Midday Stem Water Potential

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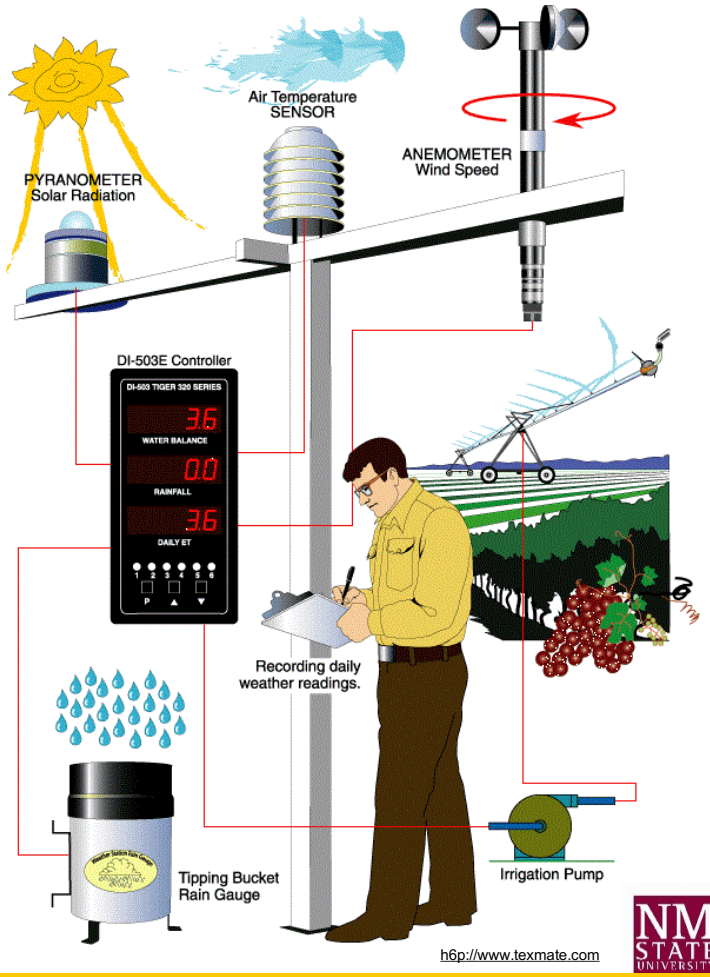
Plant and Environmental Sciences

Ways to improve irrigation efficiency in pecans

Irrigation scheduling

- When to irrigate
- How much to apply

Irrigation scheduling depends on the sensitivity of field measurements to water deficit.



Measurements used for detecting water status in pecan orchards

Plant-based

Midday stem water potential (Ψ_{smd})

Soil-based

Soil TDR

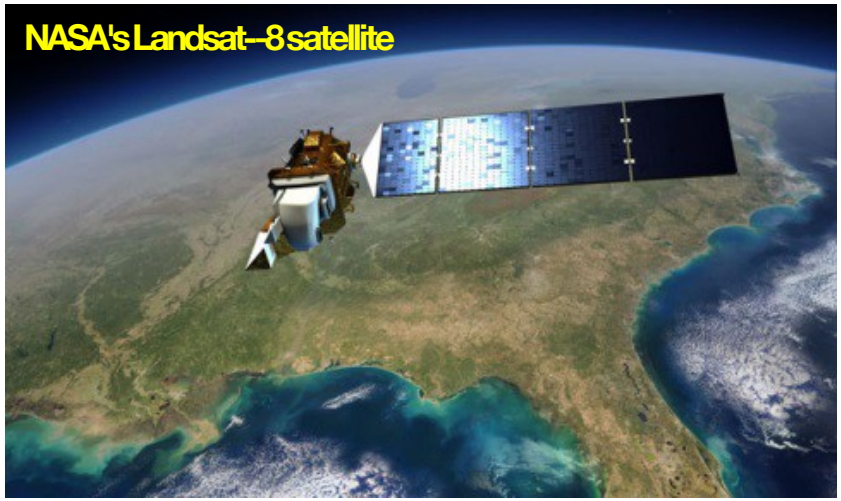
Plant-soil-based

Lysimeters

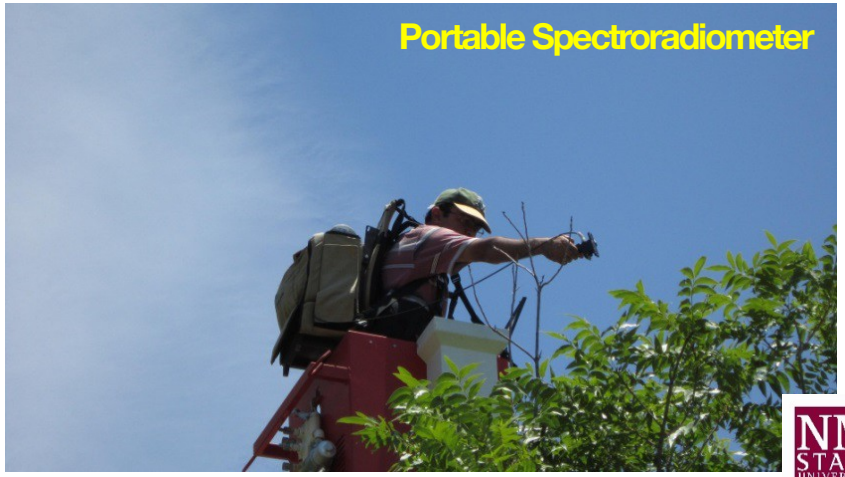
Limitations:

Small area, extraordinary cost, extraction time, leaf destruction

We tried remote sensing to detect moisture status



Handheld portable Spectroradiometer

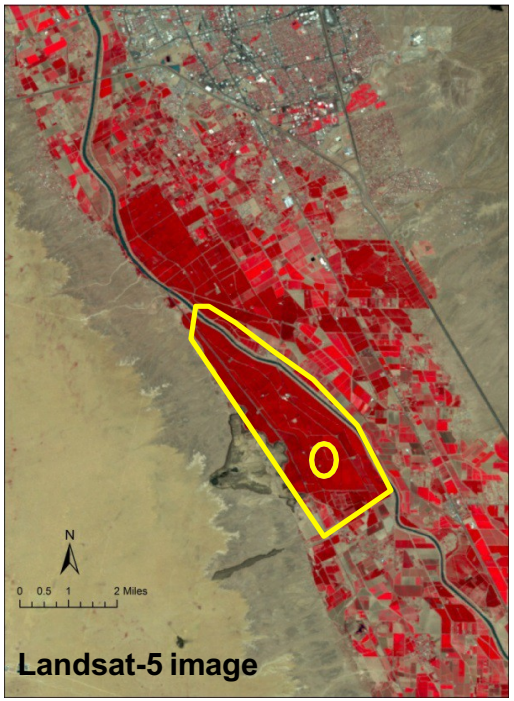


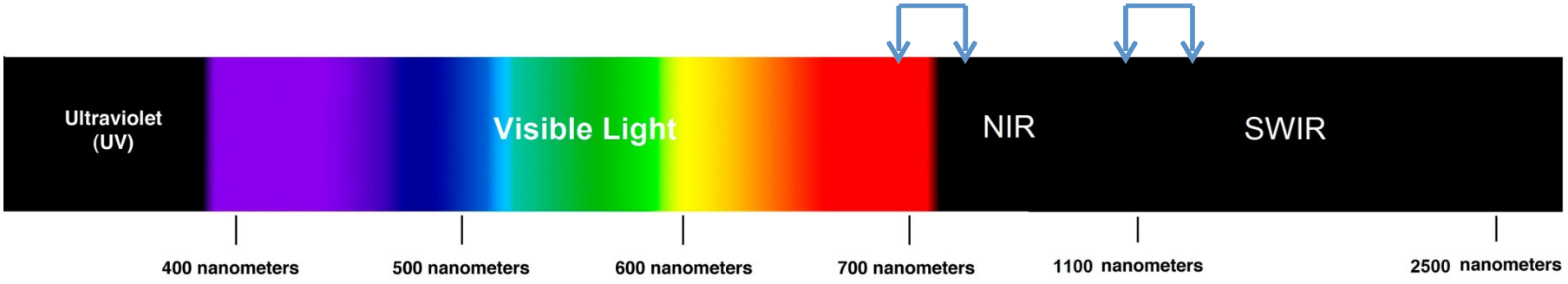
Remote sensing applications

Scale up leaf-level physiological responses to large areas

Detect pigment concentration

Spectral regions from 680-750 nm and 1275-1640 nm were correlated with pecan water deficit (Johnson 2004).





Electromagnetic spectrum

Objectives

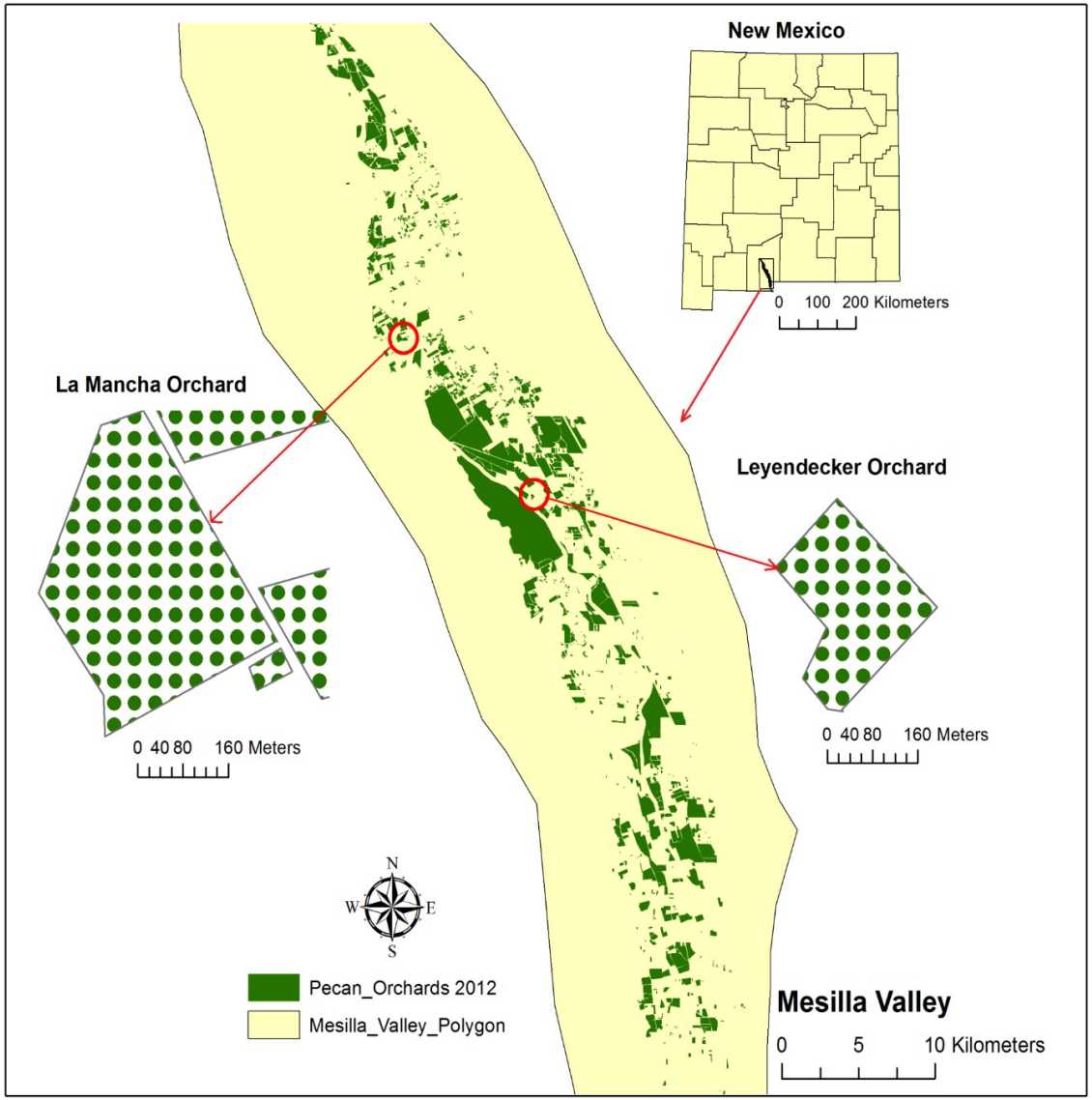
The overall goal of this research was to develop an advanced sensing and management technologies to optimize water resources and drought monitoring of pecan orchards. Initial research objectives:

1

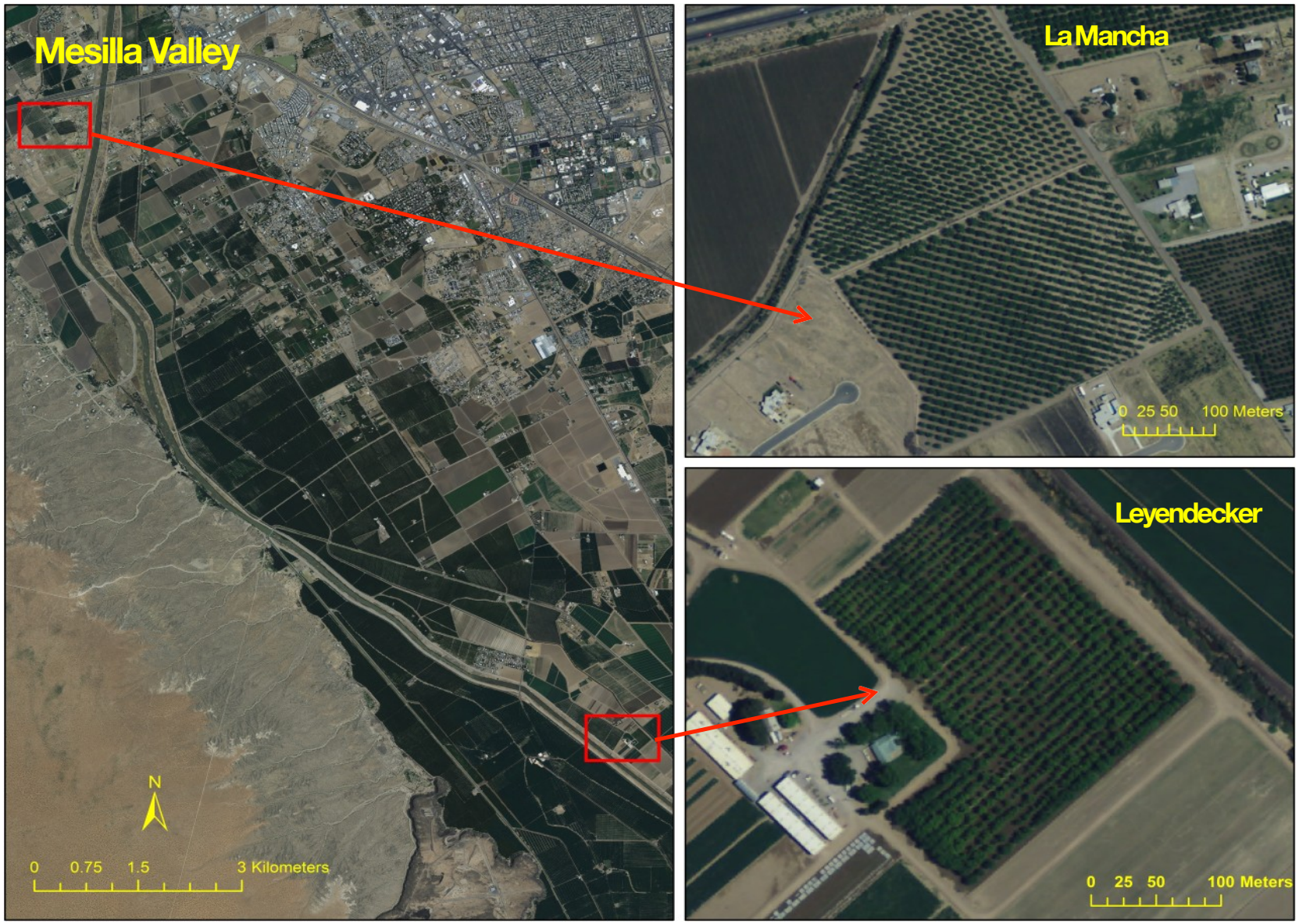
2

3 Establish preliminary values of midday stem water potential where photosynthesis and gas exchange of pecans are affected.

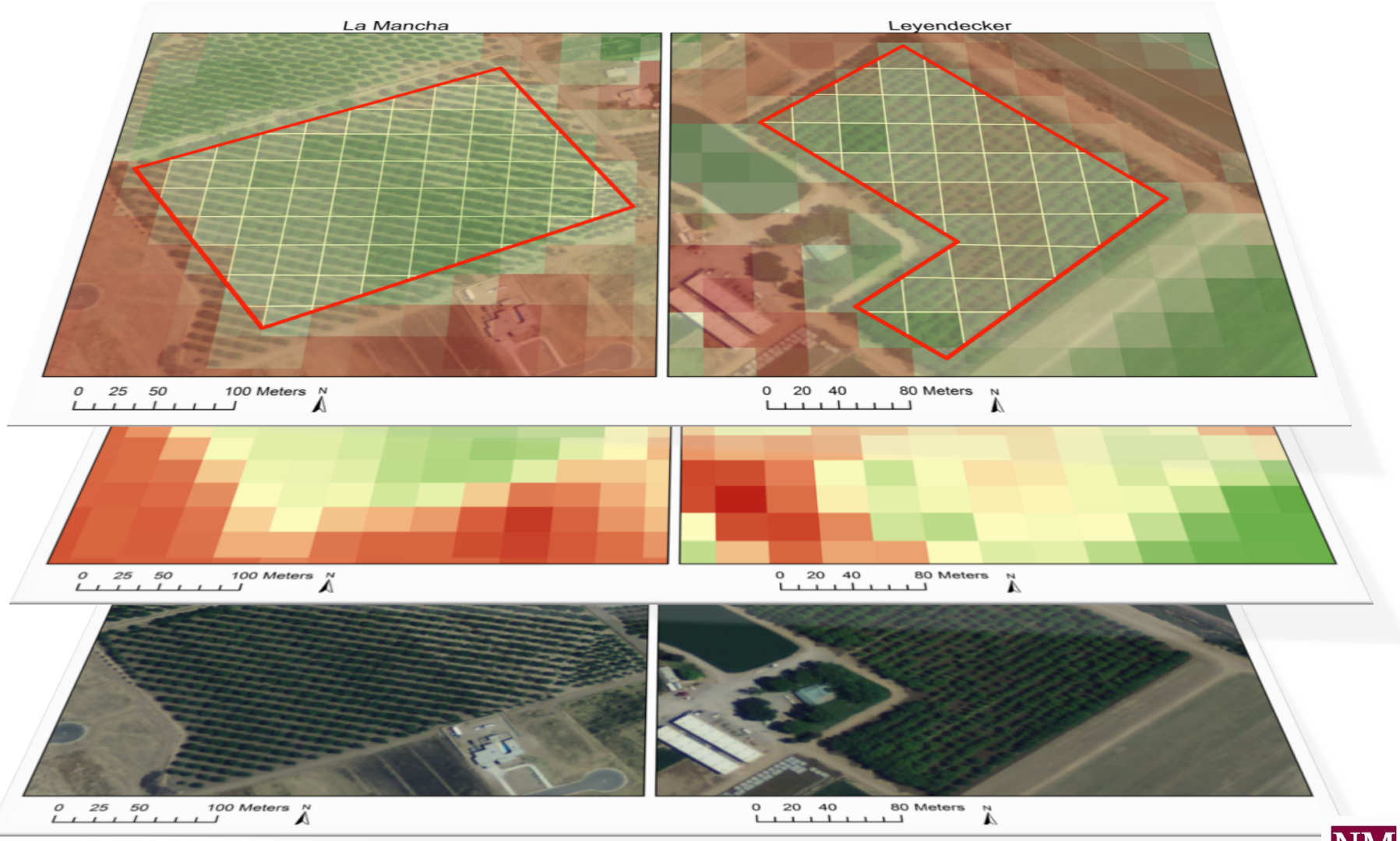
Locations of the studies



Locations of the studies

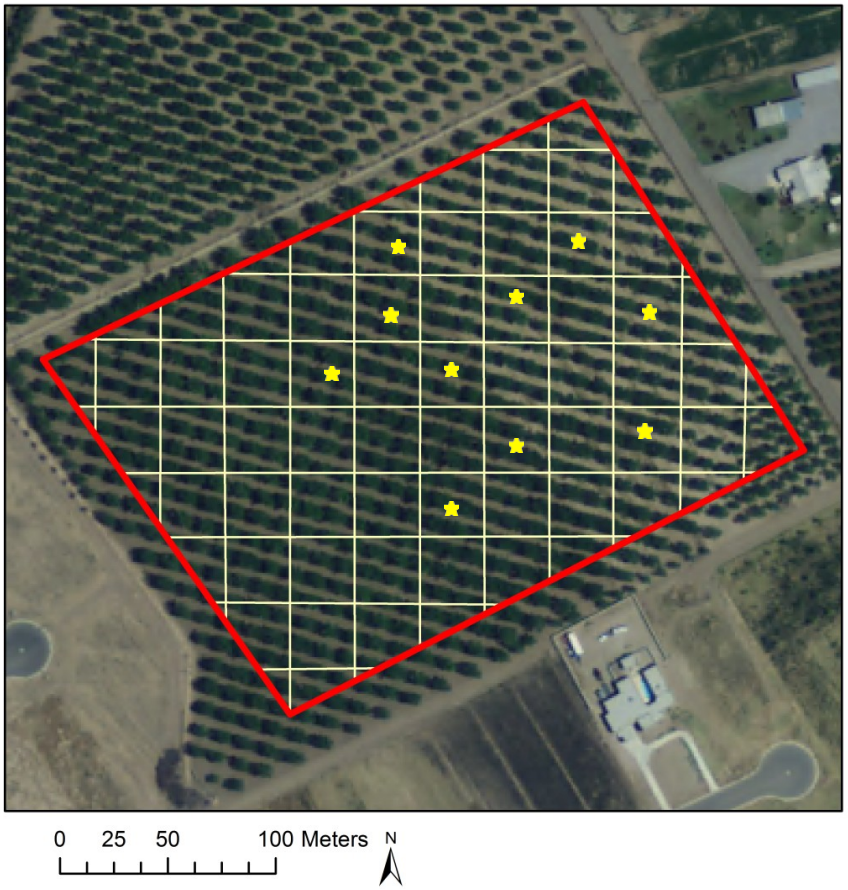


Sampling design



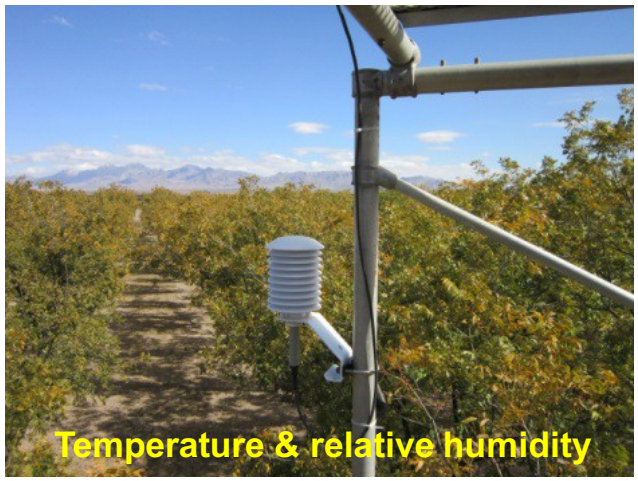
Sampling design

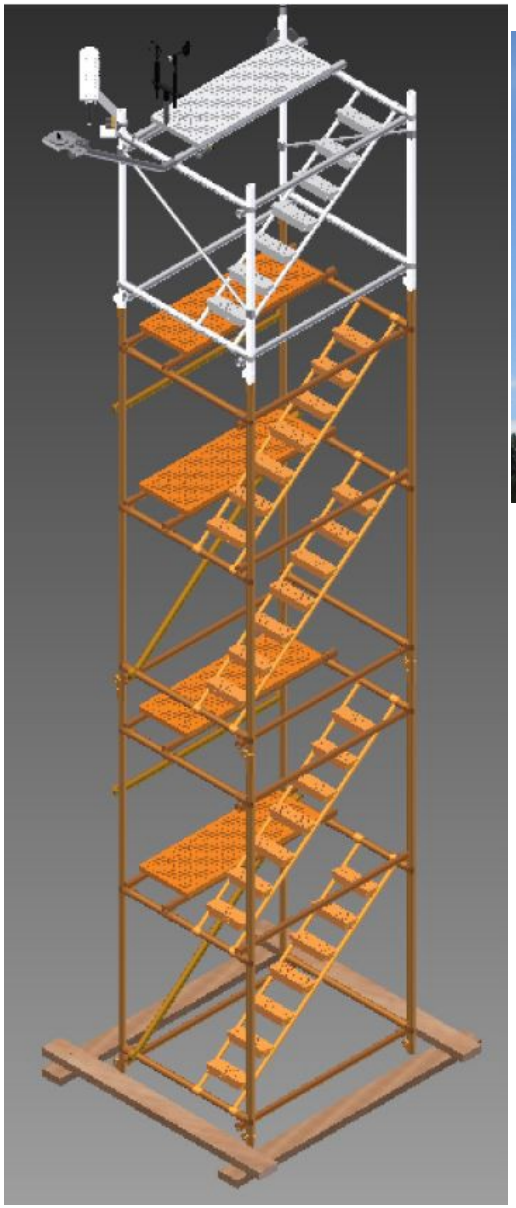
La Mancha

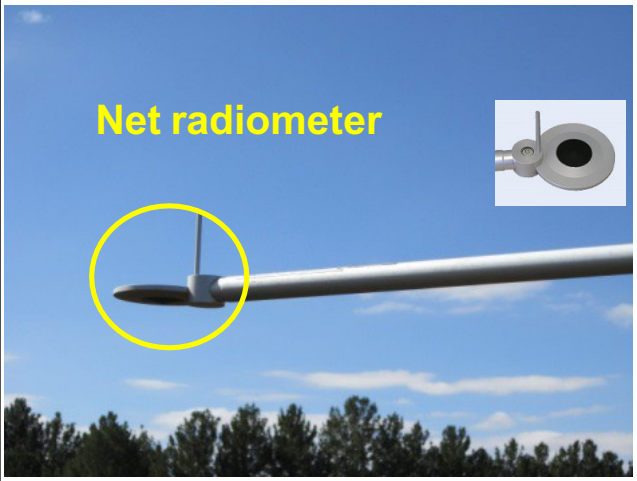


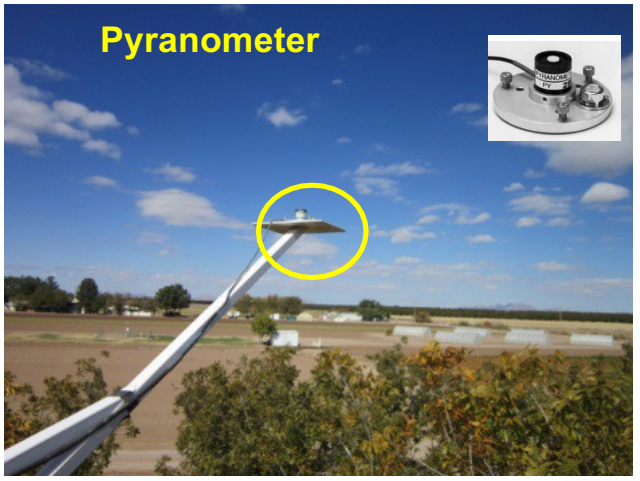
Leyendecker

Meteorological instrumentation

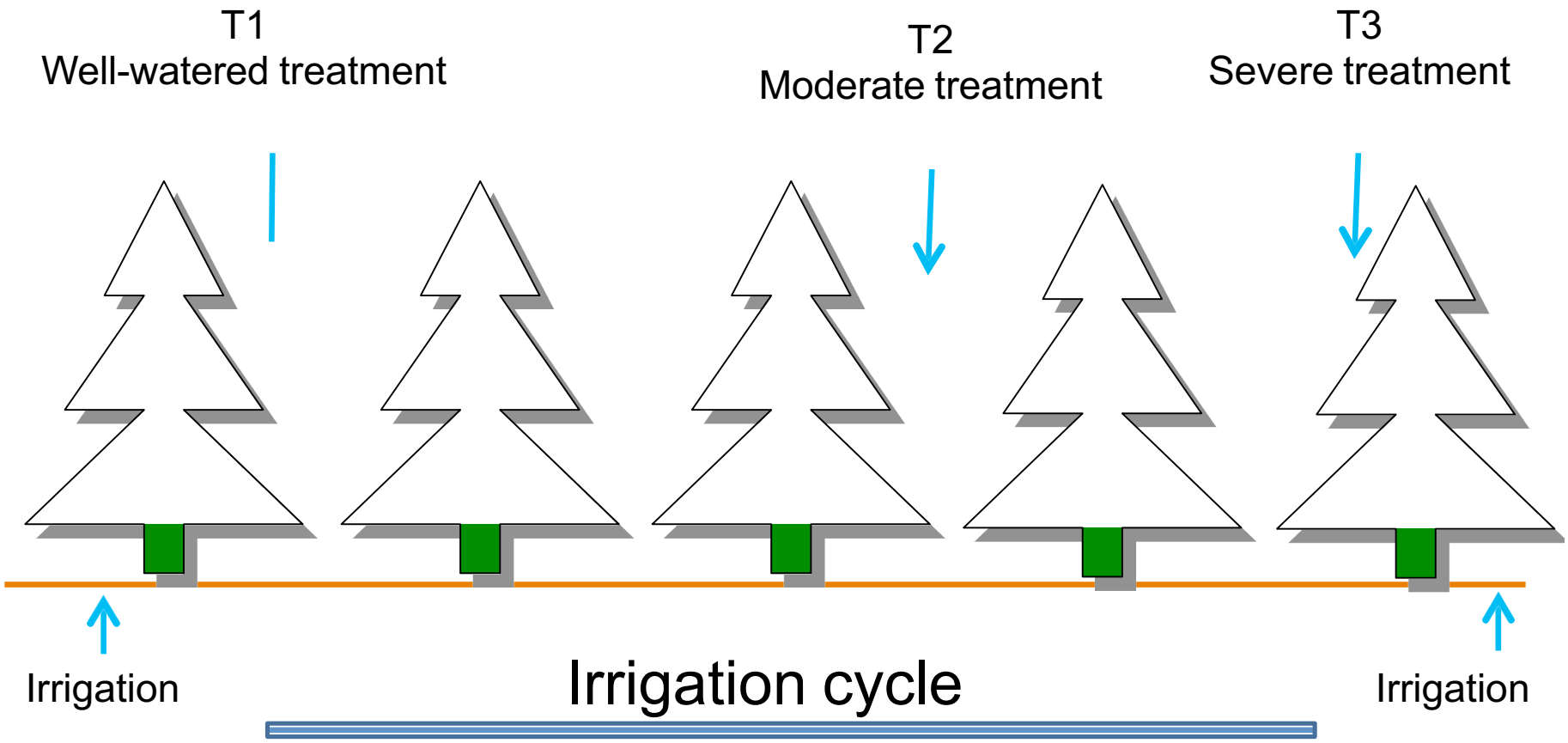




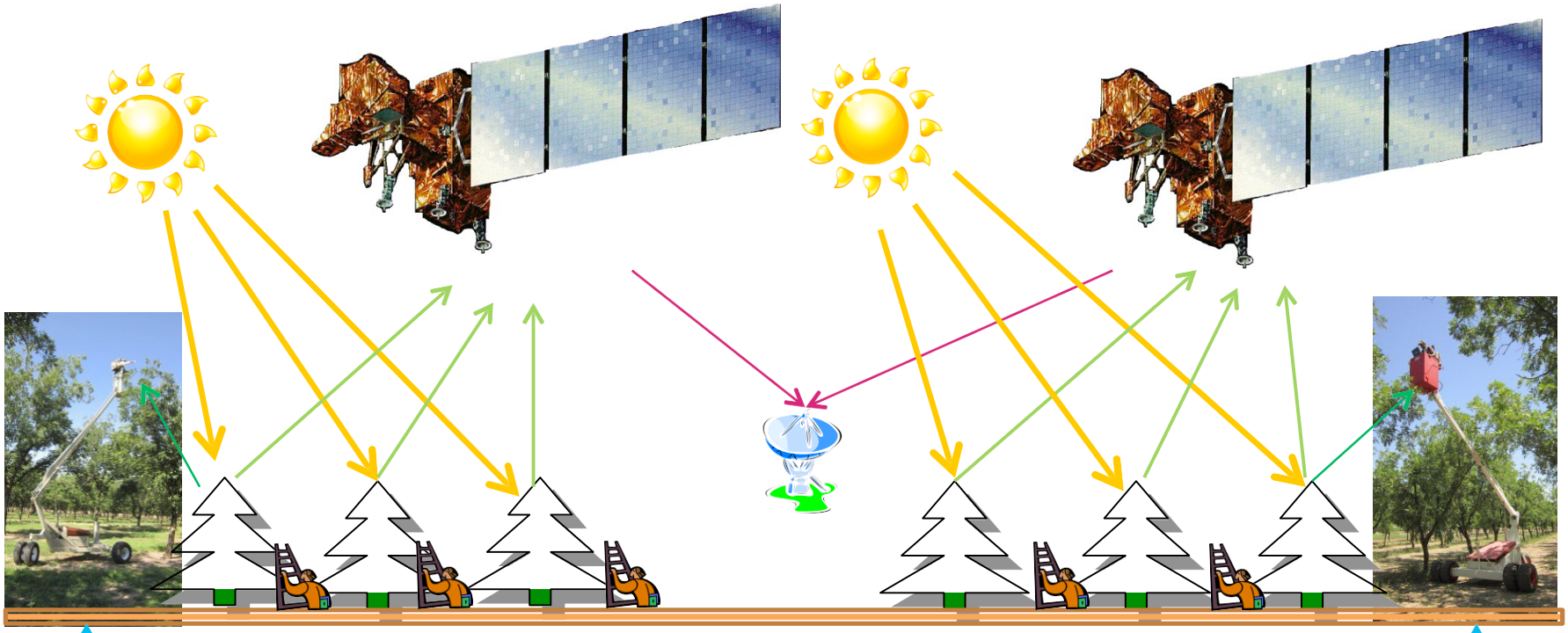




Treatment


T1
Well-watered treatment
T2
Moderate treatment
T3
Severe treatment
Irrigation
Irrigation cycle
Irrigation

Spectral and physiological measurements



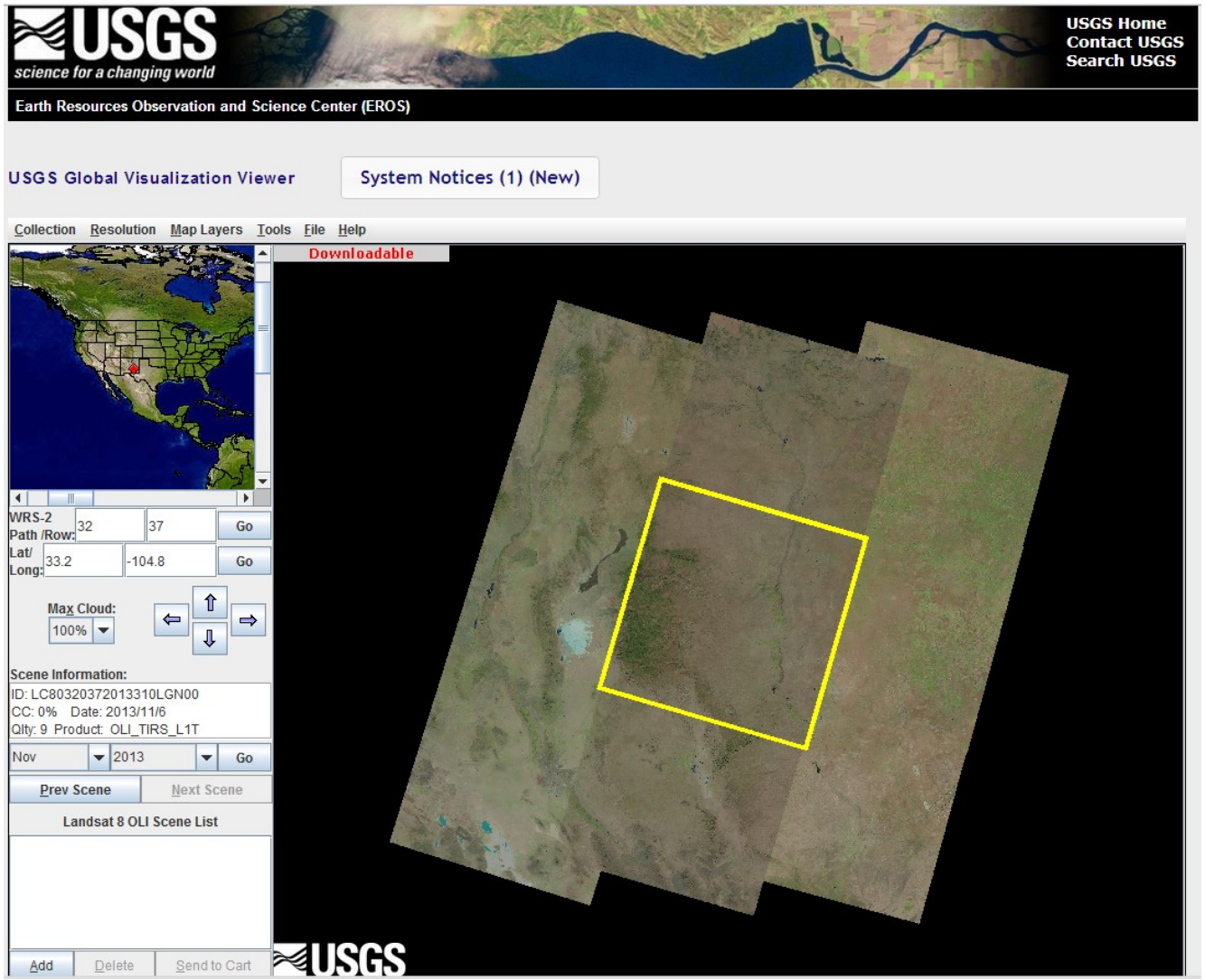
Measurements

a) Midday stem water potential

b) Remotely sensed surface reflectance data

Satellite image processing

1) Satellite images were downloaded from United States Geological Survey Global Visualization Viewer



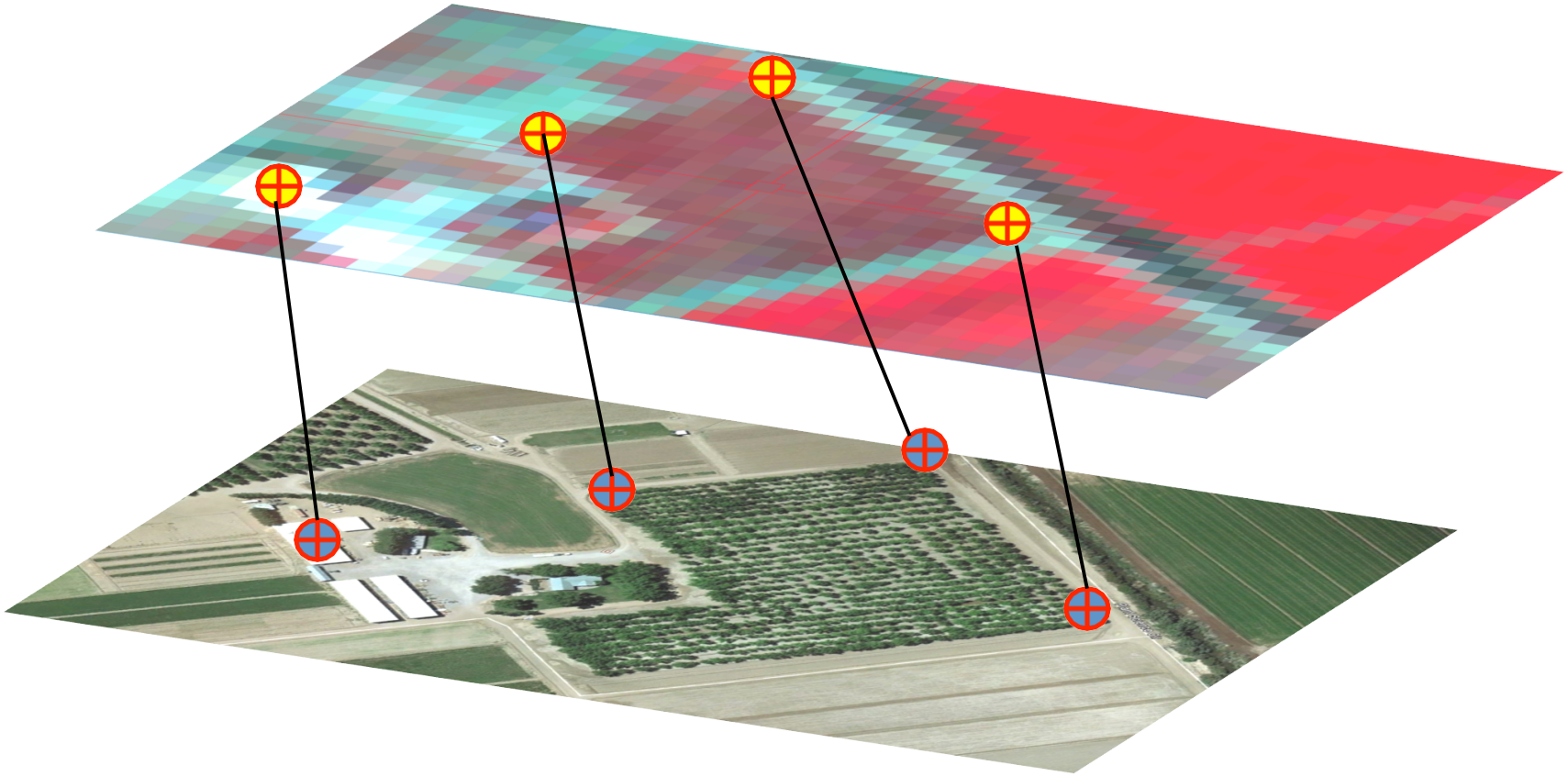
Satellite image processing

2) Radiometric correction

Improve the accuracy of surface spectral reflectance

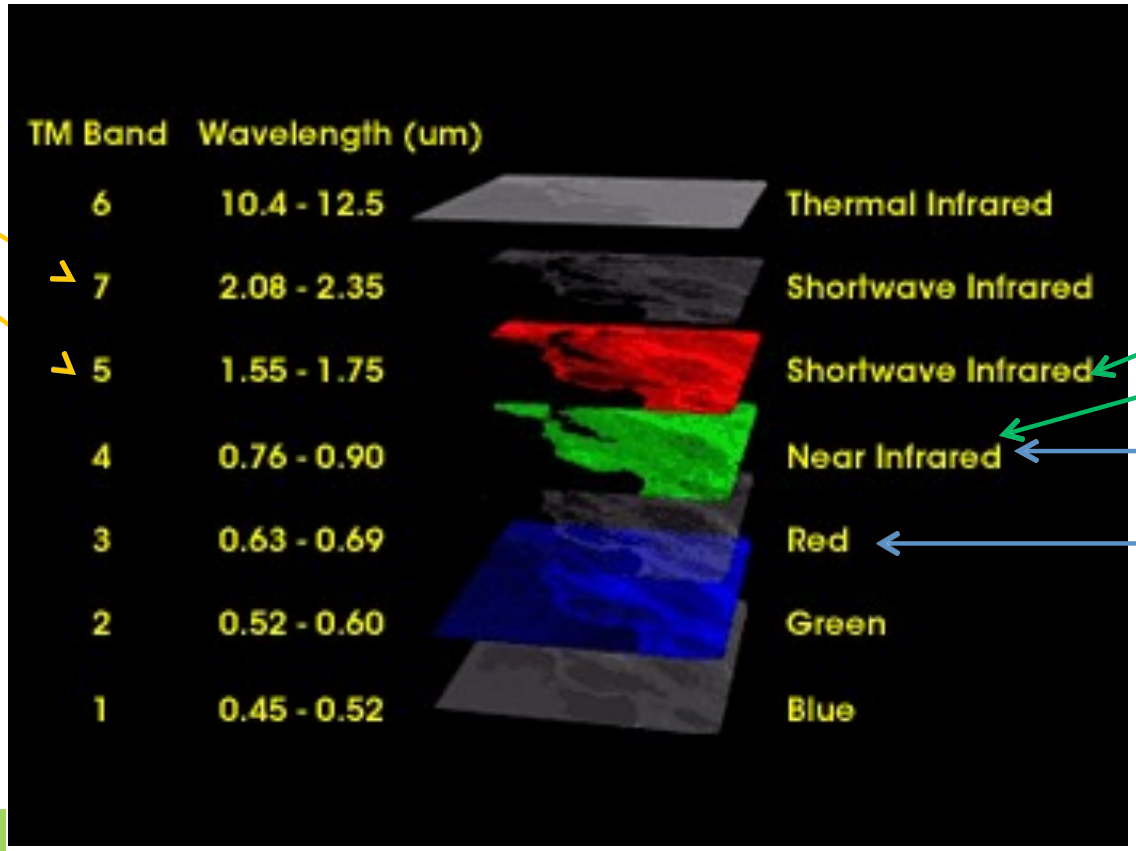
3) Geometric correction

Place data in their proper position.



Vegetation indices

Band ratio
B5/B7



Normalized Difference Infrared Index (NDII)

$$(\rho_{NIR} - \rho_{SWIR(5)}) / (\rho_{NIR} + \rho_{SWIR(5)})$$

$$(\rho_{NIR} - \rho_R) / (\rho_{NIR} + \rho_R)$$

NDVI

Vegetation moisture index II(VMI–II)

$$(-0.002 \times \rho_B) + (0.002 \times \rho_G) - (0.001 \times \rho_{SWIR(2)})$$

Physiological measurements

Midday stem water potential

Leaf area ratio

Relative water content (%)

Leaf temperature, transpiration
Photosynthesis, stomatal conductance,
vapor pressure deficit.

Chlorophyll fluorescence (F_v/F_m)

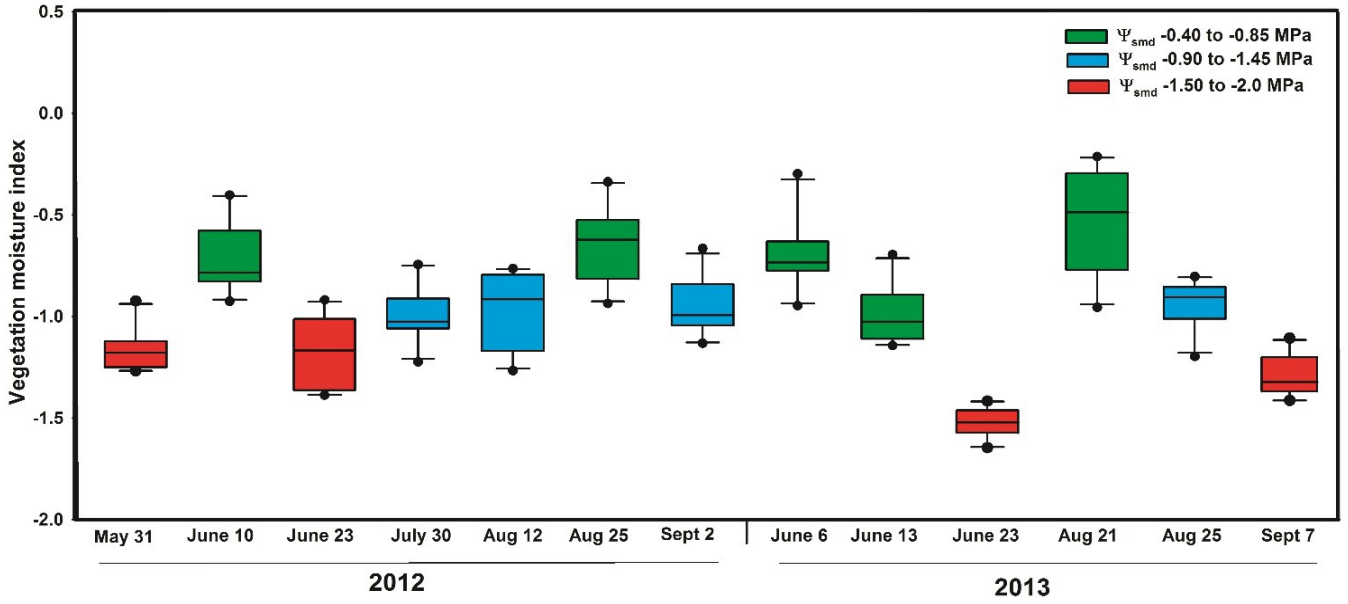
Chlorophyll content (SPAD)

Screen leaf-level physiological variables

Midday stem water potential
Relative water content
Leaf temperature
Leaf area ratio
Transpiration
Photosynthesis
Stomatal conductance
Vapor pressure deficit
Chlorophyll fluorescence
Chlorophyll content (SPAD)

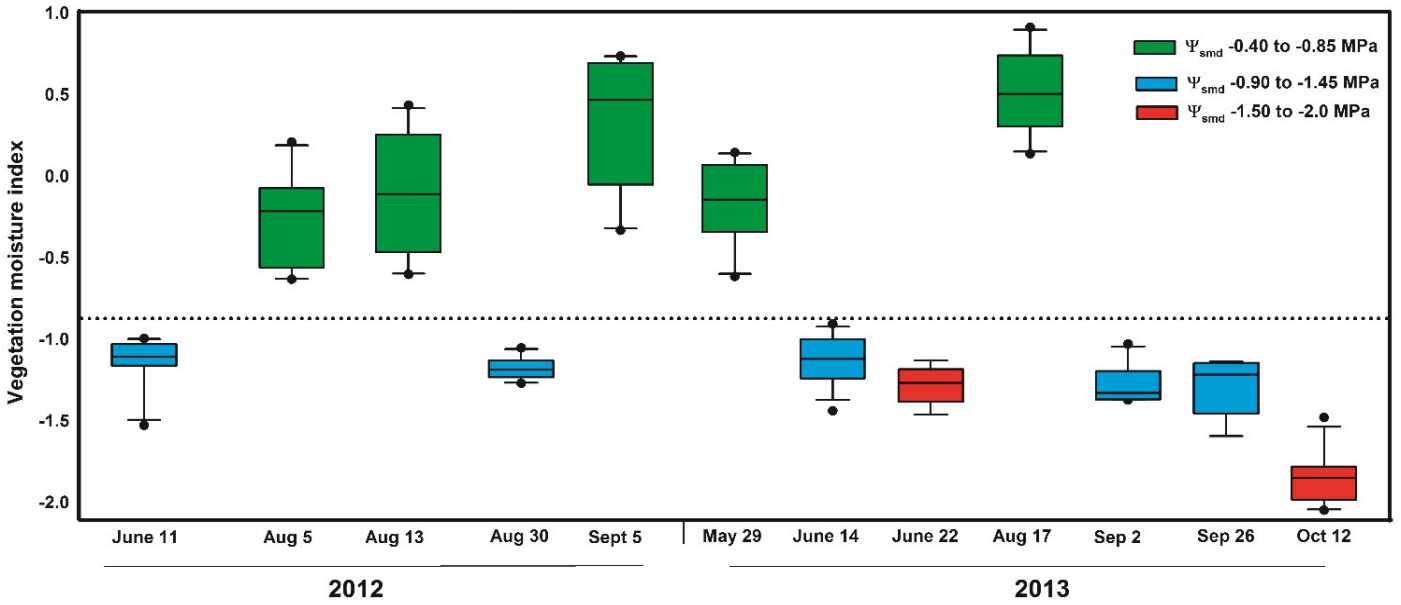
Midday stem water potential (Ψ_{smd})

Remote sensing data



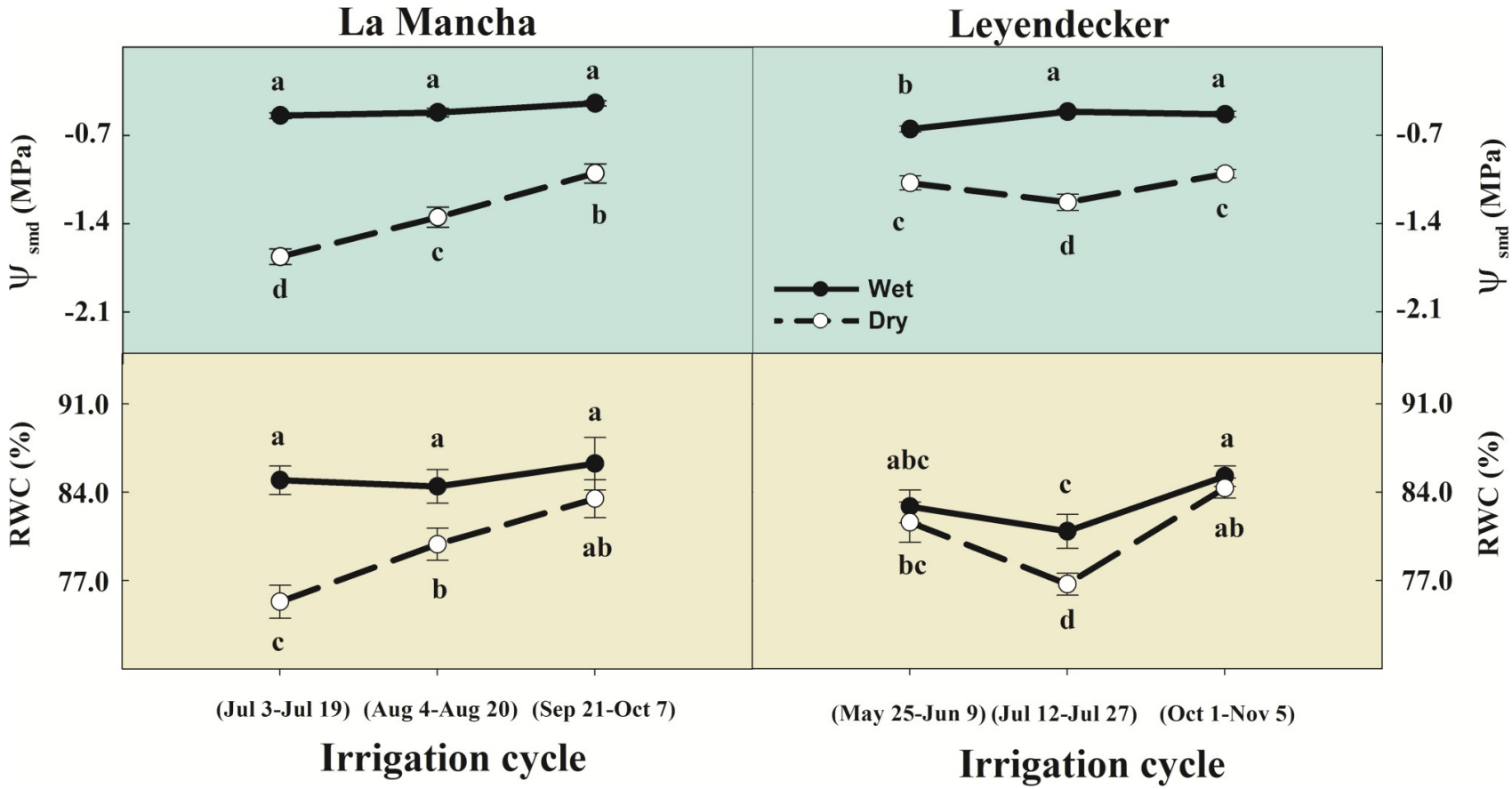
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential (Ψ_{smd}) at the La Mancha pecan orchard measured in 2012 and 2013.

Remote sensing index



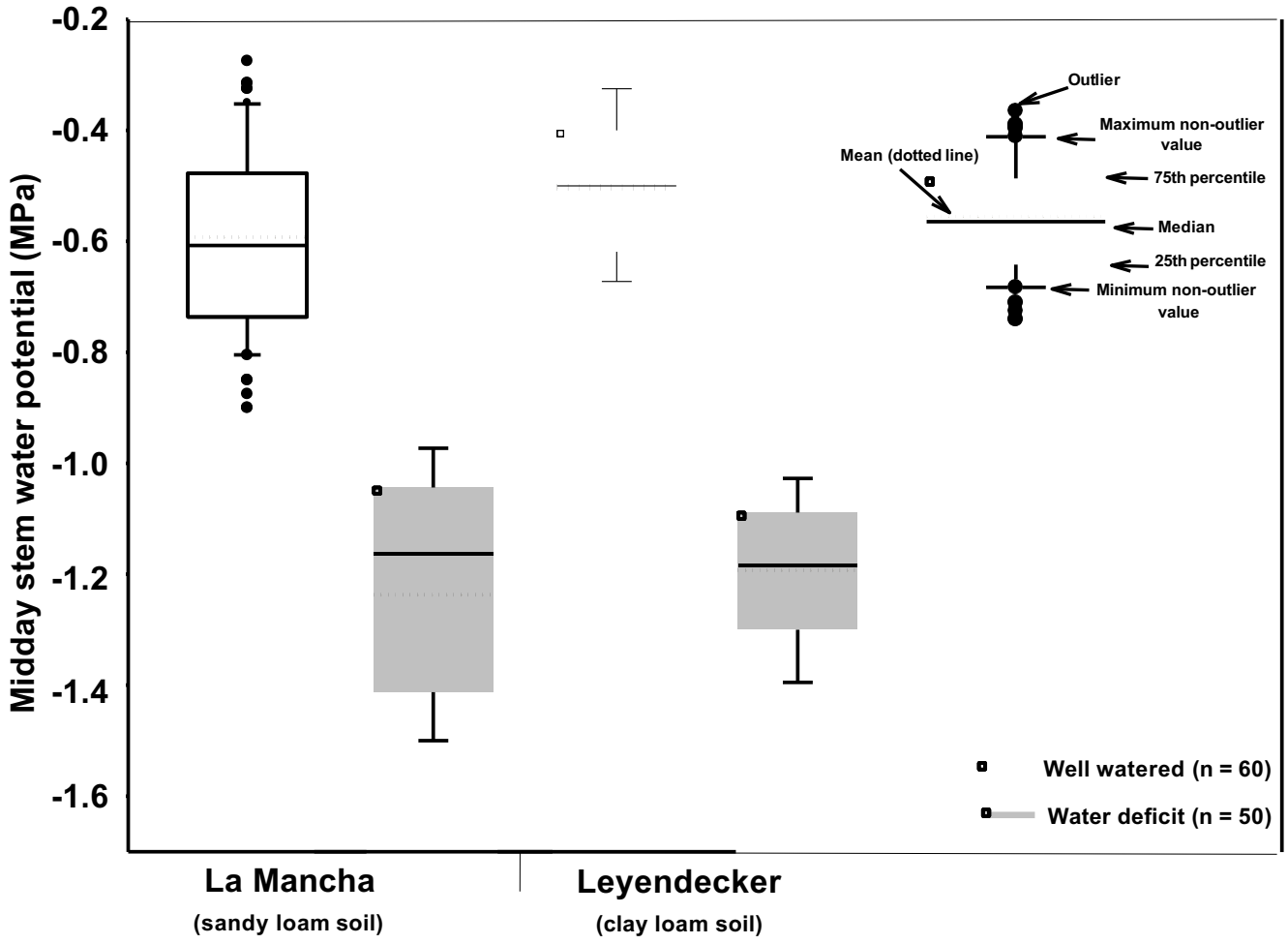
Boxplot analysis of vegetation moisture index at three levels of midday stem water potential (Ψ_{smd}) at the Leyendecker pecan orchard measured in 2012 and 2013.

Screen leaf-level physiological variables

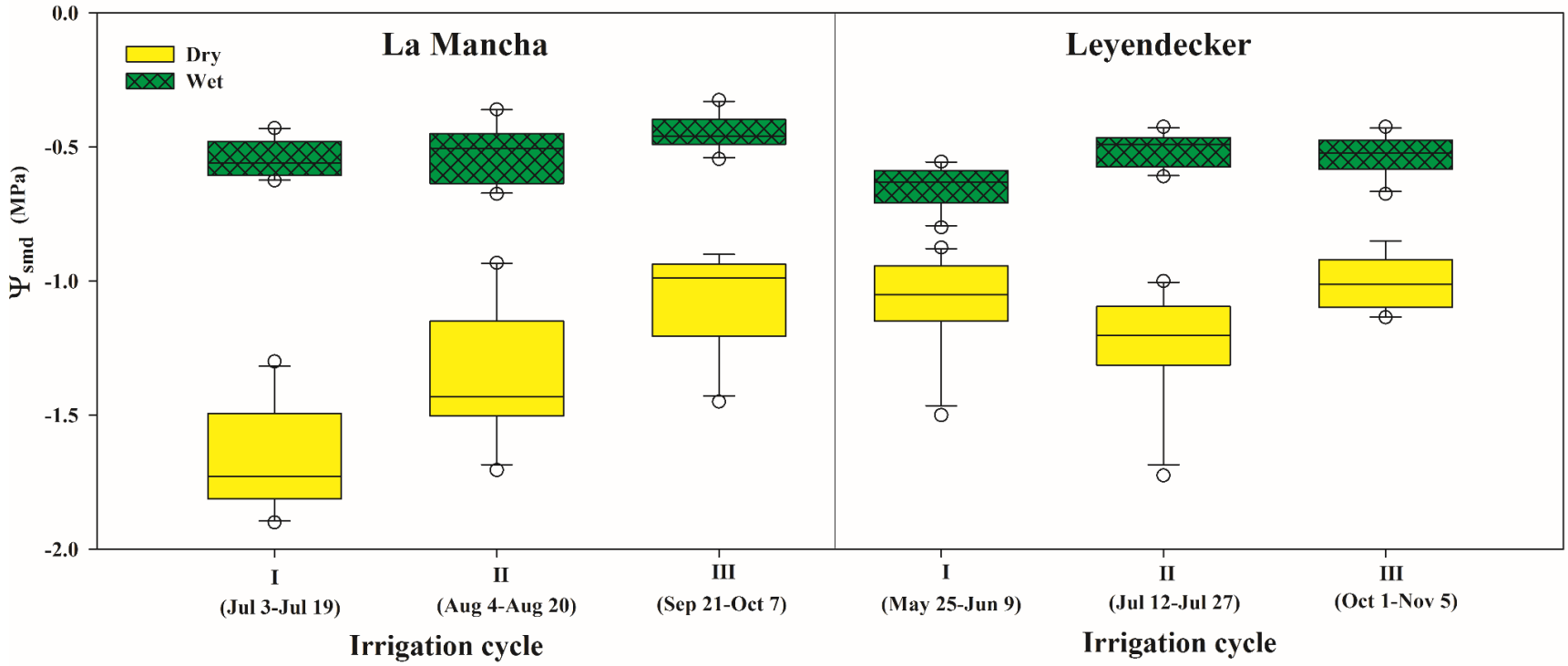


Midday stem water potential (Ψ_{smd}),and relative water content (RWC) of La Mancha and Leyendecker orchards measured in 2011. Different letters indicated a significant difference between irrigation treatments ($P < 0.05$).

Midday stem water potential boxplots of La Mancha and Leyendecker pecan orchards (Mesilla Valley, New Mexico) measured in 2012 and 2013. Rectangles represent the 25%, 50% (median), and 75% percentile of the data.

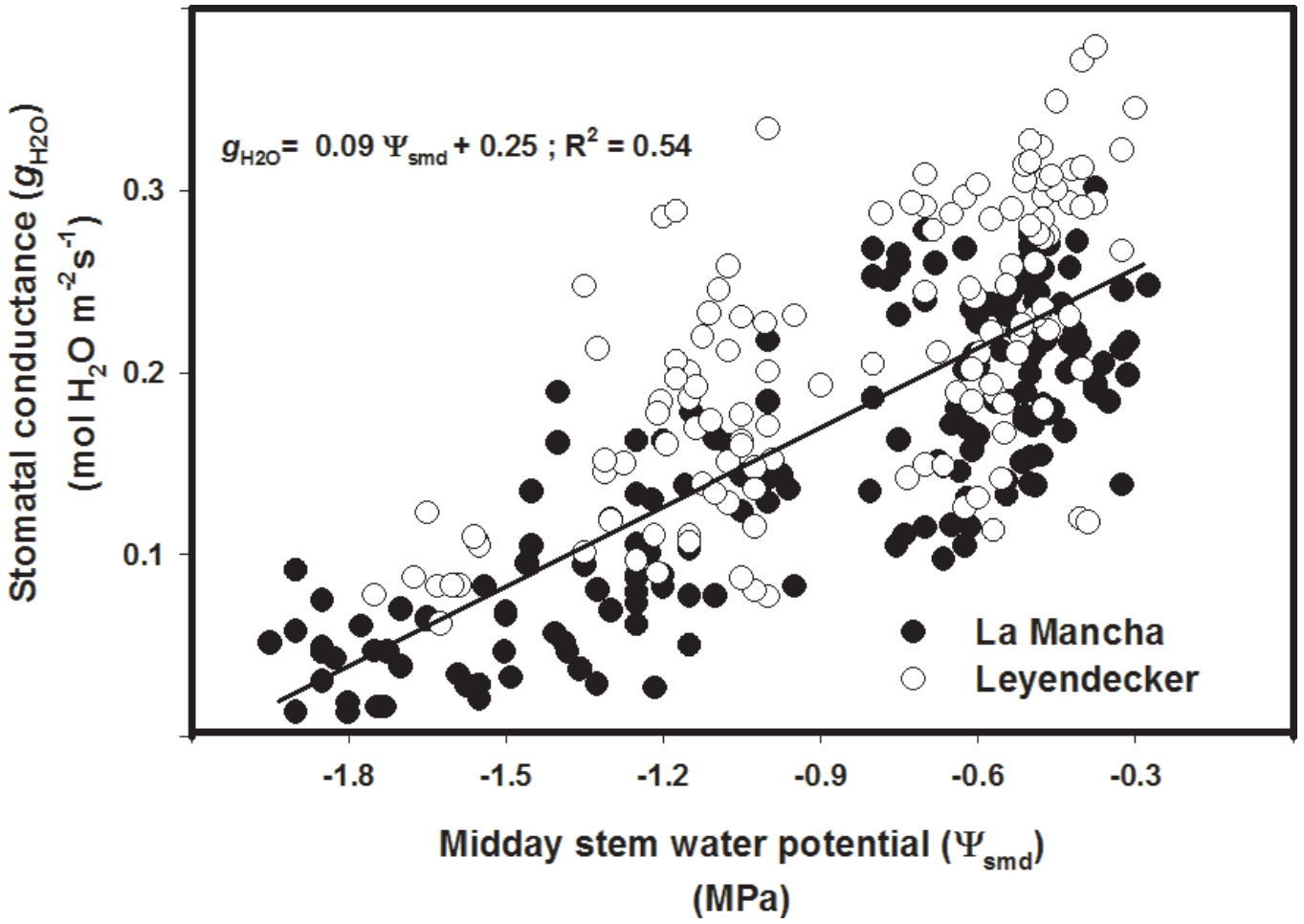


Screen leaf-level physiological variables

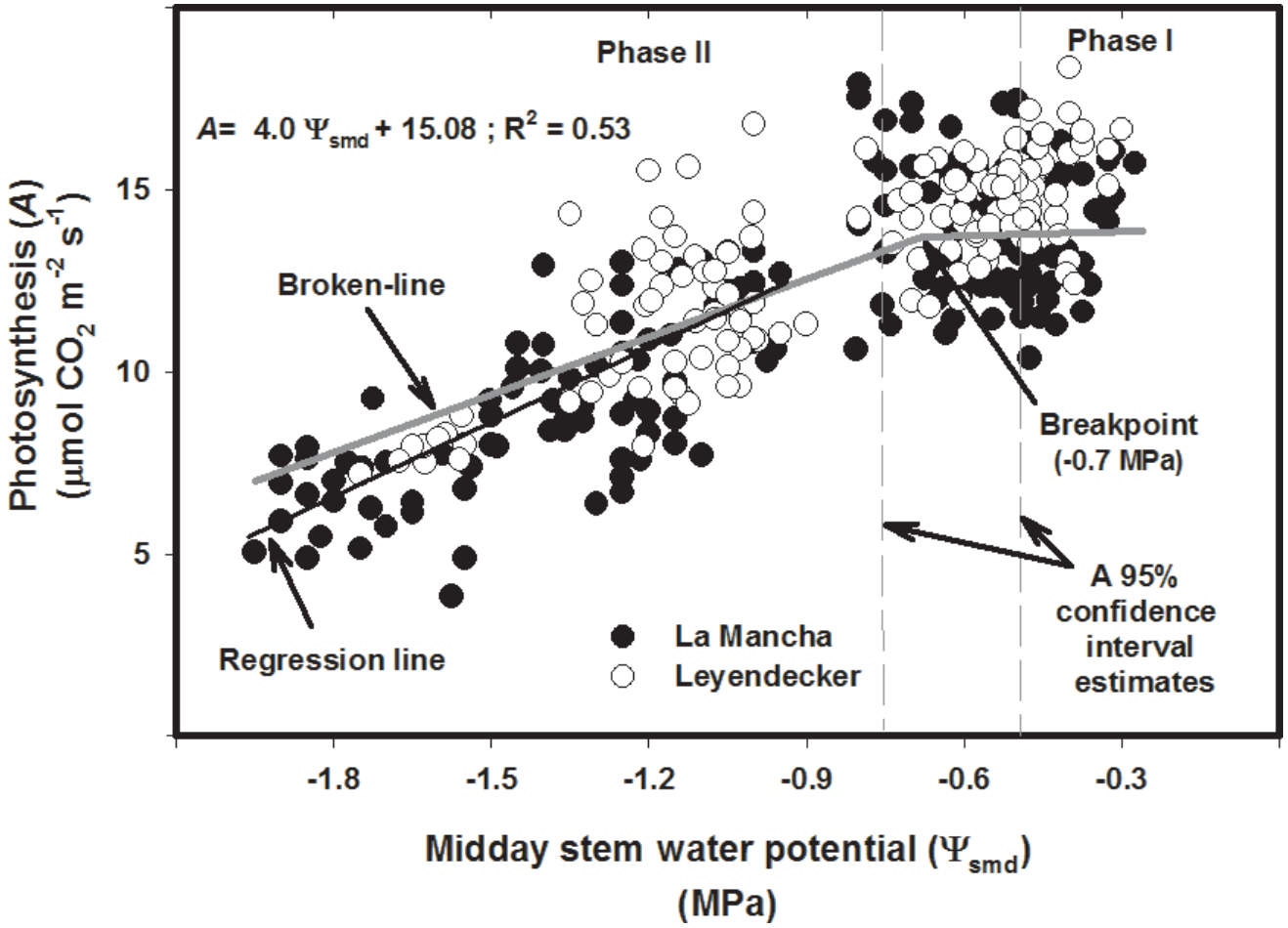


Boxplots of midday stem water potential (Ψ_{smd}) of two southern New Mexico pecan orchards subjected to cyclic flood irrigation (La Mancha and Leyendecker) during the 2011 growing season.

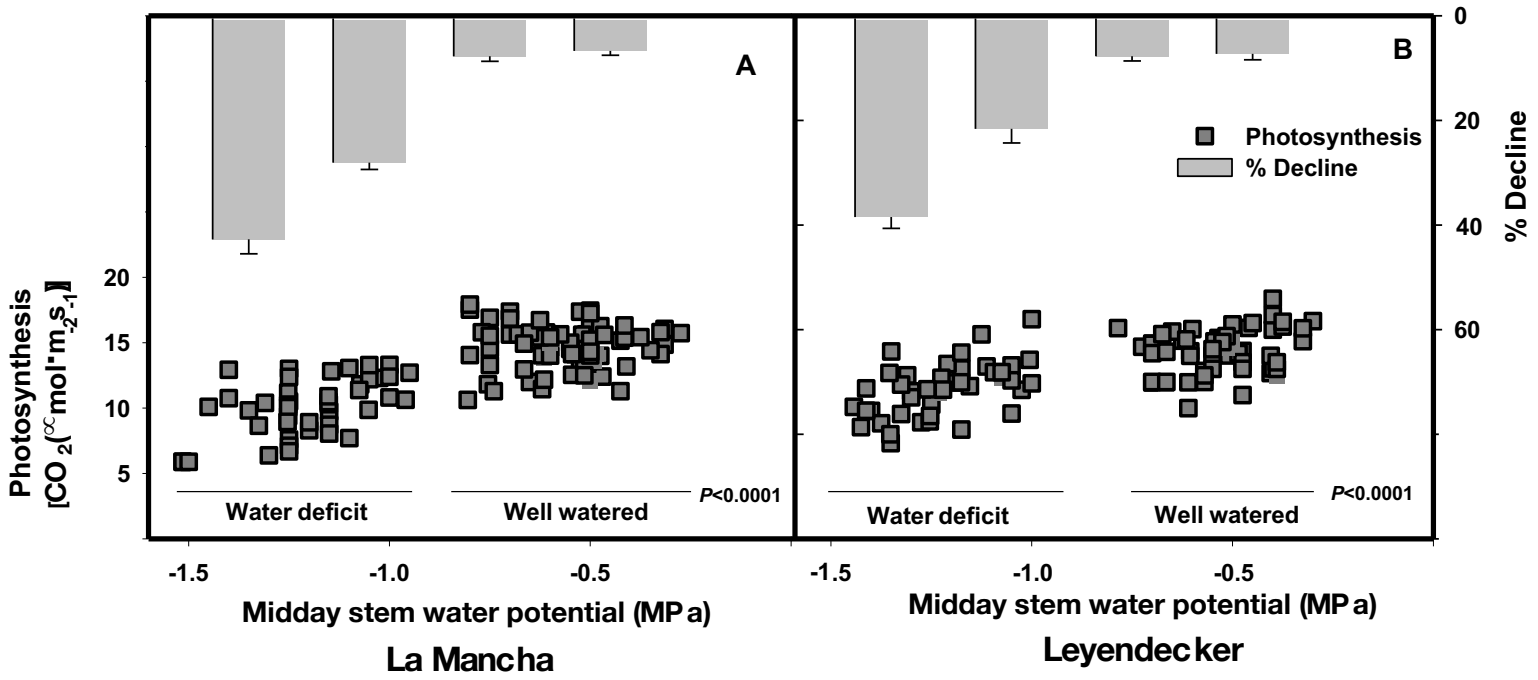
Relationship between stomatal conductance and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards.



Relationship between photosynthesis and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards. We used data set within the range -0.9 to -2.0 MPa to derive the mixed model equation.



Relationship between photosynthesis (decline) and midday stem water potential of trees at La Mancha and Leyendecker, southern New Mexico pecan orchards.



Conclusions

Midday stem water potential was the best performing leaf-level physiological response variable for detecting moisture status in pecans.

A marked decline in photosynthesis was noticed when midday stem water potential dropped below -0.9 MPa.

A 50% reduction in photosynthesis and gas exchange only occurred when midday stem water potential exceeded -1.5 MPa.

Data from a handheld spectroradiometer could be used to differentiate between well watered (Ψ_{smd} -0.4 to -0.85 MPa) and moderate water deficit (Ψ_{smd} -0.9 to -1.5 MPa) trees.

Recommendation

Maintain pecan orchards at midday stem water potentials that range between -0.80 to -0.90 MPa to prevent significant reductions in carbon assimilation and gas exchange.

Acknowledgements

Personnel

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