



THE UNIVERSITY OF ADELAIDE AUSTRALIA

Viticulture and climate change.

Known unknowns and unknown unknowns that might catch us by surprise

Professor Steve Tyerman
email steve.tyerman@adelaide.edu.au


 Wine 2030
 Research Network University of Adelaide Wine 2030




Australian Wine Industry Environment Conference Sept 2009

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Summary

- **Climate change**, elevated CO₂ and consequences, elevated temperatures, drought, water quality.
- **Elevated CO₂** no dispute that this is increasing, but it is generally neglected in viticulture.
- **Knowns**: some responses of vines to CO₂, but relative short term.
- **Known unknowns**: (from other plants) vine growth and interactions with temperature, drought, nutrition.
- **Unknown unknowns**: we still have a lot to learn about the biology of vines that are important for adaptation to climate change.
- **What we need**: we need to know more about impacts of high CO₂ and interactions, and basic vine biology.

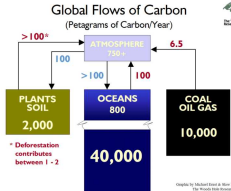


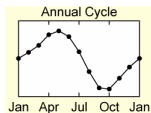
THE UNIVERSITY OF ADELAIDE AUSTRALIA

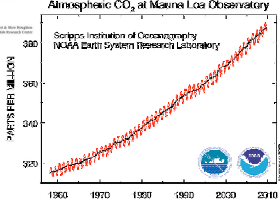
Where does all the carbon go?


Global Flows of Carbon (Petagrams of Carbon/Year)

One Pg (petagram)=one billion metric tonnes =1000 x one billion kg)





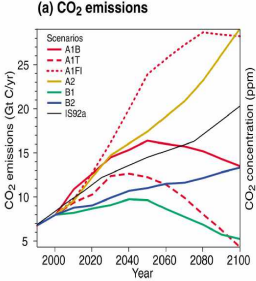




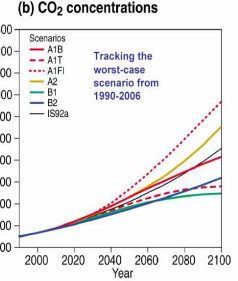
THE UNIVERSITY OF ADELAIDE AUSTRALIA

Scenarios


(a) CO₂ emissions



(b) CO₂ concentrations



Tracking the worst-case scenario from 1990-2006

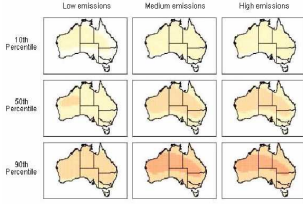

IPCC 2007

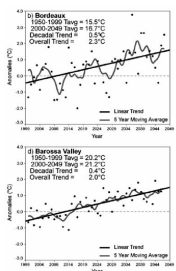
THE UNIVERSITY OF ADELAIDE AUSTRALIA


Predicted changes in temperature

National Temperature change 2030 Annual


Low emissions Medium emissions High emissions








<http://www.climatechangeinaustralia.gov.au> Jones et al., 2005



THE UNIVERSITY OF ADELAIDE AUSTRALIA

Effects of temperature on vines

Timing of budburst, flowering, fruit set, harvest will be earlier.
Less chilling over winter may also lead to uneven budburst.



By 2030 harvest date of Cabernet Sauvignon may be:
(c.f. 1961-1990 baseline)


15 to 23 days earlier in Coonawarra

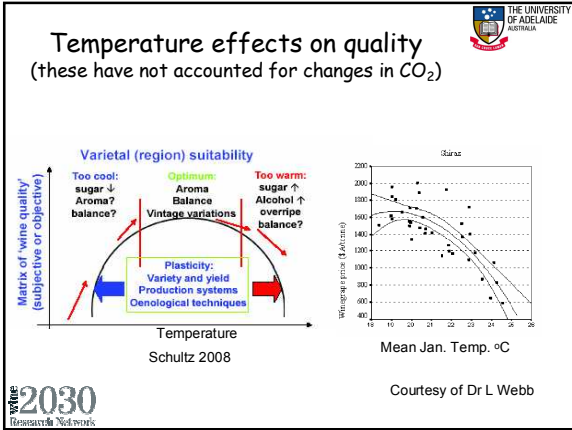
6 to 13 days earlier in the Riverland

10 days earlier to 4 days later in Margaret River

Model used: VineLOGIC Vineyard performance simulator (CRC Viticulture)

Courtesy of Dr L Webb





Rumsfeld's known knowns

(as applied to viticulture and climate change)

That there are known knowns,
There are things we know that we know,

We have some knowledge specific to grapevines.

There are known unknowns,
That is to say there are things that we now know, we don't know.

We know from other plants that there is likely to be an effect on grapevines but we do not know the exact response.

But there are also unknown unknowns,
There are things we do not know we don't know
And each year we discover a few more
Of those unknown unknowns.

—Feb. 12, 2002,
Department of Defense news briefing

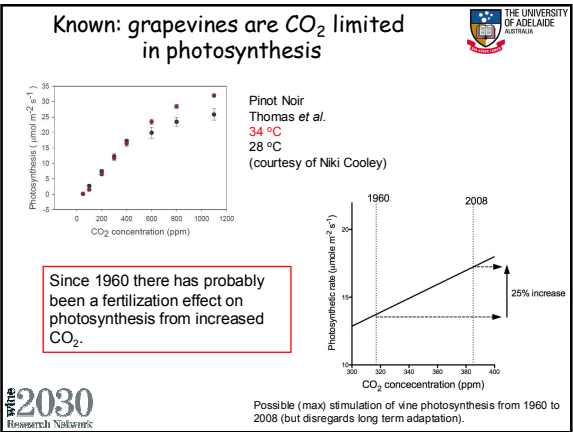
2030 Research Network

Vine biology and climate change

Knowns and Known unknowns

- Increase in CO₂
 - will increase yield (known)
 - will affect some wine quality parameters (known)
 - will change vegetative structure (known)
- Increase in CO₂ for plants (C3) generally:
 - Increases leaf temperature (reduced stomatal conductance) (known unknown)
 - Increases water use efficiency (known unknown)
 - Interacts with temperature and nutrition (known unknown)
 - May interact with water deficits (known unknown)
 - Long term effects (known unknown)
- Increase in Ozone
 - Strong inhibitor of photosynthesis and transpiration at low concentrations (20% reduction at 60 ppb) (known unknown)

2030 Research Network



Known: there will be an increase in yield.

	550 ppmv	700ppmv
■ Crop development:		
■ Phase length:	↔ (no visible change)	↔ (no visible change)
■ Leaf area:	↑ (+30-38%)	↑ (+33-41%)
■ Biomass accumulation:		
■ Vegetative biomass:	↑ (+33-42%)	↑ (+36-45%)
■ Reproductive biomass:	↑ (+40-43%)	↑ (+44-51%)

↔: n.s., ↑: P<0.05

From Free Air CO₂ Enrichment (Sangiovese)
Courtesy of M. Bindi

2030 Research Network

Known: there will be changes in wine quality

	550 ppmv	700ppmv
■ Grape quality:		
■ Acidity:	↔ (-2/-5%)	↔ (-4/-7%)
■ Sugars:	↔ (-4/-7%)	↔ (+2-3%)
■ Wine quality (18 parameters):		
■ Total flavonoids:	↑ (+38-25%)	↑ (+39-22%)
■ Total anthocynins:	↑ (+30-26%)	↑ (+32-25%)
■ Non-anthocynins flavonoids:	↑ (+38-37%)	↑ (+41-33%)

↔: n.s., ↑: P<0.05

From Free Air CO₂ Enrichment
Courtesy of M. Bindi

2030 Research Network

Known: Growth stimulation will be disproportionate

Aust. J. Plant Physiol., 1976, 3, 605-18

Vine Response to Carbon Dioxide Enrichment during Heat Therapy

P. E. Kriedemann,^A R. J. Sward,^{AB} and W. J. S. Downton^A

Dry weight increment (g per plant)

low high

low high

2030
Research Networks

Known unknown: interaction with temperature?

A B

Elevated [CO₂] 27.5°C

Ambient [CO₂] 28.1°C

30.9°C

30

28

26

25.0°C

Source: Long *et al*, 2006

This is soybean, we do not know what grapevines will do.

2030
Research Networks

Known unknown: interaction with water deficits.

CONTROL (no ABA)

0.7 nmol/mL (±) ABA

Gs, % initial

Time (mins)

CO₂ (ppm)

100

400

700

ABA is the hormone signal that is implicated in deficit irrigation techniques; controls stomata pores in the leaf.

This data for grapevine leaves shows that the response to this hormone is dependent on the CO₂ concentration. (Data from Alex Tucker and Brian Loveys)

2030
Research Networks

Known unknown: Ozone may depress yield

Seasonal mean of ambient ozone concentrations between 09:00 and 16:00 h over the continental United States from 1 July to 31 September 2005 (Tong *et al*, 2007, *Atmos. Environ.* 41:8772). Areas shown in brown, orange and red can experience significant crop yield loss and damage to ecosystem function from ambient ozone.

<http://www.ars.usda.gov/Main/docs.htm?docid=12462>

2030
Research Networks

Known unknown: Ozone may depress yield

Proportional Yield Response

Seasonal Ozone Concentration (ppb)

Sorghum

Field Corn

Winter wheat

Soybean

Peanut

Control

Gawler 4 hour maxima exceeded 60 ppb Jan 1999. What happens in grapevine??

<http://www.ars.usda.gov/Main/docs.htm?docid=12462>

2030
Research Networks

An example of an unknown unknown, important in climate change responses

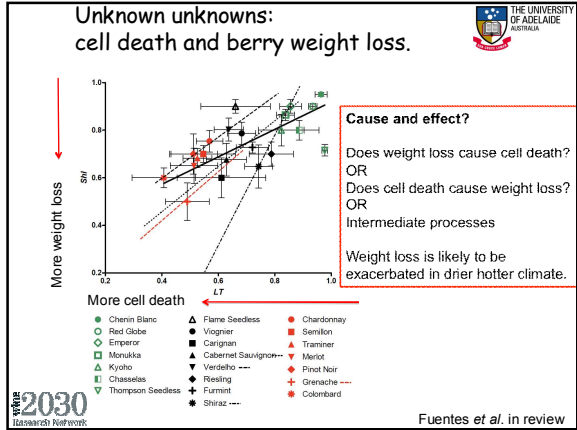
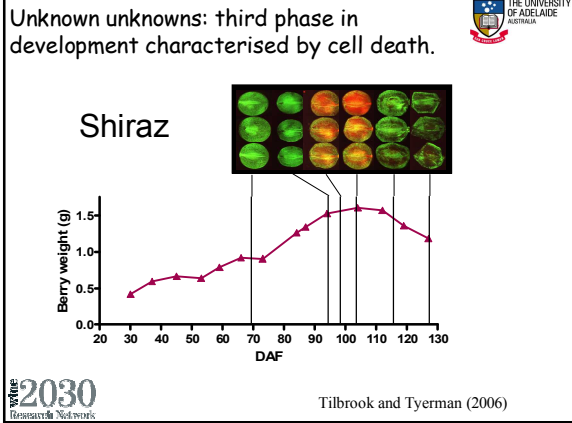
A newly discovered phase in pre-harvest berry development:

- Characterized by onset of cell death in the berry.
- Interactions with heat stress and drought are unknown.

Sultana Chardonnay

Similar Brix and age.

2030
Research Networks



What we need

- We need to turn the *known unknowns* into *knowns*, generally these relate to detailed measurements on vines in simulated future climate scenarios, (CO₂ x temperature x water x variety).
- We need to remember that almost all biological processes will respond to climate change. There are still many important things about vine biology yet to be discovered, that may be important for the way we adapt to climate change.

Hawkesbury Forest Experiment

Read more.....

Anderson, K., Findlay, C., Fuentes, S., Tyerman S.D. (2008) Viticulture, wine and climate change. *In: Garnaut Climate Change Review.*

[http://www.garnautreview.org.au/CA25734E0016A131WebObj/01-HViticulture/\\$File/01-H%20Viticulture.pdf](http://www.garnautreview.org.au/CA25734E0016A131WebObj/01-HViticulture/$File/01-H%20Viticulture.pdf)

Thanks to GWRDC for funding towards a workshop on developing a high CO₂ facility for grapevines.