

Screened Success in the South: Feasibility of CUPS for Cold-Hardy Citrus in the North

Arnold Schumann, Laura Waldo & Laura Cano-Castro

UF/IFAS Citrus Research and Education Center

Lake Alfred

Cold Hardy Citrus Field Day

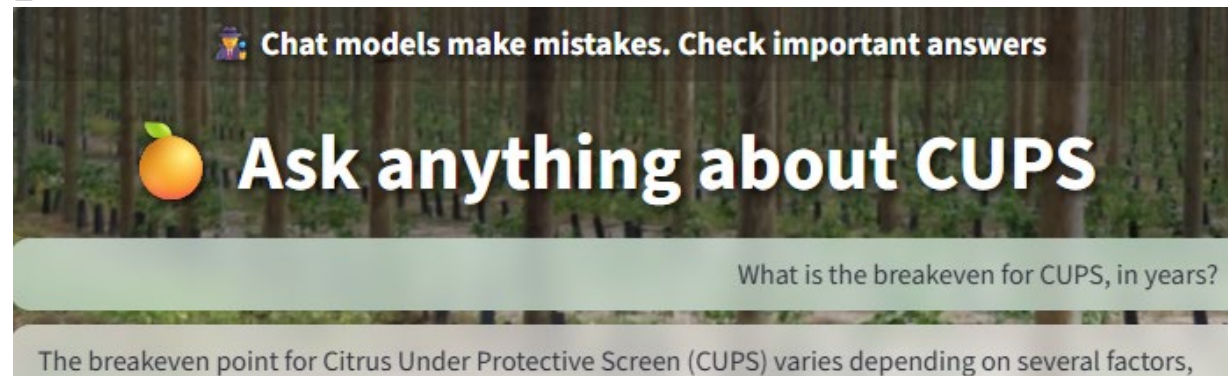
October 1, 2026

Take home messages: Citrus Under Protective Screen

- CUPS successfully excludes ACP and HLB from trees for >10 years
- The grapefruit production in CUPS is extremely early (3y) and high, attributable in part to the unique microclimate of CUPS screen houses
- CUPS screen uses fiber-optic technology to boost light distribution in tree canopies and improve photosynthetic efficiencies
- CUPS offers multiple benefits for cold-hardy citrus production
- To answer additional questions about CUPS, use the **CUPSchat** chatbot



CUPS seminar
08/07/2025



CUPSchat

CUPS is a high-potential protected-agriculture system

Fully enclosed screen houses with high-density HDPE 40-50 mesh screen; ~14 feet high



Commercial CUPS: June 2025; age 7 years; >800 boxes/acre/yr

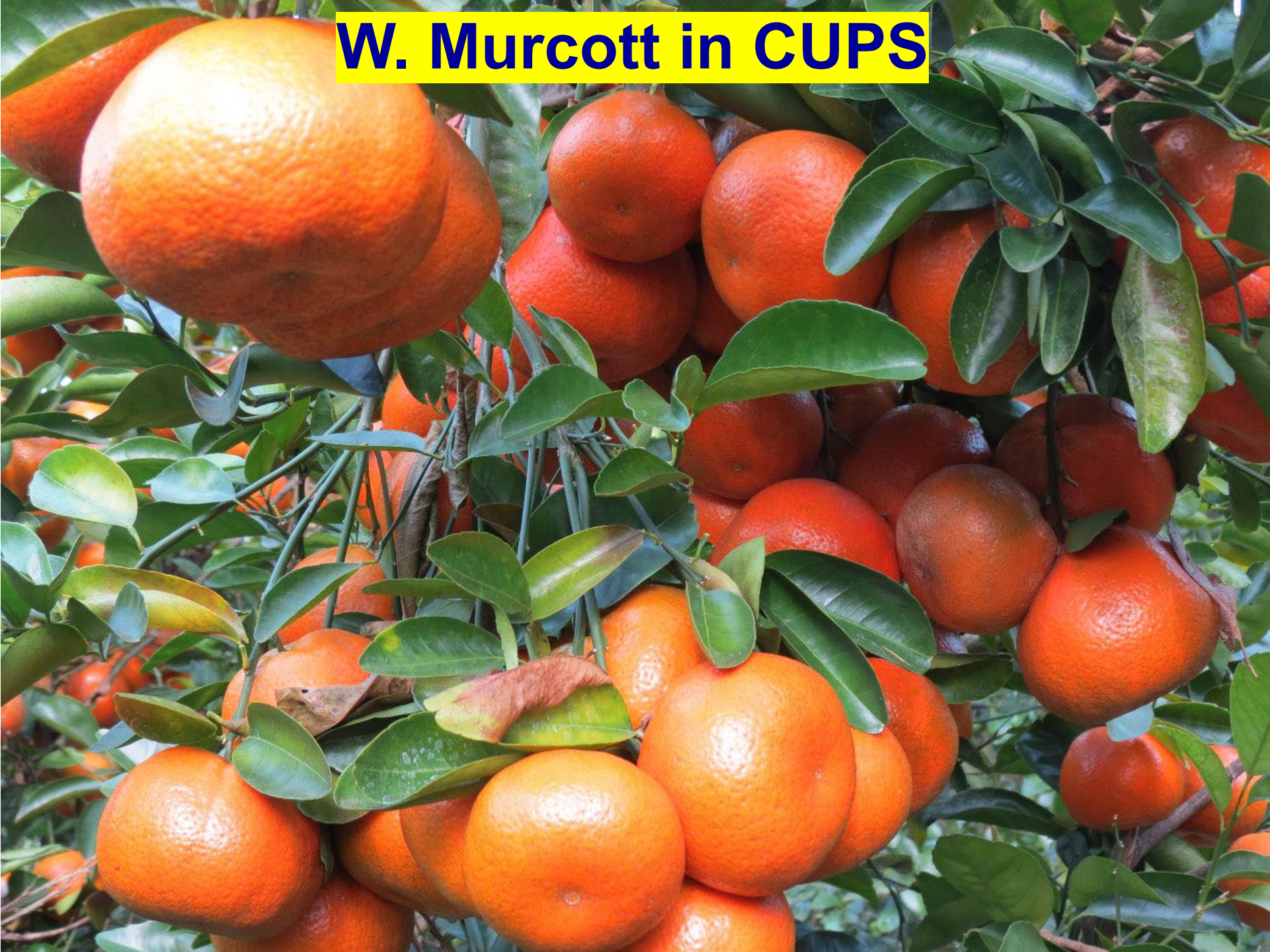




CUPS grapefruit trees:

- ✓ Grow ~2x faster than outside
- ✓ Year 3 production ~300-400 boxes/acre
- ✓ Year 5+ production ~800 boxes/acre
- ✓ Excellent fruit size and quality
- ✓ >90% pack-out
- ✓ Annual net fruit revenue ~\$20,000/acre
- ✓ Economic break-even in 7 to 10 years

W. Murcott in CUPS



Dancy in CUPS



What contributes to
the high fruit
production in CUPS?

How does the unique
microclimate in CUPS
affect tree growth and
fruit production?

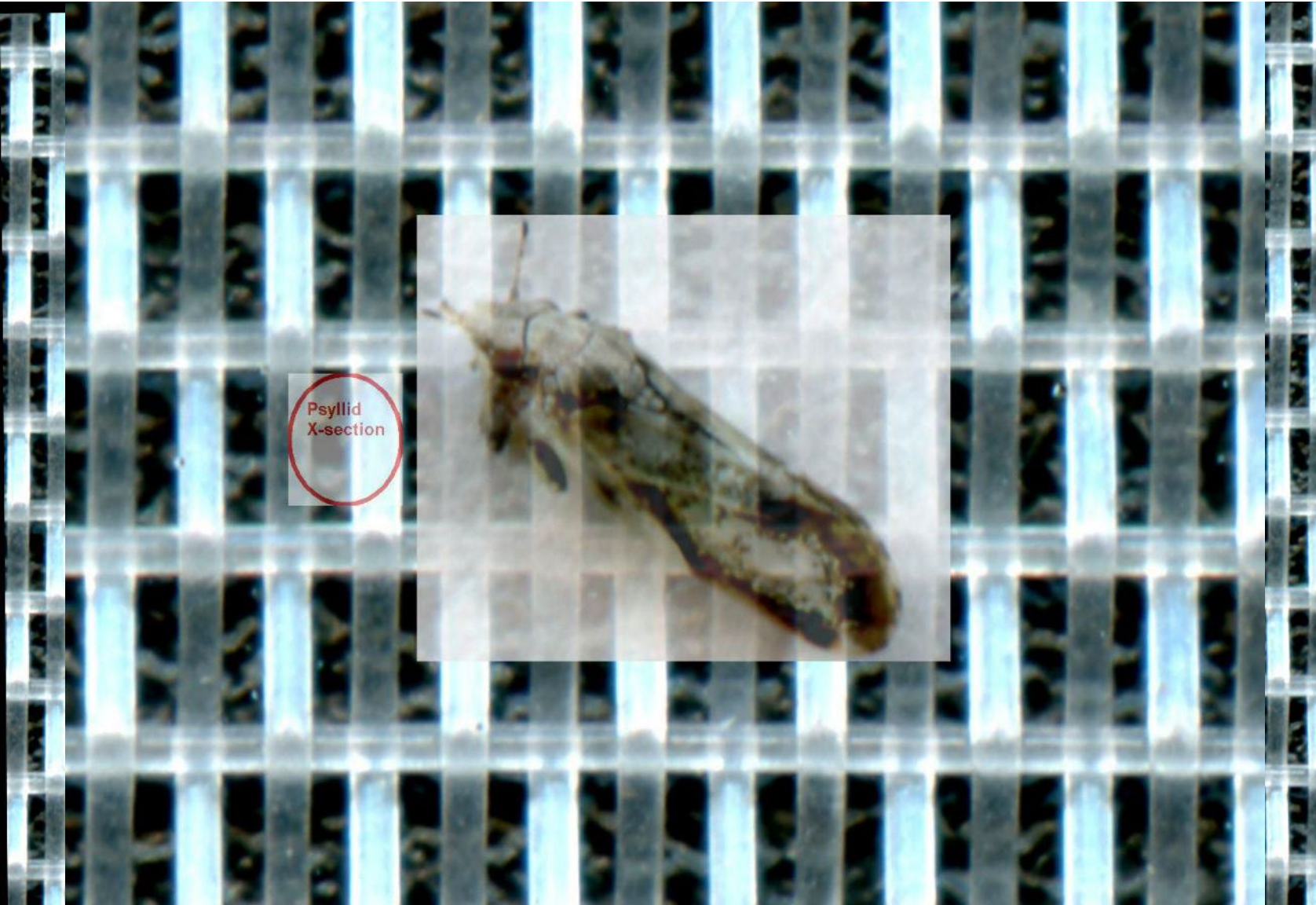


The CUPS microclimate is determined
by the screen house enclosure used to exclude
Asian citrus psyllids

The sunlight in CUPS is strongly modified by the screen



CUPS screen is woven with high-density polyethylene (HDPE); 50-mesh:



Hole size: 0.78 x 0.26 mm

Monofilament: 0.28 mm diameter

Wind speed is 75% lower in the CUPS than outside

ET in the CUPS is 25% lower than outside

CUPS creates a warmer micro-climate during the day (a few degrees above ambient) while maintaining outside-like temperatures at night, with only negligible differences

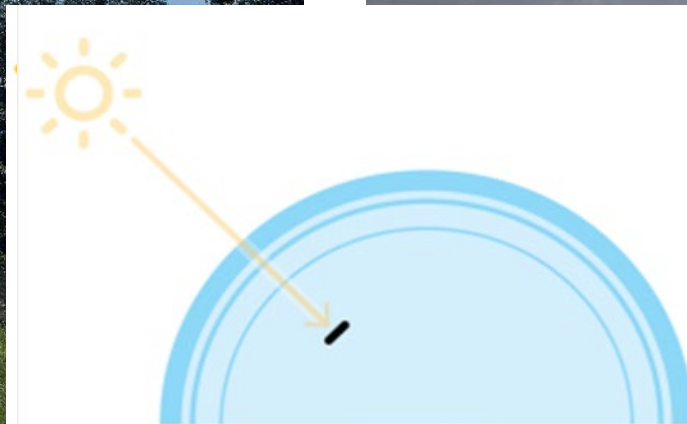
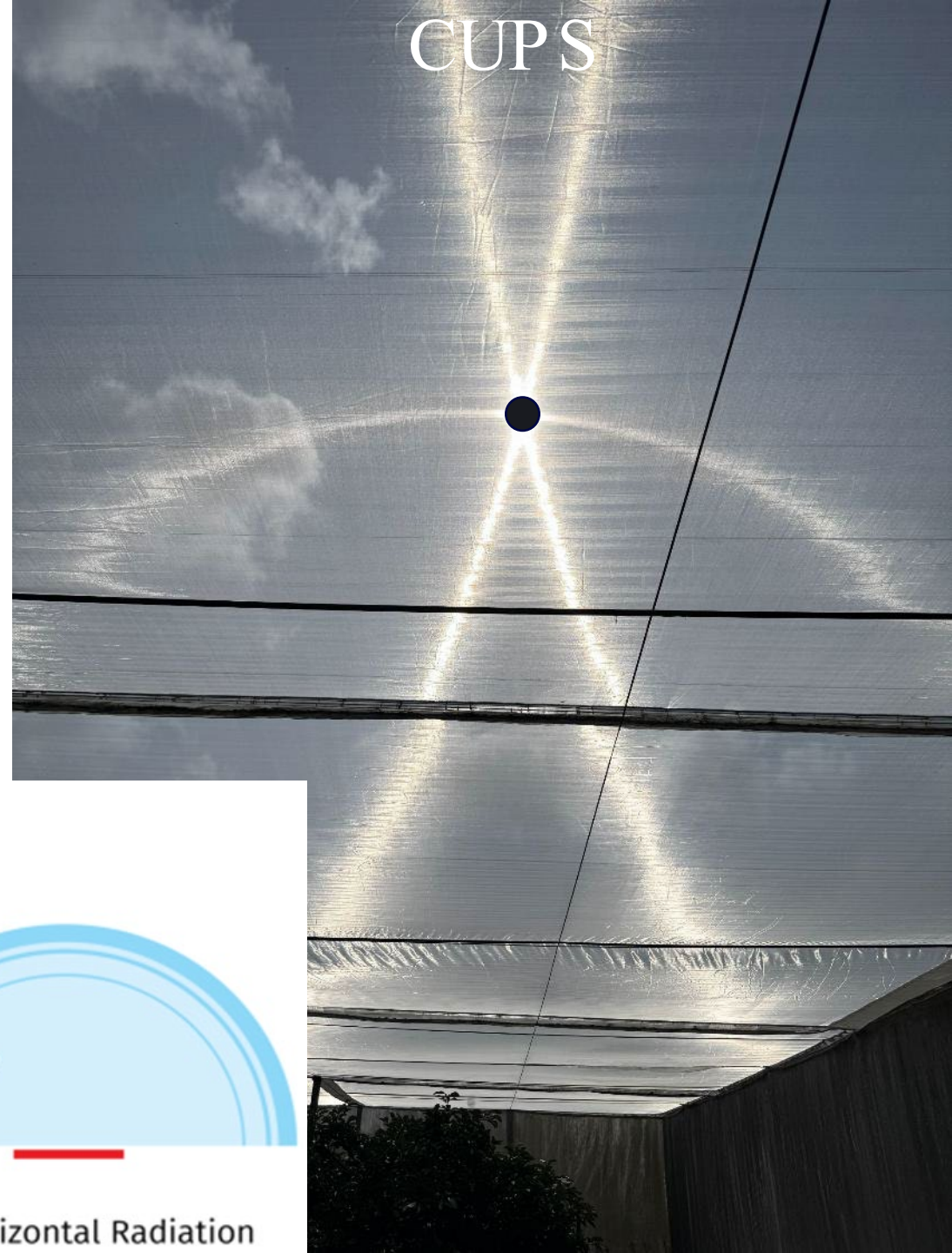
Even though nighttime minimum temperatures are essentially the same as outdoors, the dew-point inside CUPS is usually a few °F higher, which helps reduce evaporative cooling during cold events

Diffuse
sunlight

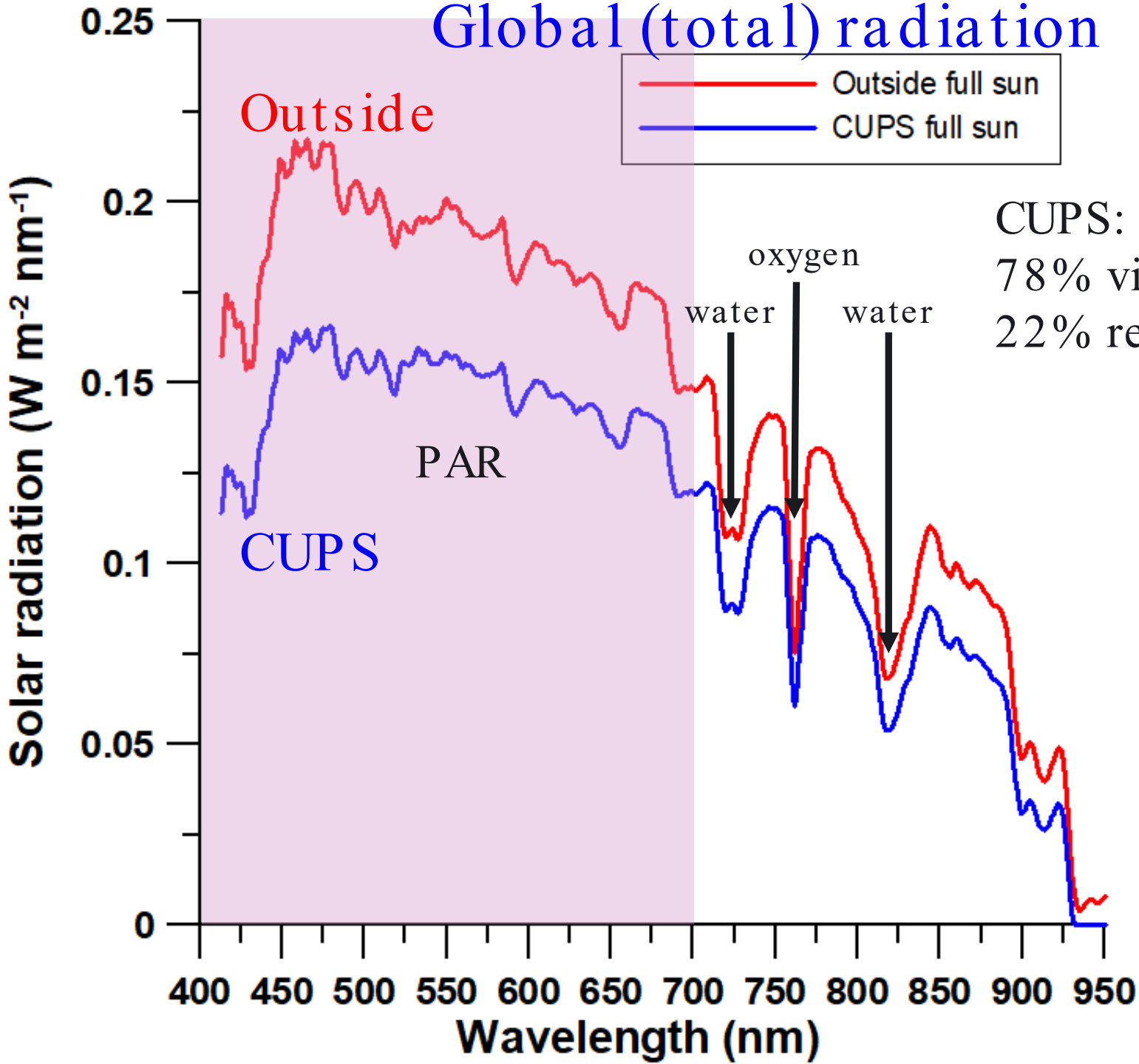
Outside



CUPS



Diffuse Horizontal Radiation



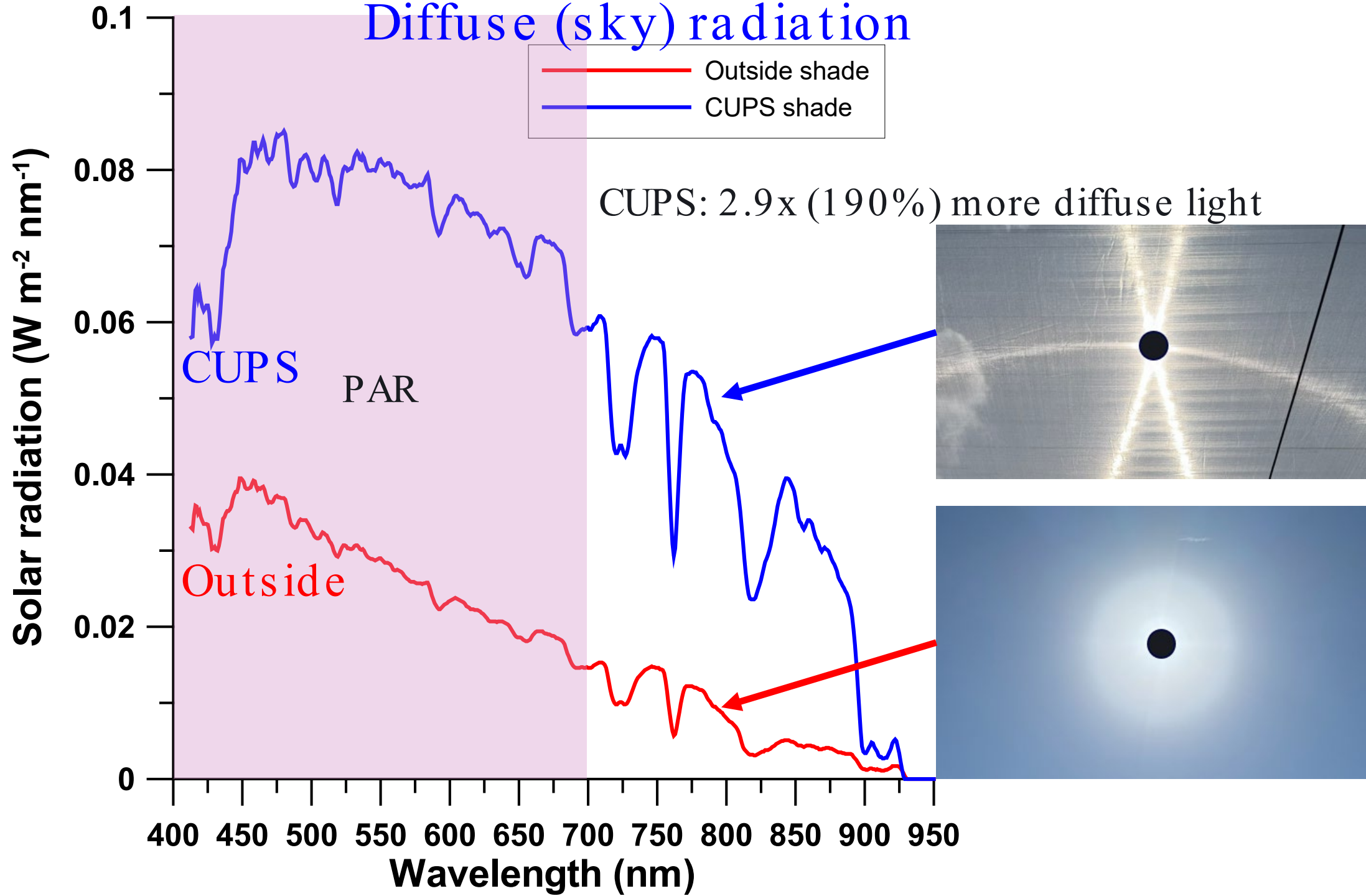
CUPS:

78% visible light transmission

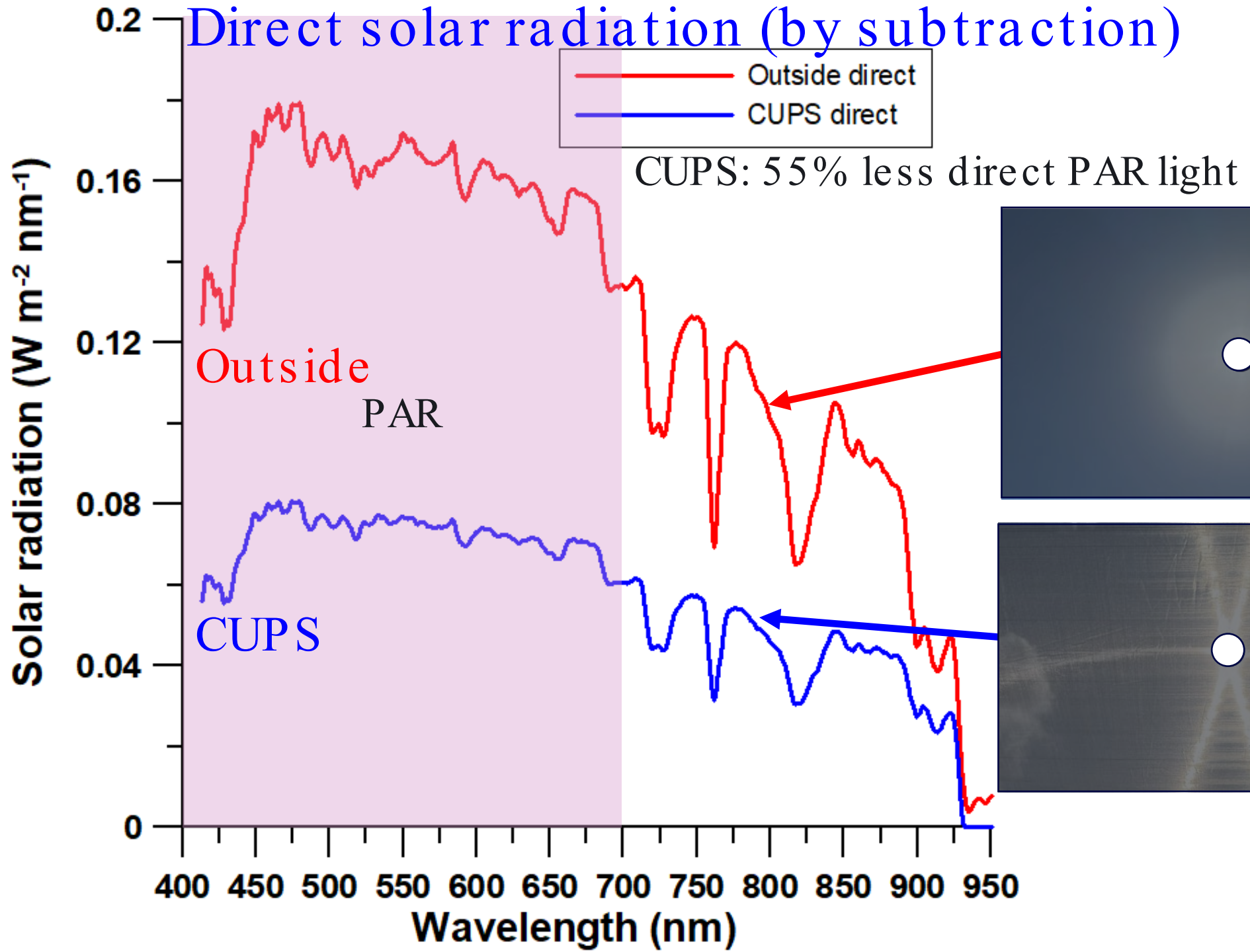
22% reduction in total PAR

Integrating the solar radiation curve for the following spectral regions showed that the CUPS screen is acting as a neutral attenuator and diffuser, rather than a color band filter

Band	Wavelength range
Blue+violet	412–500 nm
Green+yellow	500–600 nm
Red	600–700 nm
PAR range	412–700 nm
Far-red	700–800 nm
Near-infrared	800–950 nm

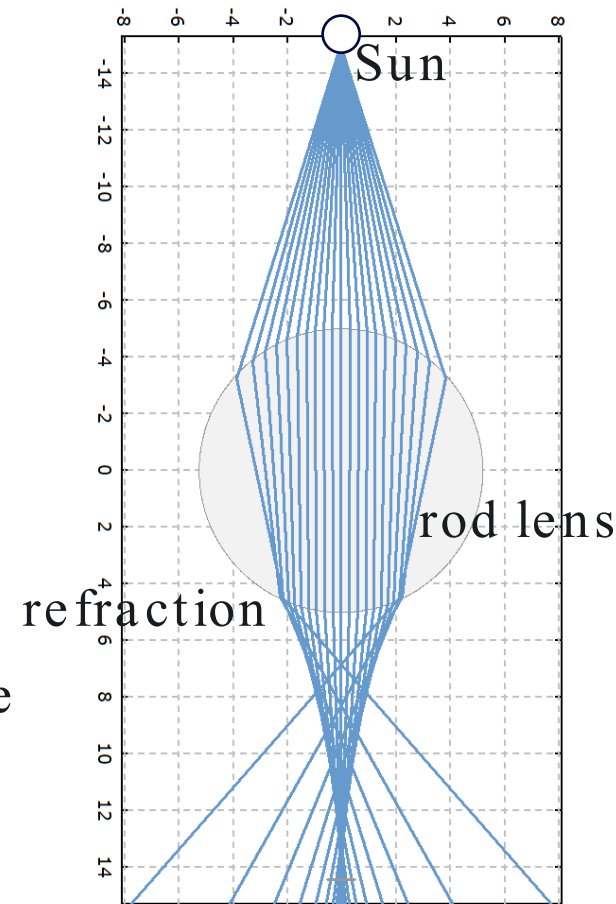


Direct solar radiation (by subtraction)



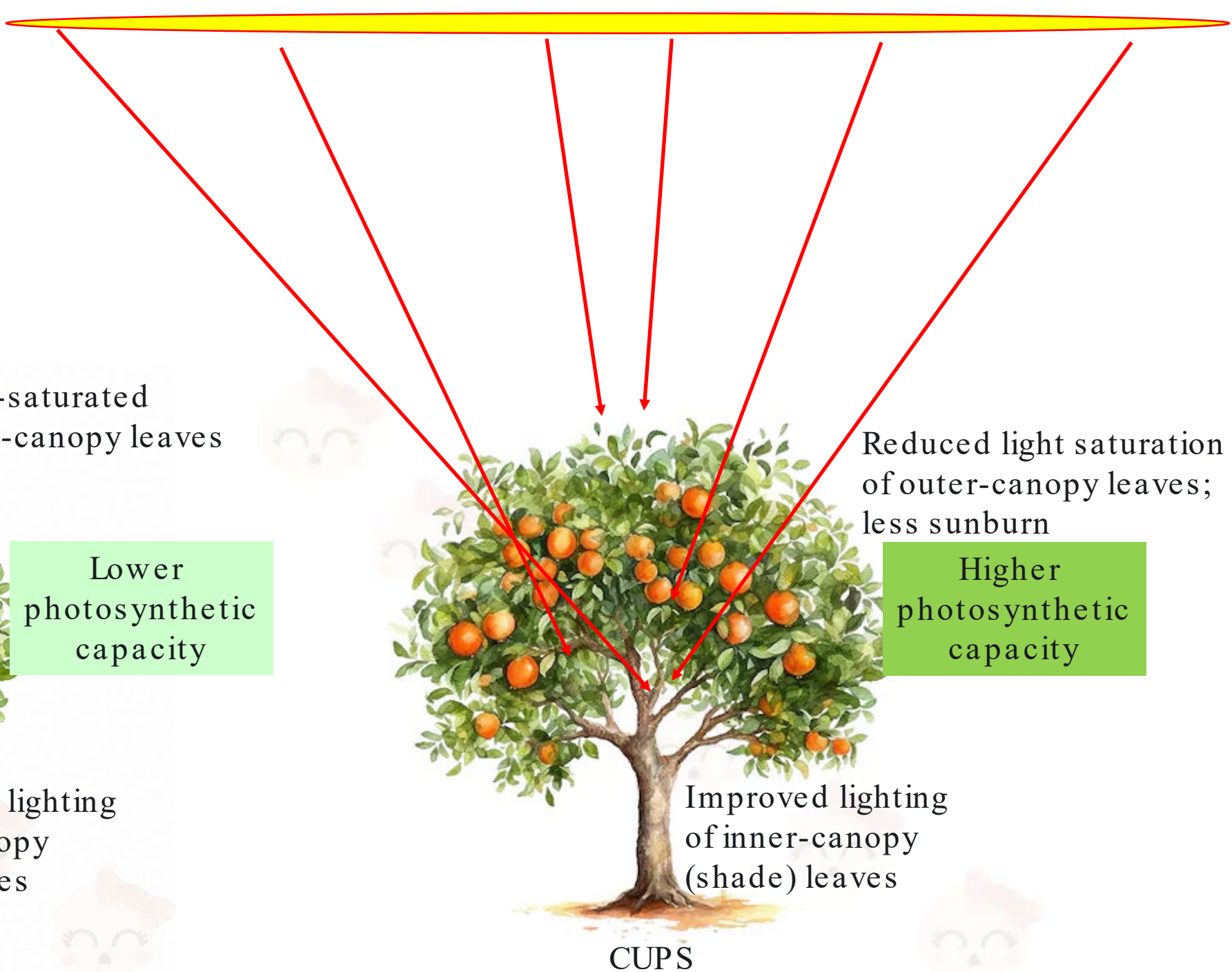
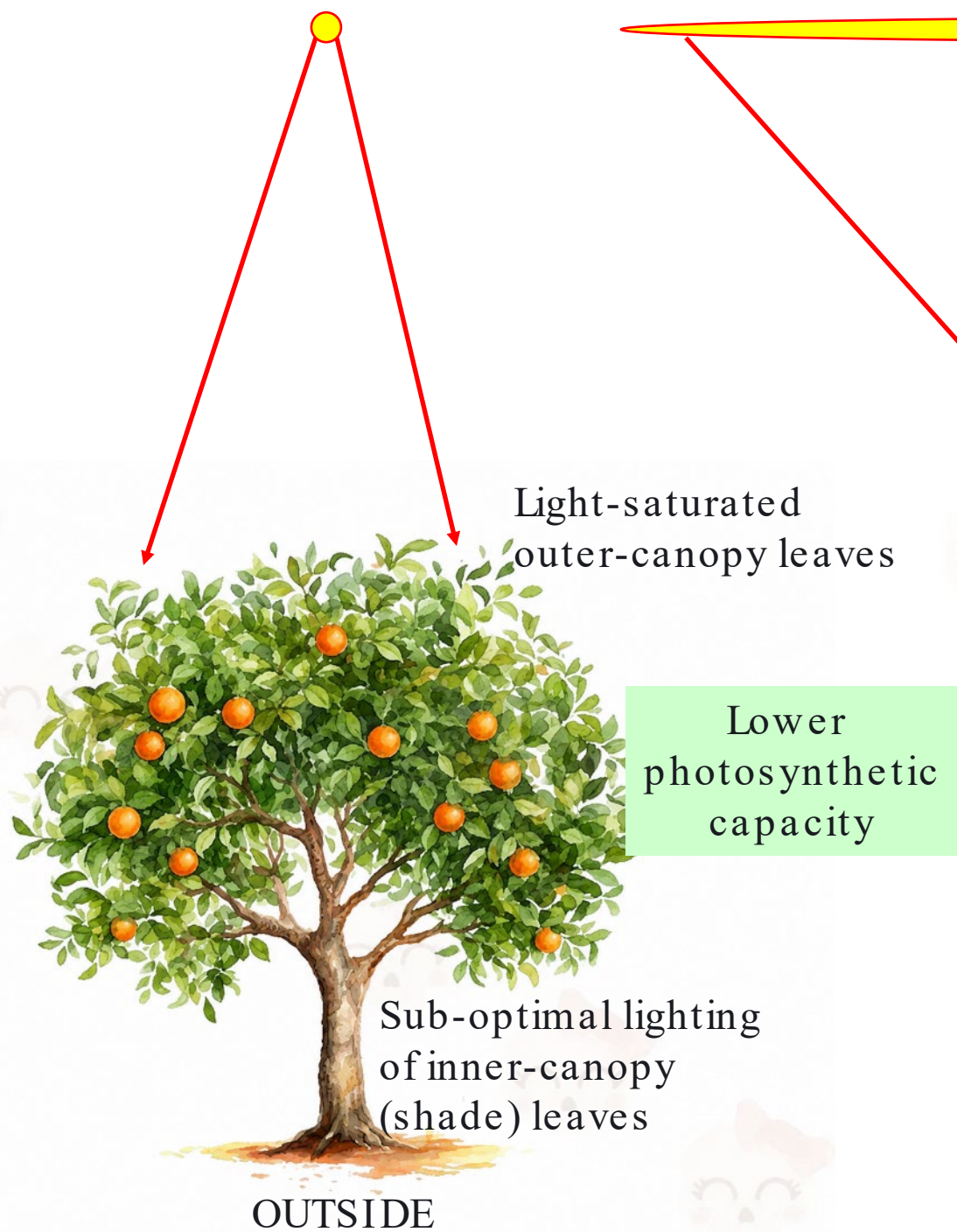
The optical physics of light in the CUPS microclimate

- The dominant physical mechanism converting the 0.53° solar disc into a wide-angle illumination field is refraction
- Each translucent HDPE thread acts like a cylindrical rod lens in air
- When illuminated by a narrow parallel solar beam, it diverges the light into a broad angular emission pattern below the screen
- The result is that the screen roof of the CUPS essentially becomes a light-diffusing panel delivering soft, near-uniform illumination to the citrus canopy below, regardless of the sun's position



Net Lighting Effect: Narrow Disc to Wide-Angle Source

Feature	Solar disc outside	Solar disc through 50-mesh
Angular diameter	0.53°	Effectively tens of degrees
Source type	Collimated, directional	Diffuse, hemispheric
Shadow sharpness	Hard, defined	Soft to absent
Canopy penetration	Sunfleck-dominated	Uniform diffuse; effective



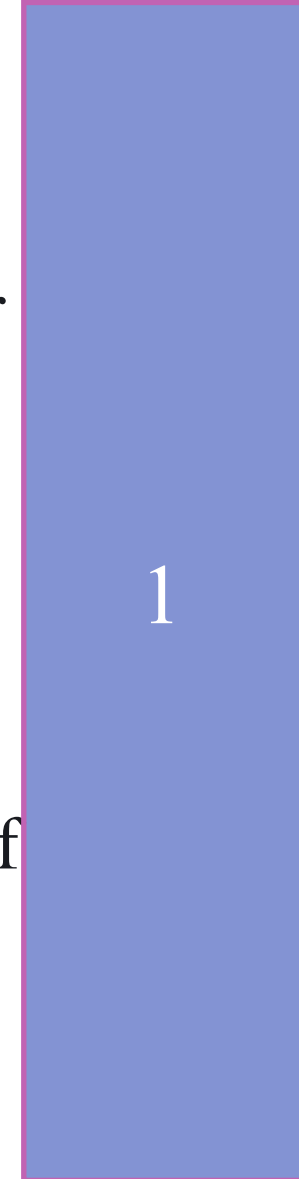
CUPS grapefruit yields are 4-5x higher than outside:

- ✓ Unaffected by HLB
- ✓ Optimal nutrition
- ✓ Lower ET stress
- ✓ Less sunburn (direct light)
- ✓ More efficient photosynthesis
- ✓ Higher TSS (Brix)
- ✓ Lower TA → better flavor
- ✓ Higher planting densities
- ✓ No fruit/tree losses from storms
- ✓ Efficient freeze protection

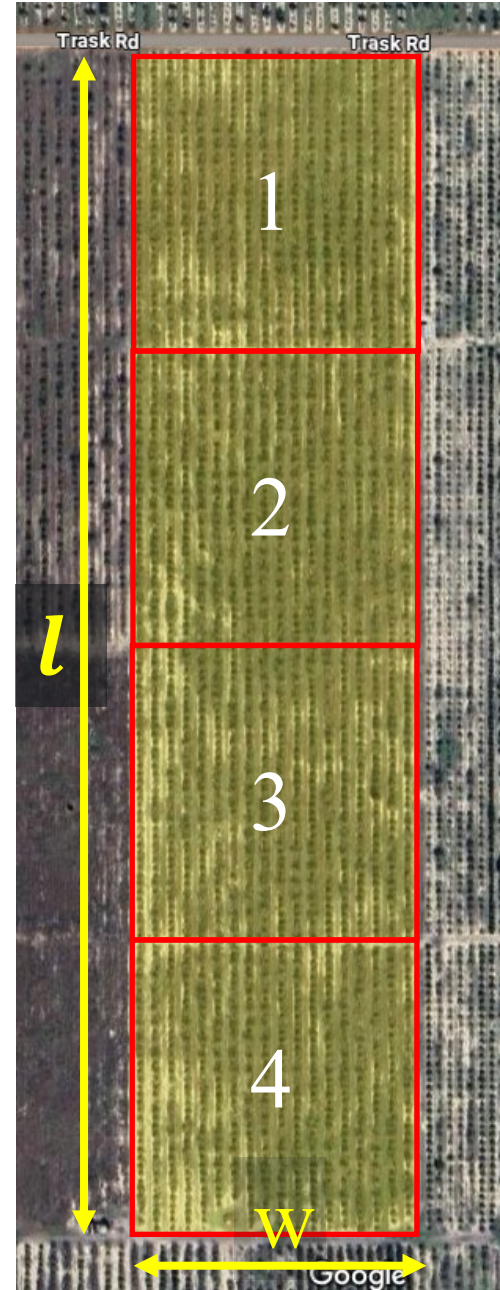


Tips for designing CUPS structures

- Existing citrus block: 2,607' x 634' ~38 acres
- 4.1 : 1 ratio of length : width
- Is it better to build one large elongated CUPS or four smaller square CUPS structures?
- As the size of the CUPS increases, the construction cost per acre decreases because the perimeter increases at a slower rate than the area
- As the length : width ratio increases, the cost of constructions increases. A square (1:1) is the shape with lowest cost

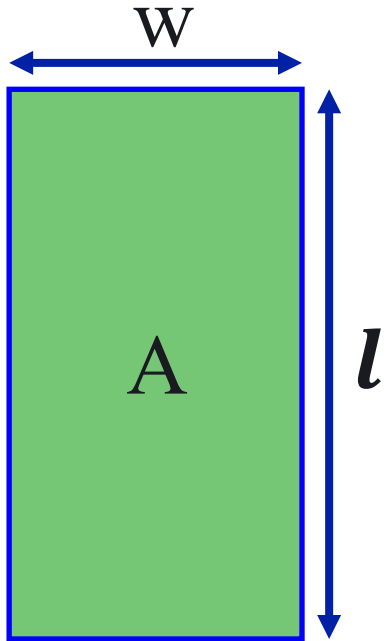


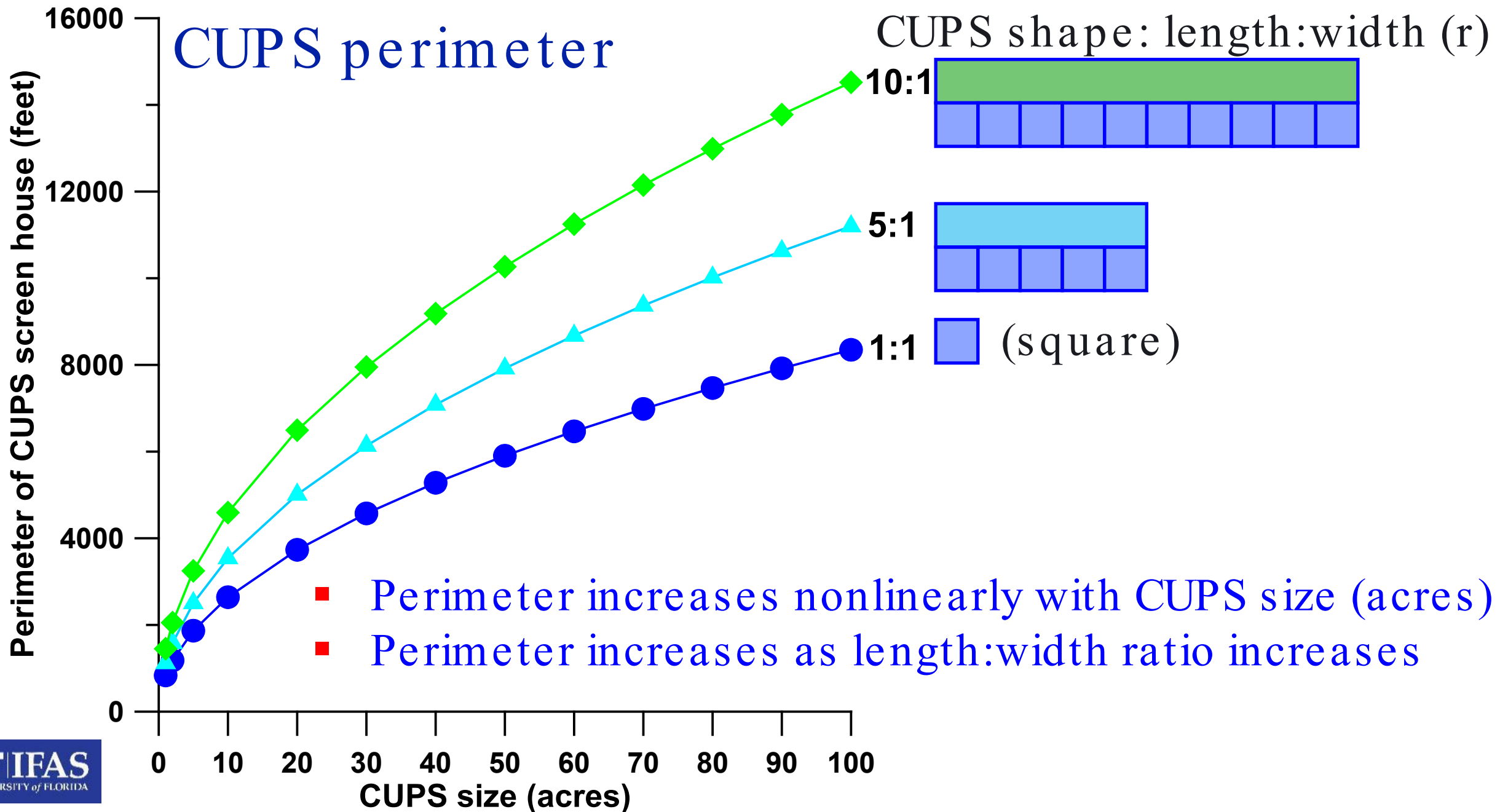
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CUPS perimeter & area

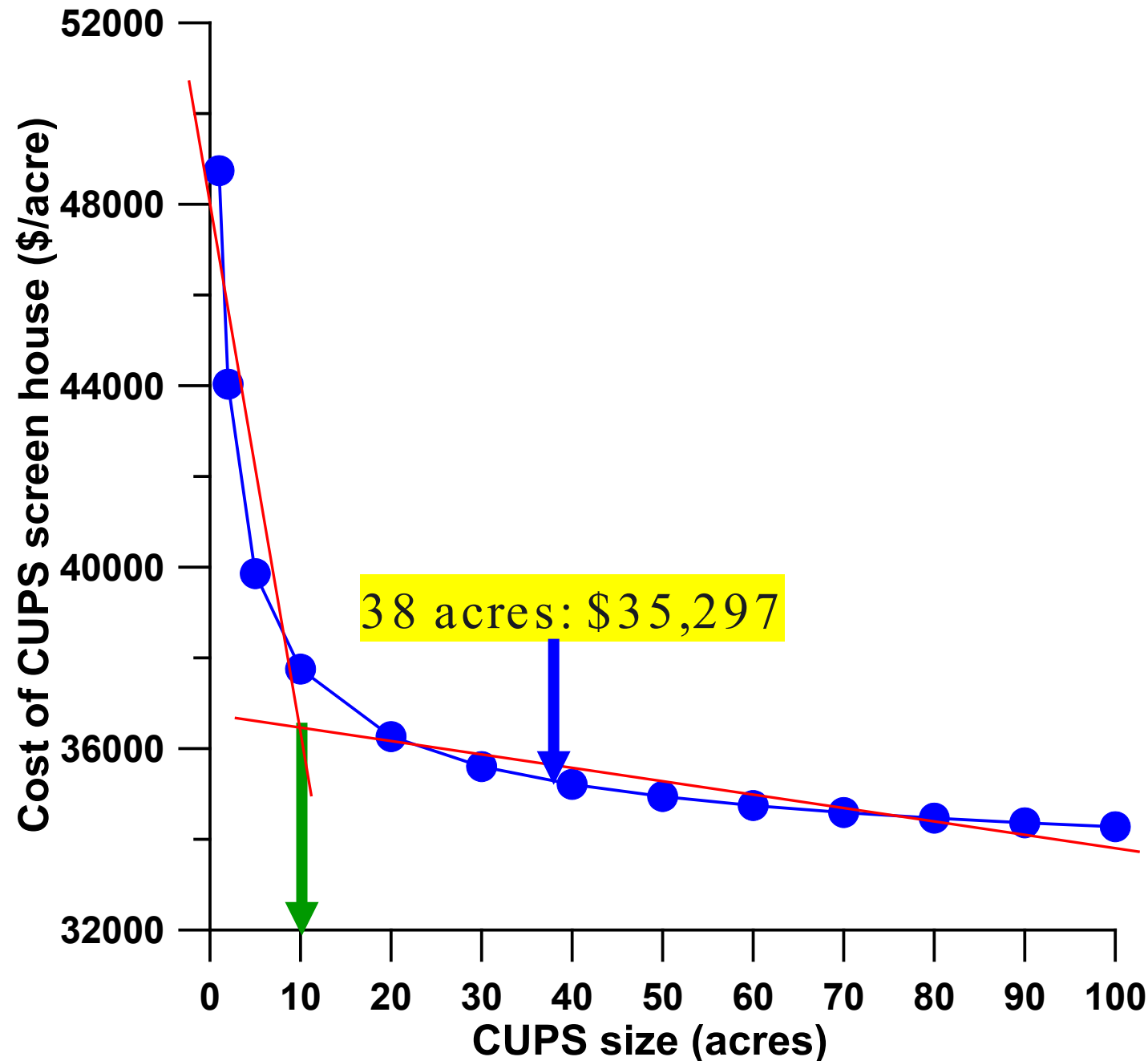
- Perimeter (P) = $2l + 2w$
- Area (A) = $l \times w$
- Shape ratio (r) = $\frac{l}{w}$





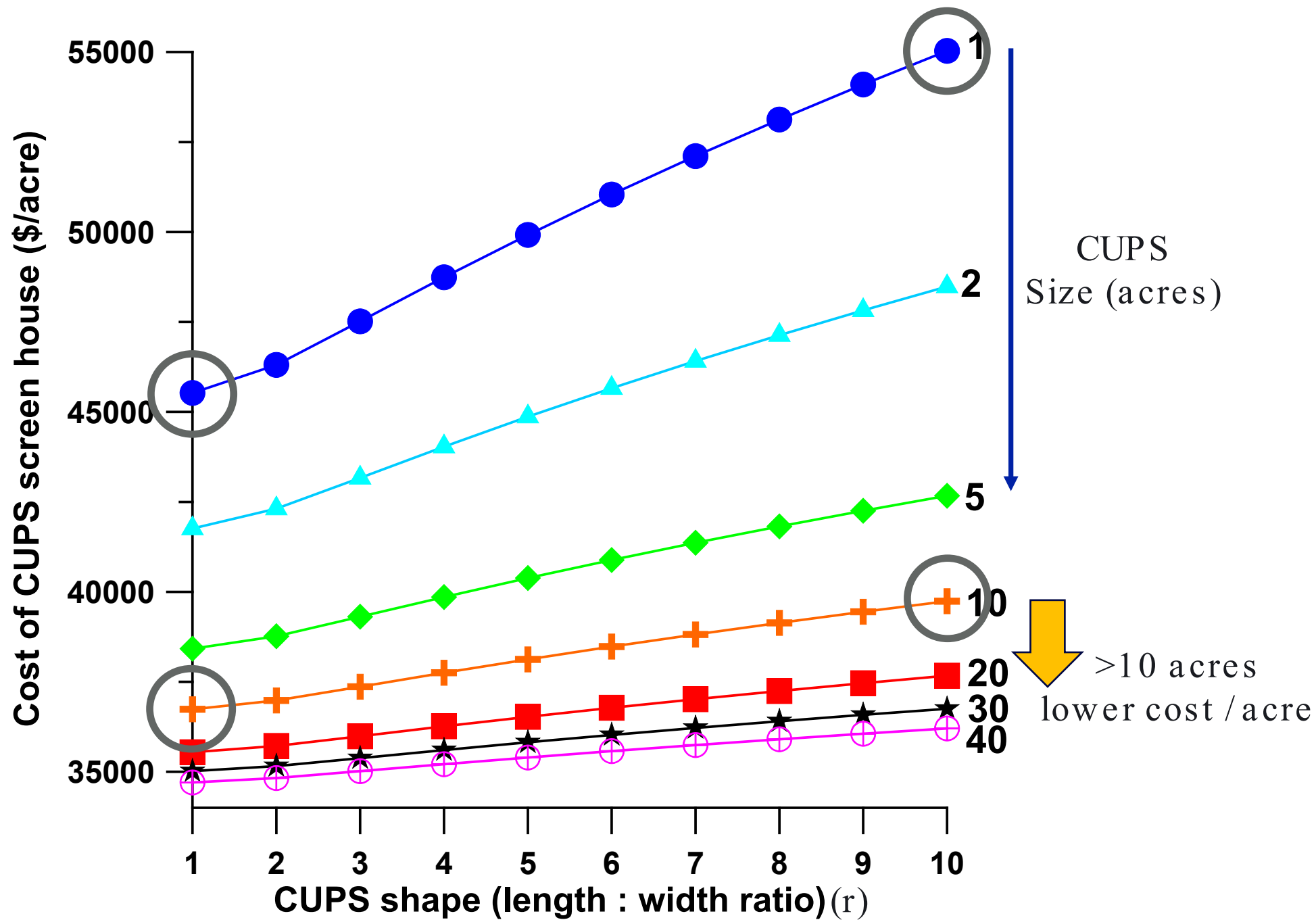
CUPS cost calculation

- Existing citrus block: 2,607' x 634' ~38 acres; 4.1 : 1 ratio
- Roof cost per acre is constant: $\$0.75/\text{sq. ft.} \times 43,560 \text{ sq. ft.} = \$32,670$
- Wall cost per acre: $\$1.1/\text{sq. ft.} \times \text{perimeter (6,482 ft)} \times \text{wall height (14 ft)} / 38 \text{ acres} = \$2,627$
- Total cost per acre = roof cost + wall cost = \$35,297
- CUPS size >10 acres best



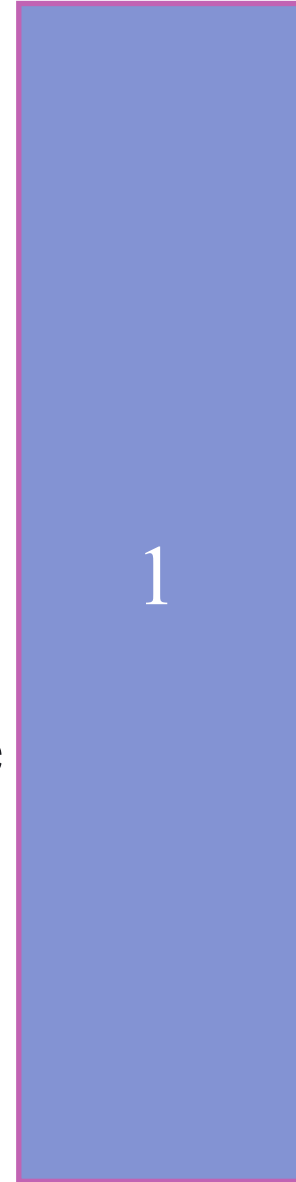
CUPS cost/acre for shape & size

- 1:10 shape:
10 acres = 28%
lower cost than
1 acre
- 1:1 shape:
10 acres = 19%
lower cost than
1 acre

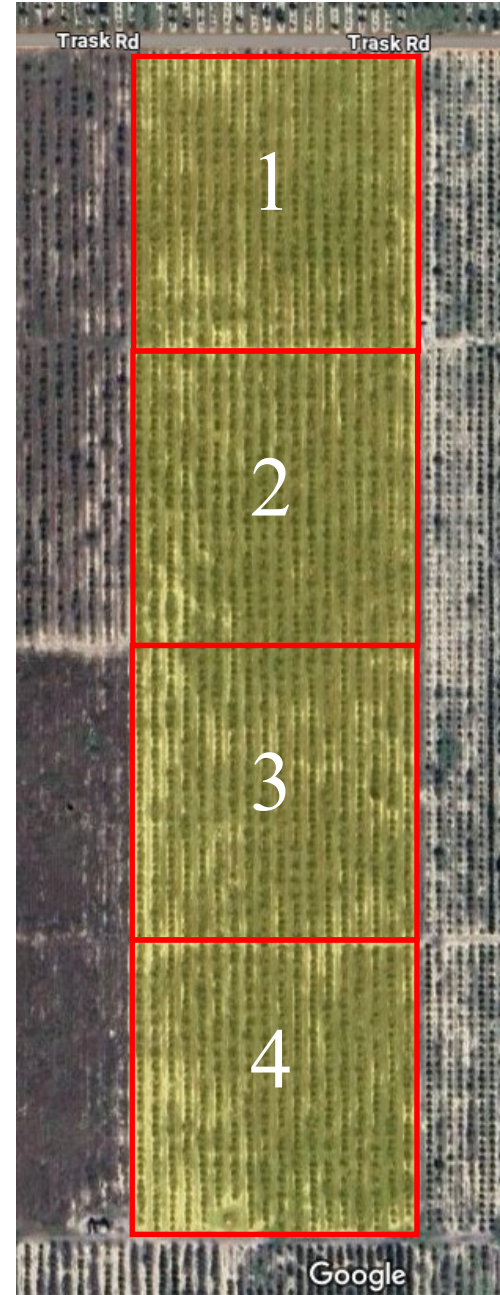


A single large CUPS or 4 smaller CUPS?

- Existing citrus block: 2,607' x 634' ~38 acres
- Single CUPS of 38 acres = \$35,297/acre
- Four CUPS of 9.5 acres each = \$36,841/acre
- The four square CUPS cost 4.2% more (+\$58,672) than the single large 38-acre CUPS
- Cost estimates don't include additional doors, buffers between structures, accessories
- There are cost – benefit factors to consider. The more expensive four individual CUPS can be better managed for pests and diseases, storm damage can be isolated, pest invasions quarantined, and cross-pollination prevented



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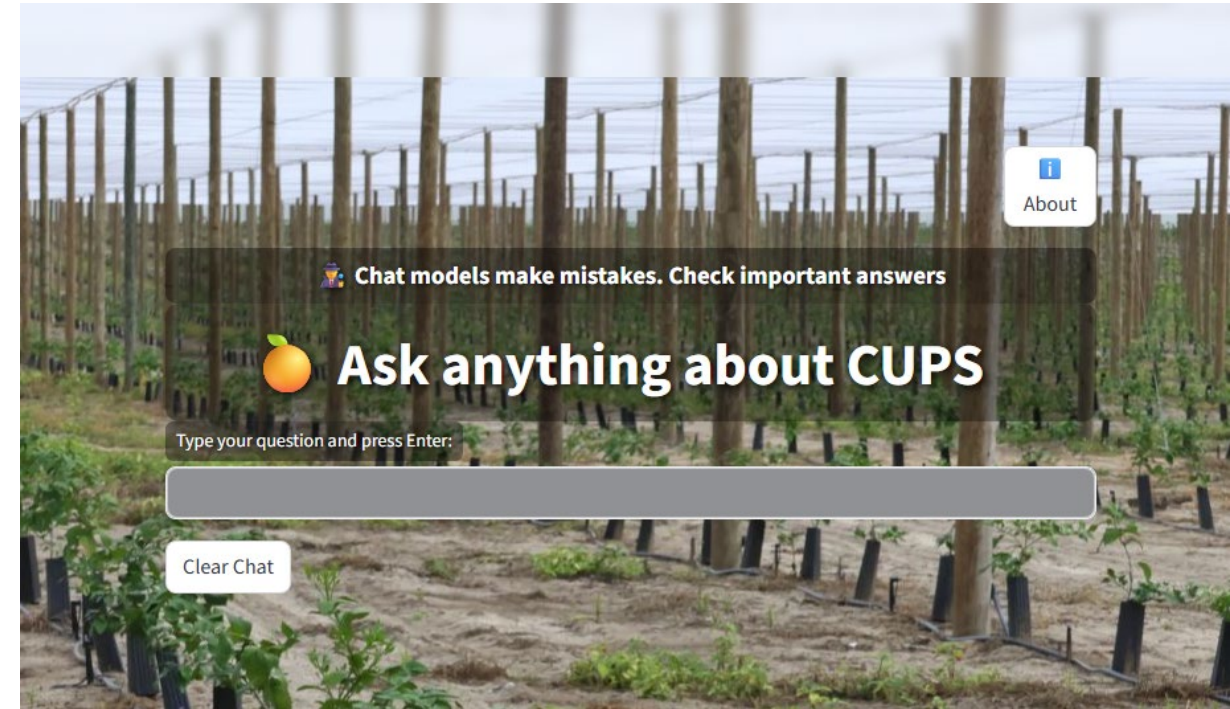
CUPSchat: a modern artificial intelligence tool for extension

<https://citrusdiagnosis.ifas.ufl.edu/CUPSchat/>



What is CUPSchat?

- Pools 12 years of knowledge about CUPS from >100 documents (2026)
- Can be continuously updated with new information
- Collates and interpolates information, including data collected over time in different documents
- Use with discretion – like any chatbot



CUPSchat answers

- PROMPT: What is the breakeven for CUPS, in years. Be concise but show sources of information
- Answer: The breakeven point for Citrus Under Protective Screen (CUPS) is **around 7-8 years**. This is based on various studies and reports, including...

Including... A study by Arnold Schumann, a professor at the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS), found that the breakeven point for CUPS is around 7-8 years, with an initial investment cost of around \$43,000 per acre. CUPS Expensive but Beneficial - CUPS Specialty Crop Grower.pdf

. Another report by the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) estimated that the breakeven point for CUPS is around 7 years, with an initial investment cost of around \$1 per square foot (\$43,560 per acre).

Return-on-Investment Potential of CUPS - Citrus Industry Magazine.pdf

. A report by the Irrigation Association (IA) noted that the breakeven point for CUPS is around 7-10 years, depending on factors such as tree density, variety, and market prices.

CUPS works to protect citrus trees - Irrigation Today.pdf

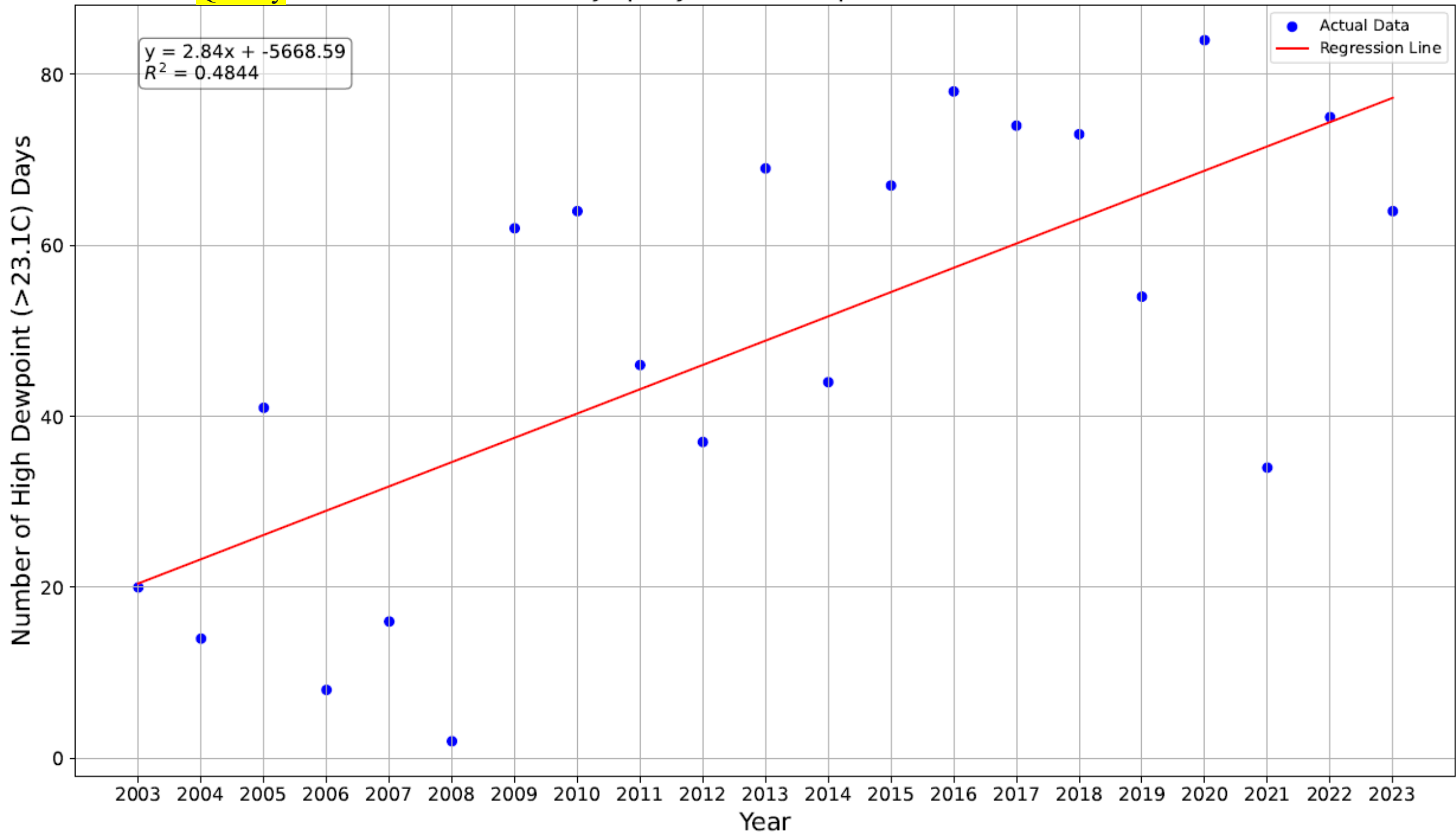
. Overall, the breakeven point for CUPS is generally estimated to be around 7-10 years, depending on various factors such as initial investment costs, tree yields, and market prices.

Is CUPS feasible for North FL / South Ga?

- In the South, CUPS was designed specifically to exclude ACP and HLB; this proven design should achieve the same result in the North
- Enhanced light distribution in CUPS is the most likely microclimate factor improving citrus growth and production and should also benefit CUPS in the North; excess direct light is diminished, and beneficial diffuse light is increased
- Winter protection is built-in: the screen's micro-climate reduces freeze damage, a crucial advantage for North FL growers with susceptible varieties
- The screen raises daytime temps $\approx 6^{\circ}\text{C}$ and night-time temps stay at ambient, preserving chill-hours needed for bud break (good for cold-hardy varieties)

Quincy

Number of days per year the dewpoint exceeded 23.1C



Concerns about CUPS for North Fl / South Ga

- Initial capital is high >\$30,000 /acre likely, but changing {tariffs}
- Winter snow & ice accumulation is likely on 50-mesh screen roof
- The warmer daytime microclimate in CUPS may be detrimental to traditional cold-adapted varieties like Satsuma (granulation?)
- Secondary pests (mites, leafminer, thrips) can infiltrate CUPS screen
- Damage to CUPS from frequent powerful hurricanes
- If Satsuma and other N Florida varieties are not HLB-affected, then the growth and yield advantage of CUPS citrus over outside citrus will be diminished - and may not be the most profitable option
- Suggest a phased approach—pilot 1-2 acres, collect data, then expand to ~10 acres—allows risk mitigation while capitalizing on early revenue streams

Conclusions

- CUPS grapefruit growth and production is remarkably higher than outside
- Typical mature yields exceed 800 boxes/acre with just 160-180 lb N/acre (4.5 – 5.0 boxes /lb N)
- Enhanced light distribution in CUPS is the most likely microclimate factor improving grapefruit growth and production (whole-canopy photosynthetic efficiency)
- Excess direct light is diminished, and beneficial diffuse light is increased
- Plan to plant at higher densities (~360 trees/acre) on dwarfing rootstocks like US897 to exploit the full potential of improved sunlight utilization
- **CUPSchat** is a CUPS-specific AI tool that can help growers, extension agents and researchers obtain instant answers and reports from 12 years of CUPS knowledge



THANK YOU

Grower stakeholders & cooperators

UF/IFAS Extension Agents

Laboratory and Support Staff

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UF/IFAS Citrus Initiative

USDA/ECDRE

Contact: schumaw@ufl.edu



CUPS seminar
08/07/2025

CUPSchat



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