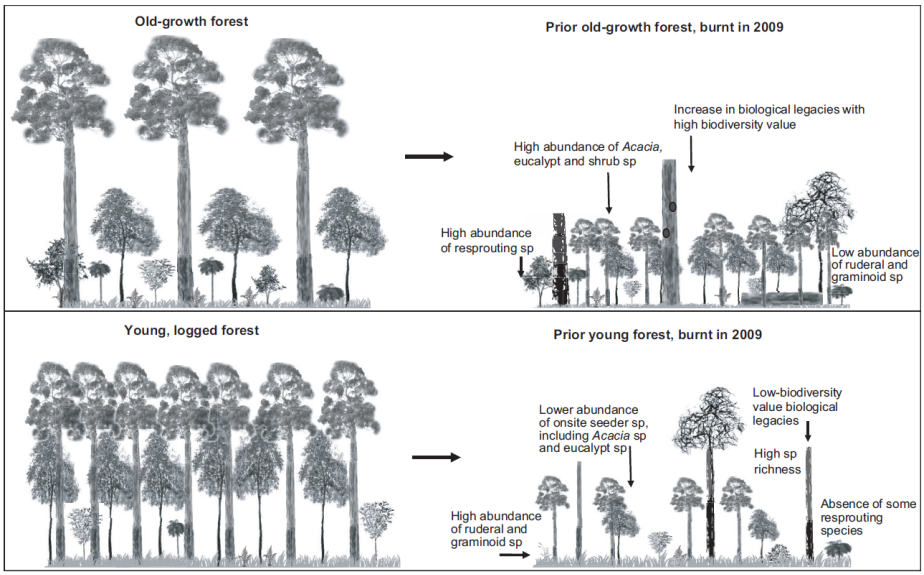

Figure 2. *Differences in forest regeneration after high-severity wildfire (right of diagram), in old-growth forest (top), compared to young post-logging forest (bottom). Image: Bowd, Blair, Lindenmayer (2021).*

We found that the age and condition of the vegetation (prior disturbance history) at the time a high severity fire occurred, affected how the vegetation recovered and the resources available to wildlife. There was more advanced recovery for eucalypts, Acacia and various shrub species in the forests that were older at the time they were burnt, with recovery vegetation slow after fire in young logged forest. The older forests had greater variation in vegetation structure than the young forests, and this structural variation provided habitat and resources for other forest species post fire (Figure 2). For example, fire helped create hollows in older trees, but this does not occur in young forests.

We found that the type of logging conducted impacted the recovery of the understory vegetation after fire. Sites subjected to post-fire salvage logging had a lower diversity and abundance of Acacia species and shrub species. Some important shrub and tree species were also absent from sites that had been salvage logged including *Acacia obliquinervia, Acacia frigescens, Cassinia arcuealta, Olearia argophylla, Pimelea axiflora, Polyscias sambucifolia*, and *Prosanthera melissifolia*. Salvage logged sites also had the lowest overall richness of seedlings, relative to clear-cut and unlogged burnt forests of the same age.

Post fire salvage logging is a higher intensity disturbance than clear-cut logging, with the heavy logging machinery killing many seedlings as they emerge after a fire. Seedling emergence is a key indicator of the recovery of forest ecosystems post disturbance and is important for predicting long-term responses to future altered disturbance regimes.

There are differences in the plant species present in Alpine Ash and Mountain Ash forests. However, we found they responded to disturbance in a similar way, and

LEFT: Greater glider. Image Steven Kuiter

Key findings (continued)

they had similar rates of post-wildfire recovery. These means that management implications may be broadly similar across these two forest types.

Forests that are subject to multiple disturbances within a short time may be vulnerable to declines in the abundance of eucalypts and Acacia species that reproduce by seed (obligate seeders). For example, Mountain Ash trees need to be at least 20 years zold to be sexually mature and begin producing seed.

Above and below ground responses

Fire and logging disturbance in these forests alters the soil, fungi, and plants, and the inter-relationships between these parts of the ecosystem. We found that 43% of total disturbance effects are indirect, such that an ecosystem can appear to be recovering above ground, but this may not be the case below ground. Indirect impacts are mediated by plant-soil-microbial interactions.

Overall, we have found that logging was associated with more negative effects on the soil than fire. Clear-cut logging and post-fire salvage logged sites had lower soil microbial diversity, lower soil carbon, phosphorous and potassium than sites that had only been burnt. The soil at sites that had been salvage logged was more negatively affected than soils at sites that had been clear-cut.

Clear-cut and salvage logging both involve physical disturbance of the ground, and post-logging burning consumes much of the remaining slash and debris instead of it contributing to the leaf litter layer, which eventually breaks down into the soil. We also found that the large declines in tree ferns, trees and shrubs in salvage logged forests also had indirect effects on the soil microbial community.

Arboreal marsupial responses to changes in landscape cover

Our data from the past 23 years shows that changes at both the site and landscape scale have had negative impacts on arboreal marsupials. The site occupancy for Leadbeater's possum has halved since 1997, and is now below 10%. Some sites that were previously occupied, now have no possums. In 1997 we used to detect greater gliders at 64% of our monitoring sites, but this declined to 16% in 2019–2020.

We have found a strong positive correlation with the number of hollow bearing trees and the likelihood of occurrence for the greater glider, Leadbeater's possum, and mountain brushtail possum. The abundance of very large old trees with hollows is declining very rapidly. It has halved since 1997, and is on track to be 10% of what it was by 2030. Large trees with hollows are part of the forest that takes the longest to be recruited, but are pivotal for arboreal marsupials. We have also found that greater glider occupancy decreases as the amount of fire in the landscape increases.

Implications

Alpine and Mountain Ash forests are at risk from predicted increases in fires at decreased time intervals. If the spatial extent of fires increases this will have a major impact on high conservation value areas and biodiversity.

At smaller scales, there is a need for land management reform, especially in areas distant from human settlements. Logging and the creation of young flammable stands of trees can contribute to fire risk, such that the areas of old growth (which is less prone to high severity fire) needs to be expanded to limit the risk of megafires.

Demands for more burning, such as through additional prescribed or hazard reduction fires, in these ecosystems would be inappropriate. Mountain and Alpine Ash forests need less, rather than more fire if they are to recover. Fire recurring after a short period of time could result in these ecosystems being replaced by Acacia woodlands, that would store less carbon, generate less water for human consumption, and fail to provide suitable habitat for a wide range of forest species.

It is important to limit anthropogenic disturbance of these forests, especially logging, if we want to conserve forest dependent threatened species in these ecosystems. Crucially, we need to protect the existing hollow-bearing old trees present in these forests, and we need to protect regrowth forest, so that it eventually becomes old forest that supports nesting resources. Frequent disturbance may erode the

LEFT: Conducting ecological surveys in the Victorian Mountain Ash Forests. Image ANU.

Implications (continued)

resilience of forests to additional high-severity wildfire.

Our research has indicated that management recommendations may be broadly applicable to both Alpine Ash and Mountain Ash forests. However, further consideration is required in early successional stands, where differences in species composition between forest types may have implications for some aspects of management (e.g. increases in flammability).

The below-ground component of ecosystems also needs to be considered in the management of these forests. Soil microbes play a key role in carbon and nitrogen cycling, and the regulation of plant growth.

Material cited

Bowd, E.J., Banks, S.C., Bissett, A., May, T.W. and Lindenmayer, D.B. (2021) Direct and indirect disturbance impacts in forests. *Ecology Letters*, 24: 1225-1236. https://doi.org/10.1111/ele.13741

Bowd, E.J., McBurney, L., Blair, D.P. and Lindenmayer, D.B. (2021) Temporal patterns of forest seedling emergence across different disturbance histories. *Ecology and Evolution*; 11: 9254– 9292. https://doi.org/10.1002/ece3.7568

Bowd, E.J , McBurney, L. and Lindenmayer, D.B. (2021) Temporal patterns of vegetation recovery after wildfire in two obligate seeder ash forests. *Forest Ecology and Management*, Volume 496, 2021, https://doi.org/10.1016/j.foreco.2021.119409

Bowd, E. J., Blair, D. P., and Lindenmayer, D. B. (2021) Prior disturbance legacy effects on plant recovery post-high-severity wildfire. *Ecosphere* 12(5):e03480. 10.1002/ecs2.3480

Cary C.J., Blanchard W, Foster C.N. and Lindenmayer D.B. (2021) Effects of altered fire intervals on critical timber production and conservation values. International *Journal of Wildland Fire* 30, 322-328. https://doi.org/10.1071/WF20129

Lindenmayer, D., Bowd, E., Taylor, C. and Likens, G.E. (In Press) Interacting Fire, Logging and Climate Change has Sprung a Landscape Trap in Victoria's Montane Ash Forests. *Plant Ecology* https://doi.org/10.21203/rs.3.rs-559747/v1

Lindenmayer, D.B., and Taylor, C. (2020) New spatial analyses of Australian wildfires highlight the need for new fire, resource, and conservation policies. Proceedings of the National Academy of Sciences DOI: 10.1073/pnas.2002269117

Lindenmayer, D.B., and Taylor, C. Extensive recent wildfires demand more stringent protection of critical old growth forest (2020). Pacific *Conservation Biology,* 26, 384–394. doi.org/10.1071/PC20037

Lindenmayer, D.B., Blanchard, W., Blair, D., McBurney, L., Taylor, C., Scheele, B.C., Westgate, M.J., Robinson, N. and Foster, C. (2021), The response of arboreal marsupials to long-term changes in forest disturbance. *Animal Conservation*. https://doi.org/10.1111/acv.12634

Taylor, C. and Lindenmayer, D.B. (2020) Temporal fragmentation of a critically endangered forest Ecosystem. *Austral Ecology*, 45, 340–354. doi:10.1111/aec.12863

VicForests Timber Release Plan (Including Approved Changes) September 2021. *VicForests* https://www.vicforests.com.au/static/uploads/files/vicforests-trp-including-approved-changes-2021-wfbggenyyswt.pdf

Further Information

David Lindenmayer - david.lindenmayer@anu.edu.au

Threatened Species Recovery Hub

National Environmental Science Programme

Cite this publication as NESP Threatened Species Recovery Hub. 2021. Long term monitoring of ecosystem fragmentation and disturbance in Victorian Alpine Ash and Mountain Ash forests. Project 3.3.2 Research findings factsheet.

This project is supported through funding from the Australian Government's National Environmental Science Program.