This presentation premiered at WaterSmart Innovations

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Assessing Tree to Grass Water Use Ratios

Tamara Wynne

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UNLV

History

- 20 years ago, a study was done with potted young trees and separate grass plots.
- Trees used more water than grass per basal canopy area basis.

- Devitt, D. A., Neuman, D. S., Bowman, D. C., & Morris, R. L. (1995). Comparative Water Use of Turfgrass and Ornamental Trees in an Arid Environment. Journal of Turfgrass Management. *Journal of Turfgrass Management, 1*(2), 47-63.


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Hypotheses

- In Southern Nevada, mature landscape trees use more water than landscape grasses, based on tree basal canopy area.

Hypotheses

- Landscape tree morphological characteristics, such as height, basal canopy area, and canopy volume can be used to estimate Evapotranspiration.

Experimental design

- 100 mature trees planted in the ground in a grid
- 10 replicates of each 10 species
- 20 years old

- In this study: 3 reps of each species

Tree Species

- Elm
- Arizona Ash
- Mesquite
- Vitex
- Crepe Myrtle
- Desert Willow
- Locust
- Oak
- Modesto Ash
- Palo Verde






Trenching between Trees

Four types of Grass

- Fescue
  - *Festuca arundinaceae* var. Monarch
- Bermudagrass
  - *Cynodon dactylon* var. Tifway
- Bent grass
  - *Agrostis stolonifera* var. TI Creeping
- Rye grass
  - *Lolium perenne* var. Palmer Prelude

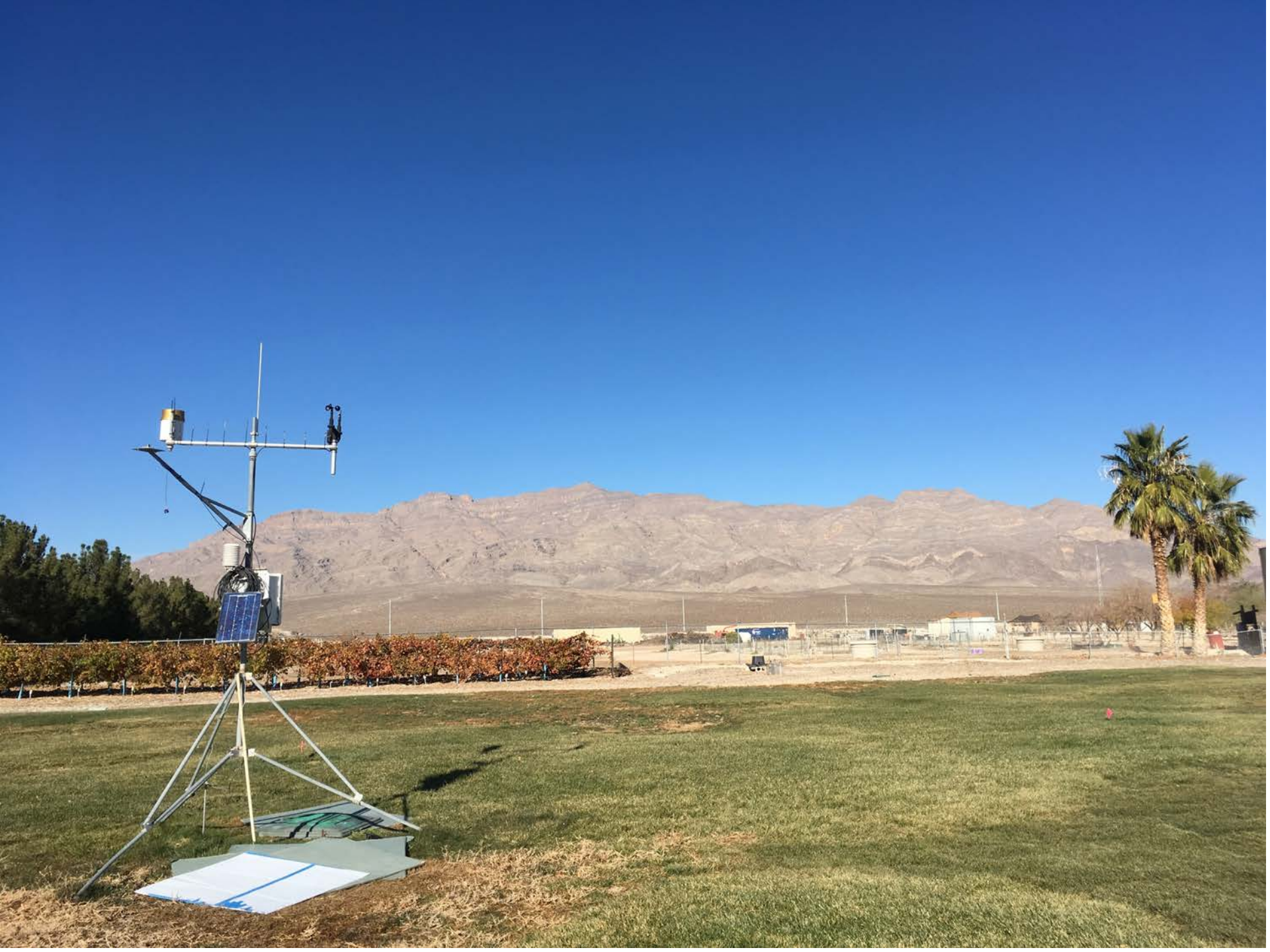
Four Grasses

C. dactylon

A. stolonifera

F. arundinacea

L. perenne



Grass Lysimeter

- Cups at the Bottom
- Vacuum Pump pulls out Water drainage

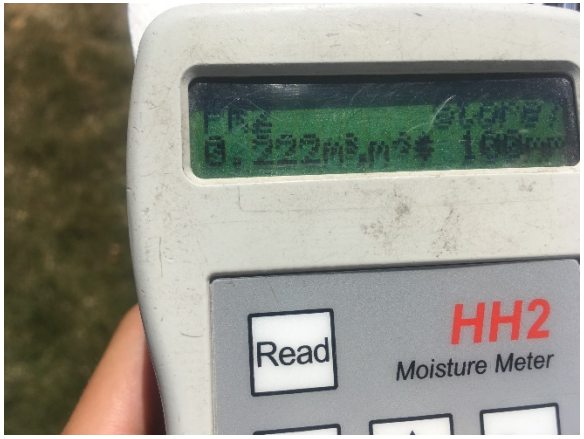
https://www.gfz-potsdam.de/en/section/hydrology/infrastructure/lysimeter-station/

Watering at Evapotranspiration (ET)

- ET=Input-Output-Change in Storage
  - Input=watering
  - Output=drainage
  - Change in Storage=change in soil moisture within the soil profile

Watering

- Watering based on Evapotranspiration (ET)
- Measured soil moisture with a theta probe
  - 6 depths:
    - 10cm
    - 20cm
    - 30cm
    - 40cm
    - 60cm
    - 100cm



PR2/6

100 cm

https://www.delta-t.co.uk/product/pr2/

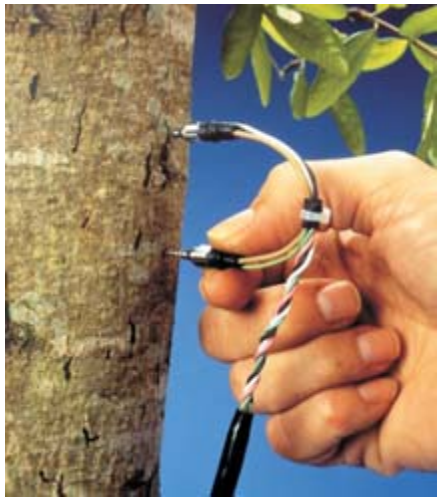

LET'S
GO
THIS

Drainage is checked

- Tree soil moisture is checked also at 150 cm to ensure no drainage.
  - Ideally no drainage due to watering at ET

Measuring sap flow

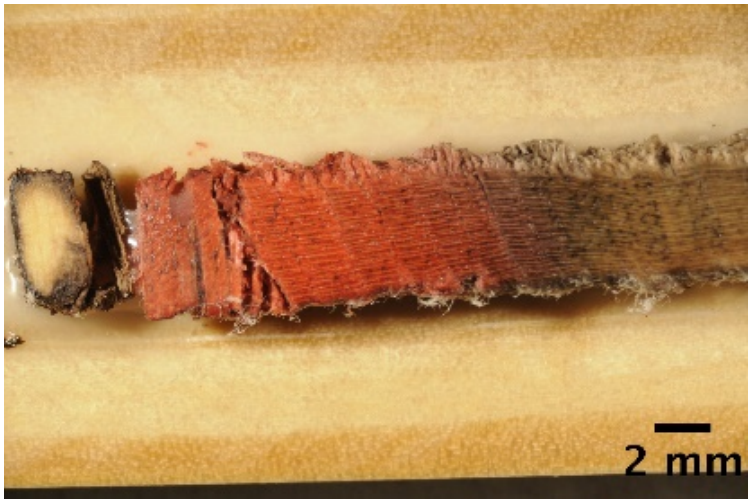
- Using a heated probe into tree trunk
- Mutiply sap flow by sap wood to get total water consumption.



http://dynamax.com/products/transpiration-sap-flow/tdp-sap-velocity-thermal-dissipation-probe

Dyeing the sapwood

Hopefully catching active xylem



Sapflow Equations

- $J_s = A_s * F_s$
- $F_s = 0.0119k^{1.23}$
- $k = \frac{\Delta Tmax}{\Delta T} - 1$

Granier, A. (1987) Evaluation of transpiration in a Douglas fir stand by means of sap flow measurements, *Tree Physiology,* 3(4), 309-319

Measuring Morphology

Tree Morphology

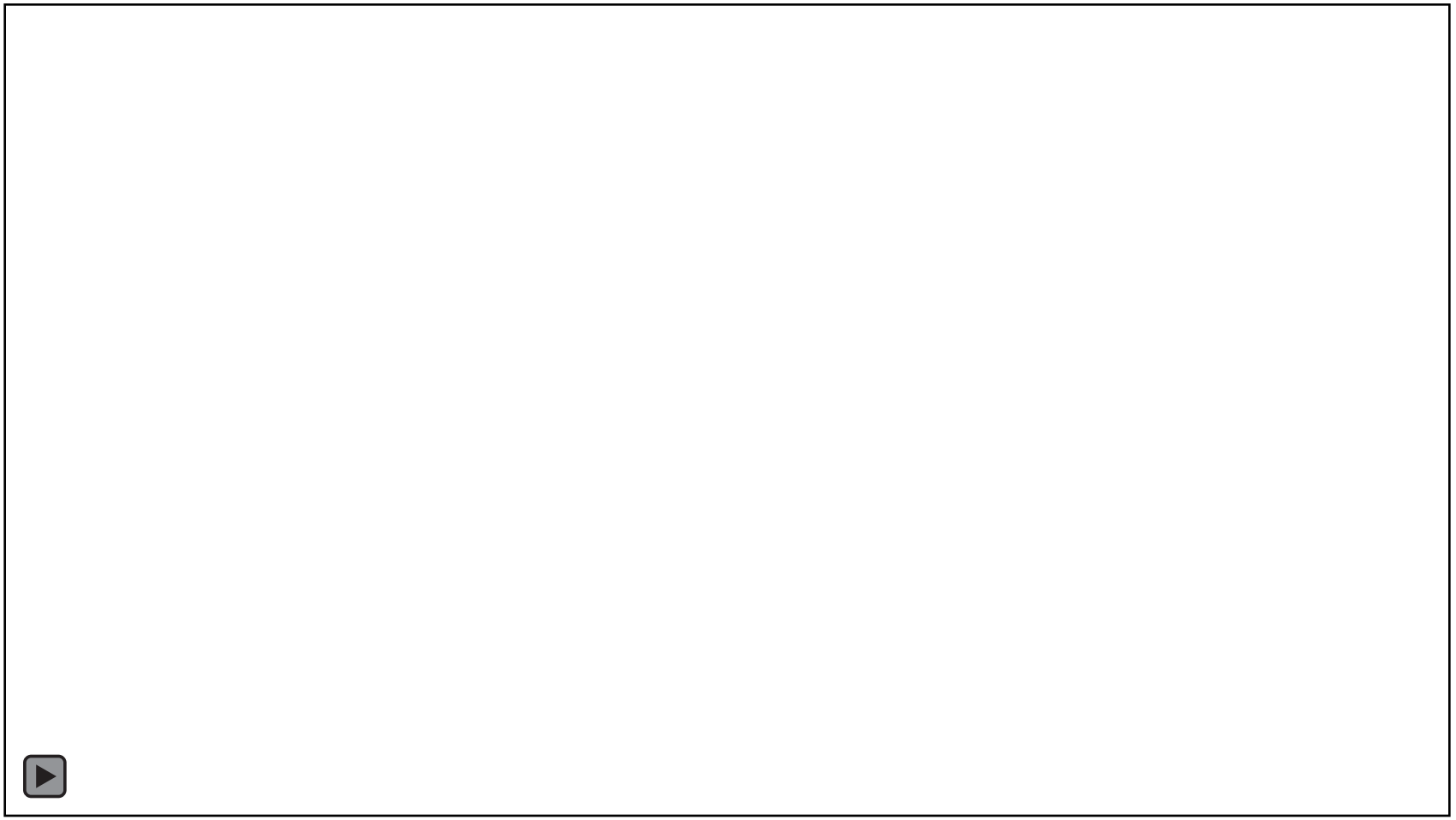
- Height
- Stem diameter
- Basal Area
- Canopy Volume
- LAI
- 1/PAR
- Sun Leaf
- Shade Leaf

Physiological Measurements

Tree Species	Chlorophyll Index	Xylem Water Potential	T_c-T_a
C. linearis	170.20± 32.07$_a$	17.89± 1.23$_b$	-1.88±1.05$_c$
F. velutina 'Arizona'	172.20± 23.95$_a$	21.75± 4.68$_b$	-1.42±0.88$_c$
F. velutina 'Modesto'	156.93± 18.22$_a$	24.63± 6.73$_b$	-2.65±1.32$_c$
G. tricanthos	163.33± 37.33$_a$	24.39± 3.29$_b$	-1.55±0.81$_c$
L. indica	170.64± 21.80$_a$	21.94± 4.42$_b$	-2.70±1.32$_c$
P. alba	154.44± 28.61$_a$	26.58± 4.20$_b$	-1.93±0.74$_c$
P. grandiflora	136.31± 11.67$_a$	21.67± 1.16$_b$	-1.10±1.68$_c$
Q. virginana	165.98± 18.32$_a$	24.39± 3.29$_b$	-0.84±1.16$_c$
U. parvifolia	150.40± 7.29$_a$	28.61± 6.44$_b$	-2.97±1.79$_c$
Vitex agus-castus	156.18± 17.63$_a$	25.56± 6.17$_b$	-3.14±1.32$_c$

Small letters denote significant differences within each column, α=0.05

Grass Morphology

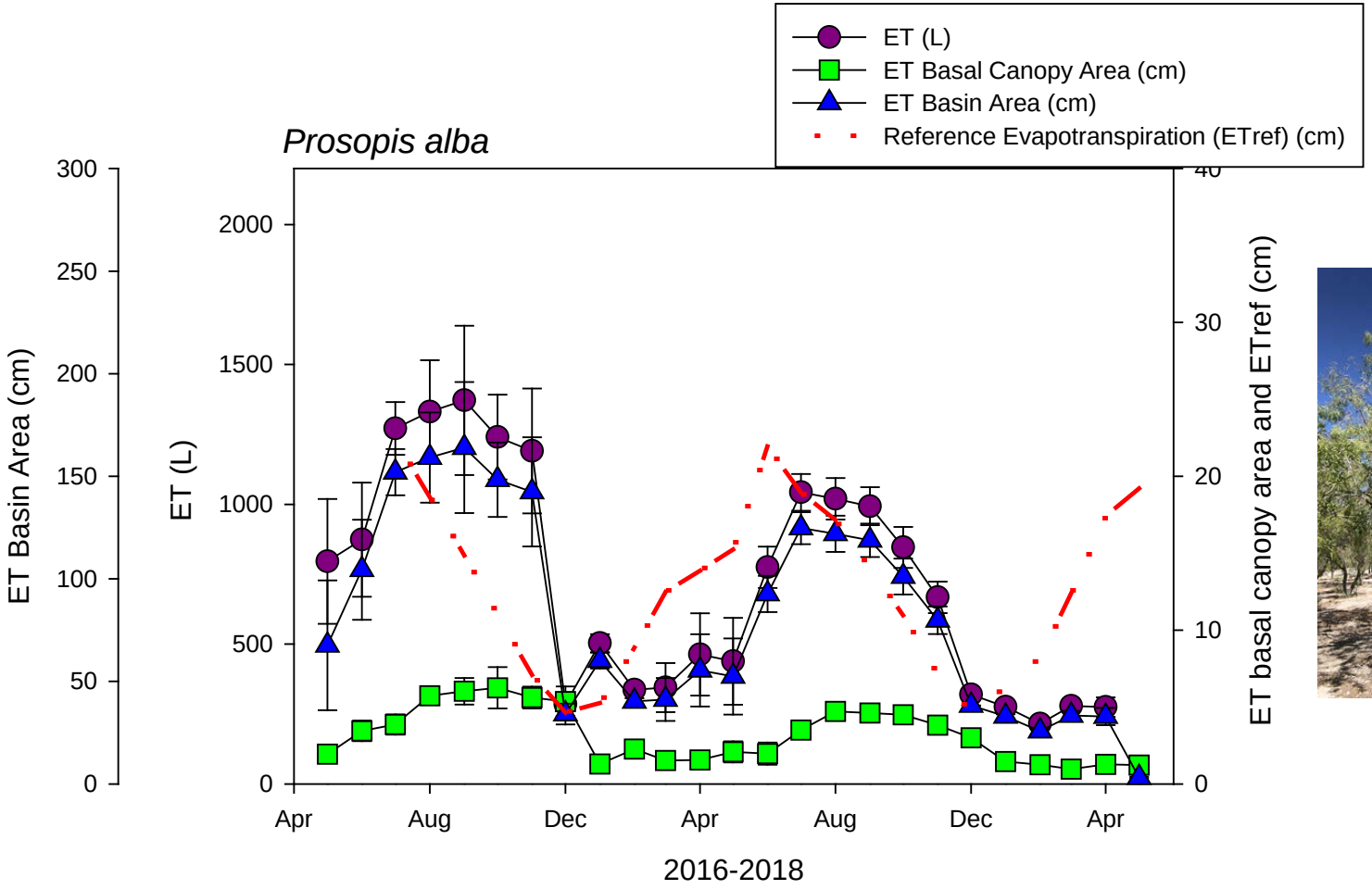


Evapotranspiration

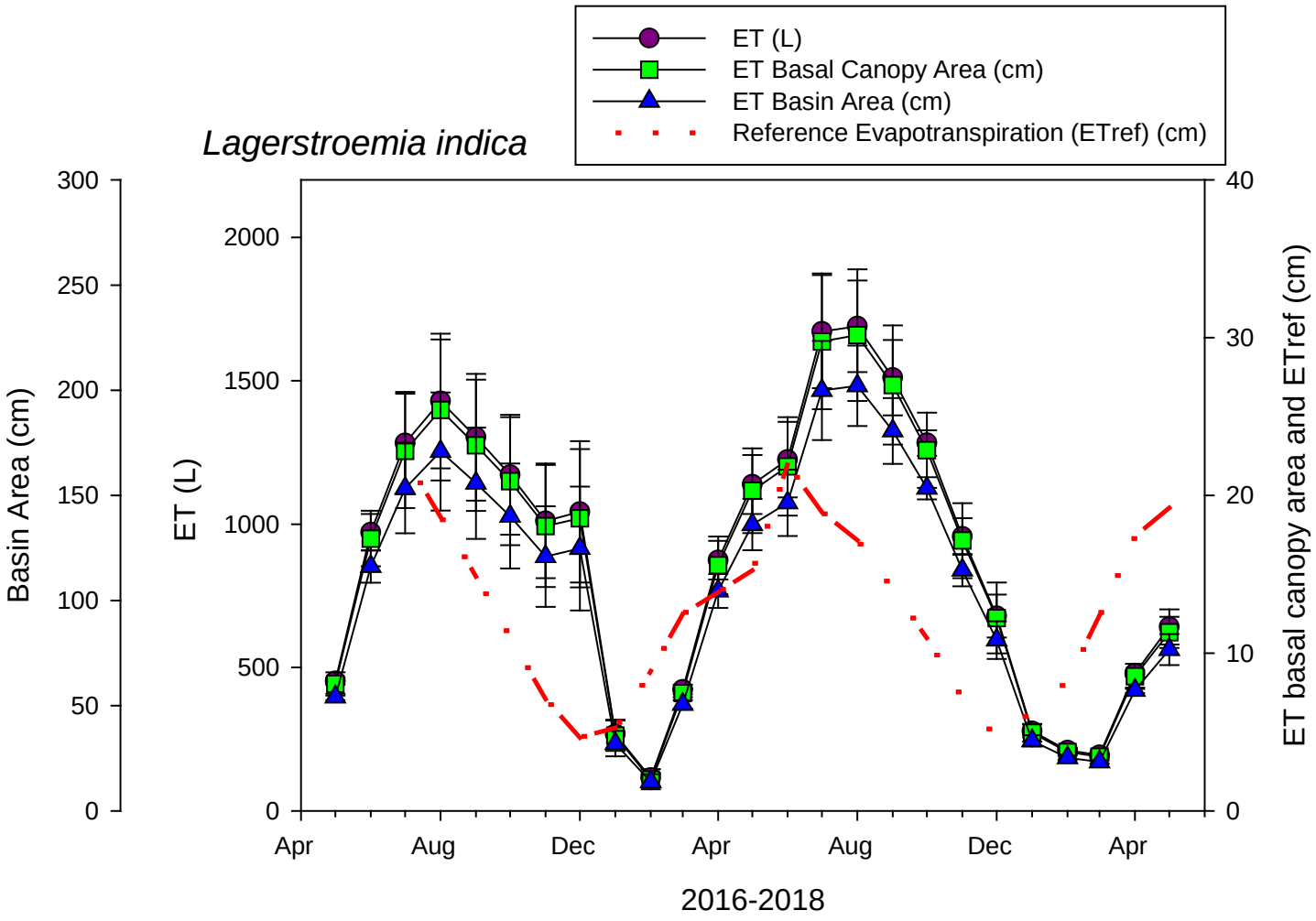
Tree Species	Hydro cm	Sapflow cm
Chilopsis linearis	$42\pm18_{ab}$	10±6
Fraxinus velutina 'Arizona'	$46\pm7_{ab}$	24±24
F. velutina 'Modesto'	$78\pm22_{a}$	26±20
Gleditsia tricanthos	$61\pm17_{ab}$	25±4
Lagerstroemia indica	$197\pm42_{c}$	50±38
Prosopis alba	$38\pm9_{ab}$	32±7
Parkinsonia florida	$31\pm16_{b}$	27±2
Quercus virginana	$42\pm17_{ab}$	12*
Ulmus parvifolia	$42\pm10_{ab}$	23±3
Vitex agnus-castus	$43\pm11_{ab}$	50±29
Cynodon dactylon Low Fert.	106±9ǂ	--
Festuca arundinacea	$192\pm15_{c}$	--
Cynodon dactylon	$213\pm56_{c}$	--

Different small letters denote significant differences within each column, $\alpha=0.05$. * signifies one tree. ǂ signifies a historical value.

Evapotranspiration



Evapotranspiration

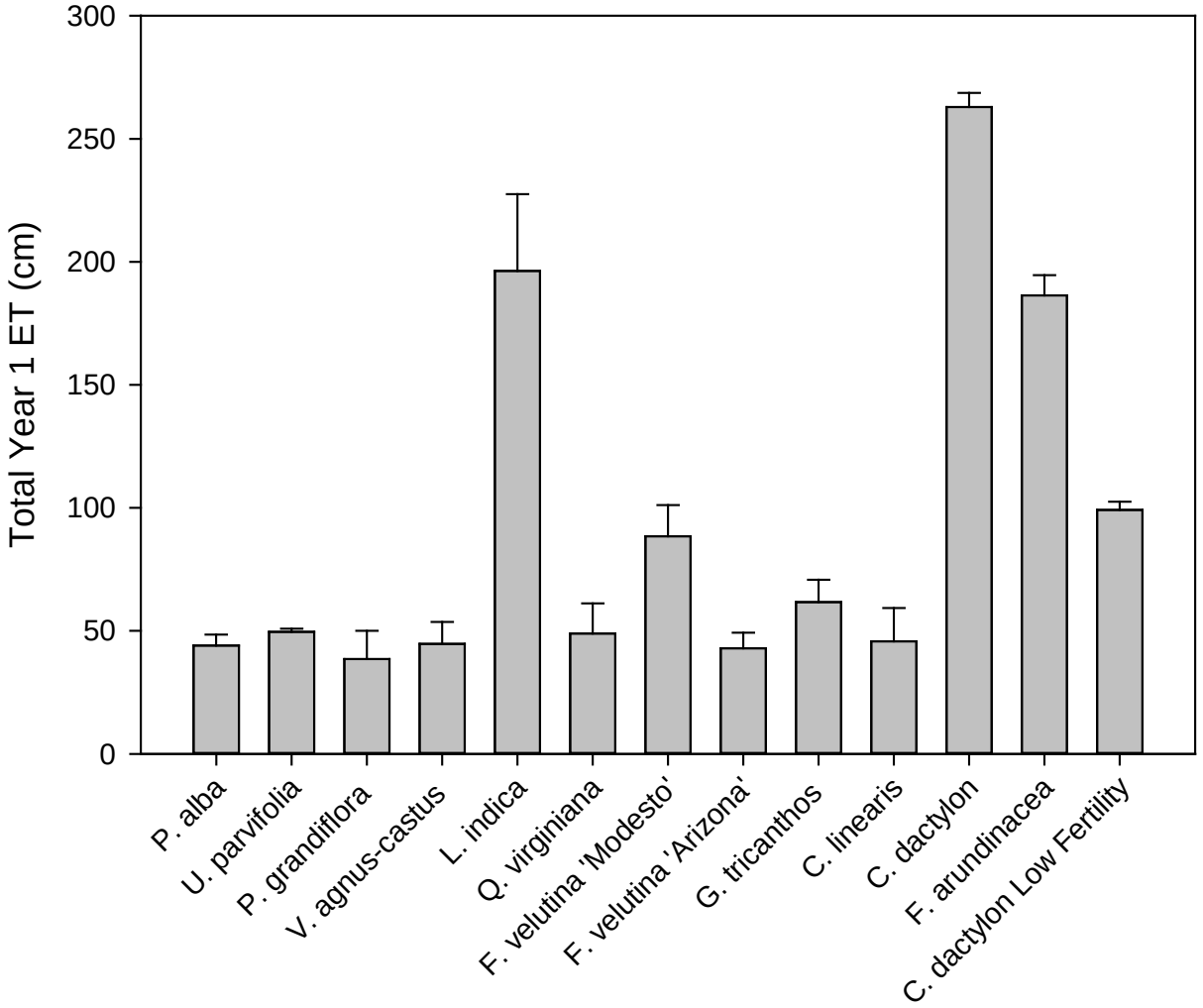


Caveats

- Stand of trees
- Irrigated at ET
- 20 years old
- Growing at Urban/Desert fringe

ET Totals

Grasses Generally Use More Water Than Trees per Basal Canopy Area



Backward Regression Results

- Year 2 ET L=12070.3-150.8*Trunk Diameter-84.6*Basal Canopy+37.1*Area of Sun Leaf
  - R^2=0.58, p<0.001

- Year 2 ET cm=2.033-0.008*Canopy Volume
  - R^2=0.642, p<0.001

ET and ETref

- Mesquite ET = 1.154 + (0.163 * ETref)
- $P<0.001$
- $R^2=0.77$

Conclusions

- With the exception of the Crepe Myrtle, trees, on a yearly basis, always reflected lower water use compared to grasses. However, these ratios varied by the type of grass.

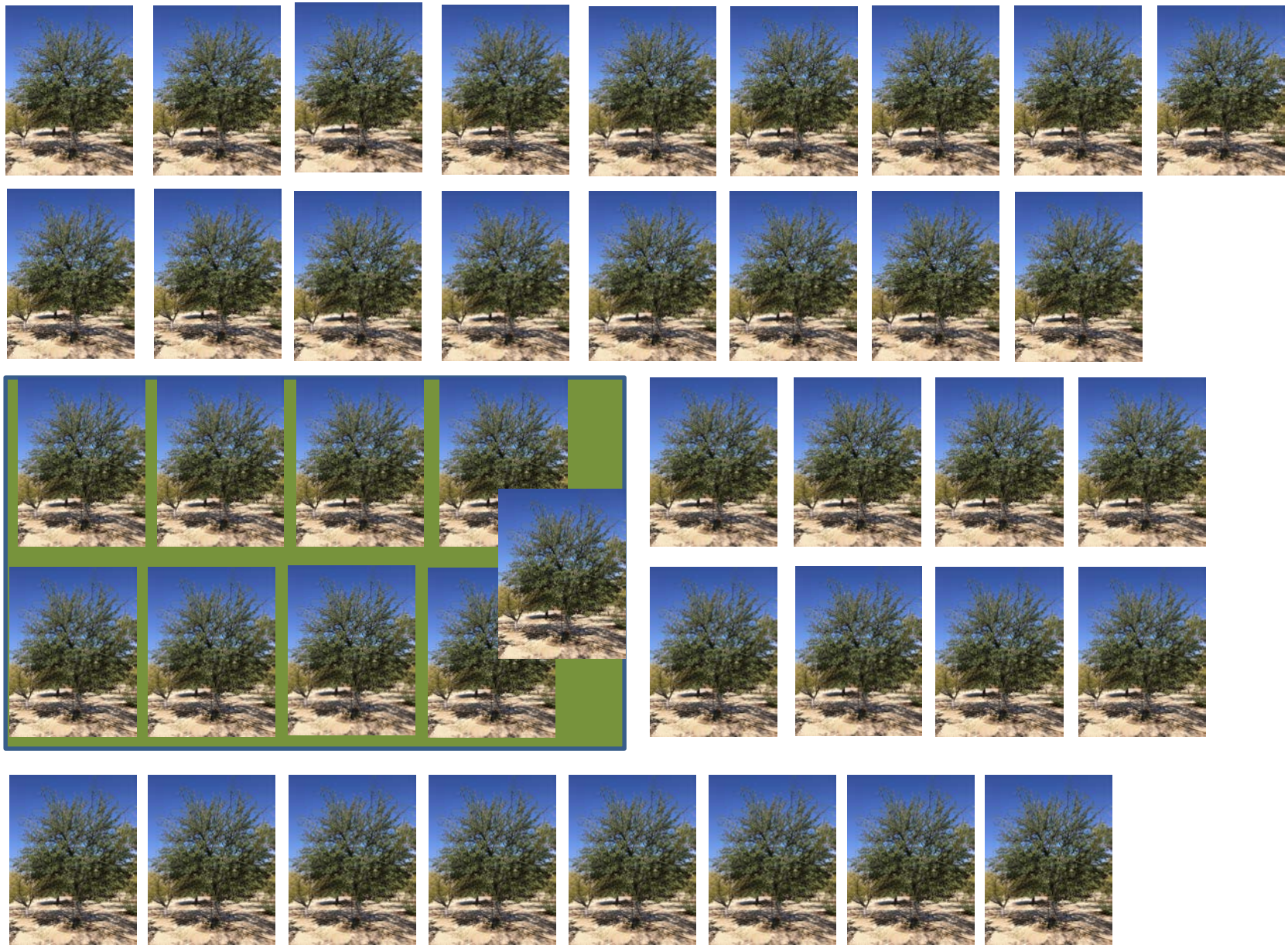
- Confirming Hypothesis 1

Conclusion

- Landscape tree morphological characteristics, such as basal canopy area, and canopy volume can be used to estimate Evapotranspiration.

- Confirming Hypothesis 2

Tree to Grass Tradeoffs



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