Lower Limb Dieback in Almond Relative to Light, Soil Moisture and Stem Water Potential

- Bruce Lampinen
- Jim Adaskaveg
- Greg Browne
- Joe Connell
- Roger Duncan
- Brent Holtz
- Themis Michailides
- Sam Metcalf

Usually beginning in late April to early May, leaves on lower limbs begin to yellow and then turn brown

Eventually, the whole limb collapses

This is different from the normal pattern of shading related dieback- more commonly individual spurs yellow and following year will be dead

- **Data collected in 2004 and 2005 in Stanislaus County suggested LLDB was not caused by:**
  - **anthracnose**
  - ***Alternaria***
  - **brown rot**
  - **hull rot**

•**Isolations in 2004, 2005 and 2006 from affected limbs showed a *Phomopsis* sp. and *Botryosphaeria dothidea*.**

Fungicide Trial #1- Duncan

- Captan or Pristine, with and without a bark penetrating surfactant, was applied to lower canopy in Orchard #1 in early May prior to expected onset of limb dieback
- Overall incidence of limb dieback was low
- No difference among treatments.

Fungicide Trial #2- Duncan

Materials applied to trunks and scaffolds on June 22, 2007

Symptoms rated August 17, 2007

Treatment	LLDB Symptoms (Rating 0-4)
Agri-fos @ 1.5 qt. / gal. solution + 3 oz penetrant	3.6 a
Captan 80 WDG @ 5.66 lb + 3 oz penetrant	2.3 b
Untreated	2.0 b
Pristine @ 14.5 oz + 3 oz penetrant	1.6 b

2008 isolations- both *Botryosphaeria* and *Phomopsis* were isolated from healthy and LLDB affected limbs

- **Frequency of fungal isolations increased with time during growing season**
- **More *Botryosphaeria* than *Phomopsis* were isolated in 2008**

•2009 isolations- both *Botryosphaeria* and *Phomopsis* were again isolated from both healthy and LLDB affected limbs

- **More *Phompsis* than *Botryosphaeria* were isolated in 2009 (opposite situation in 2008)**

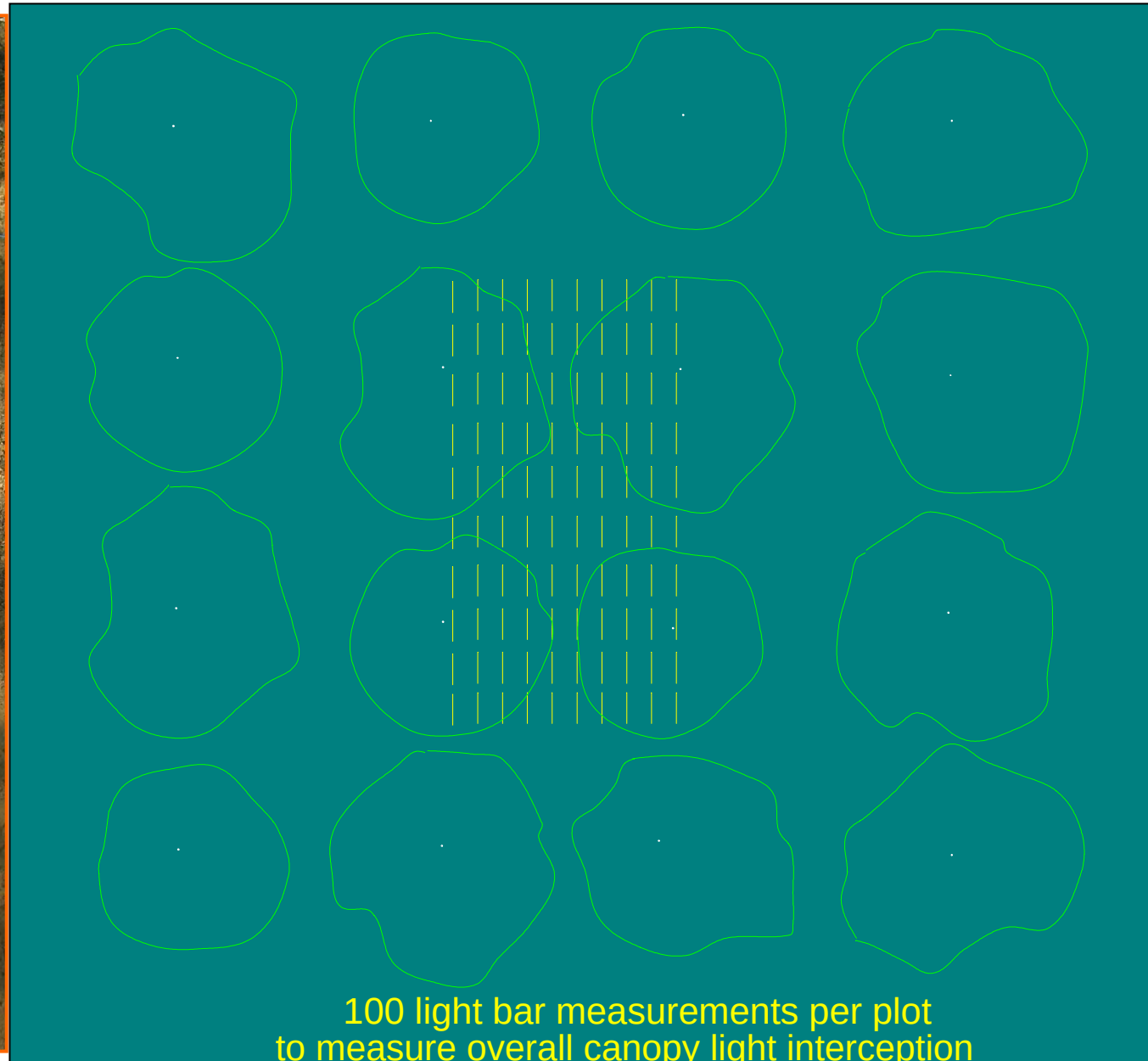
•Frequency of isolation of these fungi varied by year

"The results suggest that the frequency of isolation of these fungi depends on the year and this is another reason why the results thus far suggest that these fungi are not directly involved in LLDB" **Themis Michailides- Almond Board Report 2009**

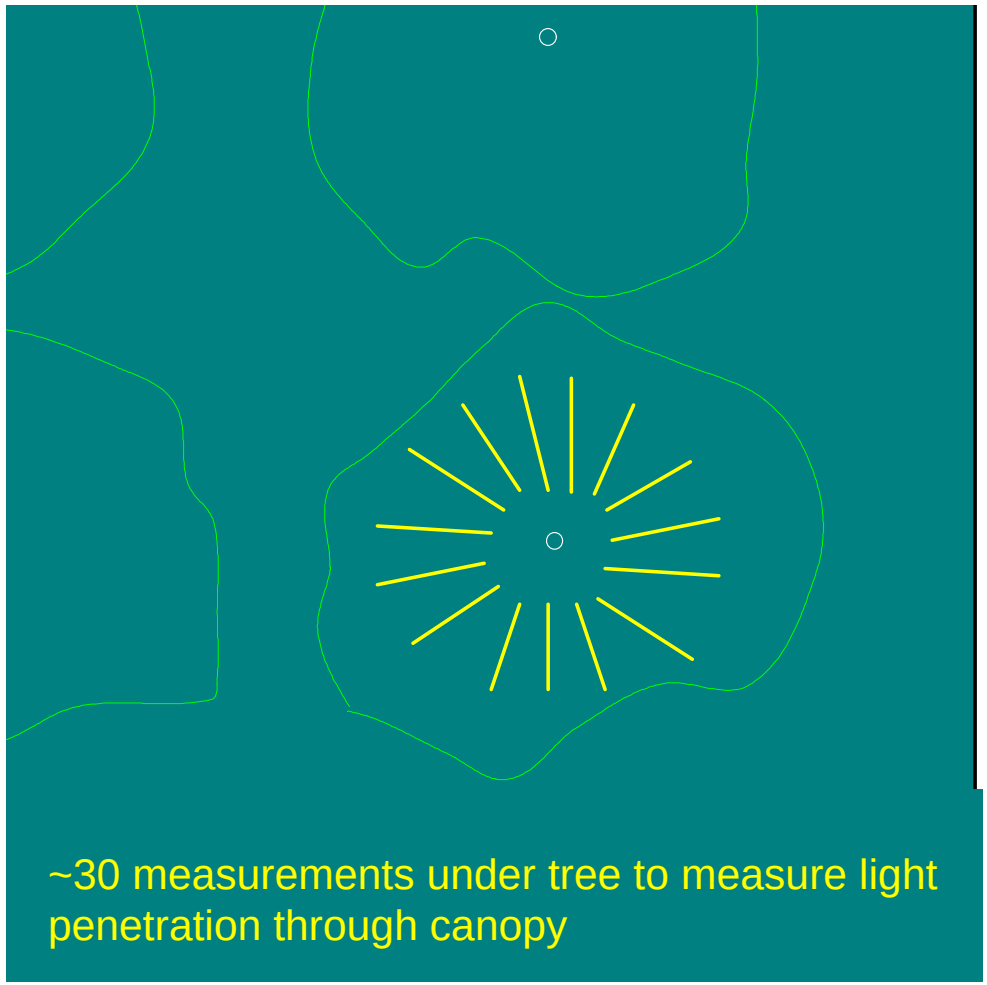
Soil and physiological measurements to assess role of stress in LLDB

- •Midday canopy light interception
- •Midday stem water potential
- •Soil moisture tension

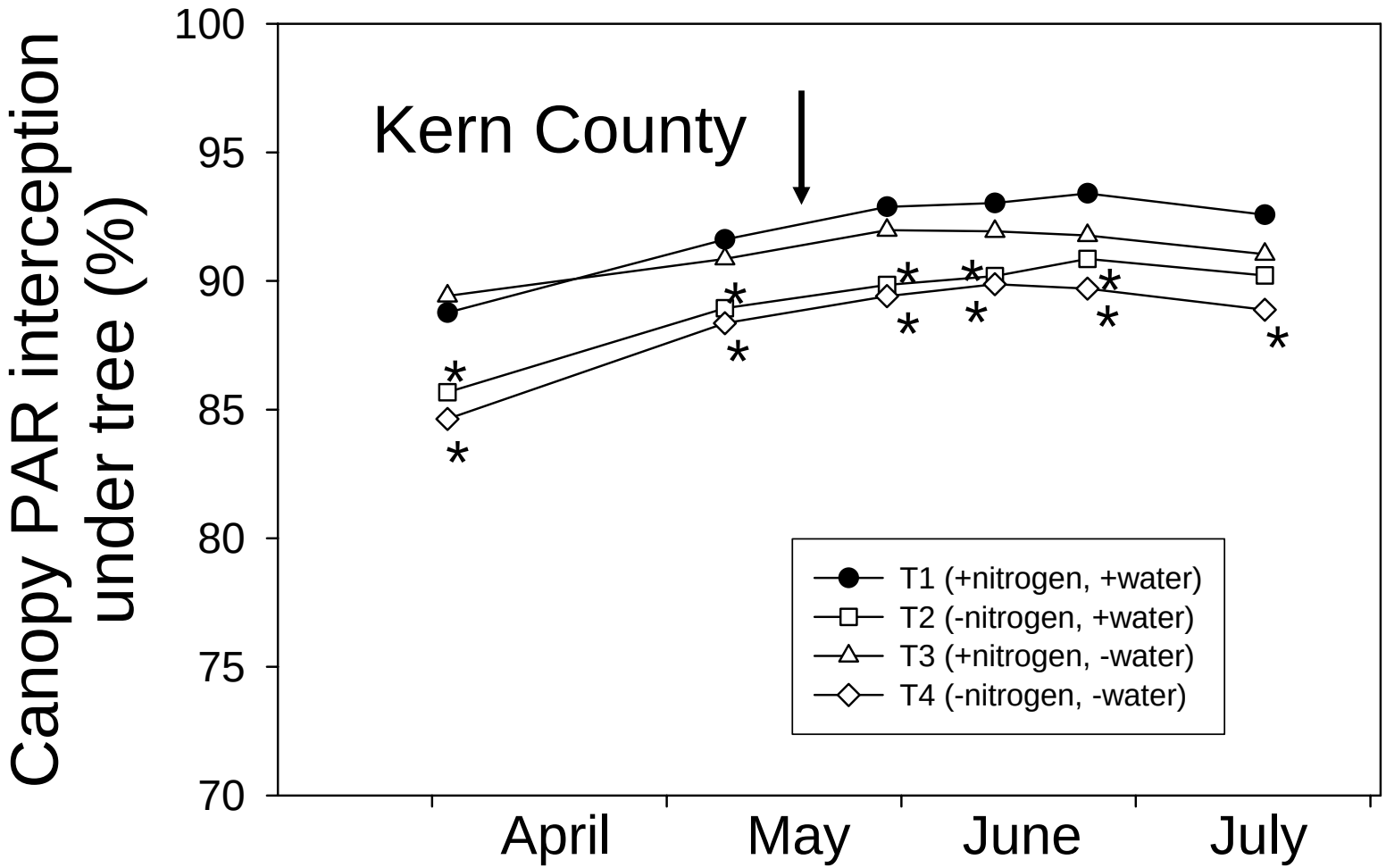
•Overall orchard midday canopy light interception measured with Decagon Sunfleck Ceptometer

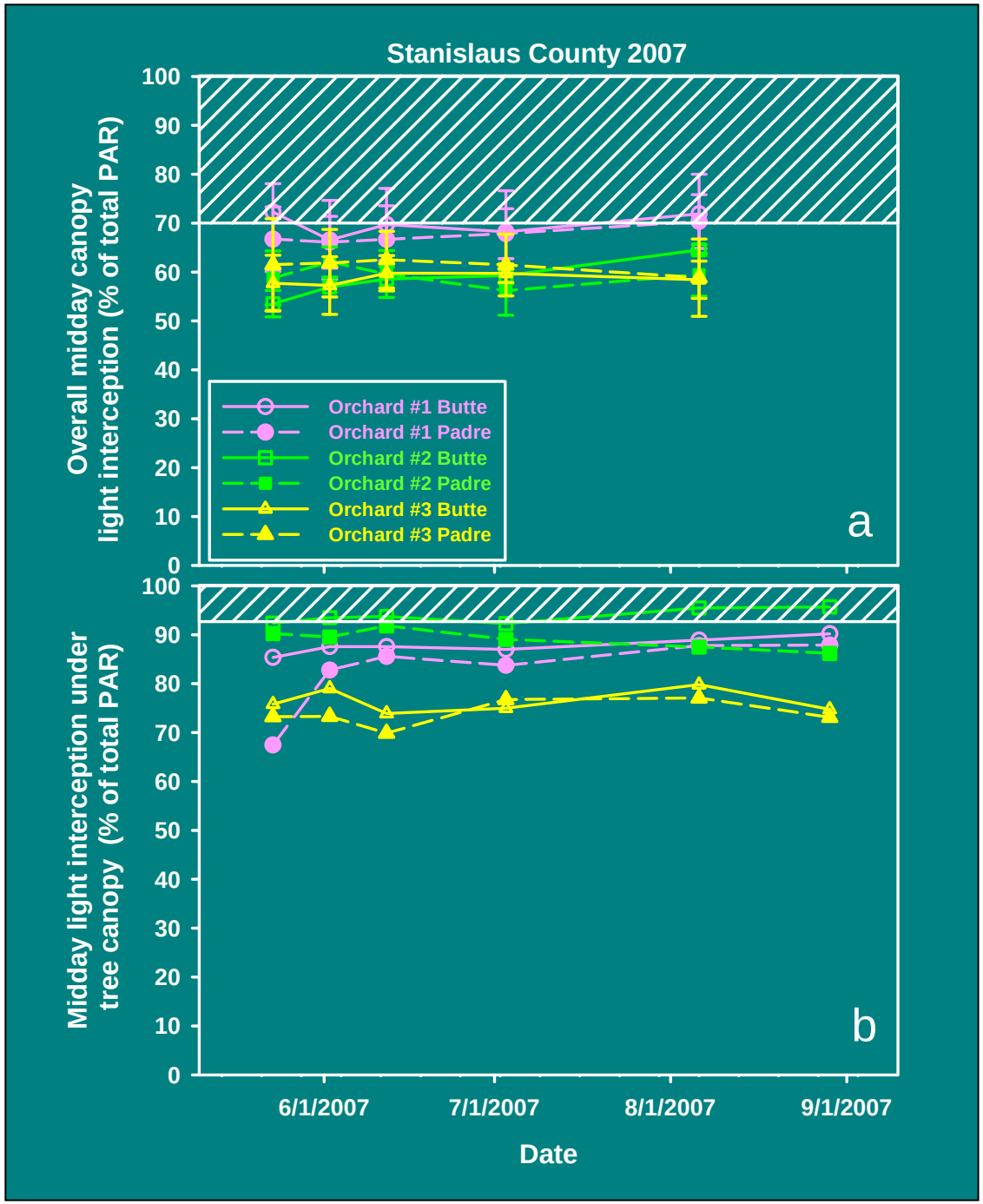


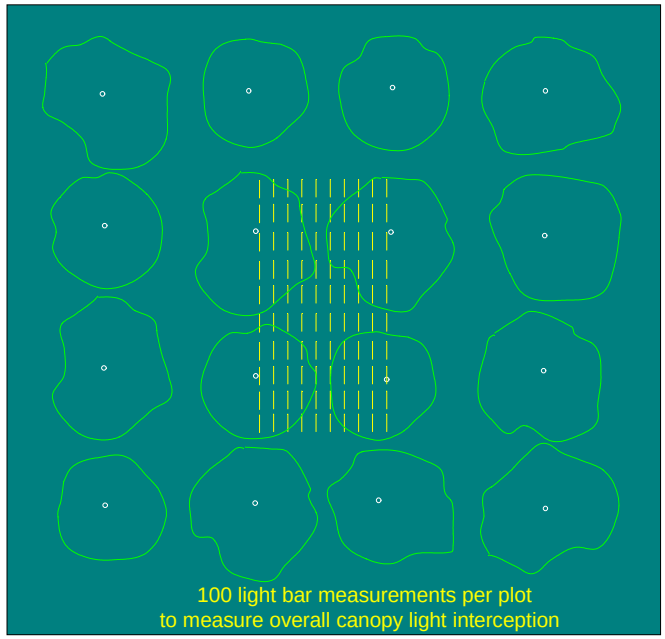
•Midday light interception under tree canopy also measured with Decagon Sunfleck Ceptometer



~30 measurements under tree to measure light penetration through canopy


Canopy PAR interception under tree (%)
100
95
90
85
80
75
70
Kern County
April
May
June
July
T1 (+nitrogen, +water)
T2 (-nitrogen, +water)
T3 (+nitrogen, -water)
T4 (-nitrogen, -water)

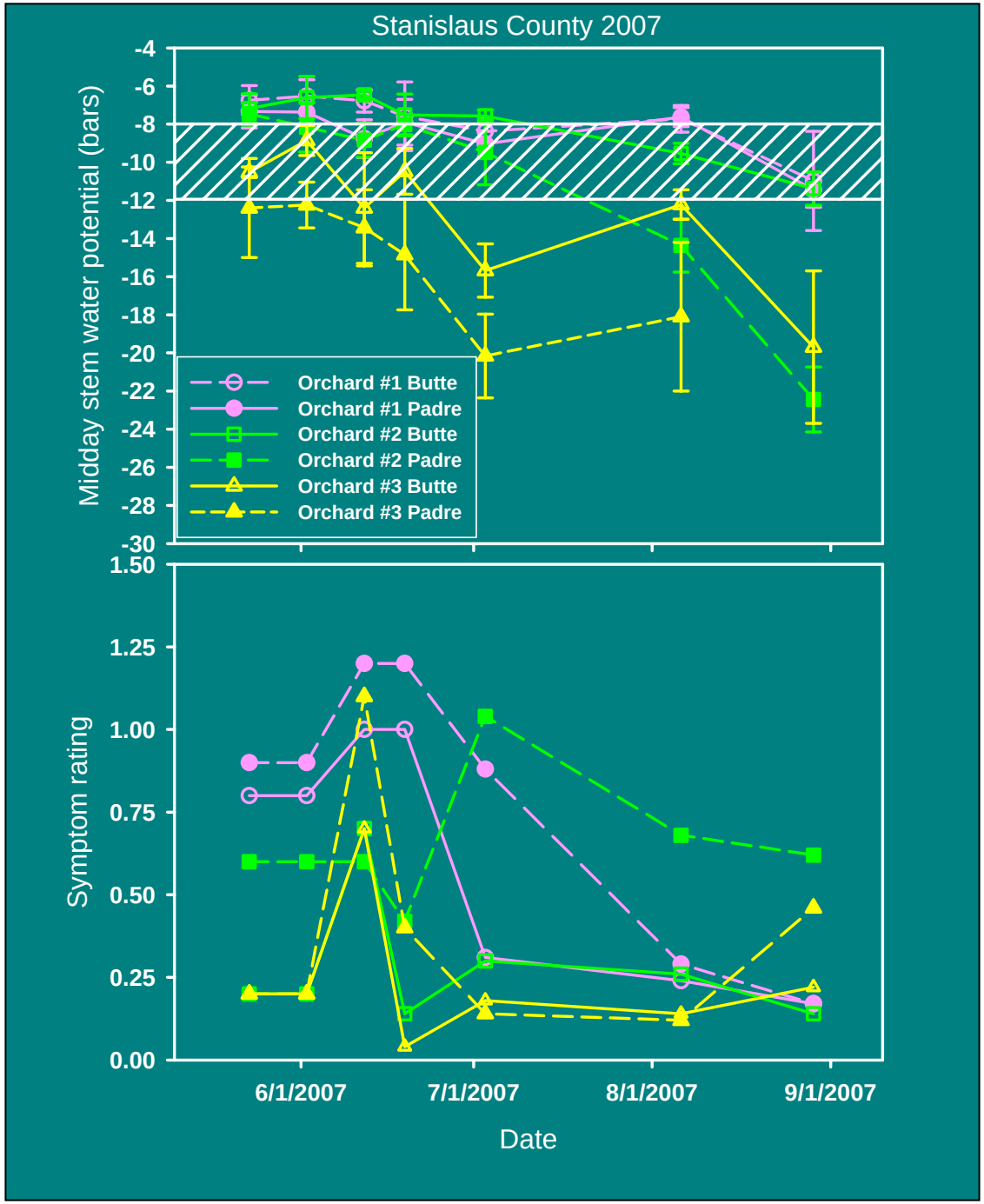

Stanislaus County 2007
Overall midday canopy light interception (% of total PAR)
Midday light interception under tree canopy (% of total PAR)
Orchard #1 Butte
Orchard #1 Padre
Orchard #2 Butte
Orchard #2 Padre
Orchard #3 Butte
Orchard #3 Padre
a
b
6/1/2007
7/1/2007
8/1/2007
9/1/2007
Date


100 light bar measurements per plot
to measure overall canopy light interception


~30 measurement under tree to measure light penetration through canopy

Midday stem water potential was measured periodically through the season on lower canopy healthy leaves

When measuring midday stem water potential, it is important to avoid bagging any leaves on branches showing symptoms of LLDB since even green leaves on these branches were found to have much lower MSWP


Stanislaus County 2007
Midday stem water potential (bars)
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
Orchard #1 Butte
Orchard #1 Padre
Orchard #2 Butte
Orchard #2 Padre
Orchard #3 Butte
Orchard #3 Padre
Symptom rating
1.50
1.25
1.00
0.75
0.50
0.25
0.00
6/1/2007
7/1/2007
8/1/2007
9/1/2007
Date

Stanislaus orchard #1, June 16, 2007- soil uniformly wet to 4 feet, then free water at 5 foot depth

2008

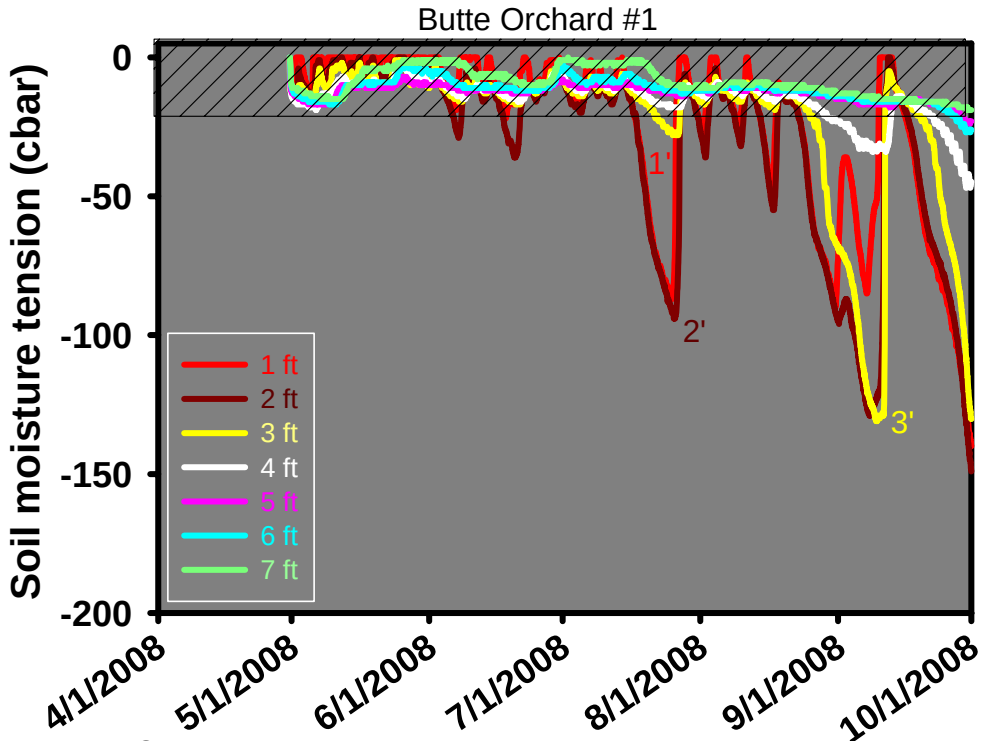
3 orchards in Stanislaus County and 2 orchards in Butte County monitored

Dataloggers with Watermark soil moisture sensors (7 depths) installed at each site

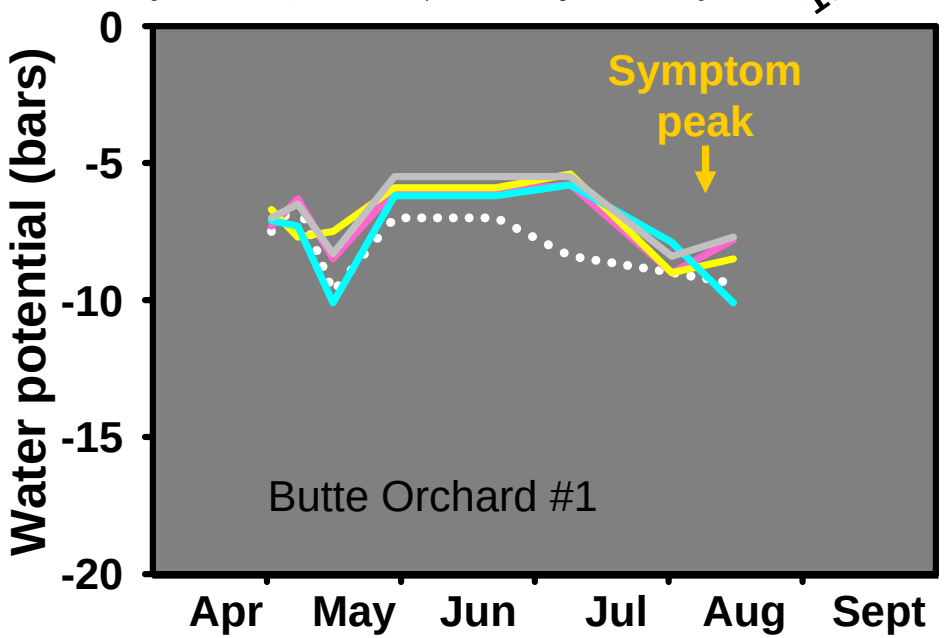
Midday stem water potential and canopy light interception monitored over season

Disease ratings performed every 2-3 weeks


2008
All 5 orchards showed symptoms of lower limb dieback starting in early to mid-May

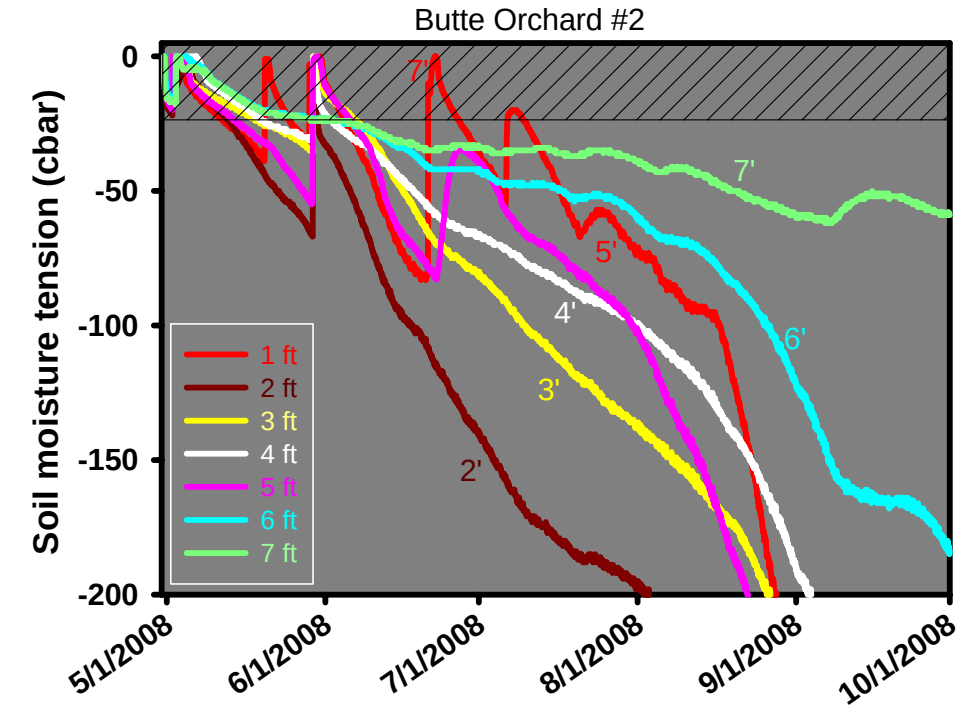


Excessively wet at all depths through mid-July



Trees wetter than fully watered baseline throughout season

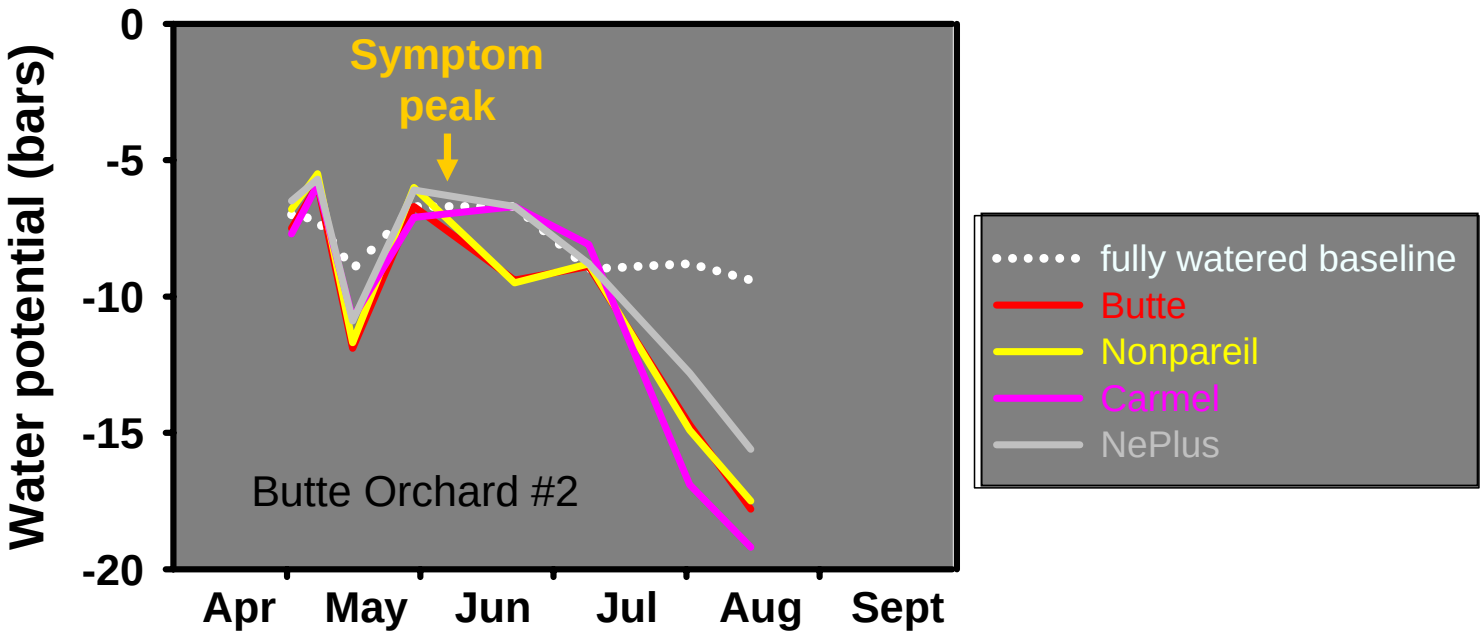
Butte Orchard #1 June 21, 2008



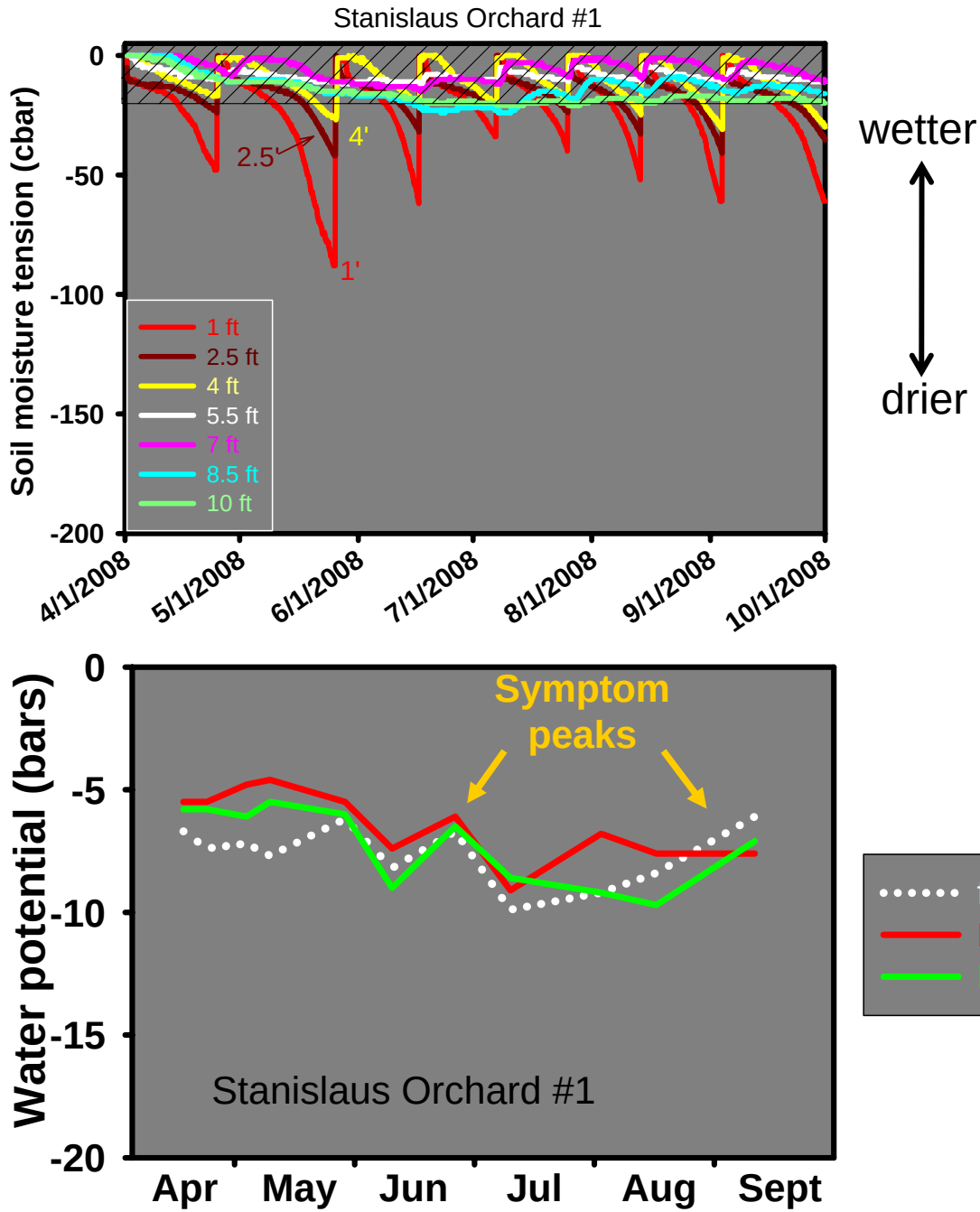
wetter

drier

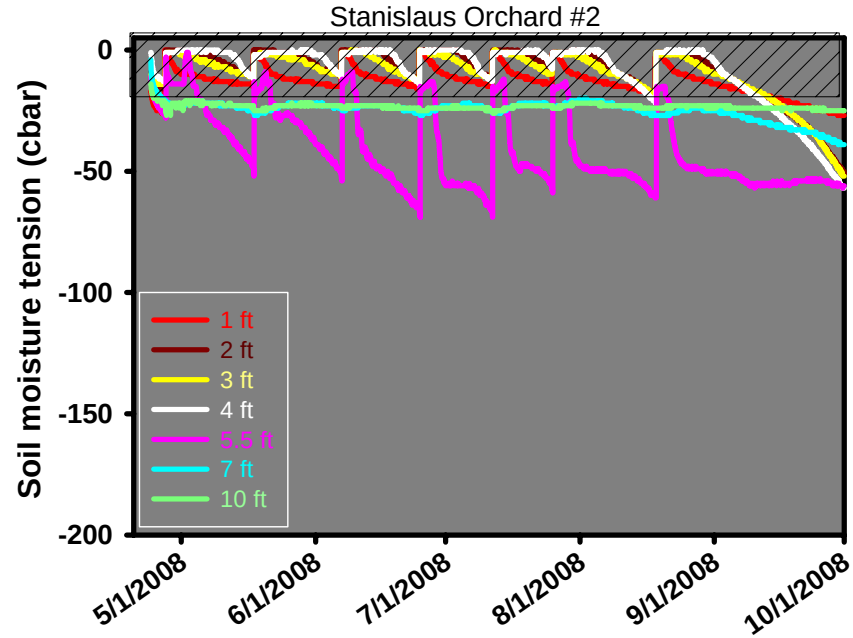
Butte Orchard #2 in 2008



Butte Orchard #2 June 21, 2008

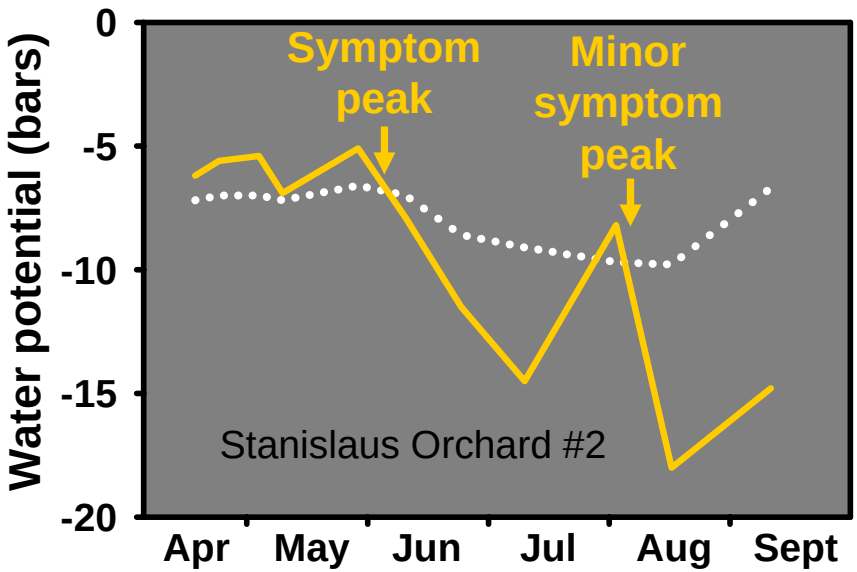

Stanislaus Orchard #1
Soil moisture tension (cbar)
0
-50
-100
-150
-200
2.5'
4'
1'
1 ft
2.5 ft
4 ft
5.5 ft
7 ft
8.5 ft
10 ft
4/1/2008
5/1/2008
6/1/2008
7/1/2008
8/1/2008
9/1/2008
10/1/2008
wetter
drier
Water potential (bars)
0
-5
-10
-15
-20
Symptom peaks
Stanislaus Orchard #1
Apr
May
Jun
Jul
Aug
Sept
fully watered baseline
Butte
Padre

Stanislaus Orchard #1 June 25, 2008



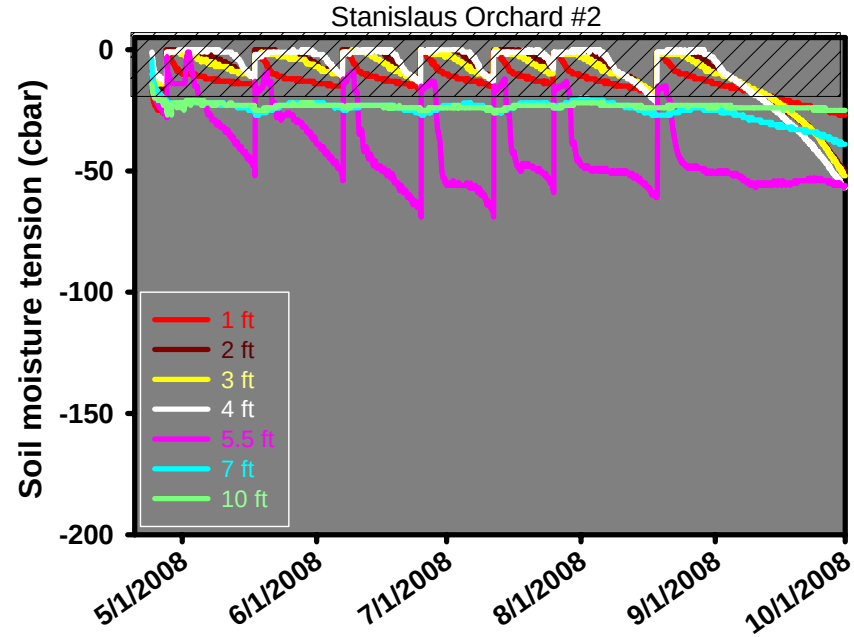
wetter

drier



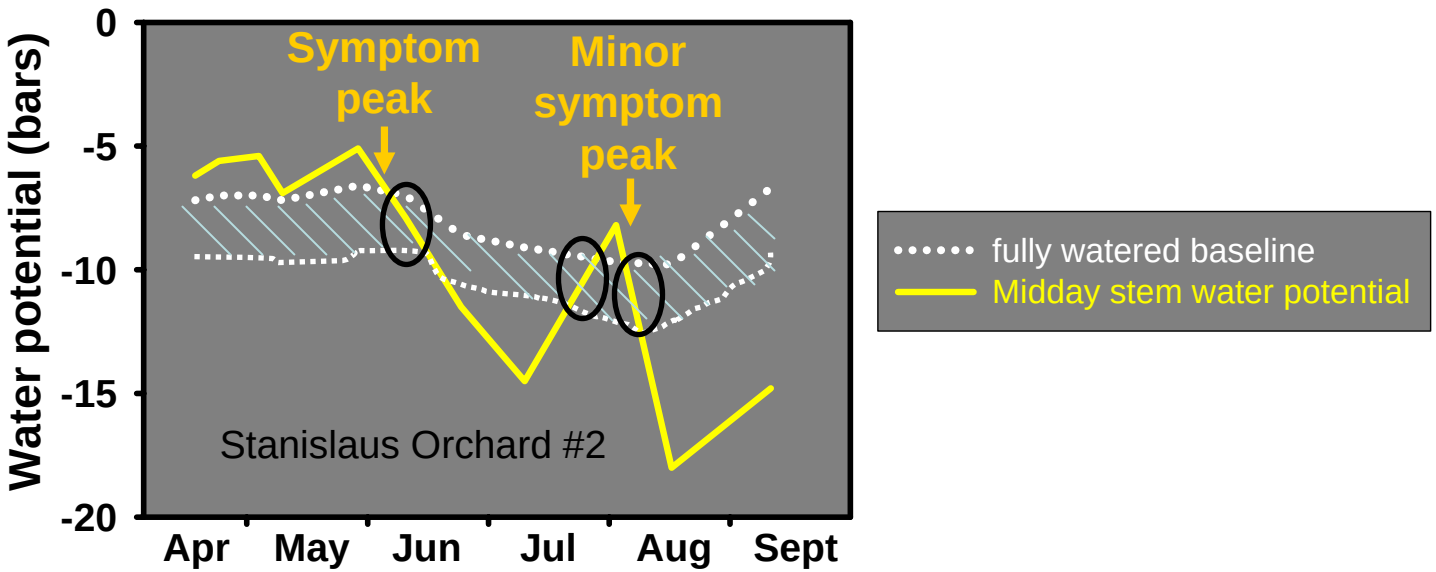
fully watered baseline

Butte midday stem water potential

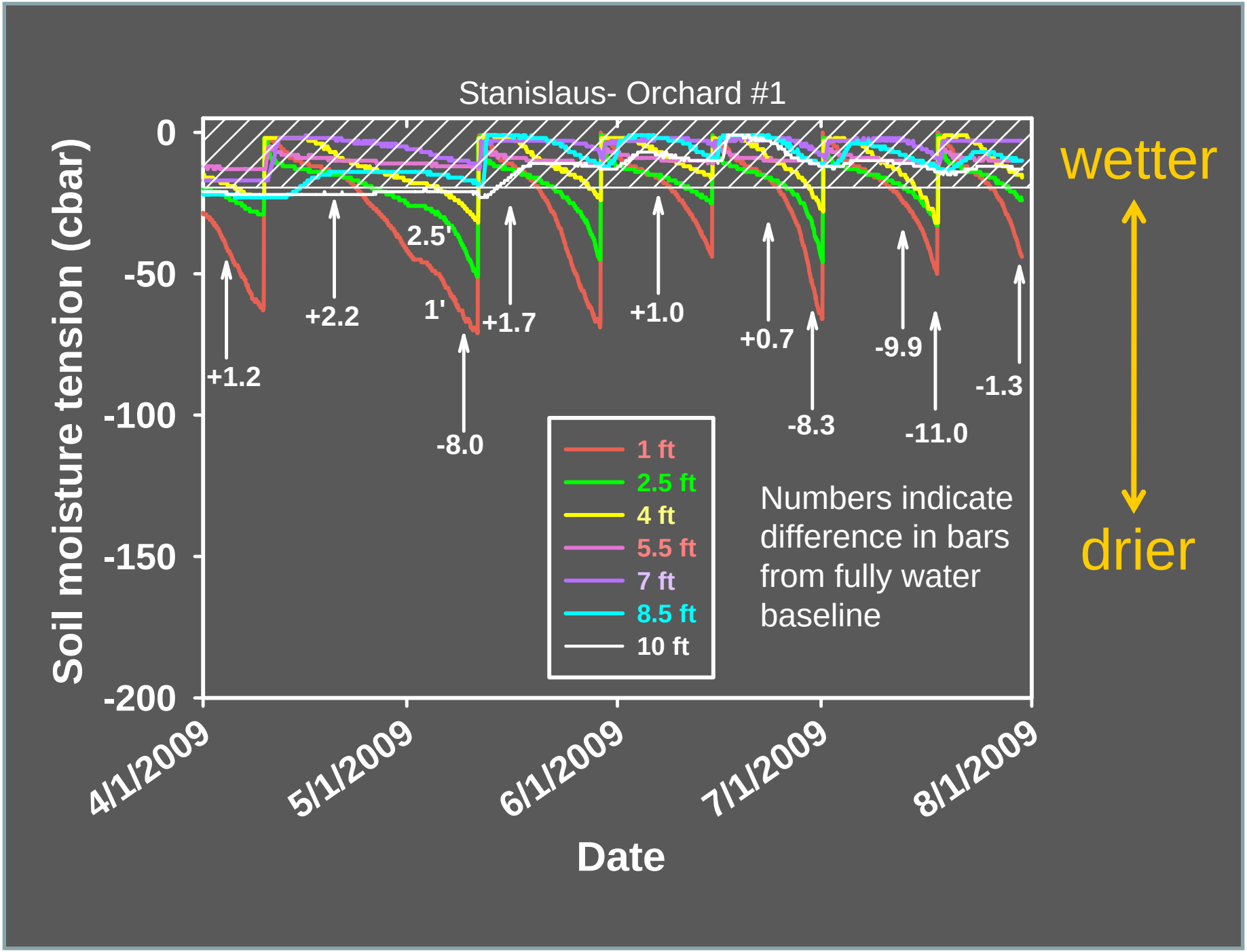


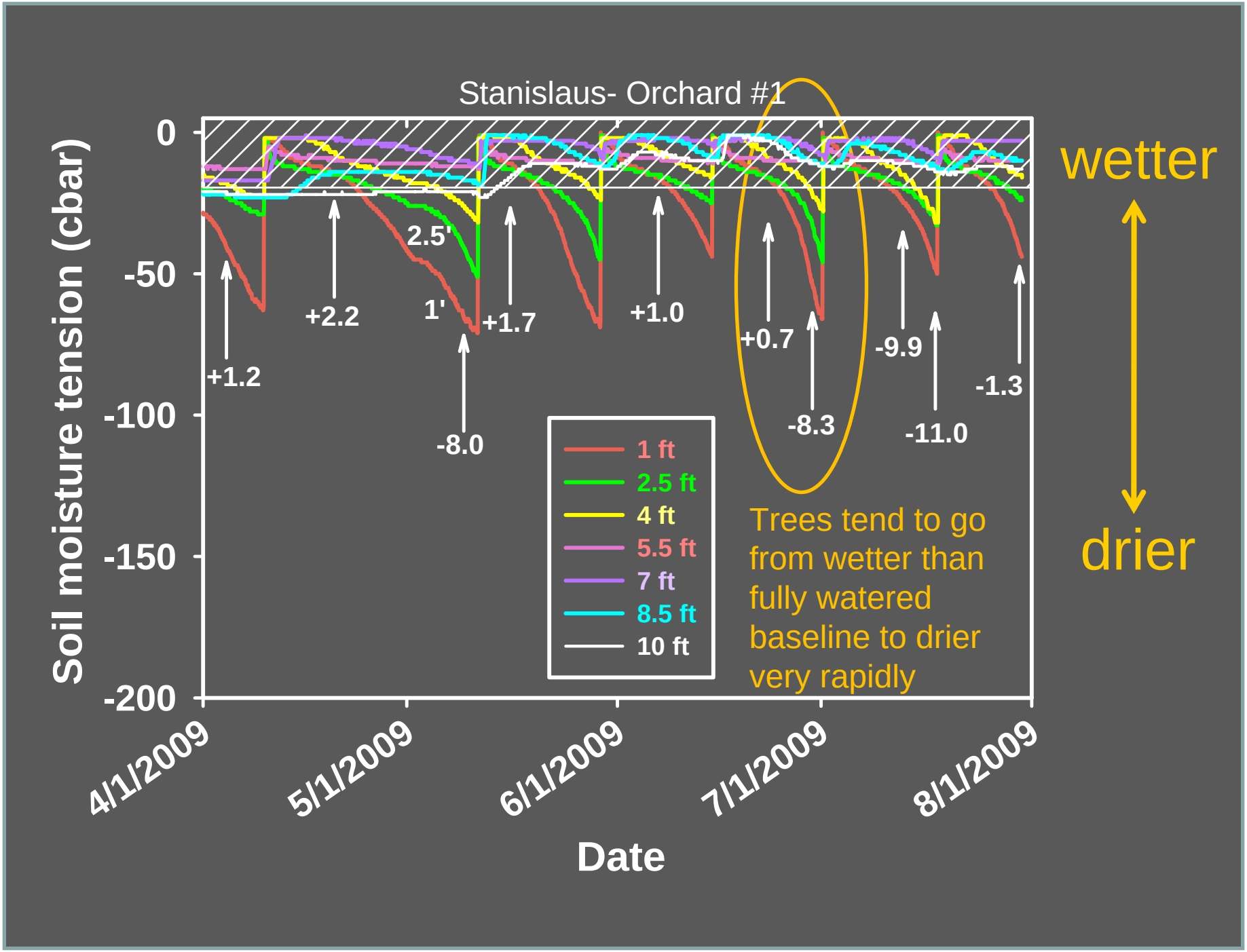
wetter

drier



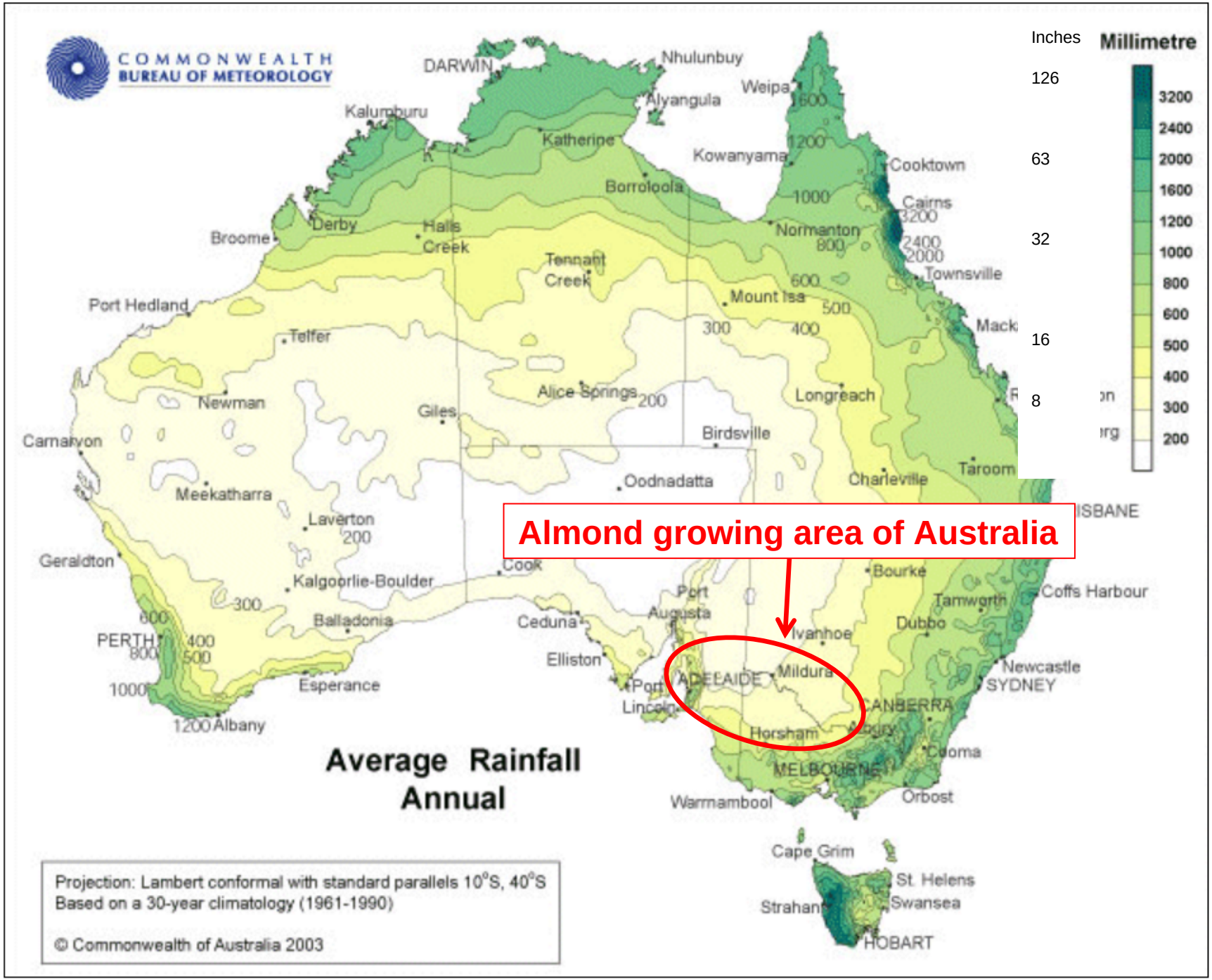
Stanislaus Orchard #2 June 9, 2008

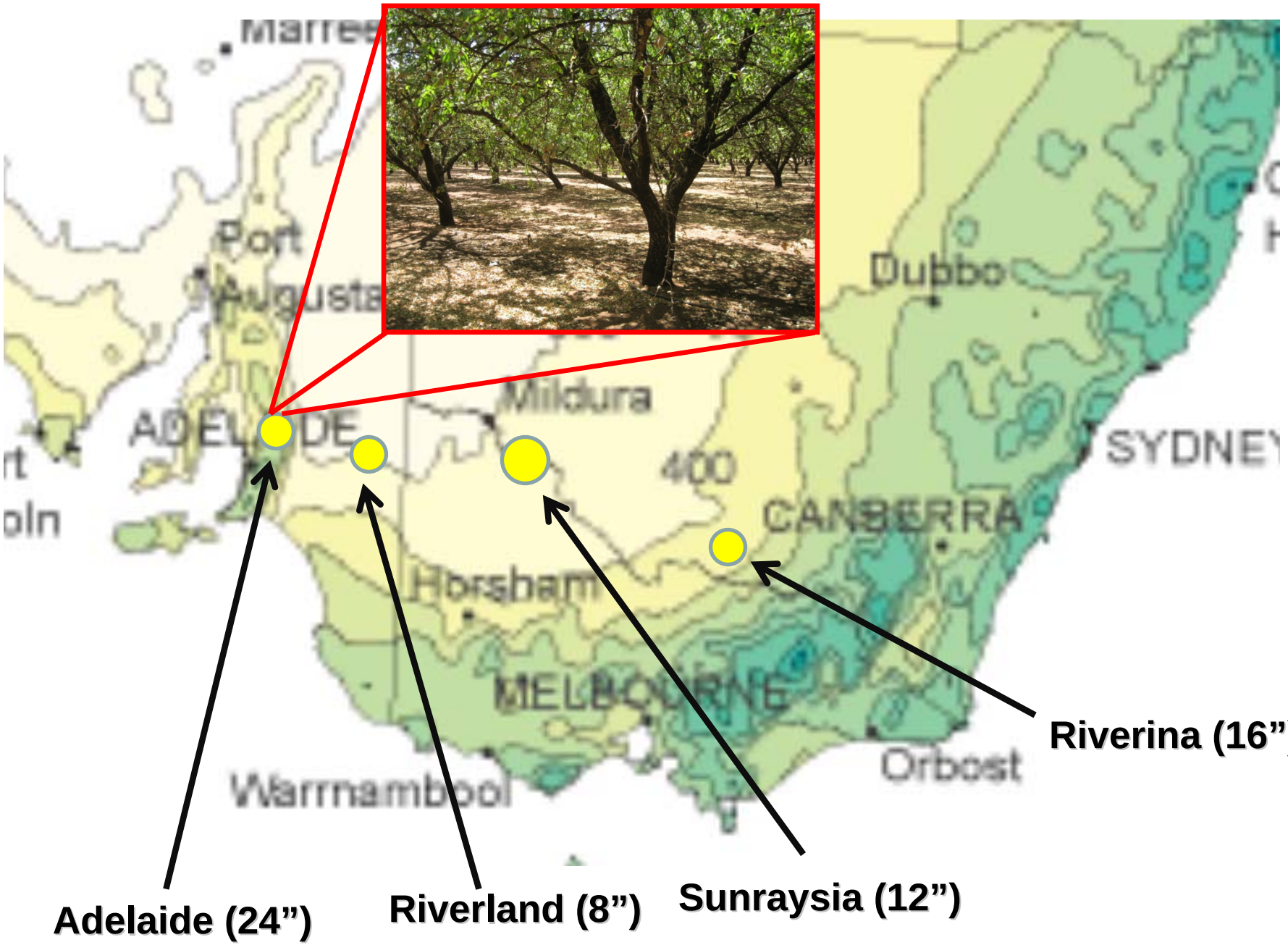

Stanislaus- Orchard #1
Soil moisture tension (cbar)
0
-50
-100
-150
-200
4/1/2009
5/1/2009
6/1/2009
7/1/2009
8/1/2009
Date
wetter
drier
+1.2
+2.2
2.5'
1'
+1.7
-8.0
+1.0
+0.7
-8.3
-9.9
-11.0
-1.3
1 ft
2.5 ft
4 ft
5.5 ft
7 ft
8.5 ft
10 ft
Numbers indicate difference in bars from fully water baseline


Stanislaus- Orchard #1
Soil moisture tension (cbar)
0
-50
-100
-150
-200
4/1/2009
5/1/2009
6/1/2009
7/1/2009
8/1/2009
Date
+1.2
+2.2
2.5'
1'
-8.0
+1.7
+1.0
+0.7
-8.3
-9.9
-11.0
-1.3
1 ft
2.5 ft
4 ft
5.5 ft
7 ft
8.5 ft
10 ft
Trees tend to go from wetter than fully watered baseline to drier very rapidly
wetter
drier

Near Adelaide, South Australia- Feb. 18, 2009

Near Adelaide, South Australia- Feb. 18, 2009


COMMONWEALTH
BUREAU OF METEOROLOGY
Inches
Millimetre
126
63
32
16
8
3200
2400
2000
1600
1200
1000
800
600
500
400
300
200
Almond growing area of Australia
Average Rainfall
Annual
Projection: Lambert conformal with standard parallels 10°S, 40°S
Based on a 30-year climatology (1961-1990)
© Commonwealth of Australia 2003
DARWIN
Nhulunbuy
Alyangula
Weipa
Kalumburu
Katherine
Kowanyama
Cooktown
Borroloola
Cairns
Derby
Broome
Halls Creek
Normanton
Tennant Creek
Townsville
Mount Isa
Port Hedland
Telfer
Mackay
Newman
Alice Springs
Longreach
Giles
Carnarvon
Birdsville
Oodnadatta
Charleville
Taroom
Meekatharra
Laverton
BRISBANE
Geraldton
Cook
Bourke
Kalgoorlie-Boulder
Port Augusta
Coffs Harbour
Tamworth
Balladonia
Ceduna
Dubbo
PERTH
Ivanhoe
Elliston
Mildura
Newcastle
ADELAIDE
SYDNEY
Esperance
Port Lincoln
CANBERRA
Albany
Horsham
Cooma
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
Swansea
HOBART


Port Augusta
Dubbo
Mildura
ADELAIDE
400
SYDNEY
CANBERRA
Horsham
MELBOURNE
Orbost
Warrnambool
Riverina (16”)
Adelaide (24”)
Riverland (8”)
Sunraysia (12”)

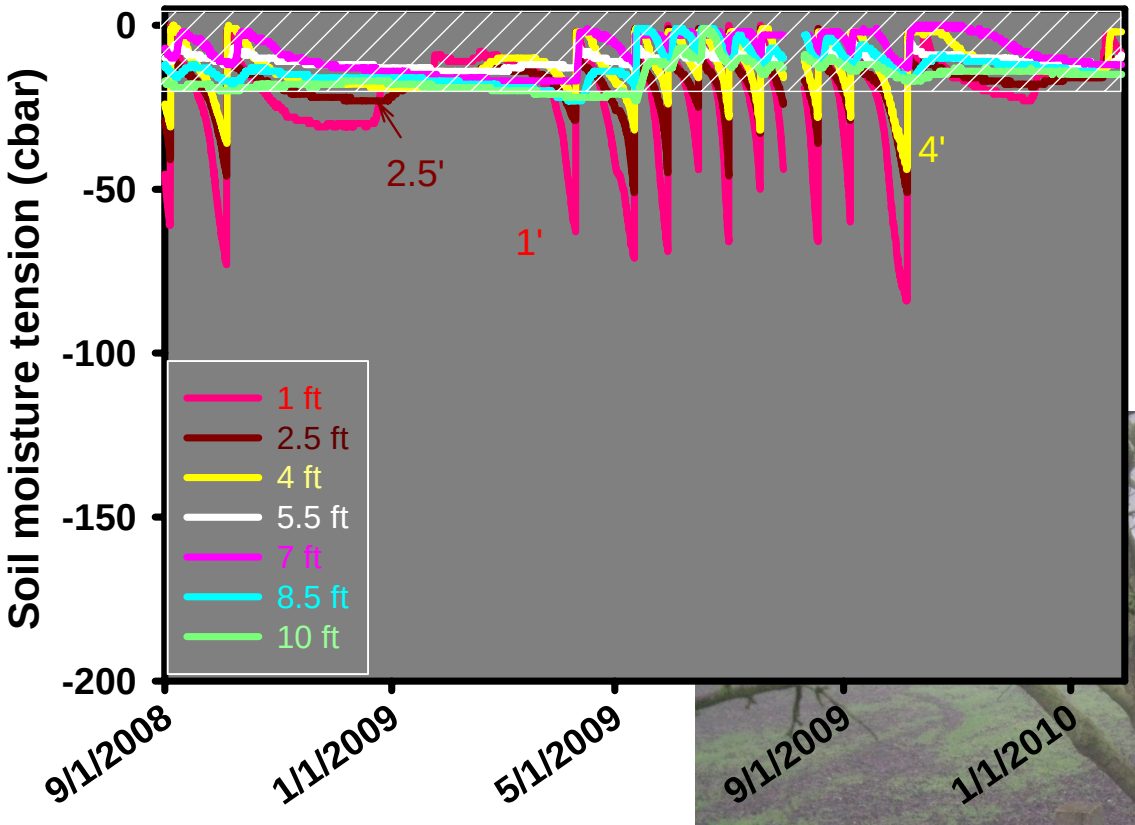
Preliminary Conclusions

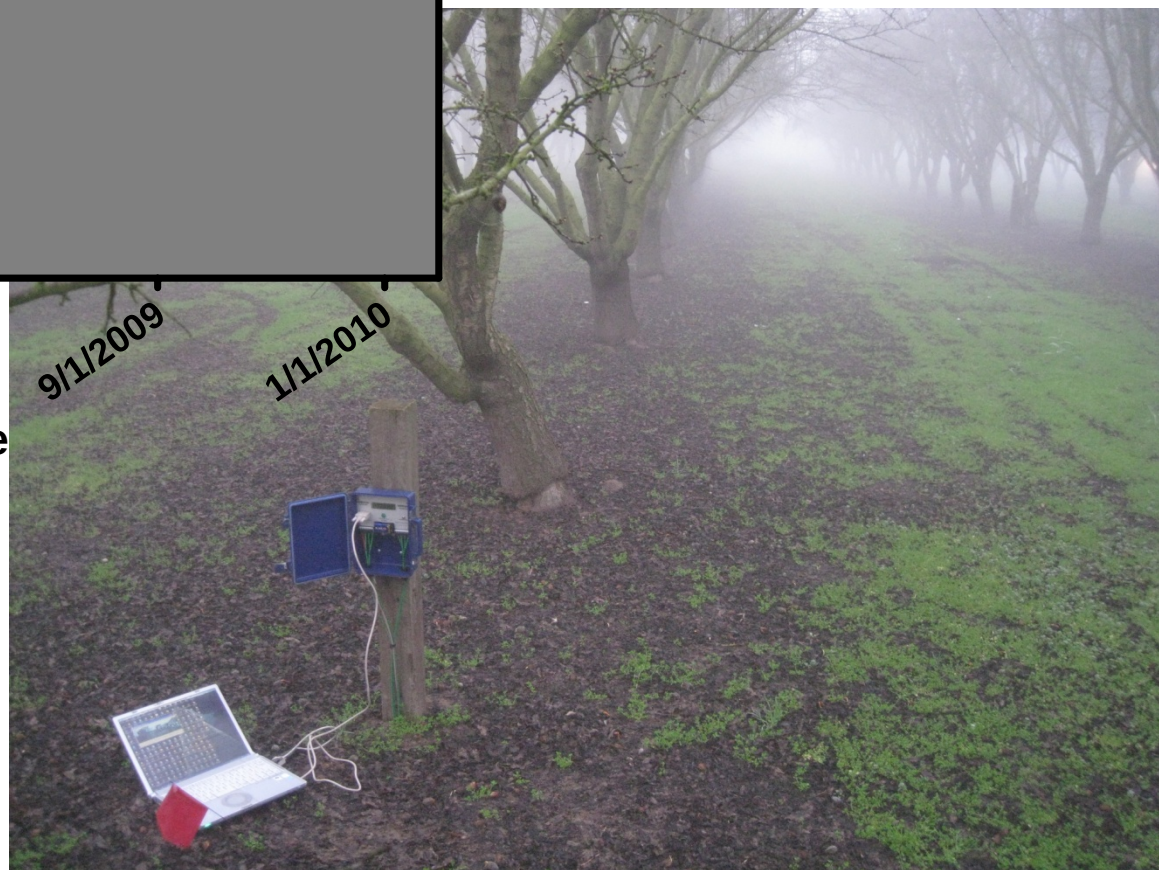
- Light levels were near level where shading related dieback would occur in some, but not all of LLDB orchards
- Likely a role of excessively wet soil conditions early in the year, possibly in conjunction with shading
  - For a given level of soil moisture, symptoms were worse in flood irrigated orchards compared to sprinkler/drip irrigated orchards suggesting soil oxygen deprivation may play a role
- 2009 results suggest that there may be a role of rapid wet to dry fluctuations in soil moisture

2010 Goals

- Create differential irrigation treatments in an orchard with history of lower limb dieback
  - convert a portion of Stanislaus Orchard #1 (flood irrigated) to microsprinklers

Stanislaus Orchard #1
Jan. 28, 2010





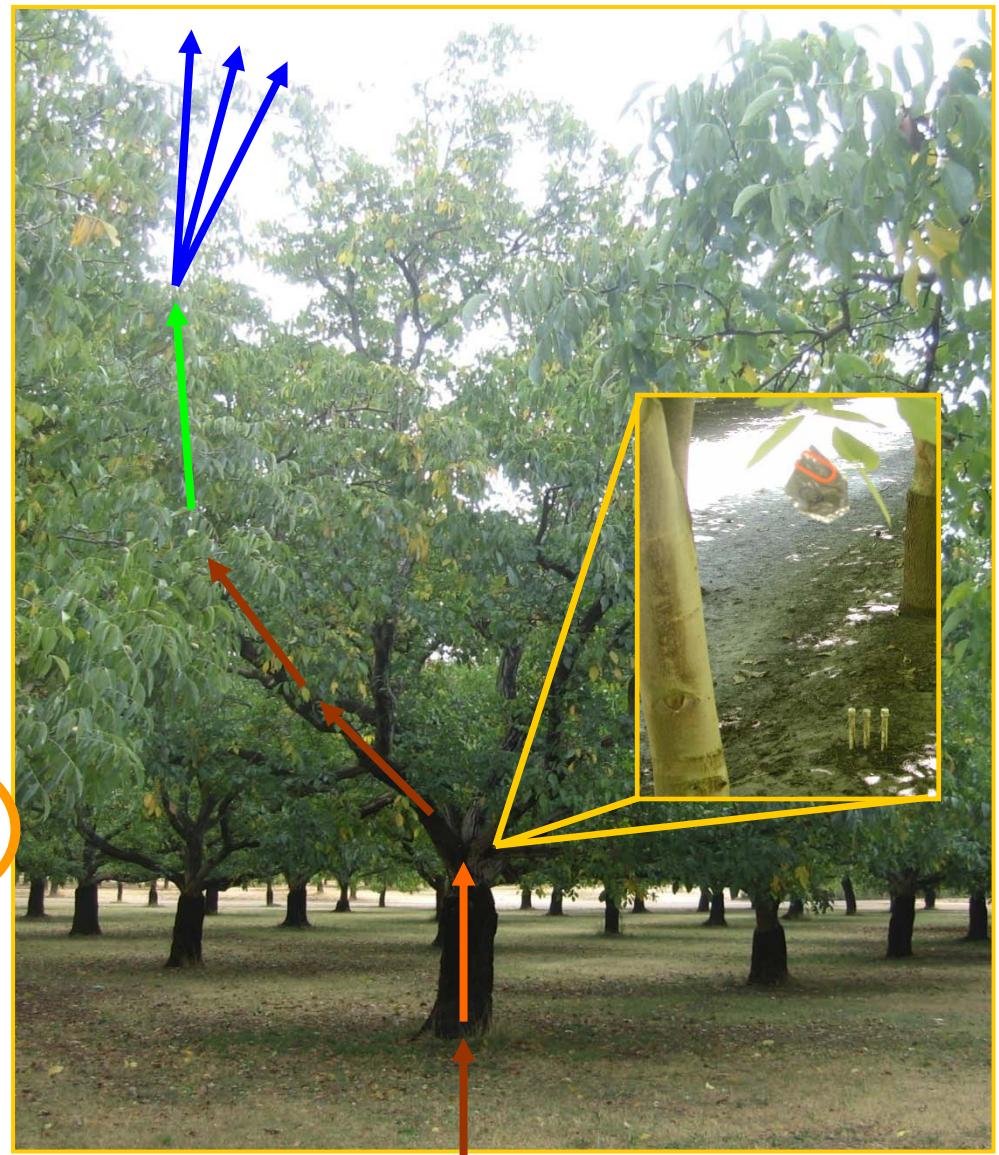
What should you do if you see LLDB in your orchard?

- Pay attention to your irrigation management
  - Be sure to not start irrigating in the spring until soil and preferably also plant based measurements tell you the trees need water
  - Ideally, monitor plant water potential over the growing season being careful not to irrigate until midday stem water potential falls below the fully watered baseline

If soil is too wet during springtime, lower roots will die and tree will be dependent on getting it's water needs met from a shallower root zone during summer and also will be prone to being blown over

Water potential in the soil-plant-atmosphere continuum

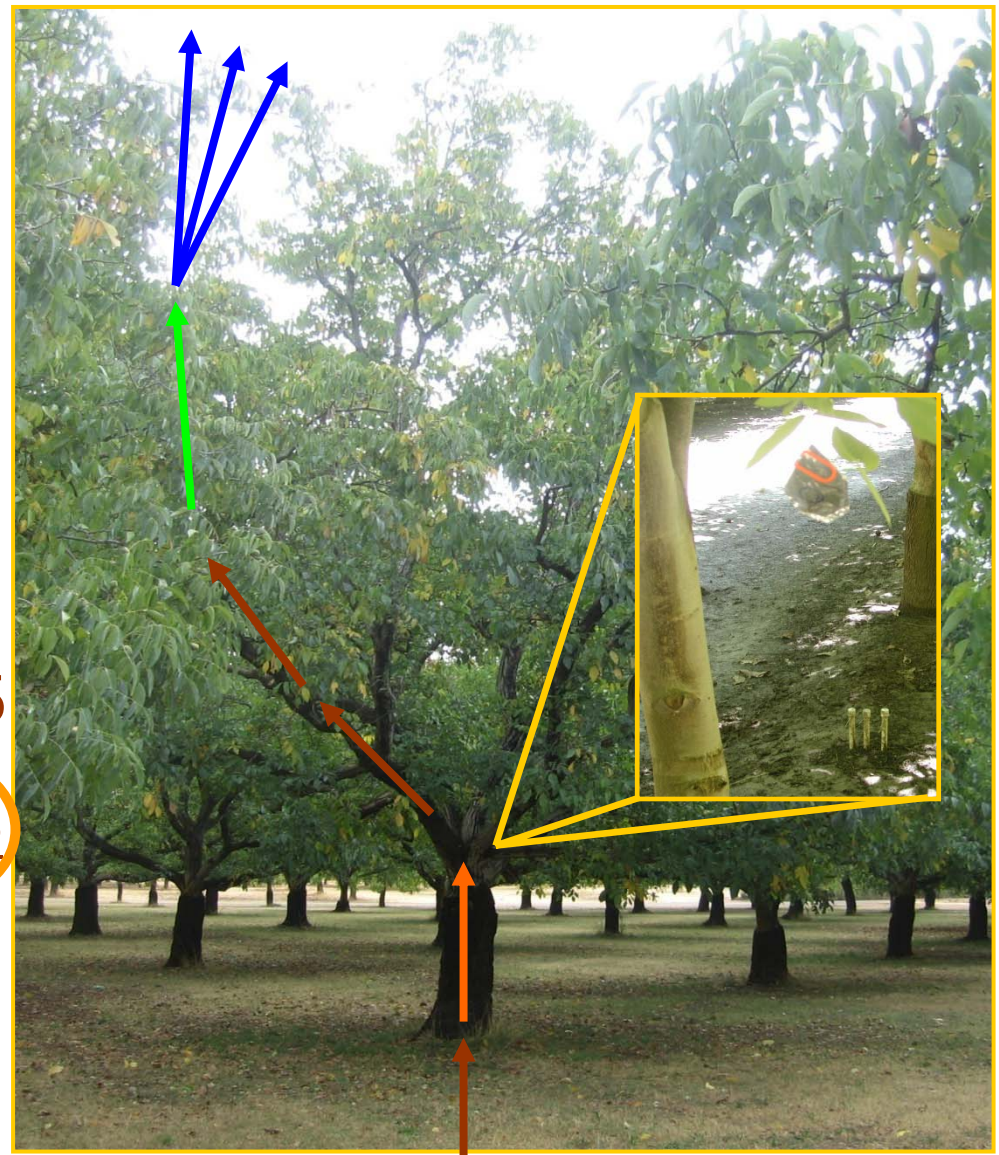
Location	(bars)
Air above tree	-95.0
Air near leaf	-70.0
Air in leaf	-16.0
Xylem in leaf (10m)	-14.0
Xylem in scaffold	-9.5
Xylem in trunk-	-8.5
Xylem in root	-2.8
Soil	-0.3



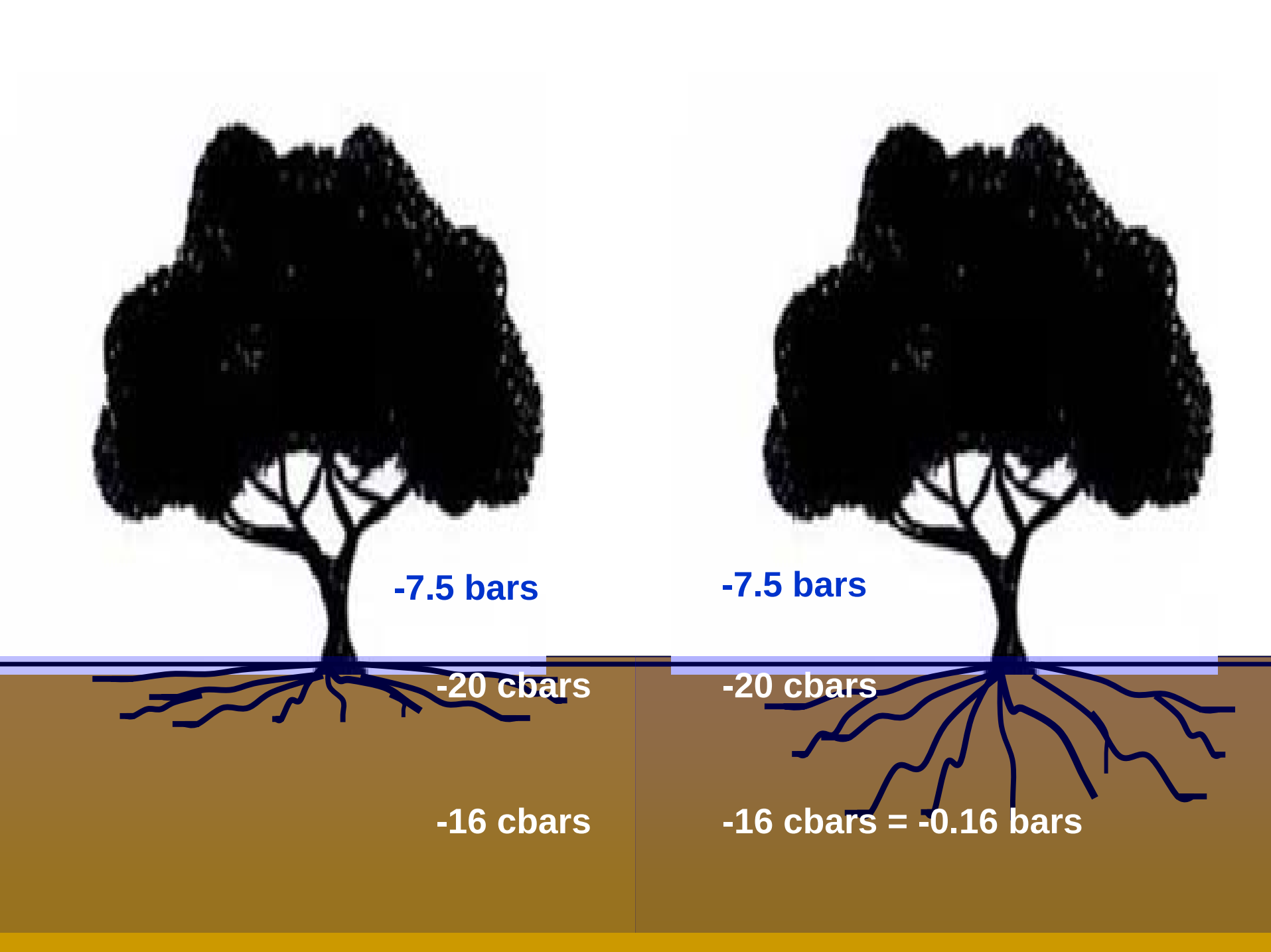
-0.3 bars equals -30 cbars

Water potential in the soil-plant-atmosphere continuum

Location	(bars)
Air above tree	-95.0
Air near leaf	-70.0
Air in leaf	-22.0
Xylem in leaf (10m)	-19.0
Xylem in scaffold	-14.5
Xylem in trunk-	-12.5
Xylem in root	-3.8
Soil	-0.9



-0.9 bars equals -90 cbars


-7.5 bars
-20 cbars
-16 cbars
-7.5 bars
-20 cbars
-16 cbars = -0.16 bars

-7.5 bars

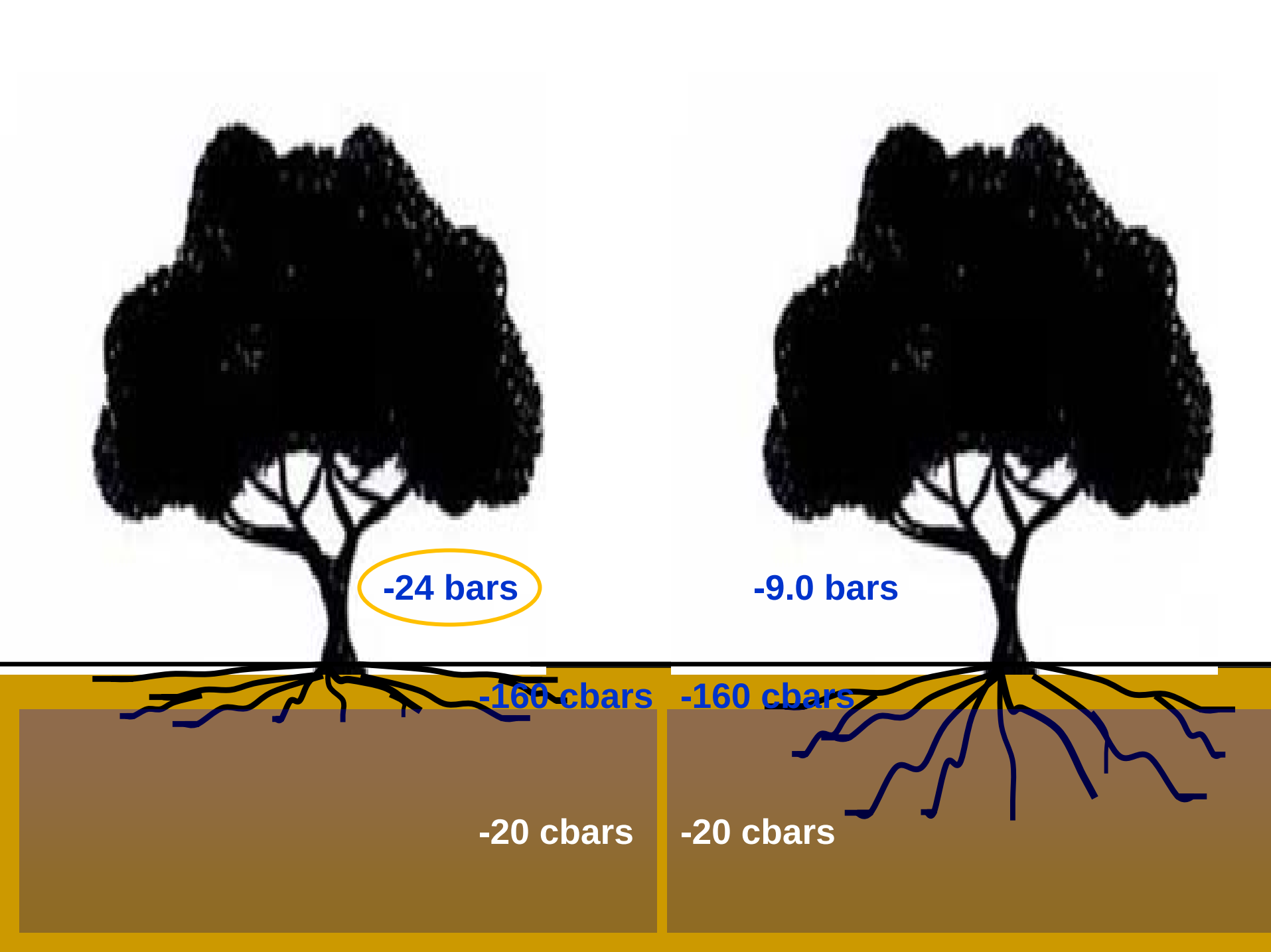
-10.0 bars

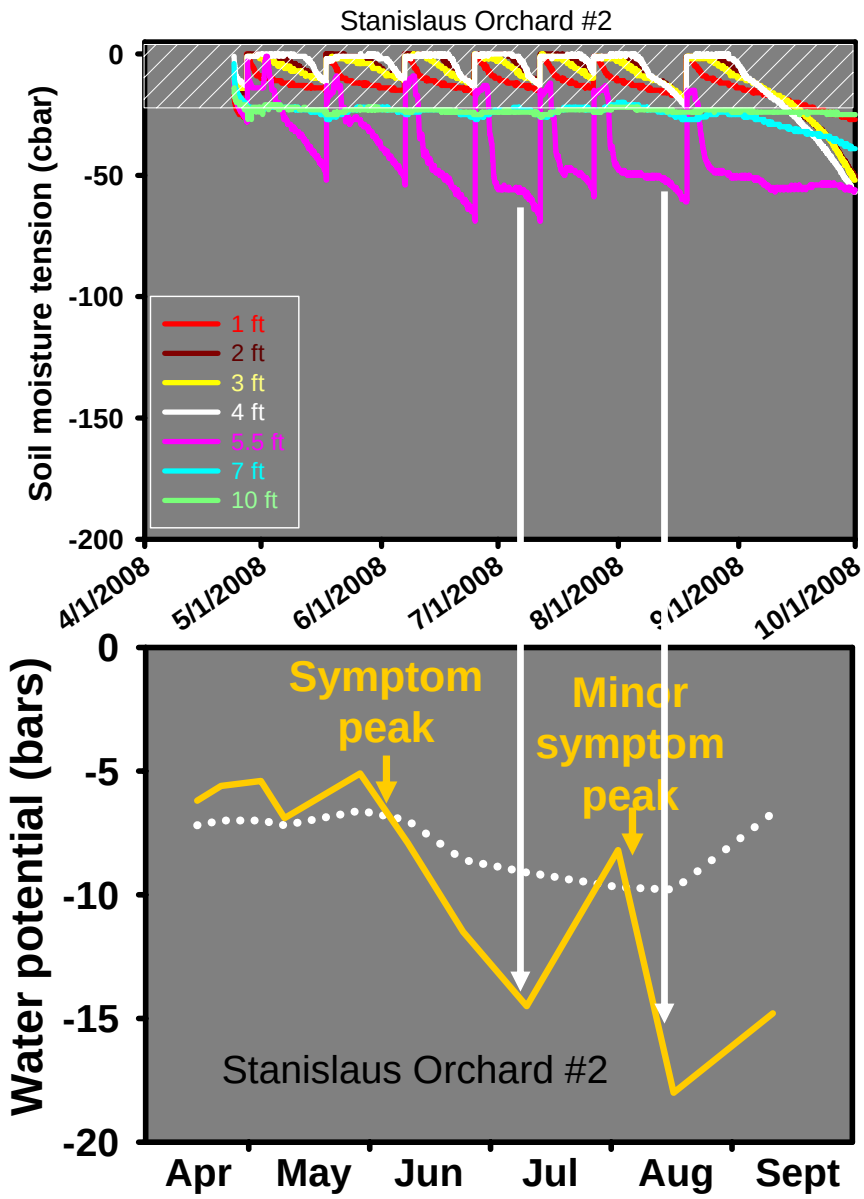
-20 cbars

-20 cbars

-200 cbars

-200 cbars = -2 bars


-24 bars
-9.0 bars
-160 cbars
-160 cbars
-20 cbars
-20 cbars



Watermark sensors at 1, 2, 3 and 4 foot depths were still at or above field capacity while trees are moderately to severely stressed suggesting large amount of roots are above 1 foot level.

fully watered baseline

Butte midday stem water potential


Thanks to the Almond Board of California for funding this work

Adelaide, South Australia and Bakersfield California are close to the same latitude (almonds in Australia range in latitude from about the base of the Grapevine to Visalia)