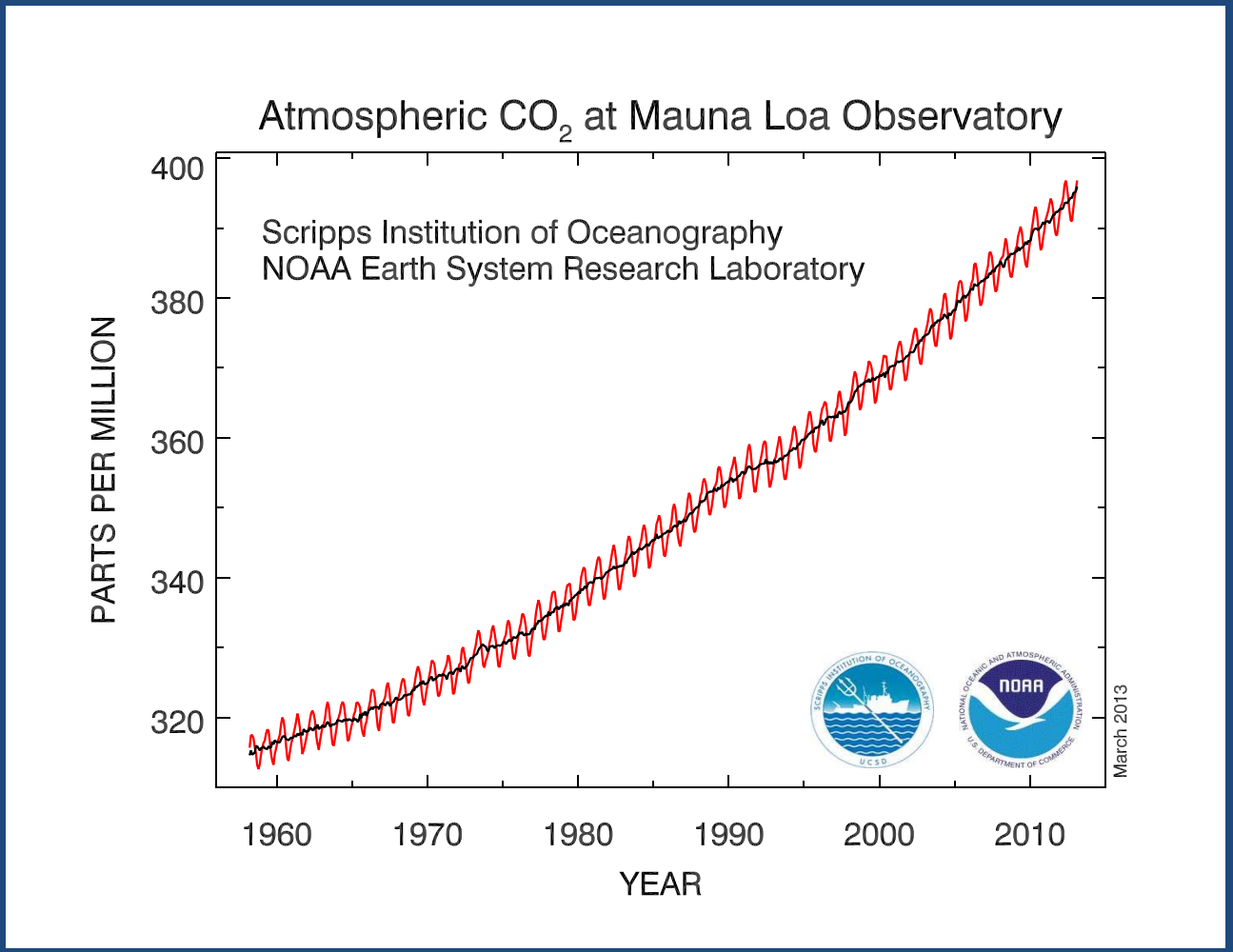
Carbon Budgets in Southern California: Sink or Source?

Darrel Jenerette & Mike Allen

CO_2 and other greenhouse gases are on the increase

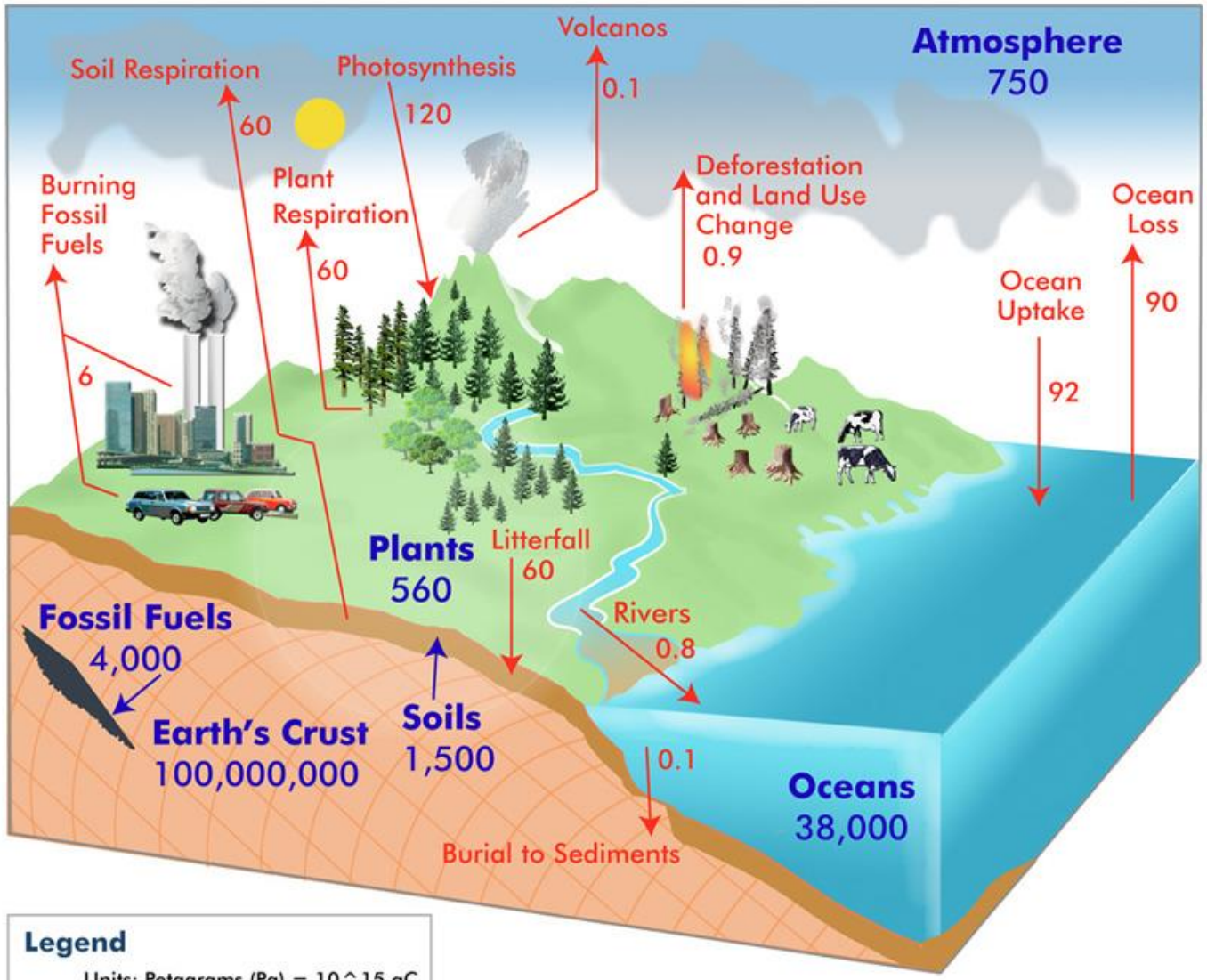
Current:
396.8ppm

450 ppm CO_2
expected:
~2035



Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/).

Global Carbon Cycle

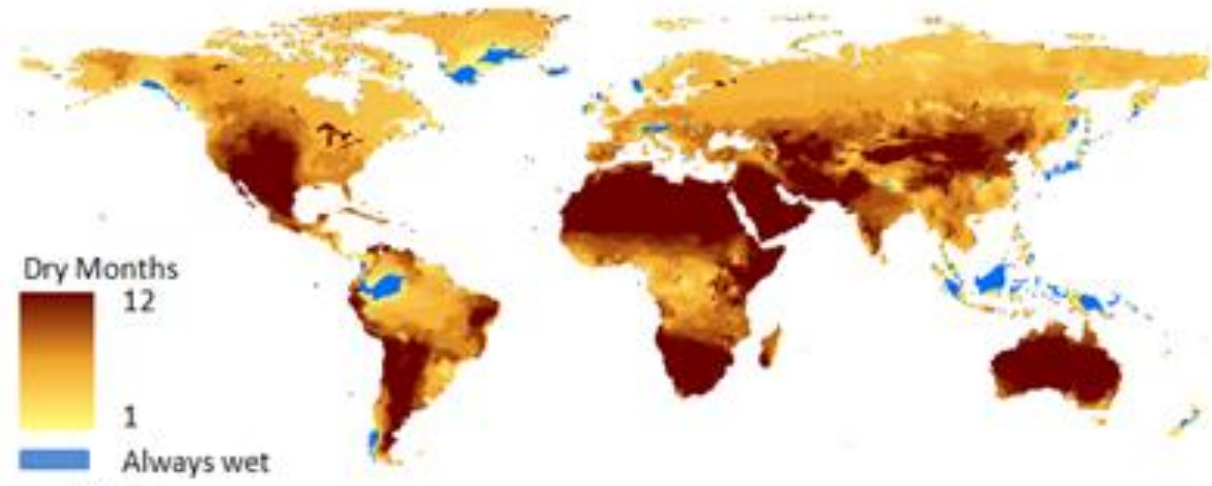


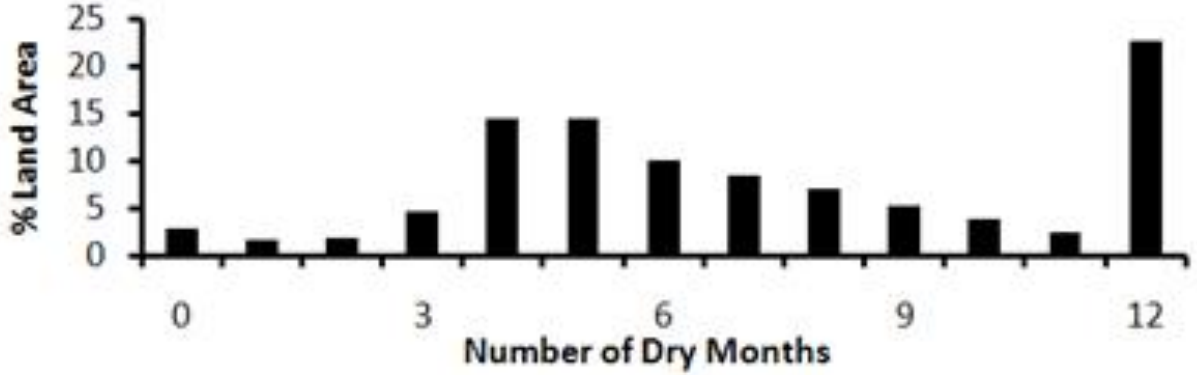
Dryland Soil

241 Pg C

16%

Global Drylands





Desert Carbon Flux and Sequestration

CO_2

Leaf detritus
Root detritus
Microbial detritus

CO_2

recalcitrant CHO

Root detritus
Microbial detritus

CO_2

recalcitrant CHO

$Ca + CO_2 <\rightarrow CaCO_3$

Carbon sequestration is the difference between fixation and respiration, NOT total fixation.

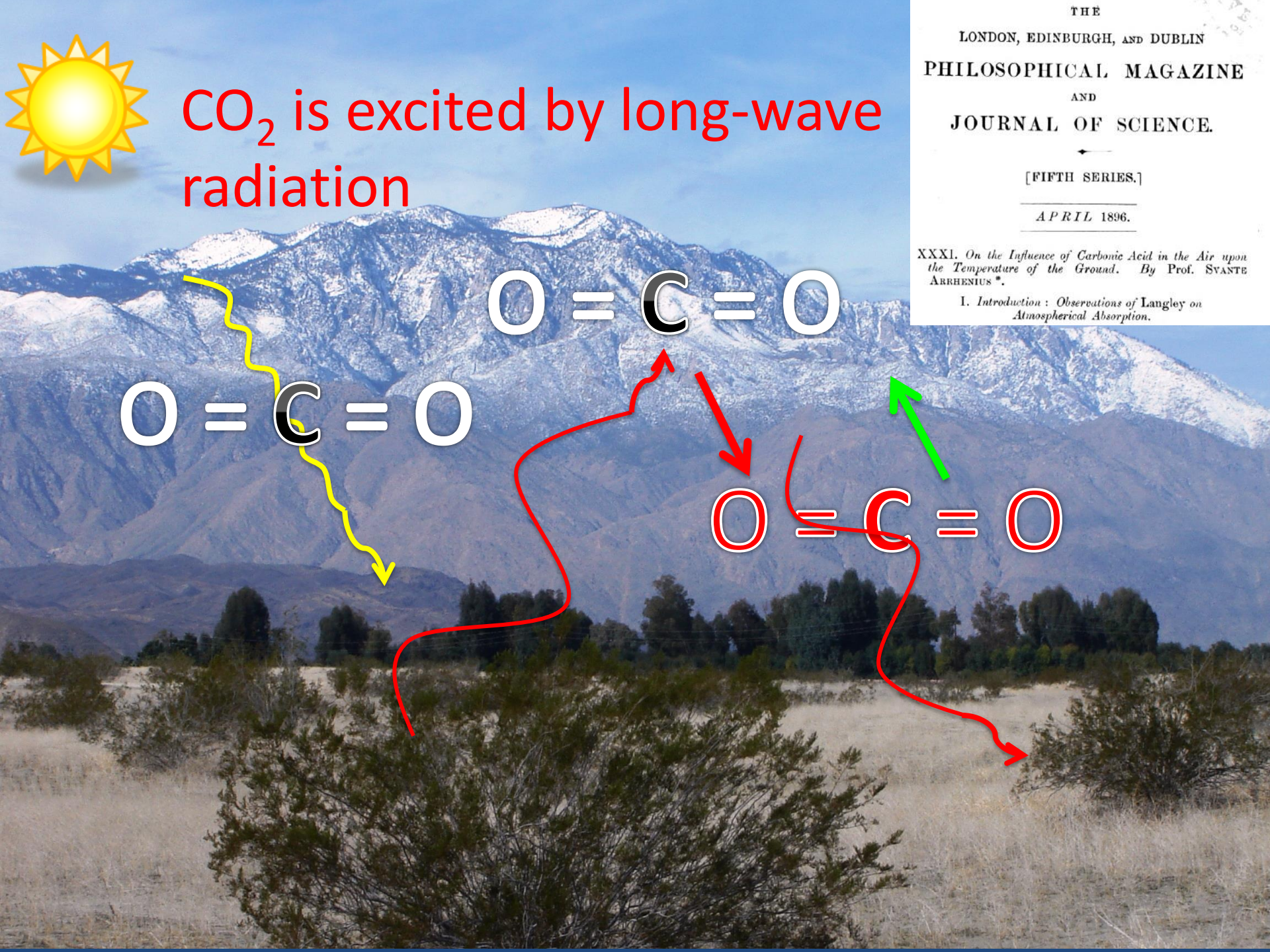
AM fungi fix CO_2
Into aggregates in complex organic C compounds called glomalin

CO_2 Enrichment Has Direct Ecological Effects

- Plant water use efficiency increases
- Secondary compound production increases
- Species interactions may change
  - Native replaced by invasive grasses

Desert CO_2 Enrichment Experiment (Desert Research Institute)

CO_2 is excited by long-wave radiation



THE

LONDON, EDINBURGH, AND DUBLIN

PHILOSOPHICAL MAGAZINE

AND

JOURNAL OF SCIENCE.

[FIFTH SERIES.]

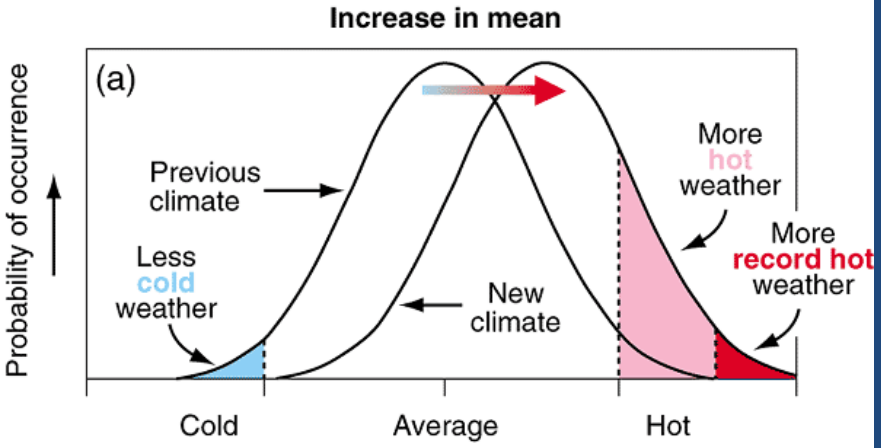
APRIL 1896.

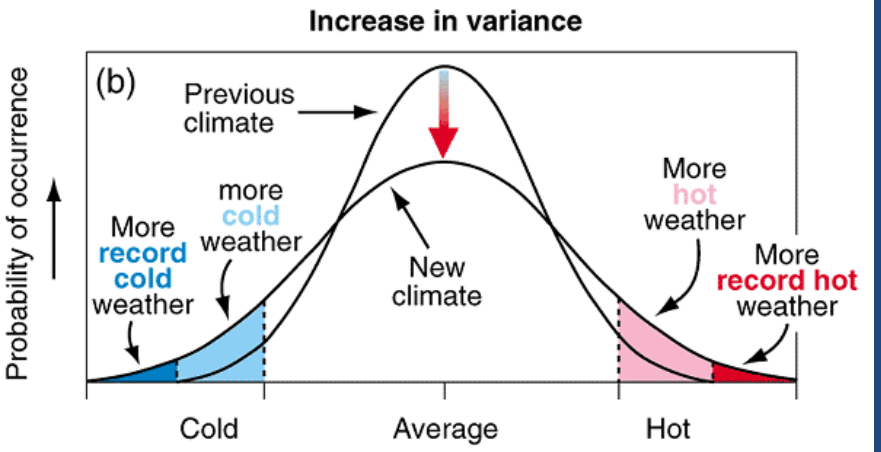
XXXI. *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground.* By Prof. SVANTE ARRHENIUS *.

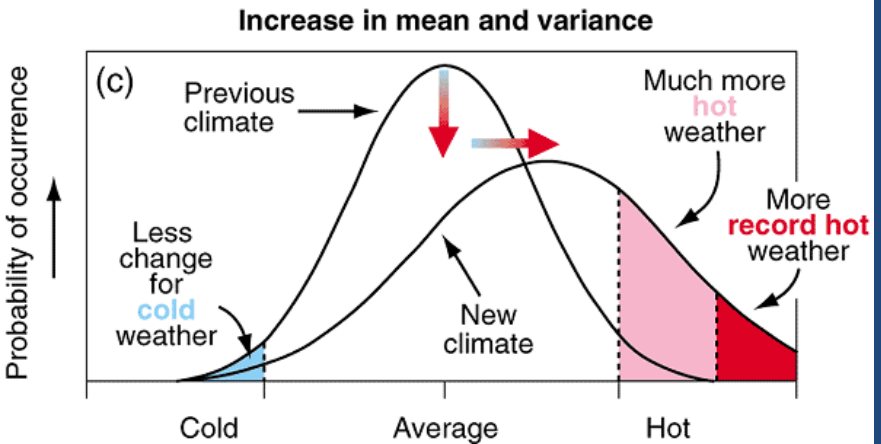
I. *Introduction : Observations of* Langley *on Atmospherical Absorption.*

Ecosystem Sensitivity to Warming

- Faster metabolic rates
- Increased heat stress
- Heat induced mortality







How are these changes manifest in a changing environment?

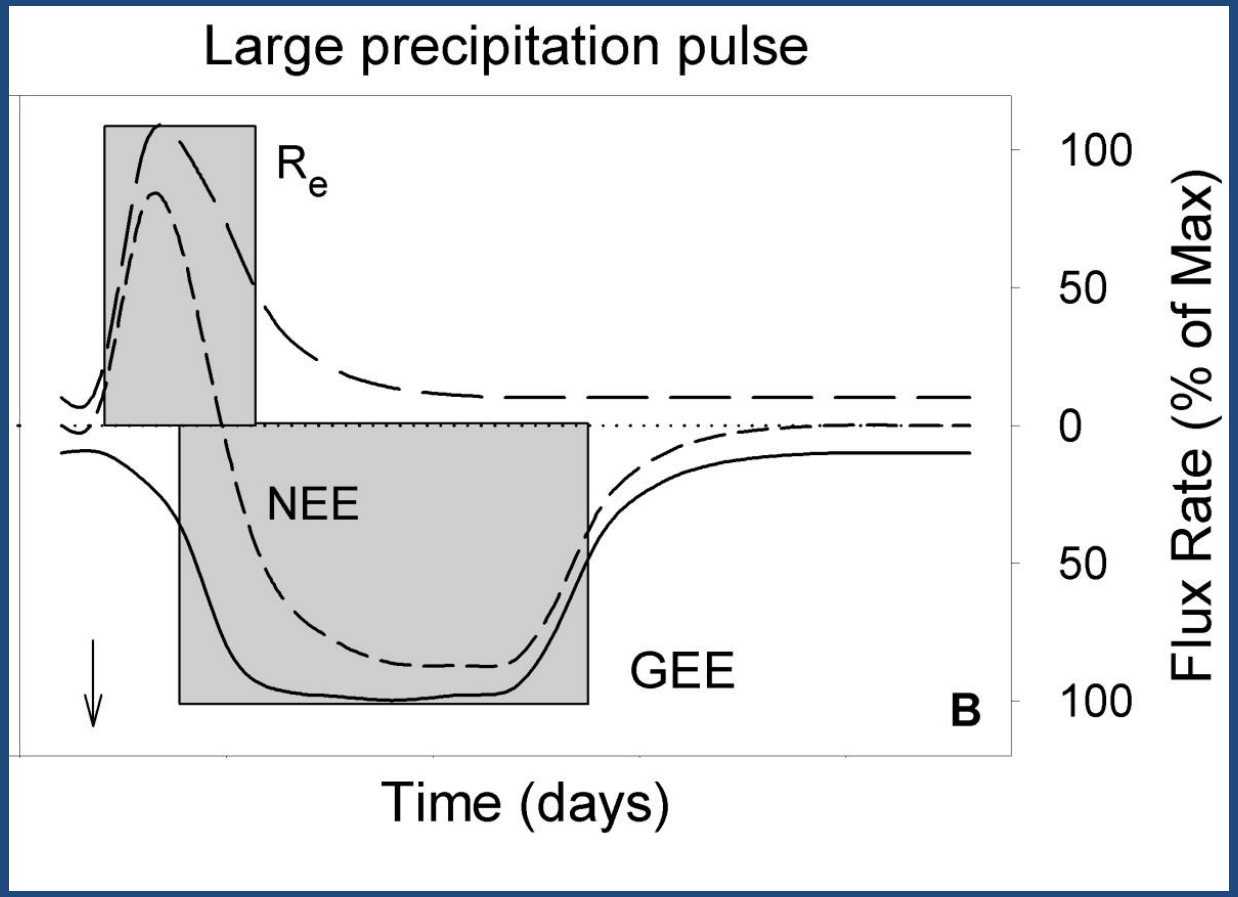
Extreme Heat Index for Phoenix: projections
(EHE = T>45.6oC for >3 days)

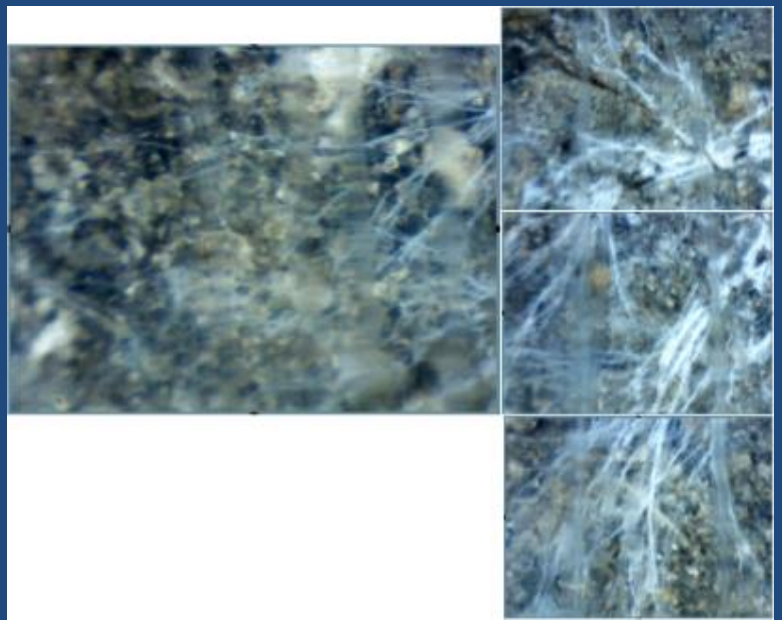
Parameter	Phoenix 1972-2004	Projection 2038-2070
# EHEs	7	55
Days >45.6°C	67	994
Ave Duration of EHE	8	20

Jenerette & Grossman-Clarke

Ecosystem Sensitivity to Precipitation

- Amount, Intensity, Timing
- Events
- Trends

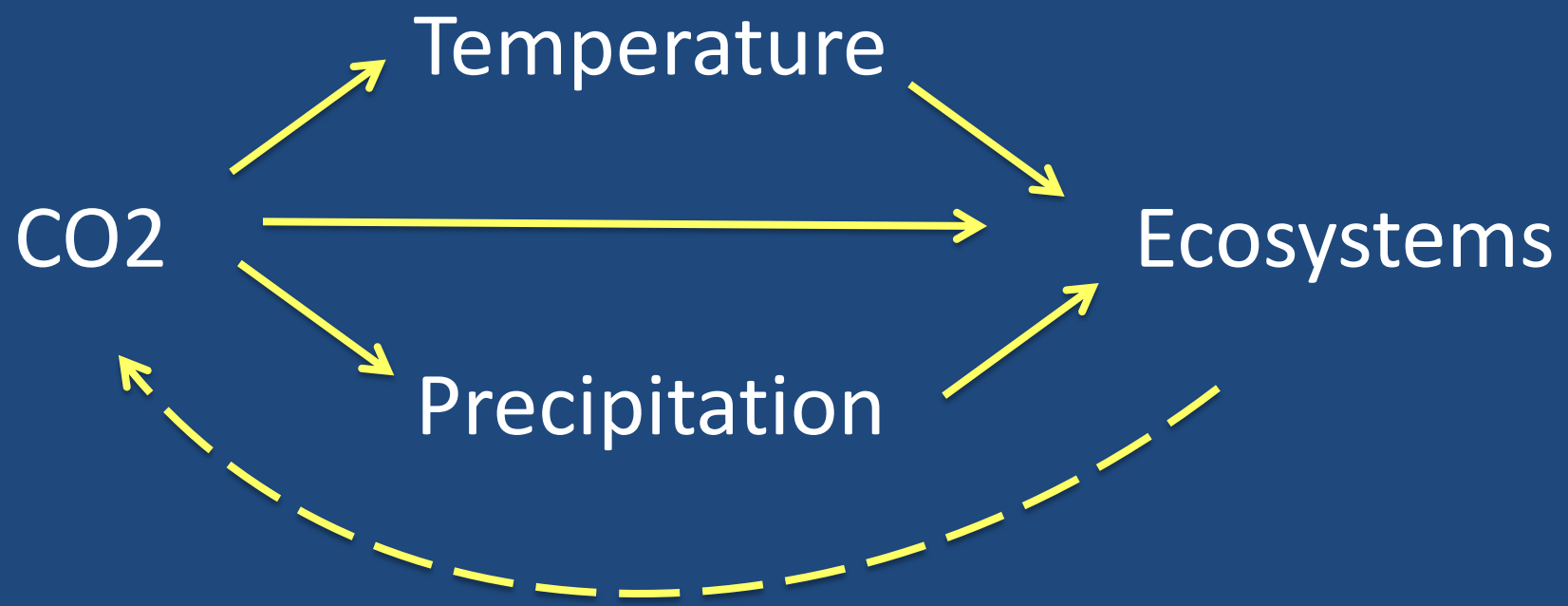




Hyphae in soil during peak drought (left) using hydraulically lifted water.

Hyphae in the granite bedrock (right) accessing water deep in the granite.

Will California drylands sequester or release additional carbon in the future?



Positive or Negative Feedback?

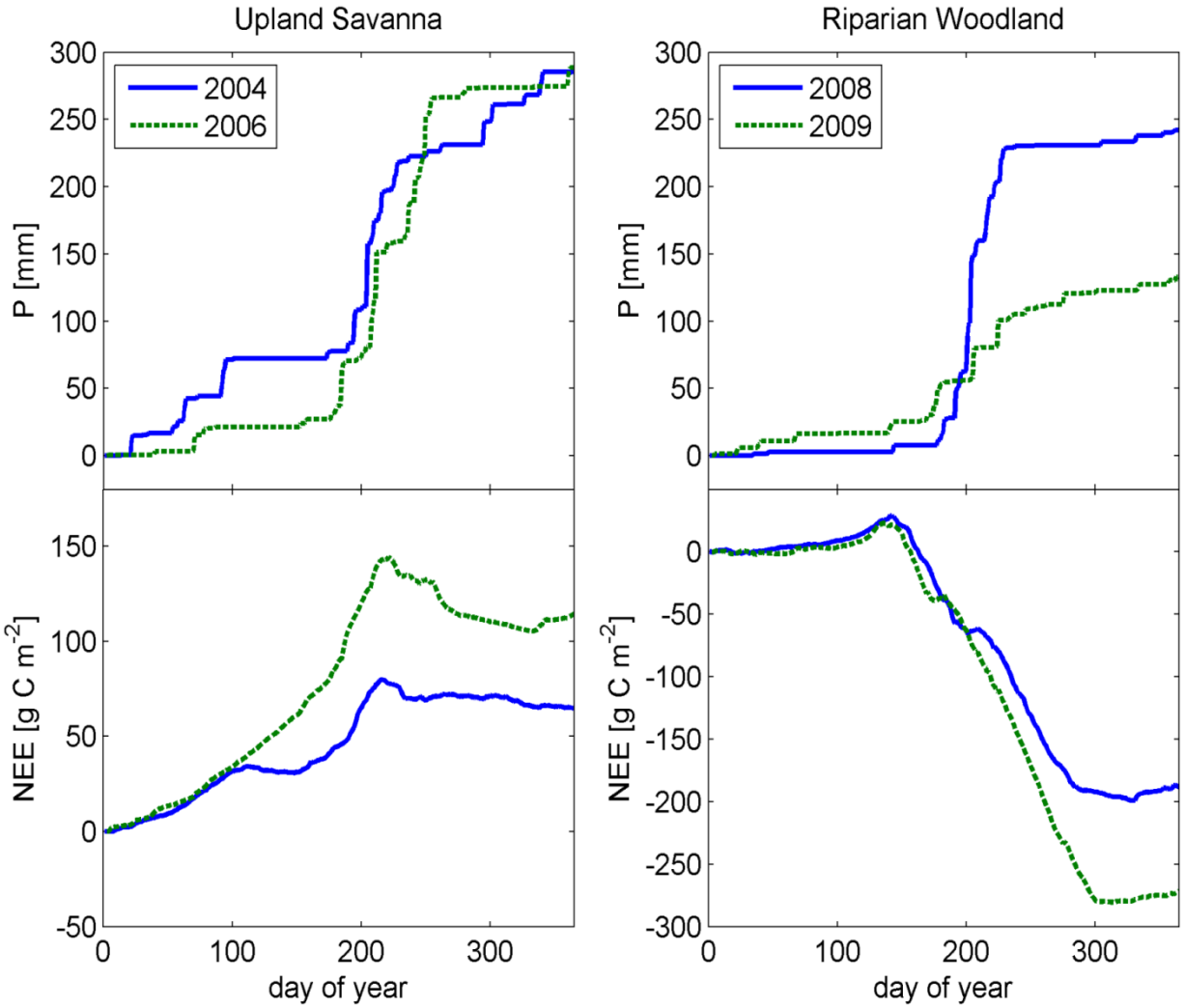
AB 32: Reducing CA Greenhouse Gases

- Reduce GHG emissions to 1990 levels by 2020
- A further 80% cut by 2050
- Critical issues: cap and trade
- Carbon sequestration: what is it really?
  - MORE than forests
  - MORE than wildlands
  - IS MEASURABLE!

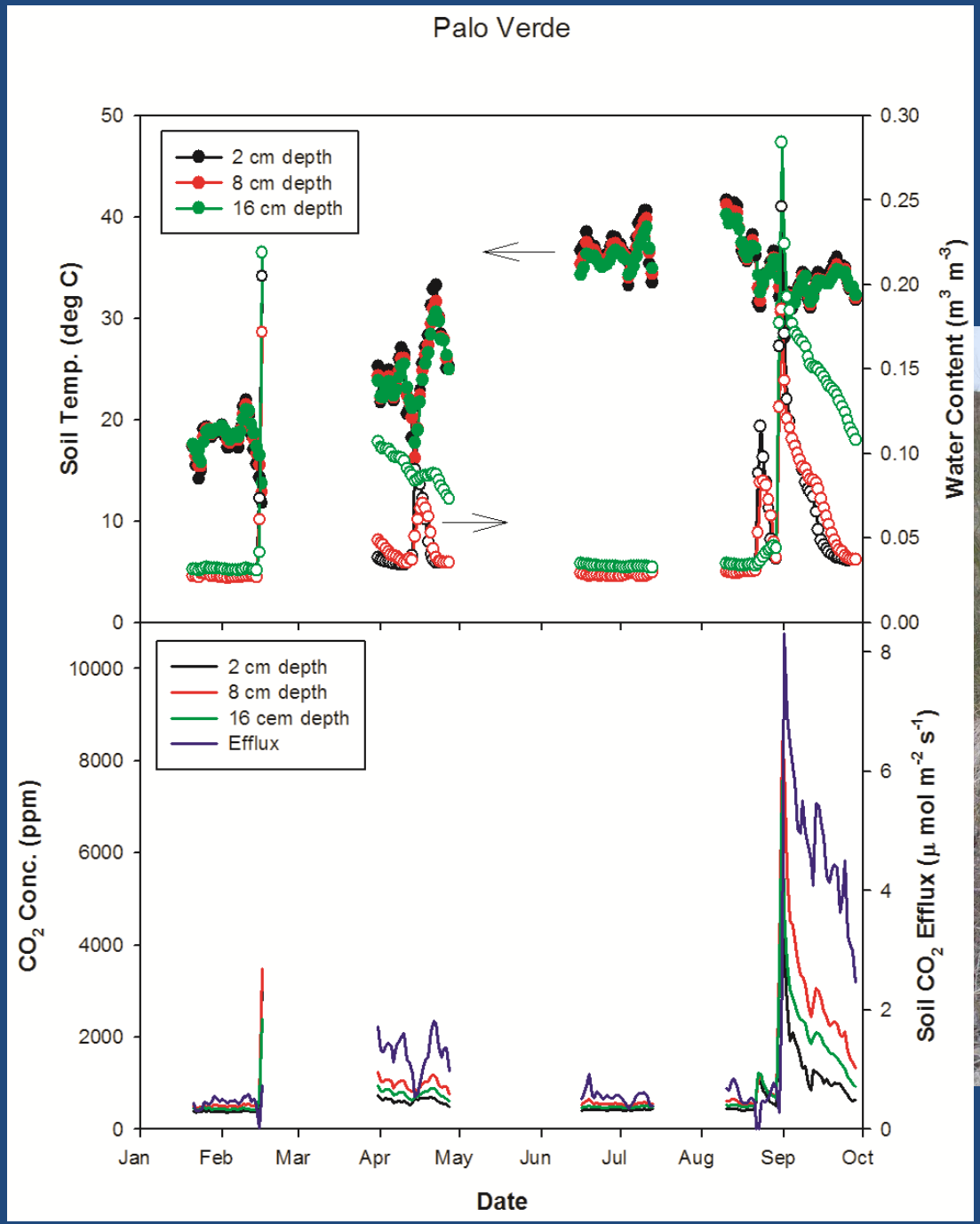
Eddy Covariance

Whole ecosystem carbon measurements

Unexpected Ecosystem Responses to Annual Rainfall



Desert Soil Fluxes



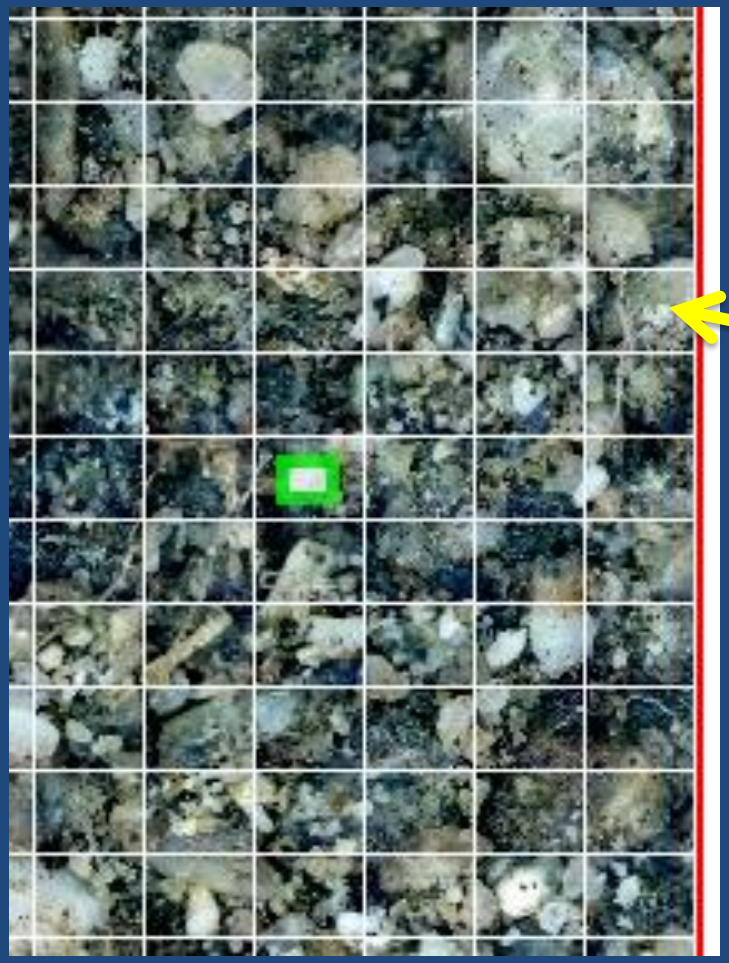
$CaCO_3$:An Unknown Source/Sink

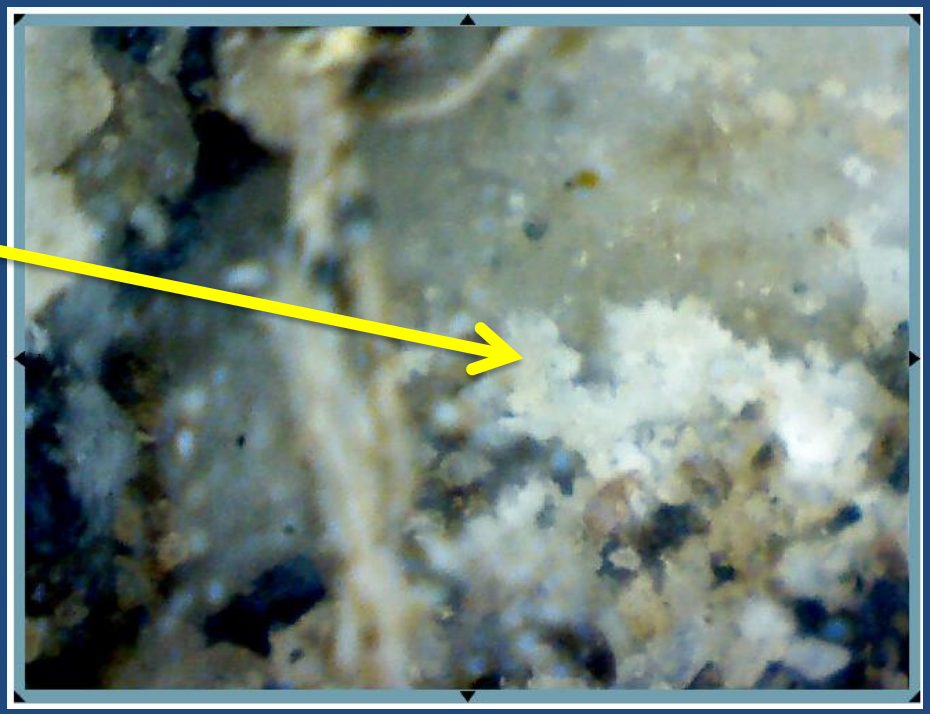
increasing soil atm CO_2

$$CaCO_3 + 2H^+ = Ca_2^+ + CO_2 + H_2O$$

decreasing CO_2, loss of rhizosphere CO_2?

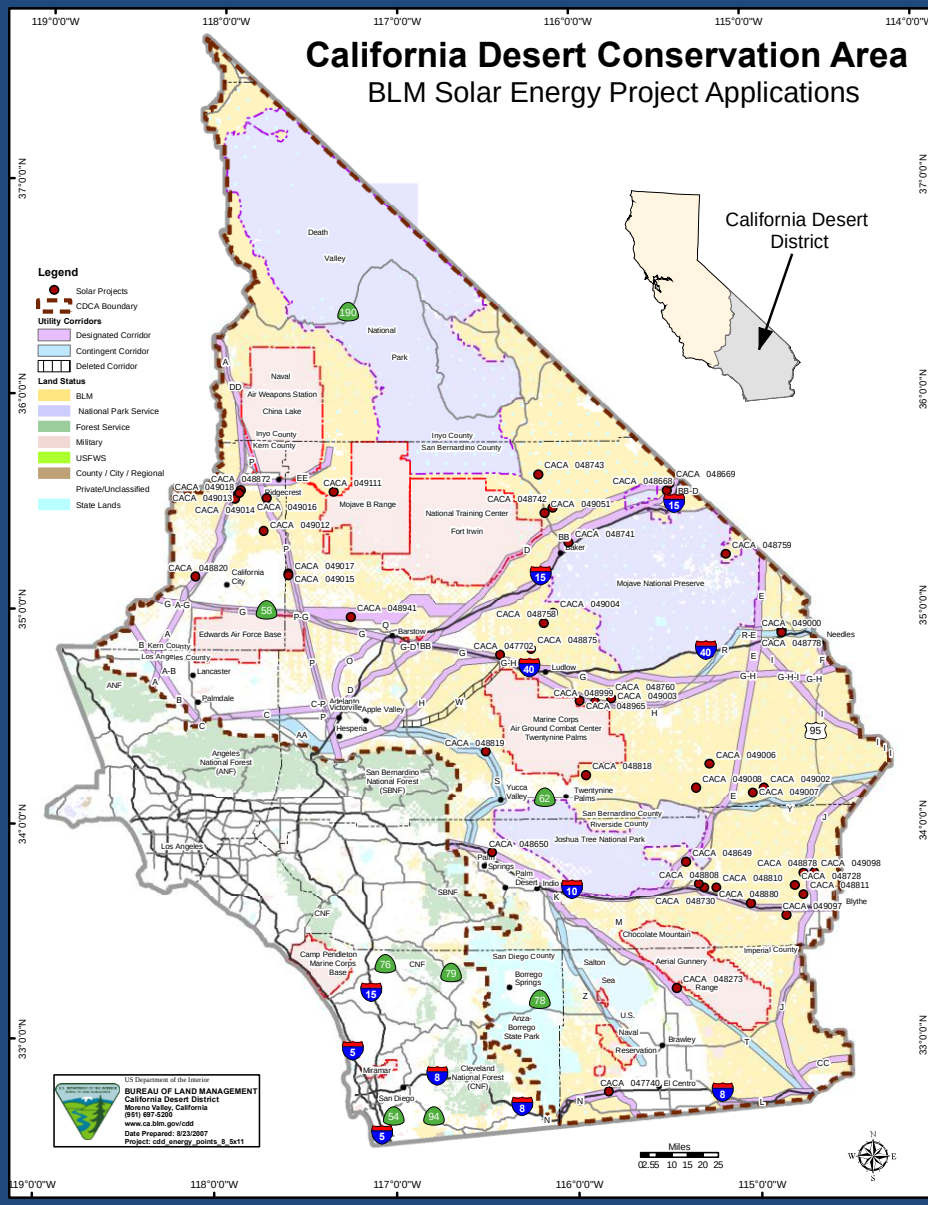
Deep Canyon Dynamic crystals, likely inorganic C such as $CaCO_3$





Mega-Projects: Net CO_2 conservation?

How does stripping vegetation affect soil carbon pools?



Take Away Points

- Rising CO_2 has direct and climate induced effects on ecosystem carbon storage
- Dryland carbon fluxes and storage pools are measureable and have large uncertainties
- Interactions between organic and inorganic carbon pools can affect long term ecosystem source or sink dynamics
- Vegetation removal may cause loss in soil carbon pools

END

$CaCO_3$: An unStable Sink?

$CO_2 + H_2O \rightarrow HCO_3^- + H^+$ (roots, AM fungi)

$CaPO_4 + HCO_3^- + H^+ \rightarrow HPO_4^- + CaC_2O_4$ (roots, AM fungi)

(Jurinak et al. 1986)

$CaC_2O_4 + H_2O \rightarrow Ca^{2+} + H_2O + CO_2 \rightarrow Ca^{2+} + HCO_3^-$ (bacteria, fungi)

(Morris & Allen 1994)

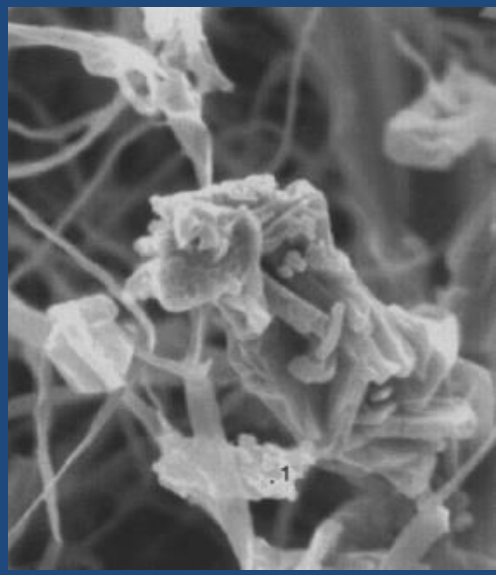
$Ca^{2+} + HCO_3^- \rightarrow CaCO_3 + 2H^+$

$NOx + H_2O \rightarrow O_3 + HNO_3^-$ (air pollution)

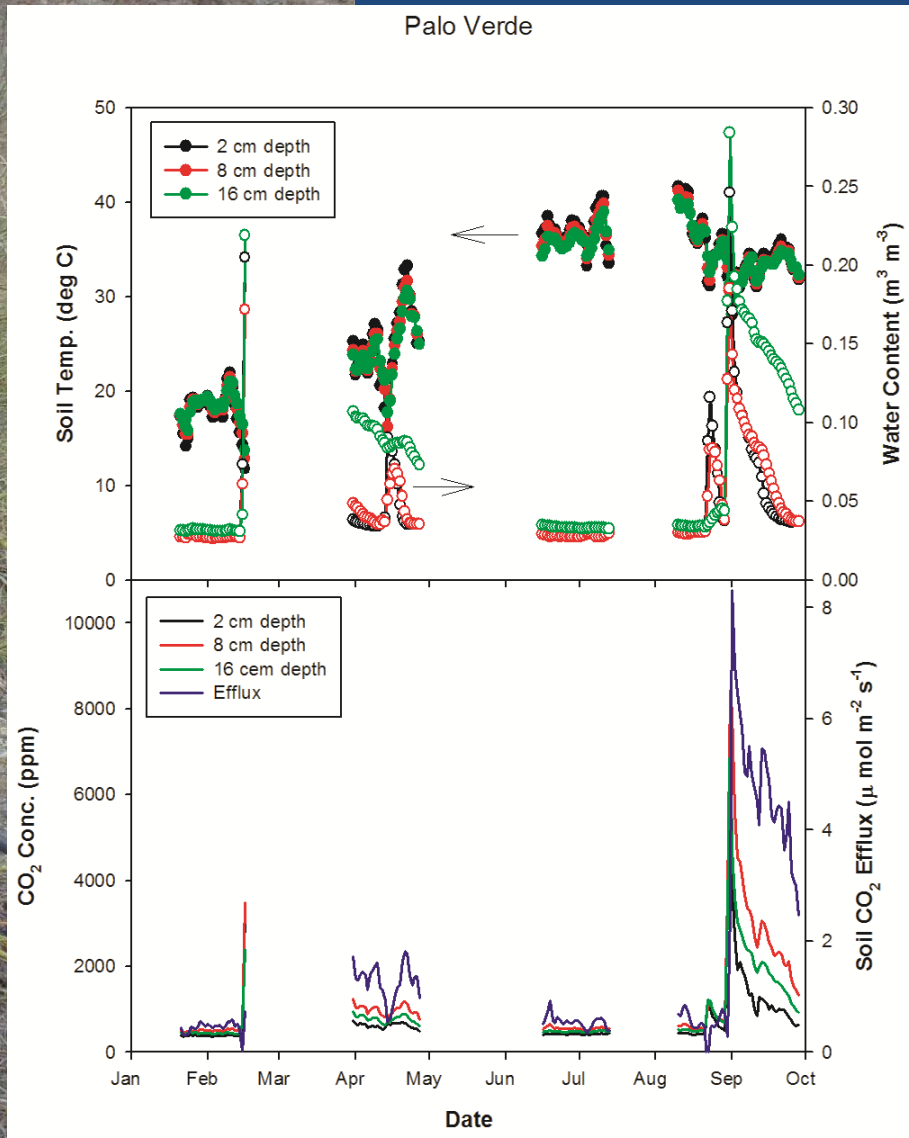
$HNO_3^- + NH_4^+ \rightarrow H^+_{(excess)} + CaCO_3 \rightarrow CO_2 + Ca^{2+}$

Weathered caliche

$CaCO_3$ and CaC_2O_4 crystals



Deep Canyon Desert Fluxes



Carbon Budget of Desert Riparian woodlands: no good data!!