Science for Saving Species

Research findings factsheet

Project 3.3.2

Threatened Species Recovery Hub

National Environmental Science Programme

Implications of the rapid loss of large old hollow-bearing trees in Victorian Mountain Ash forests

What do we mean by forest age class?

Forest age is often used a proxy for measuring condition of Mountain Ash forests. Forest age impacts on the range and value of ecosystems services the forest provides, including water, carbon, timber, aesthetics and biodiversity.[9] The oldest forest age classes in the Central Highlands system include old growth and regrowth following the 1939 fires (commonly known as 1939 regrowth). These have a significantly higher abundance of hollow-bearing trees than younger regrowth areas.

What are large old trees and why are they so important?

Large old trees are keystone structures in many ecosystems around the world. They are termed keystone structures because of their disproportionate ecological value relative to the area they occupy.[1] They are characterized by features not found in smaller, younger trees like hollows, large lateral branches, buttresses, and extensive canopies with large numbers of flowers.[2]

Large old hollow-bearing trees provide vital habitat for cavity-dependent animals such as Leadbeater's Possum and other species of arboreal marsupials.[3,4] They also play a critical role in the structure of Mountain Ash forests of different ages, including influencing the amount of carbon that is stored in these forests,[5] and in key ecological processes like nutrient cycling (e.g. storing large amount of carbon).[2] This Fact Sheet focusses on the many ecological values of large old hollow-bearing trees in Mountain Ash forests in the Central Highlands of Victoria, where populations of these key structures are declining rapidly.[6,7]

The Mountain Ash forests in Victoria form an ecosystem of competing and contested land uses, most prominently water provisioning, tourism, biodiversity conservation, and timber harvesting. Decisions about land use in this system, and in particular the allocation of forest coupes to logging, come under the auspices of the Regional Forest Agreement, which is under negotiation. The current agreement is scheduled to expire in 2018.

The condition of a native forest is an indication of the ecosystems services it can provide. Both water provisioning and biodiversity values are directly dependent on the presence of large old trees, and the ecosystems they support, while large old trees store carbon, and recreational and aesthetic values also benefit from their presence.[8] There are two main types of disturbance in Mountain Ash forests which impact on the condition of the forest ecosystem, including the abundance and condition of large old trees: logging and fire. Climate change also represents a growing risk to the system.

Image: Large Mountain Ash, Toolangi, Victoria. Photo: David Blair

Australian National University

Researching the condition of large old trees

Intensive studies of the Mountain Ash forests of the Central Highlands of Victoria over the past 35 years highlight changes in the condition and abundance of large old trees in the system. This includes:

1. repeatedly reassessing the condition and decay status of a marked population of these trees on long-term sites (e.g. whether trees have declined or not),
2. tracking radio-collared animals to large old trees used as den trees during the day,
3. repeated surveys of the occurrence of arboreal marsupials and birds on long-term field sites,
4. studies quantifying relationships between the occupancy of large old hollow-bearing trees by arboreal marsupials and the measurable characteristics of those trees (e.g. diameter, height, decay state),
5. measuring and estimating the amount of carbon stored in trees of different sizes and ages, and
6. exploring relationships between the abundance of hollow-bearing trees at a site and environmental factors (e.g slope and aspect) as well as natural disturbances (e.g. fire) and human disturbances (i.e. logging).

Most of these studies are based on a long-term dataset comprising more than 160 permanent field sites with a marked population of large old hollow-bearing trees.

Image: Leadbeater's Possum is dependent on tree hollows and prefers hollows in very old trees. Photo: D Lindenmayer and M Greer

Where are large old hollow-bearing trees most likely to occur?

Large old hollow-bearing trees in Mountain Ash forests are most likely to be found in reserves and closed water catchments where there is little or no history of past timber harvesting.[6,10] They are also more likely to be found in old growth stands, where there has not been recent fire and in wetter parts of the landscape.[6]

Recent (currently unpublished) work has indicated that changes in the composition of the landscape also influence the abundance of large old hollow-bearing trees, with significantly fewer trees likely to be found on sites where there has been extensive fire and extensive logging in the surrounding landscape.

The formation of large old hollow-bearing trees

A hollow-bearing tree is defined as any tree that contains an obvious cavity or hollow – as determined by visual inspection using a pair of binoculars. Researchers routinely measure the diameter, height and decay state of large old hollow-bearing trees in Mountain Ash forests to understand their condition, age and suitability as habitat for various hollow-dwelling species.[7]

Mountain Ash trees typically begin to develop cavities at approximately 120 years.[11] Trees with cavities generally suitable for occupancy by arboreal marsupials are approximately 190 years old (as determined by relationships between tree diameter and tree age).[3]

How do cavity-dependent arboreal marsupials use large old hollow-bearing trees?

Some species of arboreal marsupials in Mountain Ash Forests such as Leadbeater's Possum spend up to 75% of their lives within a cavity inside a large old hollow-bearing tree.[12,13] Almost all species swap regularly between different hollow-bearing trees with these trees sometimes located several hundred metres apart.[14-16] In addition, different species of arboreal marsupials typically have different nest tree requirements, e.g. trees typically occupied by Leadbeater's Possum will have different characteristics than those occupied by the Greater Glider.[4,12] Some species maintain very long-term use of a given set of large old trees, sometimes exceeding a decade or more.[12,17]

Image: ANU Researchers checking Nestboxes in a Mountain Ash regrowth forest. Research is testing the performance of nest boxes used to provide artificial tree hollows Photo: Lachlan McBurney

Image: Mountain Brushtail Possums use this stag hollow - which bears their tracks. Photo: David Blair

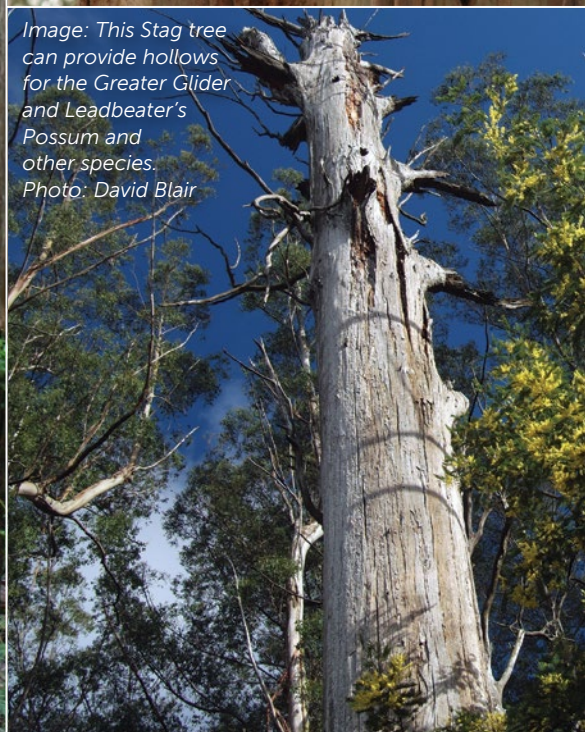

Image: This Stag tree can provide hollows for the Greater Glider and Leadbeater's Possum and other species. Photo: David Blair

Factors threatening large old hollow-bearing trees

Several processes are threatening populations of large old hollow-bearing trees in Mountain Ash forests.

Logging

Logging is a key driver of human disturbance to the Victorian Mountain Ash Forest ecosystem. Native forest logging has long history in the Central Highlands, beginning in the 19th century with selective logging, and intensifying through the 20th century. The system continues to be a major source of native hardwood ash and mixed species timber. Clearfelling has been the conventional method of logging in the region over the last 40 years, with 15-40 ha of saleable trees cleared in a single operation.[18]

Logging impairs the development of large old hollow-bearing trees because the rotation time between harvesting operations means that trees are cut down before they develop hollows.[7] A recent study has shown that the abundance of large old hollow-bearing trees is significantly lower in logged and regenerated forests, most likely because the highest rates of collapse of these trees occur in places subject to past timber harvesting operations.[6]

Fire

Fire is the primary form of natural disturbance to the Victorian Mountain Ash Forest ecosystem. High-severity fire can kill large living old hollow-bearing trees, with highly decayed trees most at risk of being consumed. Wildfire has the potential to change the stand structure (the unique assemblage of trees) of a forest. The impact of fire on the stand structure of a forest is linked to the age of the forest at the time it is burnt.[18]

In old growth forests that experience a fire, the large old trees will become large dead trees or fire-scarred living old trees. These trees are an important source of nesting habitat for a wide variety of species which depend on the availability of suitable tree hollows such as Leadbeater's possum.[19] In young burned forest, this nesting habitat does not develop because trees with a small diameter are unable to remain standing long after they are burned, and they lack the wood volume to develop hollows of a suitable nesting size for native species.[20] When fires occur in rapid succession they destroy young trees, which are unable to reach maturity and produce seeds to maintain their population, resulting in the loss of Mountain Ash trees and a change to the composition of species in a forest.[21]

Fire and logging interactions

Fire and logging also interact to affect the abundance of hollow-bearing trees. This is because forest areas regenerated after logging have a significantly elevated risk of burning at high severity than old growth forests, with fire in turn killing and/or consuming trees on burned sites.[7,22] Logging can exacerbate the risks and impacts of fire disturbance to the survival of mountain ash trees in two ways. First, salvage logging is undertaken in burned forests, where operations aim to salvage fire-damaged trees which may still have some economic value.[23] Second, conventional clearfelling methods use artificial stand regeneration practices (planting of seeds or seedlings) after harvesting timber to create young stands of dense regrowth forest.[18] These artificial stands are at high risk of re-burning in a high severity fire.[22]

The result of the interactions between logging and fire could lead the Mountain Ash forest to become caught in a 'landscape trap',[24] i.e. a positive feedback loop where the planting of young trees post-logging increases the risk of re-burning of the forest at a high severity.[22] If young trees are unable to reach maturity and maintain their population, it could create irreversible changes in the patterns of forest disturbance dynamics, forest cover, landscape pattern, and vegetation, potentially leading to a regime shift.[24]

This regime shift would be categorised by the development of vegetation cover dominated by wattle species (Acacia spp.), because Mountain Ash is maladapted to altered landscape conditions created by recurrent logging and wildfire.[24] This shift would negatively impact ecosystem services including carbon storage, water production, and biodiversity conservation. The impact on tree hollow dependent species of fauna would be significant; large old hollow-bearing trees are far less abundant in forests subject to clearfelling than those that only are burned.[18]

Climate Change

Climate change is another key process threatening populations of large old hollow-bearing trees in Mountain Ash forests. The extreme temperatures and depressed rainfall associated with the Millennium Drought killed over 14% of the measured population of large old hollow-bearing trees between 2006 and 2009.[7] There is also increasing evidence that climate change is negatively affecting the germination and subsequent survival of Mountain Ash trees.[25,26]

How severe is the decline of large old hollow-bearing trees?

Analysis of a collection of datasets from field surveys of marked populations of large old hollow-bearing trees, which has been repeated since 1983, has shown a highly significant and very rapid decline in populations of large old hollow-bearing trees in Mountain Ash Forests. Analyses from one of our datasets has revealed that 41% of large old hollow-bearing trees standing in 1997 had collapsed by 2015. Our initial sample of trees in 1997 contained no collapsed trees, yet by 2015, a total of 57% of large old hollow-bearing trees had collapsed on young-aged forest sites. The equivalent values for old-growth sites, 1939 aged sites, and mixed aged sites were 16%, 53% and 26%, respectively.[6]

More recent work indicates that even on unlogged and unburned sites, rates of collapse of large old hollow-bearing trees are significantly elevated by the amount of burned and/or logged forest in the surrounding landscape. Thus, the increasing amount of logged or burned forest in the surrounding landscape has a cumulative effect on the rates of loss of large old hollow-bearing trees in the wood production zones of Mountain Ash forest.

Large old hollow-bearing trees are becoming increasingly scarce throughout large parts of the Mountain Ash forest estate. For example, from the dataset of our 166 long-term field sites in 2015, approximately, 50% of sites supported two or fewer large old hollow-bearing trees; there were no such trees on 27 sites, only one large old hollow- bearing tree on 28 sites, and two large old hollow-bearing trees on 25 sites.[6] Other datasets such as those gathered by the Victorian Government show a similar scarcity of large old hollow-bearing trees in large parts of the Mountain Ash forest estate.[27]

This shortage of large old hollow-bearing trees is exacerbated by the fact that only 1.16% of the Mountain Ash forest estate is old growth (where the abundance of large old hollow-bearing trees is typically greatest).[7,28]

Current projections suggest that by 2040, even without further disturbance, populations of such trees will be less than 10% of what they were in 1997. These projections are based on measurements of the rate of decay and collapse of large old hollow-bearing trees alone. The projections assume no fire, no additional logging, and no effects of logging in the surrounding landscape on the loss of large old hollow-bearing trees.

Image: Even when retained withing logging coupes, large old trees can be killed by surrounding logging operations. Photo David Blair

Can artificial cavities (e.g. nest boxes) assist with the conservation of cavity-dependent animals?

Several studies have explored the potential for artificial cavities to provide a conservation solution for cavity-dependent species in Mountain Ash Forests given the catastrophic declines in large old hollow-bearing trees. Long-term work using nest boxes has shown that some species, including Leadbeater's Possum will use artificial hollows, while other species (e.g. the Greater Glider) do not use nest boxes.[30,31]

Nest boxes will likely be an important part of attempts to conserve cavity-dependent species in Mountain Ash forests in the future. However, there are critical issues to consider if nest boxes are to be employed as a conservation strategy.

First, it makes little sense to invest substantial amounts of effort and money in establishing nest boxes when existing large old hollow-bearing trees are not appropriately protected (by buffers of unlogged forest) and therefore continue to be lost.

Second, nest boxes have a limited effective lifespan and need to replaced regularly (e.g. every 5+ years).[30]

This means that many cycles of replacement and re-establishment are needed to bridge the prolonged temporal gap in which the comparatively young stands of trees which currently dominate Mountain Ash landscapes, will develop into stands of large old hollow-bearing trees. As a result, a prolonged commitment to a nest box program can be both logistically challenging over large areas as well as extremely expensive (see [32] for an example in an Australian woodland environment). Indeed, McKenney and Lindenmayer[33] estimated that in Mountain Ash forests, the recurrent costs of a nest box program could outweigh the costs of leaving trees standing in the forest.

Third, whilst nest boxes can play an important role in the conservation of some species of cavity-dependent animals, they clearly do not have many of the other key ecological roles of large old hollow-bearing trees such as in nutrient cycling, flowering, seed dispersal and affecting patterns of genetic variability in tree populations.[34]

Image: Old growth Mountain Ash forest in the O'Shannassy catchment. Photo: David Blair

Impacts of the loss of large old hollow-bearing trees

There are many important implications of the rapid decline in large old hollow-bearing trees within Mountain ash forests.

First, declines in the populations of cavity-dependent arboreal marsupials will occur due to the loss of key nesting habitat. Indeed, recent analyses suggest that there has been a decline in site occupancy by species such as Leadbeater's Possum and the Greater Glider, in part because of the loss of hollow-bearing trees.

Second, the loss of large old hollow-bearing trees is a reduction in the amount of carbon stored in Mountain Ash forests. This is, in part, because large old hollow-bearing trees store a disproportionately large amount of carbon relative to smaller stems in the same stand.[5]

Finally, old growth forests are where large old trees are most prevalent. Old growth forests are also the areas which produce the greatest volumes of water for human consumption.[29]

The loss of large old hollow-bearing trees was one of the factors which underpinned the Critically Endangered status of the Mountain Ash ecosystem under the IUCN Red Listed Ecosystem assessment completed for this ecosystem by Burns et al.[18]

Strategies to protect existing and recruit new hollow-bearing trees

Several strategies are required to protect remaining populations of large old hollow-bearing trees in Mountain Ash Forests. These strategies will also promote the establishment of new populations with succession of young trees to large old hollow-bearing trees.

Establishing buffers

Existing trees could be better protected by establishing buffers of unlogged forest around these trees. These buffers need to be large (an estimated 100m radius around a given tree) because of the effects of logging in the surrounding forest on accelerated tree-fall.

Improving streamside reserves

Widening streamside reserves will help protect existing trees because this is where large old trees are often most abundant. Protecting trees within streamside reserves would also promote the protection of other values such as water quality.

Establishing large reserves

A strategy to protect populations of existing large old trees is to set aside large areas of ecological reserves, as we have demonstrated that such places are where populations of large old trees tend to be greatest.[6]

Withdrawing forest from timber harvesting

Ensuring that large areas of forest are withdrawn from timber harvesting and grown through to an old growth forest stage will help recruit new populations of large old hollow-bearing trees.[35,36] This approach to expand the size of the old growth estate has the added advantage of moving the Mountain Ash ecosystem to a less fire-prone state than the currently young-aged dominated landscape.[22]

Image: Yellow-bellied Gliders (Petaurus australis) depend on tree hollows. Photo: David Cook CC BY-NC 2.0_Flickr

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Threatened Species Recovery Hub

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