

Climate Change Impacts on Evapotranspiration

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Sustenance and Water

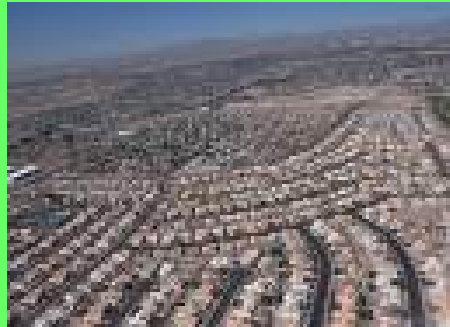
One Liter of Water
Produces One
Calorie of Food*

*“Comparative Assessment”
by the Consultative Group of
International Agricultural
Research



Evapotranspiration (ET)

In a Climate Changed CA Landscape



How is ET impacted in a future world?

Are there solutions for changes in water demand resulting from ET?

Are trends emerging that worsen risks from ET demand?

Presentation Plan

ET Demand in CA

ET Mechanism Analysis

Integrative Plant Biology

Energy Budget

Simulated ET for Climate Change

Future CA Ag Landscape

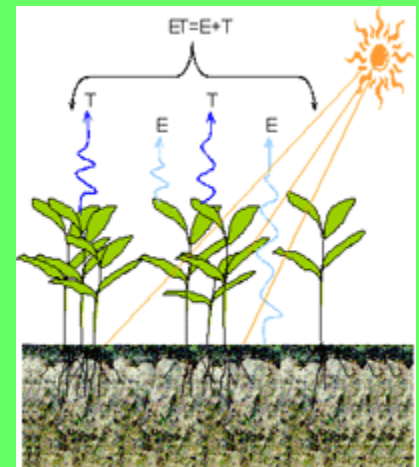
Solutions and Risks

Evapotranspiration

Evaporation (E): loss of water vapor to the atmosphere via phase change from liquid water

Transpiration (T): liquid water phase change occurring inside plants with the vapor diffusing to the atmosphere

ET is the largest consumptive use of DWR water (about 80% in a normal water year), excluding water quality maintenance and environmental needs



CA Agricultural

Land of milk and honey



\$31 billion as income (2004)

Highest agricultural crop value in the USA for over 50 consecutive years



Half of the fruits, nuts and vegetables in the USA

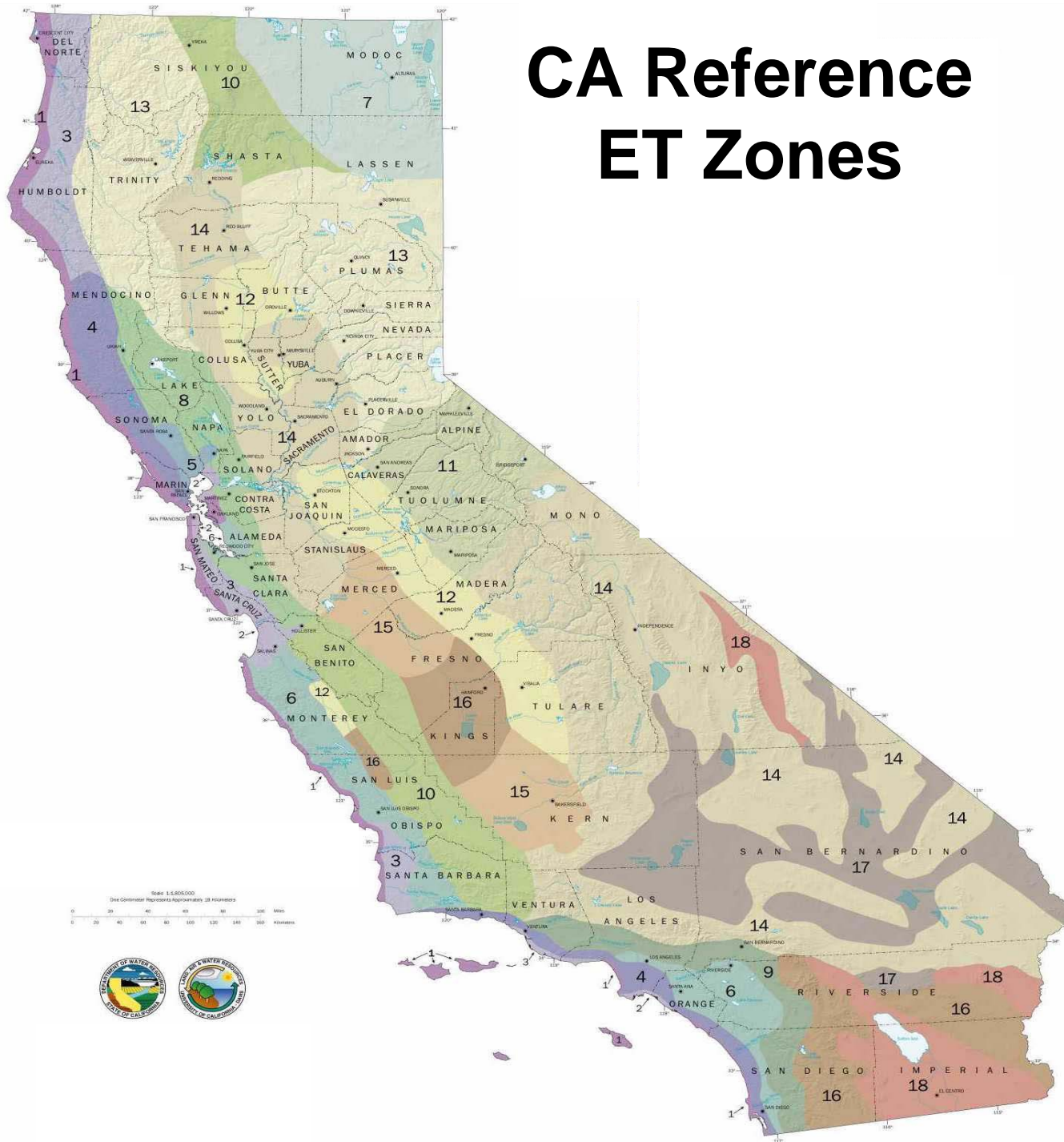
28 million acres in some type of agricultural production (1997)



Mild, Sunny climate; deep rich soils;
Infrastructure (water, transport, labor)

NASS 2006; CADFA 2006

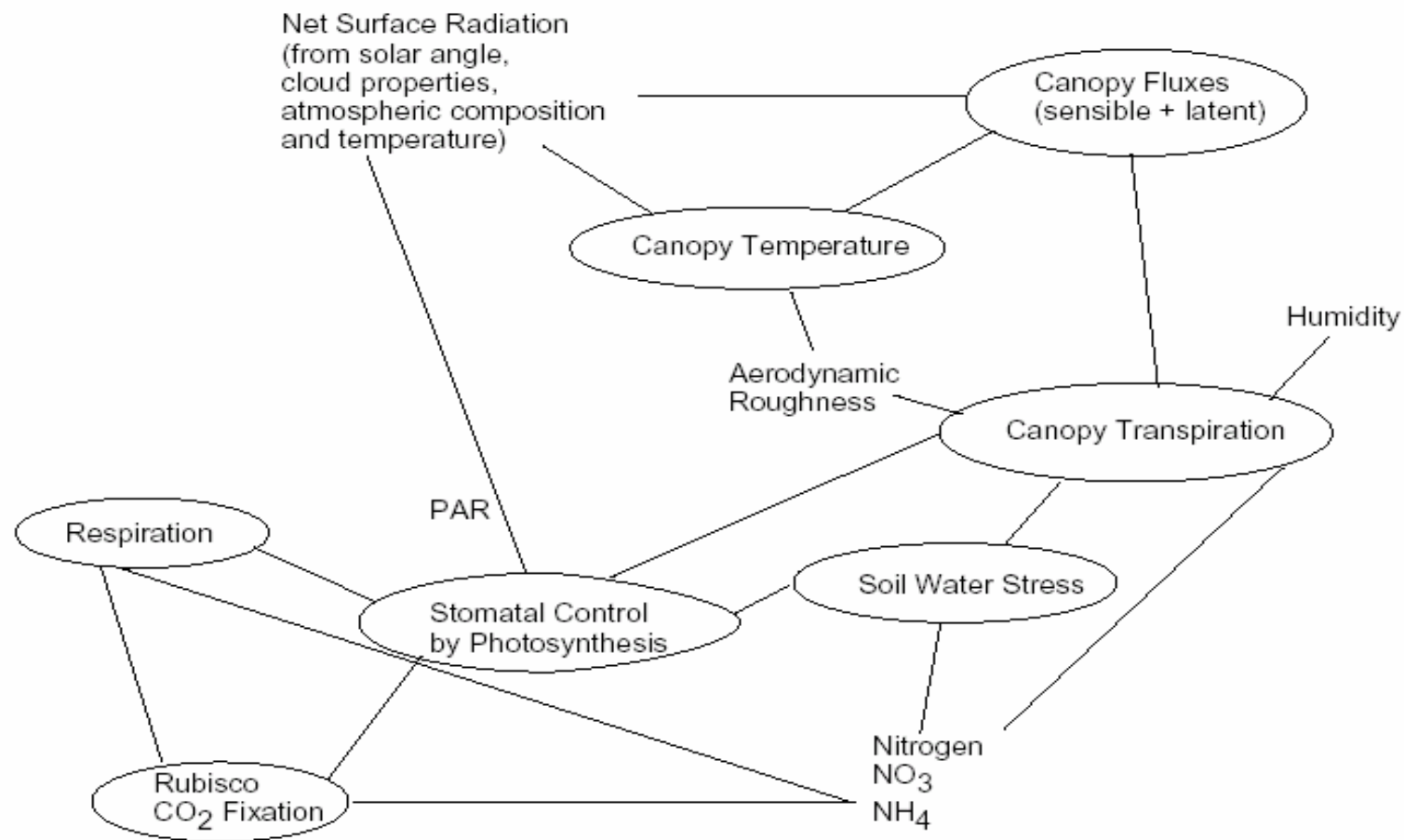
CA Reference ET Zones



ET of Applied Water in normal water year

Commodity	ETaw (acre-in/acre)
Safflower	9.5
<i>Vineyards</i>	<i>17.3</i>
Processing Tomatoes	24.4
<i>Almonds Pistachios</i>	<i>33.1</i>
Alfalfa	42.7

Relation of Transpiration and Photosynthesis



Water Use Efficiency & CO₂ Increase

Water Use Efficiency = Assimilation/Transpiration

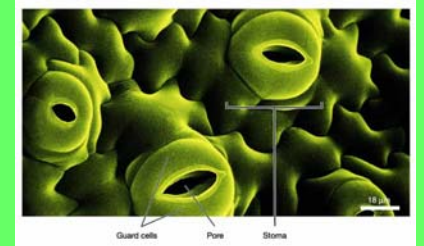
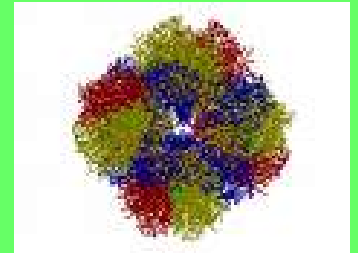
Assimilation (carbon fixation) is related to plant N

The most abundant protein on earth, Rubisco, is limiting step in C₃ photosynthesis

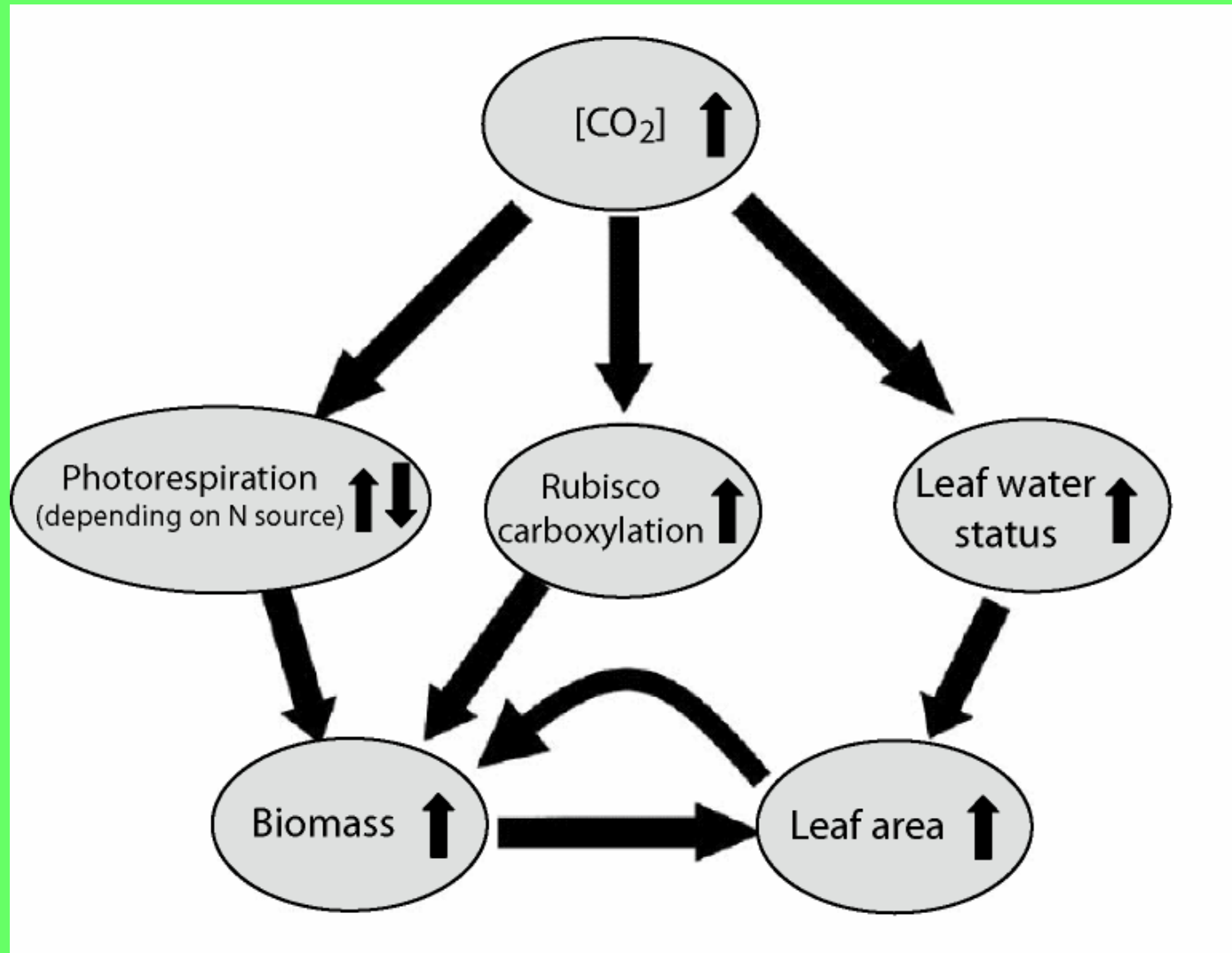
Increased interstitial CO₂ reduces Rubisco inefficiency

At higher CO₂ partial stomatal closure decreases transpiration

Increased leaf temperature increases transpiration



Effects of Increased CO₂ on Plant Production



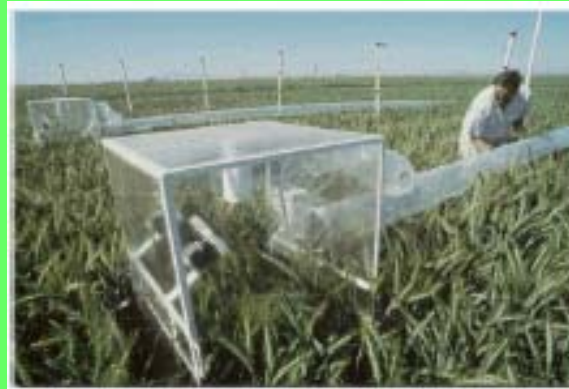
Modified from Long et. al. 2004

CO₂ Experiments

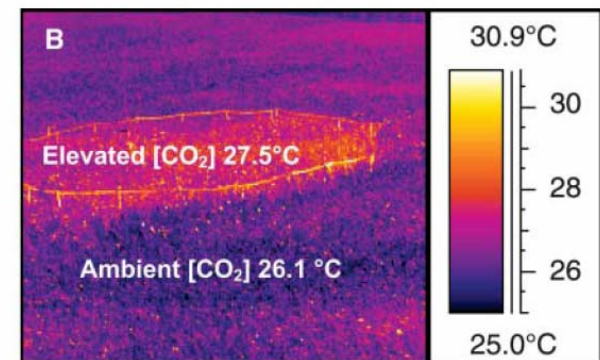
Growth Chamber



Field Chamber



FACE



Long et al Sci 2006

Penman-Monteith

$$ET = \left(\frac{\Delta(R_n - G) + K_{time} \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma \left(1 + \frac{r_s}{r_a} \right)} \right) / \lambda$$

Diagram illustrating the Penman-Monteith equation with annotations for the variables:

- f (solar radiation) points to R_n .
- f (humidity) points to e_s and e_a .
- f (temperature) points to Δ .
- f (wind) points to r_a .
- f (crop) points to r_s and r_a .

Energy Budget Changes With Increased Temperature and CO₂

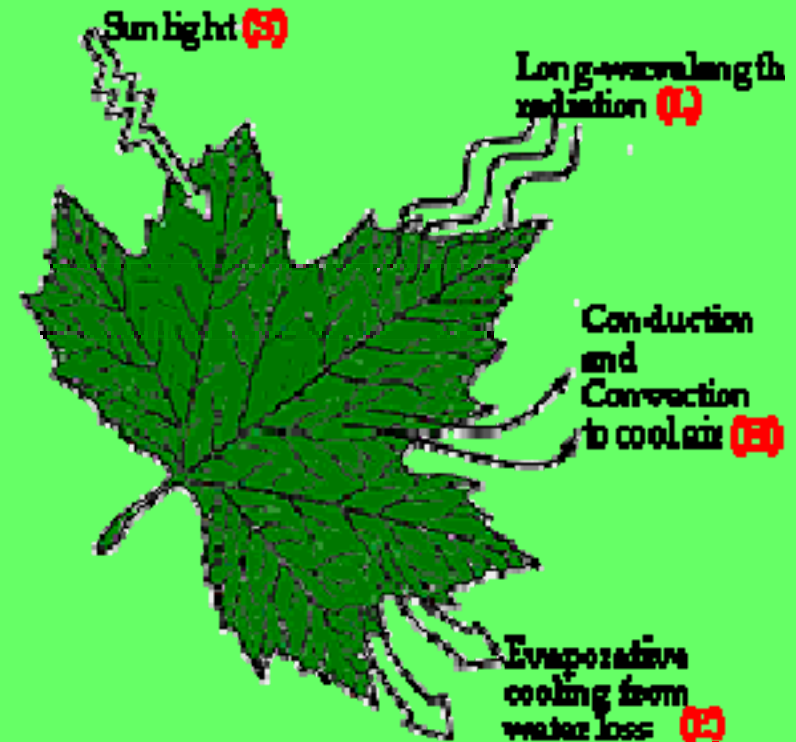
Weighting to Available Energy Increases

Weighting to Sensible Energy Decreases

Solar Radiation More Important

Vapor Deficit Pressure and Wind Less Important

Change in Latent Energy Depends Most Strongly on Solar Radiation Change



S = solar input
L = longwave radiation
rs = reflected solar
R = reradiated solar
H = sensible heat transfer
E = latent heat transfer
A = assimilation

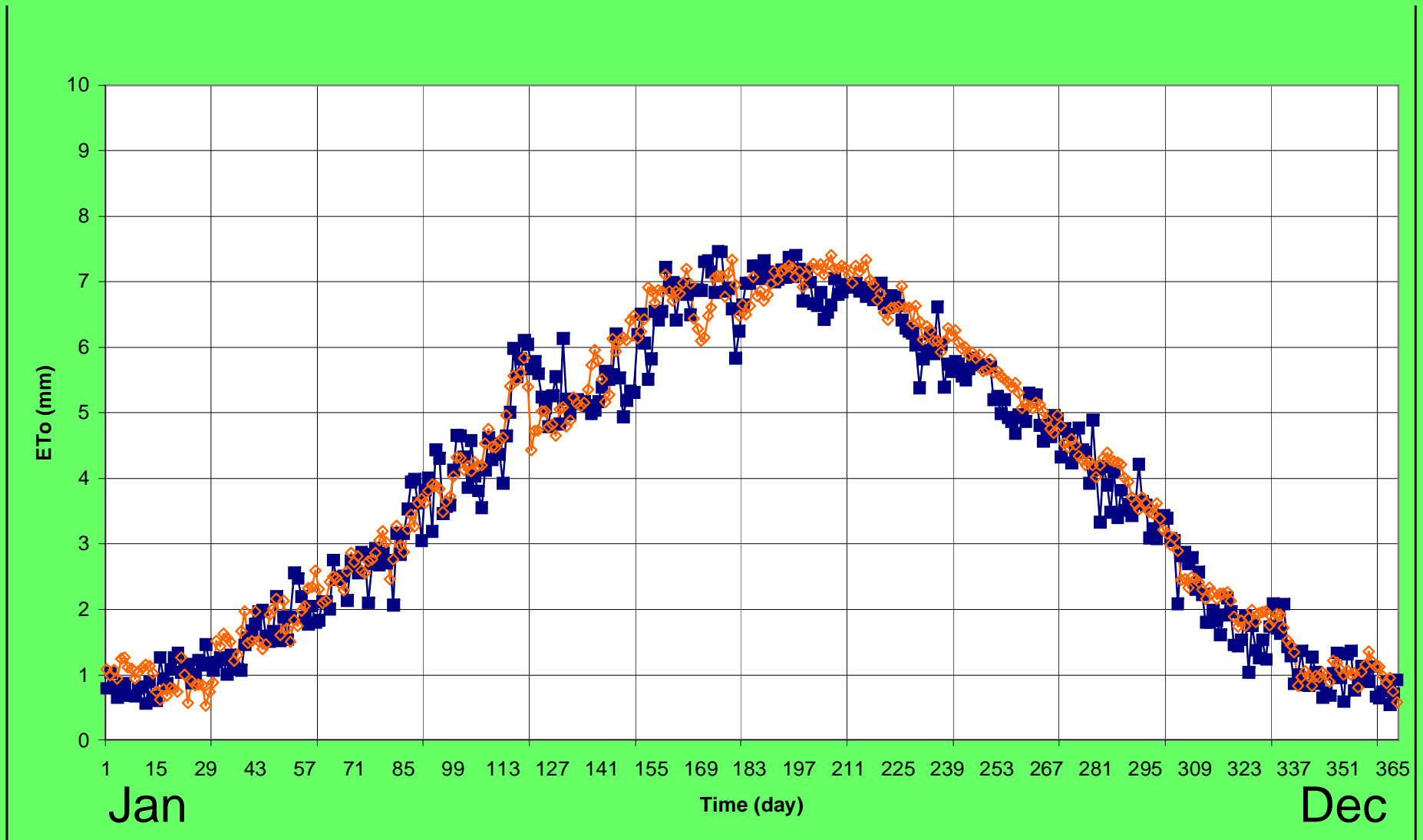
Reference ET at Davis CA



Measured

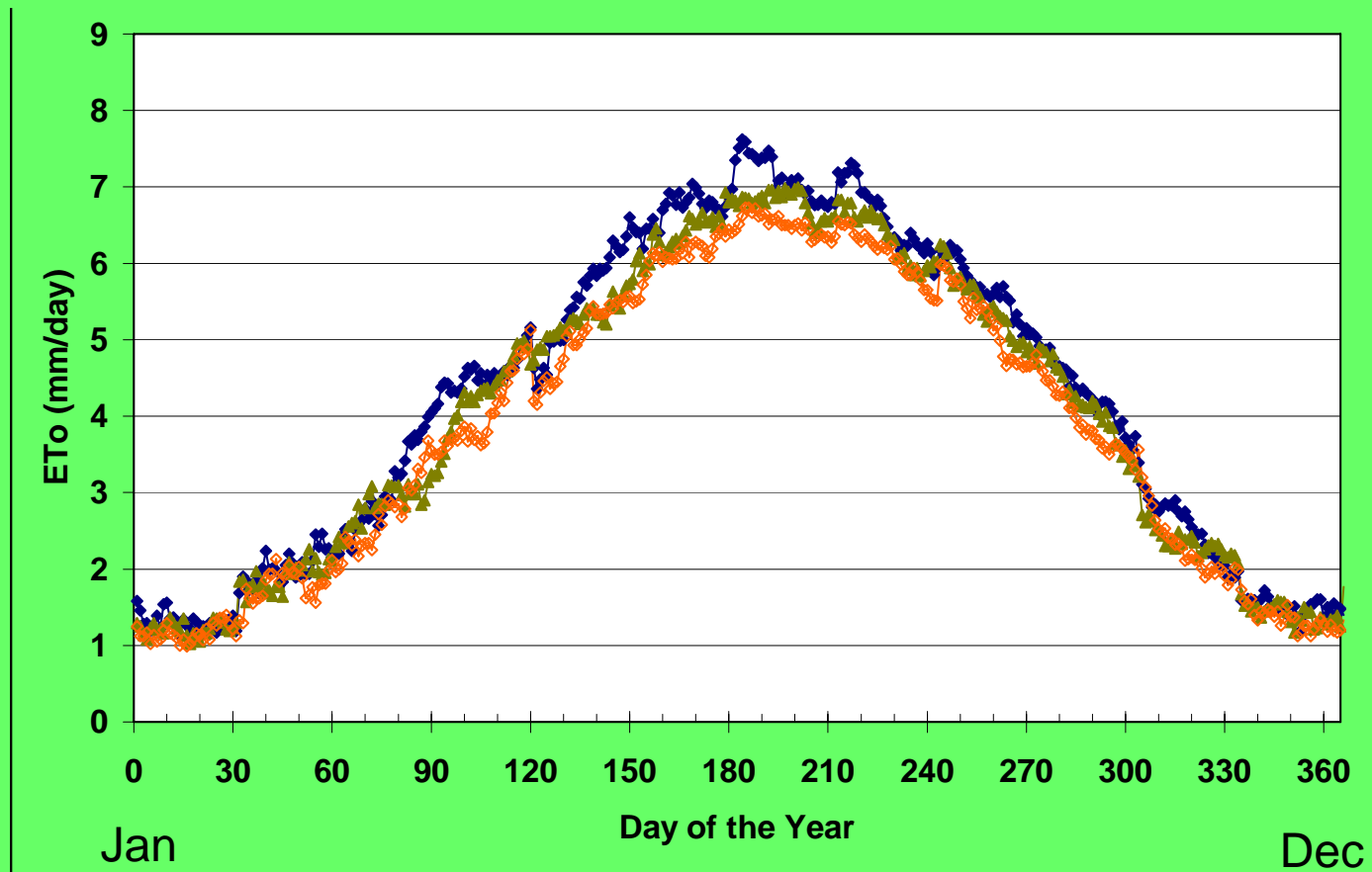


Simulated

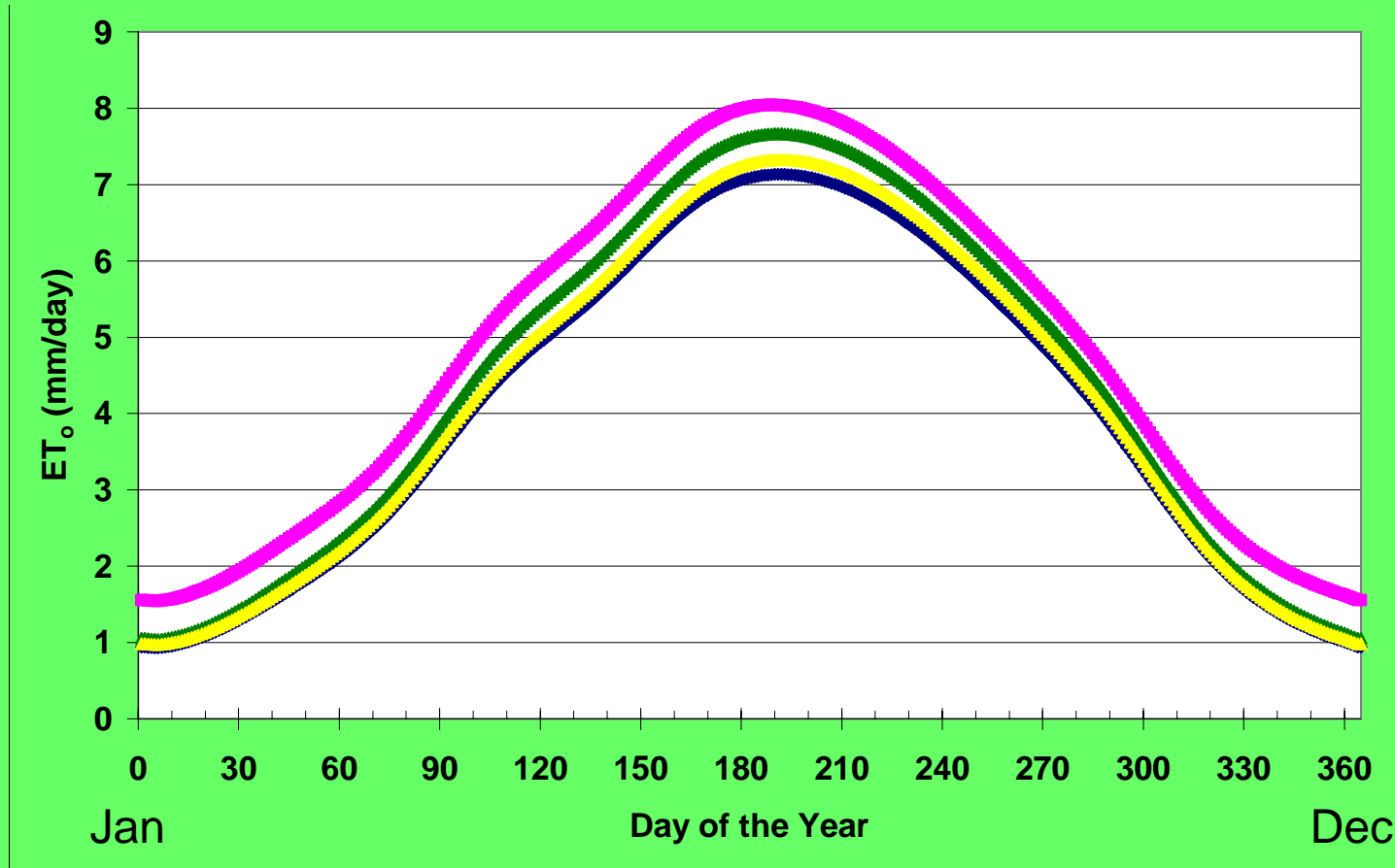


Simulated ET at Three Canopy Resistances

■ 70 s/m ■ 85 s/m ■ 100 s/m



ET Simulations Using Different Climate Change Impacts



■ +Air Temp ■ +Air & Dew Pt Temp ■ +Temp & Canopy Res ■ Current

Water Saving In ET

Plant Breeding Advancement

WUE Increased 40% in past 35 years
for Processing Tomatoes

Irrigation Improvement

Management (CIMIS)

Changes In Type

California Irrigation Trends

Irrigation method	1990 Acreage	%	2000 Acreage	%	% change
Gravity (furrow, flood)	6.5	67.5	4.9	51.3	-16.2
Sprinkler	2.3	23.8	2.8	28.8	5
Drip/micro	0.8	8.7	1.9	19.9	11.2

Acreage in million acres

Conclusions

Evapotranspiration (ET) in California is a
Predominant Water Demand

Climate Change Slightly Increases ET

CO₂ Increase Diminishes the ET Increase Resulting
from Temperature Increase

A Current Trend Toward Perennial Woody Crops
Increases Risk from Possible Droughts

Future Directions for Study of ET Impacts from Climate Change

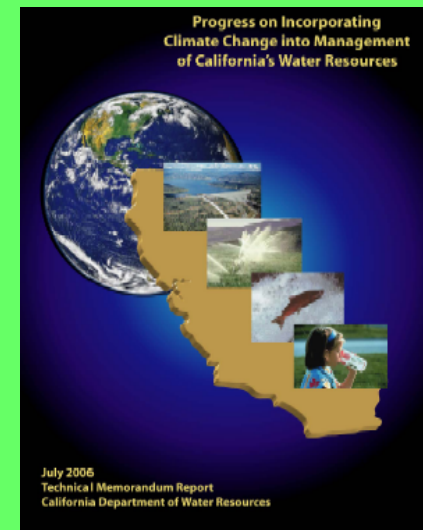
Refinement of CO₂ influences on
transpiration

Evaporation from open water bodies
with climate change

SEMETAW program integration with
other modeling tools

Stable isotope measures for WUE

Land use change and ET





Contact

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