Crown diebacks: complex syndromes that are challenging to diagnose. Can EC help?

Tim Wardlaw
Research & Development Branch
Forestry Tasmania
tim.wardlaw@forestrytas.com.au

TERN Terrestrial Ecosystem Research Network

OzFlux

Australian SupersiteNetwork

WARRA long-term ecological research

Forestry Tasmania

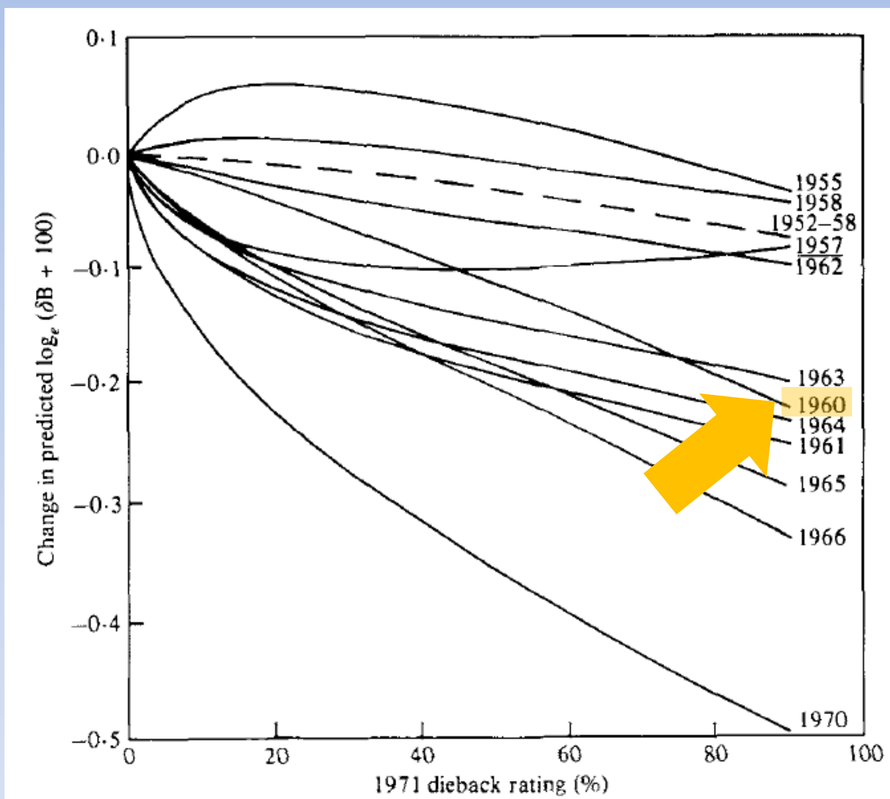
Characteristics of complex dieback syndromes

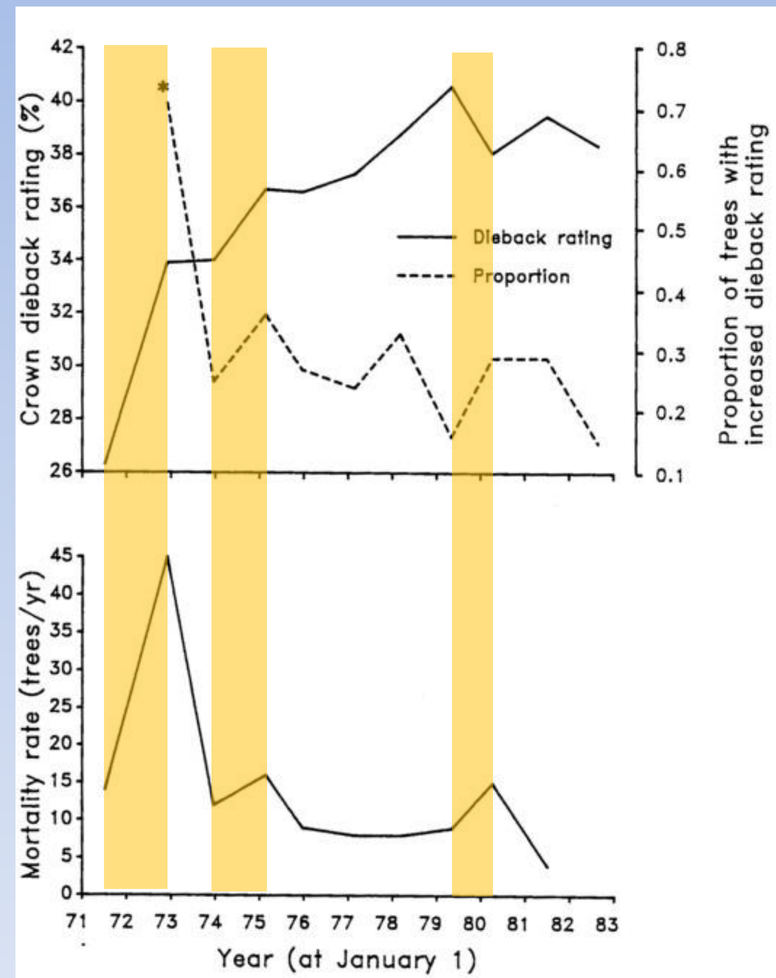
- Predisposing factors
- Inciting (trigger) factors
- Contributing factors

Regrowth dieback

- Affects *E. obliqua*, *E. regnans* & *E. delegatensis* tall forests <u>OLDER than 40 years</u>
- Rainforest / wet sclerophyll understorey <u>UNAFFECTED</u>
- Intensity of dieback <u>INSENSITIVE to stand density</u>
- Dying dominants first noticed in mid-1960's
- Symptoms rapidly intensified in 1970's then abated through the 1980's
- Several 100,000s ha affected in Southern Forests, NW, NE and Tasman Peninsula

Timing of dieback events





West, P.W. (1979) *Ann.App.Biol.*, **93**: 337-350

Wardlaw (1989) *N.Z.J.For.Sci.*, **19(2/3)**: 265-276

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- **Inciting (trigger) factors**
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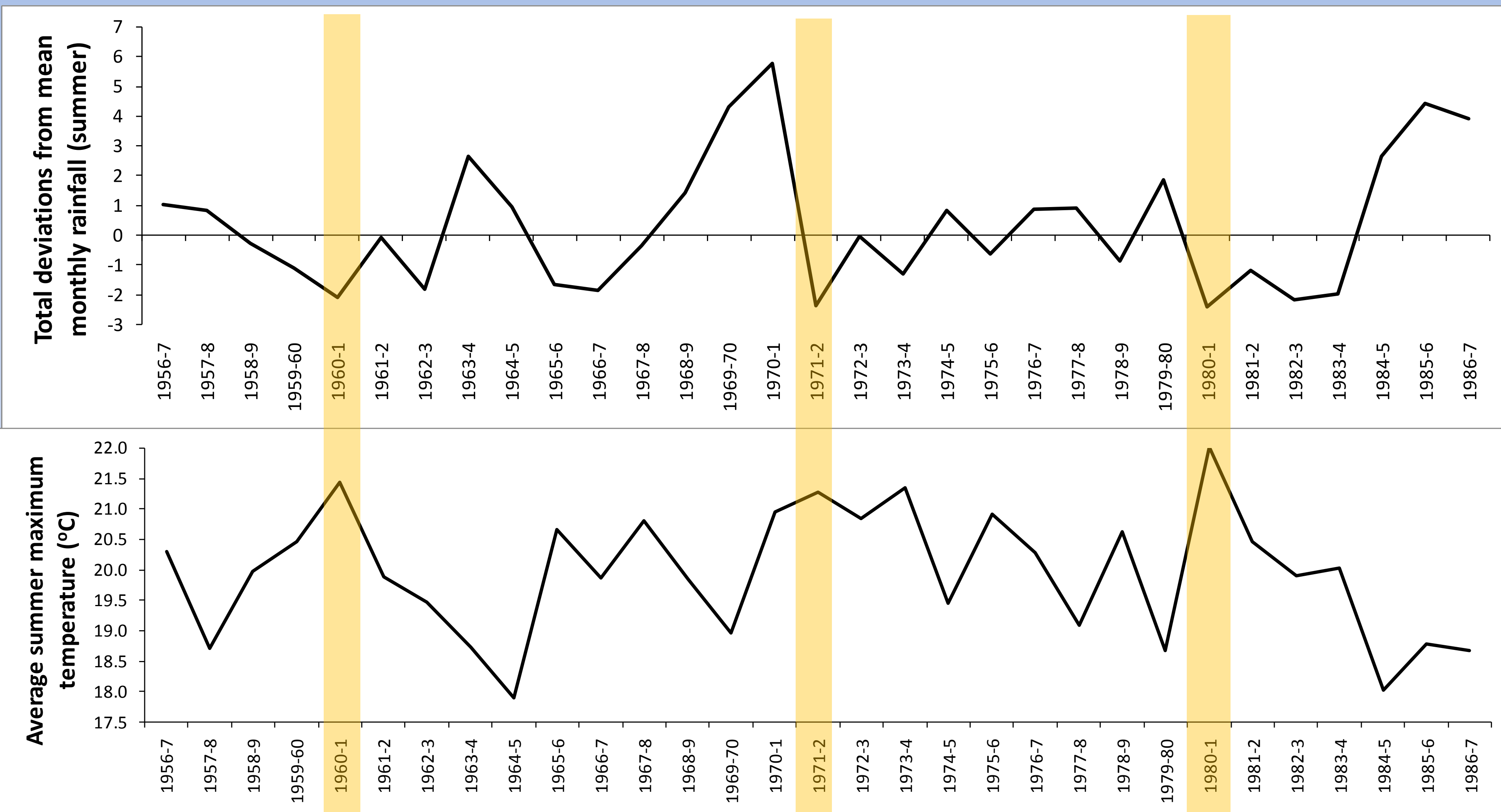
Dieback events coincide with severe summer drought and high temperatures



What triggers dieback episodes?

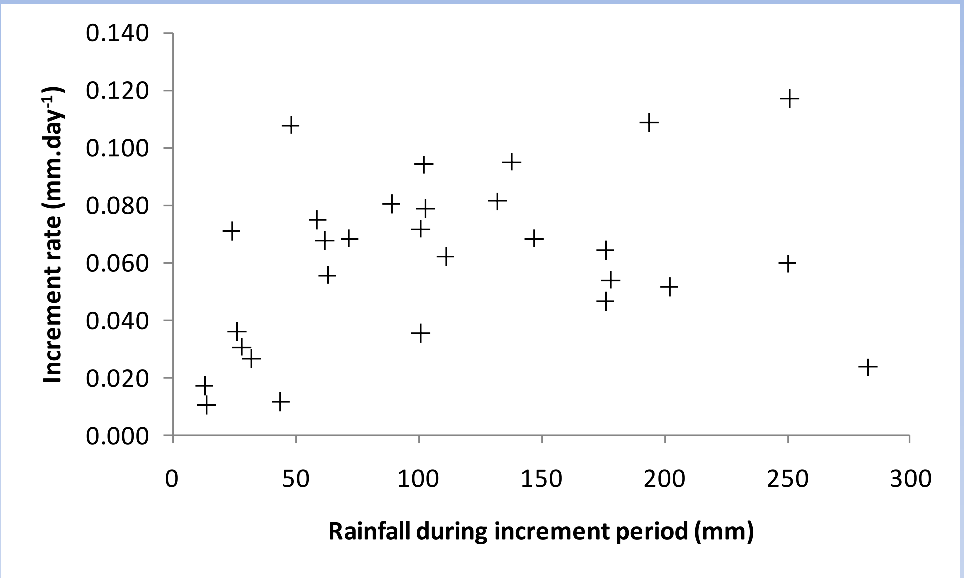
- drought
- high temperatures
- both?

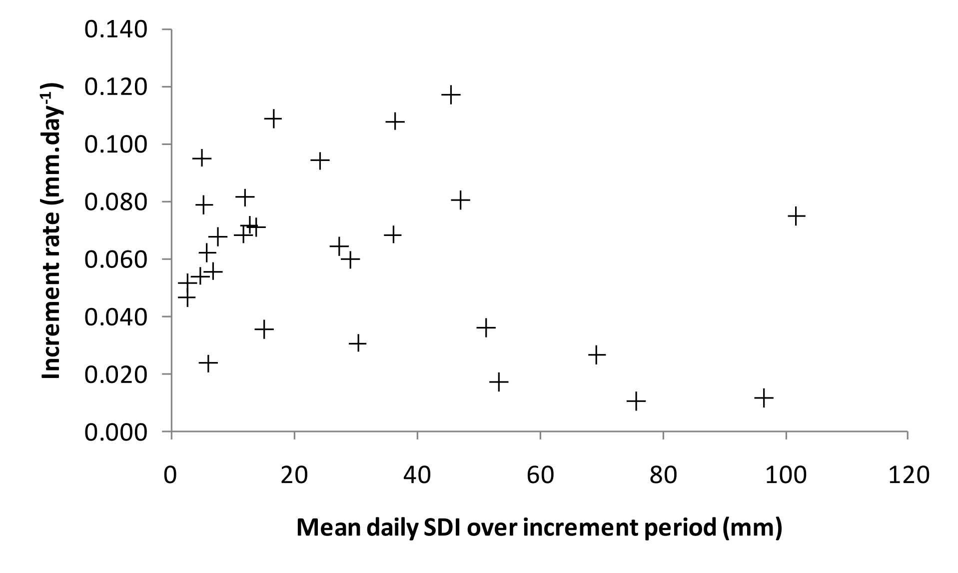
The evidence from dendrometry

Palzer and Wardlaw unpublished data:

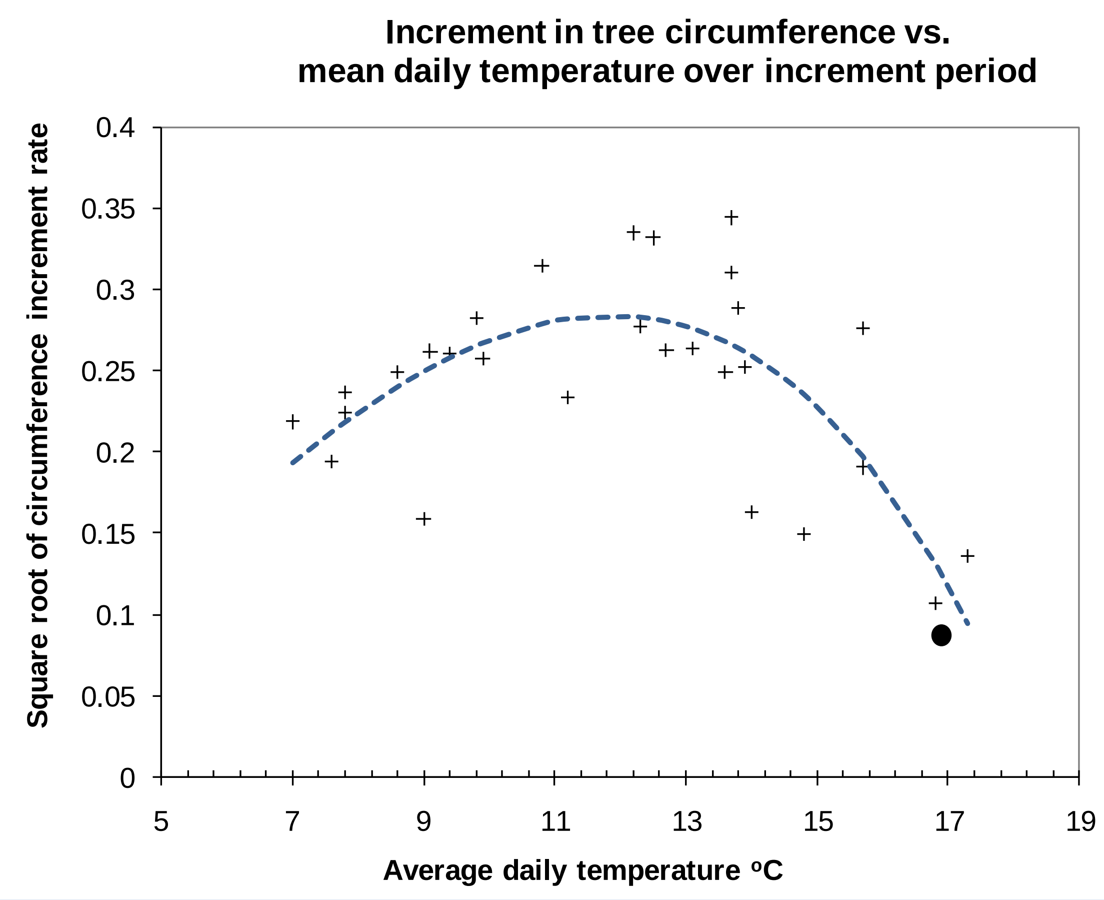
Increment in tree circumference of 15 dominant / co-dominant, 70-years-old *E. obliqua* at Hastings measured with band dendrometers between July 1980 – May 1985

Weak relationships of tree growth with rainfall and soil dryness





Decline in growth at high mean temperatures



Fitted model:

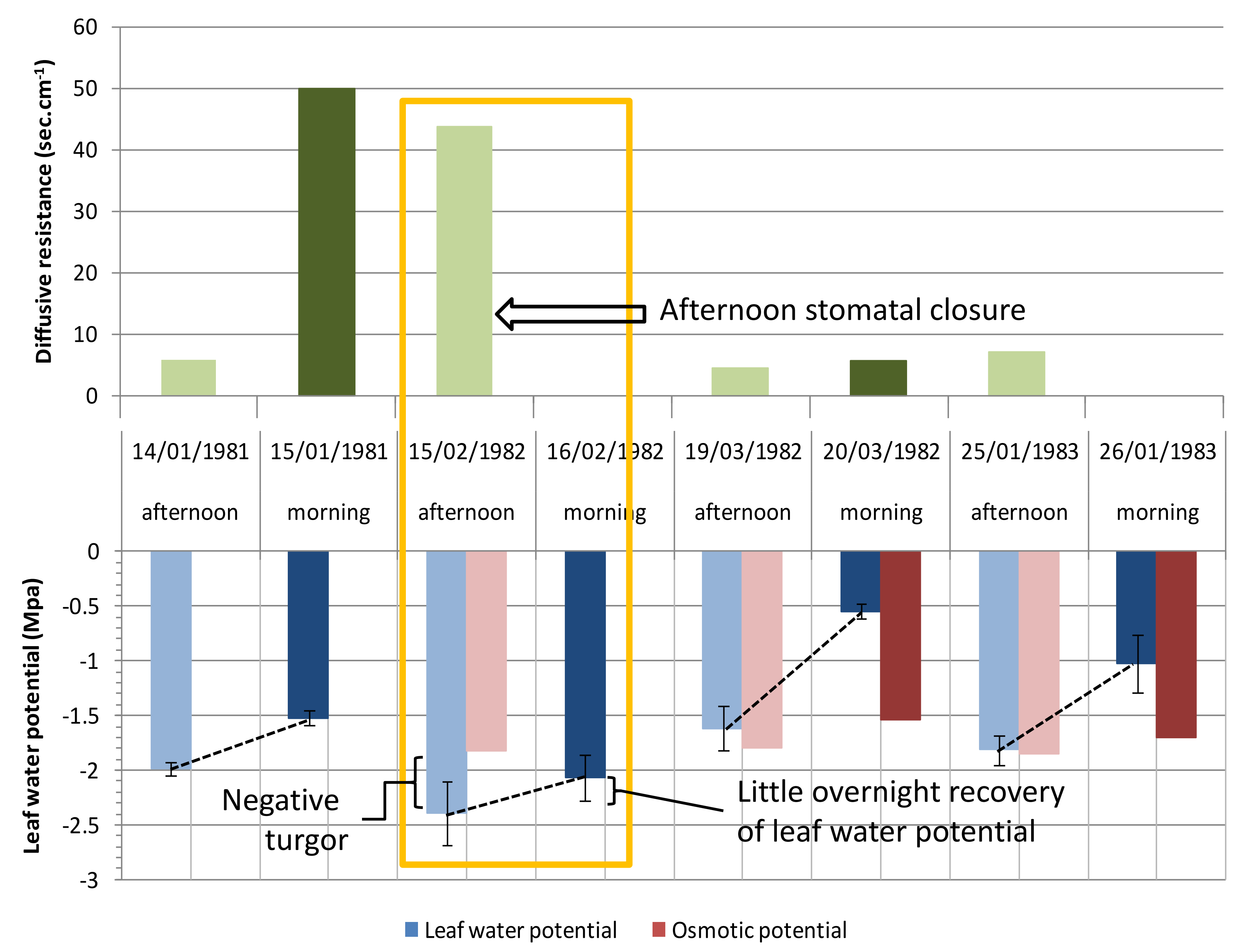
$Inc^{-\frac{1}{2}} = 0.0581(T-2.363)(1-e^{(T-18.3311)})$

Opportunistic water physiology campaigns

Palzer and Wardlaw unpublished data:

Afternoon and dawn measurements on detached leaves from the crowns of healthy and dieback-affected trees in a stand of 70 y.o. *E. obliqua*

- Stomatal conductance
- Leaf water potential
- Leaf turgor

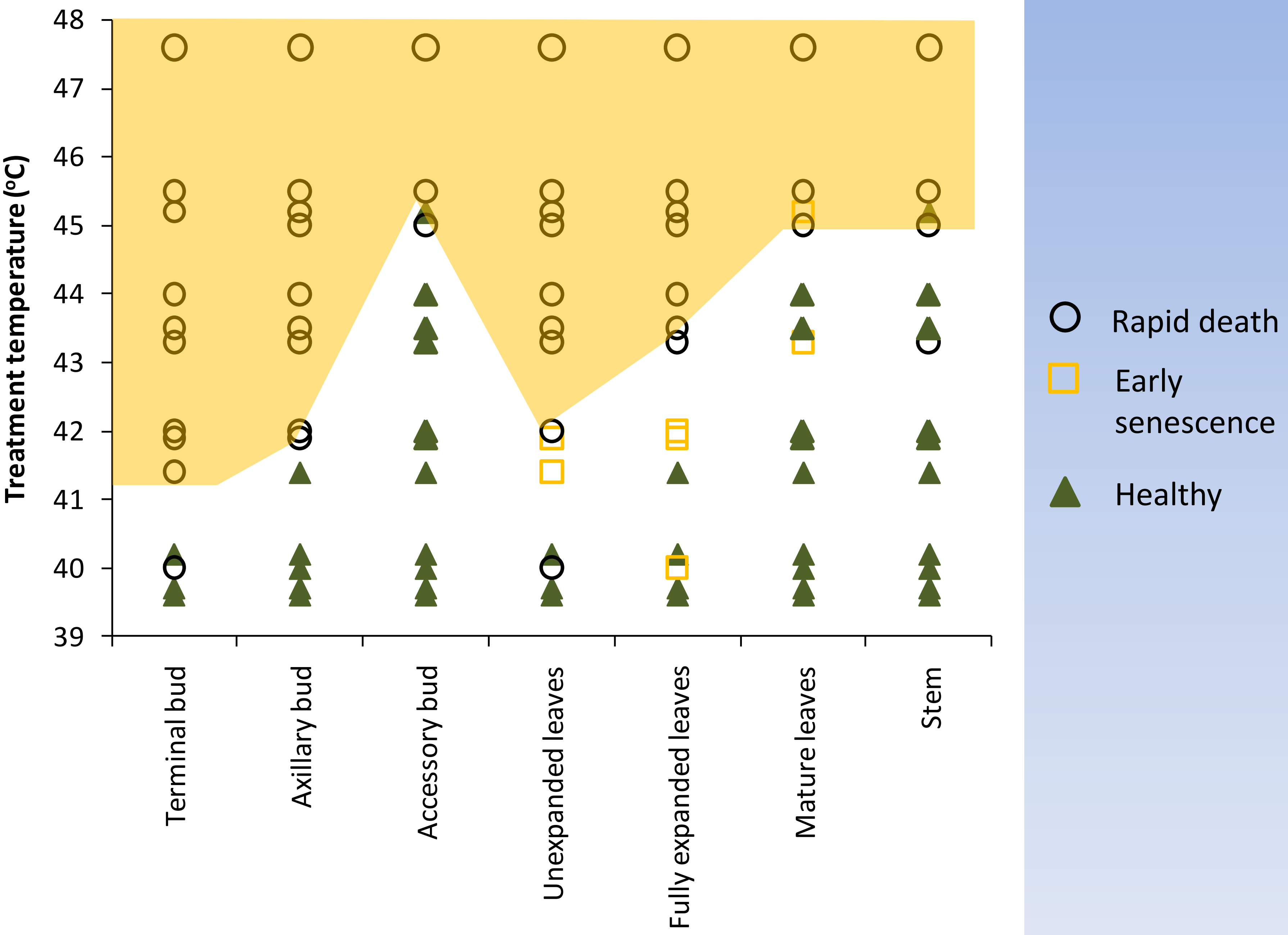


60
50
40
30
20
10
0
Diffusive resistance (sec.cm-1)
Afternoon stomatal closure
14/01/1981
15/01/1981
15/02/1982
16/02/1982
19/03/1982
20/03/1982
25/01/1983
26/01/1983
afternoon
morning
afternoon
morning
afternoon
morning
afternoon
morning
0
-0.5
-1
-1.5
-2
-2.5
-3
Leaf water potential (Mpa)
Negative turgor
Little overnight recovery of leaf water potential
Leaf water potential
Osmotic potential

The effect of exposure to high temperatures

Palzer and Wardlaw unpublished data:

Heat treatment (dry) of attached branches of *E. obliqua* saplings: 30 minute exposure; symptom assessment at 2, 4 and 6 weeks port-treatment.


Treatment temperature (ºC)
48
47
46
45
44
43
42
41
40
39
Terminal bud
Axillary bud
Accessory bud
Unexpanded leaves
Fully expanded leaves
Mature leaves
Stem
Rapid death
Early senescence
Healthy

A plausible hypothesis for the cause of regrowth dieback

Lethal heat damage to bud system during periods of stomatal closure on very hot days

Oecologia (2013) 172:317–326
DOI 10.1007/s00442-012-2494-6

PHYSIOLOGICAL ECOLOGY - ORIGINAL RESEARCH

Water flux of *Eucalyptus regnans*: defying summer drought and a record heatwave in 2009

Sebastian Pfautsch · Mark A. Adams

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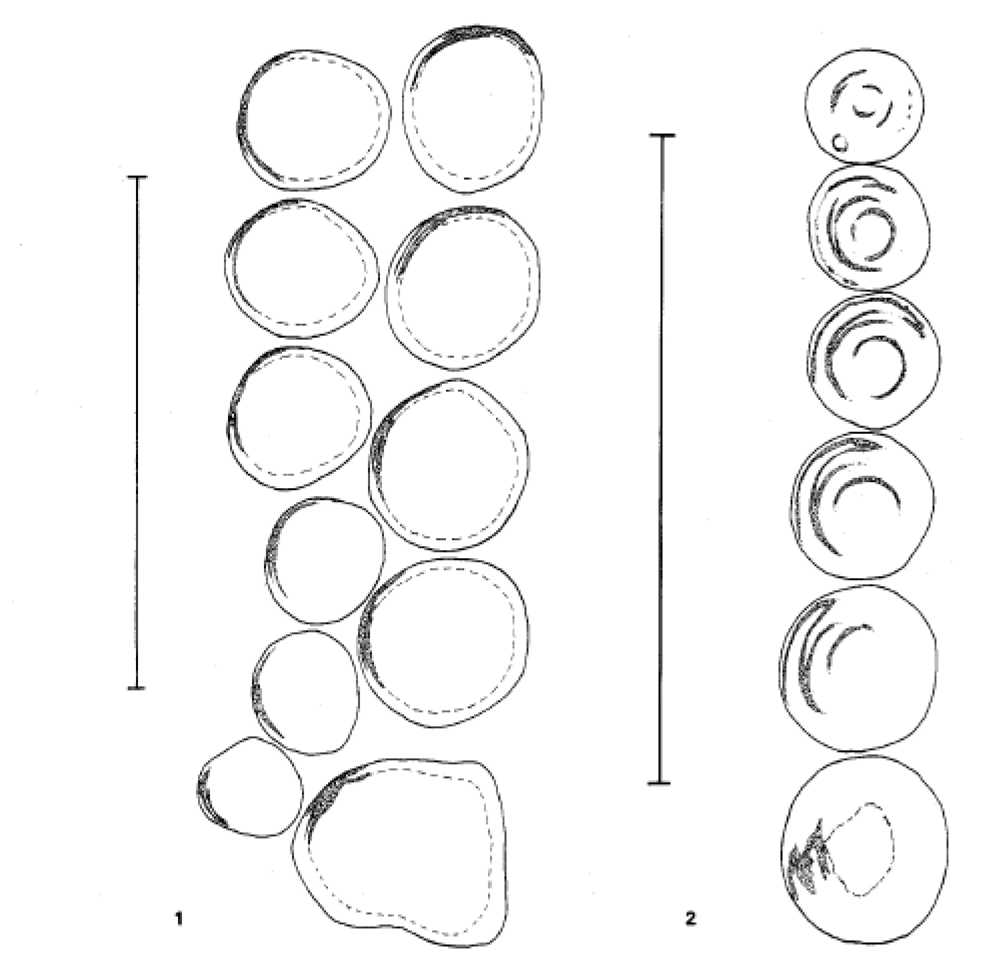
Why are trees older than 40 years predisposed to dieback?

40 y.o. 6 y.o.



6 y.o. – spiral, interlocked pathway: each root supplies many branches

40 y.o. – vertical, sectoral: each root supplies few branches

Spiral, interlocked pathway an adaptation to maintain water to crown during drought

Legge, N.J. (1985*) Aust.J.Bot.*, **33**:287-298

Challenges in getting proof of causality?

- Forest age is a predisposing factor:
  - *Need to make observations and measurements on large trees*

- Responses of tall trees to inciting events are difficult to capture in *ad hoc* measurement campaigns

So how can EC help diagnose complex diebacks?

1. Can potentially detect stomatal closure in near real time. Hypothesise we would observe:
    - Sharp increase in Fc
    - Sharp decrease in Fl
    - Sharp increase in Fs

So how can EC help diagnose complex diebacks?: Complimentary measures

1. IR thermometers to measure leaf temperatures
2. Event-triggered field campaigns to measure physiological and pathological responses during / soon after the event
3. Tower-mounted camera (particularly controlled pan/zoom) would allow tracking of symptom development following events

And the benefits

We can circumscribe the weather events that trigger dieback episodes

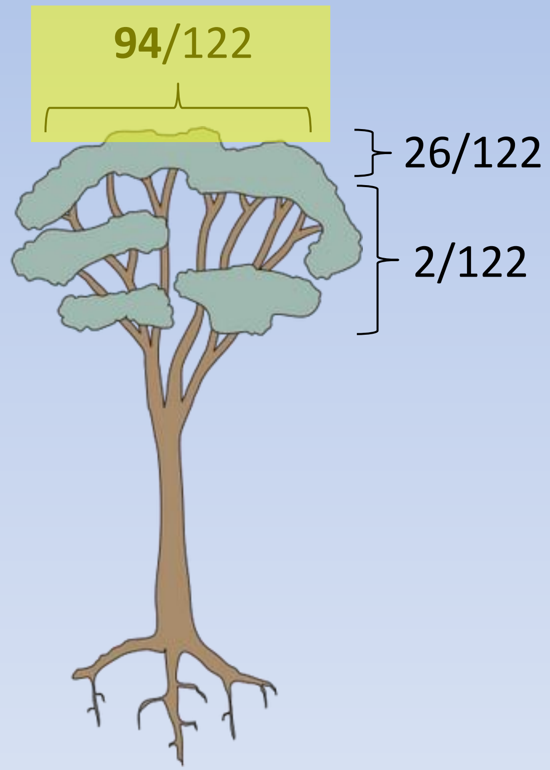
This then allows:

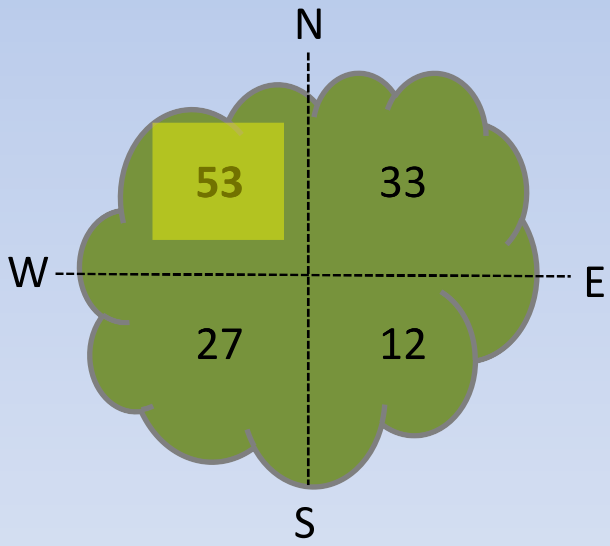
- Event-triggered flags from routine weather data collected by BOM
- Better understand vulnerabilities by evaluating return intervals for events of equal or greater magnitude

Time for a beer

What are the dieback symptoms?

1. Position of the most dieback-affected branch





Top of the crown in the quadrant exposed to afternoon sun

Palzer, C. (1983) *Pacific Science*, **37(4)**: 465-470

Shoot-leaf symptoms

Trait	Healthy	Dieback
Leaf area (cm^2)	20.5_a	7.2_b
LAI (m^2/m^2)	1.98_a	0.3_b
Dead growing tips (% of shoots)	0-8	40-60
Live accessory buds (% leaf axils)	>85	21
Leaf chlorosis / reddening	Rare	Frequent
Marginal leaf scorch	Rare	Rare

Palzer, C. (1983) *Pacific Science*, **37(4)**: 465-470