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Past temperature predictions for non-infectious bud failure

Almond Board of Australia R&D Forum 2025

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Hort Innovation ALMOND FUND

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What is NBF?

Non-infectious bud failure
AKA Crazy Top
AKA Carmel Bud Disorder
AKA Witches Brooms

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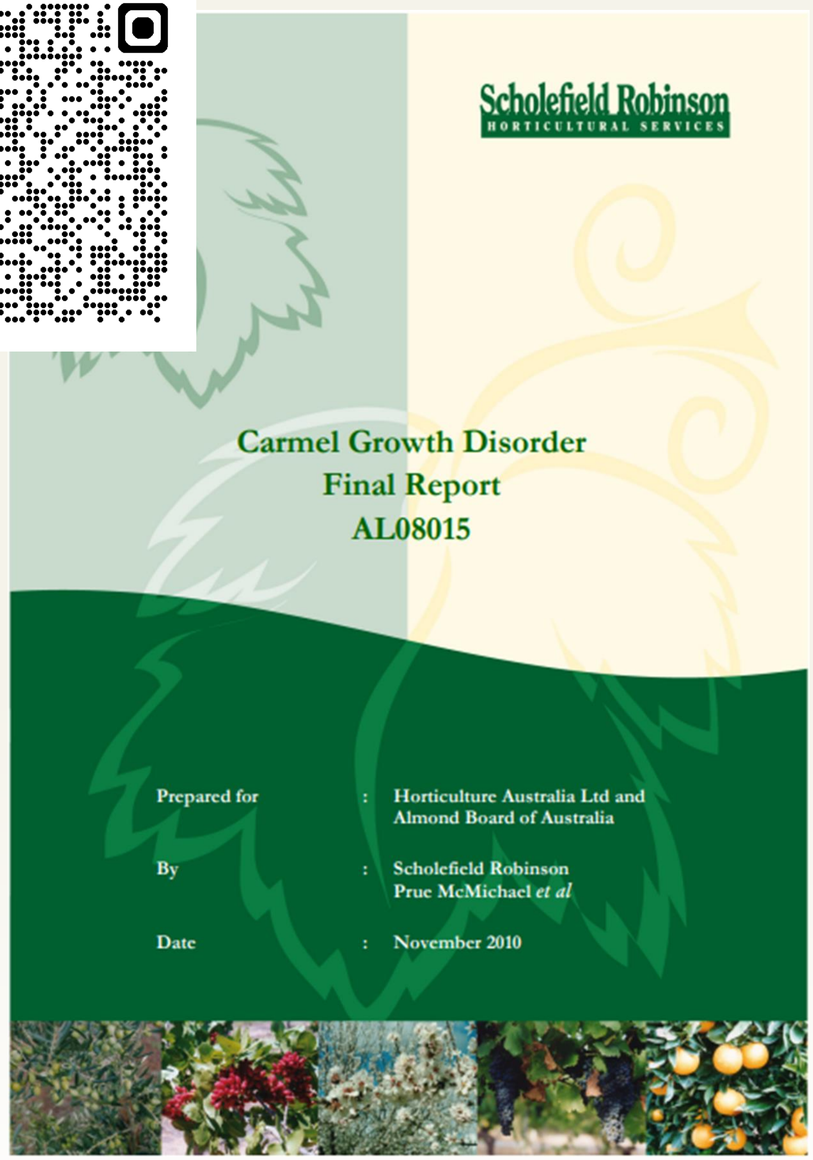
Lessons learnt

AL08015 conclusions

- Moderate and high bud failure potential exists within some Australian Carmel clones.
- Young Carmel trees planted since 2004/05 are the most severely affected.
- The choice of budwood predisposes trees to bud failure.
- Bud ‘damage’ is necrotic tissue and damaged buds do not recover.
- High temperature exposure (and budwood sources) induced the observed bud failure.
- Bud failure has not been traced to one bud source.
- Affected young (4th leaf) trees, are unlikely to be economically viable.
- Buds from Monash are consistently larger and have negligible internal damage.
- Vegetative growth has been affected more extensively than flowering, but late summer/autumn heat appears to affect more floral buds, than spring heat.
- Rough bark and tiger striping is not consistently associated with Australian bud failure.
- Bud failure in Carmel in Australian orchards cannot be generally distinguished from NBF, but Australia has not seen NBF in Non-pareil



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Genetic Source

Development of NBF

Effect of stress – EG Temperature

Genetic Source

“It’s the equivent of aging in a sense. It’s the equivalent of why as we get older, we’re still the same genetics, but we may be getting gray hairs.”

Carmel gets this disorder earlier in its life.

Growing the Valley

UC CE University of California Agriculture and Natural Resources Cooperative Extension

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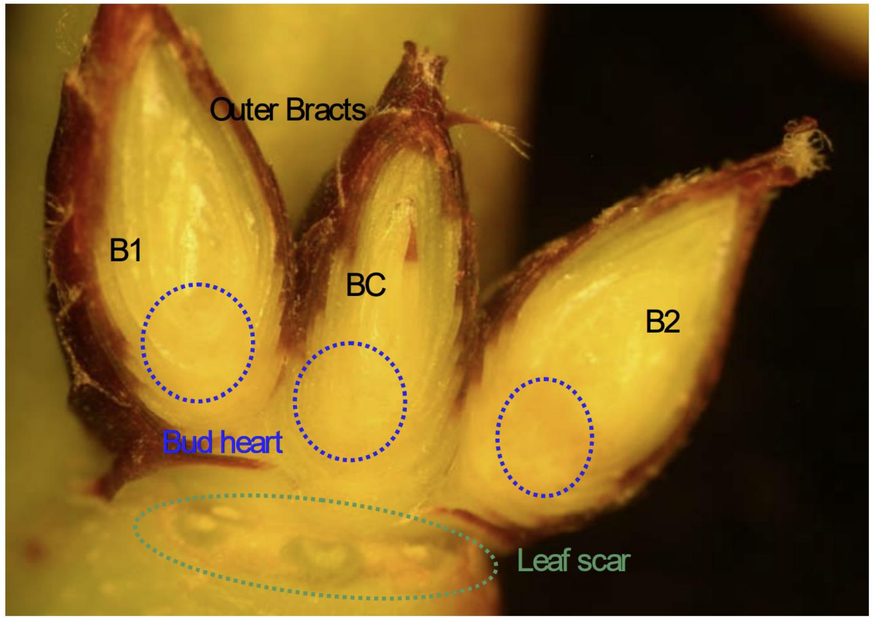
Bud ‘damage’ is necrotic tissue and damaged buds do not recover.

Figure 1: Almond bud set at a given node (longitudinally cut)



B1 = Bud 1 (Left side); BC = Centre Bud; B2 = Bud 2 (Right side)
Bud heart = the growing point of the bud
Leaf scar = the leaf attachment point
Outer bracts = the brown, lignified outer bracts that protect the bud heart

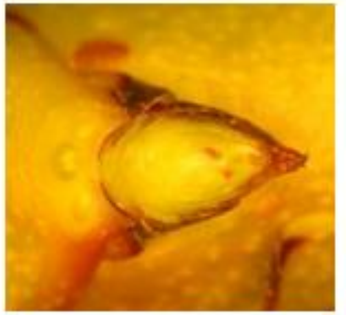
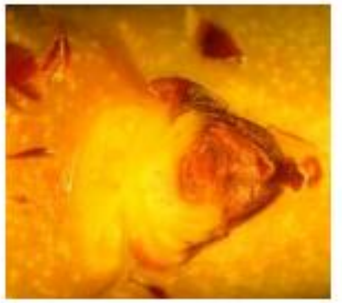
Observation description	1 = healthy green bud, 0% browning	1x = healthy green bud; with lignified section inside bud, but not at bud heart, usually tip section, 0% browning
Photo reference for Rating 1 and 1x		
Observation description	2 = bud heart brown/stained (<50%)	3 = bud heart brown/stained (>50%)
Photo reference for Rating 2 and 3		

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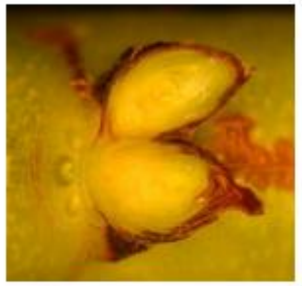
Photo reference for Rating 1 and 1x		
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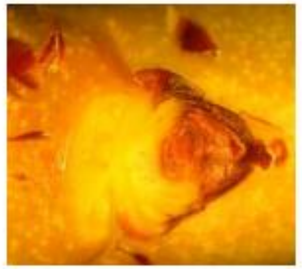
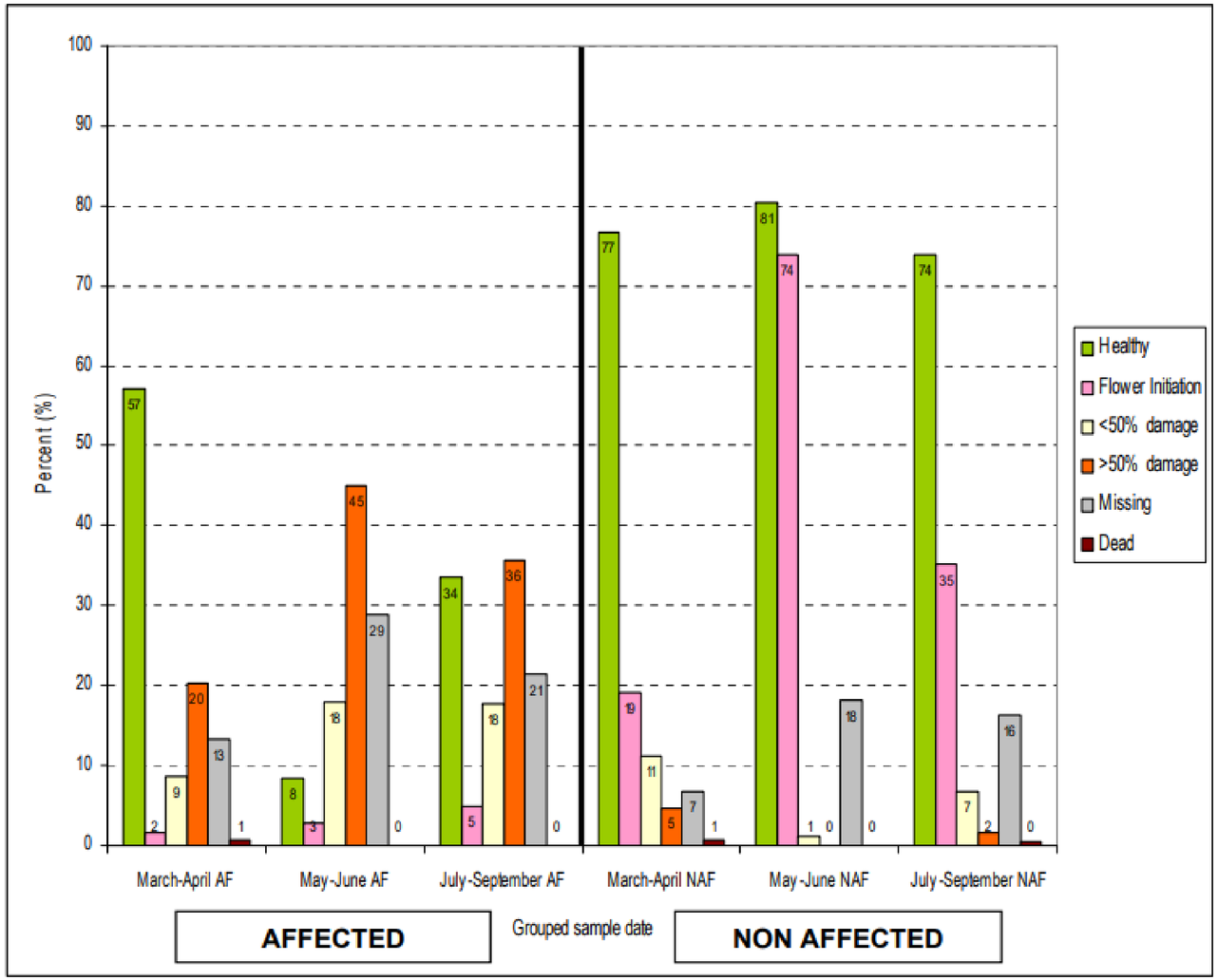
Photo reference for Rating 2 and 3		

Figure 10: MIA outside bud status during season



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Relationship of stress factors on NBF

Is temperature an indicator?

- Californian researchers identified that temperatures over 27°C can induce NBF.
- Trial consisted of a Carmel population of 2,800 trees.

Stage	Date	Description		
		Normal	**BF_{pot}**	**BF_{exp}**
III	May	Growth cessation and bud maturation	Growth cessation and bud maturation	Growth cessation and bud maturation
IV	June	Budscale formation; induction of HTD	Budscale formation; "Somaclonal" increase in BF_{pot}	Budscale formation; "Somaclonal" increase in BF_{pot}
V	July, Aug	Veg buds develop HTD; Flower buds are initiated	Veg buds have new level of $BF_{pot;}$ Flower buds are initiated from cells with higher BF_{pot}	Veg buds have new level of BF_{pot} and initiate necrosis; Flower buds are initiated with high level of BF_{pot}
VI	Sept, Oct	Veg. Buds initiate rest period Flower buds continue to differentiate	Veg buds have new level of $BF_{pot;}$ Flower buds continue to differentiate	Veg buds develop **necrosis** Flower buds continue to differentiate with high level of BF_{pot}

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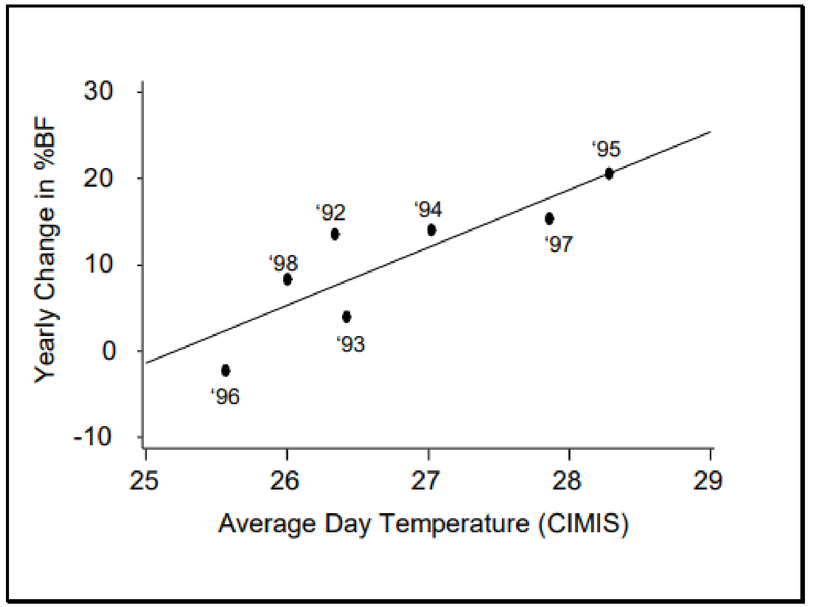

Figure 9 Regression of yearly change on BF % to average day temperature in June. Shows a range falling between 77°F (25°C) to 86°F (30°C).

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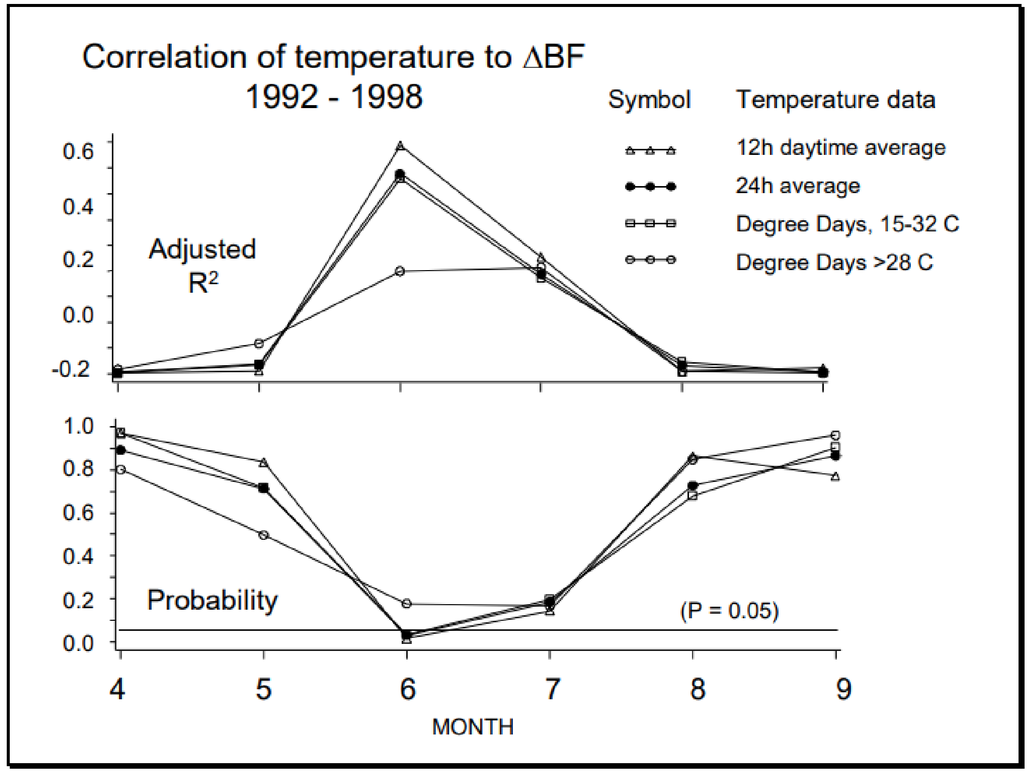

Figure 8 Above. Relationship between correlation valves (R_2) and month for four temperature data sets.
Below. Plot of Probability for each of the values above.

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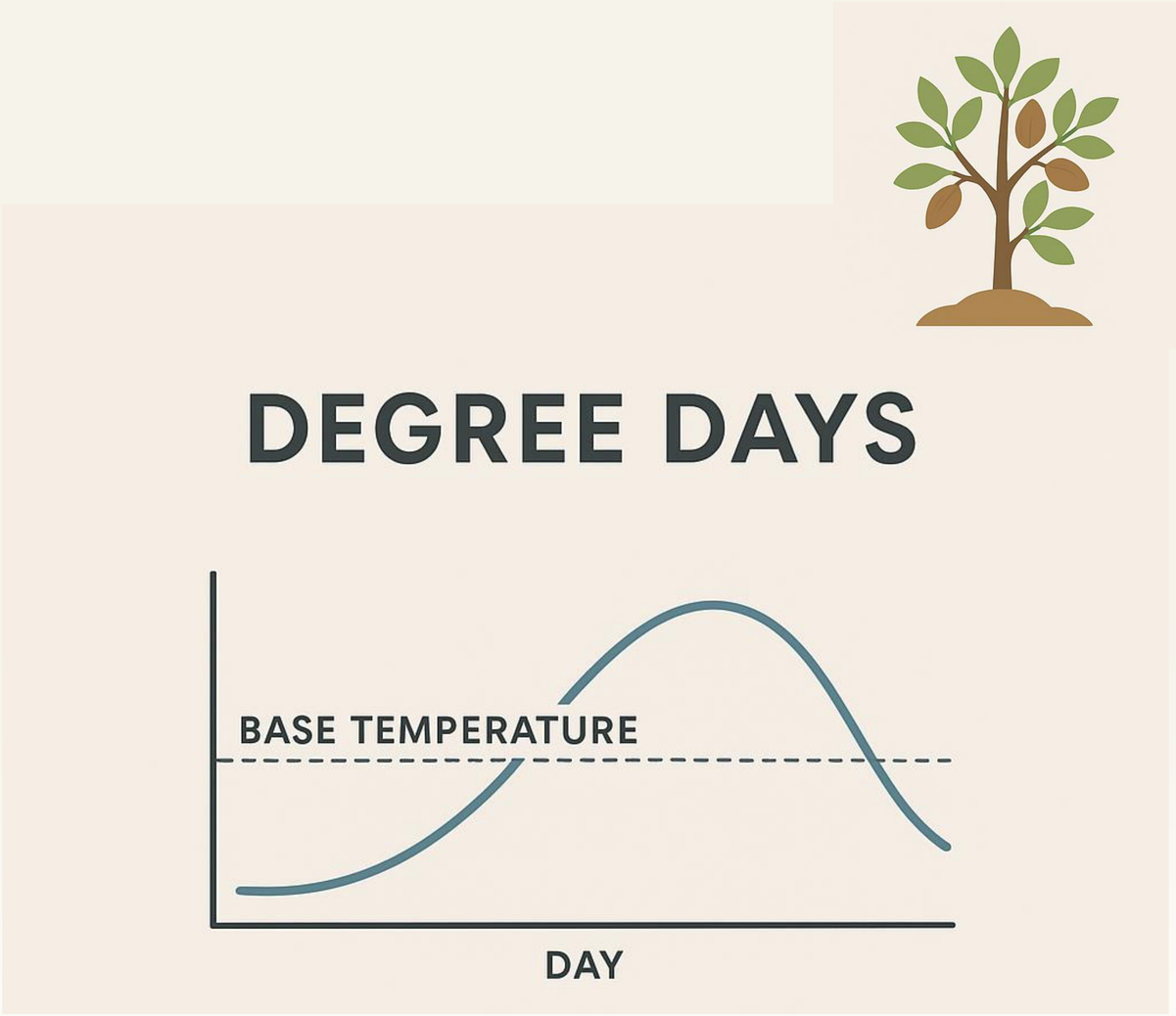
Growing Degree Days

The Calculation

$$\left\{ \frac{(\text{Maximum Temperature} + \text{Base Temperature})}{2} \right\} - \text{Base}$$



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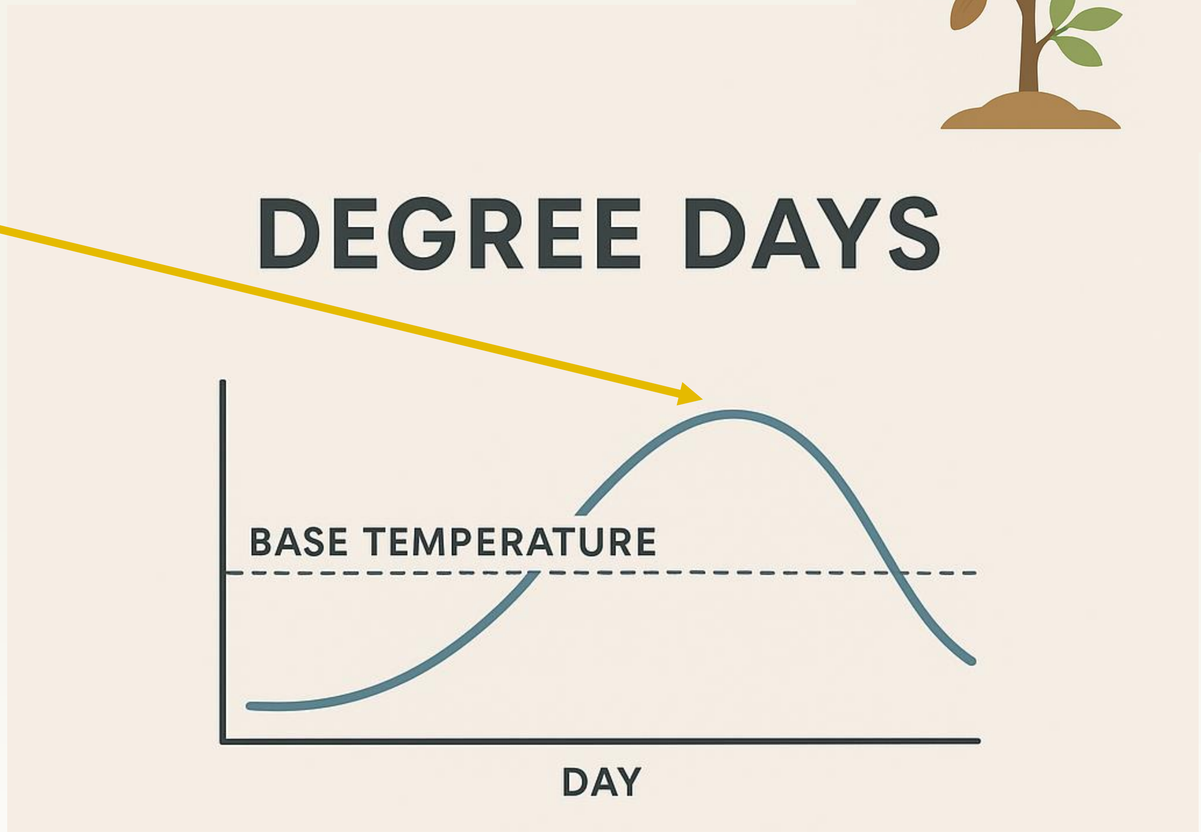

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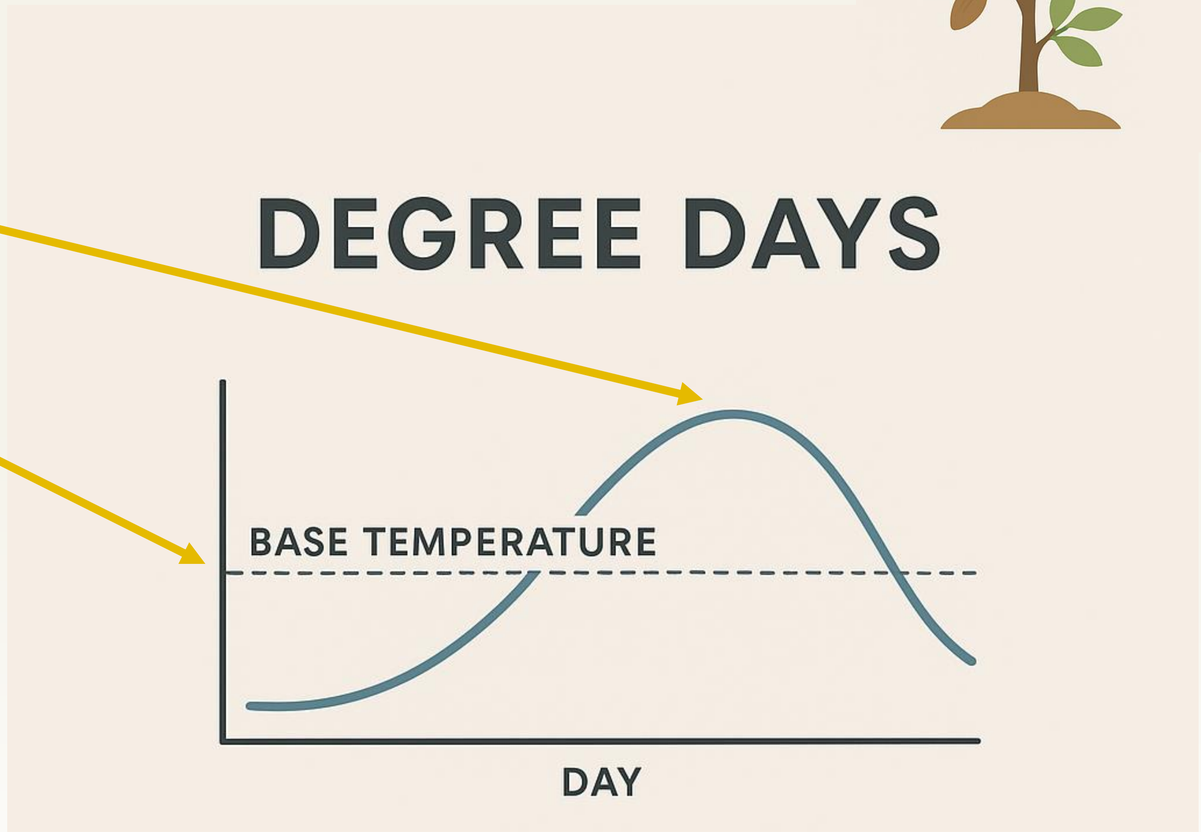


Growing Degree Days

The Calculation

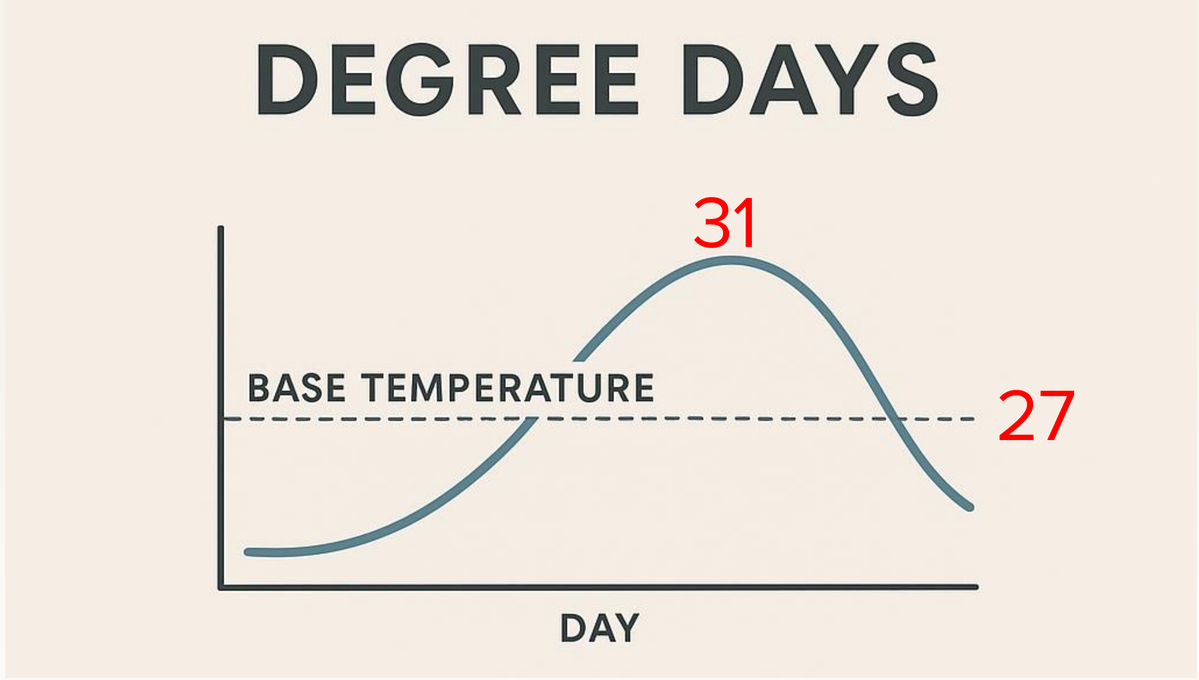
Using a maximum of 31

Step 1

$$\left\{\frac{31 + 27}{2}\right\} = 29$$

Step 2

$$29 - 27 = 2 \text{ GDD}$$



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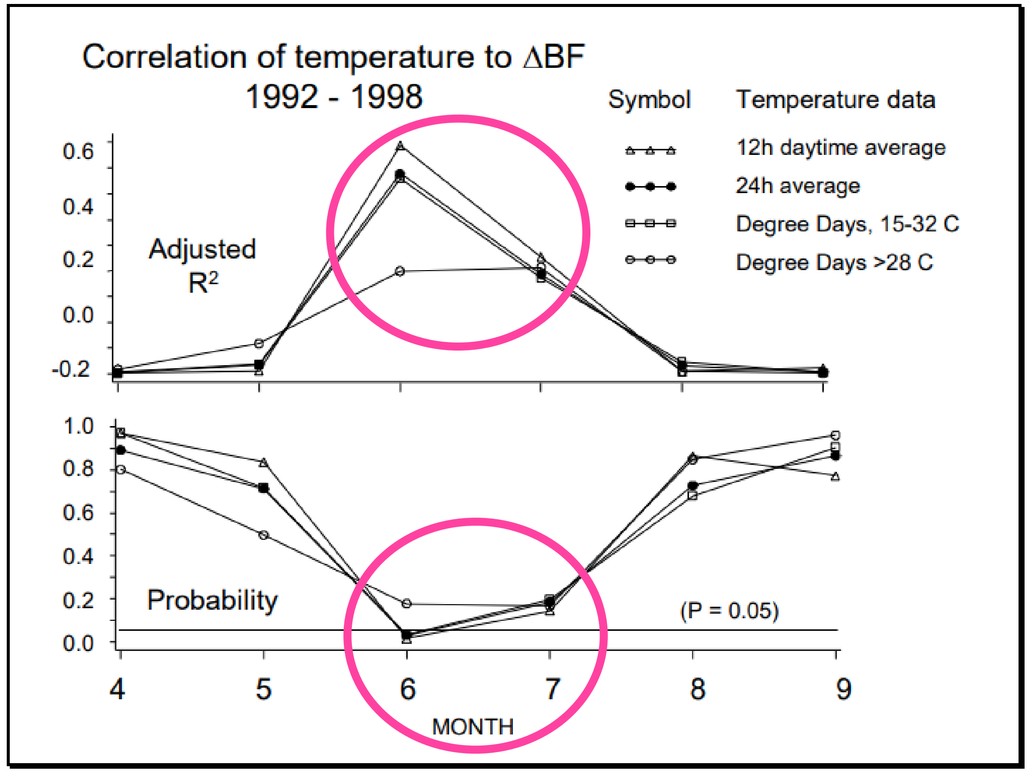

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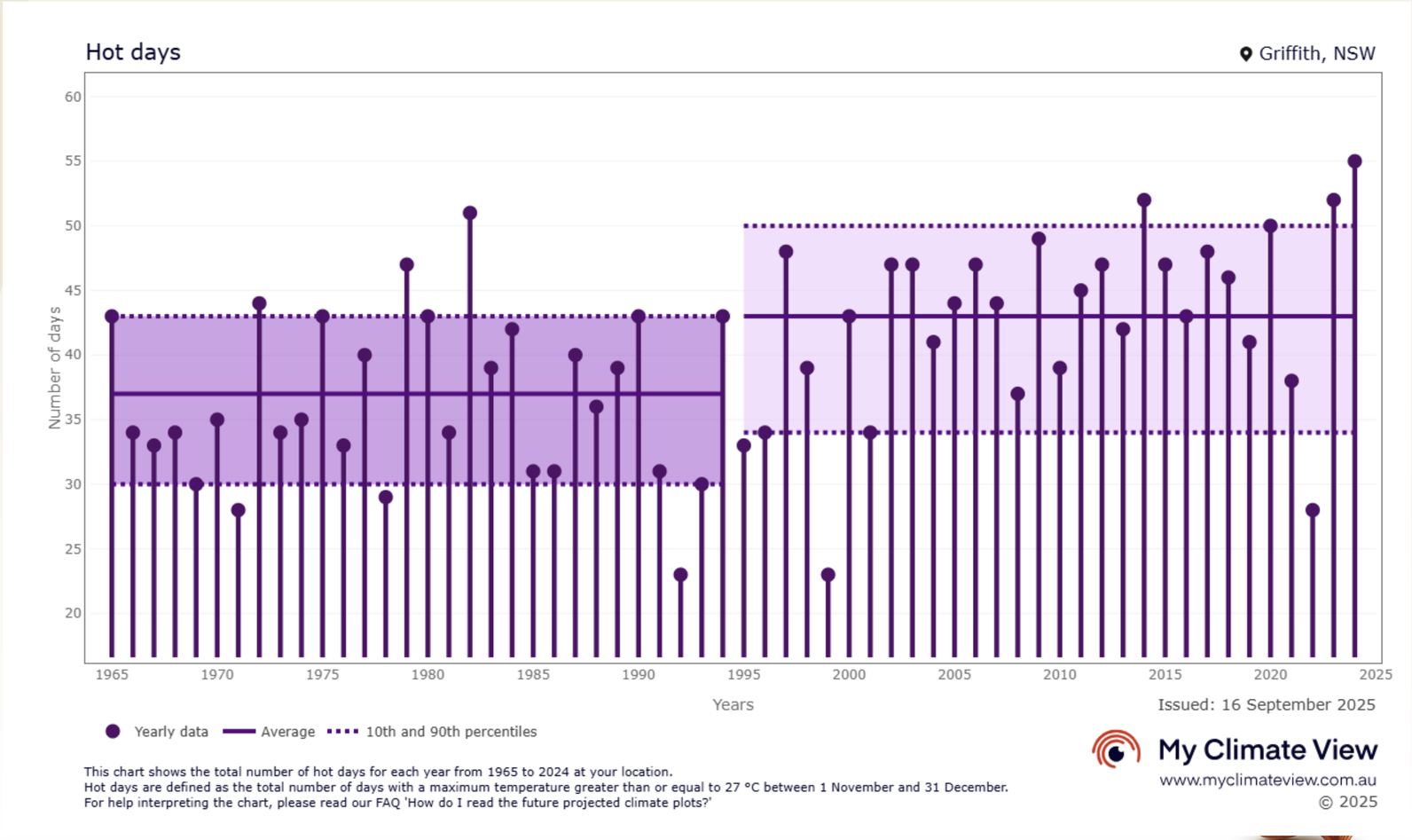
Difference between regions

Temperature days over 27 C in November, December, January

	Virginia	Loxton	Robinvale	Griffith
Average since 1965	46.5	61.7	66.6	66.6
90th percentile	56.2	71	76.2	76
Average since 2015	51.2	68.7	74.3	73.7

Griffith Observations

Hot days – Over 27°C in November and December



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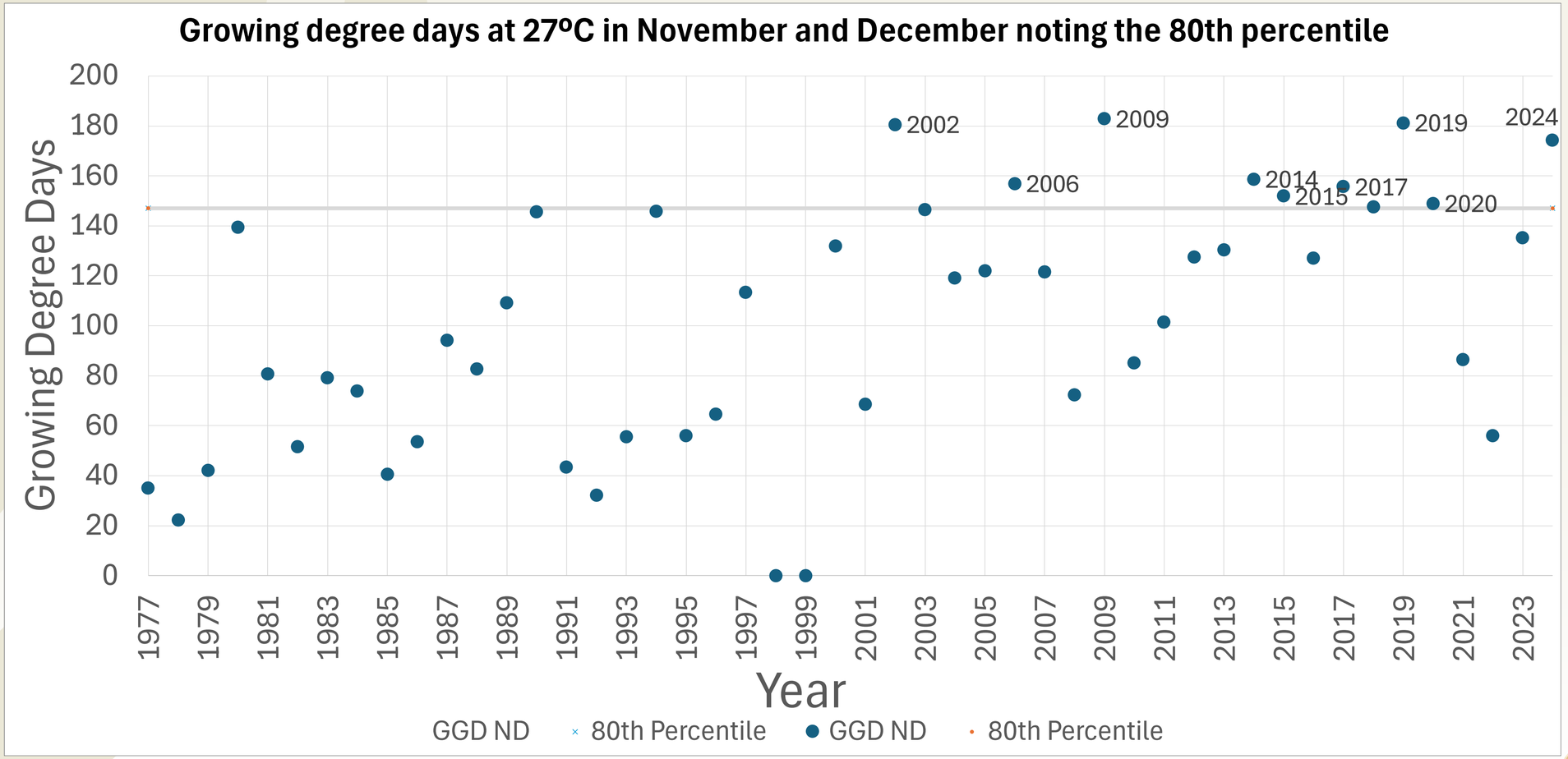

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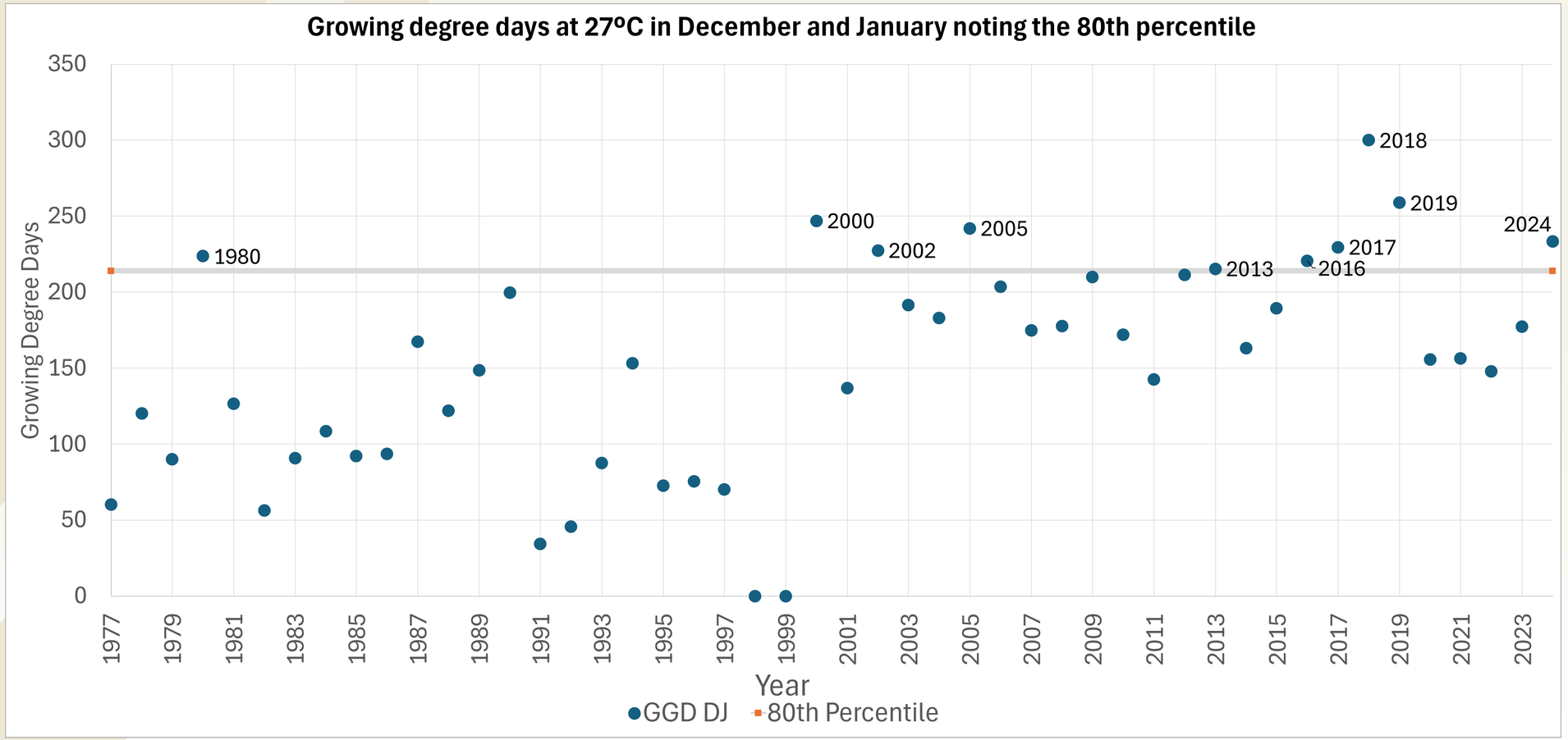

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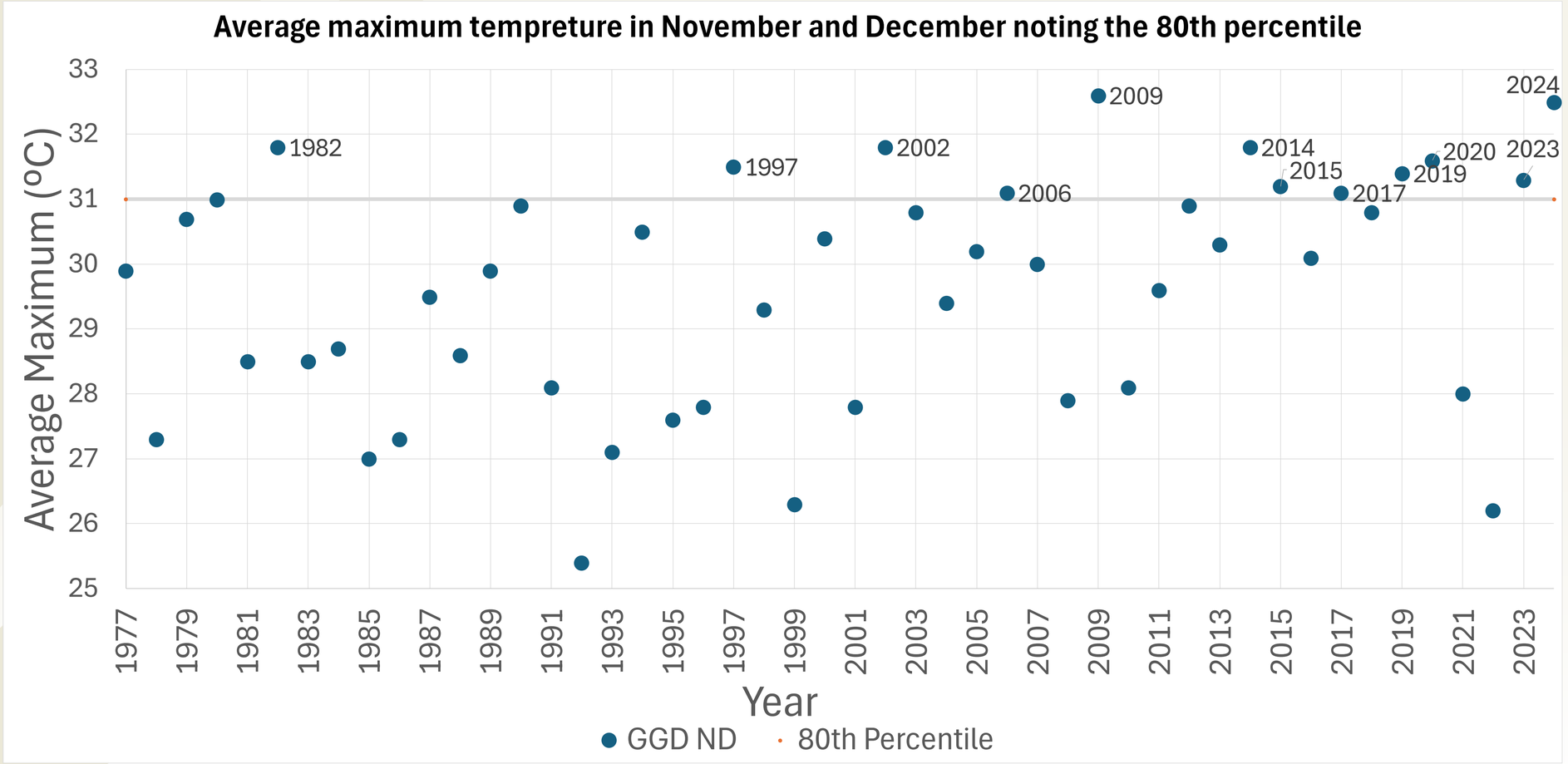
Griffith Observations

Average Maximum temperature in November and December



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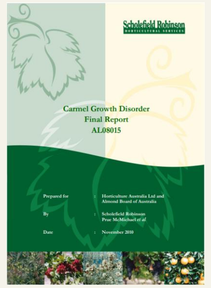
Griffith Observations

Putting it all together



High bud failure recorded in Spring 2007 and 2010

	1980	1982	1990	1993	1994	1997	2000	2001	2002	2003	2005	2006	2009	2013	2014	2015	2017	2018	2019	2020	2023	2024
Days over 27		90th				80th							80th		95th		80th			90th	95th	95th
GDD* Nov / Dec									95th			80th	95th		90th	80th	80th	80th	95th	80th		90th
GDD* Dec			80th		90th		80th		90th	80th				80th		80th		95th	95th			95th
GGD* Dec / Jan	80th						95th		80th		90th			80th			80th	95th	95th			90th
Av Max NOV / DEC		90th				80th			90th				95th		90th	80th			80th	80th	80th	95th

*GDD – Growing degree days at 27ºC

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Summary

- Non-infectious bud failure is a genetic condition.
- Stress conditions in December can create an environment that promotes the development of NBF.
- These conditions seem to be increasing in occurrence reflected in incidence of NBF.
- Other than removal of trees, management of NBF remains unclear.