Can we predict the vulnerability of Eucalypts to future drought?

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Recent record-breaking droughts


Ukkola et al. (2020) GRL
Widespread drought-induced mortality

Allen et al. (2015) Ecosphere

Observed mortality events

Dieback could have profound consequences for:
- carbon balance
- land-atmosphere feedbacks
- community composition

Critically...key feedback missing in CMIP models
Q. Can we predict species vulnerability to drought with a model?
**Problem 1: Models diverge when it is dry**

2000-9 NBP sum: 0.15 to -0.22 Pg C (>10 TRENDY DGVMs)

Teckentrup et al. (2021) Biogeosci. *in review*
Problem 2: Evergreen broadleaf forest?

- Rainforest
- Grassy Woodland
- Alpine
- Wet Sclerophyll
- Dry Sclerophyll
- Semi-Arid Woodland
Problem 3: Future climate model forcing

CMIP6 models

“representative” GCMs + RCMs

GCM + RCM ... a *random* pixel

Rainfall (mm yr$^{-1}$)
Experimental setup

Problem 1 ✓
- CABLE LSM + profit maximisation model

Problem 2 ✓
- Hydraulic traits (+$V_{cmax}$) 15 eucalyptus species

Problem 3 ✓
- Use 5 km AWAP forcing, focus on SE Aus
- Experiments:
  - 2017-2019 drought (CTL)
  - -20% rain (ePPT)
  - -20% rain + double CO$_2$ (eCO$_2$ x ePPT)
Minimum leaf water potential (\(\Psi_{\text{min}}\))

\(\Psi_{\text{min}}\) = an indication of plant water status

i.e., the largest hydraulic tension each species experienced during drought

Wetter
Minimum leaf water potential ($\Psi_{\text{min}}$)

$\Psi_{\text{min}}$ = an indication of plant water status

i.e., the largest tension each species experienced during drought

Drought pushed most species beyond the water potential inducing a 50% loss in hydraulic function (p50)
Minimum leaf water potential ($\psi_{\text{min}}$)

$\psi_{\text{min}}$ = Largest tension species experienced during drought

ePPT impacted species with a southern (wetter) distribution & lower embolism resistance (higher $p_{50}$)
Hydraulic safety margin: $\Psi_{\text{min}} - \Psi_{50}$
Minimum leaf water potential ($\Psi_{\text{min}}$)
eCO$_2$ effect on $\Psi_{\min}$
Conclusions

• Identified **where** and **which** species were most at risk

• eCO$_2$ increased $\Psi_{\text{min}}$ by $\sim$27% (4%, 54%)
  • Are the effects of eCO$_2$ too optimistic?
  • no change in LAI (see Rifai et al. 2021 in review *Biogeosci.*)

• Should stomatal close happen before the onset of xylem embolism?
  • = wider HSM -> delay time to $\Psi_{50}$
  • role of $\Psi_{\text{crit}}$ assumption in optimisation…?

• How would GW access change $\Psi_{\text{min}}$ sensitivity?
  • See Mu et al. 2021 *Earth Syst. Dyn.* - CABLE drought x HW

To what extent can rising [CO$_2$] ameliorate plant drought stress?

*New Phytologist* (2021) 231: 2118–2124

Li et al. (2018) PCE

$P_{\text{12}}$ (MPa)

$\Psi_{\text{xylem}}$ at 90% $g_s$ closure (MPa)
Any questions?

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