



## Ashes to ashes: increased fire frequency threatens alpine ash forests

Alpine ash (*Eucalyptus delegatensis*) is the dominant tree species in the iconic Australian Alps bioregion. It needs fire for its seed to germinate but high-severity fire can kill adult trees.

Since 2002, most of the bioregion has been burnt by several very large fires, in line with the regional trend of more frequent extreme fire weather. High-severity fires have removed 25% of above-ground tree biomass (leaves, branches, bark) and killed adult trees, triggering mass regeneration. When two severe fires occurred in quick succession, 97% of the highly flammable regenerating young trees were killed in the second fire.

If high-severity fires continue to occur more frequently, fewer trees will reach the reproductive stage and much of the remaining mature alpine ash forest in the alps will be lost.

## Research outcomes

- » We documented abrupt changes to populations of alpine ash in the Australian Alps bioregion as a result of multiple high-severity fires.
- » The cause of the recurrent fires is unclear, but is consistent with climate change. We are doing further work to determine if this fire activity is unprecedented.
- » This work provided the intellectual background for a unique landscape intervention implemented in the Victorian Alpine National Park in mid-2013: aerial re-seeding of burnt alpine ash forests. The intervention was a response to a fire in February 2013 that burnt alpine ash forests for the third time in the last decade in the Harrietville area.

## Why did we do this study?

### Severe fires are becoming more frequent

Climate change is projected to lead to more frequent severe fire weather, outside the range of historical variability. More frequent severe fire weather could lead to more frequent severe fires.

### Alpine ash is particularly vulnerable

Alpine ash, which is endemic to the Australian Alps, is identified as being particularly vulnerable to increased fire frequency.

Alpine ash is an 'obligate seeder' — a fire-dependent plant that is readily killed by fire but regenerates prolifically from seed after fire and matures rapidly so that it can reproduce before the next fire. Trees can reproduce after 20 years, can live for more than 200 years, and can reach 90 metres in height. Mature trees can tolerate low-intensity fires due to the thick bark on the lower third of the trunk.

Plants are not adapted to fire, per se; rather, they are adapted to fire regimes, which are characterised by the frequency, intensity, seasonality and type (for example, surface or crown) of fire. The life cycle of obligate seeders is coordinated around the fire-free intervals of the fire regime to which they are adapted. If their life cycle gets out of sync with the fire regime, they may not survive. More frequent severe fires could prevent regenerating young plants reaching maturity, resulting in landscape-wide loss of obligate-seeder forests around the world, including the alpine ash forests in the Australian Alps bioregion. This transformation in the landscape may be irreversible because, as the mature trees die, the altered understorey becomes more flammable (the regenerating trees being highly flammable).

Also, when mature trees burn, the carbon stored in the trees is released into the atmosphere.

## What did we do?

The recent extensive fire activity in the Australian Alps bioregion gave us an unparalleled opportunity to examine and document the effects of two severe fires in quick succession on an obligate-seeder forest. We sampled alpine ash forests with contrasting recent fire histories and determined the effect of a short interval between high-severity fires on:

- tree populations
- the composition and structure of fuel (fuel arrays)
- the amount of carbon stored in the trees.

## How did we do it?

We compiled fire maps, satellite data and observations to show which areas had been burnt by large wildfires, and in which years.

We selected and sampled sites in alpine ash forest with contrasting fire histories for the last decade. We selected 10 sites that had not been burnt by high-severity fire, 10 sites that had been burnt once and 10 sites that had been burnt twice. For each site, we measured the amount of fuel, and the density and size of tree stems. From this, we calculated the amount of stored carbon.

# 43%

Since 2002, high-severity fires have occurred across 43% of the geographic range of alpine ash. These burnt forests are vulnerable to further fire.

## What did the results tell us?

### 84% of the bioregion's alpine ash has been burnt since 2002

Since 2000, almost 90% of the Australian Alps bioregion has been burnt by large wildfires.

These fires have burnt 84% of the bioregion's 355,727 hectares of alpine ash forest, with 65% burnt in 2002/2003 in the north of the bioregion, 30% burnt in 2006/2007 in the south, and a smaller area (2%) burnt in 2009. Four per cent of the forest area was burnt twice within five years. Fire severity was high (canopy entirely scorched) in about half of the burnt area of alpine ash forest.

### Fire results in more biomass but less fuel

In stands of trees that had been burnt only once, the biomass of woody understorey plants was more than six times greater than in unburnt stands, and in stands that had been burnt twice it was more than double, largely due to prolific regeneration of alpine ash and acacias. However, the burnt stands had much less fine fuel (leaves, twigs and bark) and coarse fuel (dead wood) on the ground.

### Alpine ash is sensitive to increased fire frequency

Since 2002, high-severity fires have occurred across 43% of the geographic range of alpine ash and, because many of the adult trees were killed, these burnt forests are now at an immature life stage and vulnerable to further fire.

Typically, a few mature trees had survived a single fire, and these trees are now a seed source should the regenerating stands be burnt. The young trees we observed would have grown from the seeds of these remaining mature trees. A second fire caused severe attrition of regenerating trees, with 97% fewer young trees in twice-burnt than in once-burnt areas.

These results demonstrate that, as a fire-dependent obligate seeder, alpine ash is sensitive to increased fire frequencies.

### The future looks grim for the bioregion's alpine forests

Under rapid global warming, which is likely to increase fire frequency, it is hard to be optimistic about the long-term survival of the bioregion's remaining mature alpine ash forests. Large areas of regenerating alpine ash stands may not have time to reach maturity before they too are killed by fire. Worryingly, regenerating tall eucalypt forests are more prone to fire than mature stands.

## 36 million tonnes of stored carbon were lost in two fires

We estimated that in the 2002/2003 and 2006/2007 fires there was a combined loss of about 36 million tonnes of carbon (equivalent to 132 million tonnes of carbon dioxide), representing 25% of the total amount of carbon stored in above-ground biomass in mainland alpine ash forests.

### Alpine ash forest



## Where to from here?

The cause of the recurrent fires in the last decade is unclear, but is consistent with climate change. We are doing further work to determine if this fire activity is unprecedented.

Carefully designed management interventions are required to limit or reverse the demographic collapse of alpine ash forests due to more frequent fires.

In 2013, Parks Victoria undertook extensive aerial sowing of seeds in the Harrietville area where alpine ash was burnt multiple times within 10 years. Such large-scale interventions are difficult and expensive to implement because of the rugged terrain and limited mature trees from which to obtain seed.

The regenerating seedlings will also be susceptible to heat, drought and fire during the next few decades. We have negotiated with Parks Victoria to scientifically evaluate the Harrietville aerial re-seeding intervention. Our evaluation will support the development of evidence-based policy to best manage these forests.

## Who are the researchers?

Professor David Bowman



David is Professor of Environmental Change Biology at the School of Plant Science, University of Tasmania. His research is focused on the ecology, evolution, biogeography and management of Australian forested landscapes.

Prof David Bowman  
P: 03 6226 1943  
E: David.Bowman@utas.edu.au

Dr Brett Murphy



Brett is a fire and vegetation ecologist at the University of Melbourne and a research fellow with the NERP Environmental Decisions Hub. He collaborated with the Vegetation and Fire Project team in the Landscapes and Policy Hub, focusing on the Australian Alps and the processes that have shaped alpine vegetation.

Dr Brett Murphy  
P: 03 8344 3324  
E: Brett.Murphy@unimelb.edu.au

## Further reading

Bowman D, Murphy BP, Neyland D, Williamson GJ & Prior LD (2013) Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests, *Journal of Global Change Biology*, Vol. 20, No. 3, pp. 1008–15. [doi:10.1111/gcb.12433](https://doi.org/10.1111/gcb.12433)

## About the NERP Landscapes and Policy Hub

The Landscapes and Policy Hub is one of five research hubs funded by the National Environmental Research Program (NERP) for four years (2011–2014) to study biodiversity conservation.

We integrate ecology and social science to provide guidance for policymakers on planning and managing biodiversity at a regional scale. We develop tools, techniques and policy options to integrate biodiversity into regional-scale planning.

The University of Tasmania hosts the hub.

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