Climate Change Influences on Biological Components of Evapotranspiration

Roy Peterson

Problem In CO_2 – Temperature Plant Study

- Most ET description rest on an energy budget and depends on a measurement of transpiration
- Need for controlled study
- Plant Boundary layer: horizontal dimension is 100 X's vertical

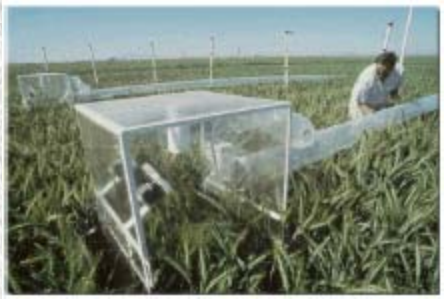
Studying Temperature and CO_2 In Plants

Caltech's Phytotron 1949

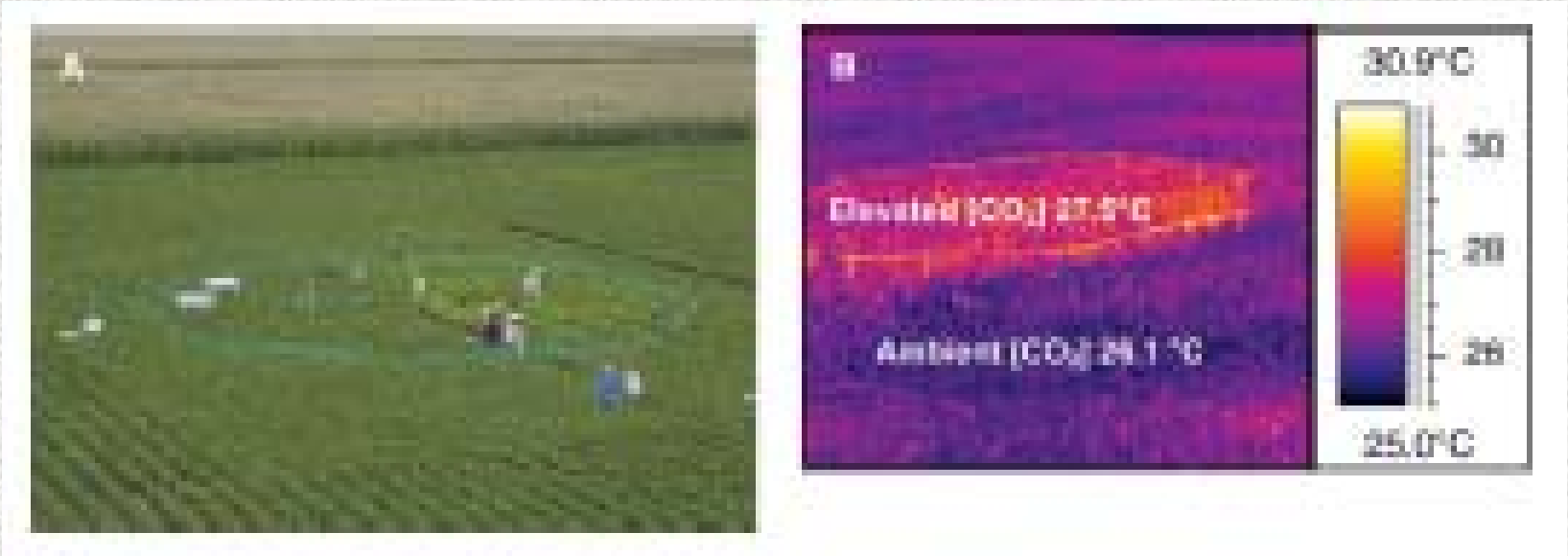
CO_2 Experiments

Growth Chamber

Field Chamber

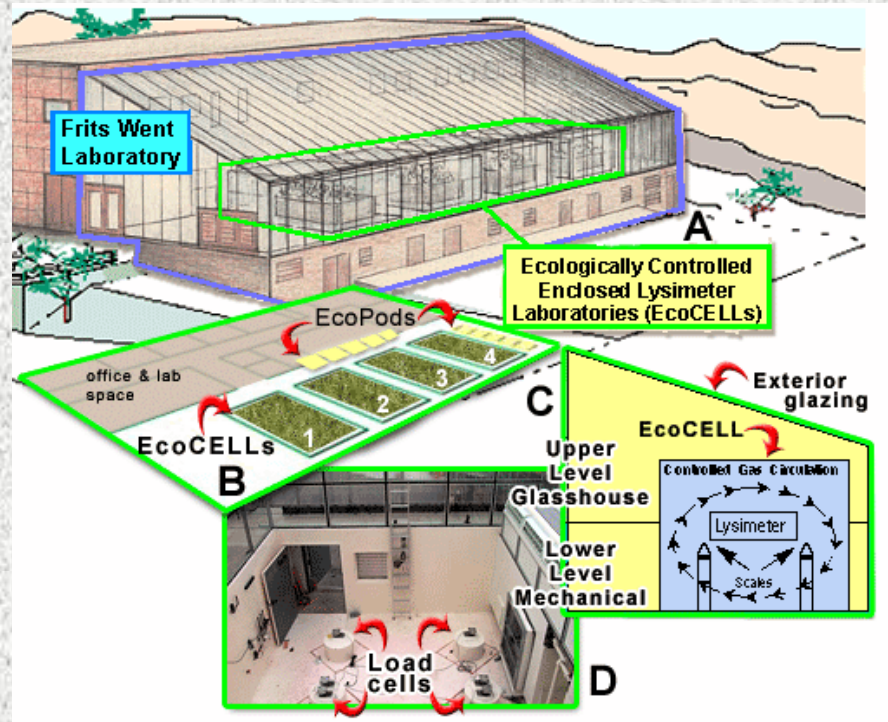


FACE



Long et al Sci 2006

EcoCELL Desert Research Institute



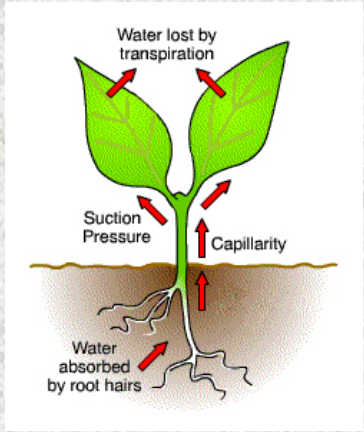
UC Davis Lysimeter

Integrative Biology of Transpiration Stream

Atmosphere

Plant

Soil

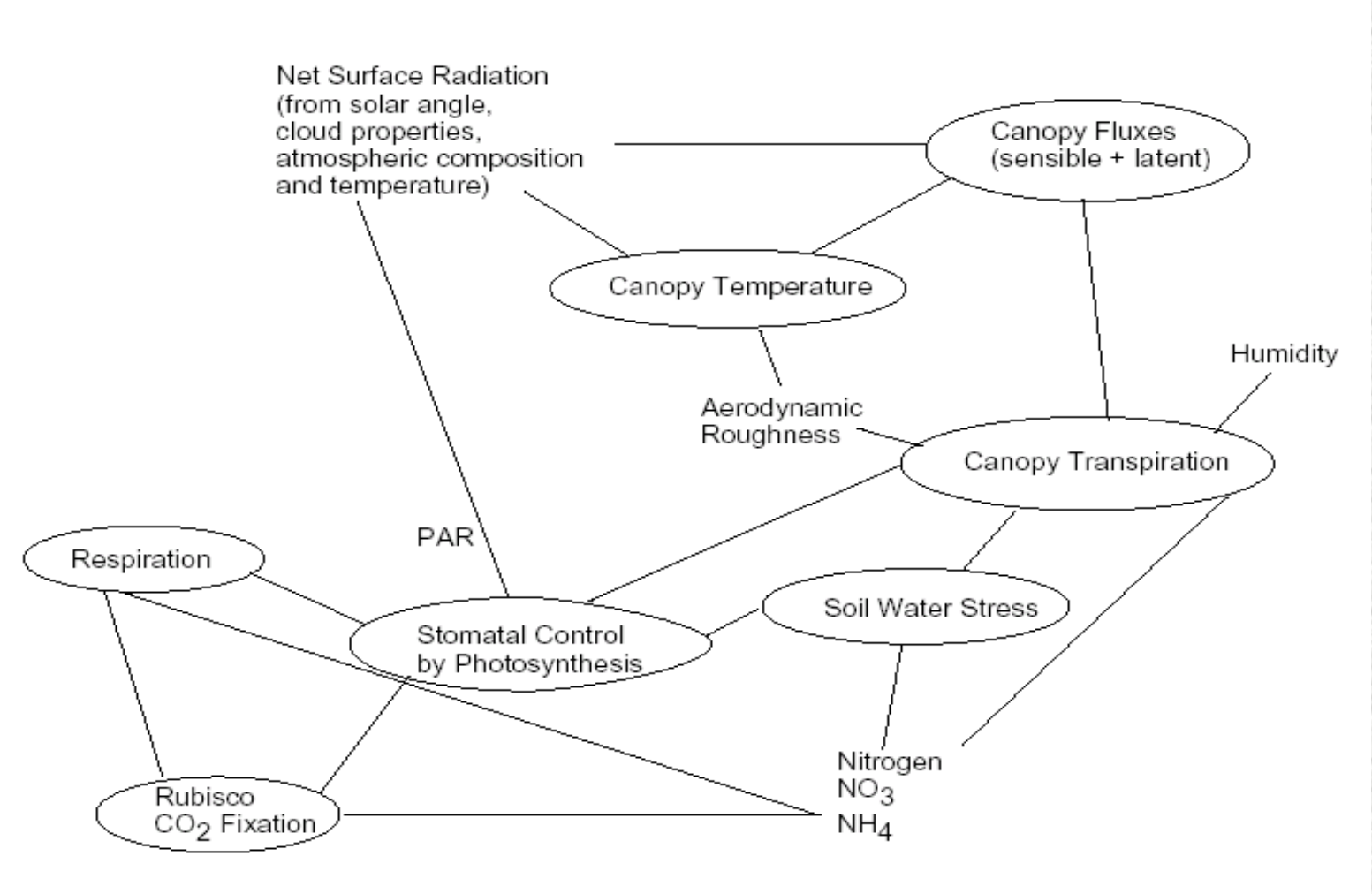


Physical features modulated by the APS continuum
Energy budget: Provision of energy for phase change of liquid water to water vapor
Chemical potential of water which is related to the Gibbs free energy change (temperature, pressure, salts)

Biological Integrative Dimension

- Molecular
- Biochemical – Metabolism and Catabolism
- Cellular
  - Stomatal Density and Arrangement
- Organism
  - Translocation – Source Sink
  - Leaf Area Index
  - Root Density and Structure
- Ecological
  - Soil Microbial Population
  - Plant Competition Multiple spp vs Monocultures
- Biome

Relation of Transpiration and Photosynthesis

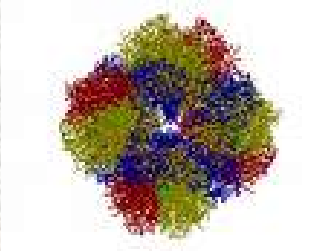


Water Use Efficiency With Temperature & CO_2 Increase

Water Use Efficiency = Assimilation/Transpiration

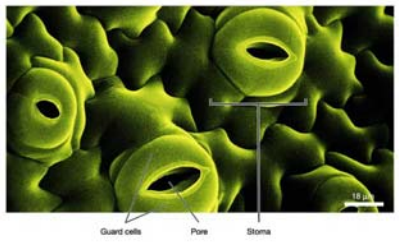
Assimilation (carbon fixation) is related to plant N

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

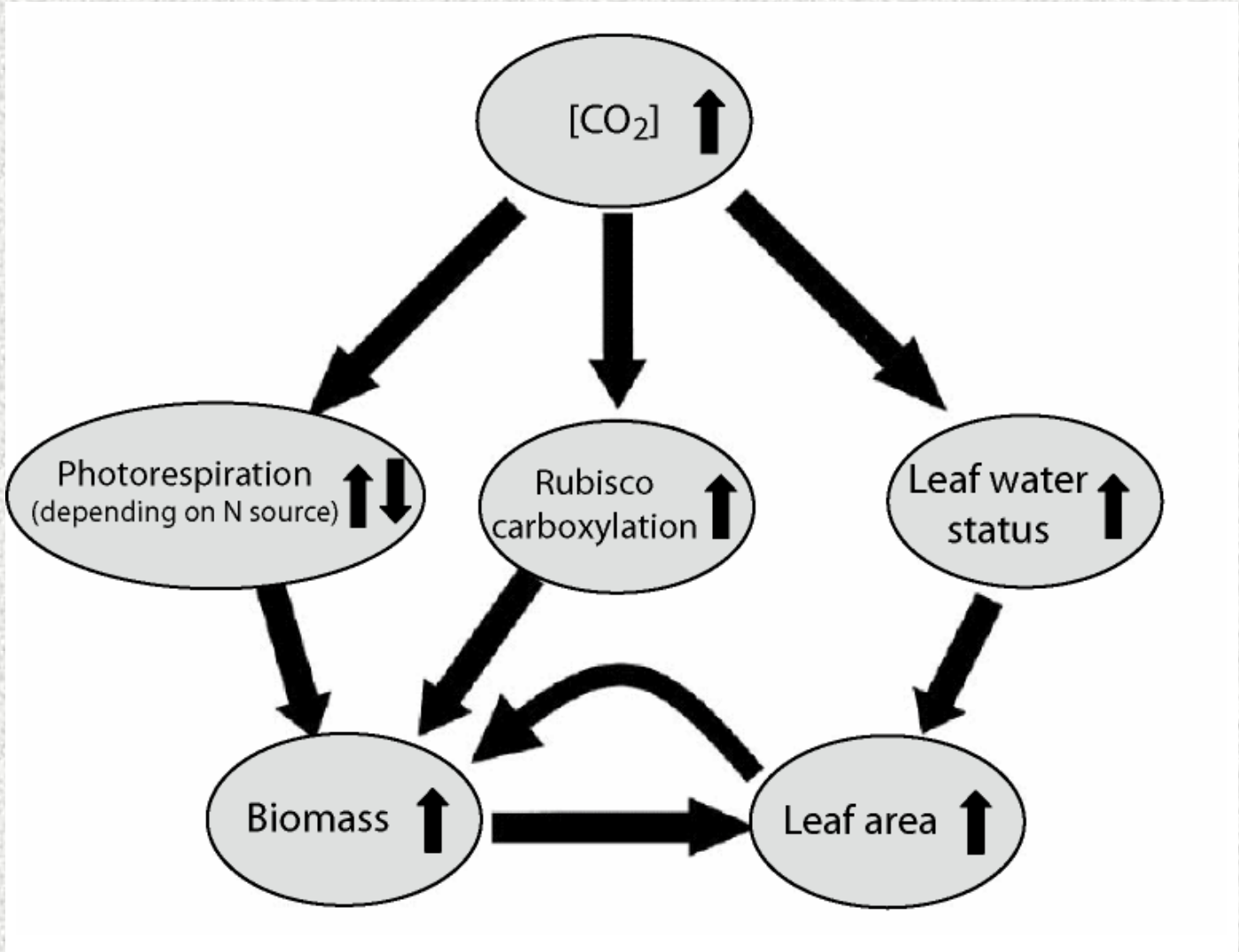


Increased interstitial CO_2 reduces Rubisco inefficiency
At higher CO_2 partial stomatal closure decreases transpiration

Increased leaf temperature increases transpiration



Effects of Increased CO_2 on Plant Production



Modified from Long et. al. 2004

No Free Lunch?

Even in California

Land of Milk and Honey

One Liter of Water Produces One Calorie of Food*

*"Comparative Assessment" by the Consultative Group of International Agricultural Research

Water Relation to Yield and Quality

- Decreased N and corresponding protein at increased CO_2
- Water productivity

Product	kcal/m^3	protein/m^3
Wheat	2279	74
Rice	1989	49
Corn	3856	77
Potato	5626	150

Renault & Wallender 2000

Recent Studies on Plants & Temperature

- Battisi & Naylor in Science 2009
- Arnone and others at DRI in Nature 2008

Contact

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