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

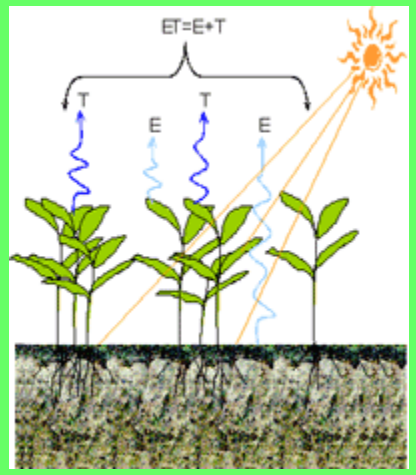
Future CA Ag Landscape

- 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

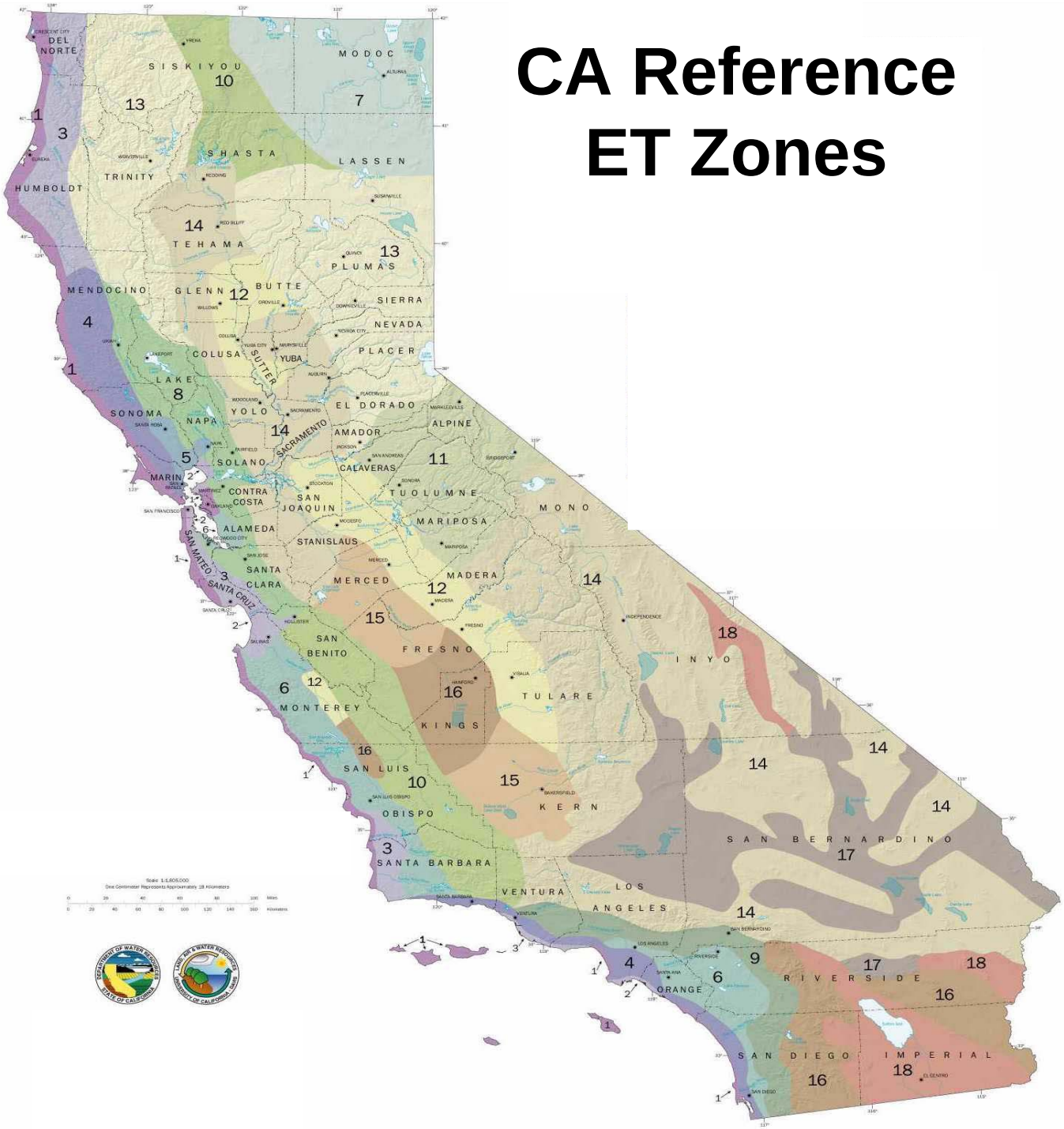
Half of the fruits, nuts and vegetables in the USA

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

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

NASS 2006; CADFA 2006

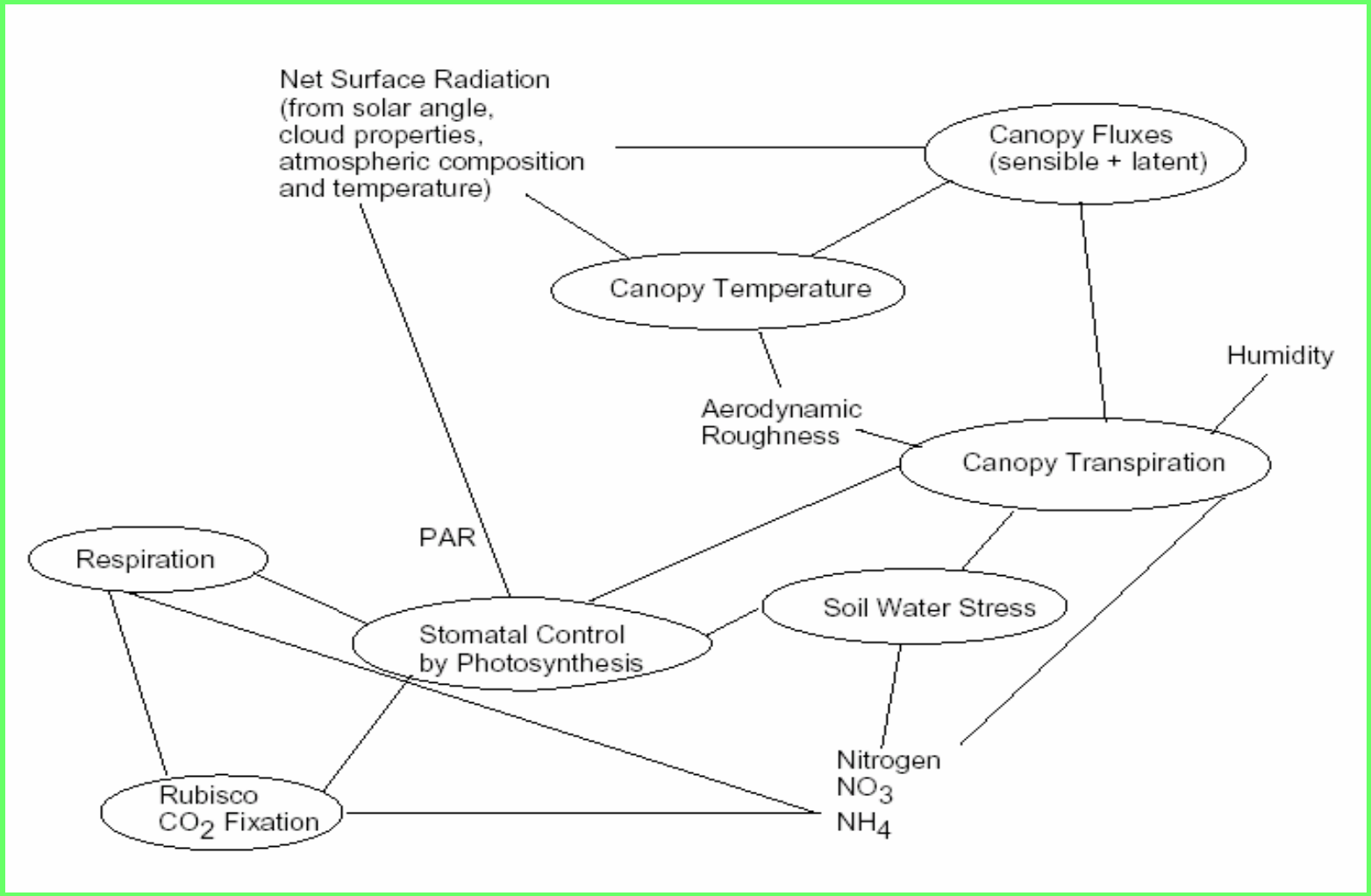
CA Reference ET Zones



ET of Applied Water
in normal water year

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

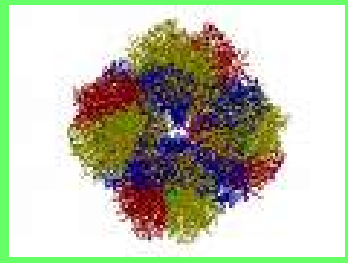
Relation of Transpiration and Photosynthesis



Water Use Efficiency & CO_2 Increase

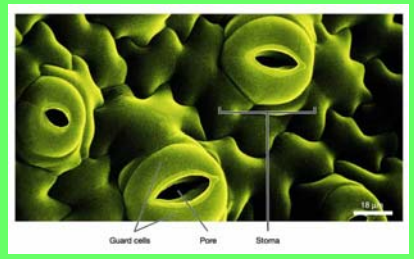
Water Use Efficiency = Assimilation/Transpiration

Assimilation (carbon fixation) is related to plant N



The most abundant protein on earth, Rubisco, is limiting step in C_3 photosynthesis

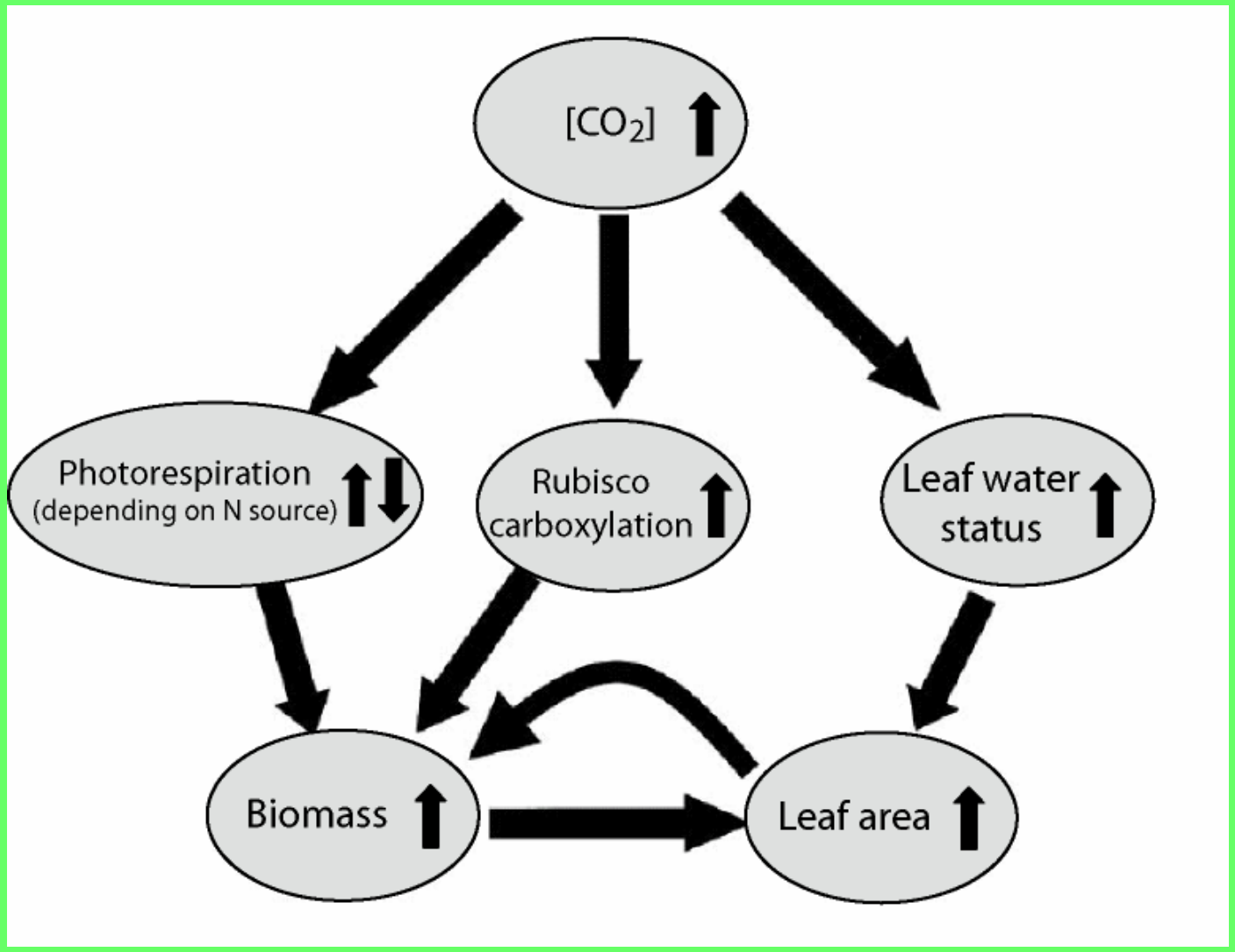
Increased interstitial CO_2 reduces Rubisco inefficiency



At higher CO_2 partial stomatal closure decreases transpiration

Increased leaf temperature increases transpiration

Effects of Increased CO_2 on Plant Production



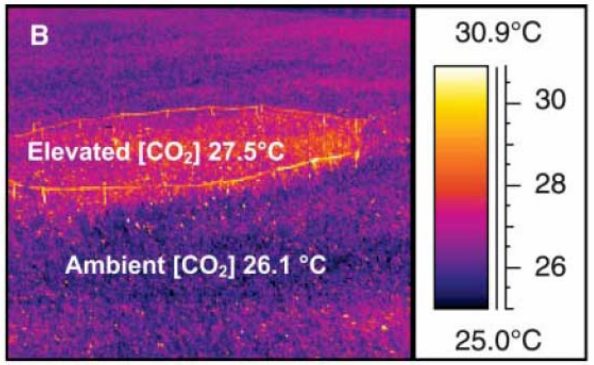
Modified from Long et. al. 2004

CO_2 Experiments

Growth Chamber

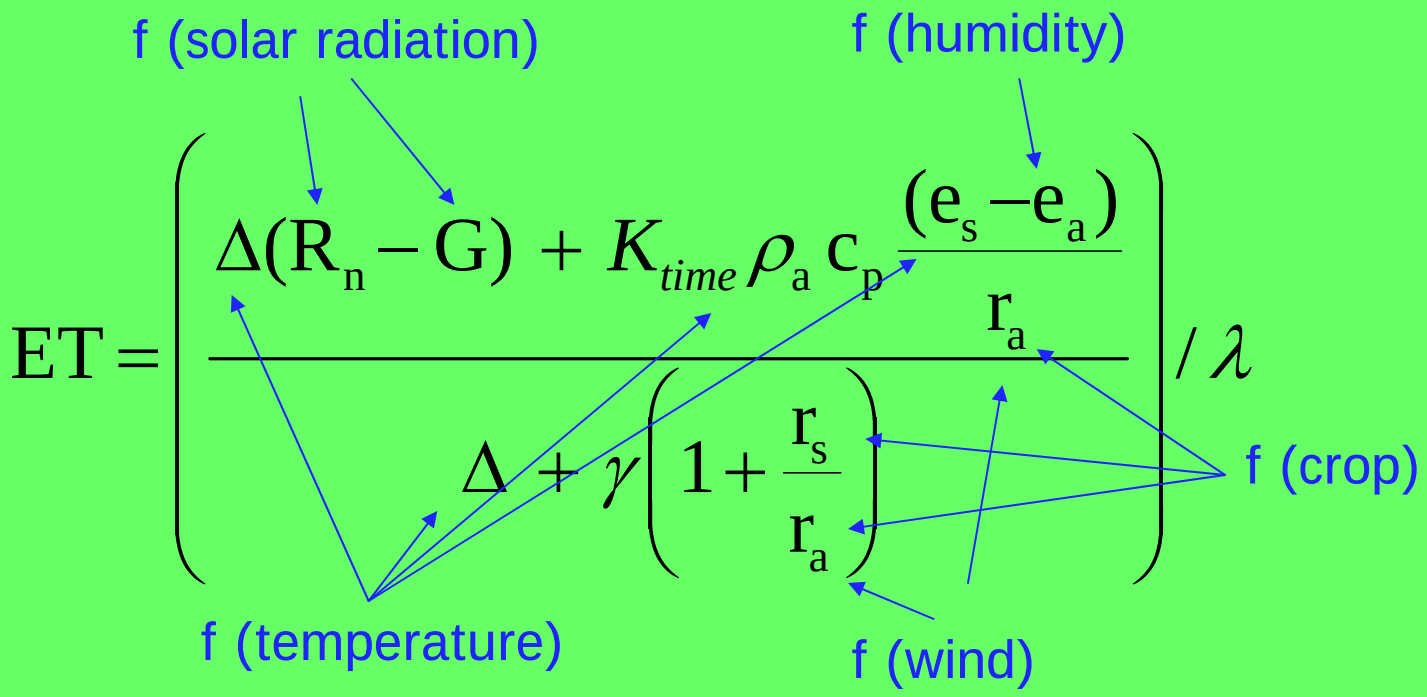
Field Chamber

FACE



Long et al Sci 2006

Penman-Monteith



R Allen (2003)

Energy Budget Changes With Increased Temperature and CO_2

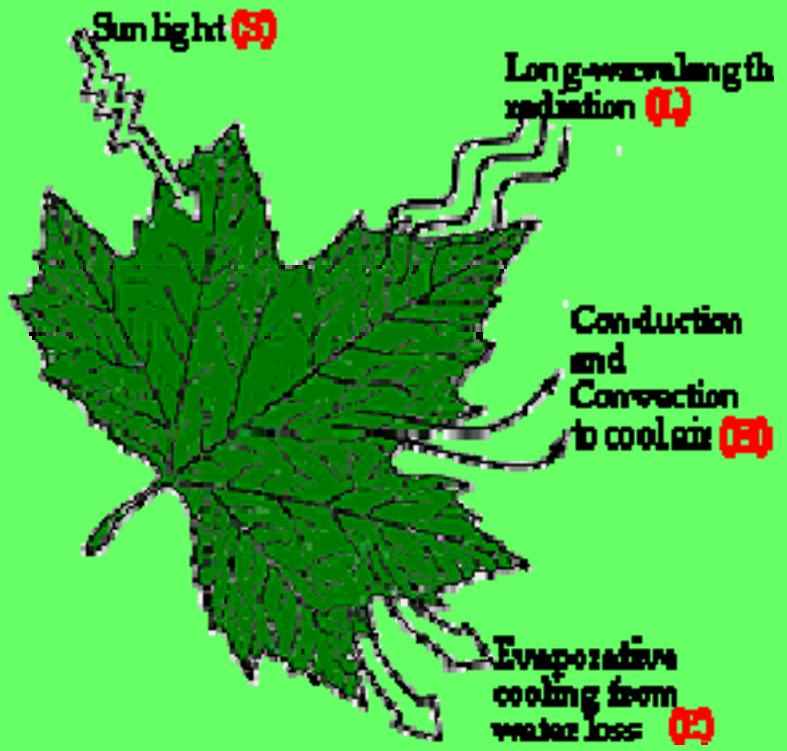
Weighting to Available Energy Increases

Weighting to Sensible Energy Decreases

Solar Radiation More Important

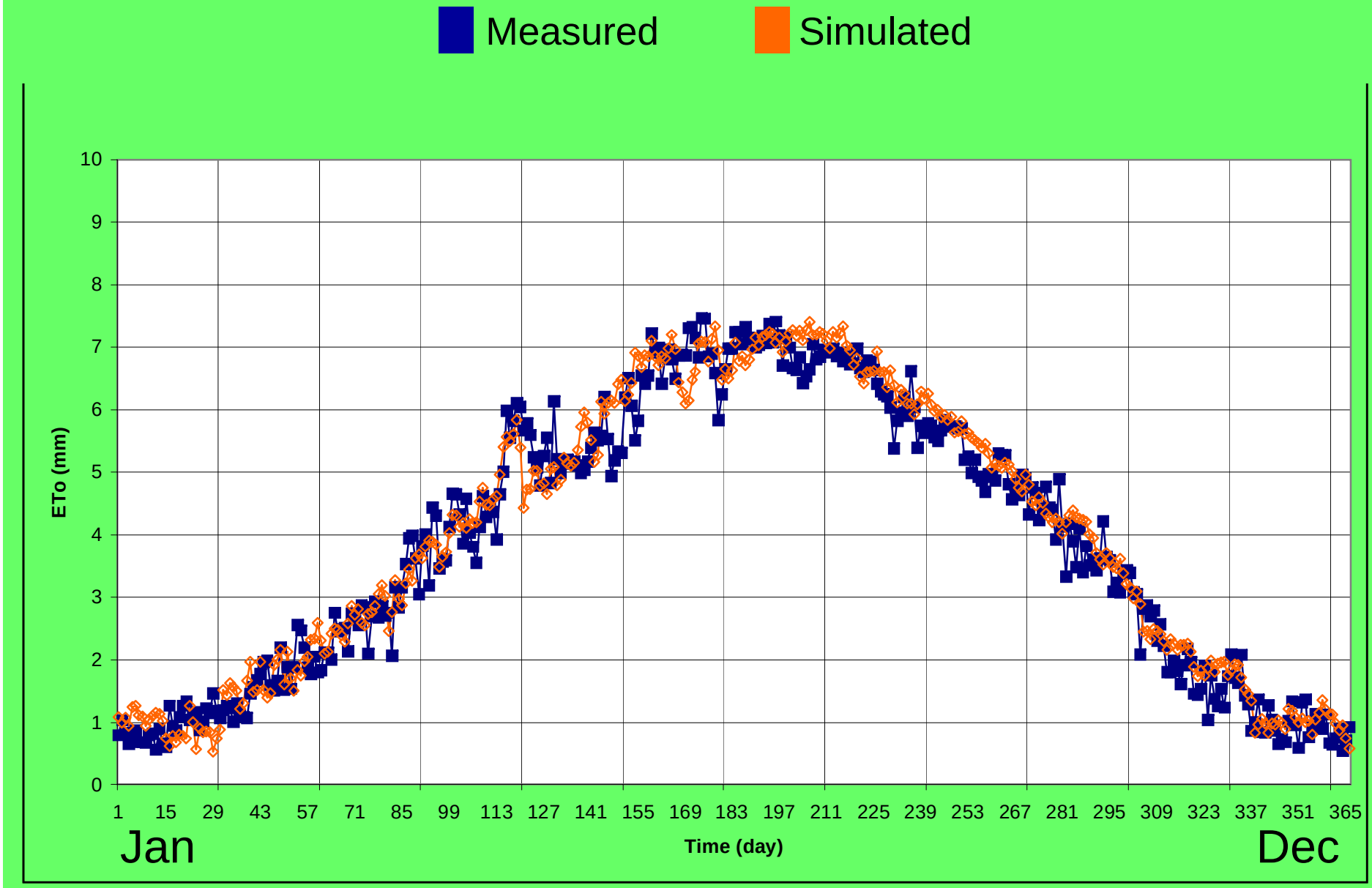
Vapor Deficit Pressure and Wind Less Important

Change in Latent Energy Depends Most Strongly on Solar Radiation Change

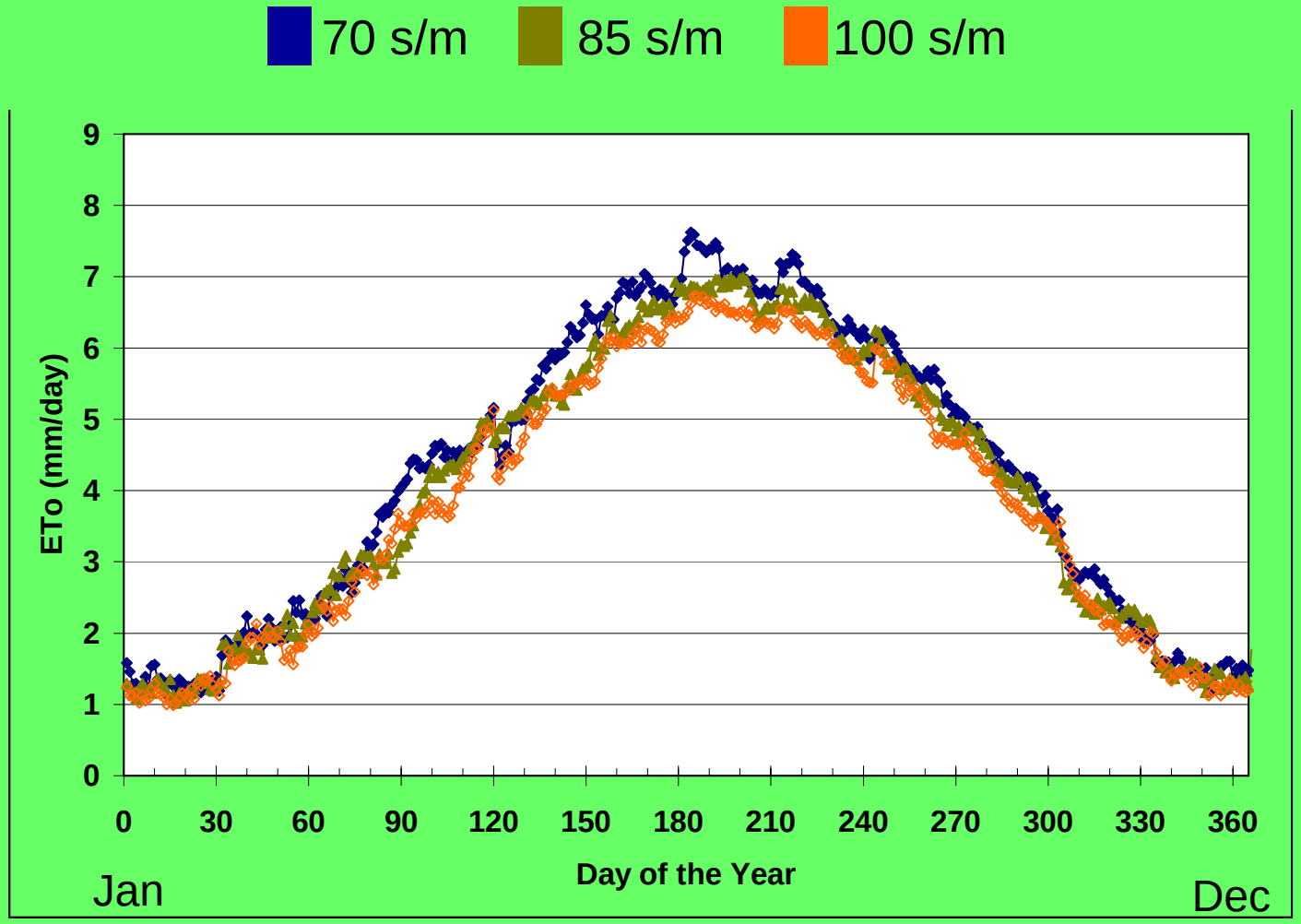


S = solar input
L = longwave radiation
rs = reflected solar
R = reradiated solar
H = sensible heat transfer
E = latent heat transfer
A = assimilation

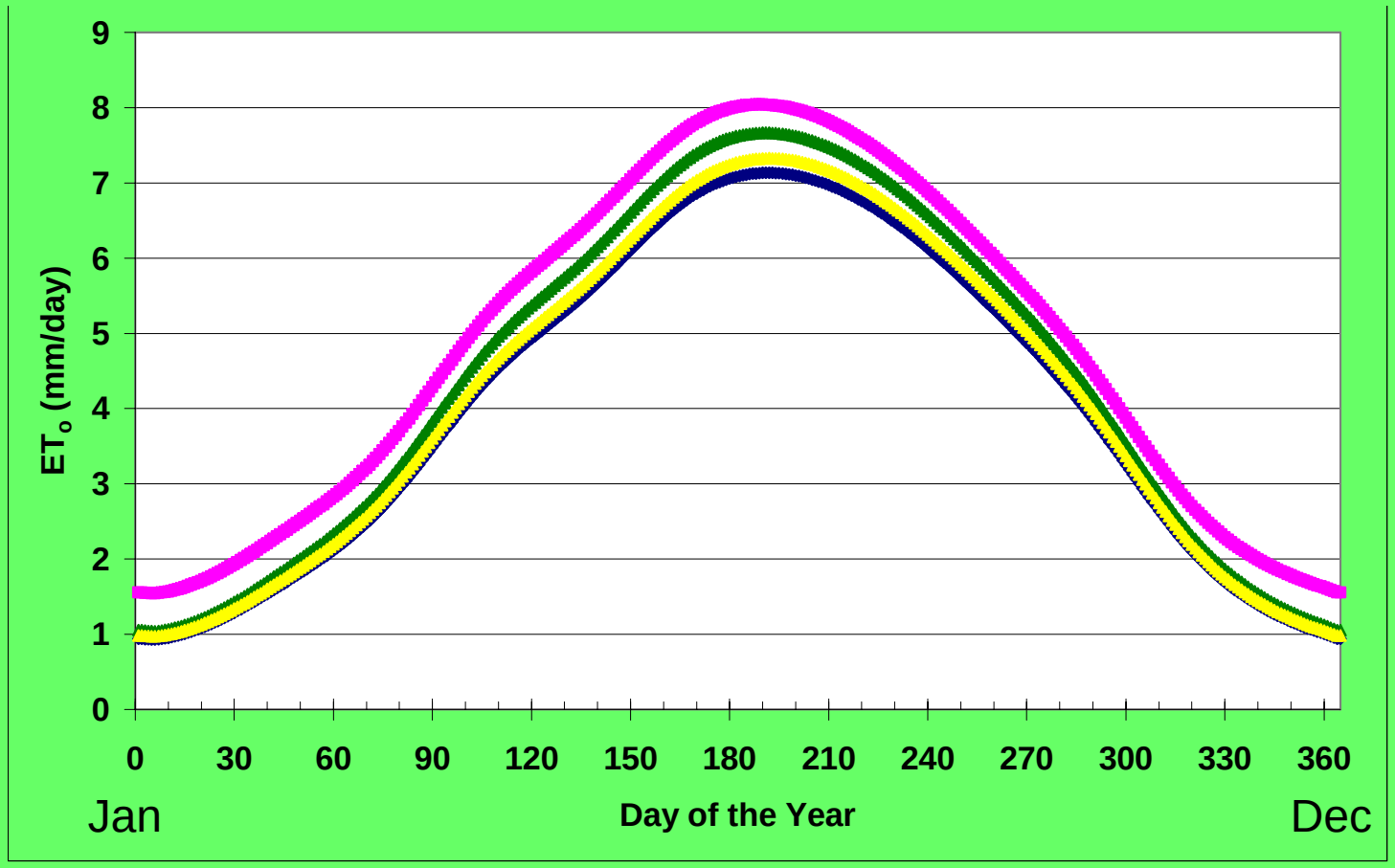
Reference ET at Davis CA



Simulated ET at Three Canopy Resistances



ET Simulations Using Different Climate Change Impacts



Water Saving In ET

- Plant Breading 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

DWR

Conclusions

Evapotranspiration (ET) in California is a Predominant Water Demand

Climate Change Slightly Increases ET

CO_2 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 CO_2 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

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