

REDUCING GREENHOUSE GAS EMISSIONS WITH AGRICULTURE

A FORTHCOMING ARPA-E FUNDING OPPORTUNITY

Joe Cornelius, Ph.D.
Program Director
Advanced Research Projects Agency – Energy

March 2, 2016



IMAGINE!

Direct Carbon Sequestration Technology:

- 
- ✓ **No Capital Cost**
 - ✓ **Market-Pull**
 - ✓ **Scale**

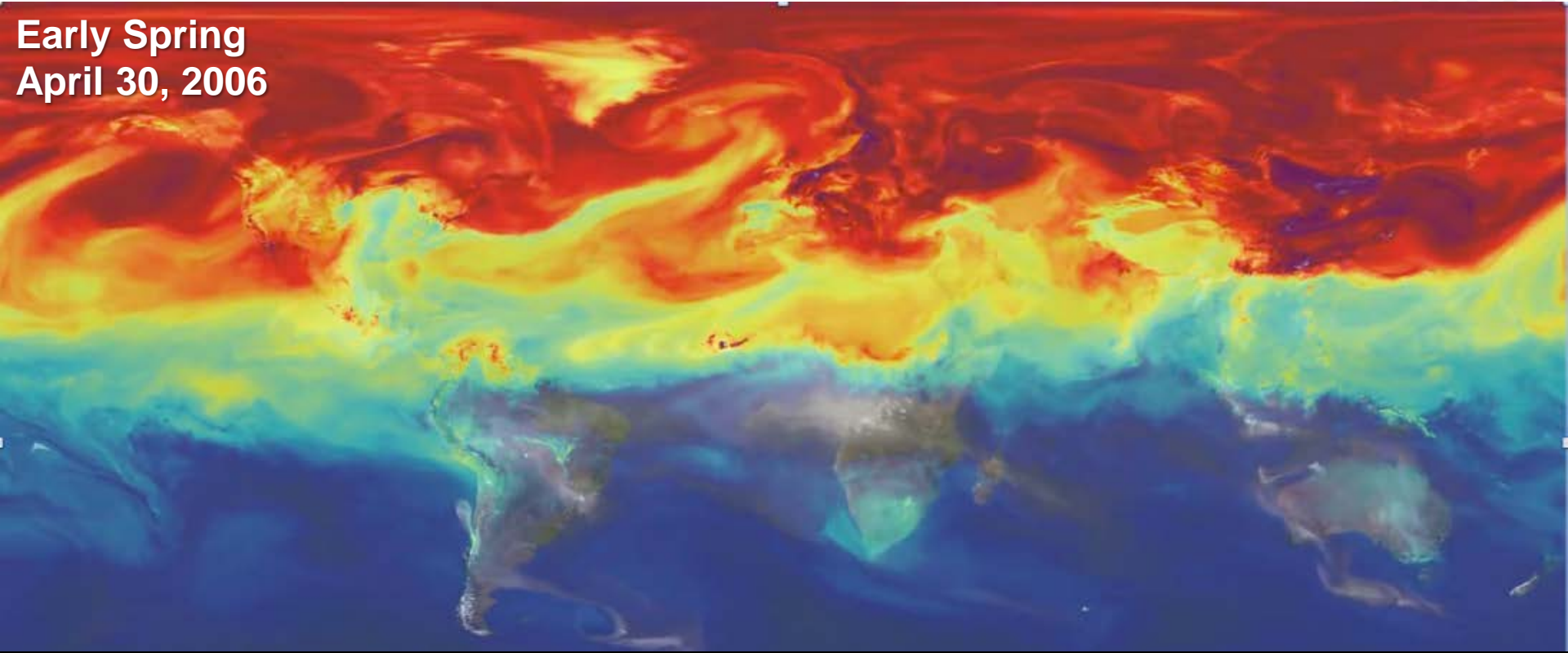
BIO-Sequestration: Agriculture

- ✓ **Capital:** Seeds are software.
- ✓ **Market:** Carbon creates value.
- ✓ **Scale:** Genetics are distributed.



ATMOSPHERIC CO₂ SEASONAL FLUCTUATIONS

Early Spring
April 30, 2006

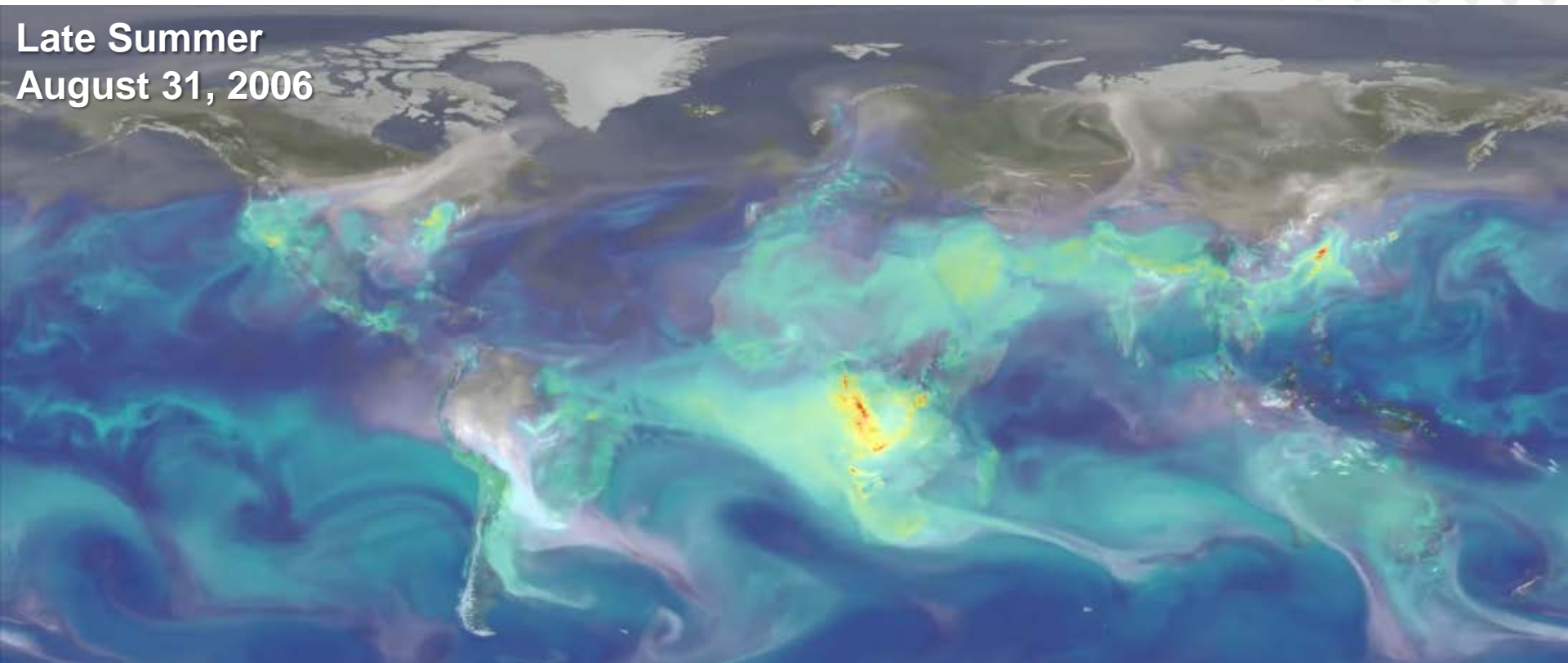


Carbon Dioxide Column Concentration (ppmv)



ATMOSPHERIC CO₂ SEASONAL FLUCTUATIONS

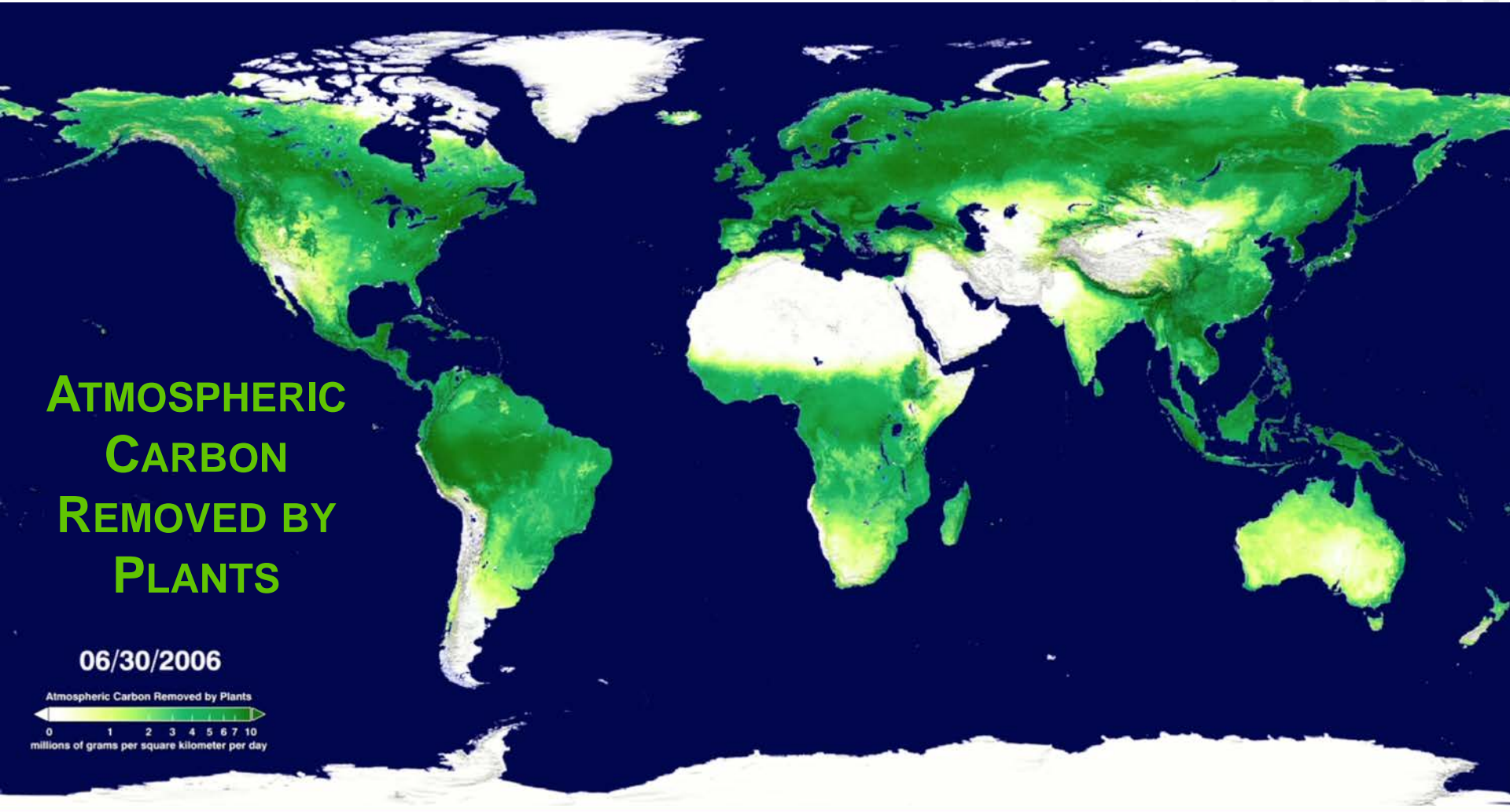
Late Summer
August 31, 2006



Carbon Dioxide Column Concentration (ppmv)

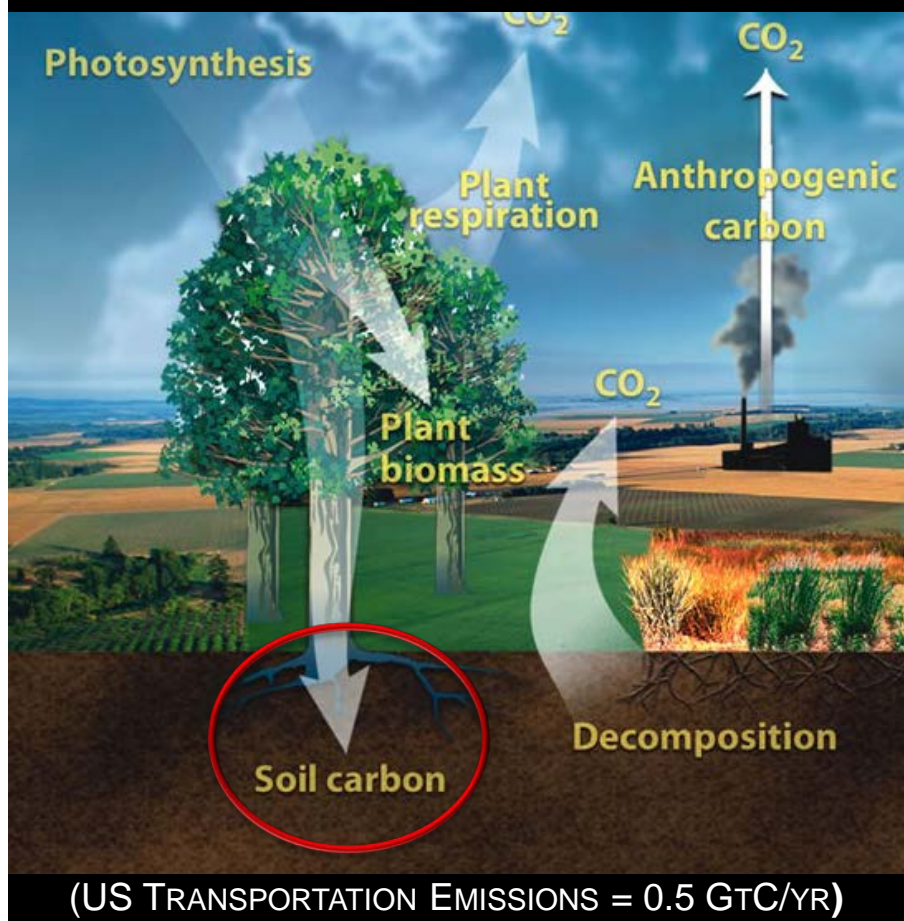


TERRESTRIAL PHOTOSYNTHETIC PRODUCTIVITY



Terrestrial GHG Mitigation Potential

HOW DO WE DOUBLE SOIL CARBON STORAGE?



Terrestrial PLANT Carbon Uptake ~120 GTC/Y

Short Term Carbon Uptake

Medium Term Carbon Storage

Long Term SOIL Carbon Storage

NET: 3 GTC/Y (~0.25 USA)



Plant Respiration



Microbial Respiration



Land Disturbance

Deep Roots are a Triple Win

1. Carbon:

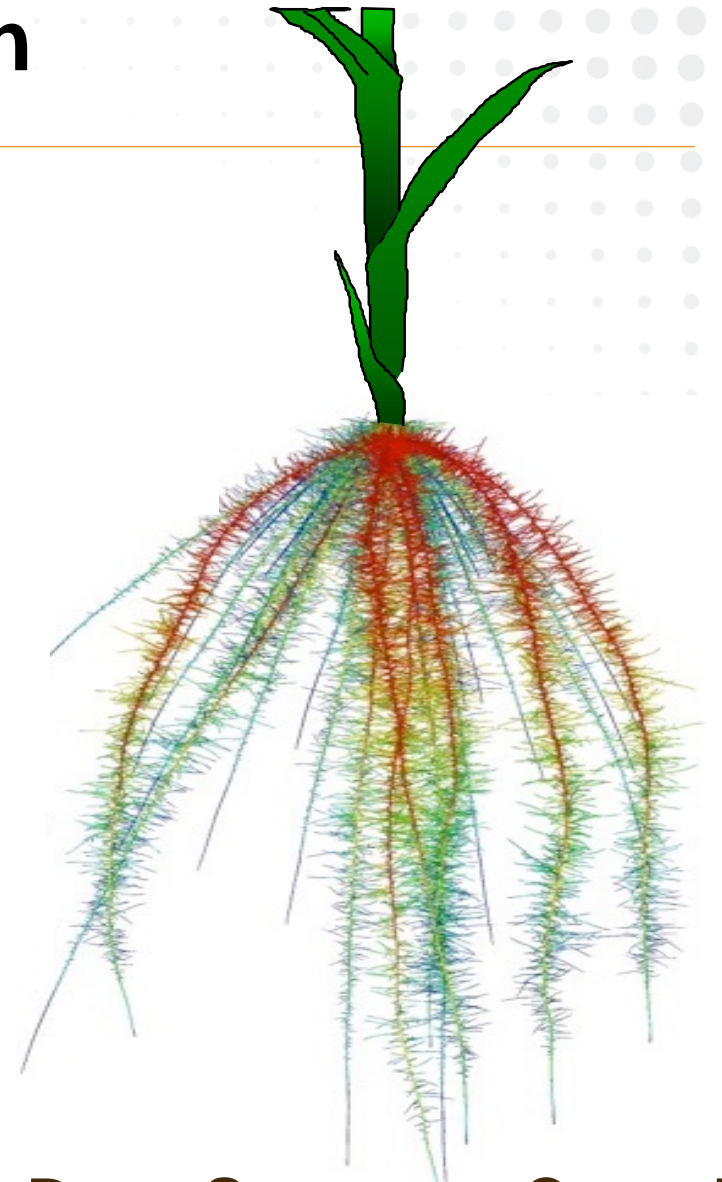
- Fix and Sequester Atmospheric CO₂
- Enhance Soil Quality
(physical, chemical, biological)

2. Nitrogen:

- Improve Nutrient Use Efficiency
- Reduce Fertilizer Runoff
- Raise Crop Yield Potential

3. Water:

- Boost Soil Water Holding Capacity
- Provide Crop Yield Assurance
- Enhance Crop Climate Resilience



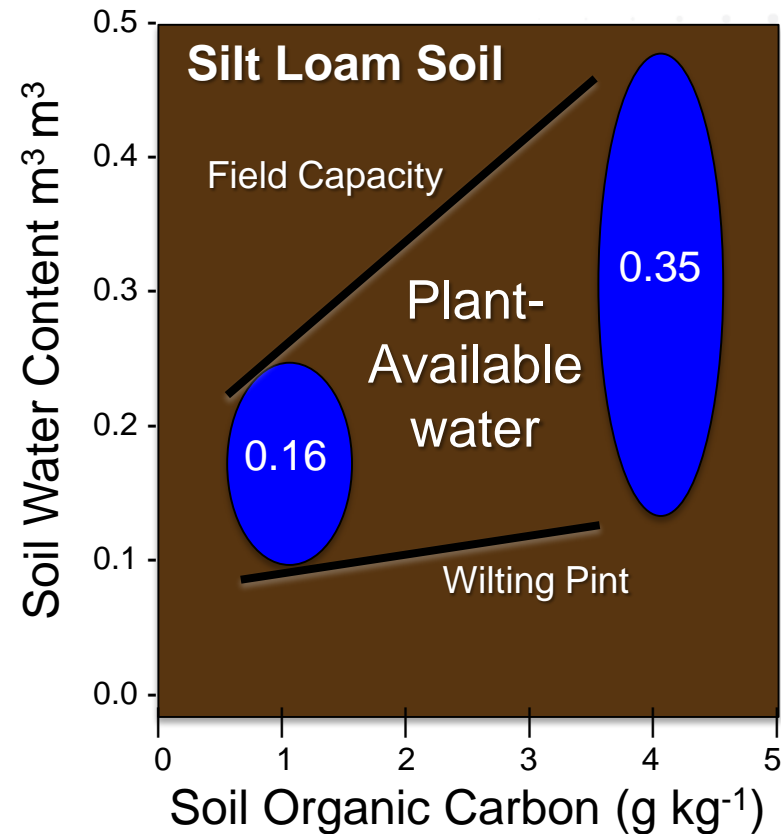
DEEP, STEEP AND CHEAP!

Value Added Carbon Sequestration

Organic Matter Boosts Soil Nutrients and Water Holding Capacity

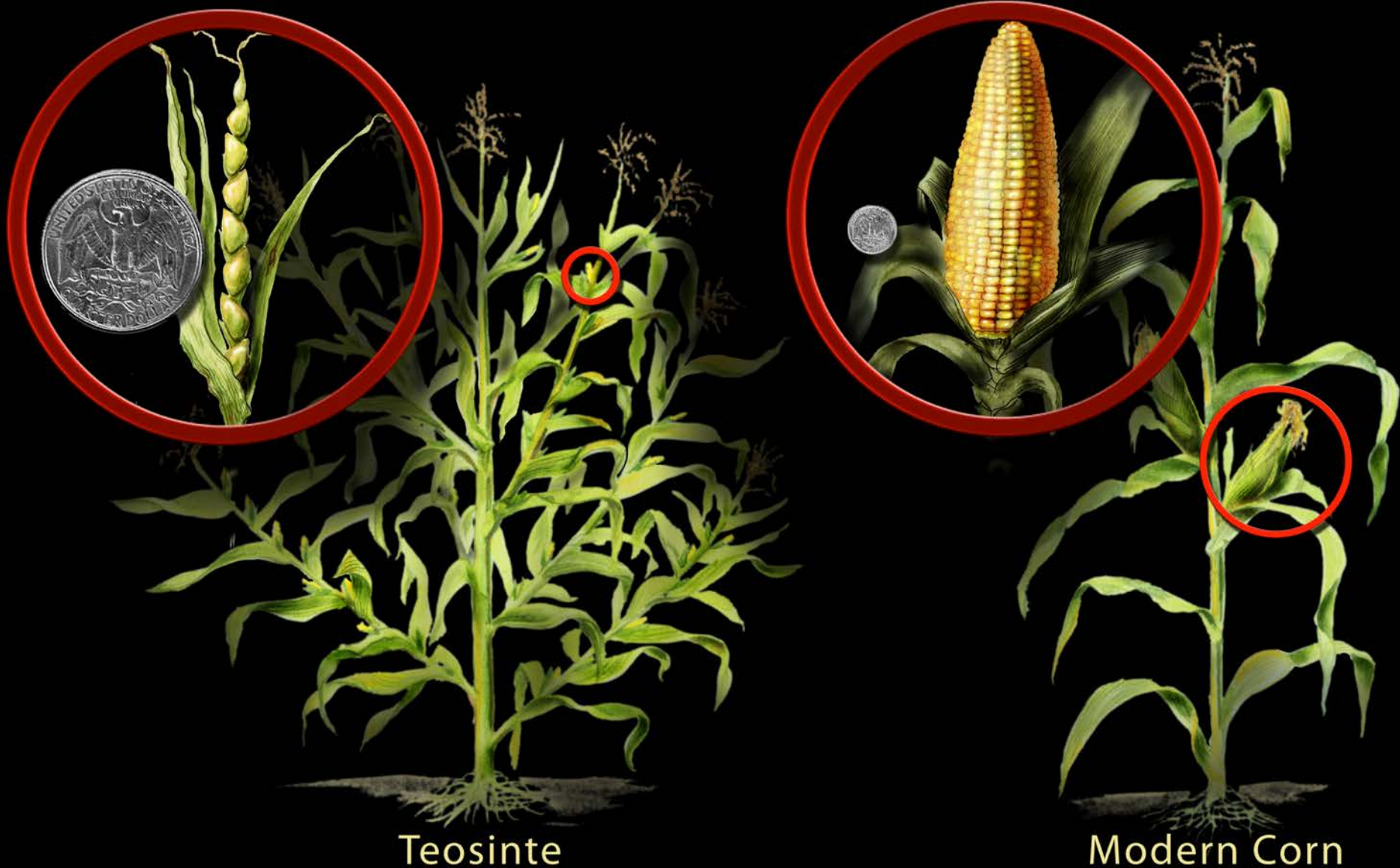


“Every 1% of SOM is ~ \$15 worth of nutrients [/yr/acre]”
(Land Stewardship Project)



Franzluebbers, A. J. (2010) ; Hudson, B. D. (1994).

Plant Breeding is Transformational... For What We Can See



Evaluating Roots & Soils - Slow & Expensive



New Tools Are Needed!

Breeding Tools for Root – Soil Rhizosphere

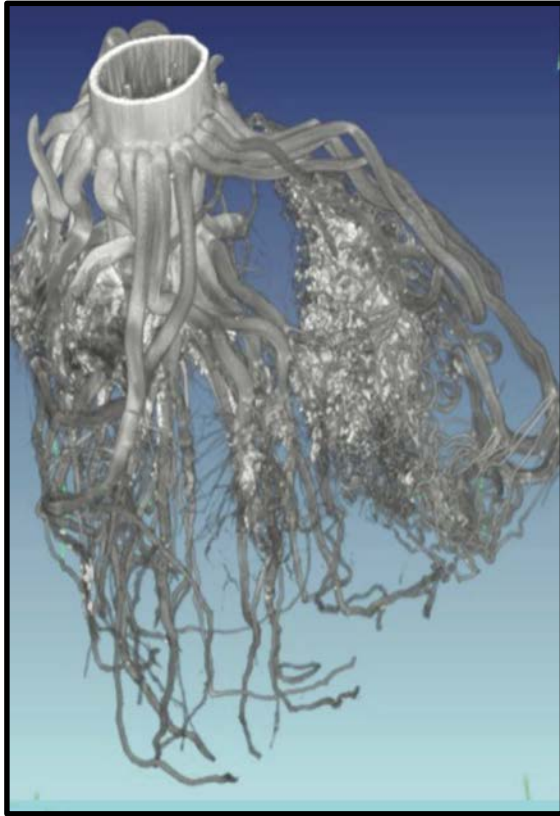


ADVANCING PLANT GENETICS BY DEVELOPING

1. FIELD DEPLOYABLE **ROOT SENSORS**
2. HIGH THROUGHPUT **SOIL SENSORS**
3. INTEGRATED ROOT-SOIL **MECHANISTIC MODELS**

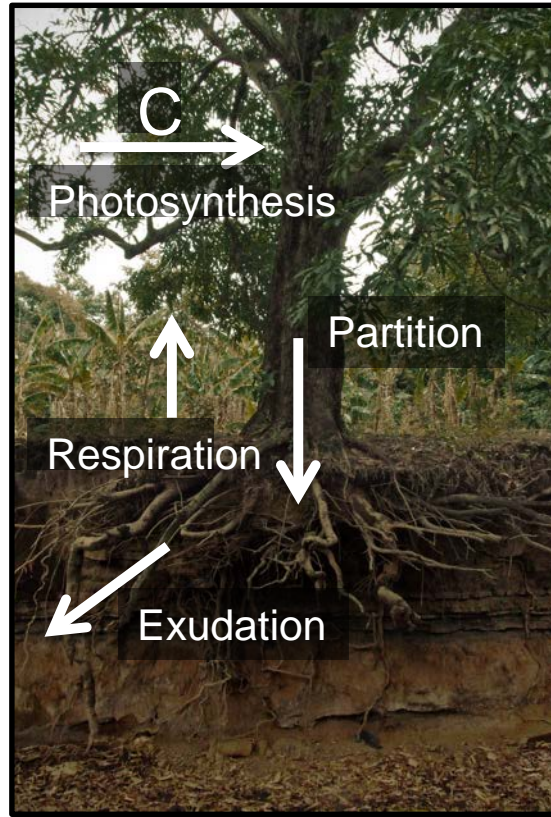
Big Technological Challenges.. (Complex Rhizosphere)

Sensor Solutions from Medical, Energy, Mining and Military Applications?



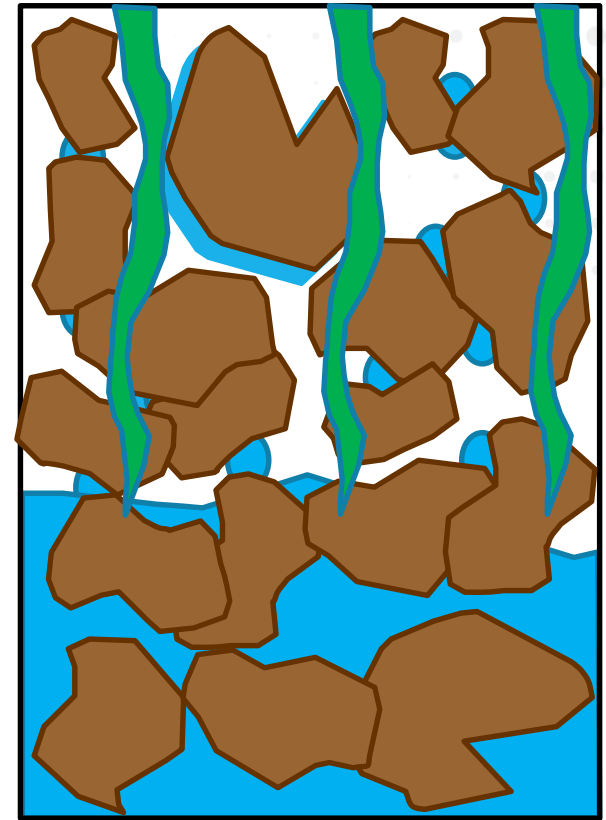
Root Architecture

- Depth & Spread
- Diameter & Density



Carbon Partition

- Flux Quantity
- Chemistry



Soil Structure Profile

- Porosity & Particle Size
- Water & Nitrates

Program Vision:

Rhizosphere Observations Optimizing Terrestrial Sequestration

Soil Quality + Crop Productivity + GHG Mitigation



Root & Soil
Sensors



Phenotypes
& Genotypes