Helping Tasmania's tall forests adapt to a warmer climate: An opportunity for forestry to shine?

2023 ANZIF Conference, 15-18 Oct 2023, Tweed Heads

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Forest Knowledge, Molesworth, Tasmania

Forest Knowledge

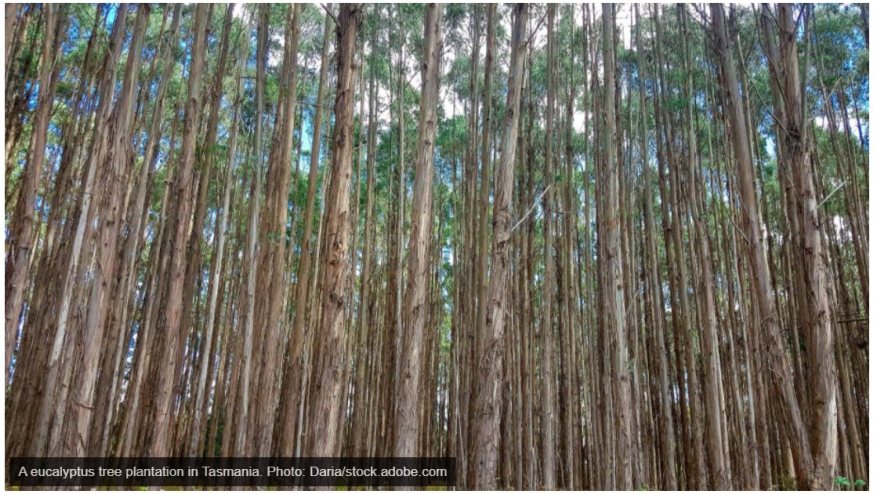
tern
Ecosystem Research Infrastructure

I acknowledge the Palawa people, Traditional Custodians of the land where I live, learn and work and pay my respects to their Elders past, present and emerging.

Is cessation of logging Tasmania's native forests a safe strategy for reducing emissions?

Stopping native forest logging key to getting to net zero

14 OCTOBER 2022



A eucalyptus tree plantation in Tasmania. Photo: Daria/stock.adobe.com

ENVIRONMENTAL RESEARCH
LETTERS

LETTER

Net carbon accounting and reporting are a barrier to understanding the mitigation value of forest protection in developed countries

Brendan Mackey[1,*], William Moomaw[2], David Lindenmayer[3] and Heather Keith[1]

"Keeping trees in the ground where they are already growing is an effective low-tech way to slow climate change."

Submission into the 2021 Review of the Climate Act 2008 by the Tasmanian Government

The Wilderness Society Tasmania pays its respects to the traditional owners of lutruwita/Tasmania, the palaw-pakana peoples and their Elders past and present. We acknowledge lutruwita/Tasmania is sovereign Aboriginal land that was never ceded and that, for land justice to take place, it must be returned to its rightful owners.

Cover photo: Bioluminescence at Eagle Hawkneck, lutruwita/Tasmania, by Mason Clay, with thanks. Increasing presence of bioluminescence around lutruwita/Tasmania is a hallmark of climate change-driven warming seawater.
www.instagram.com/masonclayimagery

Wilderness Society
LUTRUWITA / TASMANIA
Life. Support.

PNAS

Land use strategies to mitigate climate change in carbon dense temperate forests

Beverly E. Law[a,1], Tara W. Hudiburg[b], Logan T. Berner[c], Jeffrey J. Kent[b], Polly C. Buo

So is cessation of native forest logging the safest strategy?.....

Maybe, if the trees stay alive and the productivity of the forest is maintained, or increases

But what if climate change is having an adverse effect on the productivity and health of the tall eucalypt native forests?

A warming climate looks bad for productivity

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014) **23**, 925–934

A warmer world will reduce tree growth in evergreen broadleaf forests: evidence from Australian temperate and subtropical eucalypt forests

David M. J. S. Bowman[1]*, Grant J. Williamson[1], R. J. Keenan[2] and Lynda D. Prior[1]

3°C of warming (by 2070) = 23% reduction in productivity

scientific reports

OPEN

***Eucalyptus obliqua* tall forest in cool, temperate Tasmania becomes a carbon source during a protracted warm spell in November 2017**

Timothy J. Wardlaw

Scientific Reports | (2022) 12:2661 | https://doi.org/10.1038/s41598-022-06674-x nature portfolio

Record heatwave Nov 2017

- Forest switched from C sink to C source
- **GPP reduction**, ER increase
- **No stomatal regulation to reduce water loss**

A warming climate looks bad for productivity

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014) **23**, 925–934

RESEARCH PAPER

A warmer world will reduce tree growth in evergreen broadleaf forests: evidence from Australian temperate and subtropical eucalypt forests

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during a protracted warm spell in November 2017

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A response not previously encountered

Record heatwave Nov 2017

- Forest switched from C sink to C source
- **GPP reduction**, ER increase
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SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES

How close are we to the temperature tipping point of the terrestrial biosphere?

Katharyn A. Duffy[1,2]*, Christopher R. Schwalm[2,3], Vickery L. Arcus[4], George W. Koch[2] Liyin L. Liang[4,5], Louis A. Schipper[4]

Duffy *et al.*, *Sci. Adv.* 2021; **7** : eaay1052 13 January 2021

50% of land carbon sink will cross a temperature tipping point within 20-30 years unless adaptation occurs.

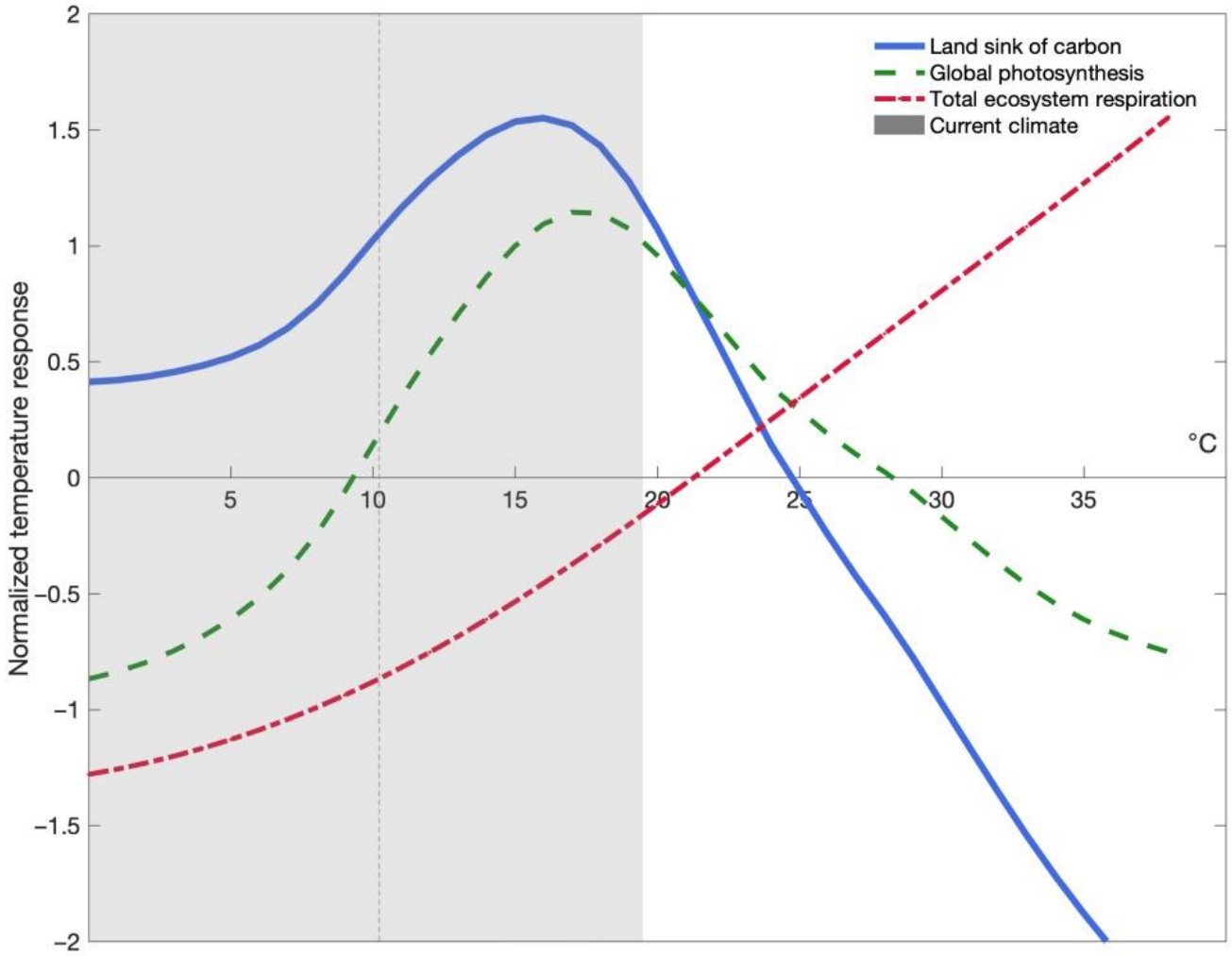
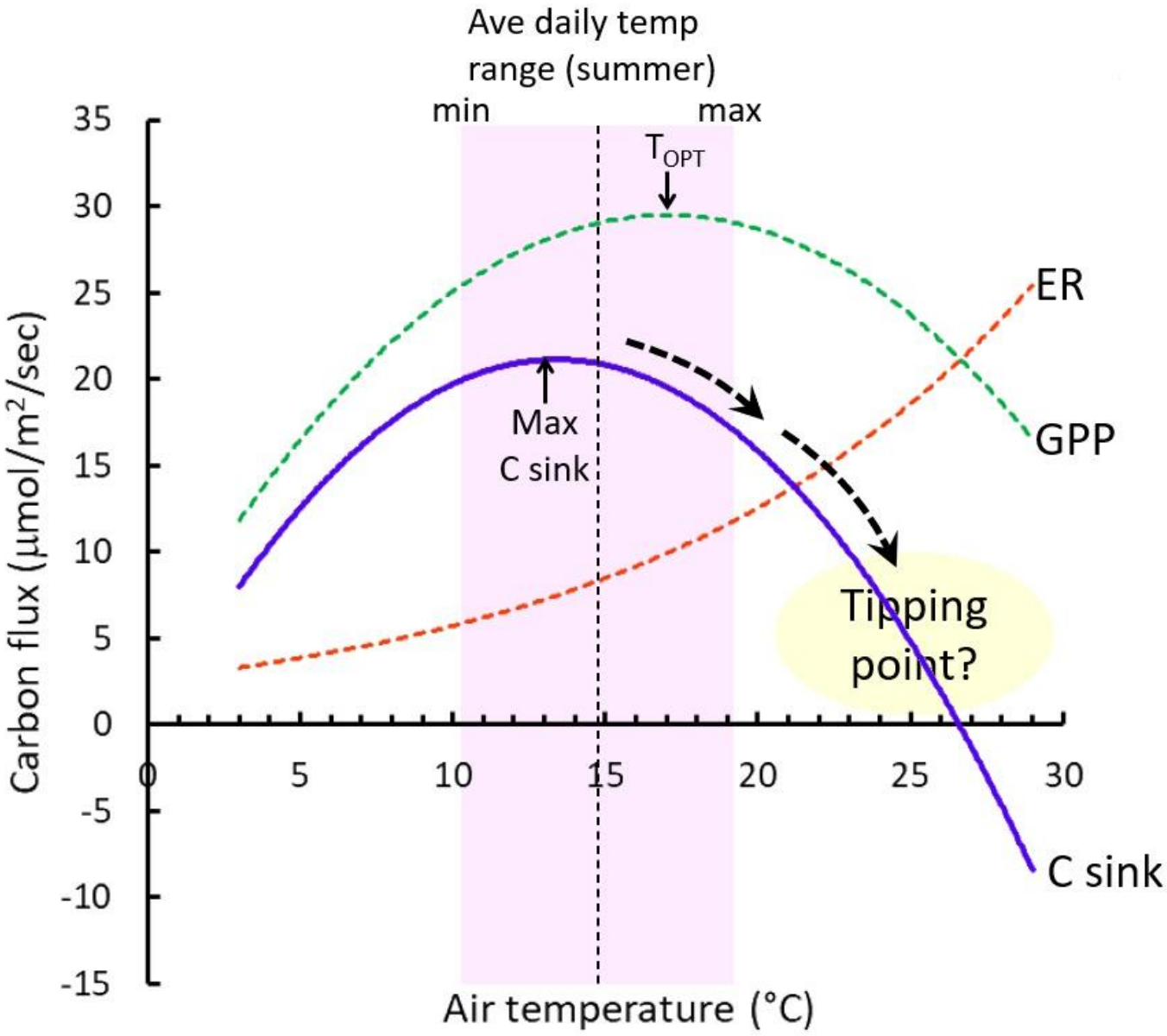


Fig. 2. Temperature dependence of the terrestrial carbon sink.

Mature *E. obliqua* tall forest in TWWHA (Warra) follows Duffy *et al.* AND average temperature is already above optimum for C sink strength

- GPP from model in Bennett *et al.* (2021) *Glob.Ch.Biol.*, **27(19)**: 4727-4744.
- ER from exponential model fitted to temperature-binned ER measurements from Warra
- C Sink is GPP-ER.
- Temperature range for Warra from Bennett *et al.* 2021.



Tall eucalypt forests in the TWWHA* are already suffering adverse effects from climate change

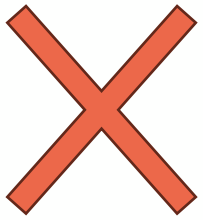
As the climate continues to warm

- The forest will remove less CO_2 from the atmosphere
- The forest approaches a tipping point, which when crossed will likely result in mass tree deaths and permanent decline in many values without restoration

Adaptation?

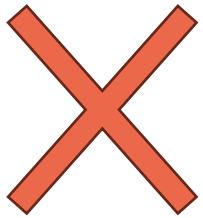
* and probably more generally in Tasmania's tall eucalypt forests

Adaptation options



Acclimation of exiting forests

- No evidence of seasonal acclimation (Zhu et al. 2018; Zhu et al. 2021)
- Little evidence of acclimation in analysis of diverse ecosystems (Duffy et al. 2021)

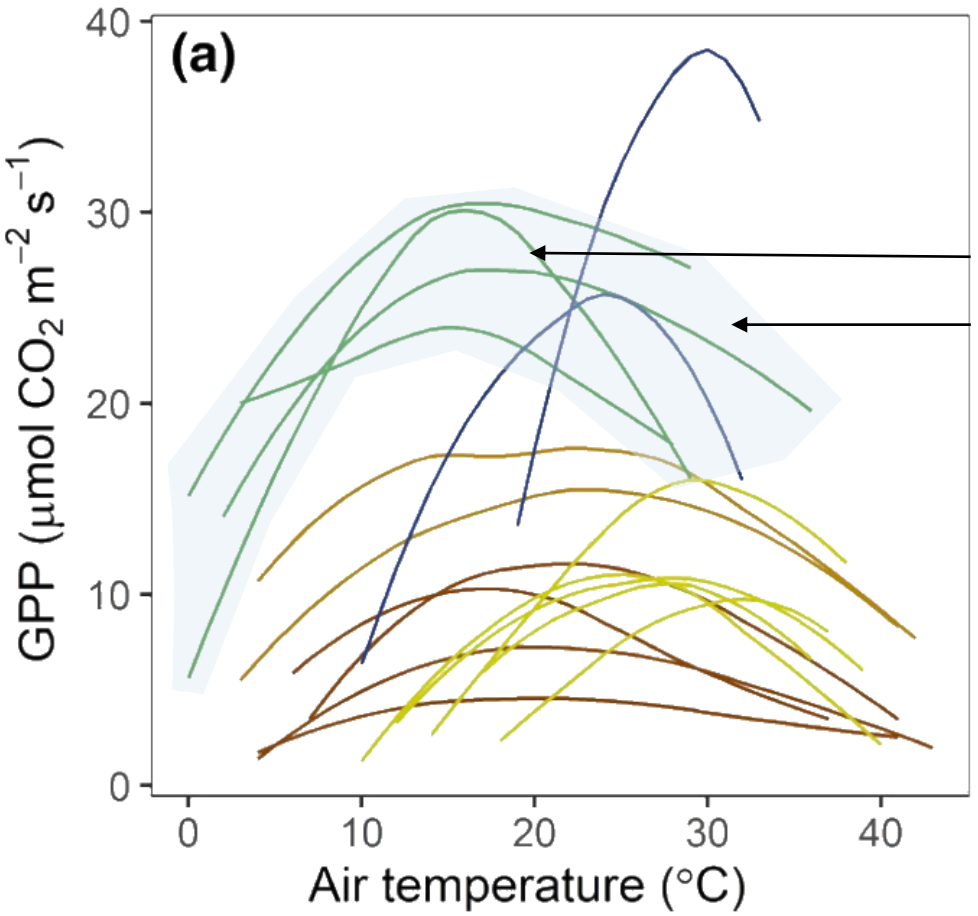


Adaptation in new forests: 1. Assisted migration

- Common traits used to identify climate analogues – drier and warmer climate – **not** associated with the strong decline in productivity with temperature
- Poorly adapted to local pest and pathogen populations

What trait(s) is important for driving the strong decline in productivity with temperature in Tasmanian tall eucalypt forests?

Response to warmer temperatures



Warra
Temperate forests

Compared with other temperate forests Warra has:

- Similar T_{opt} for GPP
- Much steeper decline in GPP as temperature moves away from T_{opt}

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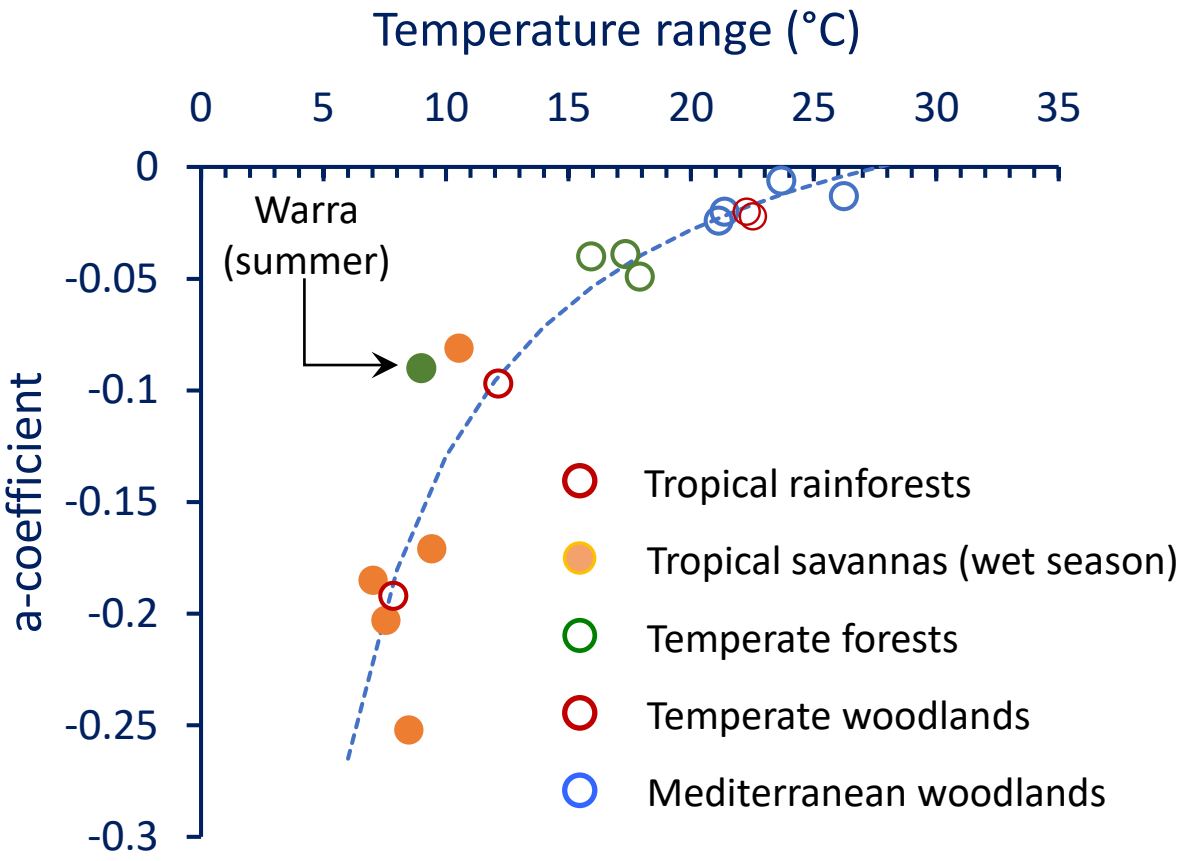
DOI: 10.1111/gcb.15760
PRIMARY RESEARCH ARTICLE
Global Change Biology WILEY

Thermal optima of gross primary productivity are closely aligned with mean air temperatures across Australian wooded ecosystems

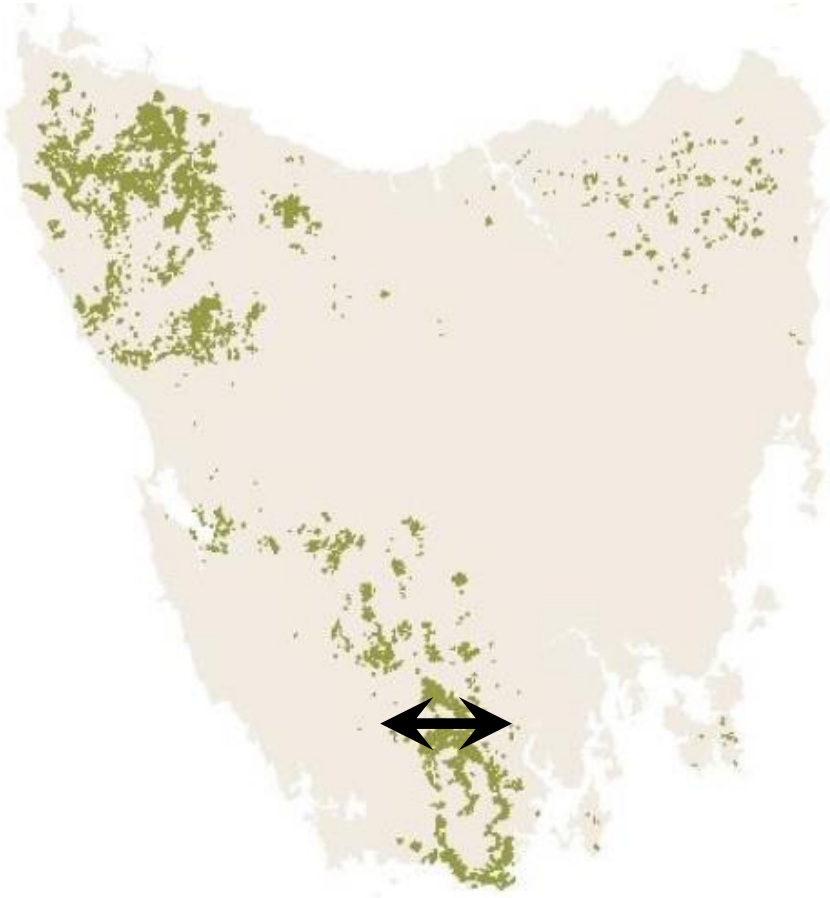
Alison C. Bennett[1] | Stefan K. Arndt[1] | Lauren T. Bennett[2] | Jürgen Knauer[3] | Jason Beringer[4] | Anne Griebel[5] | Nina Hinko-Najera[2] | Michael J. Liddell[6] | Daniel Metzen[5] | Elise Pendall[5] | Richard P. Silberstein[4,7] | Timothy J. Wardlaw[8] | William Woodgate[9,10] | Vanessa Haverd[3*]

Can we explain why tall eucalypt forest at Warra is so sensitive to temperature?



- Temperature sensitivity at Warra groups with tropical forests.
- Growing season temperature range relates to GPP sensitivity to departures from T_{opt}
- Narrow temperature range → greater sensitivity to departures from T_{opt}
- Low temperature range at Warra linked to radiation-limited compression of growing season
- High latitude drives winter radiation limitation

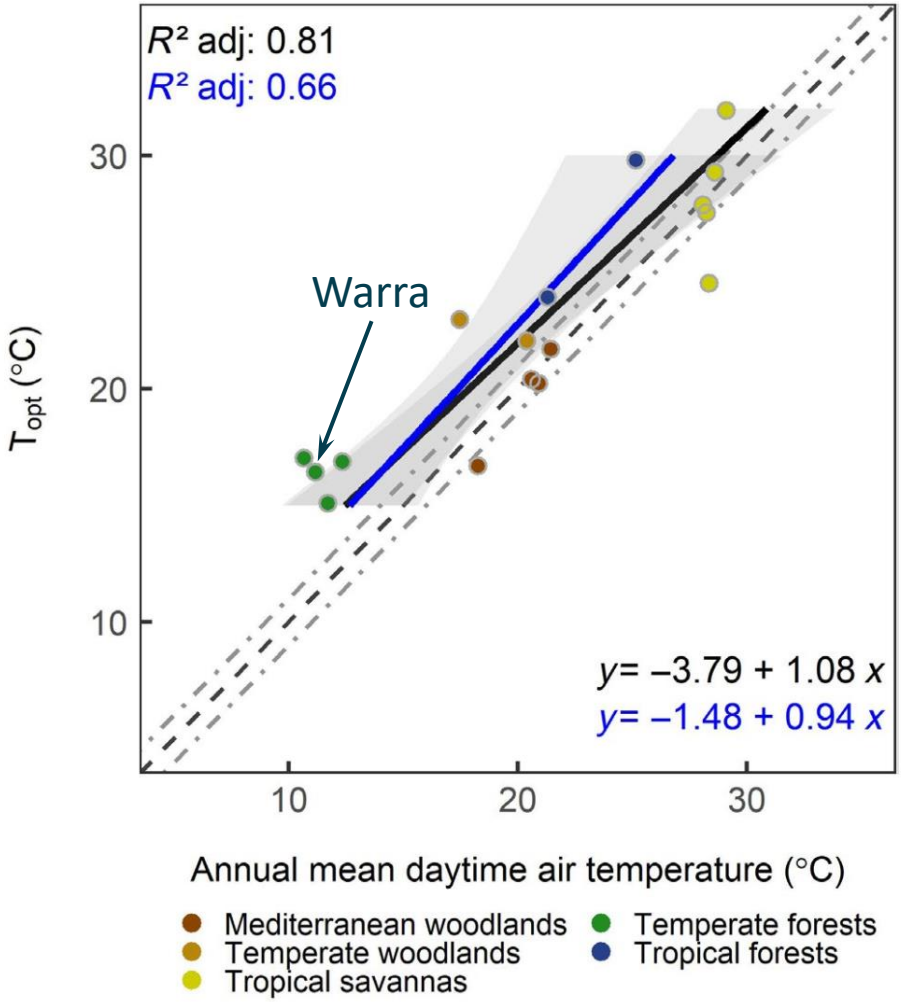
Implications of a selection trait linked to latitude



- Forest has a limited extent within a latitudinal band (particularly southern band)
- Restricts seed selection to local area to retain temperature sensitivity trait
- *In situ* enhanced natural selection advocated for adaptation
- **Aim: increase T_{opt} for productivity while retaining high temperature sensitivity**

Tasmanian distribution of *E. obliqua* tall forest with a rainforest understorey
(from Harris and Kitchener (2013) From forest to fjaeldmark : descriptions of Tasmania's vegetation

Optimum temperature for productivity of the forest is related to the historical temperature of the site



The *E. obliqua* tall forest at Warra has a low optimum temperature for productivity (16°C)

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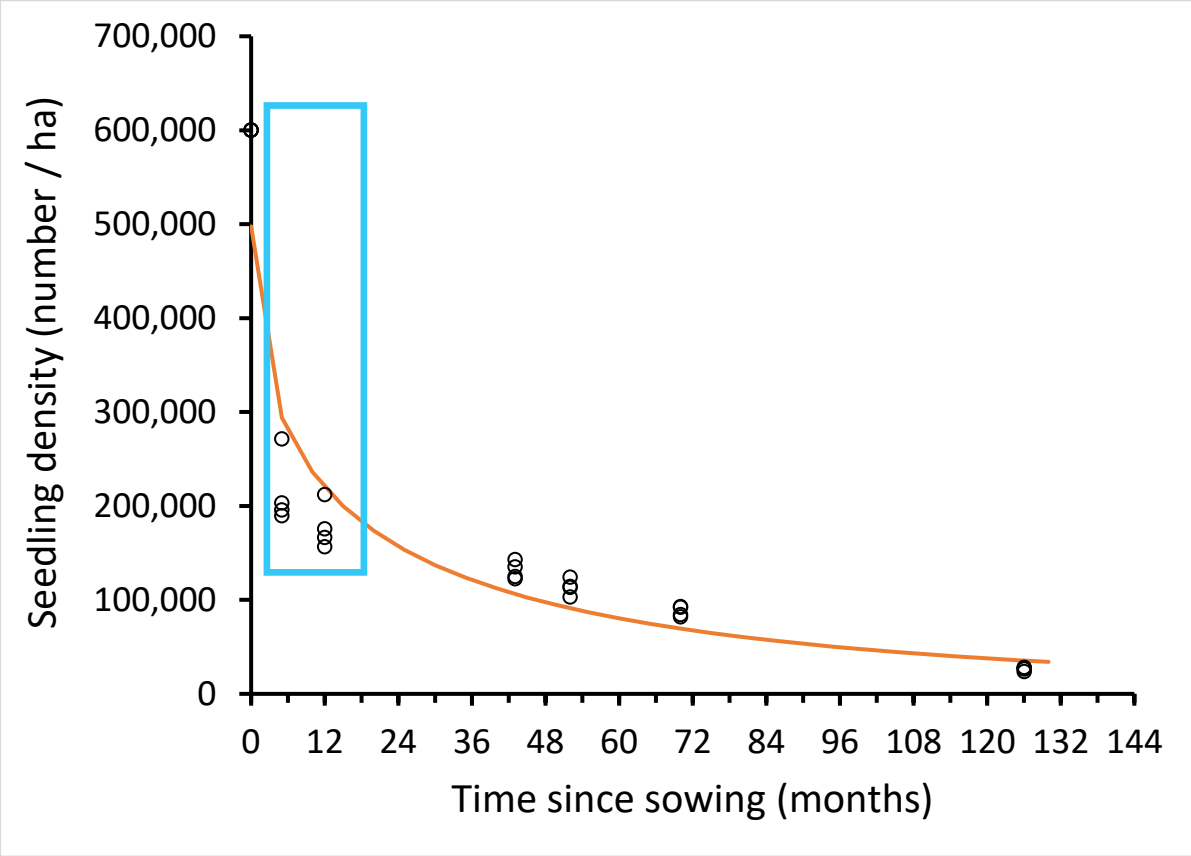
Glob Change Biol. 2021;27:4727–4744.

Intense competition in early life, An opportunity for natural selection?

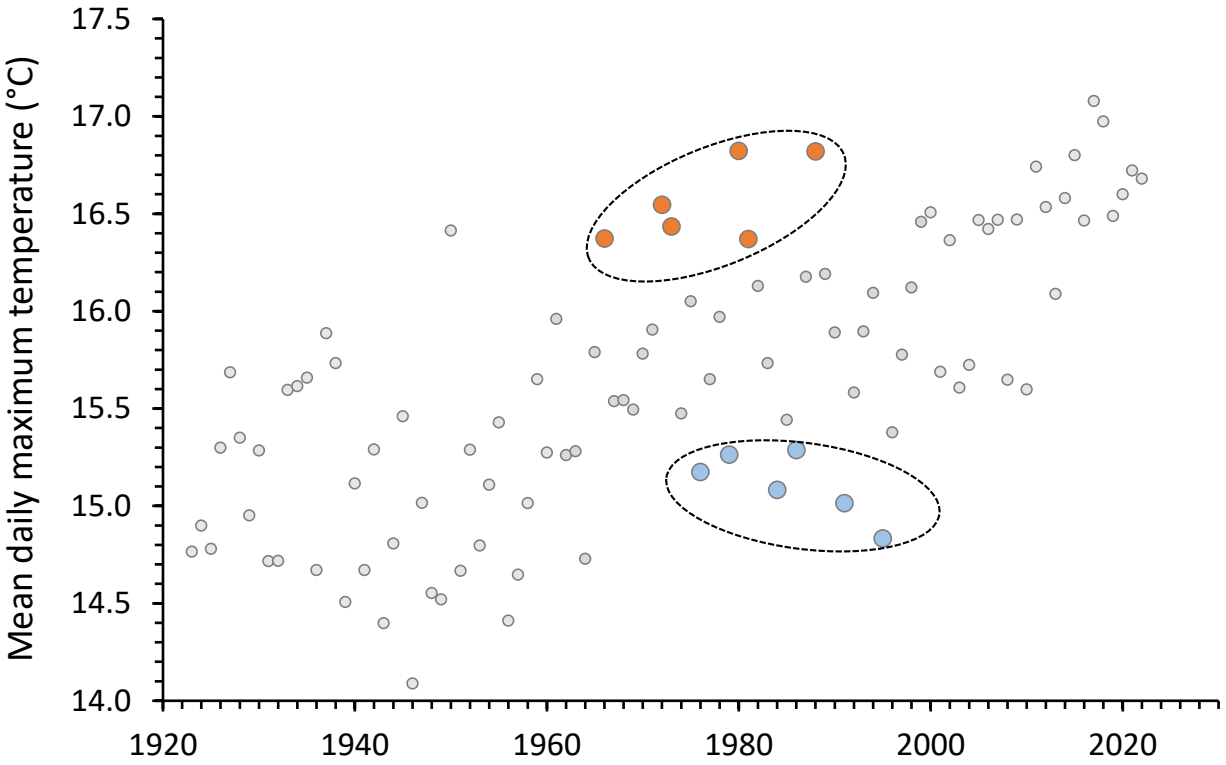


Data from Experiment 1 of Griffin *et al.* (2019) *Annals of Botany*, **124**: 179-187

If a selection pressure is present during period of intense competition the surviving plants may have a genetic advantage when exposed to that selection pressure.

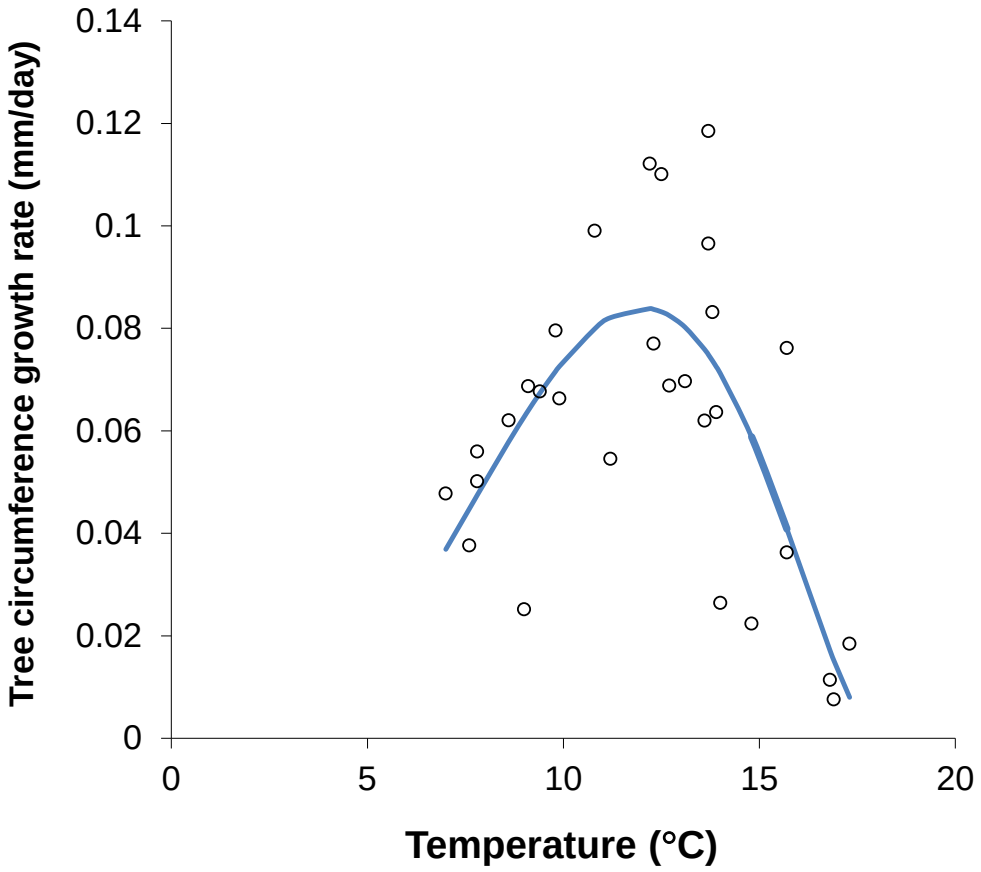
Growing season temperature as a selection pressure

Using daily maximum temperature records measured at Cape Bruny Lighthouse during the growing season (August-February)



- Silviculturally-regenerated stands from late 1960's in Sth.Tas.
- Six hottest growing seasons in initial 3 decades were, on average, 1.5°C warmer than the six coldest growing seasons
- Will the differences in average temperatures in hot and cold seasons be reflected in shift in optimum temperatures?

Growth response to temperature using dendrometry

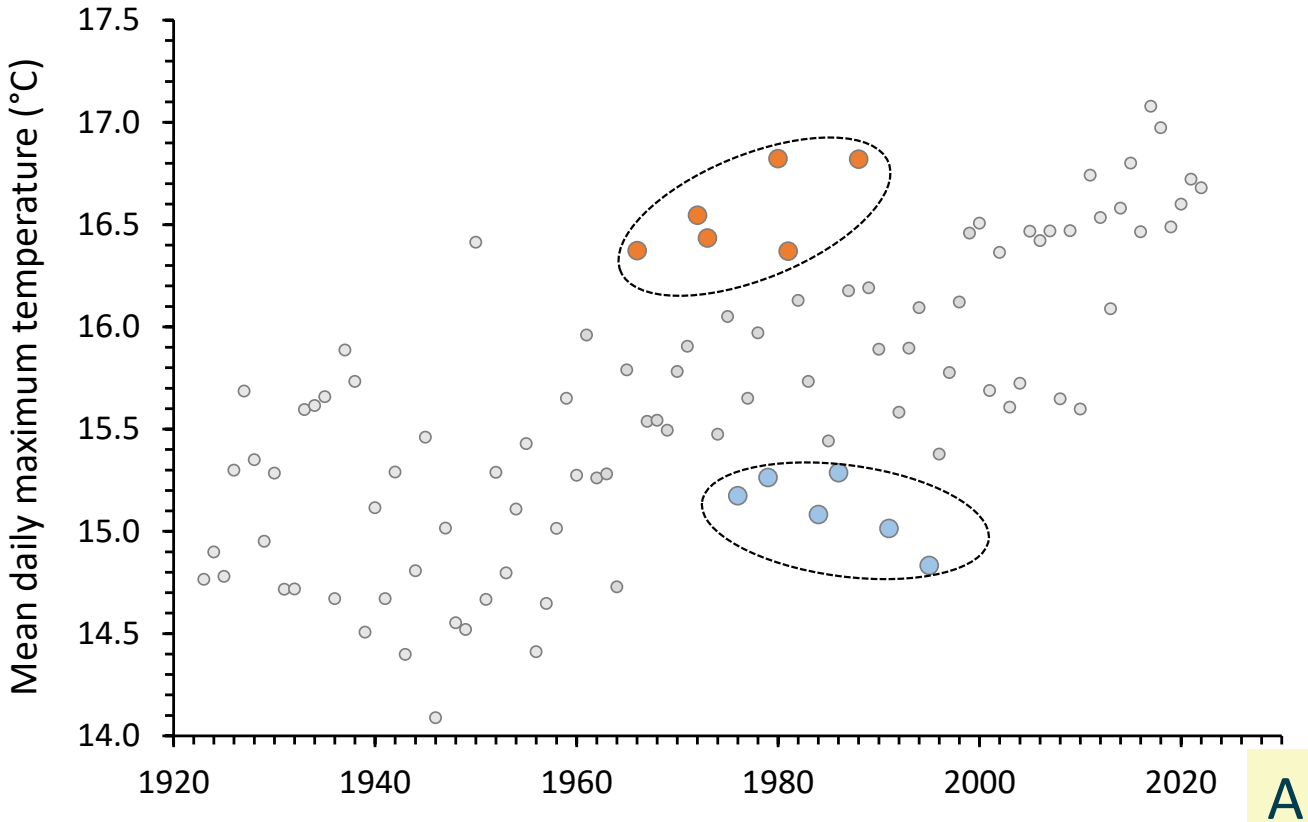


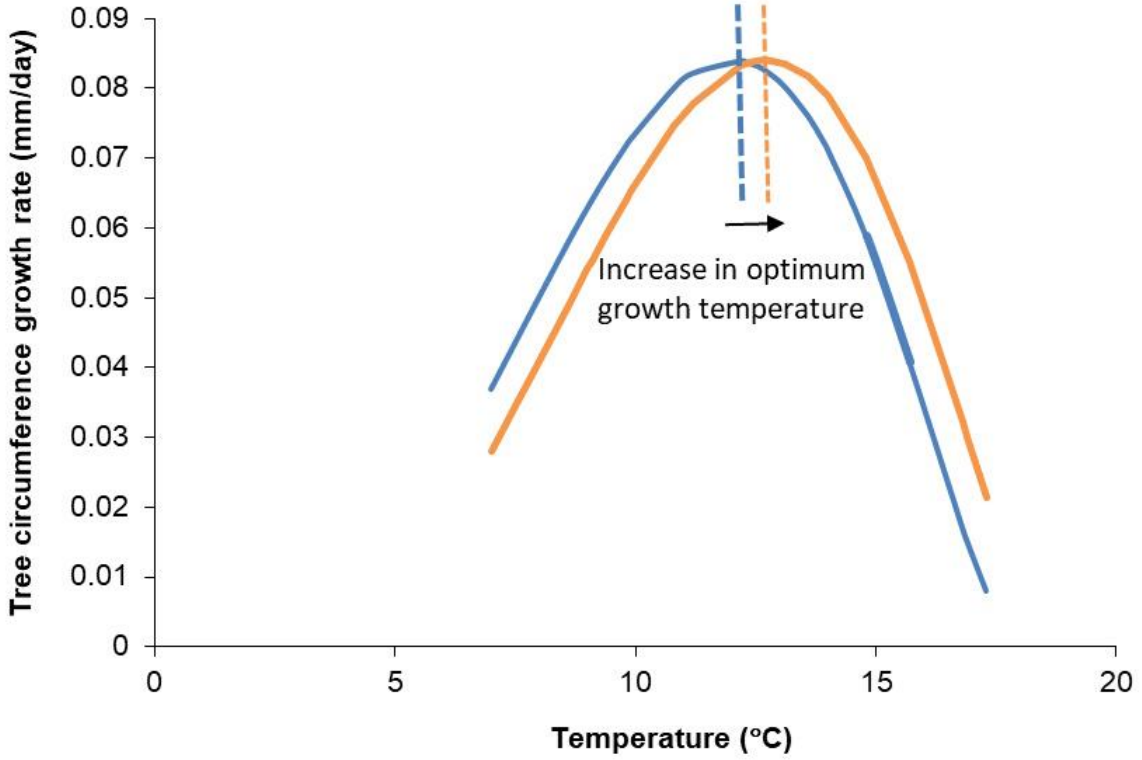
Data from manual band dendrometers installed on 21 70 y.o. *E. obliqua* at Hastings (Palzer & Wardlaw, unpublished)

Network of dendrometers + temperature sensors

- Cheap to deploy at many sites
- Can generate a temperature growth response curve within a short time (2-3 years)

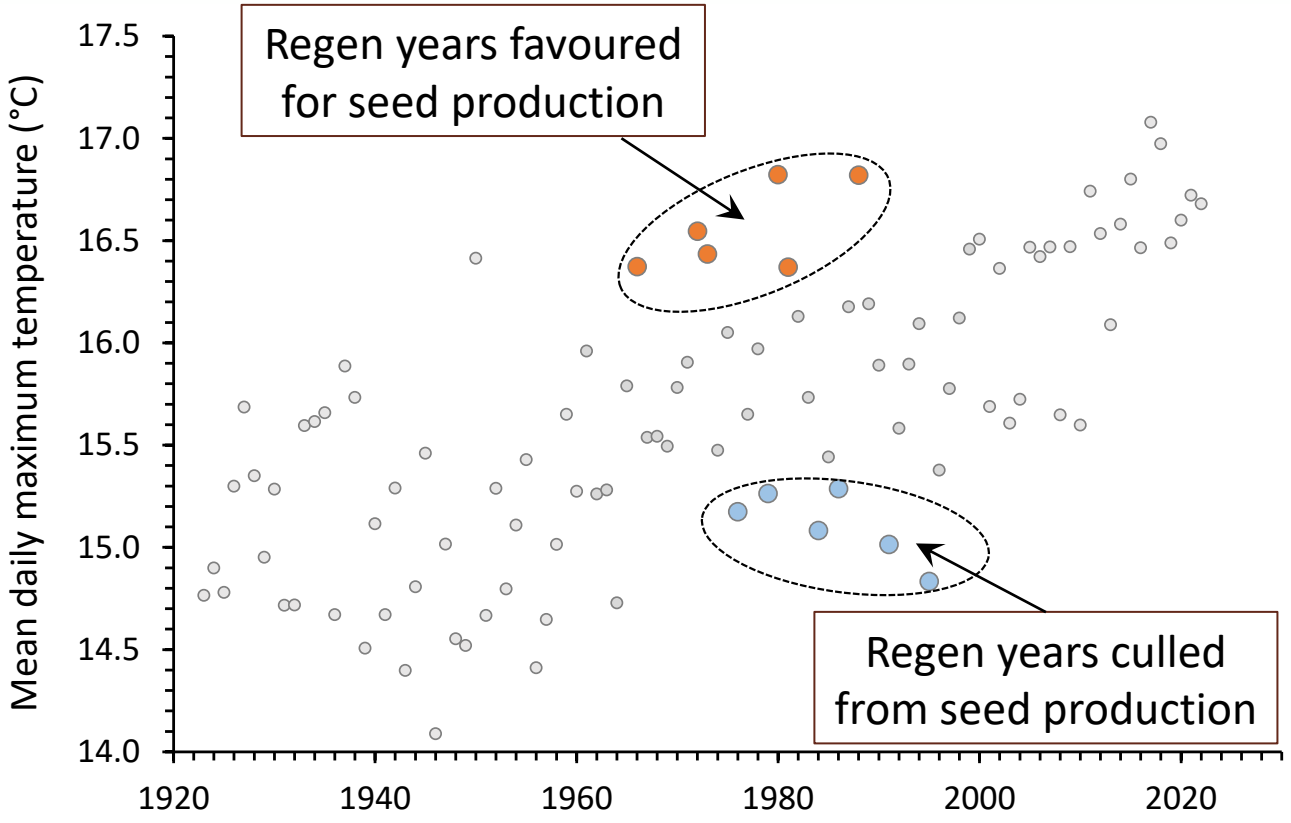
Dendrometry - A way to detect shifts in optimum temperature





A testable hypothesis. Optimum temperature for growth varies according to temperature during period of intense competition

The “enhanced” in natural selection



IF useful gains in T_{opt} measured in dendrometer study:

- Seed only from stands exposed to warmer than normal years carried into next generation
- Apply same criteria each generation
- ONLY practicable in production forests
- Gains in T_{opt} translates to gain in productivity / lower risk of crossing tipping point compared with business as usual

Is cessation of logging Tasmania's native forests a safe strategy for reducing emissions?

If enhanced natural selection is verified and useful gains in T_{opt} achieved each generation

- Wood production forests with climate-adapted seed will sequester more carbon than business as usual
- Restoration of tall eucalypt forests in protected areas will rely on access to climate resilient seed produced from production forest areas

Is cessation of logging Tasmania's native forests a safe strategy for reducing emissions?

NO! The productivity and survival of all Tasmania's tall eucalypt forests in a future warmer climate will be reliant on access to climate-resilient seed from native forests managed for wood production .

Thank you

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