

What can the vine tell us about its water status?

Everard J. Edwards

Irrigation management

The basics:

We irrigate to produce an economically viable crop.

Efficient irrigation is applying only the water needed to produce the required crop.

The question:

How can we irrigate efficiently (how much and when)?

This is why we are interested in vine water status



Plant based sensors

Most growers measure soil moisture,

But are they interested in soil moisture *per se*?

We typically use soil H_2O as an indicator of the vine water status.

So why not look to the vine itself?

We can measure many aspects of plant function, but costly and time consuming.

Interpretation requires knowledge of physiology.

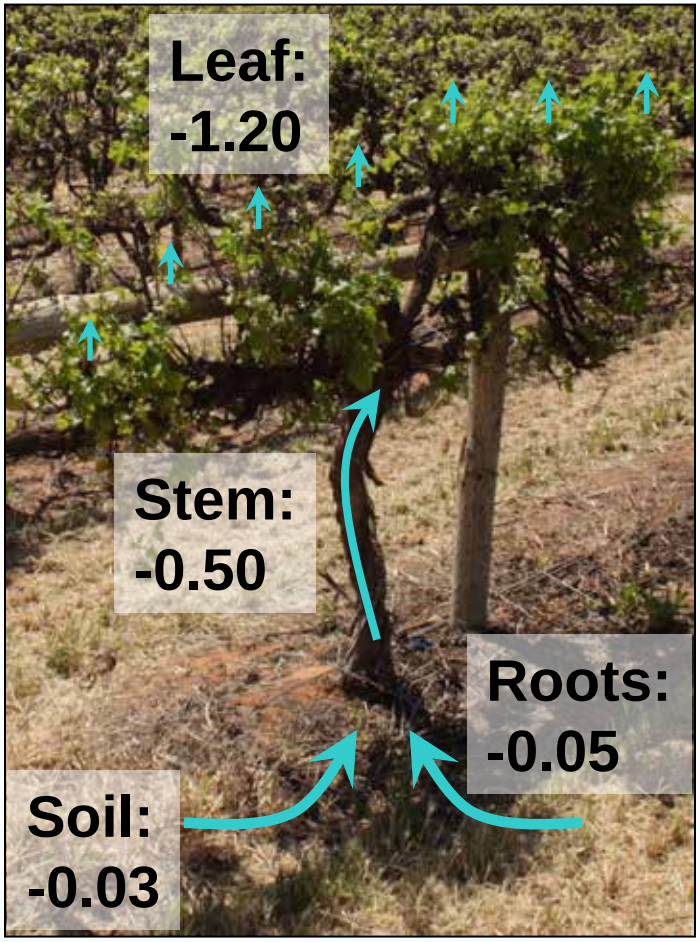








What do we mean by water status?



Water potential

The plant is part of a soil-air continuum.

Water potential is the ‘suction force’ that causes water to move and is measured as a negative pressure (MPa).

Water moves from less negative to more negative potential.

Leaves are site of evaporation and have the lowest (most negative) potential.

Lower potential = greater water ‘requirement’ in that tissue.

At night leaf water potential typically reaches equilibrium with soil

How? When? Where?



Balance pressure: leaf and ‘stem’.

Near infra-red spectroscopy: leaf and destructive samples.





Psychrometry: leaf and woody tissue.

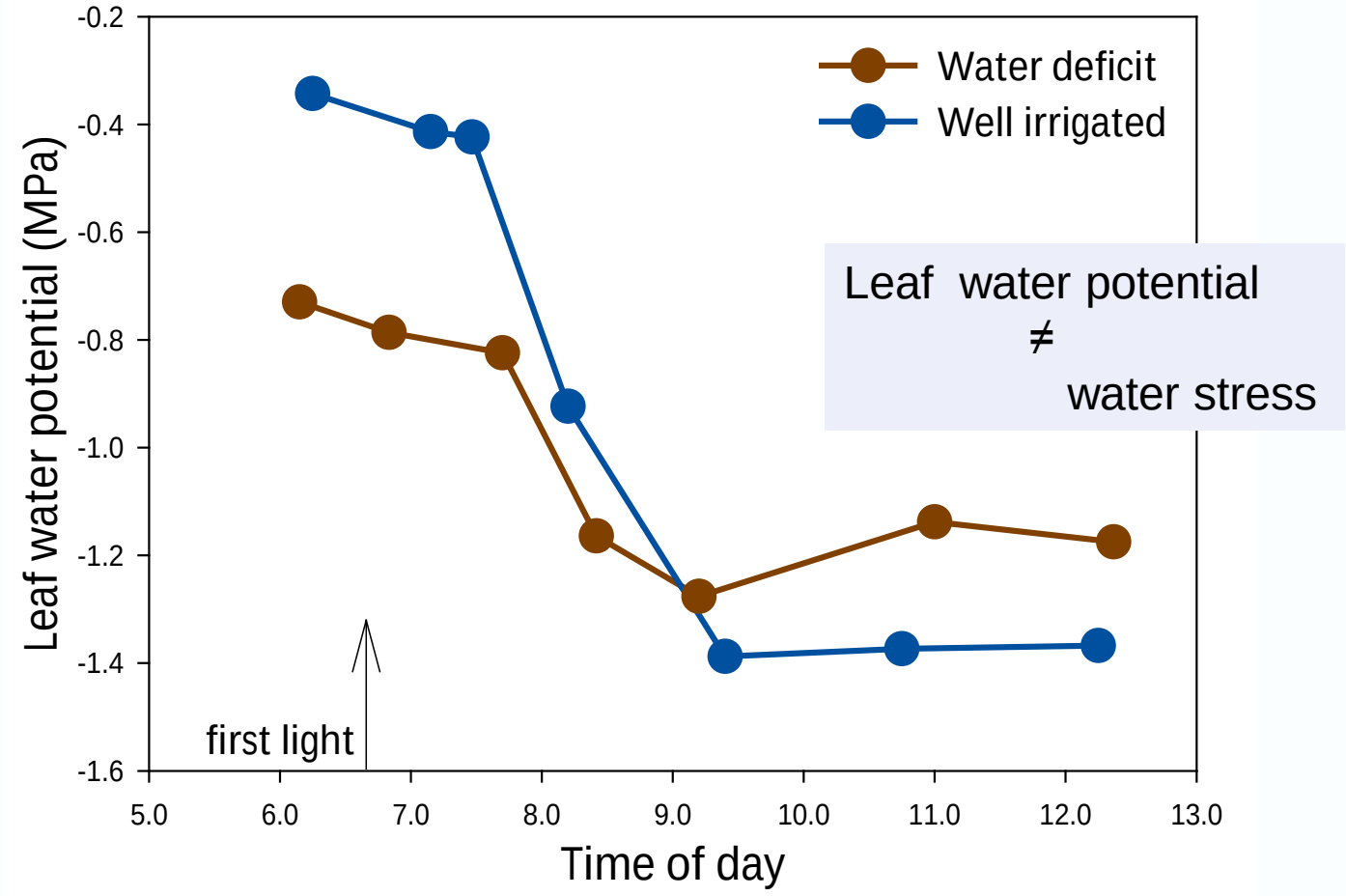


Thermal diffusivity: canes and woody tissue.



How? When? Where?

Measures of plant function (including water potential) are dynamic and respond to multiple environmental factors.



Merlot vines in Adelaide Hills, data courtesy of Brian Loveys

Interactions

Why does the deficit irrigated vine end up with a “better” water potential than the well watered vine?

Due to differences water loss during the day.

Controlled by pores in the leaf: *stomata*.

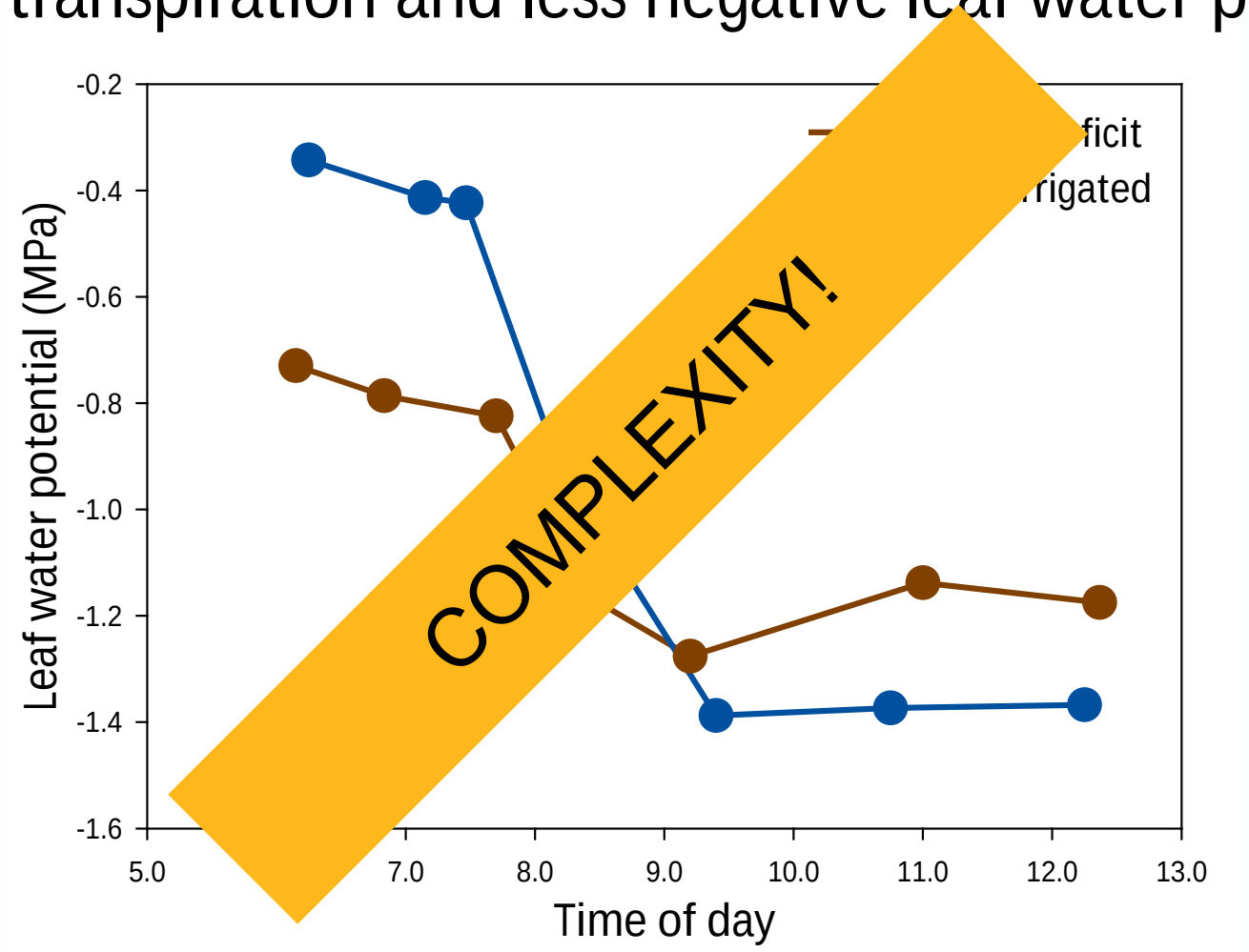
Regulate gas exchange between leaf and air.

Affects photosynthesis and transpiration (water use).



Interactions

Low soil water availability results in stomatal closure, reduced transpiration and less negative leaf water potential.



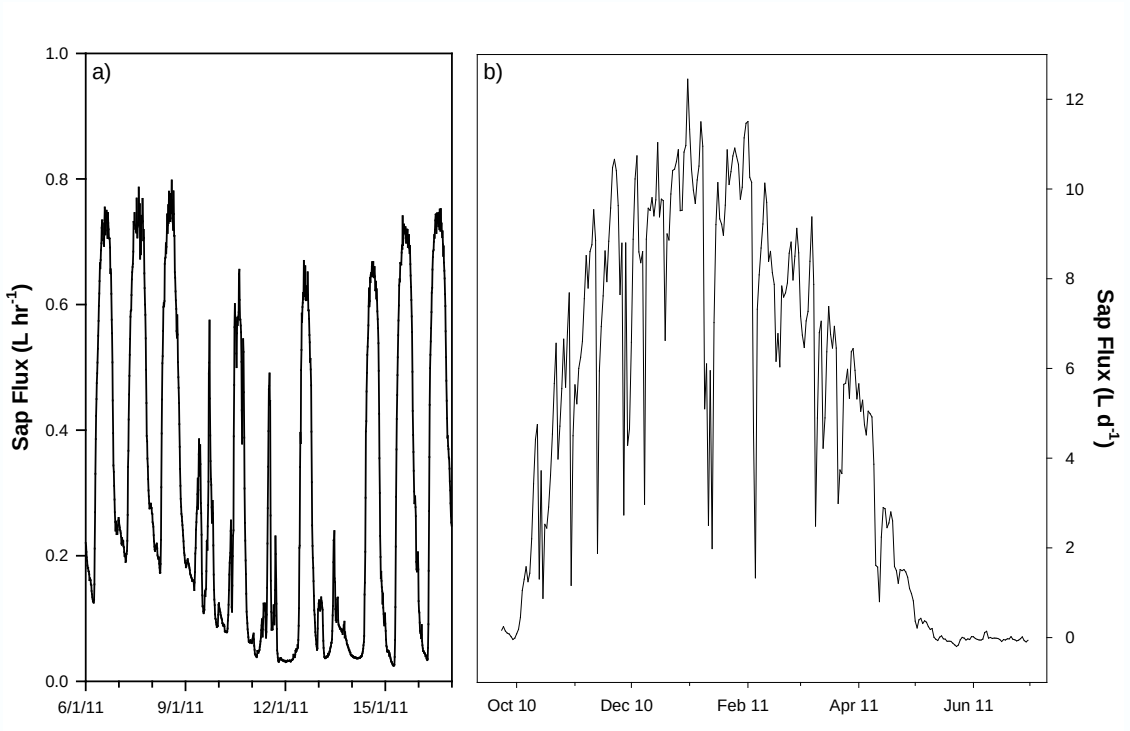
Merlot vines in Adelaide Hills, data courtesy of Brian Loveys

Other measures: sapflow

Vine water use can be measured directly.

Data can also be combined with information on weather to make irrigation decisions.



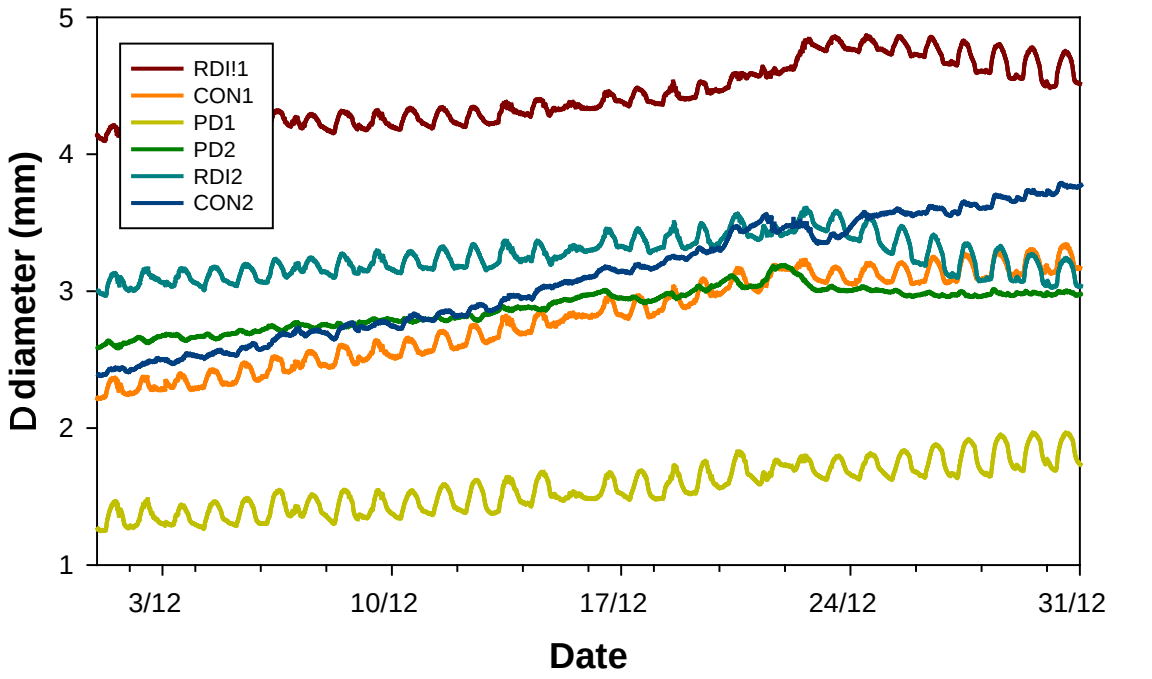


Other measures: dendrometers

Dendrometers measure very small variations in trunk diameter.

More negative water potential during day results in trunk shrinkage.





Where is the emerging technology?

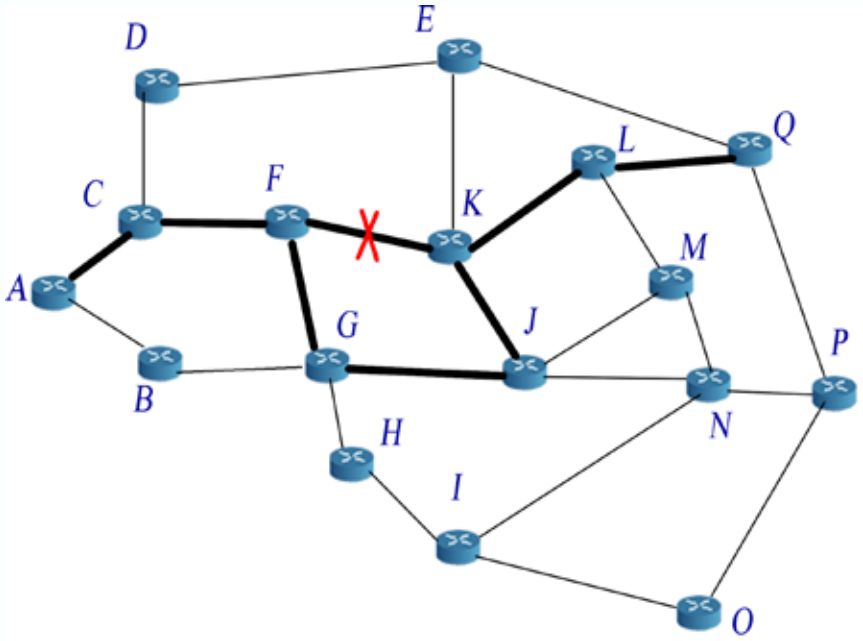
Most of these sensors/techniques have been around for some time...

But modern manufacturing is bringing the price down year by year, e.g. NIR.

Wireless mesh networks for the field.

Powerful IT everywhere.





Remote sensing

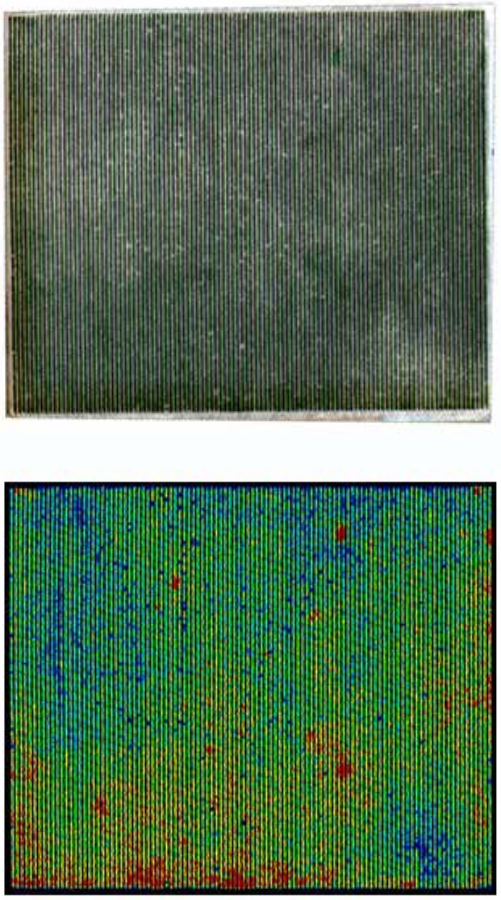
Technologies discussed so far are single point (leaf/vine).

Remote sensing offers:

non-contact/non-destructive,
large area sampling,
wide range of possible wavebands.

Limitations for irrigation scheduling:

infrequent coverage,
speed of data/analysis provision,
limited view angles.



Colour and multi-spectral images of vineyard
Remote Sensing Australia

Proximal remote sensing

Remote sensing imaging technologies can be used at a smaller scale:

Multi-spectral, e.g. NDVI, PCD
Hyperspectral,
LIDAR, etc.

Sensors can be mounted to moving machinery or fixed.

Many possible viewing angles.

Instant data availability (local hardware / web-based tools).





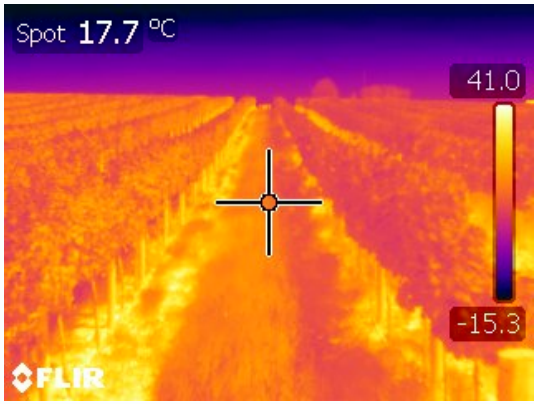


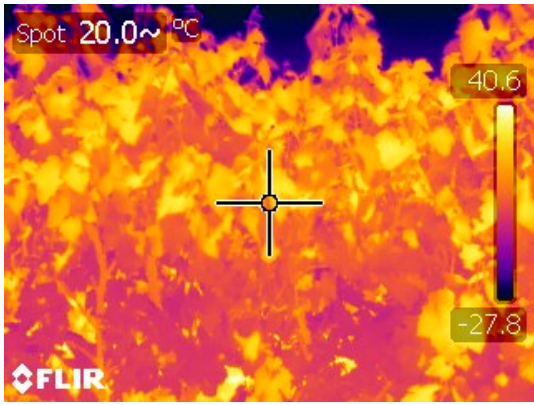
Canopy temperature

Easy to get a value.

Lots of methods to obtain measurements.

Popular with plant scientists – must be good!



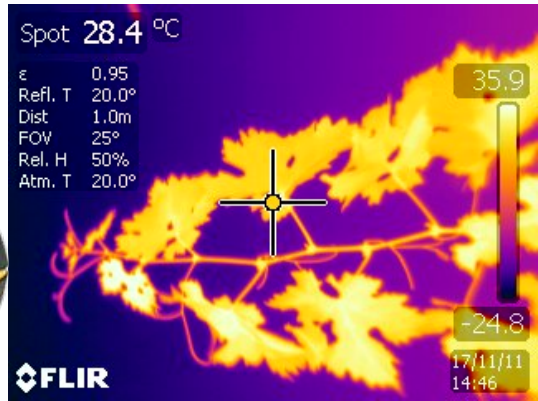








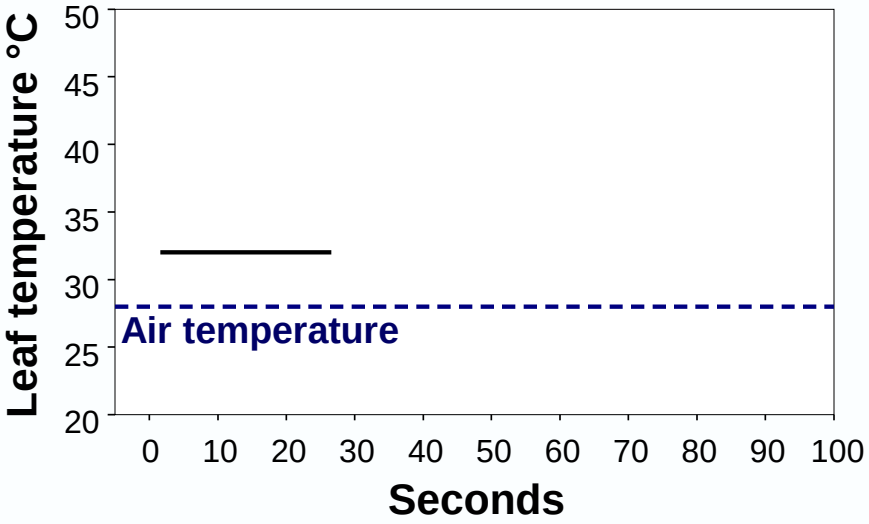




Transpiration affects leaf temperature





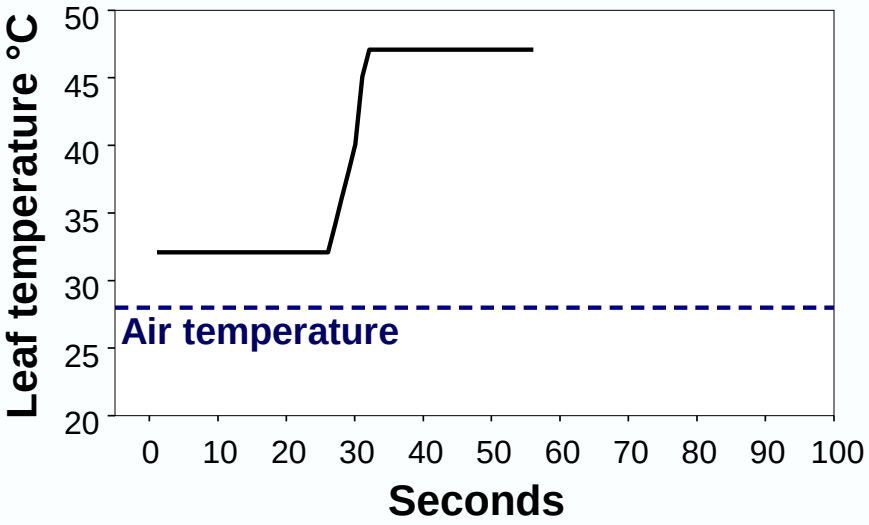


Slide courtesy of Brian Loveys

Transpiration affects leaf temperature







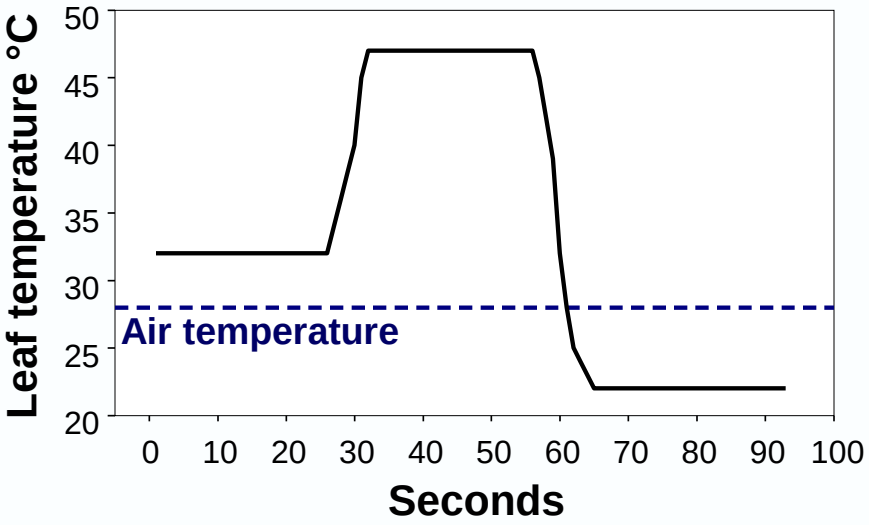


Slide courtesy of Brian Loveys

Transpiration affects leaf temperature



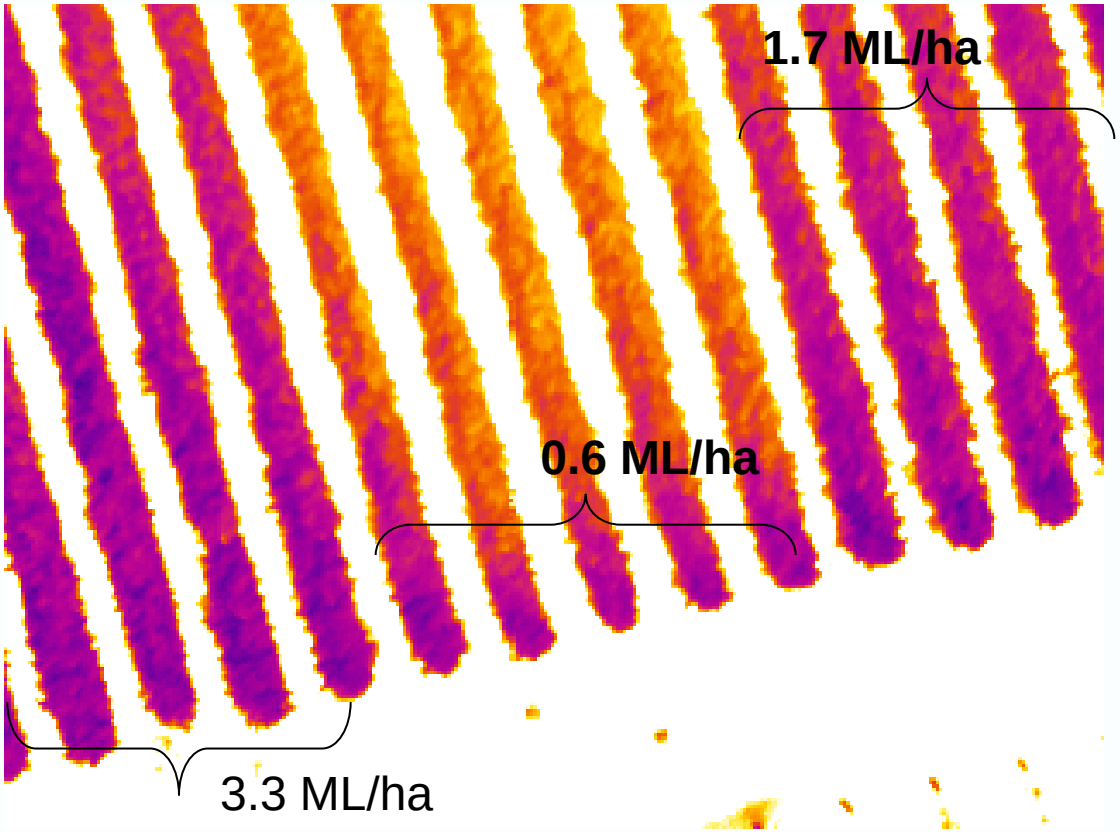




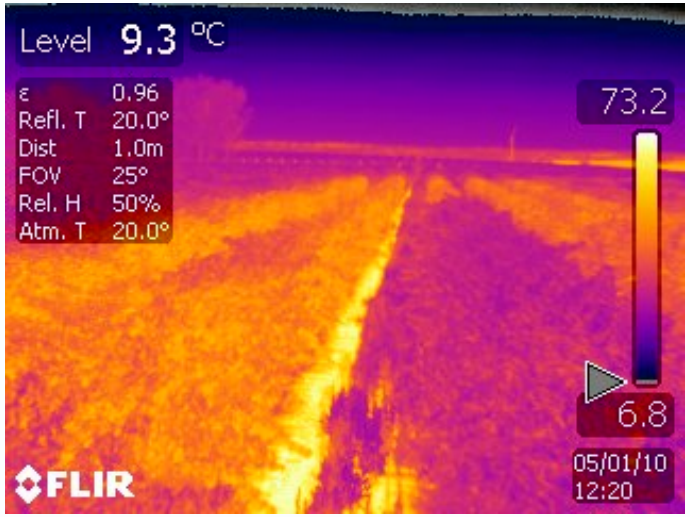


Slide courtesy of Brian Loveys

Transpiration affects leaf temperature



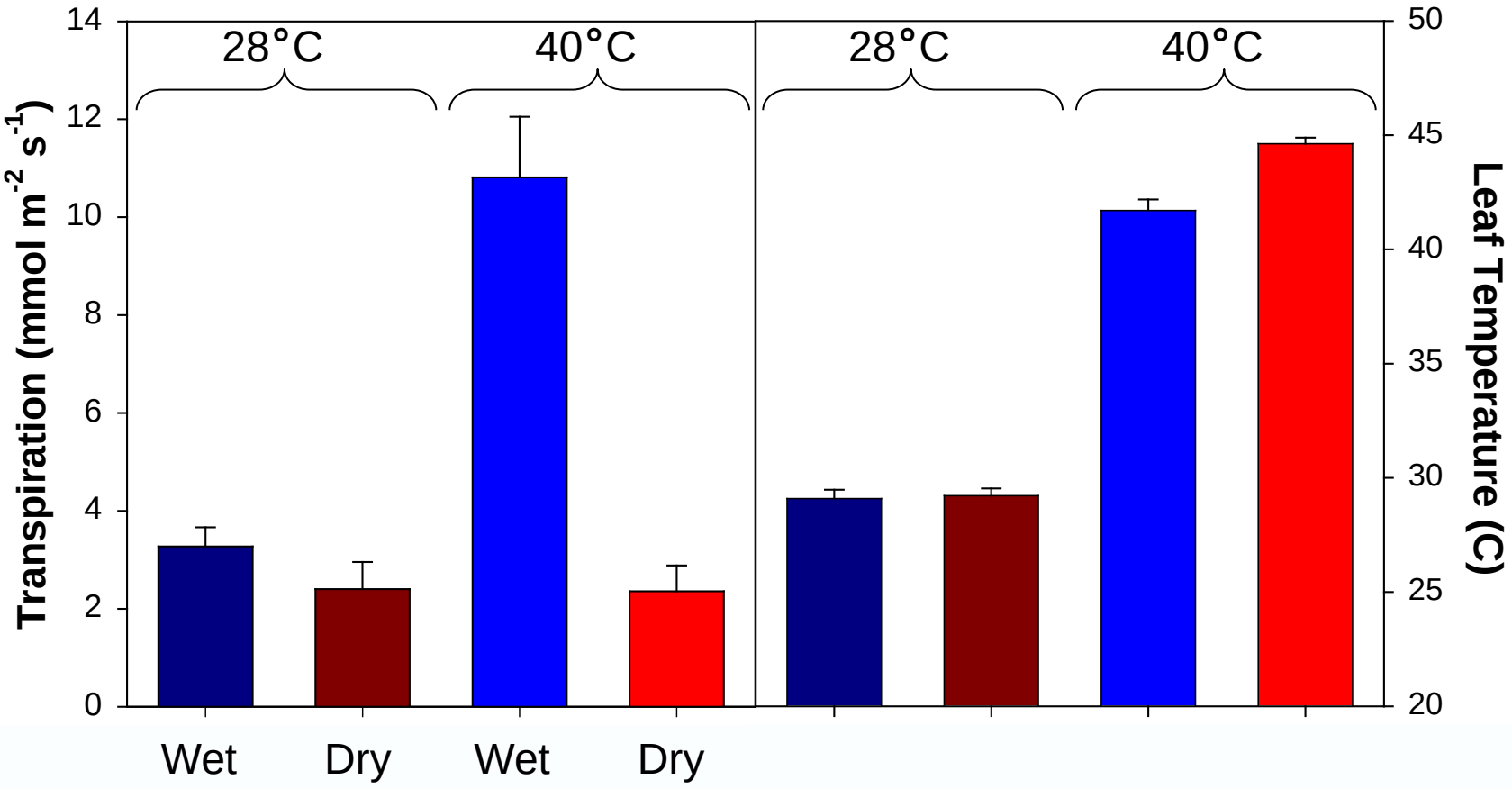




Canopy temperature of deficit irrigated vines is higher than well-watered vines.

Aerial image courtesy of Ashley Wheaton, University of Melbourne.

Using canopy/leaf temperature



A small temperature difference can represent a large difference in transpiration.

Transpiration can be a poor measure of stress in mild conditions.

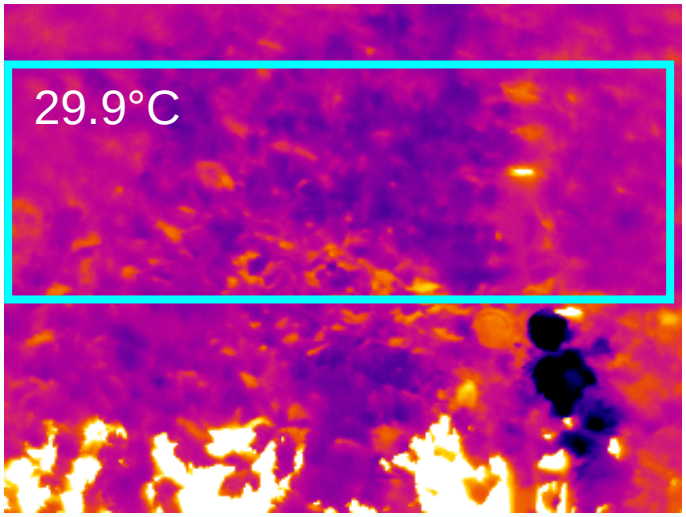
Using canopy/leaf temperature

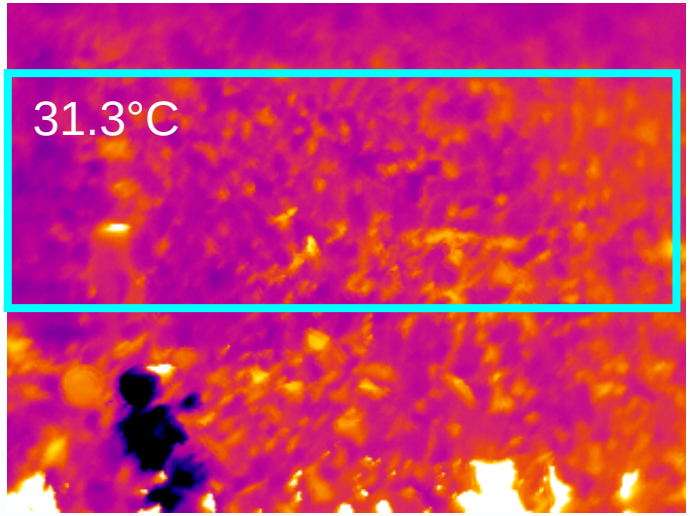
Transpiration controlled by stomata, stomata responsive to water stress.

Index of conductance:

$$I_g = \frac{(T_{dry} - T_{leaf})}{(T_{leaf} - T_{wet})}$$





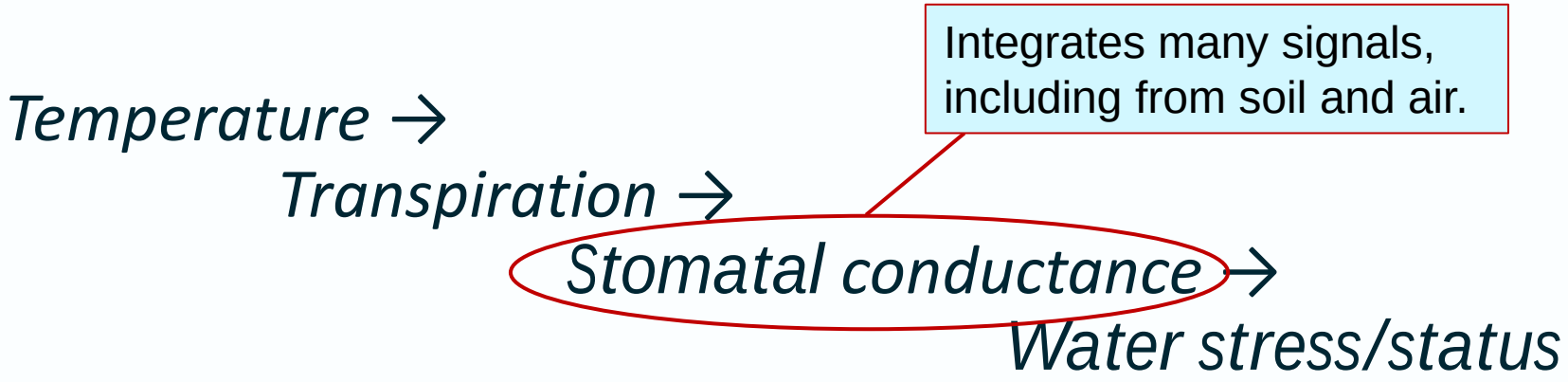


Images/data courtesy of Brian Loveys

Using canopy/leaf temperature

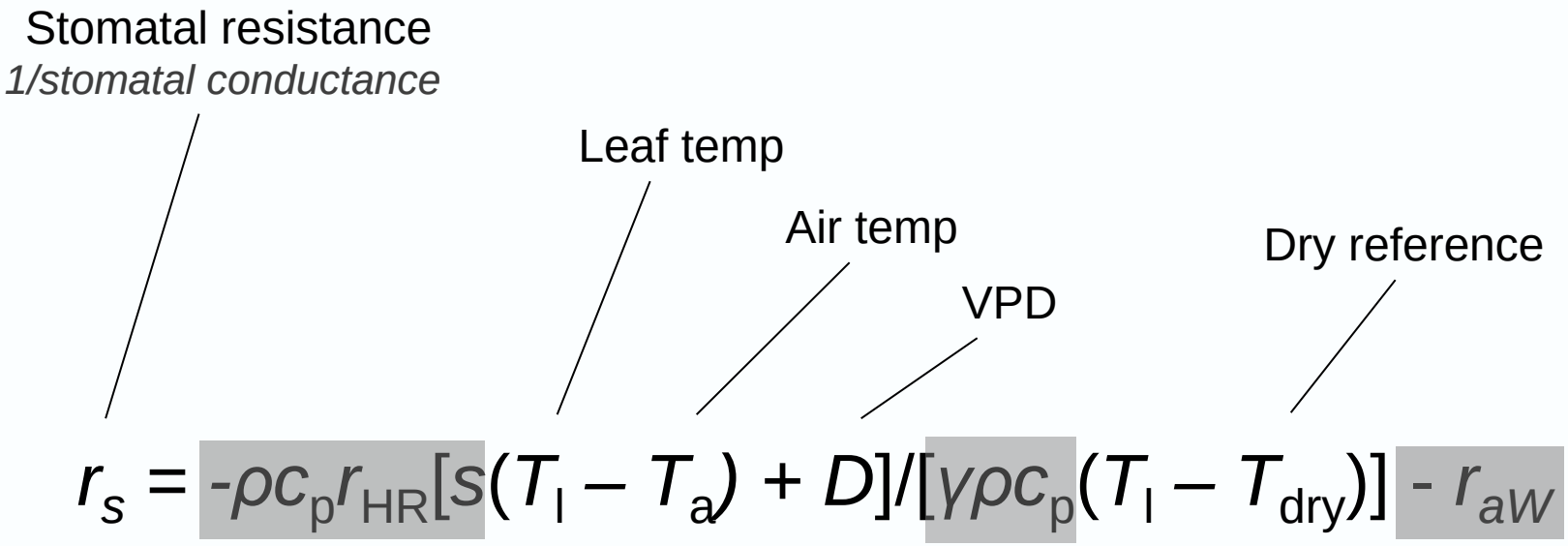
Transpiration controlled by stomata, stomata responsive to water stress.

So:



Canopy temperature is a measure of water stress, when considered *in relation* to the environment.

A simpler alternative?



Can get rid of wet reference if measure humidity.

Leinonen et al. *2006. Plant Cell Environment* ***29****, 1508-1518.*

A simpler alternative?

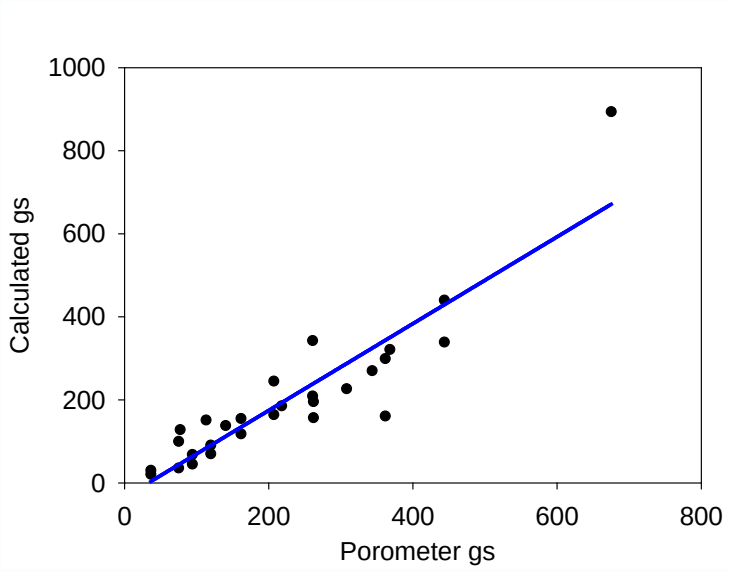




IR temperature gun relatively cheap,

Box of tricks incorporating a dry reference.

Collect data across vineyard block.



Images/data courtesy of Brian Loveys

Difficulties in using canopy temperature for irrigation scheduling

Air temperature and humidity have huge effect on leaf temperature,

Can't compare measurements on different days.

Need additional environmental measurements to estimate actual vine stress.

Need coverage of entire block,

Aerial imaging expensive/infrequent.

Small variation in temperature = large variation in stomatal conductance.

What are the practical options?

You shouldn't need a degree in plant science to decide when to turn the tap on.

Point measurements (leaf water potential, sapflow, trunk shrinkage) possible for very high value crops.

Remote sensing useful for long-term effects,

e.g. differences in soil depth.

Farm-based assessment of canopy temperature for irrigation scheduling requires more development.







Conclusions

The reason we use soil moisture measurement is to estimate plant water stress.

The plant lives in air and soil, therefore plant based measures are a better estimate of this.

But,

Measuring plant function is hard (=expensive).

Interpreting plant function is complicated.

***Need*,**

Simplified measurement, simplified indexes for decision making.

Acknowledgements

Brian Loveys

Past and current staff of grapevine physiology group at CSIRO.

Most work described funded by GWRDC.

Plant Industry
Everard Edwards
Research Team Leader

t +61 8 83038649
e everard.edwards@csiro.au