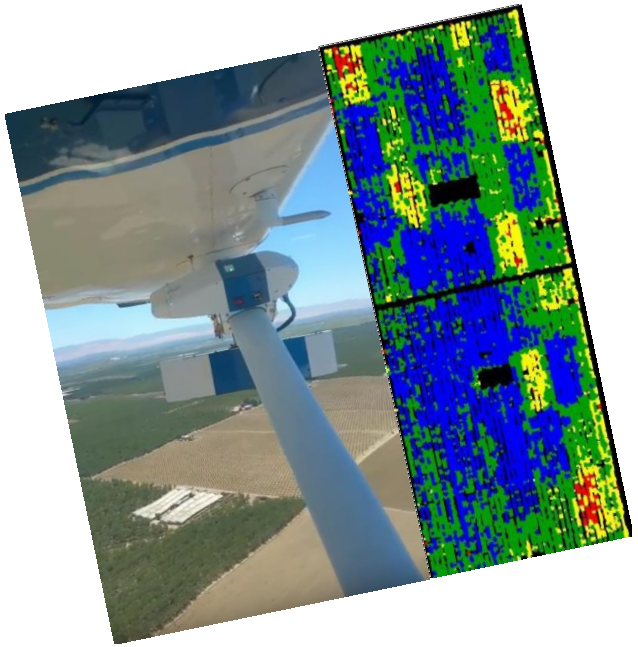
Emerging Technologies in Walnut Water Management



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Monitoring orchard water stress helps to:

- Bring new orchards into full production ASAP
- Improve long term tree health
- Achieve higher yield potential and consistency
- Stabilize nut quality
- Lessen costs for IPM, fertilizers, water, and energy

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Pressure Chamber and Midday Stem Water Potential – Current Standard to Monitor Orchard Water Stress

Reference: UC ANR Publication 8503

Using the Pressure Chamber for Irrigation Management in Walnut, Almond, and Prune

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Features of Pressure Bomb Express

In Field Data Collection

Record pressure bomb readings on your mobile device or tablet utilizing any brand of pressure chamber

No Cell Service Required

Instant Results

Results and recommendations for each location are instantly calculated using UC data. After results are **adjusted for temperature humidity and growth stages**, they are automatically posted to the manager's account.

Detailed Task Management

The ability to delegate **ANY** tasks to individual employees with the push of a button. **Alert employees of dangerous sprayed fields or any other issues,**

Strengths and Weaknesses of Pressure Chamber

Strengths:

- Direct measurement of tree water stress
- Integrates the weather, soil moisture, and tree root system into an indicator of orchard water status
- Research has been done to interpret measurements
- Affordability

Weaknesses:

- Labor intensive
- Points in time measurements (information gaps)
- Concerns that deep soil moisture will become overly depleted and can't catch up

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Emerging Technologies for Monitoring Orchard Water Stress in Walnuts

- Dendrometers – monitoring tree growth
  - http://www.phytech.com/
- ET Stations – monitoring actual ET
  - https://www.tuletechnologies.com/contact?utm_source=demo
- Aerial Imagery – monitoring whole orchard canopy temperature
  - http://www.ceresimaging.net/

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In the Field a dendrometer might look like …

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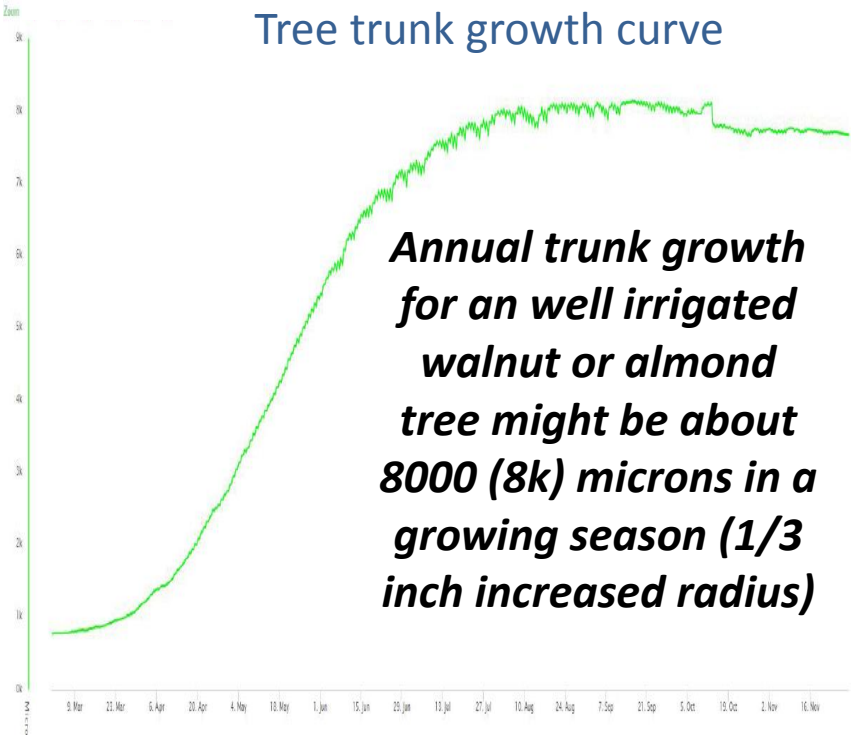
Dendrometers: An alternative tool

Tree trunk growth curve



Annual trunk growth for an well irrigated walnut or almond tree might be about 8000 (8k) microns in a growing season (1/3 inch increased radius)

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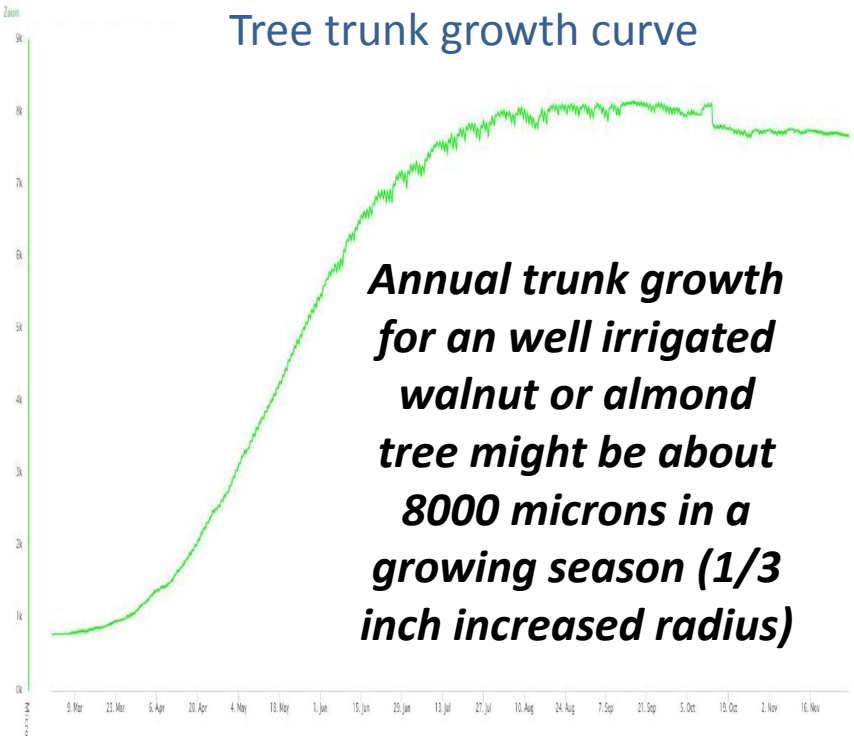
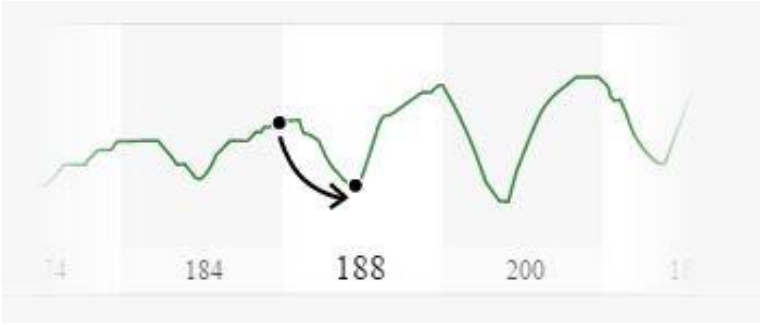
Dendrometers: An alternative tool

Tree trunk growth curve



Annual trunk growth for an well irrigated walnut or almond tree might be about 8000 microns in a growing season (1/3 inch increased radius)

Maximum Daily Shrinking (MDS)



- MDS is the difference between daily maximum and minimum trunk diameter
- Less water in soil or more demand from weather or crop causes the trunk to shrink more each day

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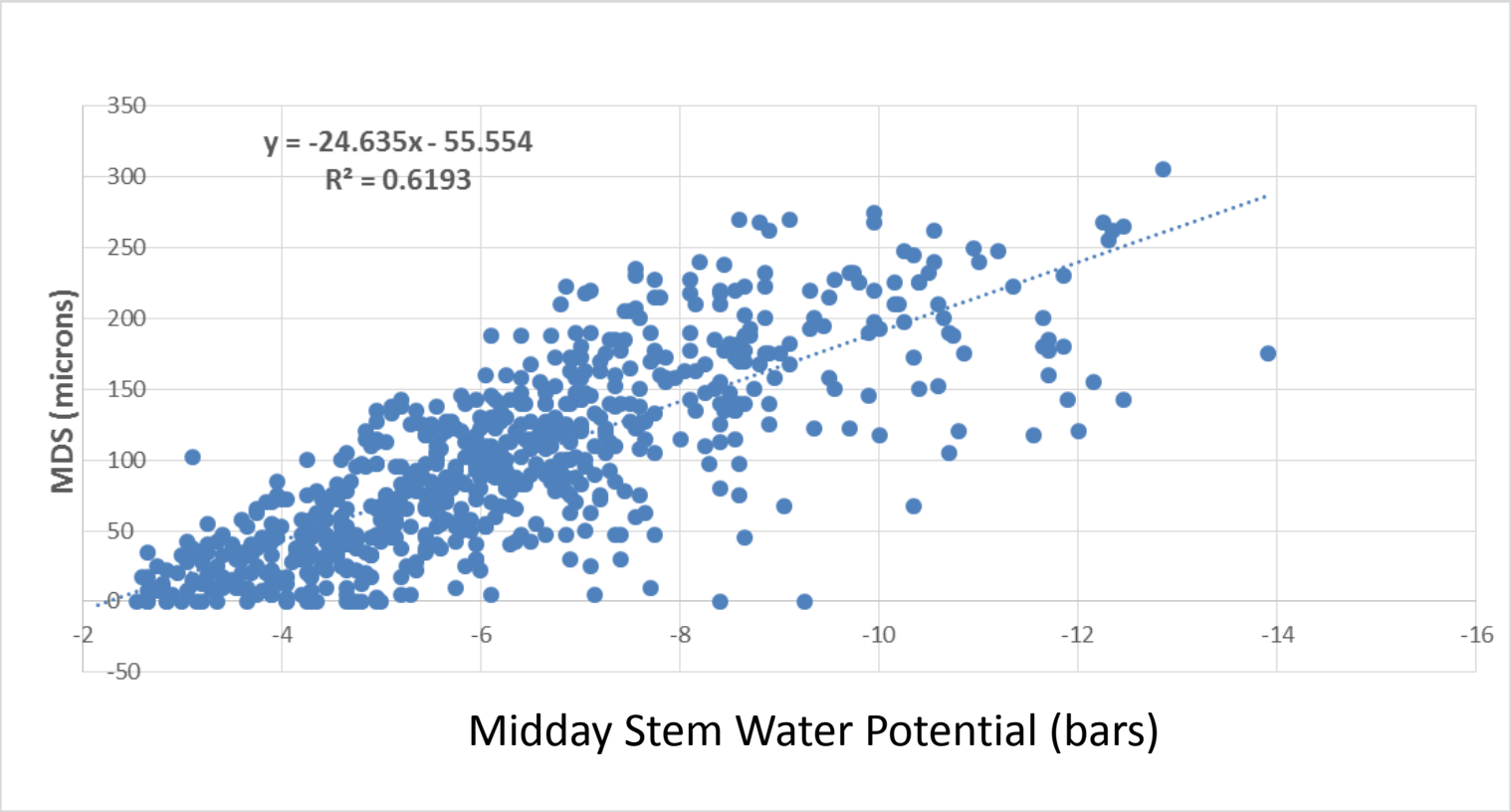
Correlation between MDS and Midday Stem Water Potential (Pressure Chamber) in Chandler walnut



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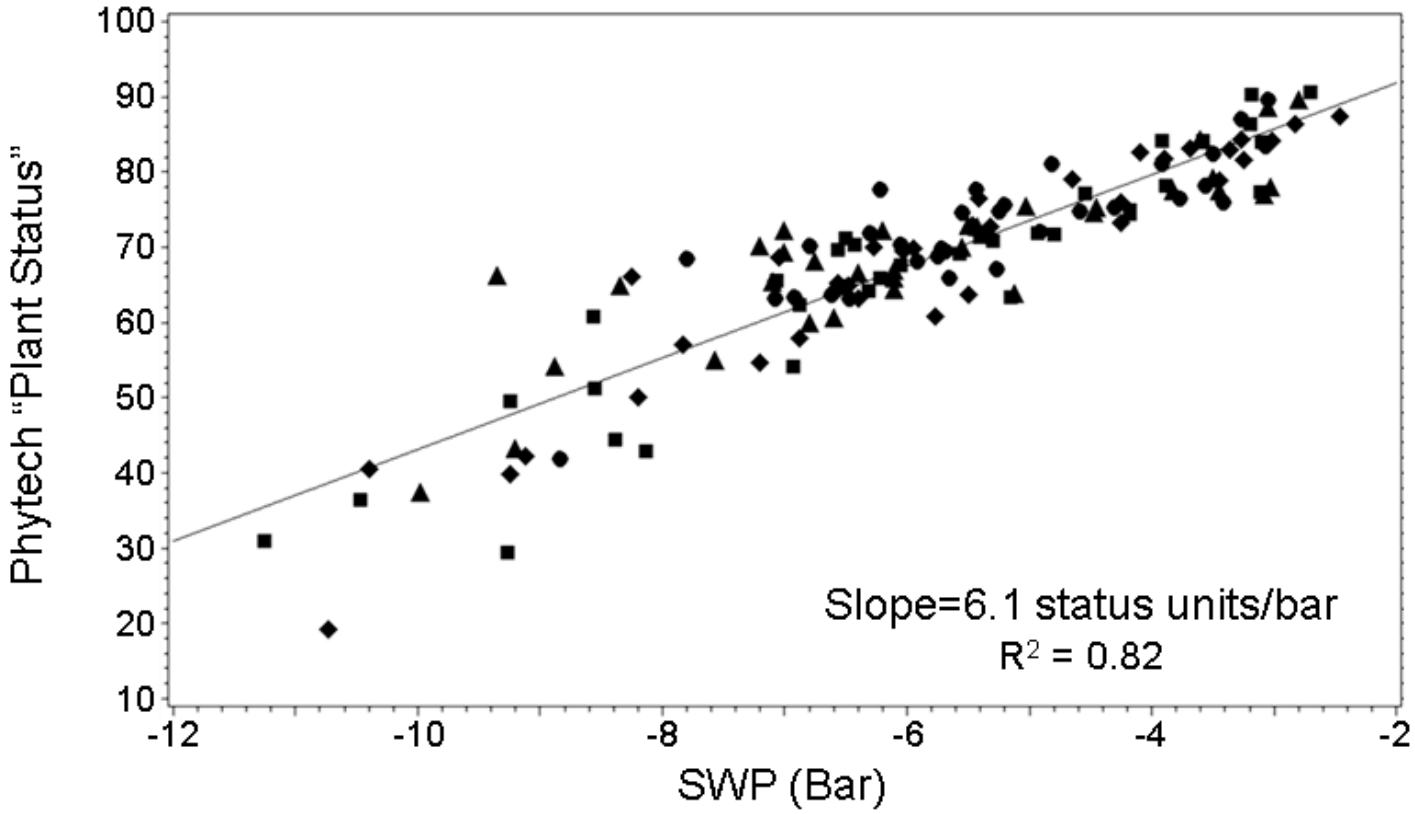
Correlation between Phytech's "Plant Status" and Midday Stem Water Potential (Pressure Chamber) in Chandler walnut



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SWP (pressure chamber) versus “Plant Status” (dendrometer) in walnut

Crop Water Stress Level	Pressure Chamber SWP (bars)	Dendrometer (Plant Status)
Low	2 to 4	100 to 80
Mild	4 to 6	80 to 60
Moderate	6 to 8	60 to 40
High	8 to 10	40 to 20
Very High	>10	20 to 0

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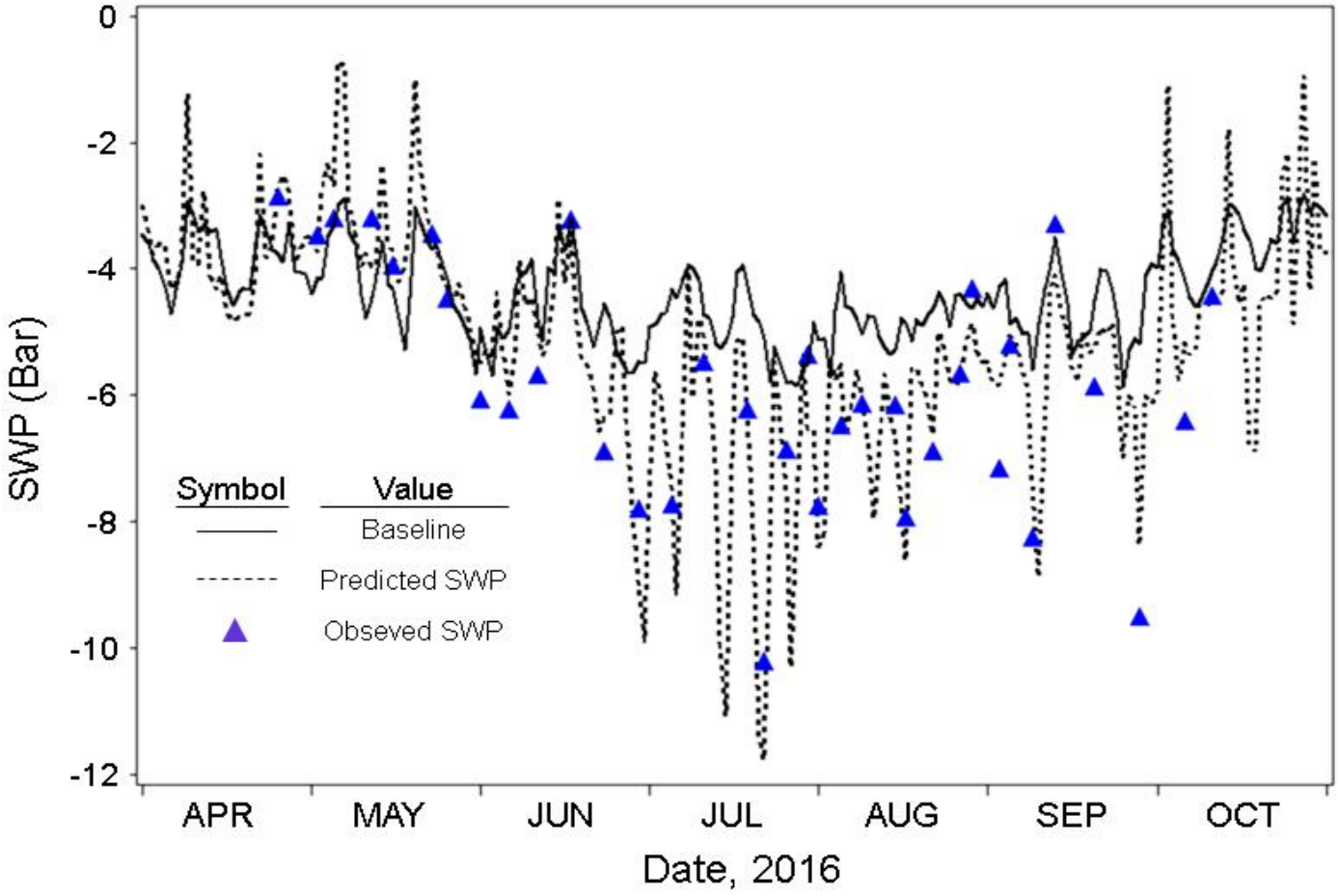
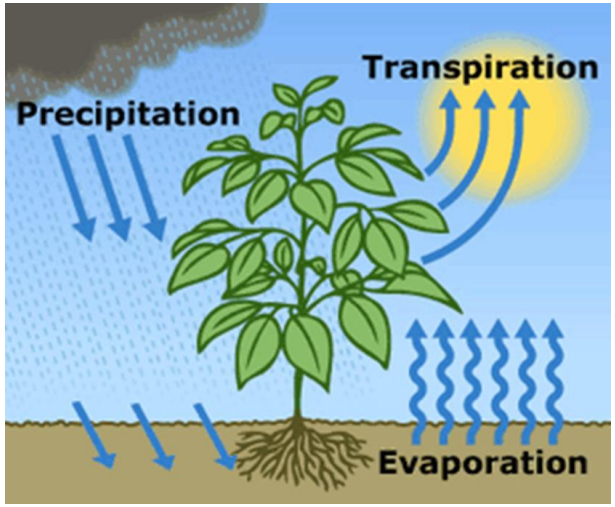
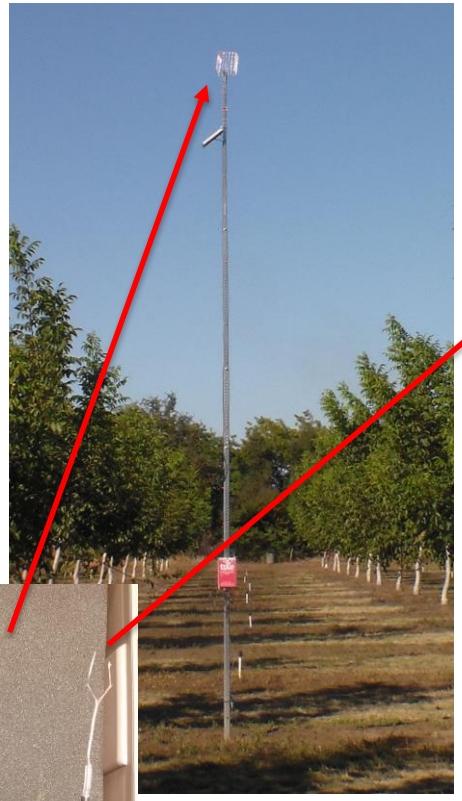
Comparison of directly measured SWP (blue triangles) and predicted SWP from dendrometer (dashed line) in Chandler walnut orchard. Also shown as a reference is the daily walnut baseline value.



Monitoring Actual Orchard Evapotranspiration (ET_a) (Climate-based approach – mid size foot print)





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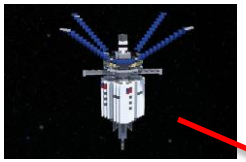
Tule Measures Actual (ET_a) in Your Orchard
(Residual Energy Balance Method)



Incoming Energy from the Sun

Heat Exchange with the Ambient Air

$$LE = Rn - G - H$$

LE: Latent Heat of Evaporation

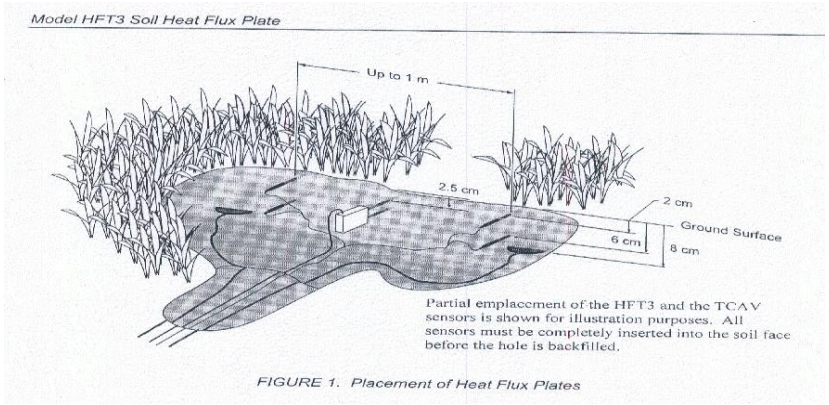
Conversion of water to water vapor

G: Heat Exchange with the Orchard Floor

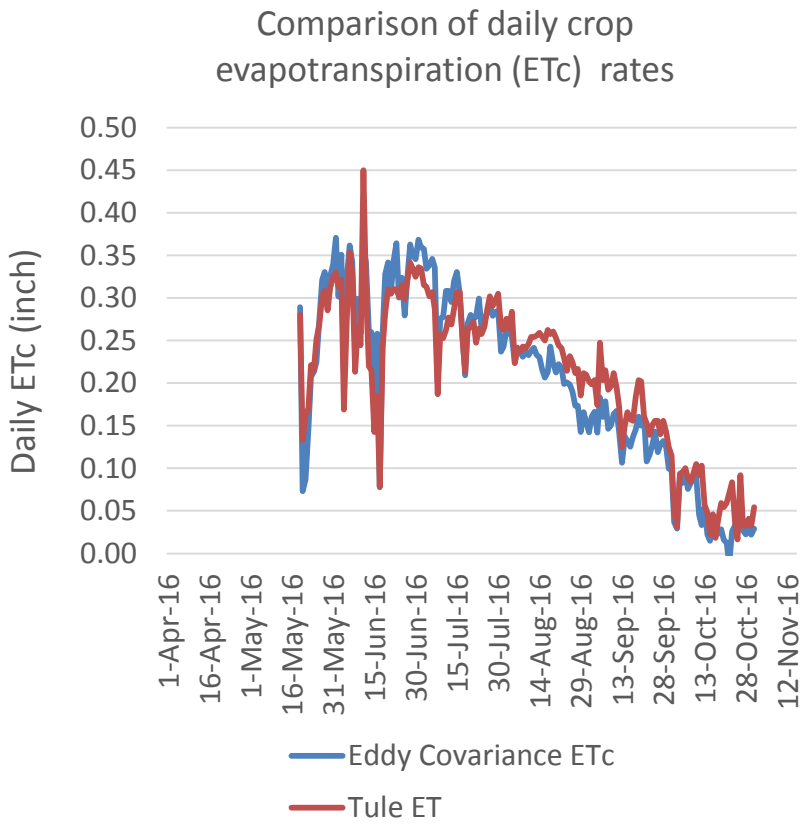
ET_a

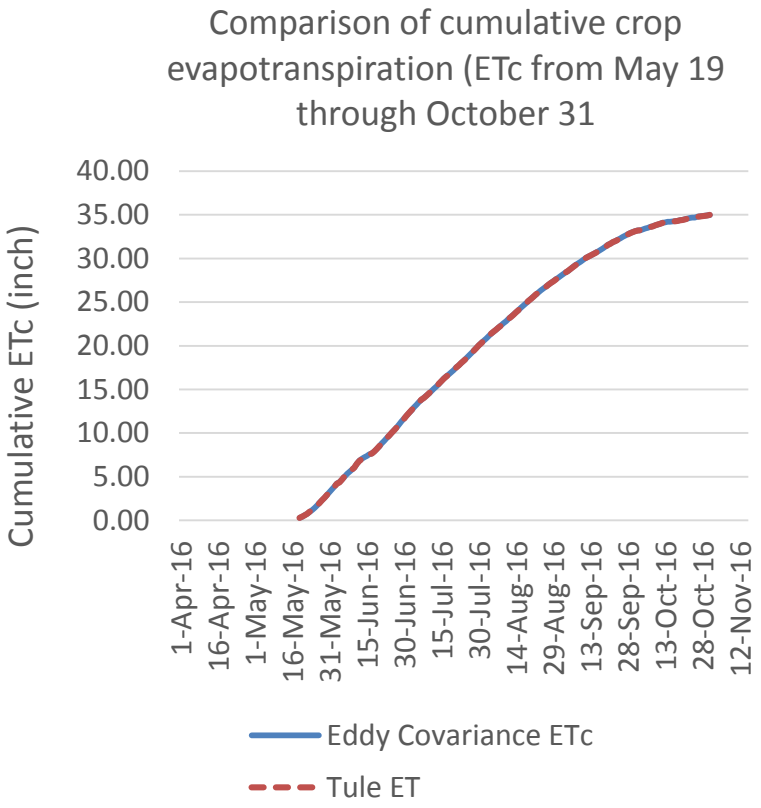
Actual ET

Are Tule Estimates of Actual Walnut ET Accurate? (Comparison to Eddy Covariance Method)



2016 Comparison of Actual ET in mature walnuts, Dairyville



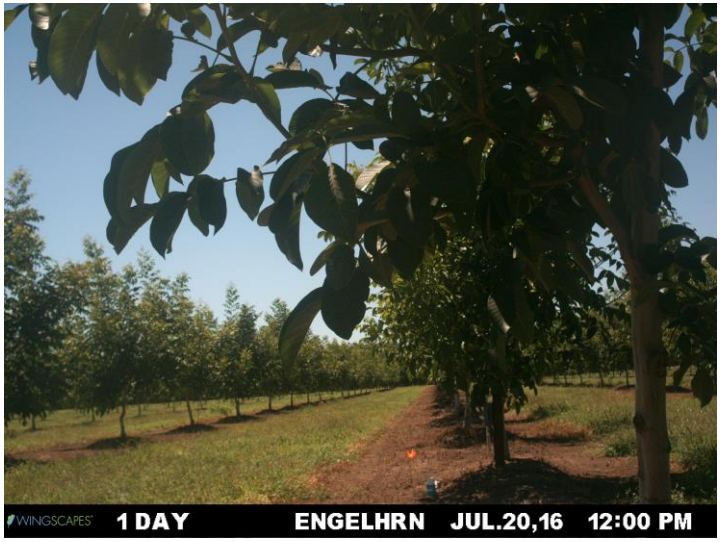


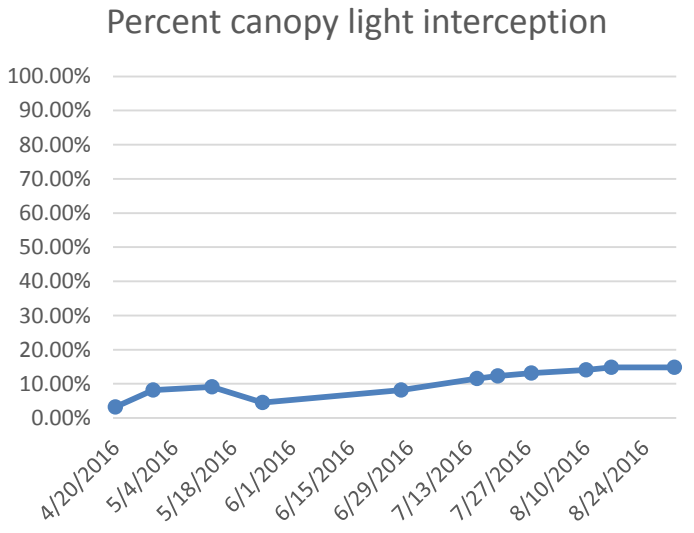
Comparison of seasonal ET_a (Tule) and estimated supplied water in four Sacramento Valley walnut orchards in 2016

Orchard ID	Tule Seasonal ET_a (inch)	Estimated Applied Water (inch)	Rainfall for analysis period (inch)	Analysis period Measured Change in soil moisture (inch)	Total Water Supplied (inches)
Red Bluff Chandler 4th Leaf	**42.0**	35.3	2.8	1.3	**39.4**
Red Bluff Mature Chandler	**40.1**	28.3	2.8	8.7	**39.8**
Dairyville Mature Chandler	**41.5**	28.2	2.8	5.7	**36.7**

Comparison of seasonal ET_a (Tule system) and estimated supplied water in a 3rd leaf walnut orchard, Los Molinos, 2016

Orchard ID	Tule Seasonal ET_a (inch)	Estimated Applied Water (inch)	Rainfall for analysis period (inch)	Analysis period Measured Change in soil moisture (inch)	Total Water Supplied (inches)
Los Molinos Chandler 3rd Leaf	40.8	20.7	2.8	4.5	28.0 ?





Tule offers “FieldStat” as an indicator of orchard water stress

- FieldStat = Crop stress coefficient (Ks)
- “FieldStat” is an index of orchard water stress calculated from your specific orchard ET_a data and nearby estimates of ET_o (grass reference ET)
- If ET_a is low, it may be because the weather is unusually cool or the orchard is lacking water and the trees are stressed
- Method of calculating FieldStat
  - Compare ET_a to ET_o to see if unusually cool weather explains low ETa
  - If unusually cool weather does not explain low ETa in orchard, Tule compares the specific days ETa to the maximum ETa measured in your orchard and calculates “FieldStat”

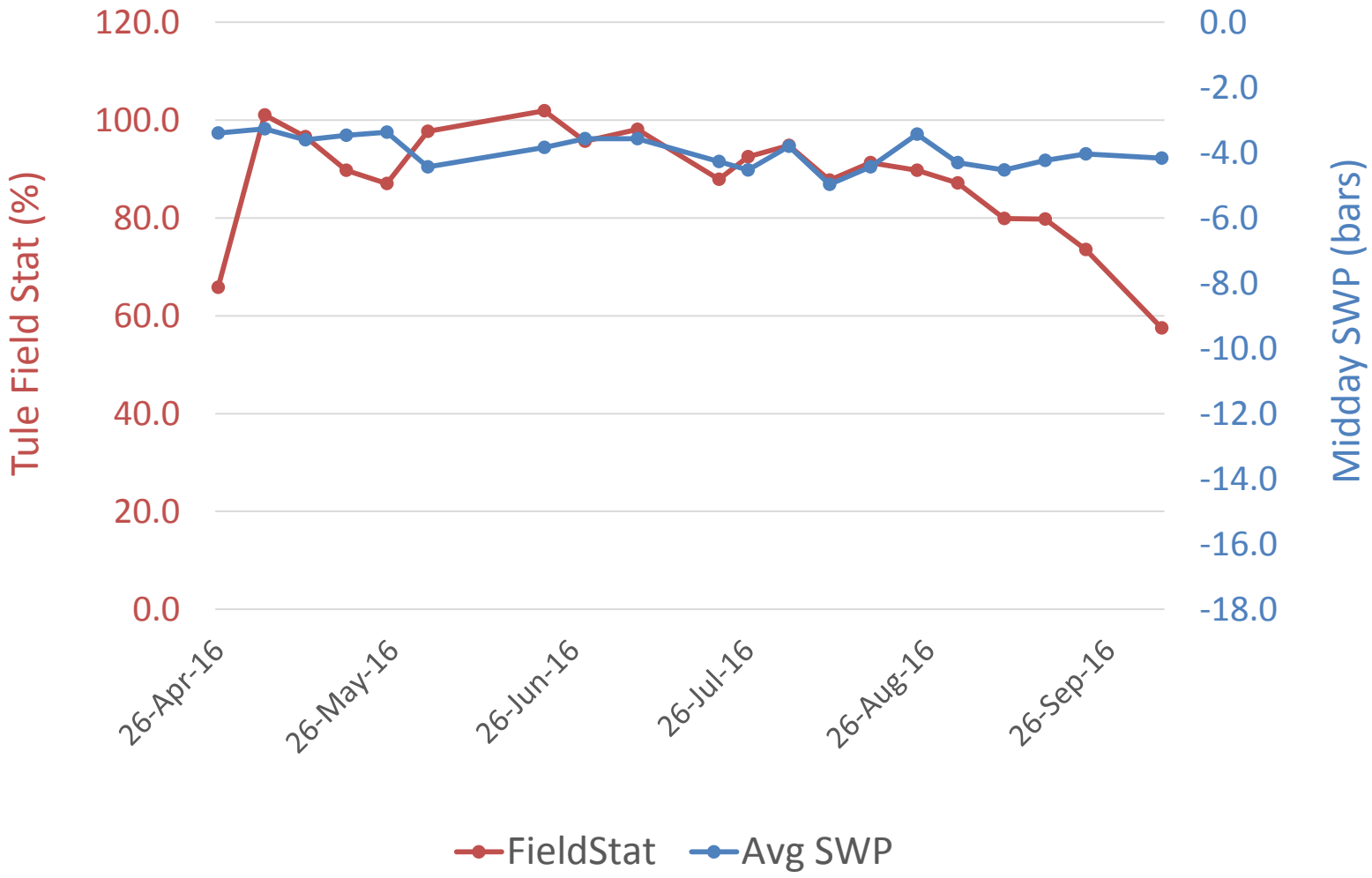
SWP (pressure chamber) versus "FieldStat" (Tule System) in walnut

Crop Water Stress Level	Pressure Chamber SWP (bars)	Tule (FieldStat)
Low	2 to 4	>100
Mild	4 to 6	100 to 75
Moderate	6 to 8	75 to 65
High	8 to 10	65 to 50
Very High	>10	< 50

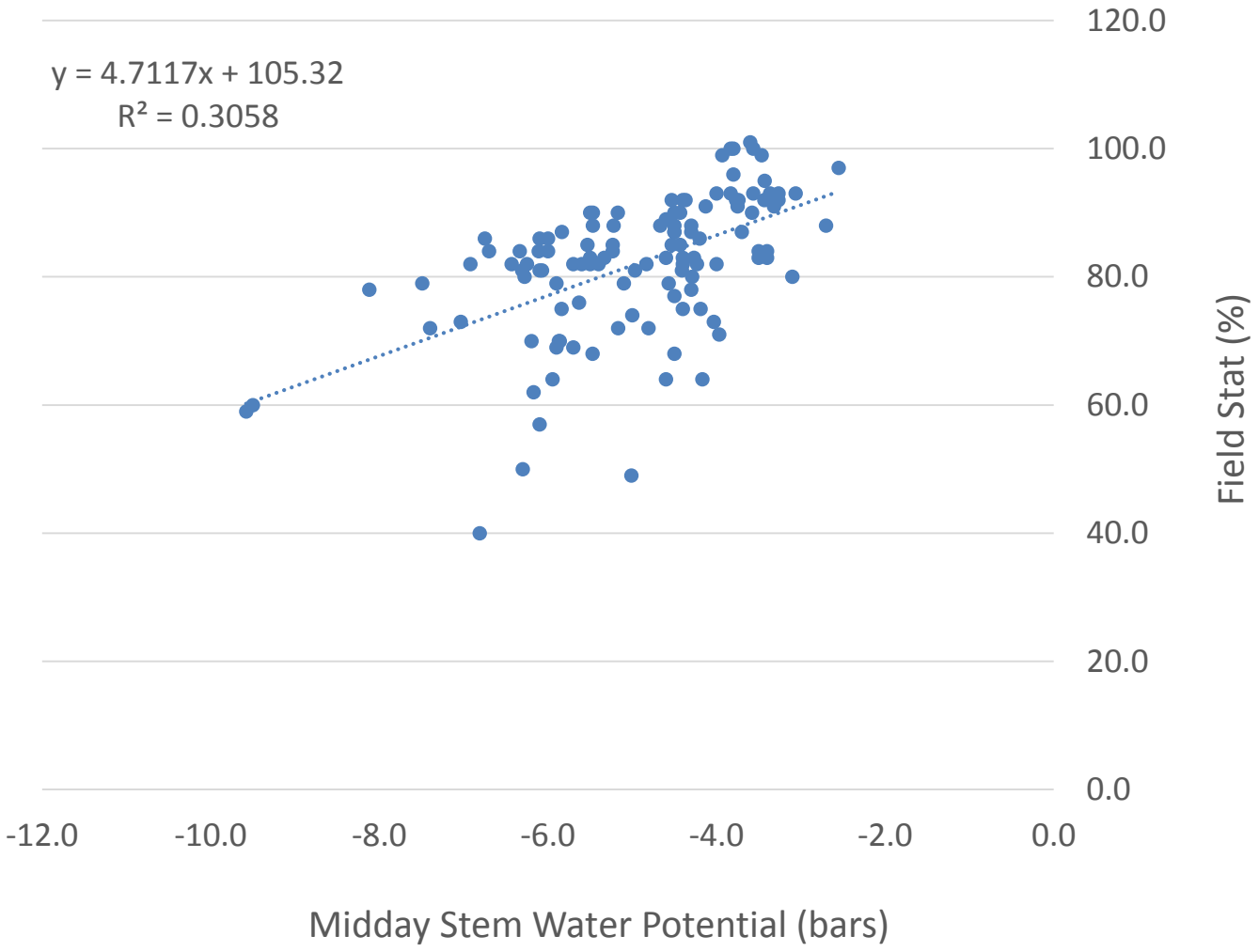
An Example of Tule “FieldStat”

Example: Comparison of midday stem water potential (SWP) levels and Tule FieldStat index of orchard water stress.

Dairyville mature walnuts.

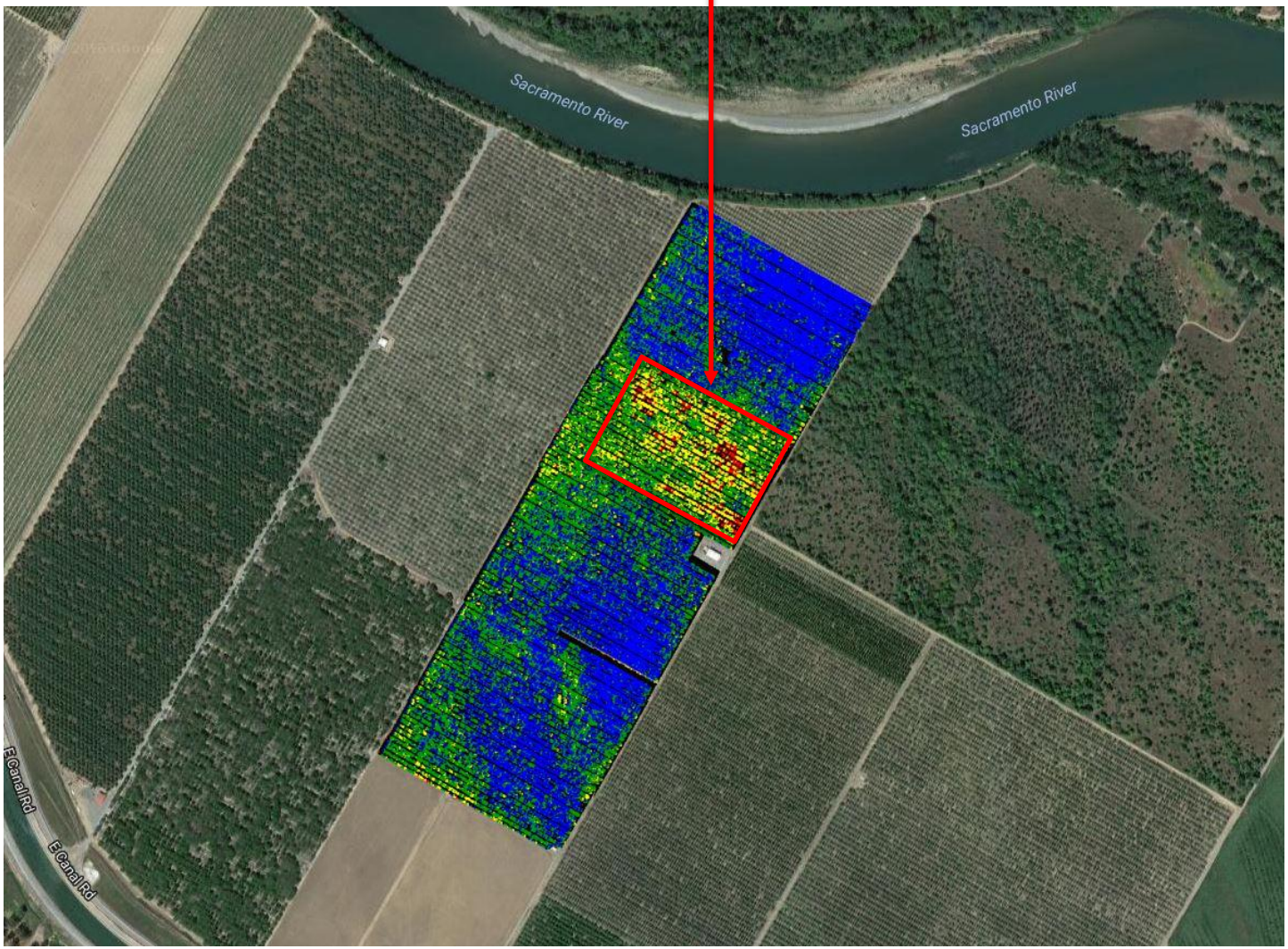


General correlation between midday SWP levels measured with a pressure chamber and Tule “FieldStat”, 2016. Six Chandler walnut orchard in Tehama and Butte Counties.



Ceres Imaging

Image of early season walnut irrigation experiment on June 24, 2016, Red Bluff

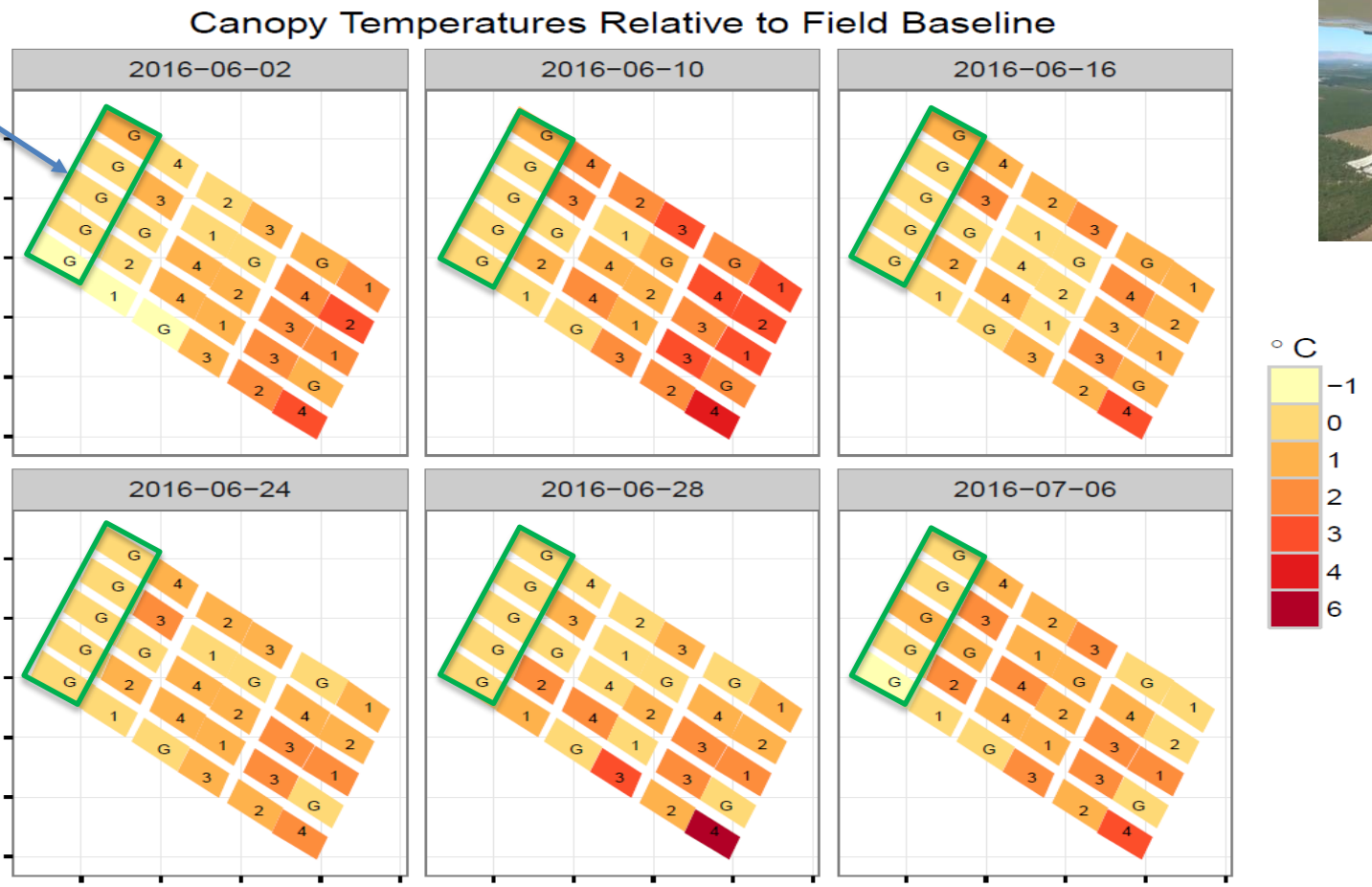


Scope of data collection at walnut experiment

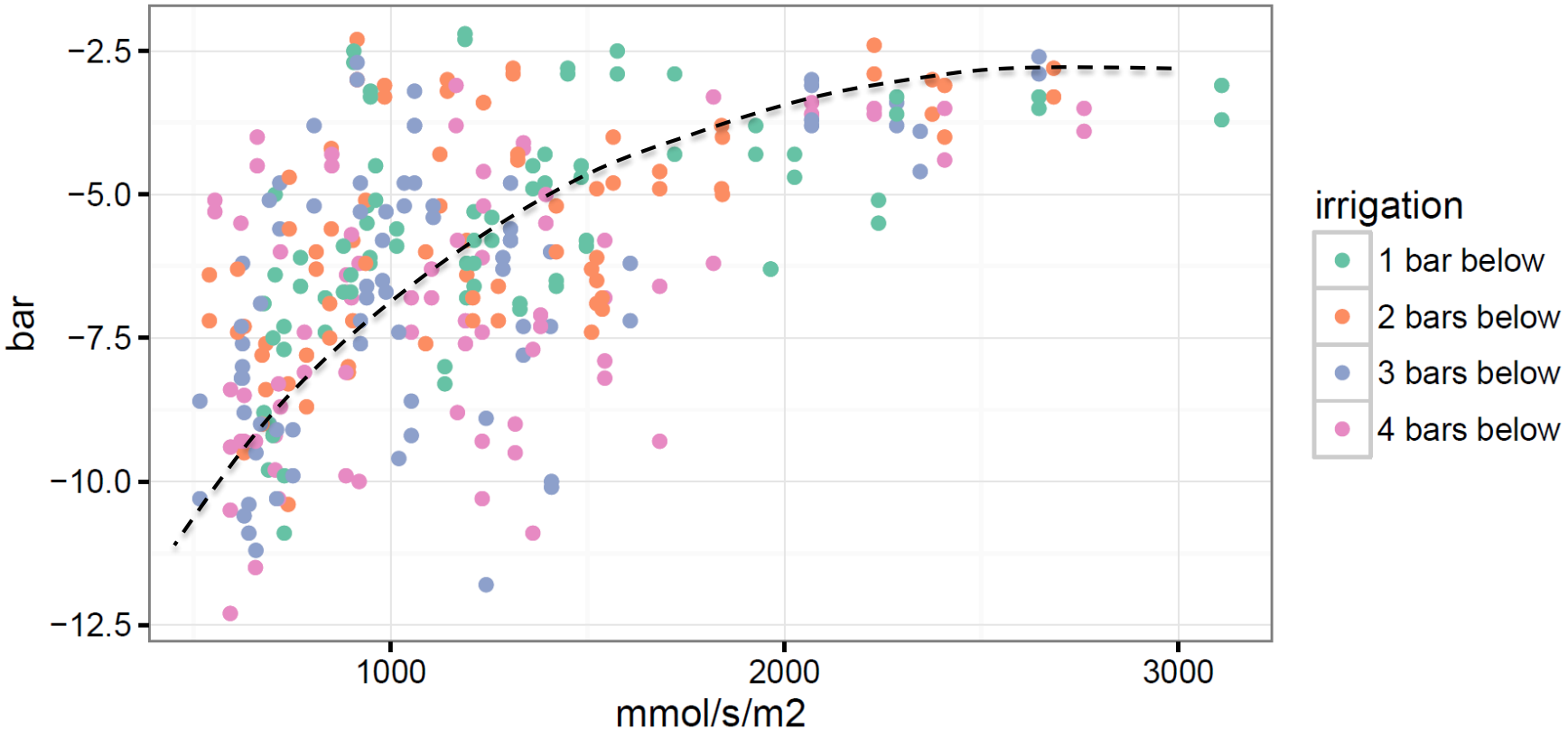
- 18 flights in 2016
- Approximately weekly from April 1 through July 6, then monthly in late July and August
- Aerial images taken at 2500 feet with fixed wing aircraft
- Thermal images measure canopy temperature, then evaluate relative temperature across an orchard
- Canopy temperatures can be used to estimate stomatal conductace of CO_2 across an orchard

Question #1 : Are differences in crop temperature detected in the irrigation experimental plots?

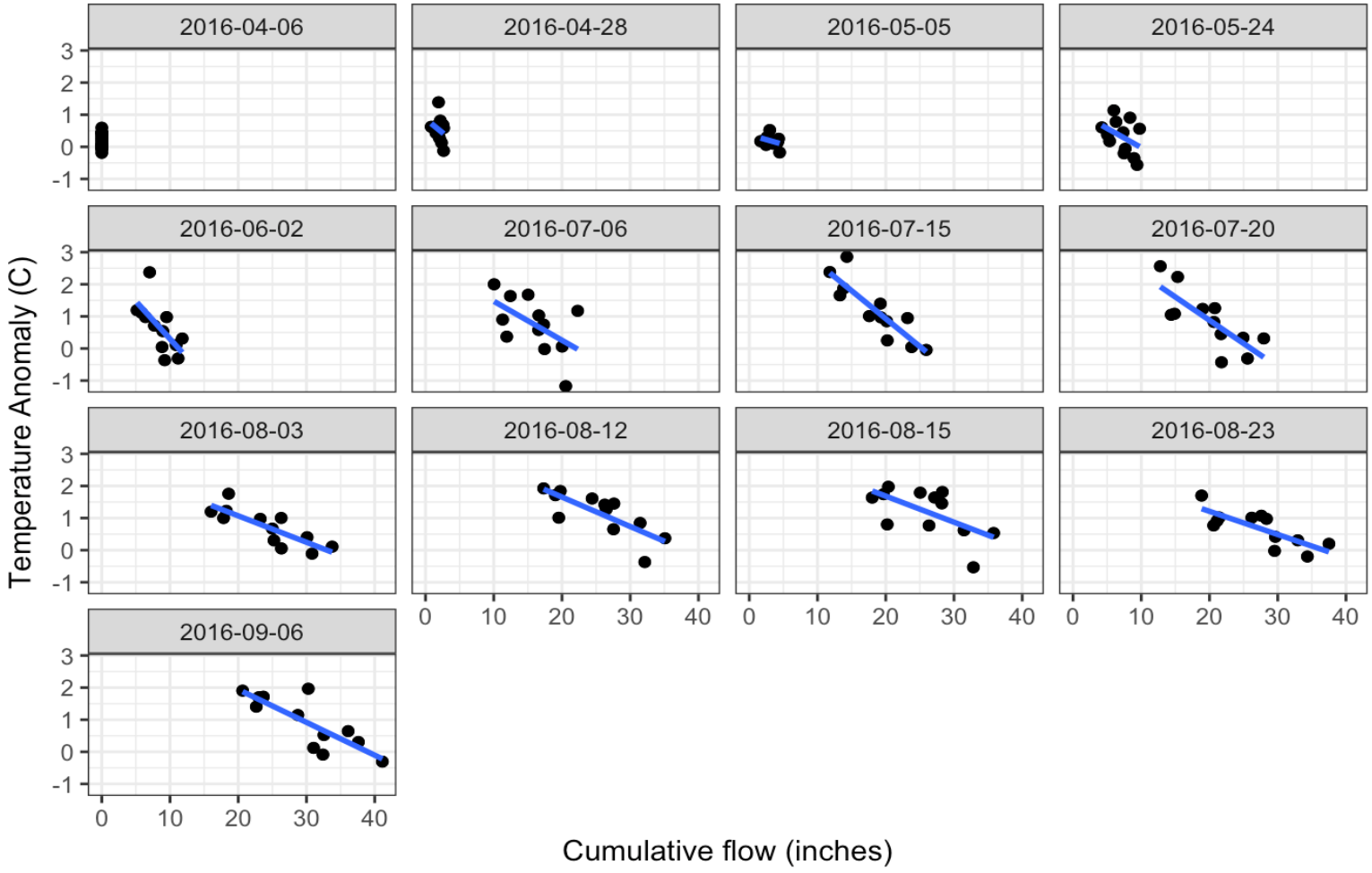
Area used as Baseline (Low stressed area)



Question # 2: Is there a relationship between estimates of stomatal conductance and on-the-ground SWP measurements?



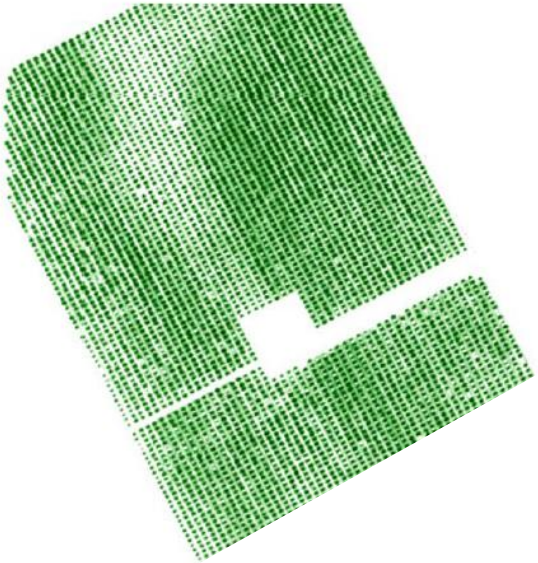
Whole orchard canopy temperature measurements correlate with applied water



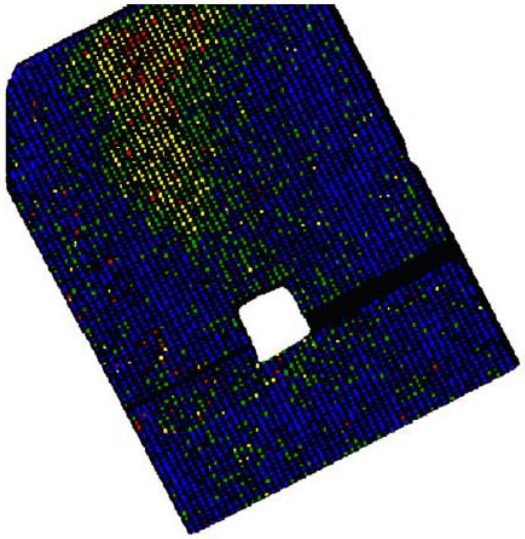
Using aerial imagery for troubleshooting

Soil Layer

Vegetation (Tree) Vigor Layer



Canopy Temp/ Water Stress Layer



Summary Points

- Monitoring tree stress pays back
- Traditional and new options to monitor tree water stress are available now
  - Some offer automated, conveniently delivered, information sources
  - Others offer whole orchard perspective
  - Expect the emergence of new technology to continue and improve


Thank You