



Photo: Sam Wood

Eucalypt forests of temperate Australia: a landscape set to transform

- In eucalypt forests in temperate regions of Australia, the optimal mean annual temperature for tree growth is around 11 °C. Above or below this temperature, growth is slower. Large trees are especially affected above this temperature.
- Most of Australia's temperate eucalypt forests already grow in temperatures higher than the optimal. With the projected temperature rise of 3 °C by 2070, tree growth rates in these forests are likely to drop substantially (by 22%), as is the amount of carbon stored.
- As growth rates drop, trees will recover more slowly from wildfire and landscapes could transform.

Research summary

The rate at which a tree grows affects the character of the landscape and has implications for forestry, conservation, fire management and carbon storage.

We examined the relationship between climate and tree growth for eucalypt forests in temperate regions of Australia and found that the optimal mean annual temperature for tree growth is around 11 °C. Above or below this temperature, growth is slower. Large trees are especially affected above this temperature.

Most of Australia's temperate eucalypt forests already grow in temperatures higher than the optimal. By 2070, with the projected 3 °C rise in temperature and without any change in rainfall, tree growth rates in these forests are likely to drop substantially, as is the amount of carbon stored.

As growth rates drop, trees will recover more slowly from wildfire and the landscapes could transform. There are likely to be fewer very large trees.

The tree growth – climate relationship

With global warming, trees are likely to grow faster in cold climates and slower in warm climates, but few studies have tested this proposition at the continental scale.

The aim of this study was to correlate tree growth with climate at the continental scale. We examined the relationship between tree growth and water availability and temperature in eucalypt forests throughout temperate Australia. We focused on eucalypts because they grow in a wide variety of climates.

We compiled half a million measurements of growth in tree diameter, collected from 2409 permanent plots in native forests (not plantations). These plots have been established by forest management agencies since the 1930s and experience climates ranging from cool temperate wet to subtropical. Average annual rainfall ranges from 558 mm to 2105 mm and average annual temperature ranges from 6 °C to 22 °C.

High rainfall is good for growth, to a point

We found that trees receiving moderate rainfall grow faster with higher rainfall, but with a diminishing response above 1400 mm/year.

Optimal mean annual temperature is 11 °C

We found growth rates are optimal at mean annual temperatures of around 11 °C. Lower temperatures limit growth by slowing down the tree's metabolism. High temperatures limit growth largely by increasing evaporation, which reduces water availability. They also have a direct negative effect — as the

temperature rises, respiration increases faster than photosynthesis, leading to less growth at high temperatures.

Large trees are most affected

As the climate warms, large trees will be affected more than small trees because they have proportionately less foliage for photosynthesis. And because their hydraulic system has to draw water further, to the top of the canopy, large trees are also especially vulnerable to drought stress, which is made worse by high temperatures.



Tree growth and climate change: We compiled half a million measurements of growth in tree diameter. Photo: Sam Wood



Slower tree growth: As growth rates drop, trees will recover more slowly from wildfire. Photo: Sam Wood

By 2070, trees are likely to grow 22% slower

Most (87%) of Australia's temperate eucalypt forests already experience mean annual temperatures above 11°C, the optimal growing temperature, so overall tree growth rates will drop substantially as the climate warms.

We calculated that by 2070, with the 3°C temperature rise projected under a high emissions scenario, tree growth rates in Australia's temperate forests are likely to fall by 22%, on average.

A transformation is looming

As temperatures rise, we can expect changes in our temperate eucalypt forests.

The forests of the fastest-growing species, such as mountain ash, are among the tallest in the world, and are found in cooler, wetter areas. As the climate warms, less water will be available and fires will become more frequent and intense. Trees will grow more slowly and have shorter average life spans. As a result, the largest trees of the future may never attain the majestic sizes found in today's forests.

The very large species may also gradually be replaced by smaller, slower-growing species.

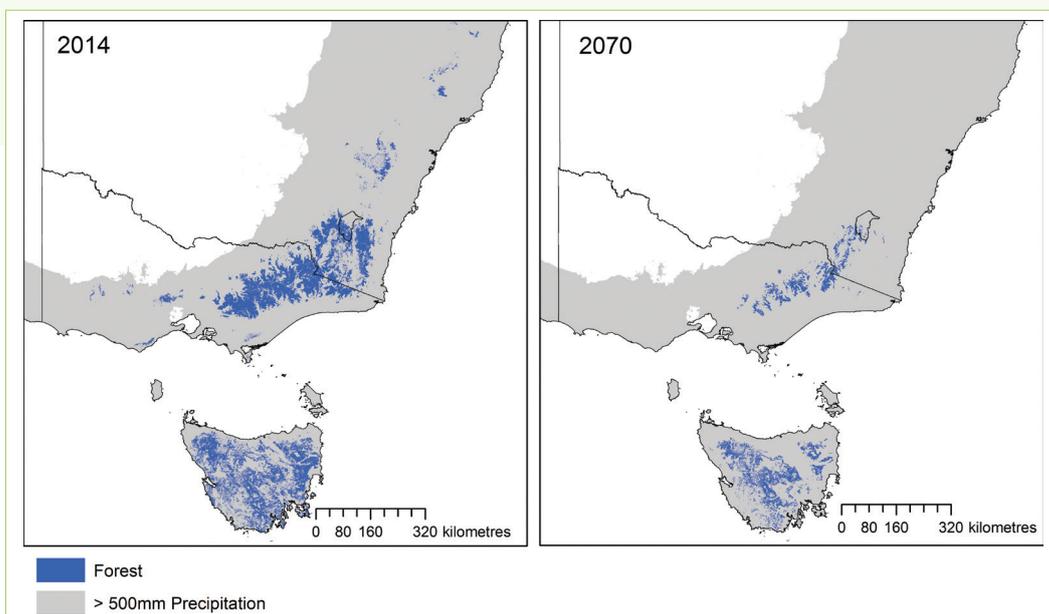
Where to from here?

New plots will give more consistent measurements

The plots we studied were selected according to different criteria and varied in size and measurement time periods. Using funding from TERN (the Terrestrial Environment Research Network), we are establishing a network of permanent one-hectare plots in tall eucalypt forests across Australia to more consistently measure tree growth, tree mortality and carbon stocks.

Fine-scale climate projections allow regional analysis

The fine-scale climate projections for 2070 developed by the Landscapes and Policy Hub allow these relationships between tree growth and temperature to be applied to individual bioregions in temperate Australia.



Forest shrinkage: In Australia's temperate eucalypt forests, the optimal mean annual temperature for tree growth is around 11°C. Under a high-emissions scenario, the area experiencing temperatures less than or equal to this in 2014 (left) is expected to shrink substantially by 2070 (right).

Credit: Grant Williamson

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 landscapes.

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Lynda is an ecologist and research fellow at the University of Tasmania. Tree growth is one of her major research interests.

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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.

www.nerplandscapes.edu.au

Collaborators

This research was supported by TERN, the Terrestrial Environment Research Network.

Collaborators include Dr Grant Williamson and Dr Sam Wood (University of Tasmania), and Dr Rod Keenan (University of Melbourne).

Further reading

Bowman DMJS, Williamson GJ, Keenan RJ & Prior LD (2014) A warmer world will reduce tree growth in evergreen broadleaf forests: evidence from Australian temperate and subtropical eucalypt forests. *Global Ecology and Biogeography*, doi: 10.1111/geb.12171.

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March 2015