WELCOME

10th ANNUAL LANDSCAPE SUMMIT

22nd CENTURY LANDSCAPES

Dr. Cynthia Daley

Center for Regenerative Agriculture

Valley Water

The Center for REGENERATIVE AGRICULTURE
CALIFORNIA STATE UNIVERSITY, CHICO

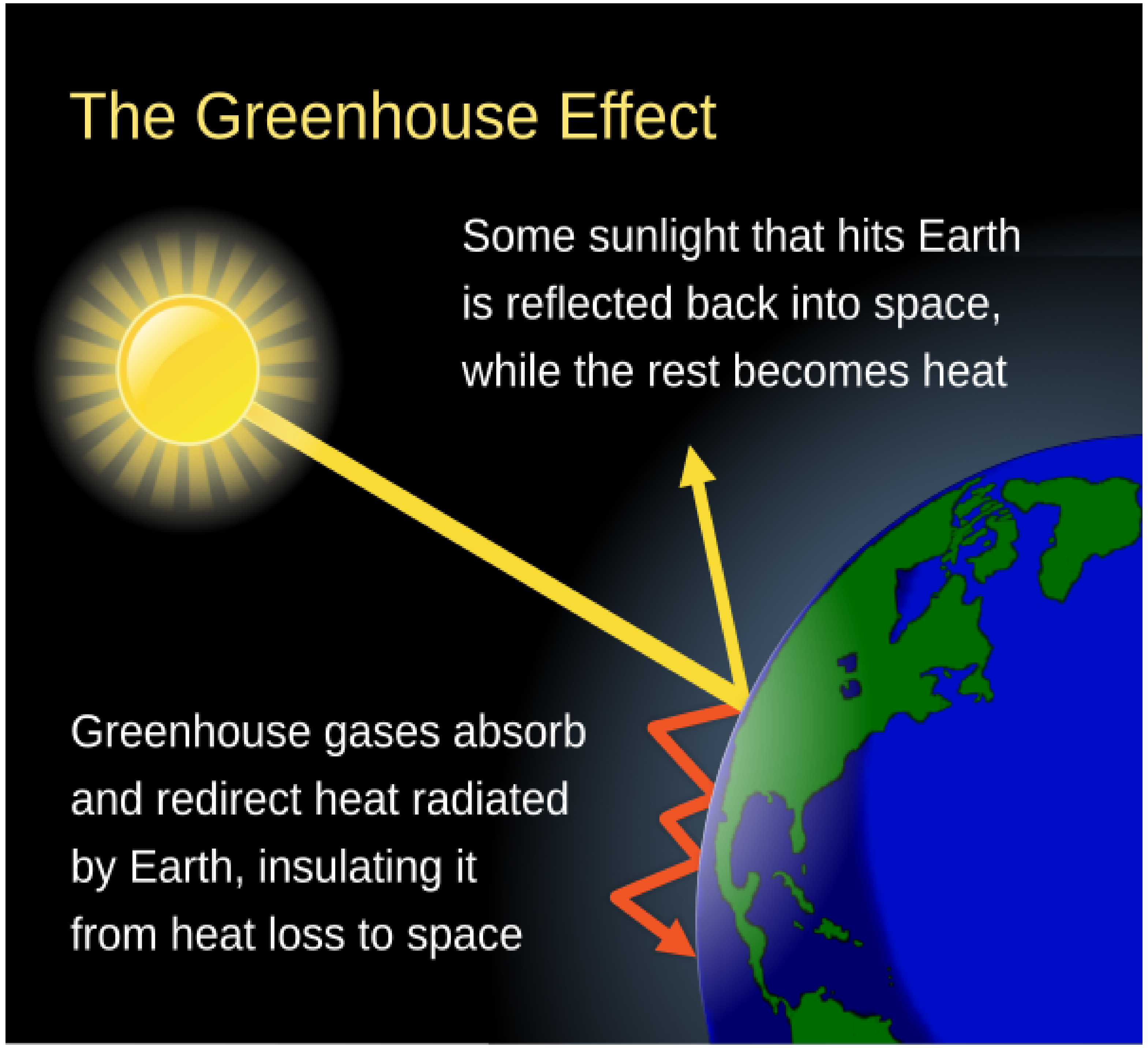
Regenerative Agriculture: Solutions for Urban Landscapes

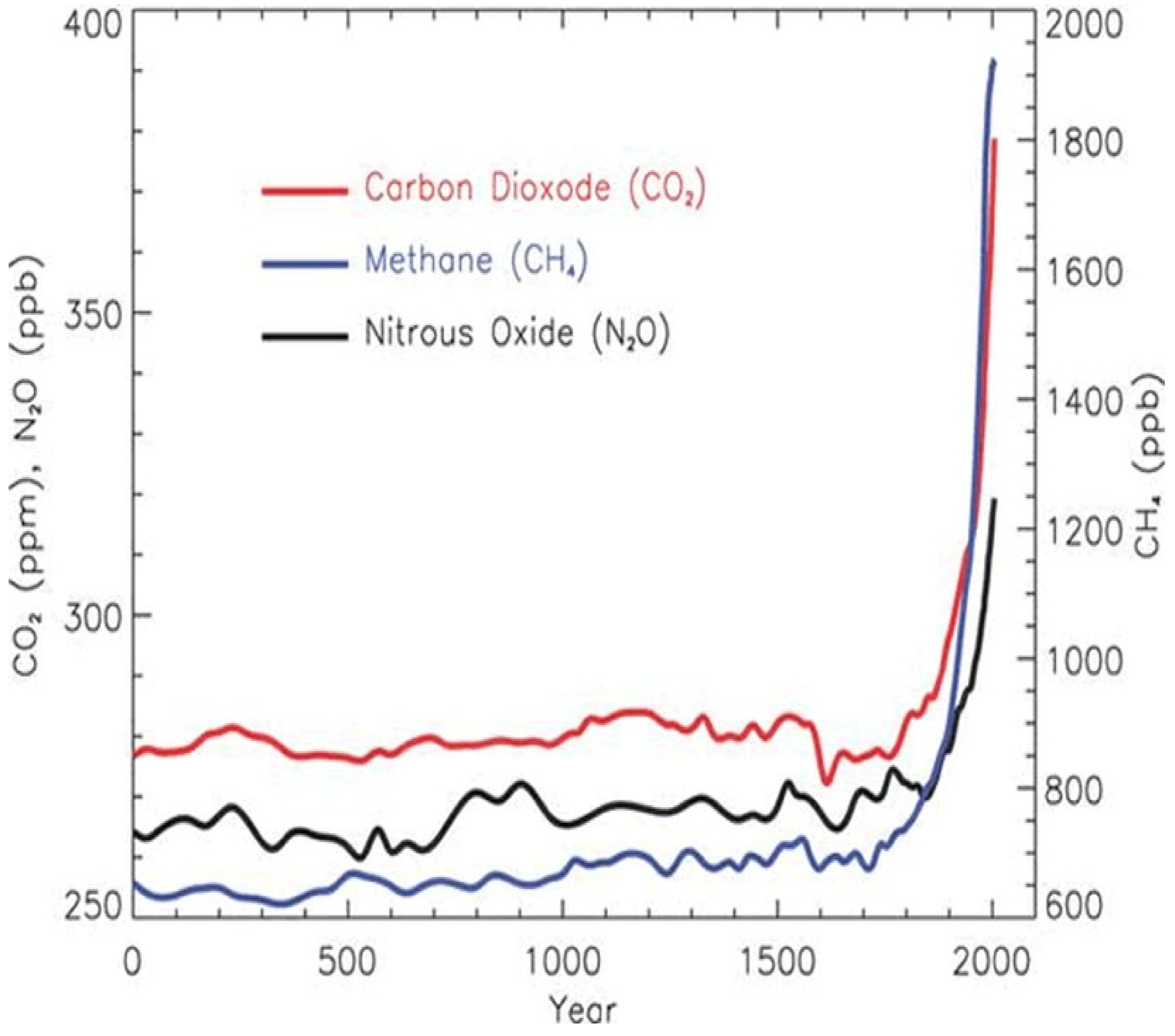
Valley Water Landscape Summit – February 27th, 2025

Cynthia Daley, Ph.D.
Director of *The Center for Regenerative Agriculture, CSU, Chico*

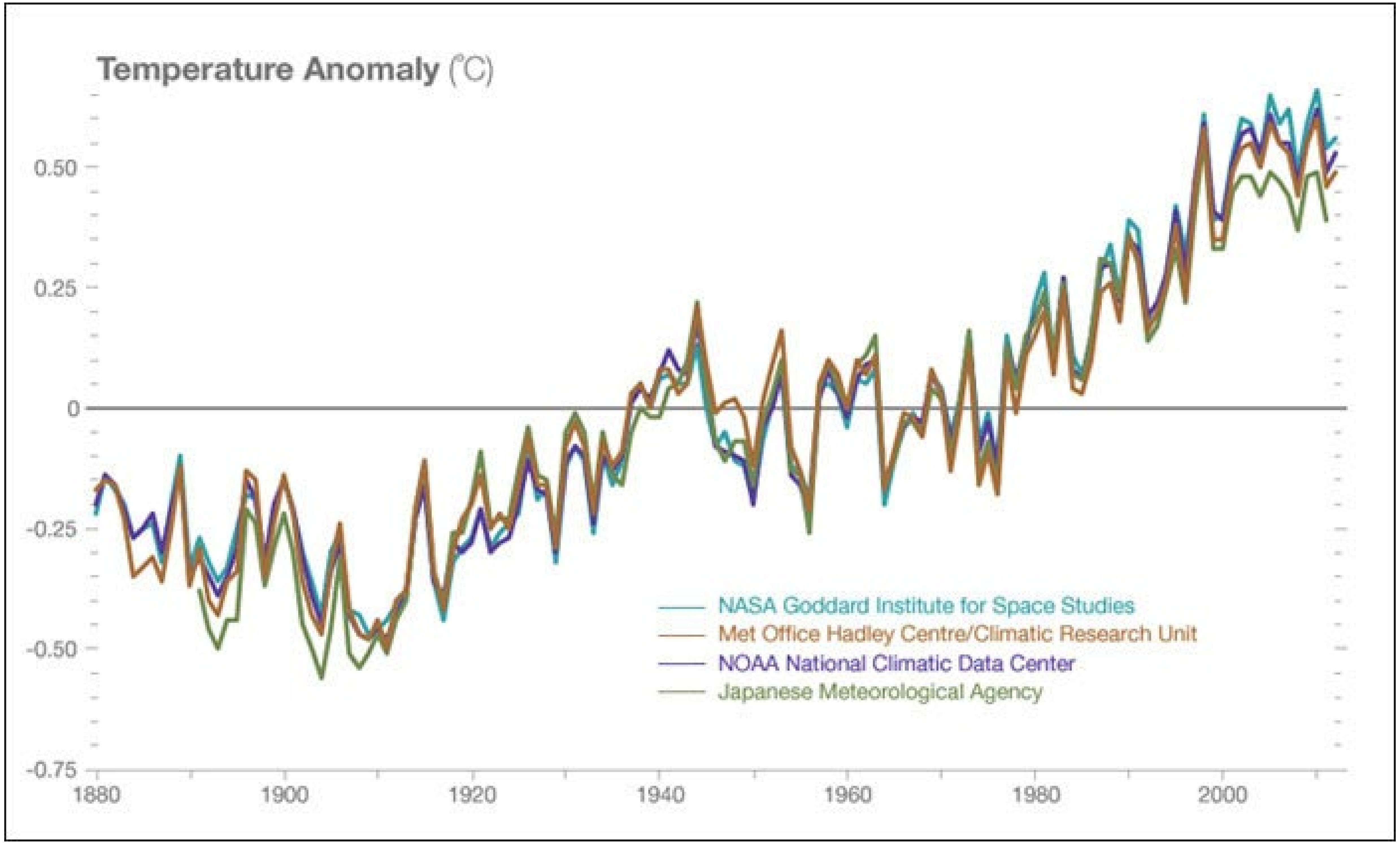
To solve problems, you first have to recognize the problem exists.

Agriculture is Responsible for 10.6% of GHG Emissions in US





The Planet is Heating Up… Green House Effect



Unpredictable rainfall with intense flooding

Longer more severe droughts

Water shortages

Soil Degradation & Soil Loss Crisis

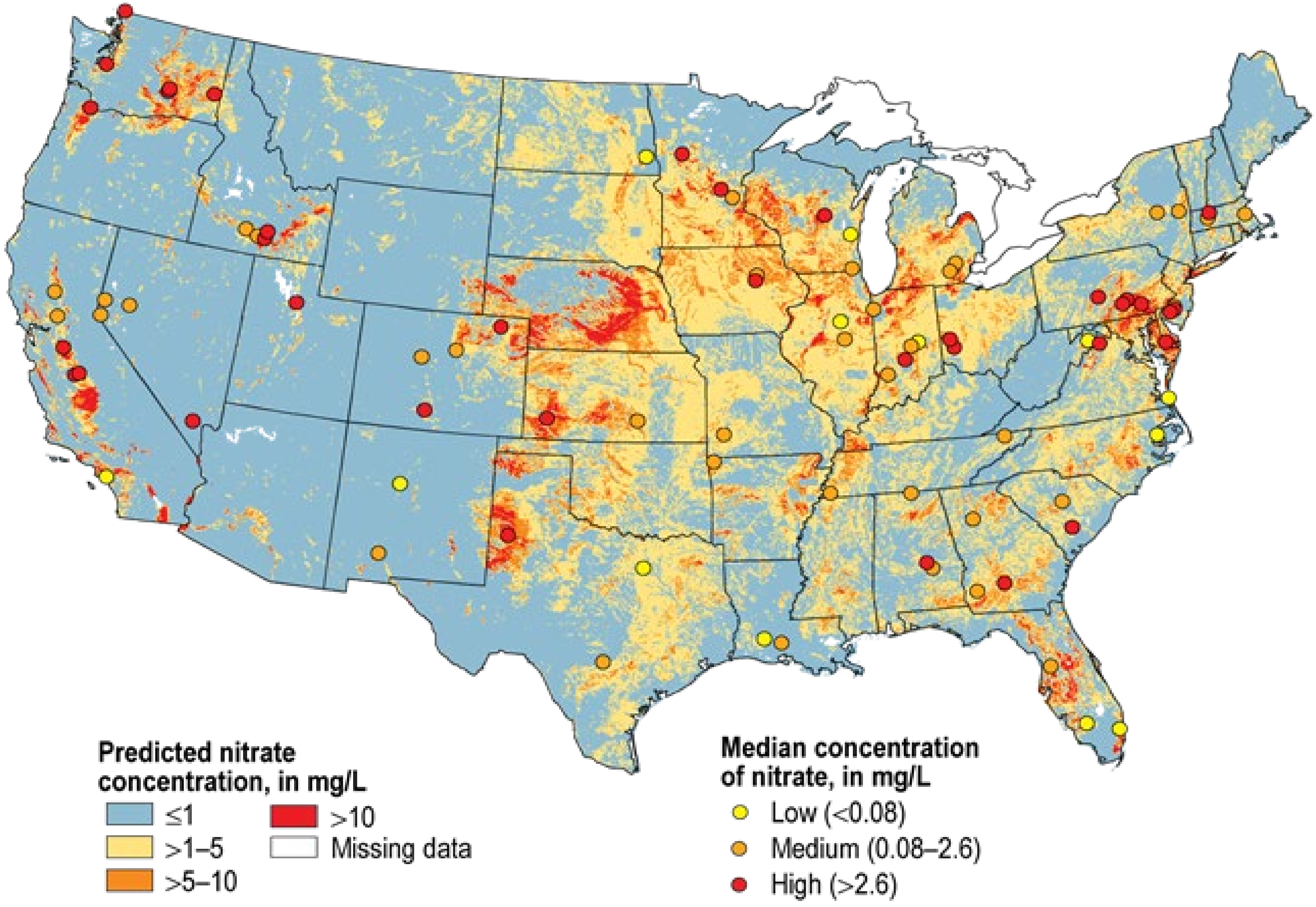
US loses 1% of topsoil every year

“Annual cost of erosion from agriculture in USA is $44 billion per year…”

$70/person per year

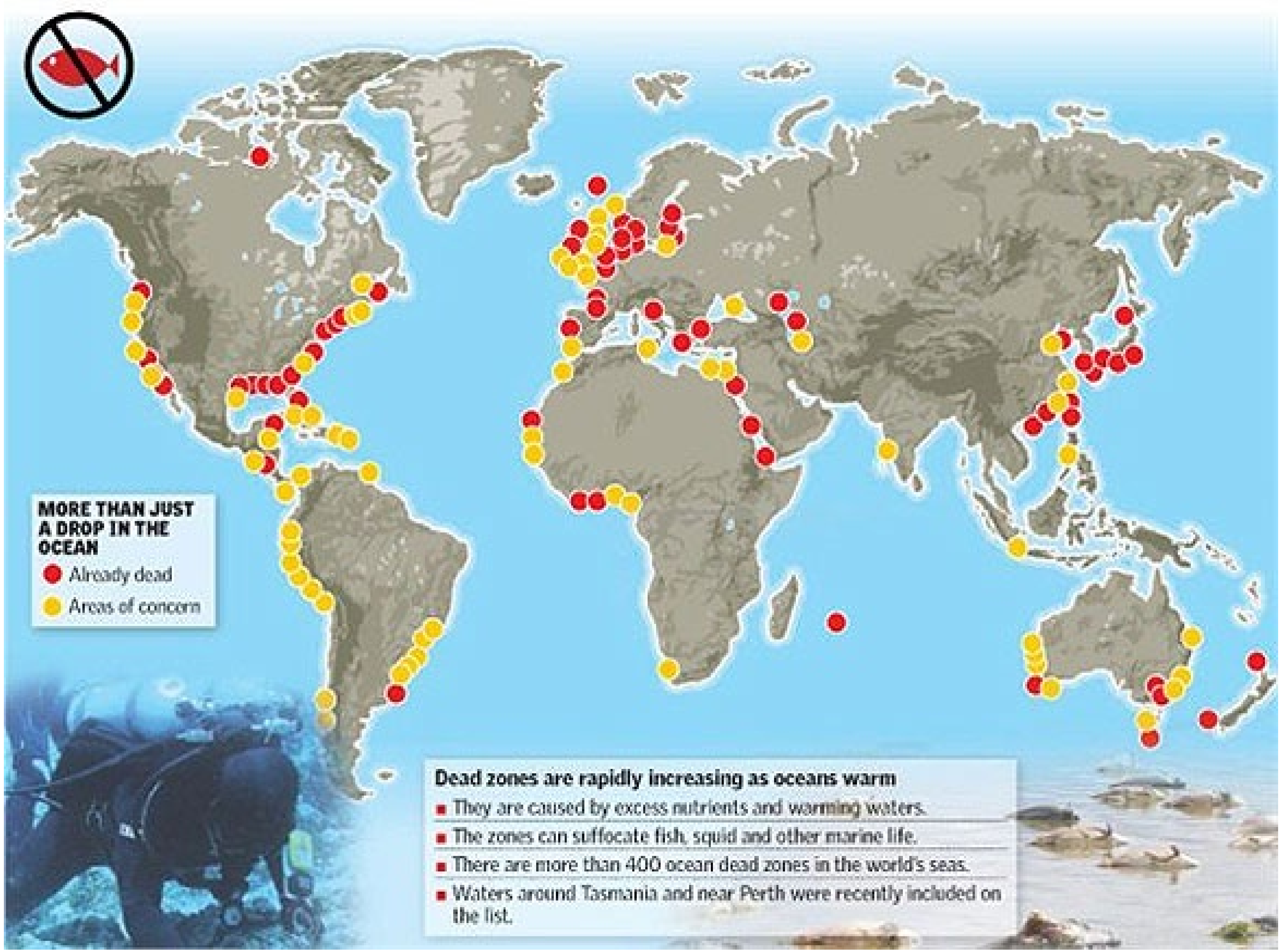
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/college/?cid=nrcs142p2_054028

Groundwater aquifer contamination is a national concern



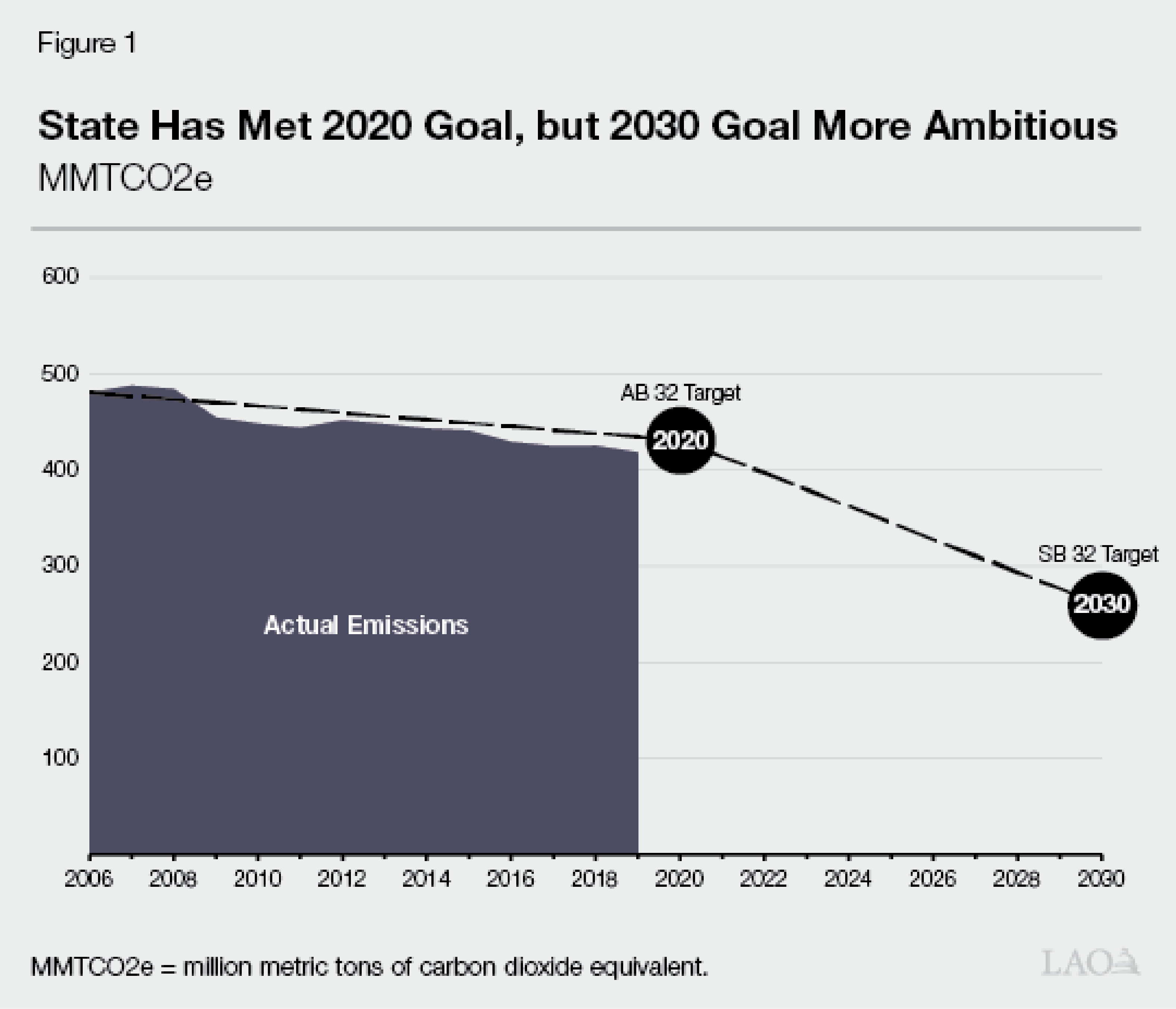
http://nemwuppermiss.blogspot.com/2013/10/usgs-mississippi-river-nitrate-levels.html

More than 405 Dead Zones occupy coastal waters worldwide covering 95,000 square miles

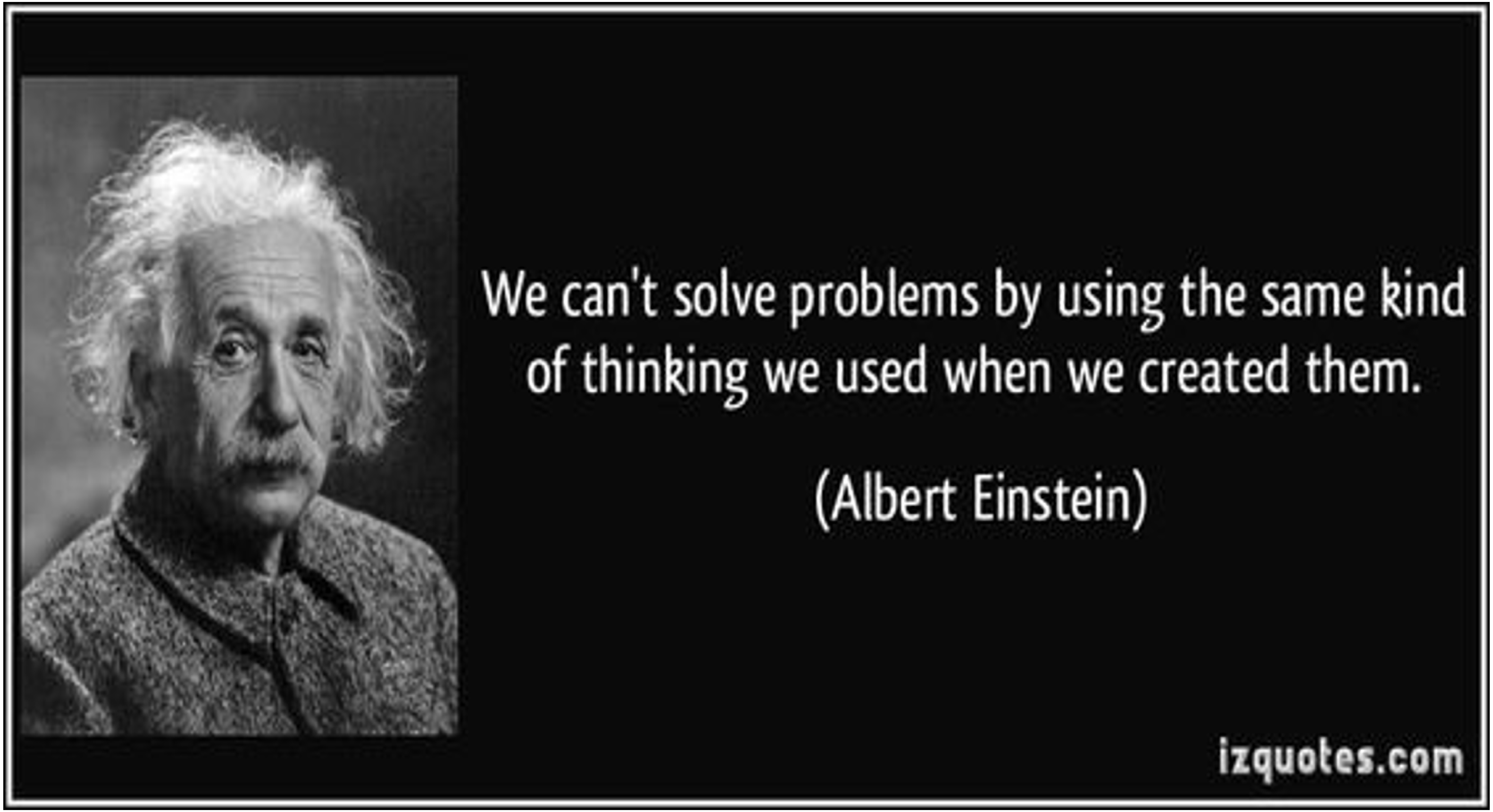


https://robertscribbler.com/2015/05/05/ocean-dead-zones-swirl-off-africa-threatening-coastlines-with-mass-fish-kills/

The State of CA has ambitious GHG Reduction Goals: AB 32/SB 32 - Limit GHG emissions to 40% below 1990 levels by 2030



- Agriculture is 5th largest source of GHG Emissions
- 5 T soil lost/year in US
- Regenerative Agriculture cuts emissions, reduces erosion, rebuilds soil, and sequesters carbon


We can't solve problems by using the same kind of thinking we used when we created them.
(Albert Einstein)
izquotes.com

California Department of Food & Agriculture

Member of the CDFA Working Group to define Regenerative Agriculture for the purposes of programming and future funding opportunities.

REGENERATIVE AGRICULTURE

is an integrated approach to farming and ranching rooted in the principles of soil health leading to improved target outcomes.

Target Outcomes:

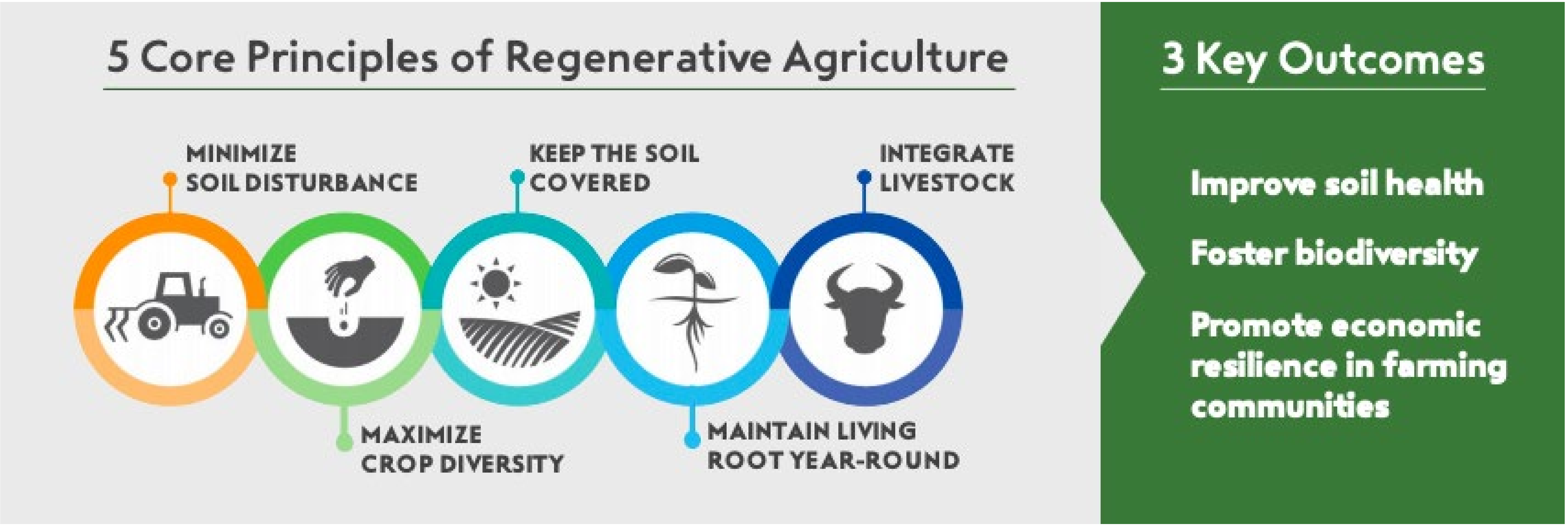
a) Build soil health, soil organic matter and biodiversity;
b) Restoration and maintenance of water resources;
c) Protection of air quality;
d) Sequestration and reduction of greenhouse gas emissions;
e) Use of sustainable and integrated pest management to eliminate reliance on pesticides;
f) Improve nutrient cycling to reduce use of external fertilizers;
i) Improve/enhance human health and rural communities

Total Soil-Centric Acres in the US

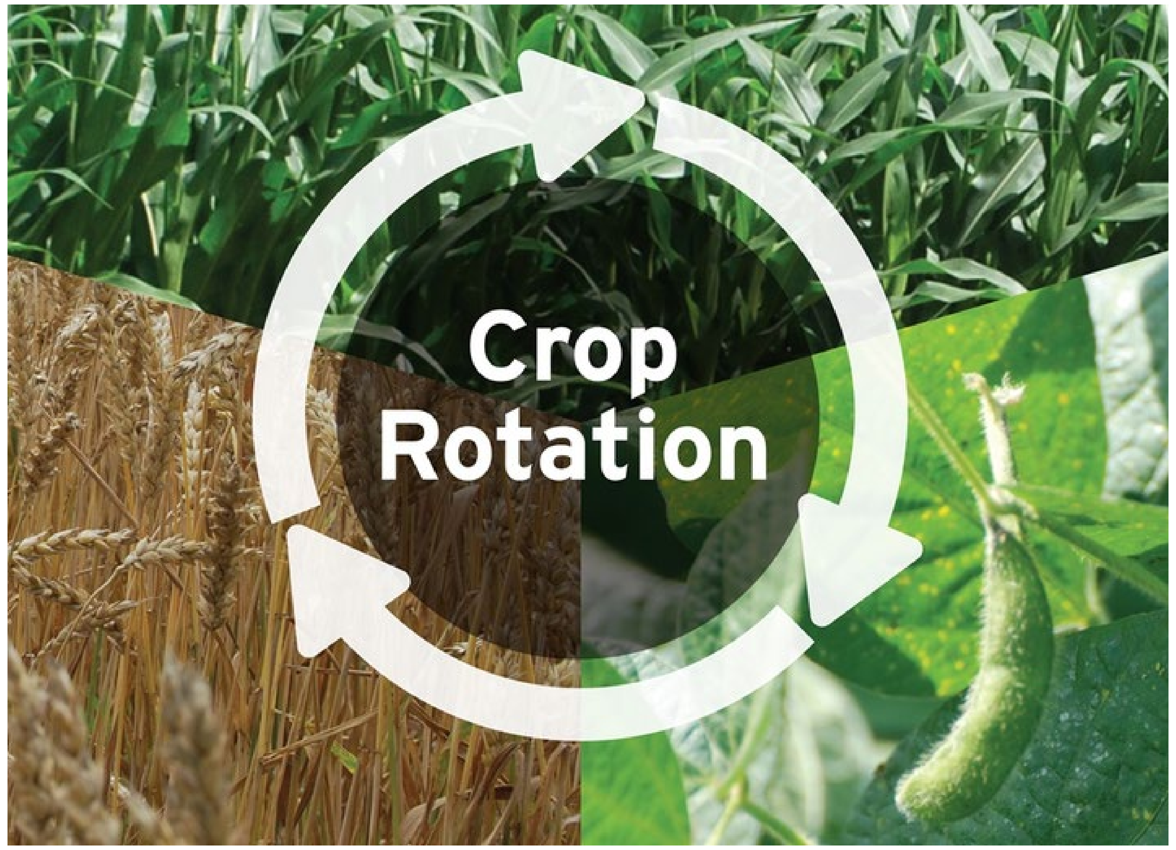
- Agriculture 895 M acres
  - Cropland = 390 M acres
  - Pasture & Range = 600 M acres

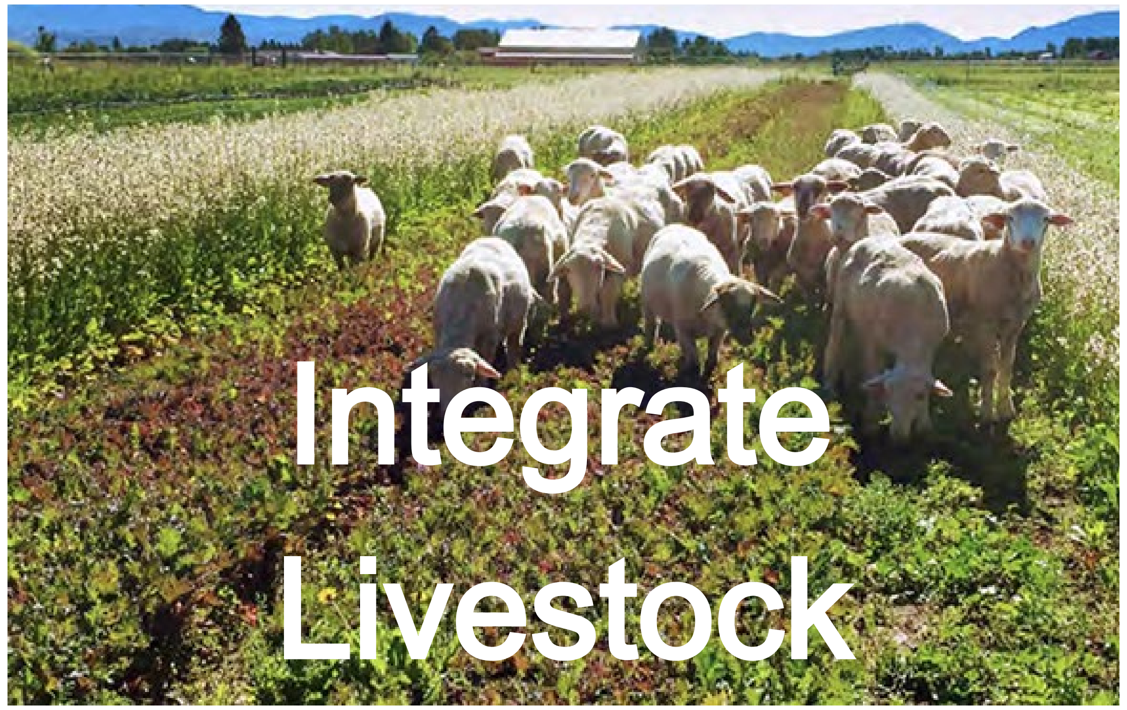
- Landscaped areas: 40 – 50 M acres
- Residential lawns = 40 M acres
- Golf courses = 2 M acres
- Public parks and commercial landscaping = several million

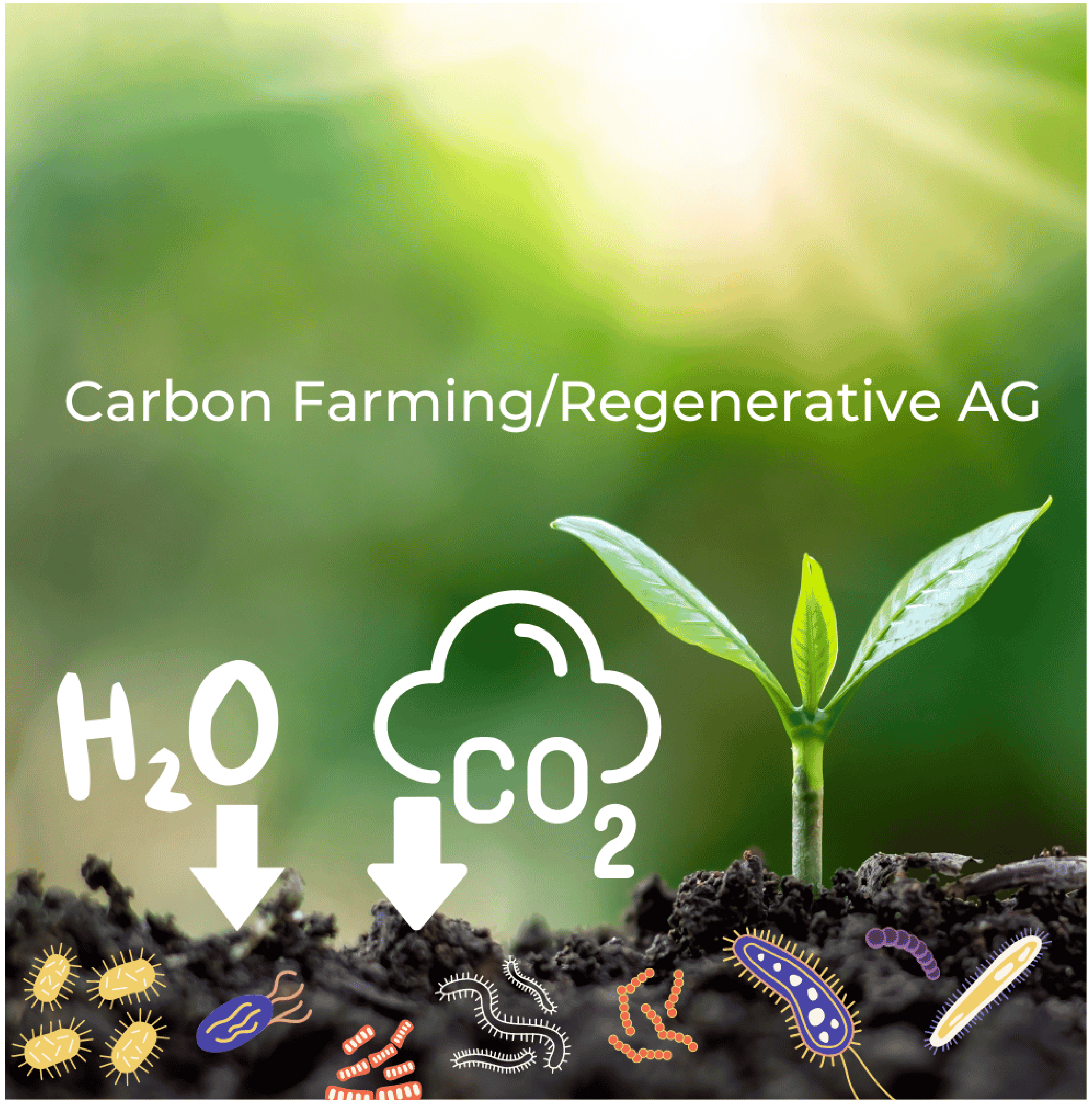
RA based on the 5 core Soil Health Principles



Tools in the RA Toolbox






Carbon Farming/Regenerative AG
H2O
CO2


Conventional Agriculture
H2O
CO2

Change the Paradigm

Standard practice

Diverse, enlivened, resilient, nutrient dense

Change the Paradigm

Standard practice

Diverse, enlivened, resilient, nutrient dense

Same Soil - Different Management

Regenerative Conventional

“System-based RA reconciles the need of producing adequate and nutritious food with the necessity of restoring the environment, making farming a solution to environmental issues.”

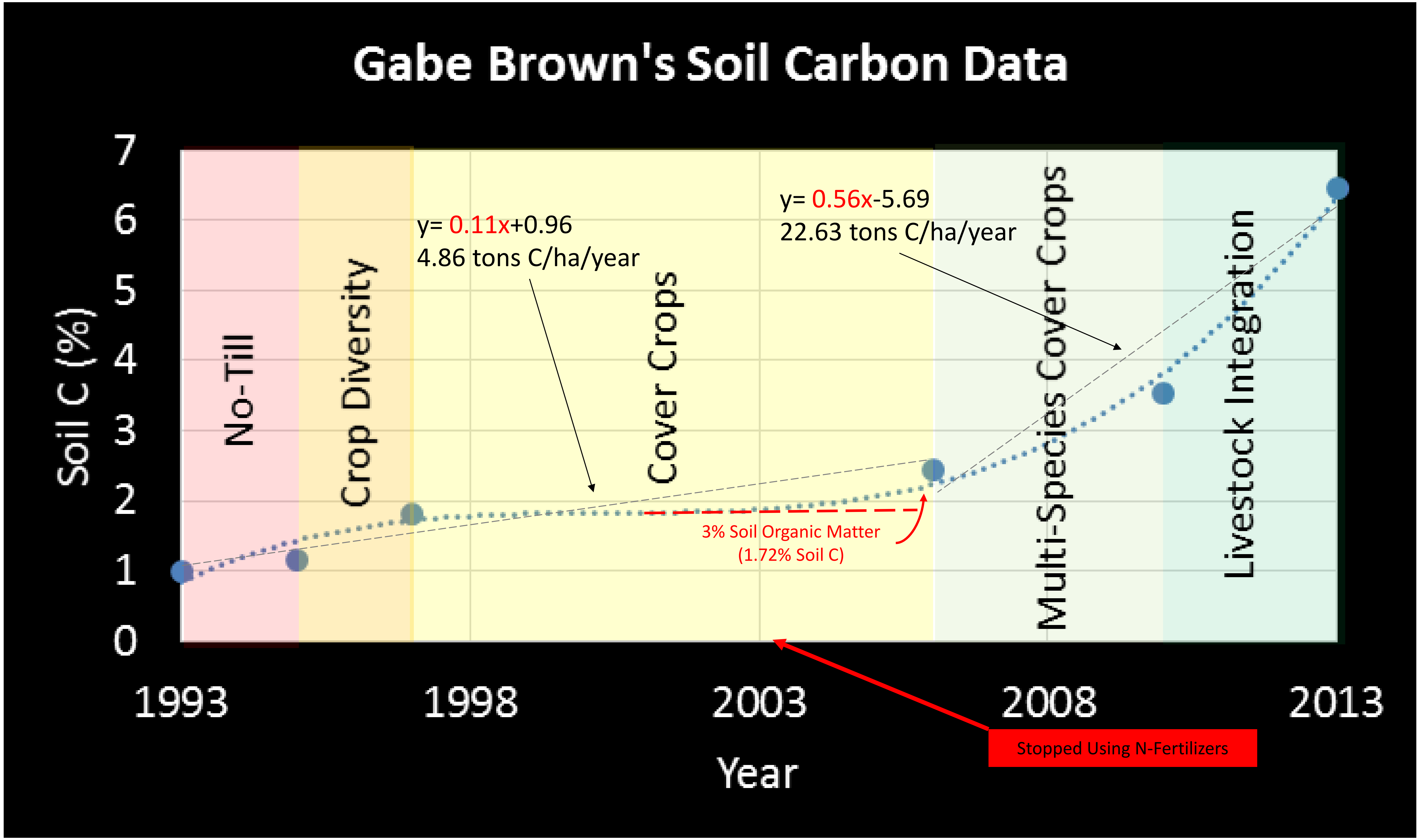
Rattan Lal

Regenerative Farmer – Gabe Brown – North Dakota

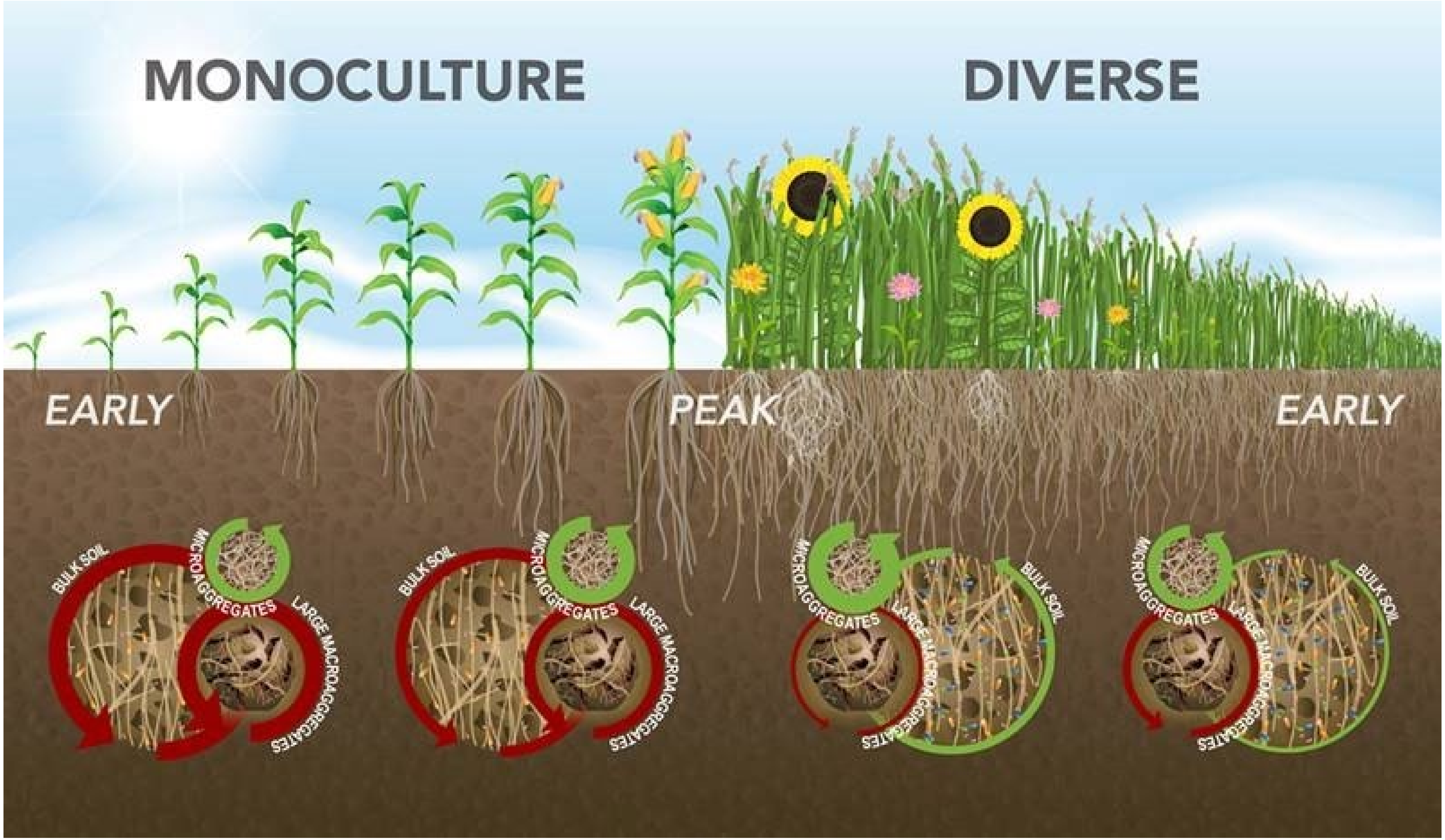
Layering RA Practices May be Synergistic

Stacking Practices

- ❖No-Till/Minimum Till
- ❖Multi-Species Cover Crops
- ❖Crop Rotation
- ❖Compost Applications
- ❖Adaptive Multi-paddock Grazing
- ❖Maximizing diversity



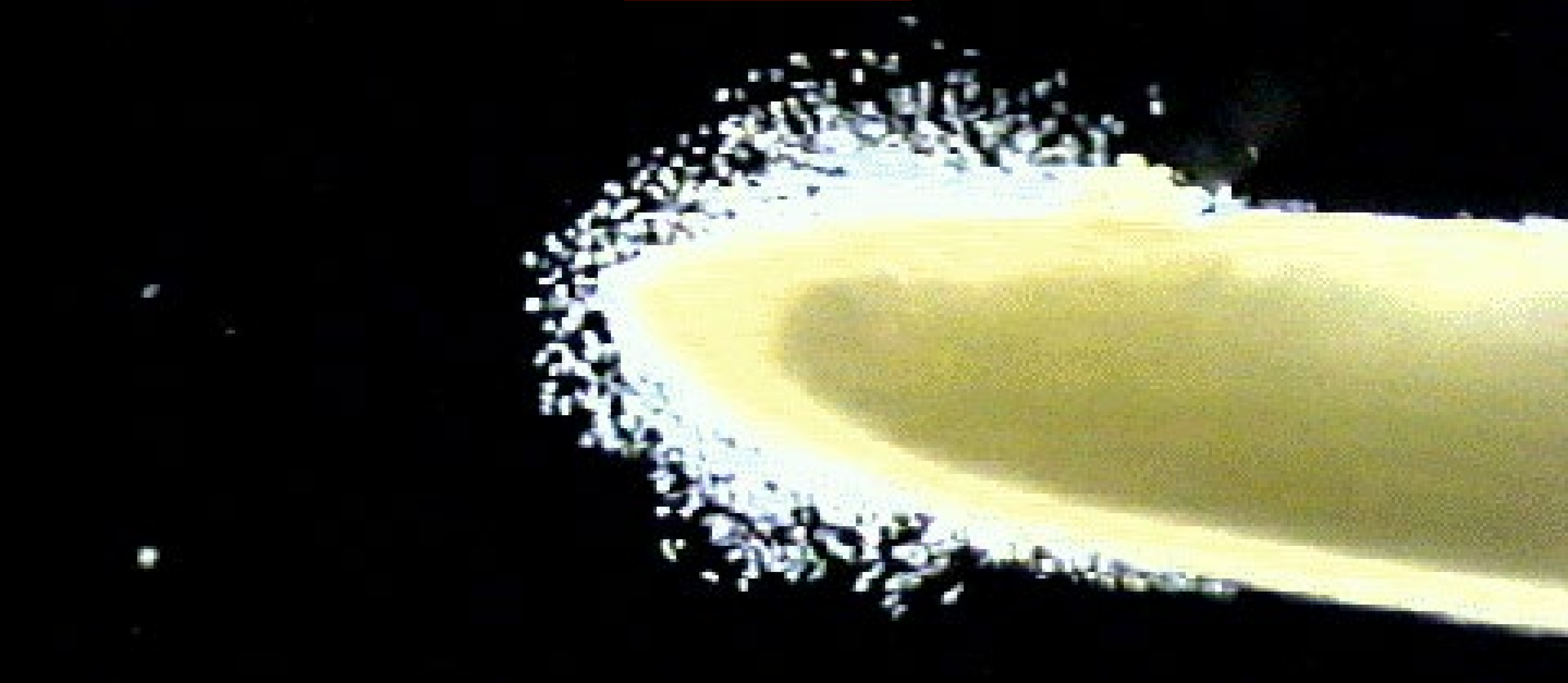
David C. Johnson- NMSU Institute for Sustainable Agricultural Research (ISAR) davidcjohnson@nmsu.edu



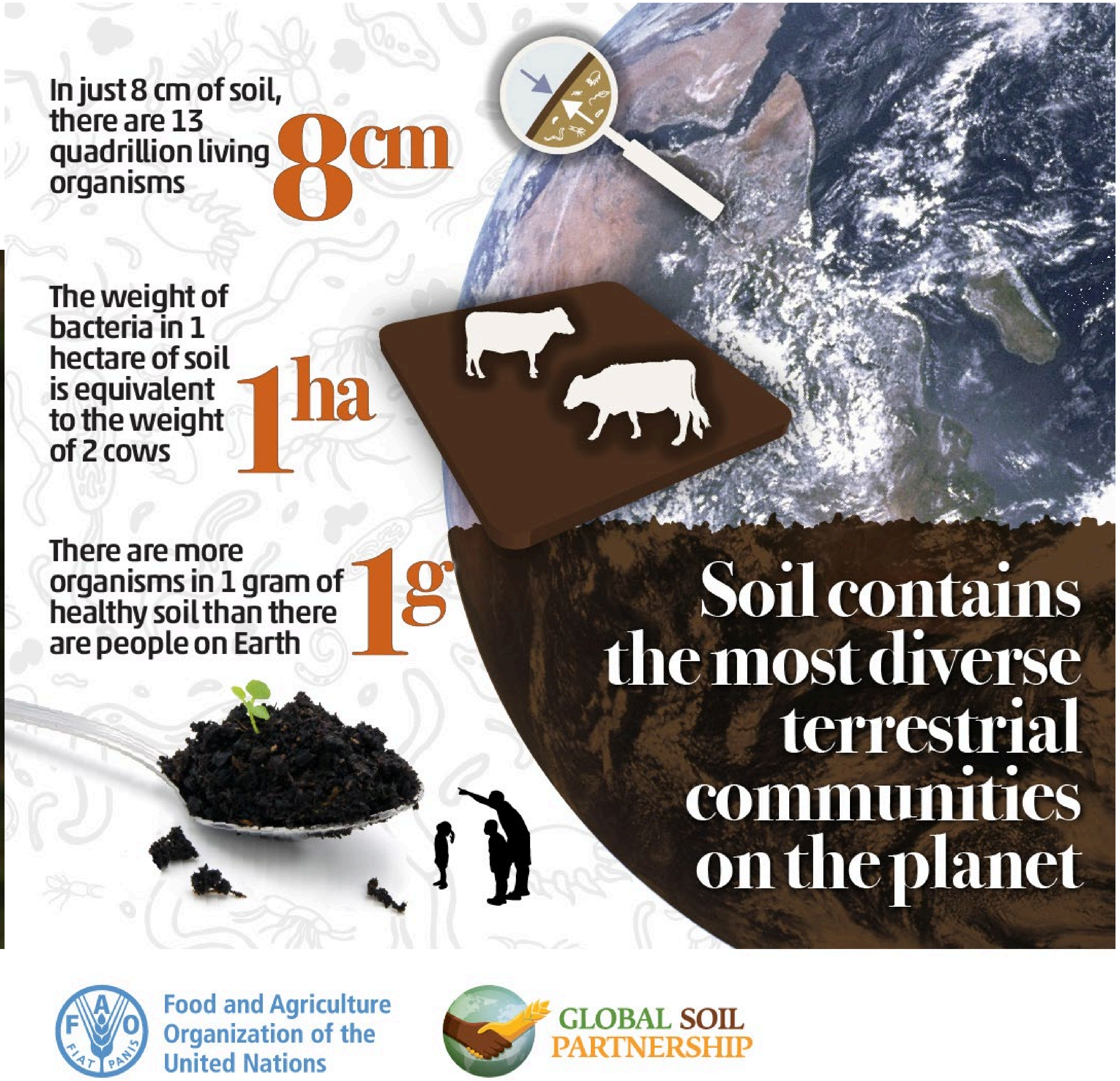
MONOCULTURE
DIVERSE
EARLY
PEAK
EARLY
BULK SOIL
MICROAGGREGATES
LARGE MACROAGGREGATES
BULK SOIL
MICROAGGREGATES
LARGE MACROAGGREGATES
MICROAGGREGATES
LARGE MACROAGGREGATES
BULK SOIL
MICROAGGREGATES
LARGE MACROAGGREGATES
BULK SOIL

Liquid Sun: Roots Leaking Exudates!

California State University Chico



Soil is alive!

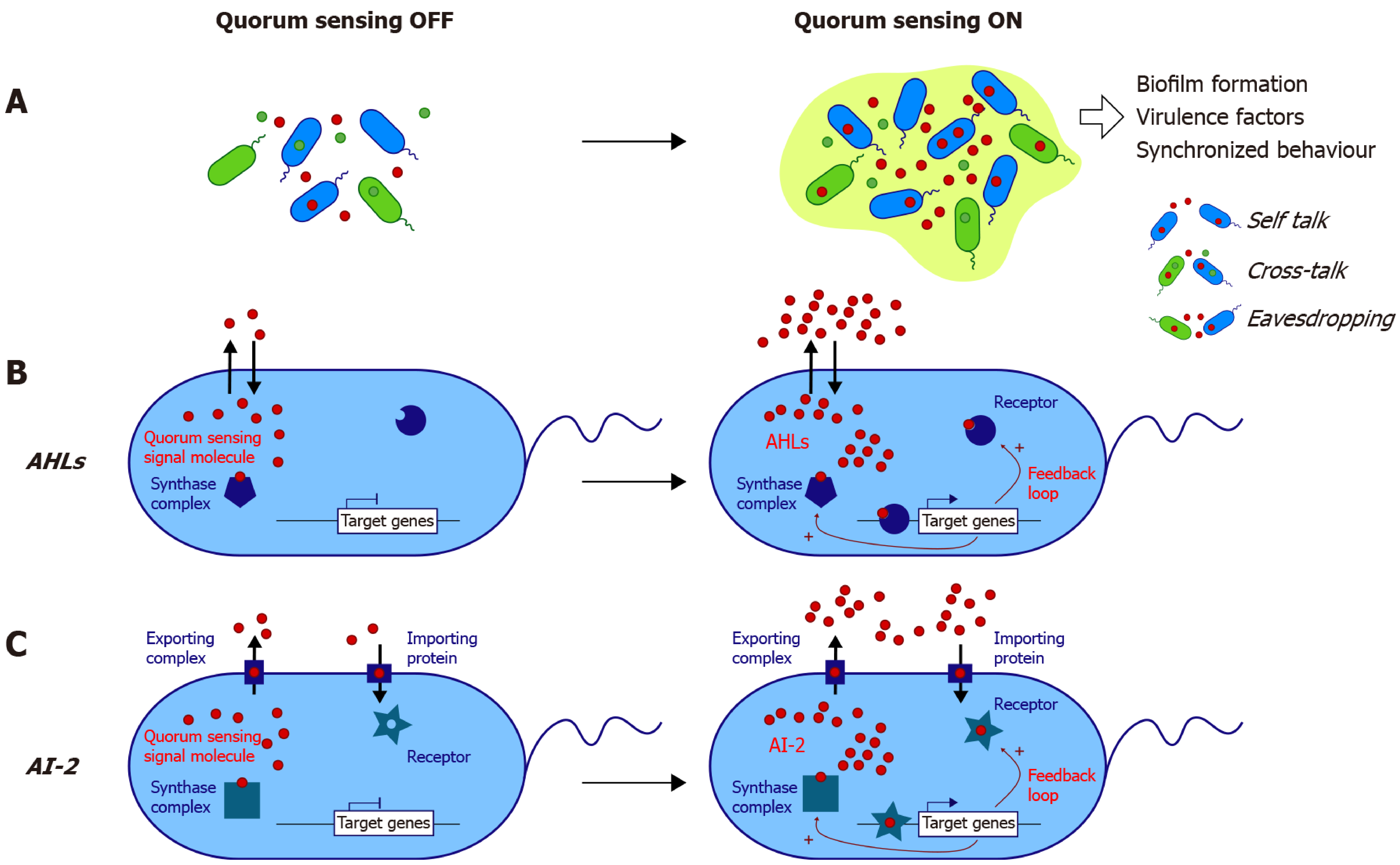


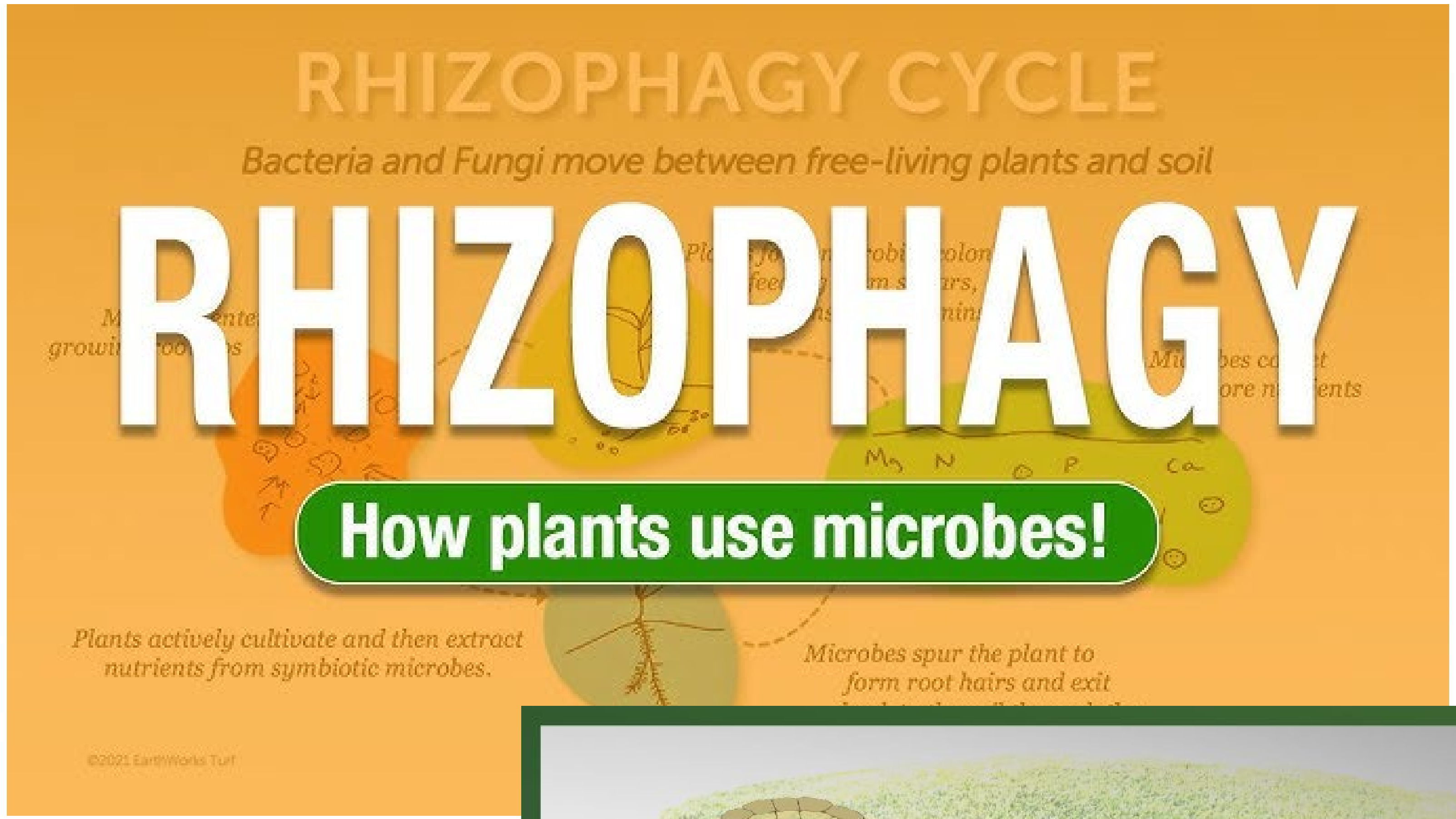
Quorum Sensing

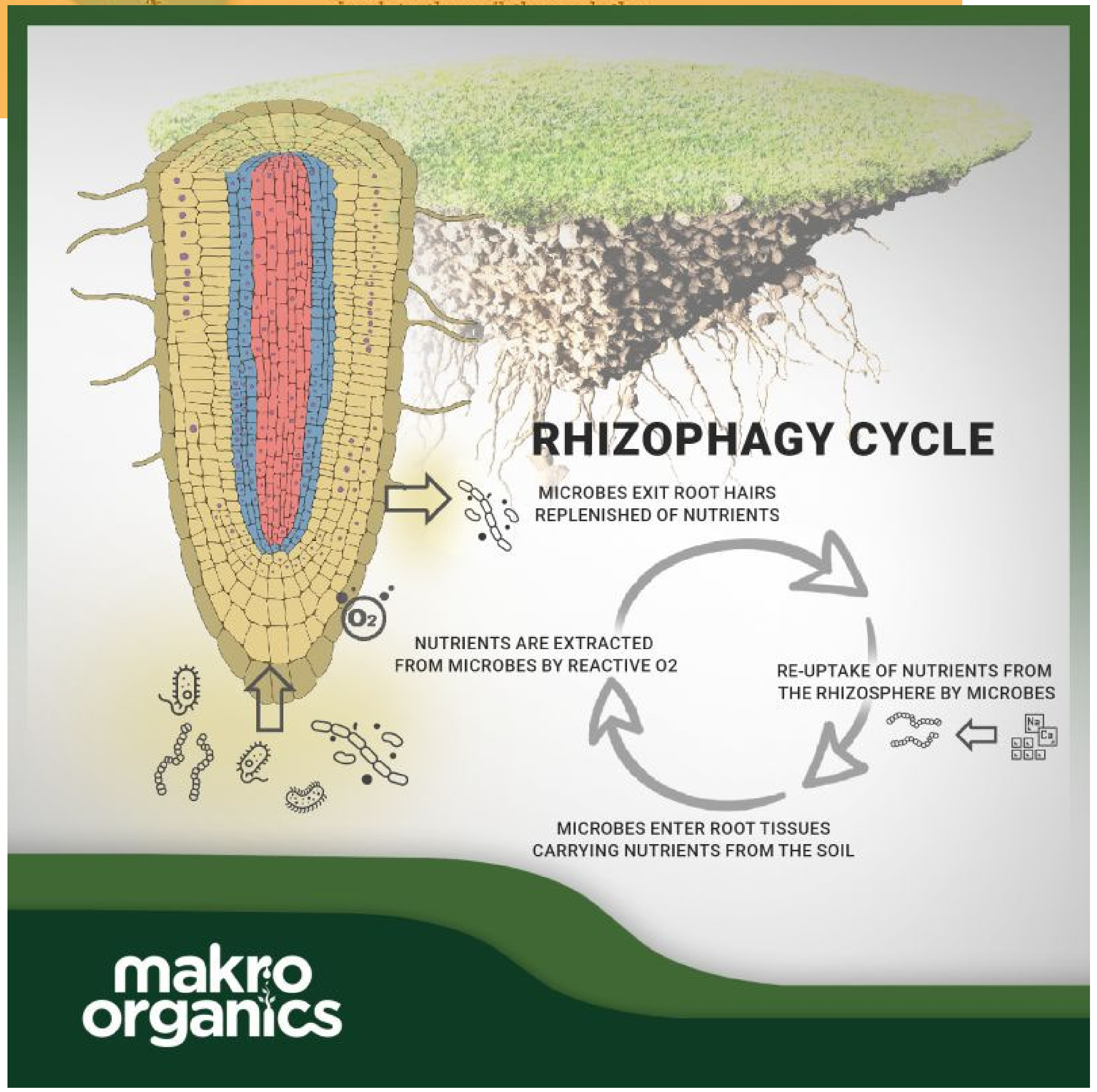
Many bacteria use a cell-cell communication system called quorum sensing to coordinate population density-dependent changes in behavior. In many species, quorum sensing modulates virulence functions and is important for pathogenesis. Over the past half-century, there has been a significant accumulation of knowledge of the molecular mechanisms, signal structures, gene regulons, and behavioral responses associated with quorum-sensing systems in diverse bacteria.

https://mbio.asm.org/content/9/3/e02331-17#

Quorum Sensing: Signaling between microbes -







microorganisms MDPI

Review

Rhizophagy Cycle: An Oxidative Process in Plants for Nutrient Extraction from Symbiotic Microbes

James F. White [1,*], Kathryn L. Kingsley [1], Satish K. Verma [2] and Kurt P. Kowalski [3]

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2 Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, UP 221005, India; skvermabhu@gmail.com
3 U.S. Geological Survey, Great Lakes Science Center, 1451 Green Road, Ann Arbor, MI 48105-2807, USA; kkowalski@usgs.gov
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Received: 22 August 2018; Accepted: 5 September 2018; Published: 17 September 2018

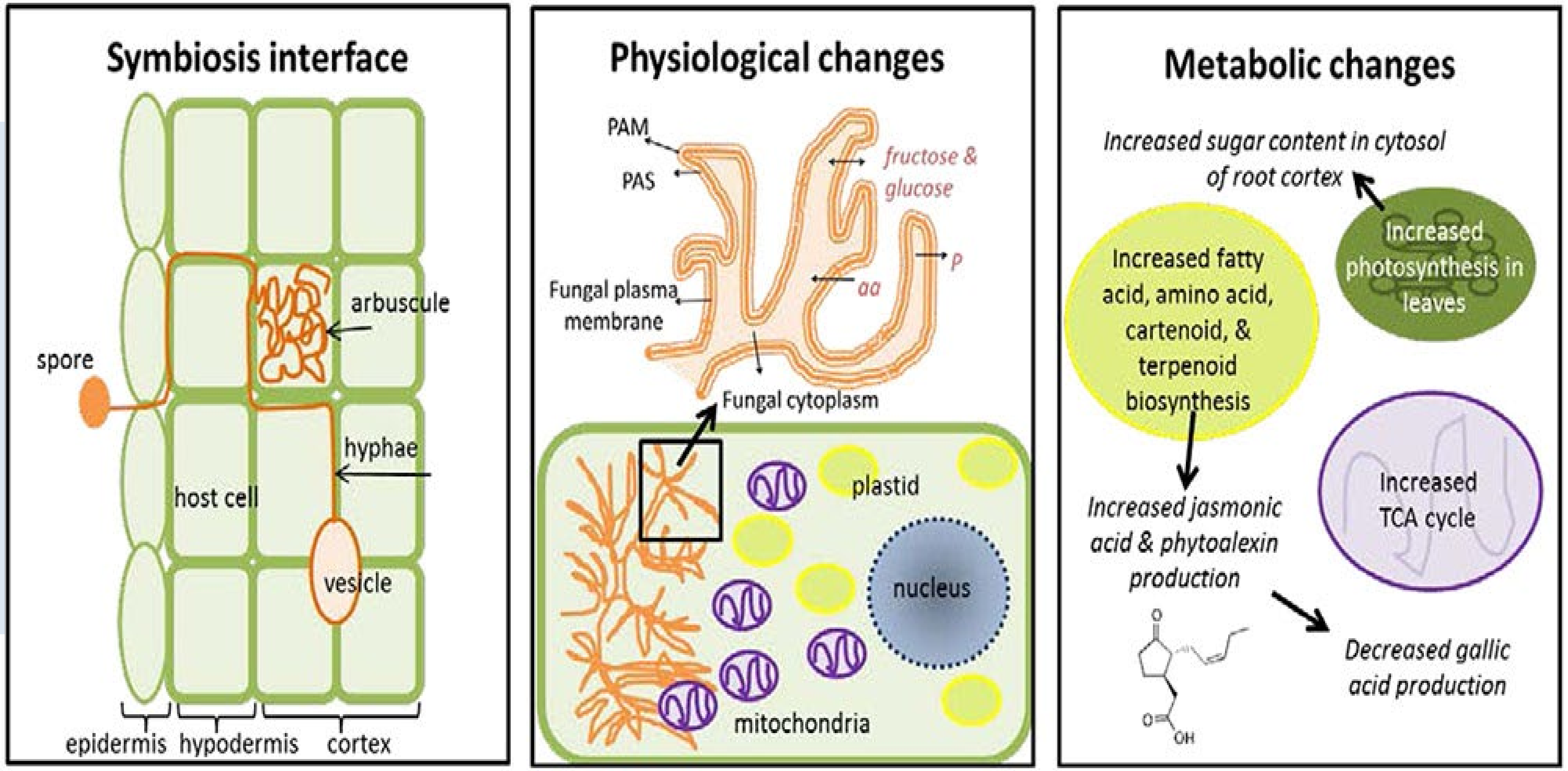
check for updates

Abstract: In this paper, we describe a mechanism for the transfer of nutrients from symbiotic microbes (bacteria and fungi) to host plant roots that we term the 'rhizophagy cycle.' In the rhizophagy cycle, microbes alternate between a root intracellular endophytic phase and a free-living soil phase. Microbes acquire soil nutrients in the free-living soil phase; nutrients are extracted through exposure to host-produced reactive oxygen in the intracellular endophytic phase. We conducted experiments on several seed-vectored microbes in several host species. We found that initially the symbiotic microbes grow on the rhizoplane in the exudate zone adjacent the root meristem. Microbes enter root tip meristem cells—locating within the periplasmic spaces between cell wall and plasma membrane. In the periplasmic spaces of root cells, microbes convert to wall-less protoplast forms. As root cells mature, microbes continue to be subjected to reactive oxygen (superoxide) produced by NADPH oxidases (NOX) on the root cell plasma membranes. Reactive oxygen degrades some of the intracellular microbes, also likely inducing electrolyte leakage from microbes—effectively extracting nutrients from microbes. Surviving bacteria in root epidermal cells trigger root hair elongation and as hairs elongate bacteria exit at the hair tips, reforming cell walls and cell shapes as microbes emerge into the rhizosphere where they may obtain additional nutrients. Precisely what nutrients are transferred through rhizophagy or how important this process is for nutrient acquisition is

Mycorrhizal Fungi

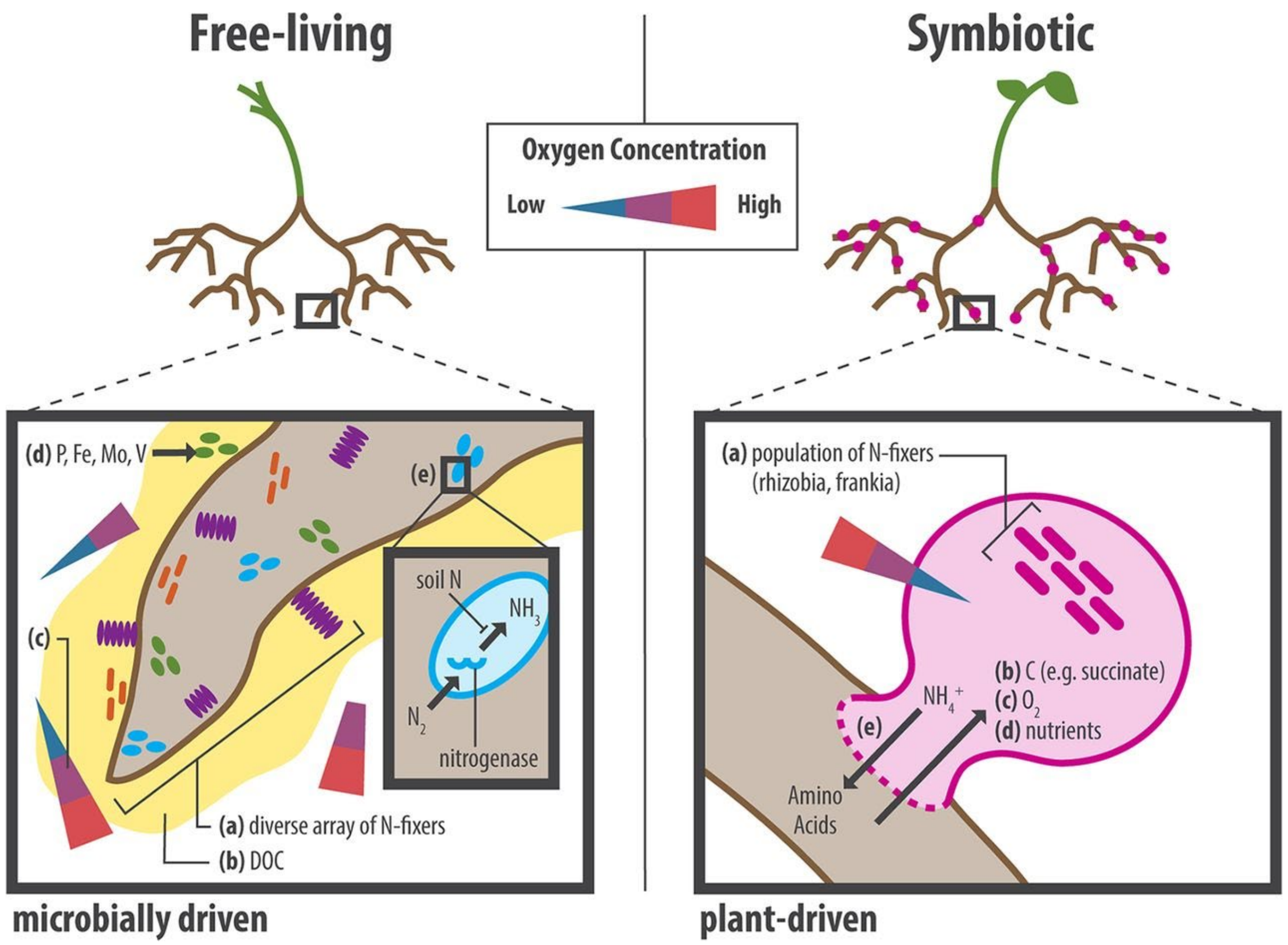
- Help plants take up water and nutrients
- Improve nitrogen fixation by legumes
- Help to form stable aggregates
- Help plants resist fungal diseases and parasitic nematodes, drought, salinity and aluminum toxicity
- Have been show to stimulate free-living nitrogen-fixing bacterial azotobacter - in turn stimulates plant growth-stimulating chemicals

Fungal species become a part of the plant root structure



Biofilms provide anaerobic environment for nitrogen fixing bacteria

Nitrogen Paradox
Free Living Nitrogen Fixing Bacteria



Some nitrogen fixing organisms

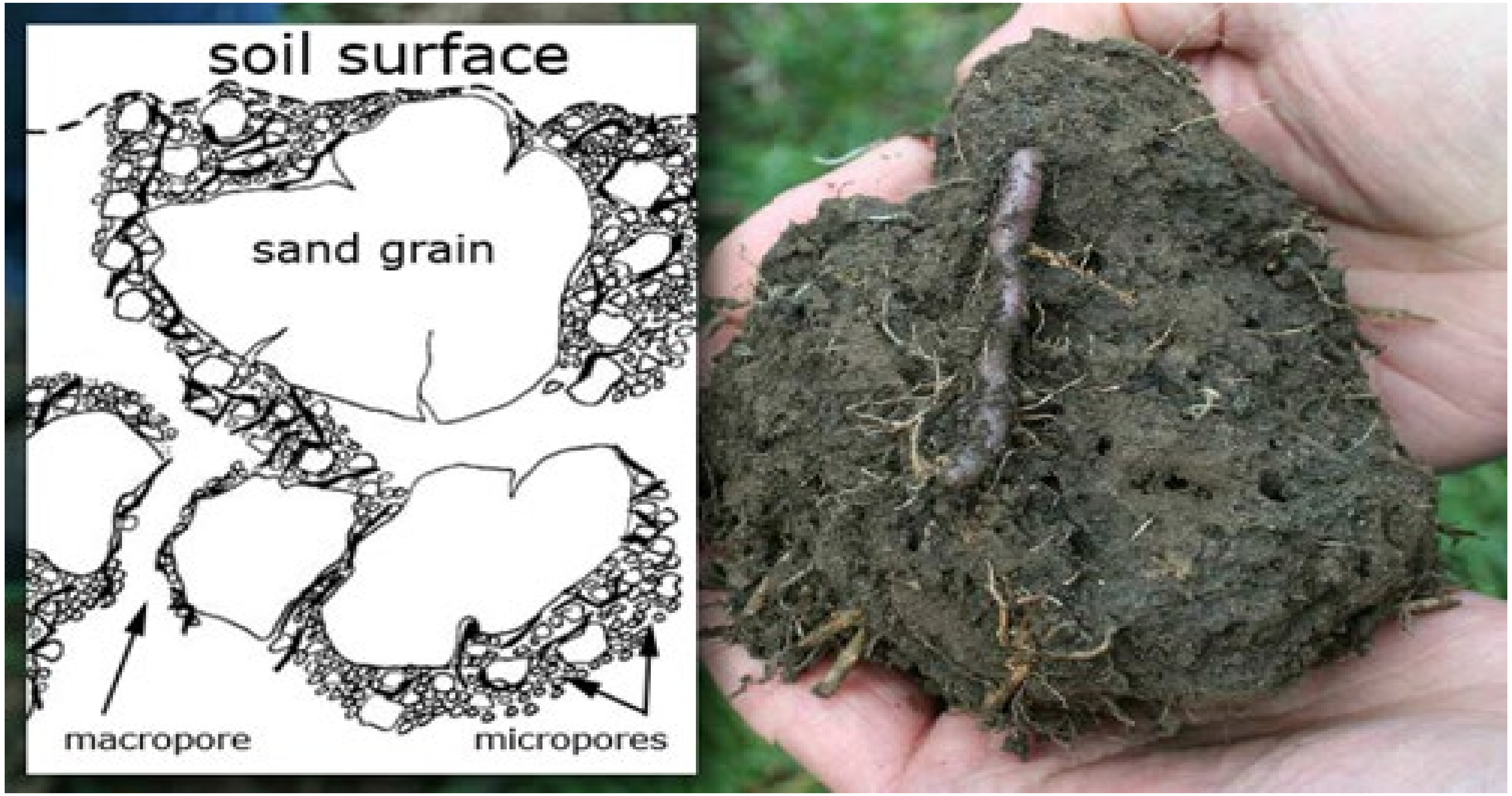
- Free living aerobic bacteria
  - *Azotobacter*
  - *Beijerinckia*
  - *Klebsiella*
  - *Cyanobacteria* (lichens)
- Free living associative bacteria
  - *Azospirillum*
- Free living anaerobic bacteria
  - *Clostridium*
  - *Desulfovibrio*
  - *Purple sulphur bacteria*
  - *Purple non-sulphur bacteria*
  - *Green sulphur bacteria*
- Symbionts
  - *Rhizobium* (legumes)
  - *Frankia* (alden trees)

Soil Aggregation/ Slake Test

Conventional Till | No-Till | Minimum till

Conventional Till | No-Till | Pasture

Signs of Regenerative Farming Practices



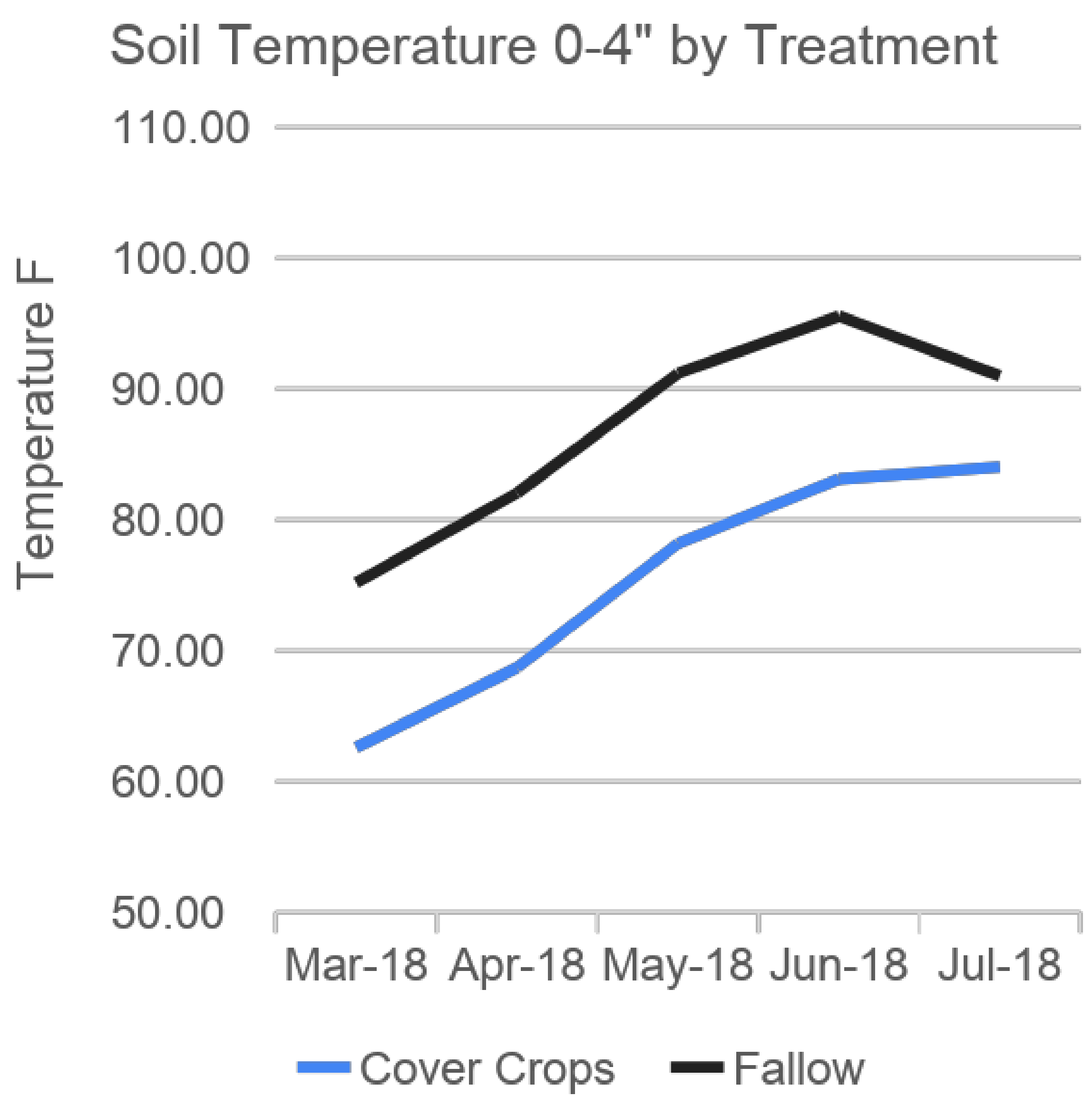
Regenerative Agriculture Farming Research in the Palo Verde Valley

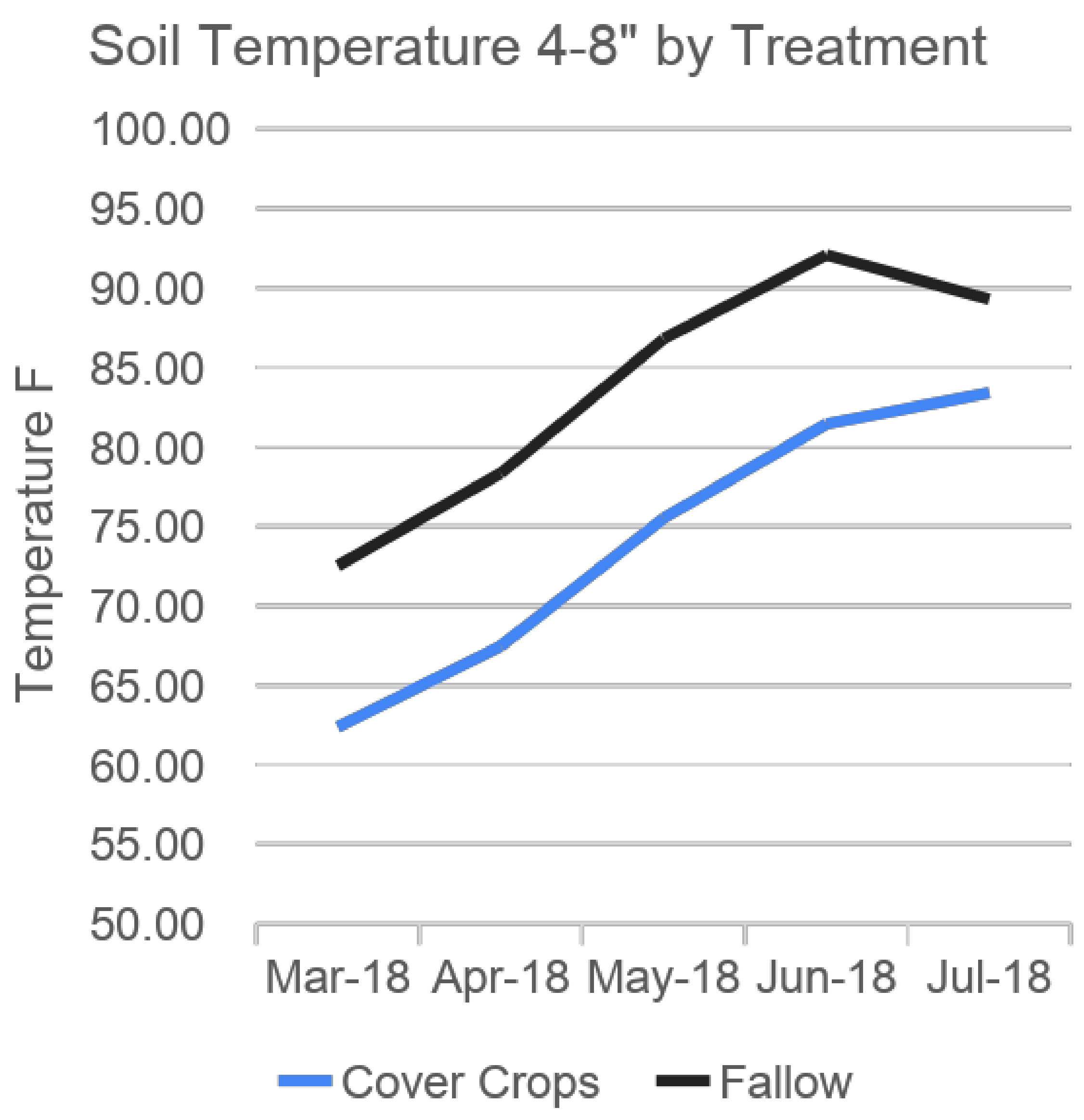
Metropolitan Water District Project in Collaboration with Hay Day Farms

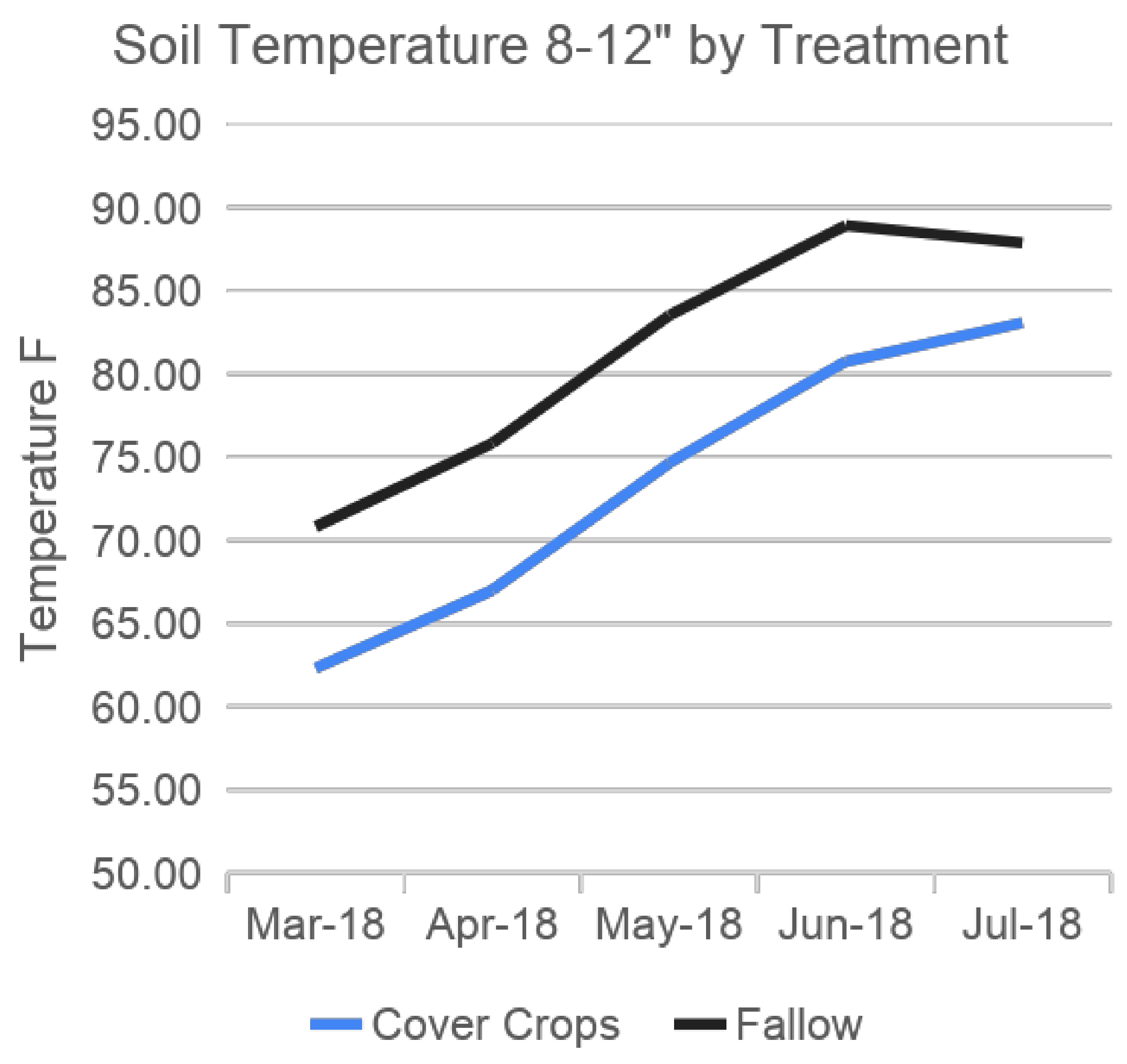
Fallow fields using tillage - for weed control

Using Cover Crops for soil health purposes - including SCA and WI

Significant Difference in Soil Temperature Down to 12”







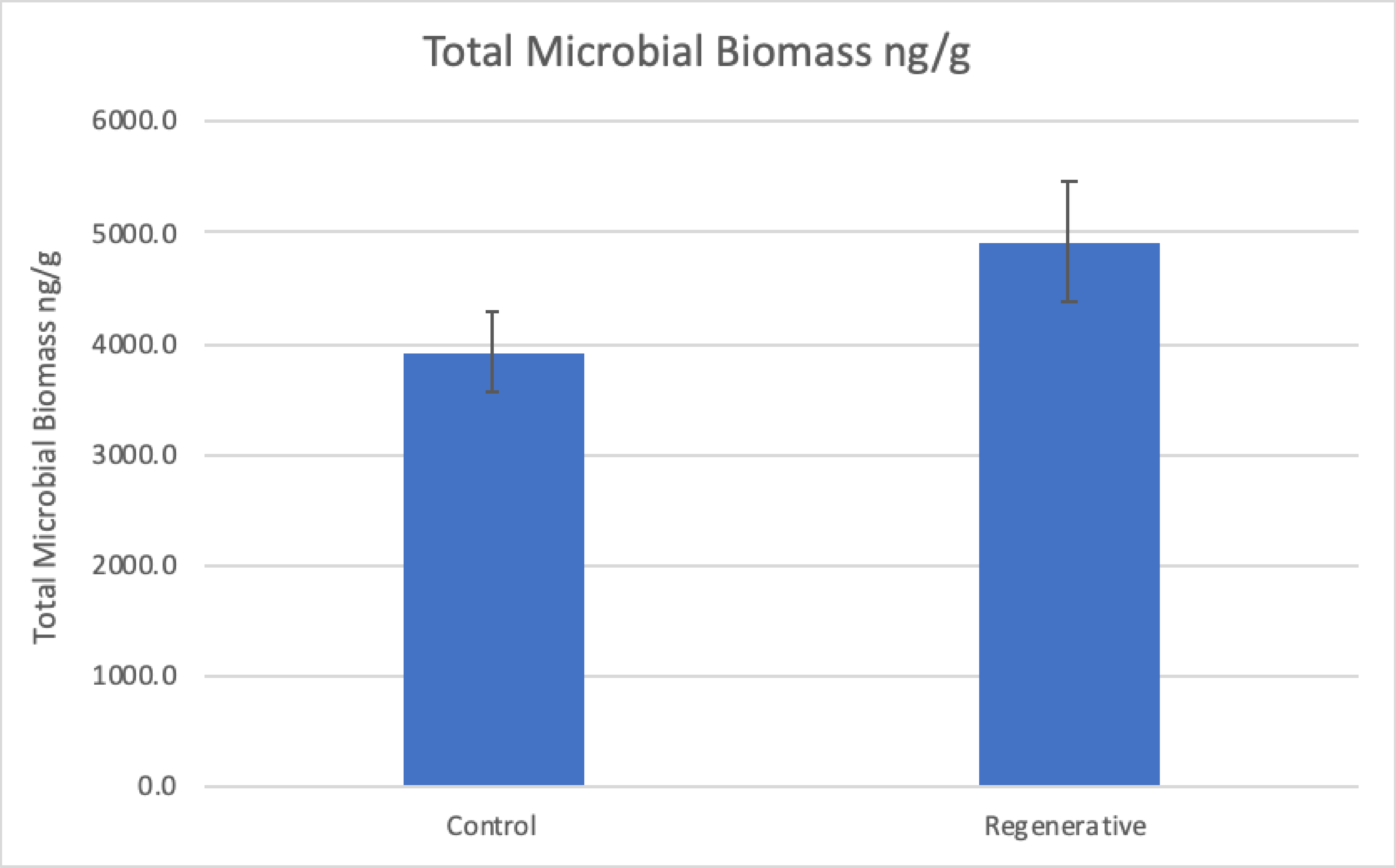
12.5 ^oF difference

10.5 ^oF difference

8.5 ^oF difference

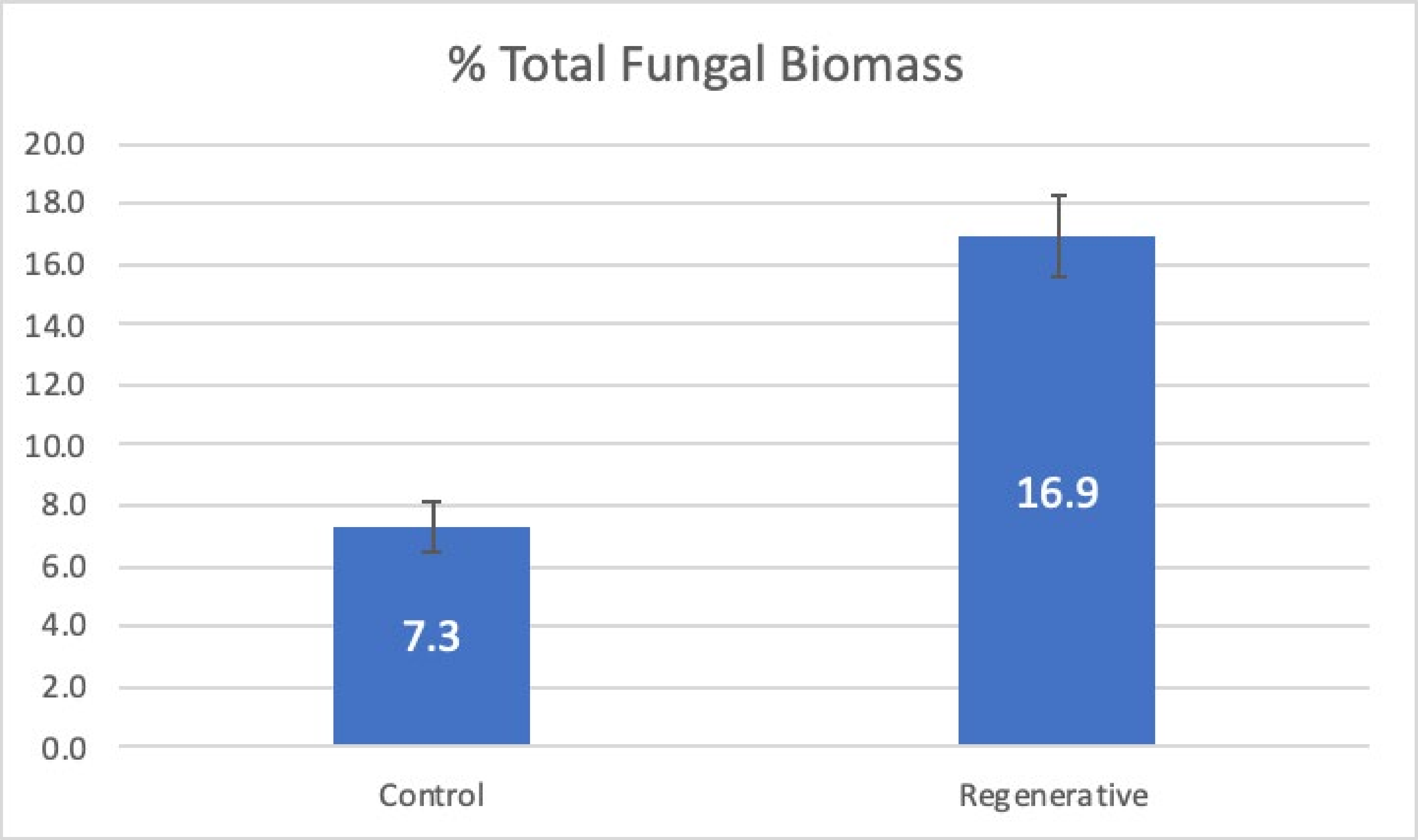
Regenerative Practices Enhances TMB (ng/g)

More diverse biology created within this regenerative system

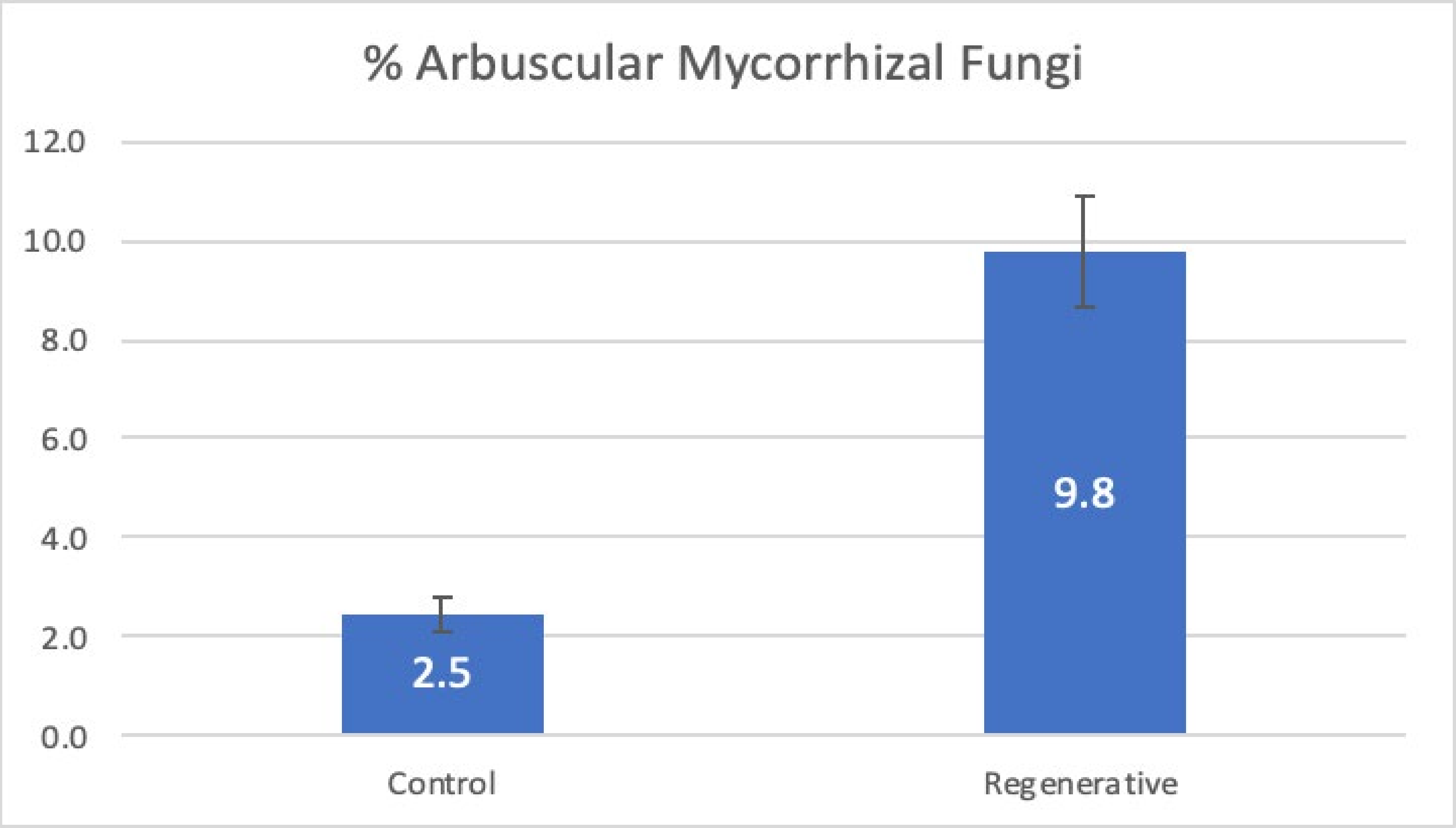


Regenerative Practices Enhances % Total Fungal Biomass

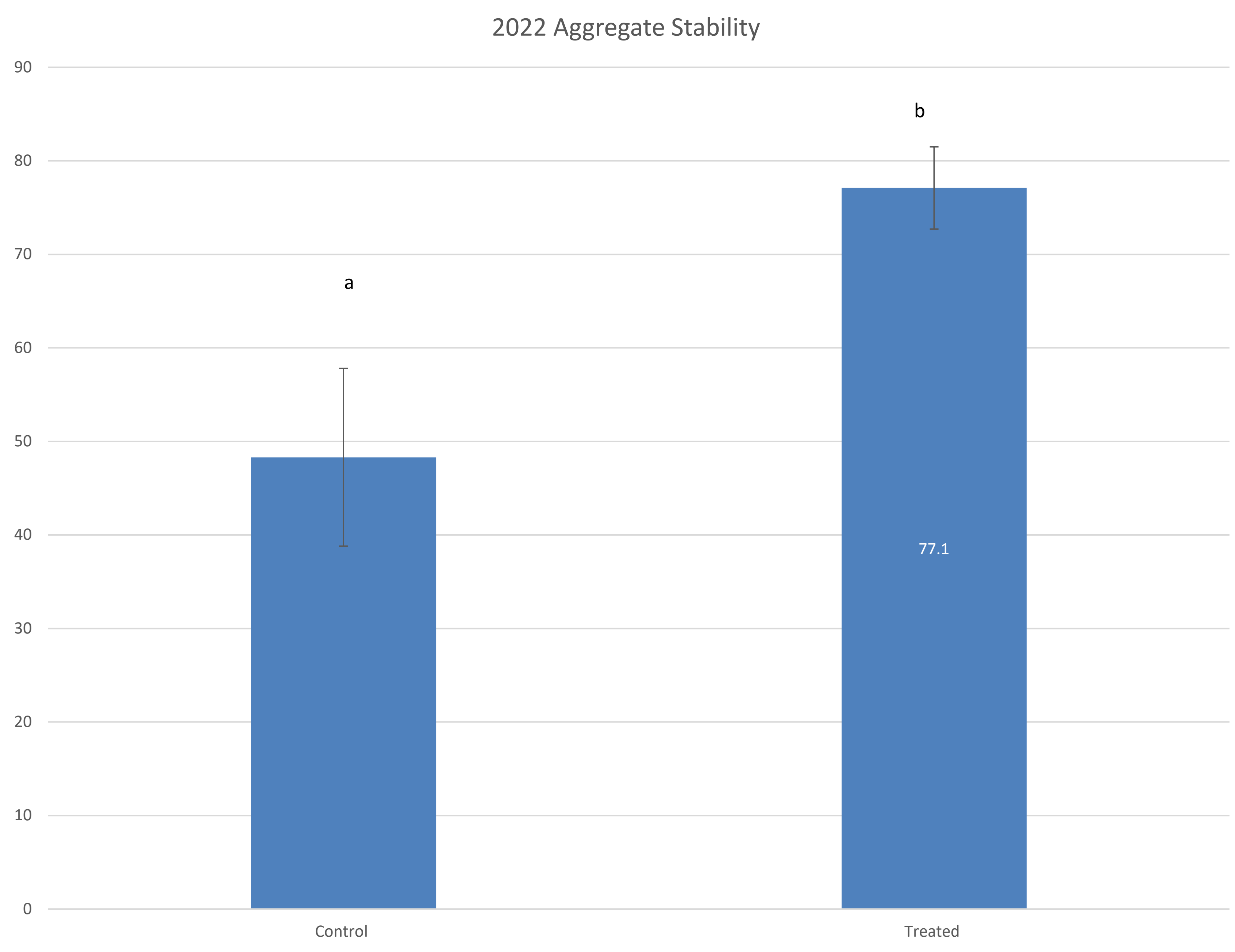
This sets the stage for soil aggregation and soil carbon accrual



Regenerative Practices Enhances Arbuscular Mycorrhizal Fungi %

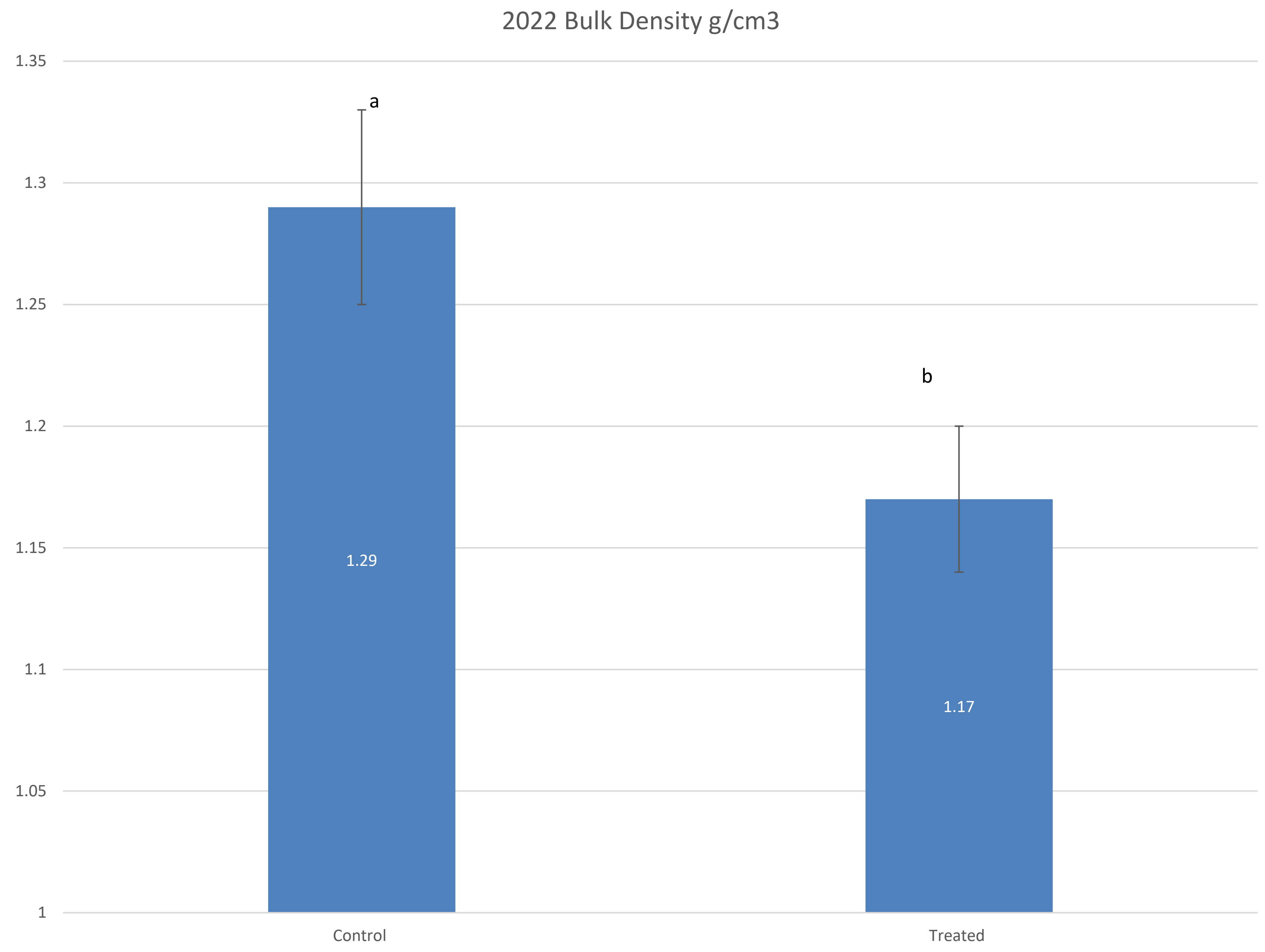


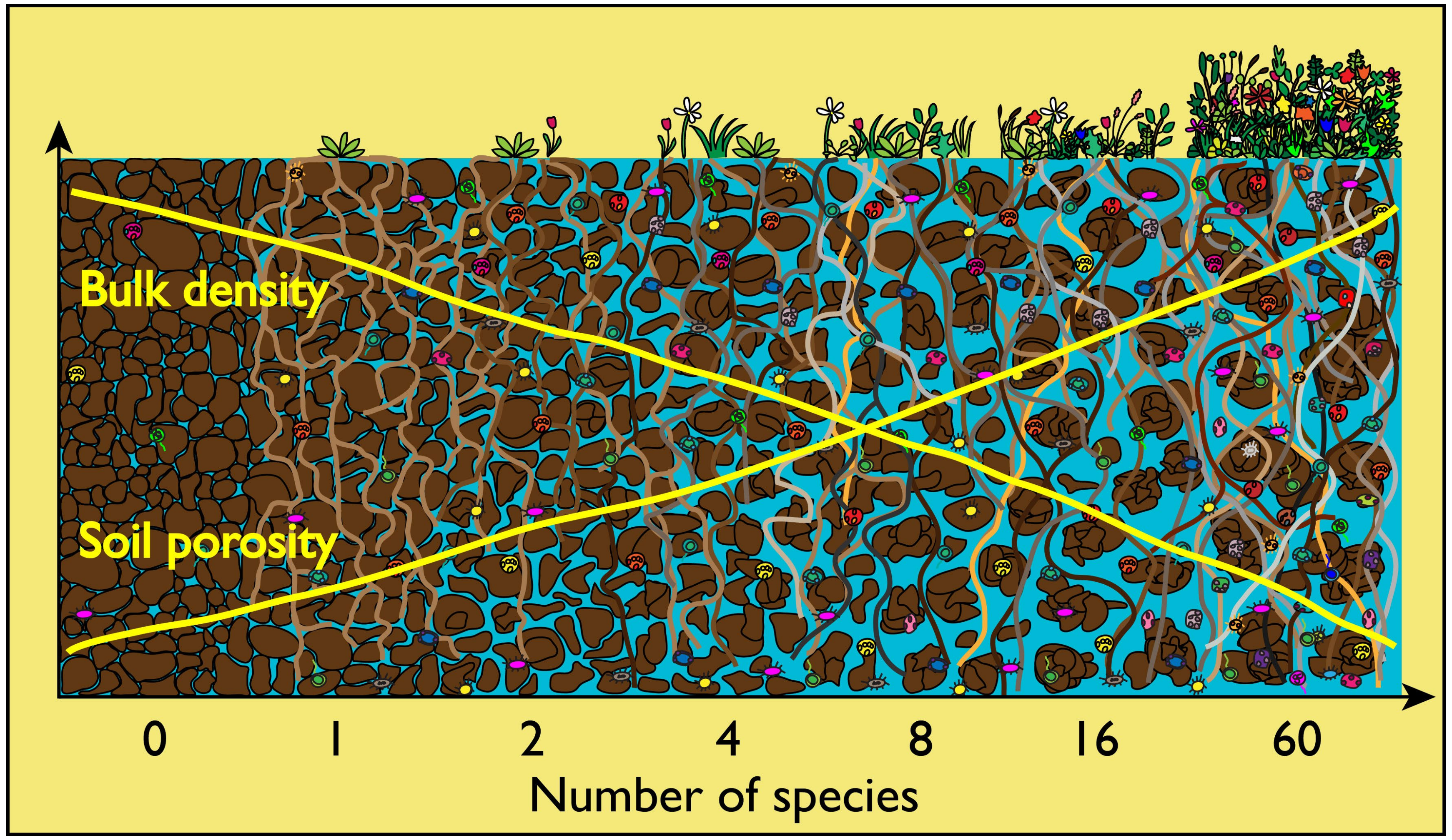
Changes in Soil Tilth



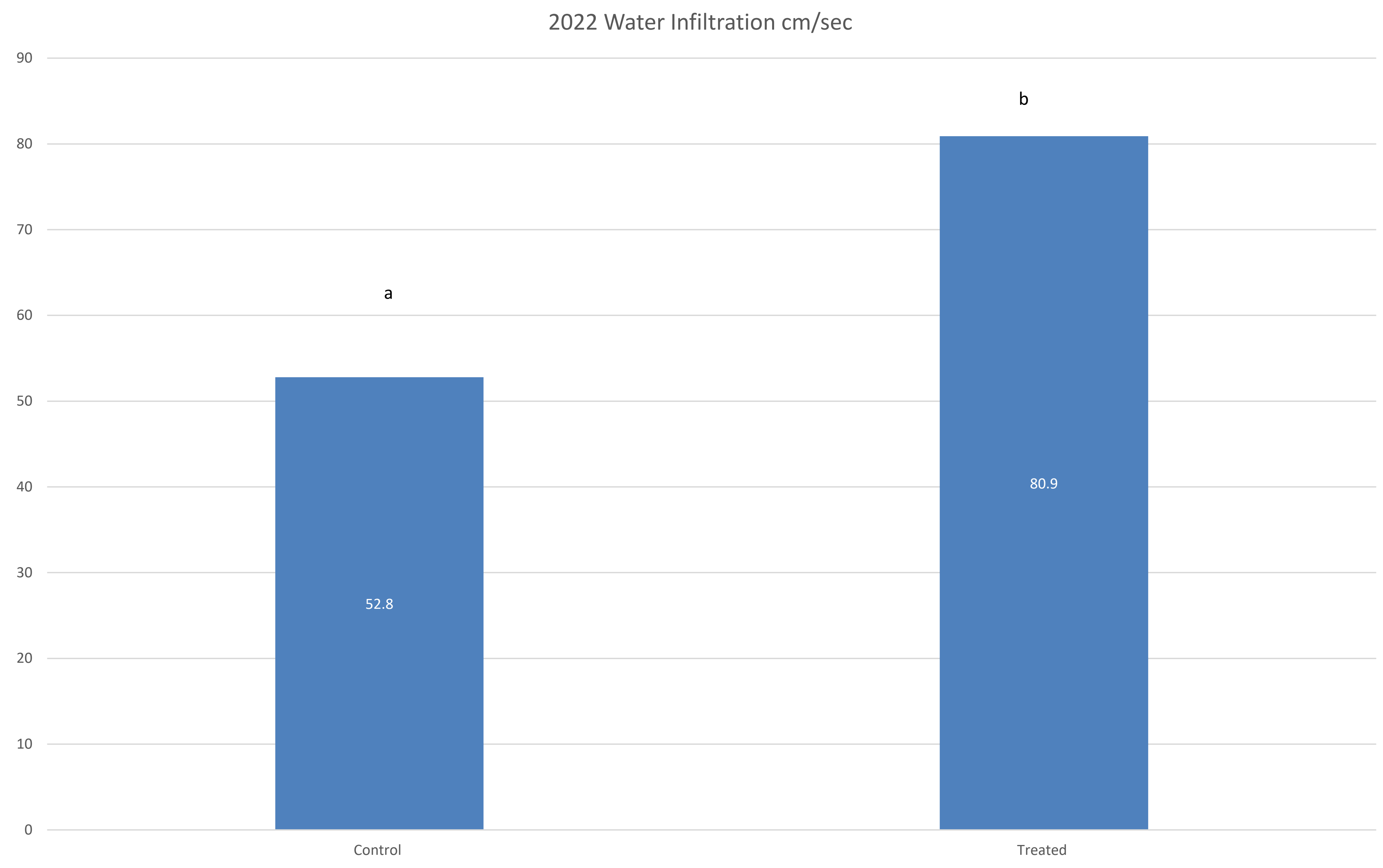
Soil samples collected from 20 year old conventional till corn and perennial bluegrass sod systems were saturated with water and allowed to dry. Note the soil crusting in the low organic matter conventional till sample compared to the abundance of stable aggregates in the high organic matter perennial sod sample. Photo courtesy Ray R. Weil, University of Maryland.

Changes in Soil Tilth





Changes in Soil Tilth



Carbon (0”- 4” soil depth) by Treatment 2022

Carbon	Regenerative	Conventional
% SOM	3.4 ± 0.19 [a]	3.08 ± 0.17 [b]
% MAC	48.1 ± 10.6 [a]	28.64 ± 8.3 [b]
CO_2-C	86 ± 18.33	68.14 ± 29.5
% Total Carbon	4.07 ± 0.18[a]	3.62 ± 0.02[b]

Changes in Soil Tilth

After ← Before

Effective Rainfall – how much water infiltrates/min?
This rain event = 0.15" of rain


For every 1% increase in SOM:
Increase water holding capacity by 25,000 gallons/acre

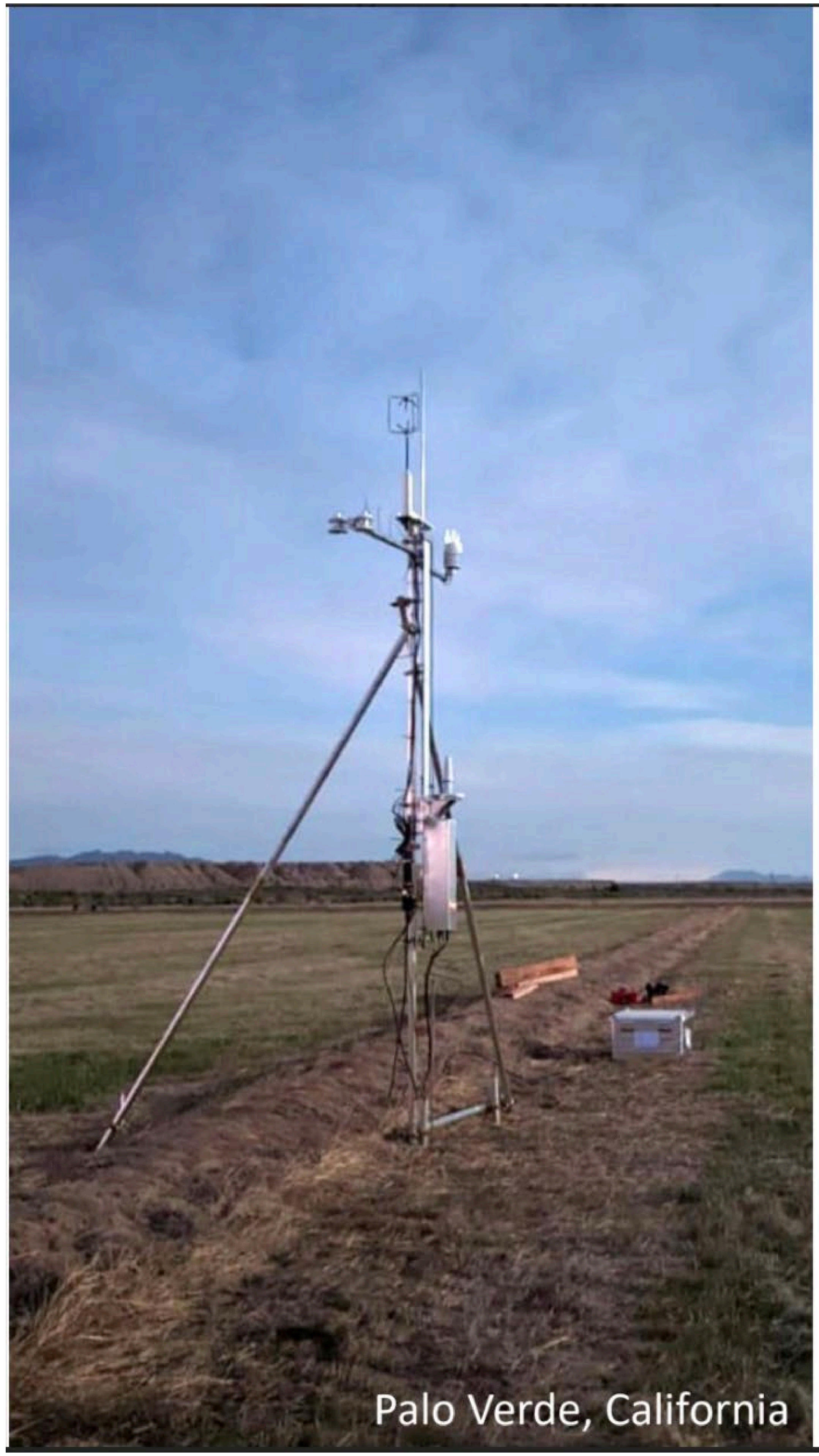
The California Soil Carbon Accrual Project

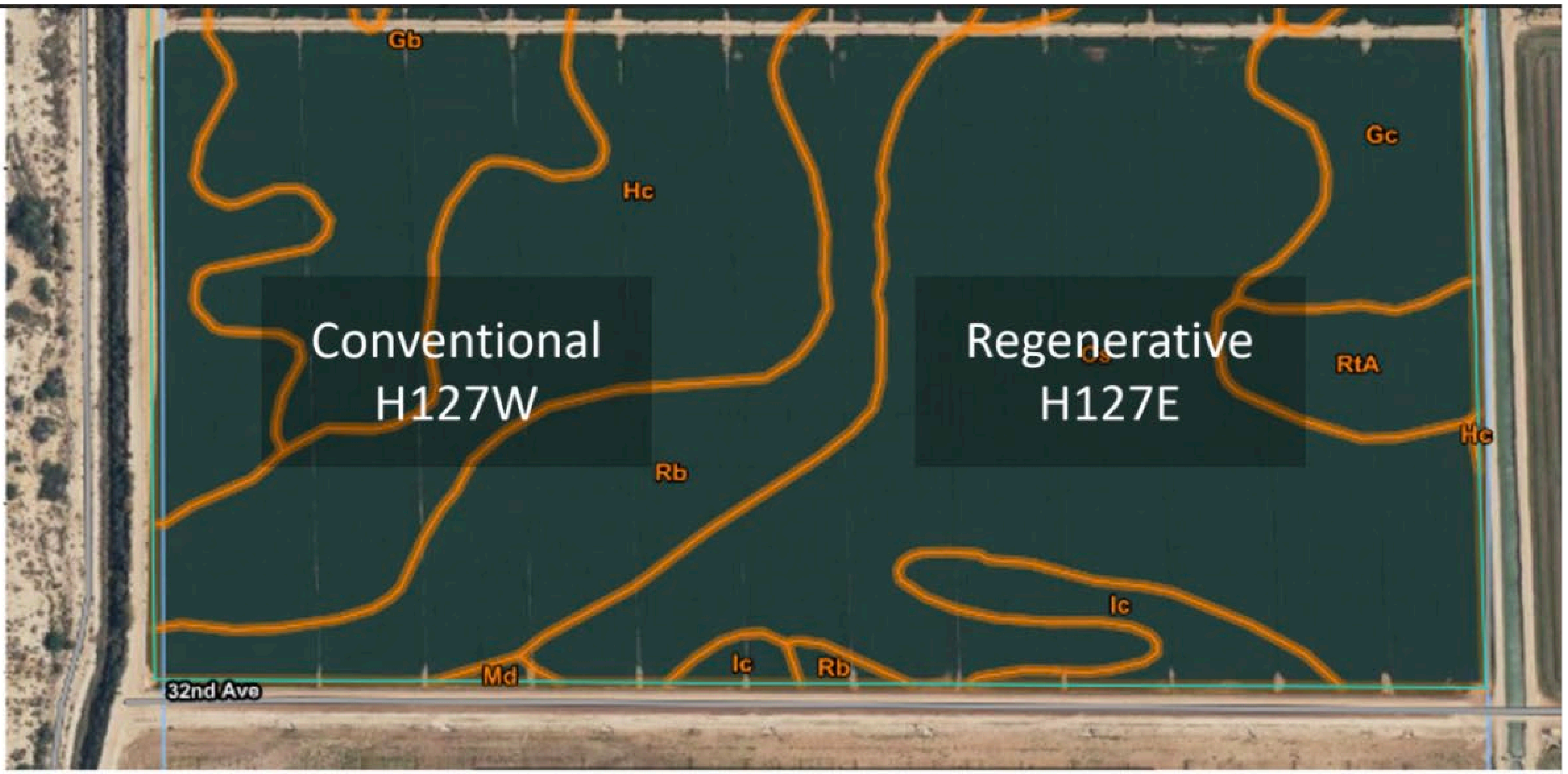
The Center for
REGENERATIVE AGRICULTURE
AND RESILIENT SYSTEMS
CALIFORNIA STATE UNIVERSITY, CHICO

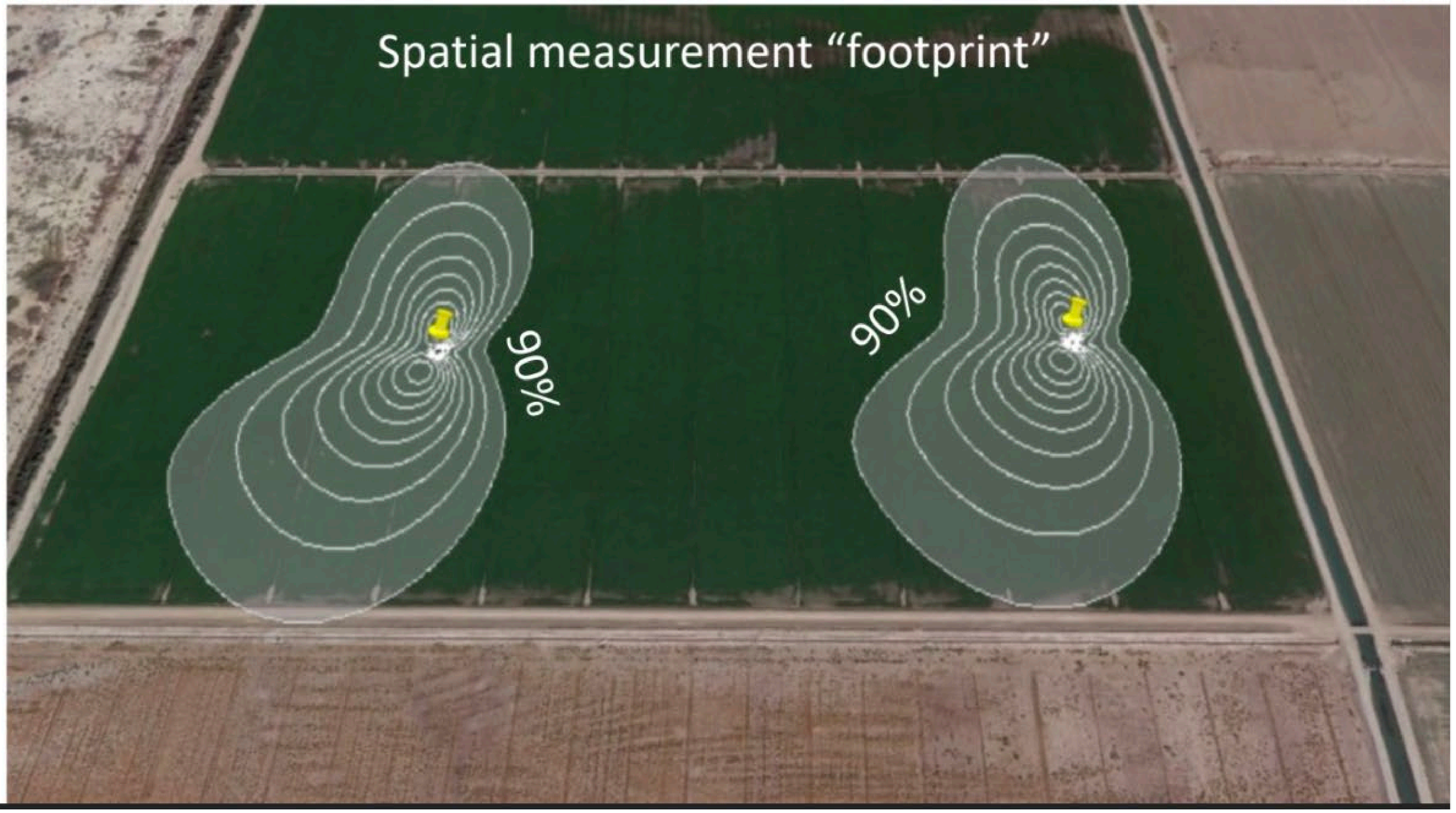
John Knowles, Jake Brimlow, Garrett Liles, Sandrine Matiasek, Patty Oikawa, Logan Smith, Cindy Daley

California State University Chico

CALIFORNIA STATE UNIVERSITY, EAST BAY


Palo Verde, California

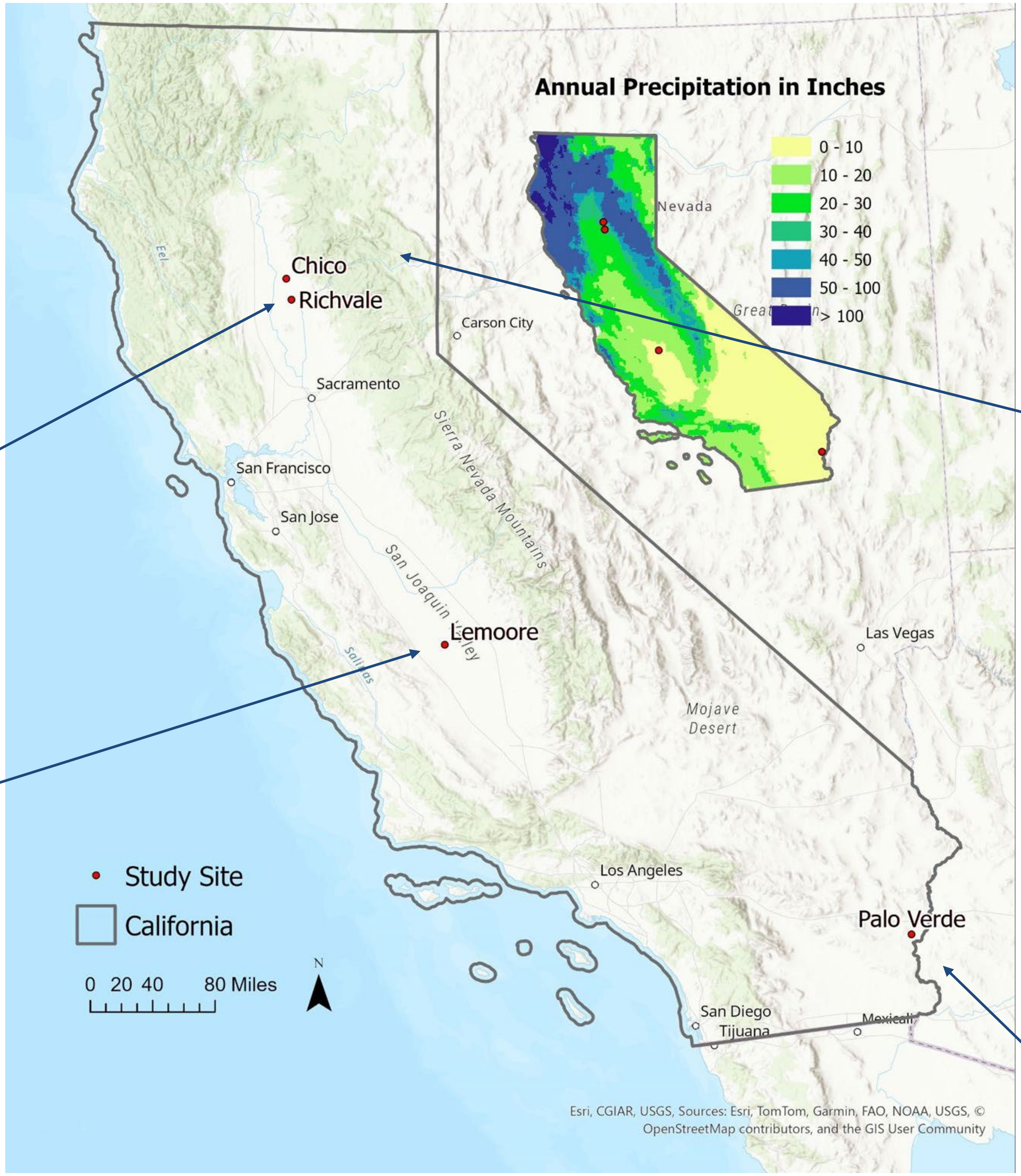

Conventional
H127W
Regenerative
H127E
Gb
Hc
Gc
RtA
Hc
Rb
Ic
Md
Ic
Rb
32nd Ave


Spatial measurement “footprint”
90%
90%

A Statewide 'Network'

Josiassen - Rice

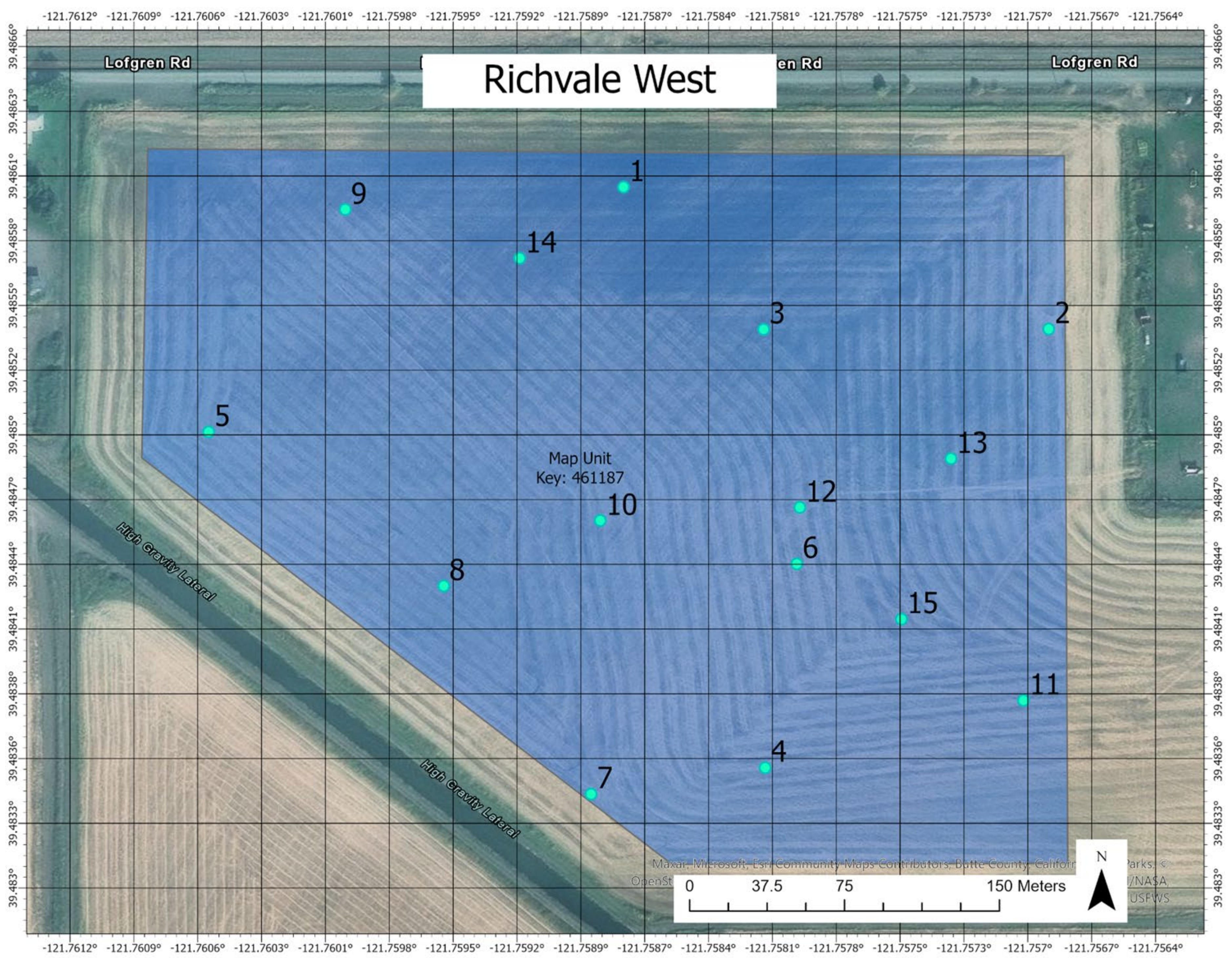
Stone Land - Cotton

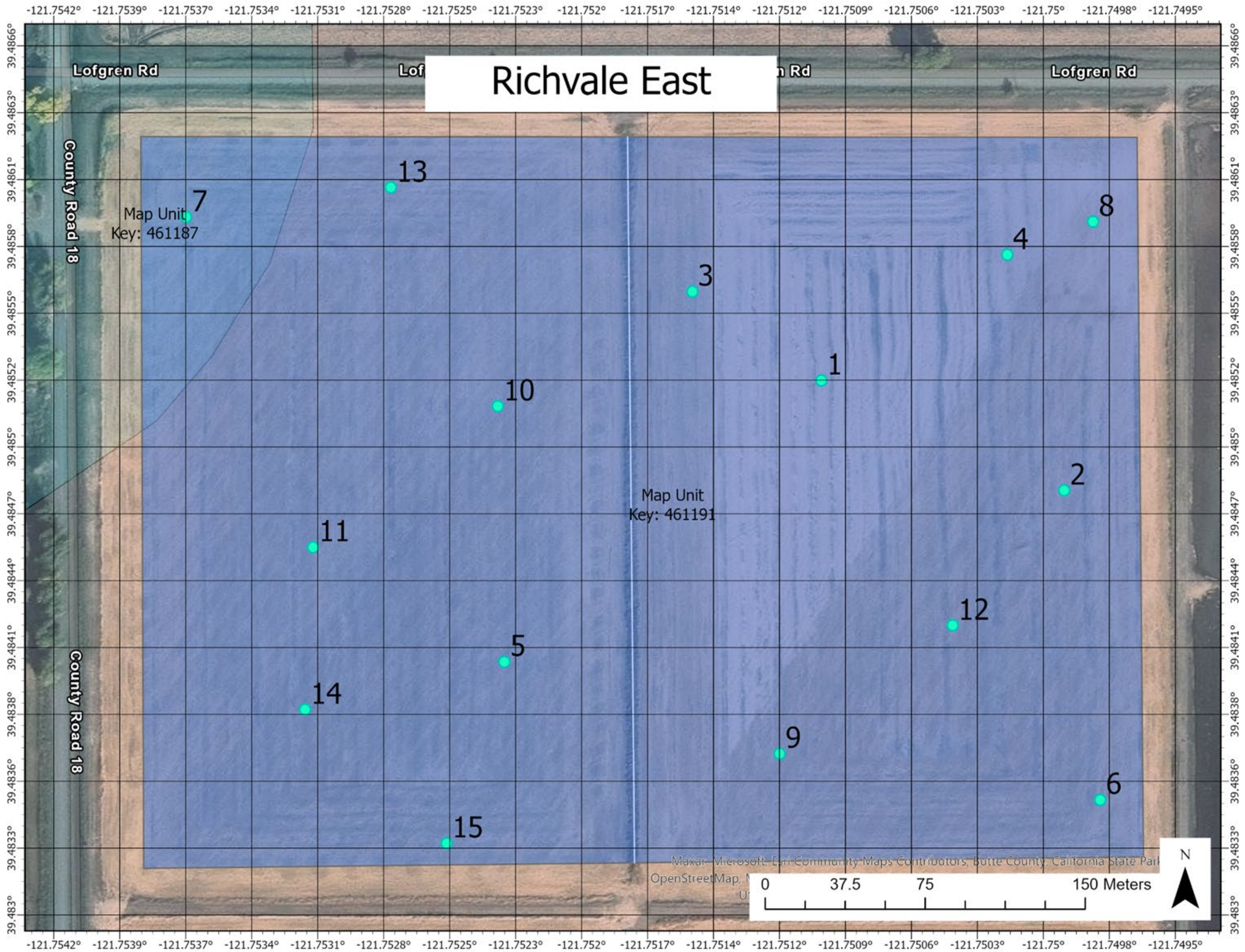


Chico State - Grain

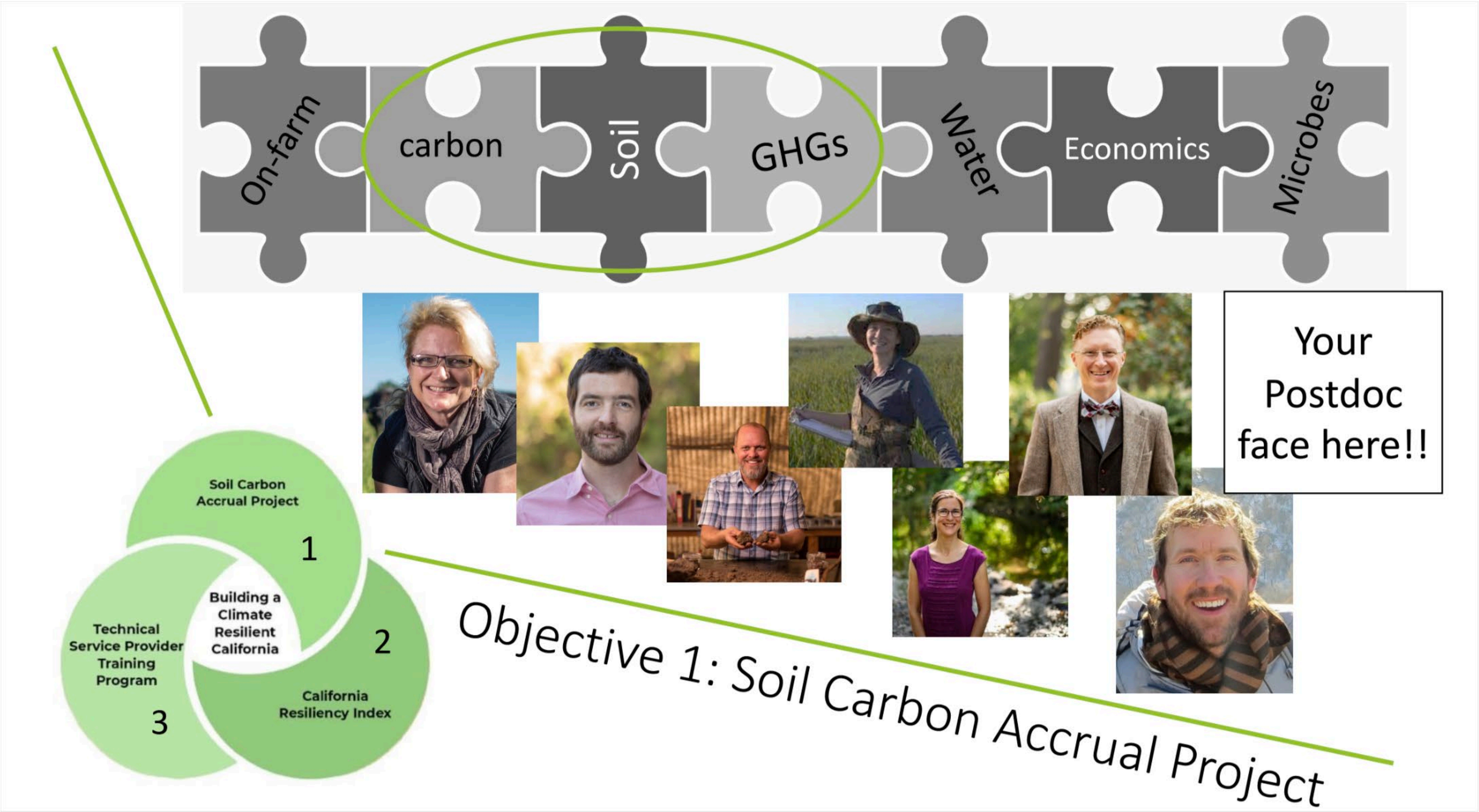
Hay Day - Alfalfa

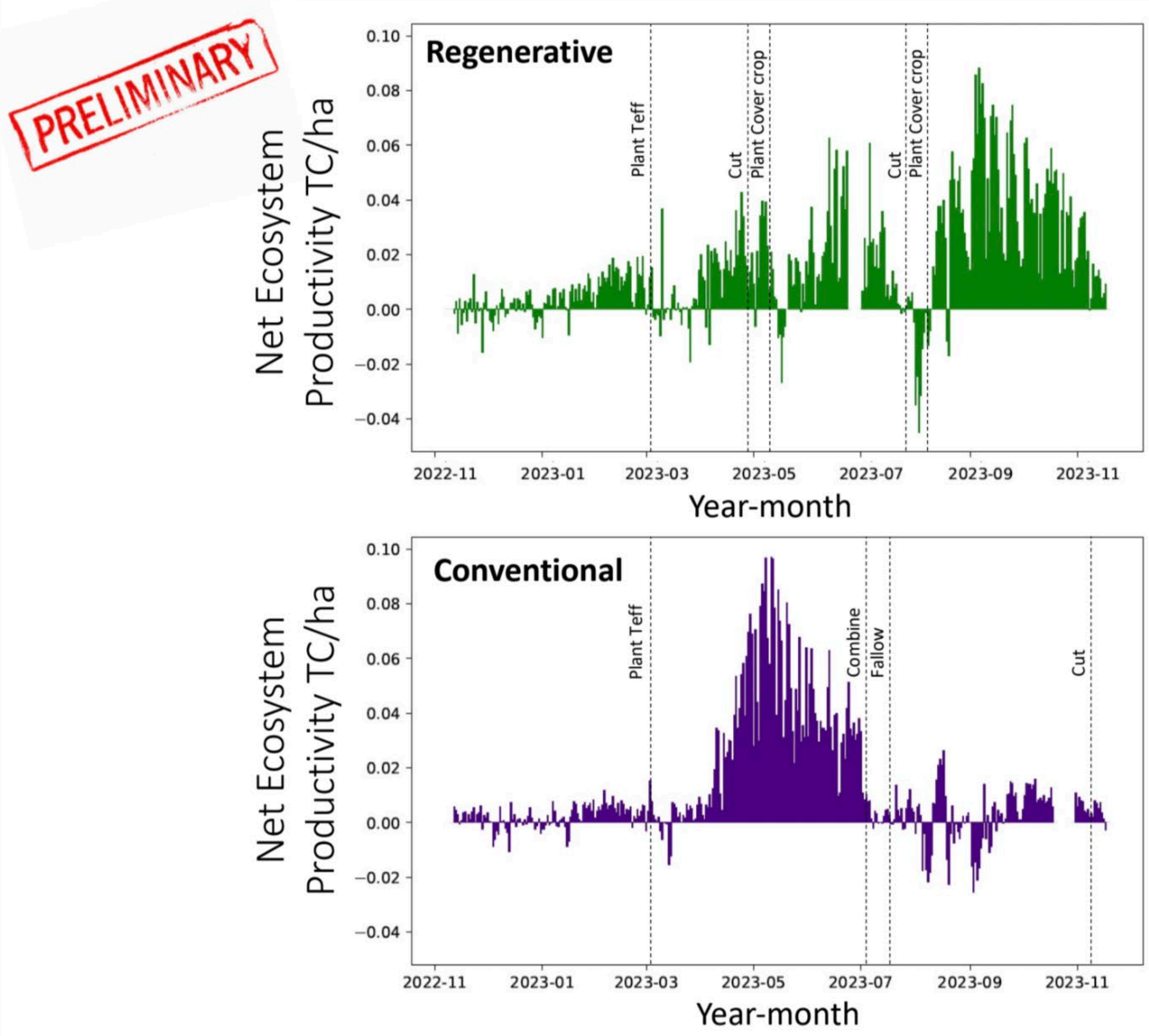
Consistent Design





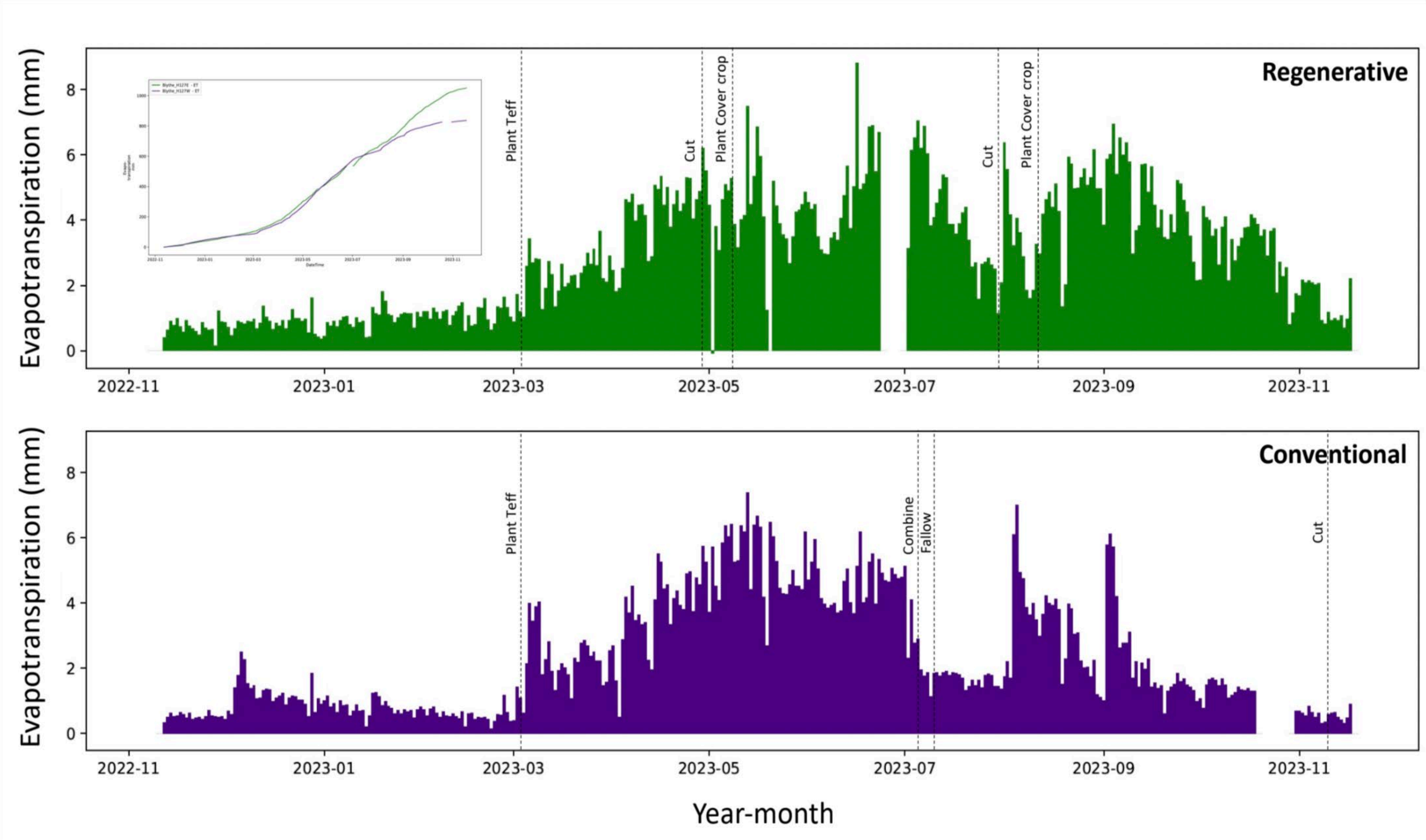
- ~ 30 acres/treatment → 15 sample points each
- Two Transitional Sites & Two with varying land use legacy


On-farm
carbon
Soil
GHGs
Water
Economics
Microbes
Your Postdoc face here!!
Soil Carbon Accrual Project
1
Building a Climate Resilient California
2
California Resiliency Index
Technical Service Provider Training Program
3
Objective 1: Soil Carbon Accrual Project



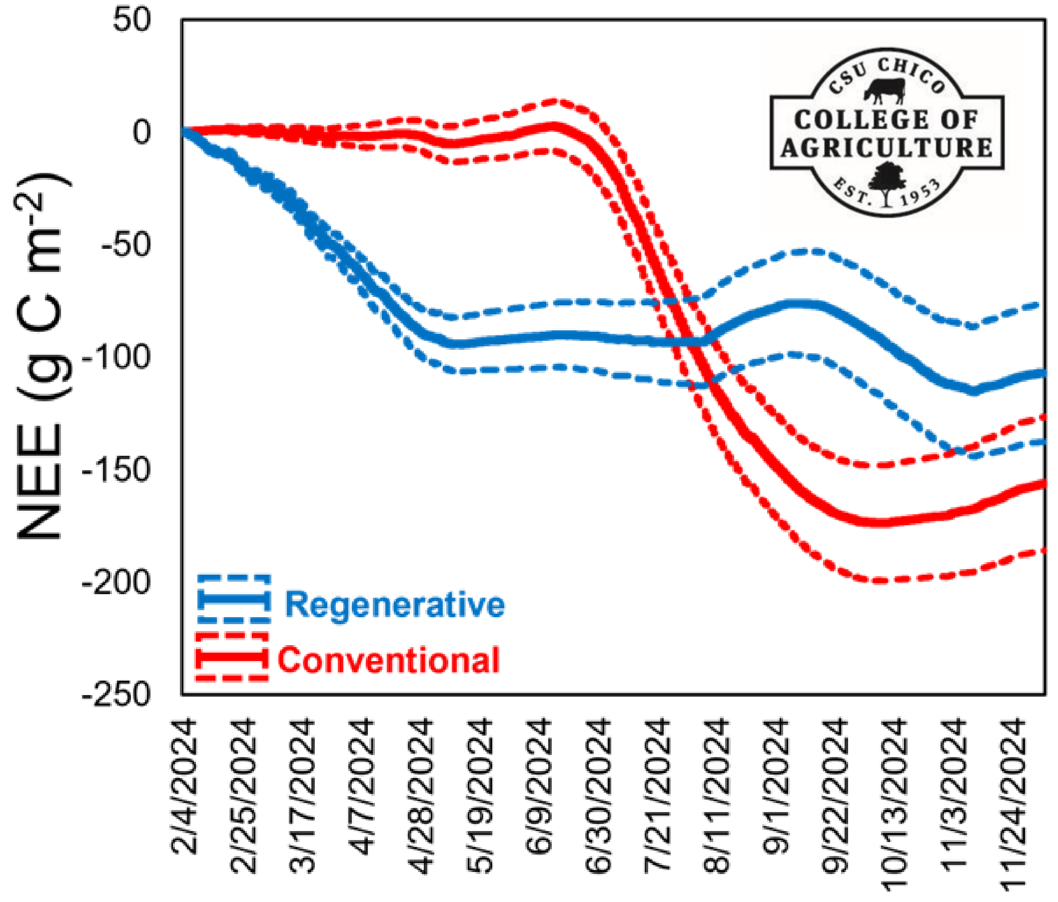
PRELIMINARY
Regenerative
Net Ecosystem Productivity TC/ha
Plant Teff
Cut
Plant Cover crop
Cut
Plant Cover crop
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
2022-11
2023-01
2023-03
2023-05
2023-07
2023-09
2023-11
Year-month
Conventional
Net Ecosystem Productivity TC/ha
Plant Teff
Combine
Fallow
Cut
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
2022-11
2023-01
2023-03
2023-05
2023-07
2023-09
2023-11
Year-month

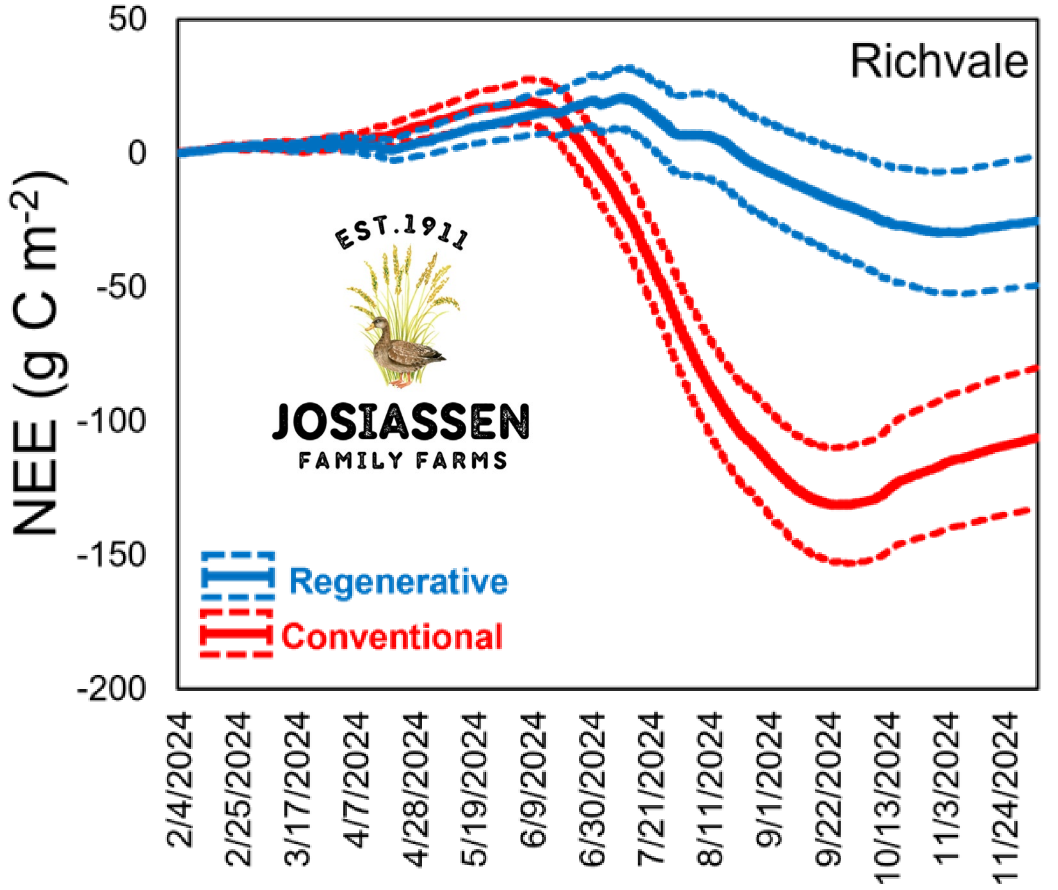
Peas, vetch, and daikon cover crop mix, Hayday farms, Palo Verde, CA

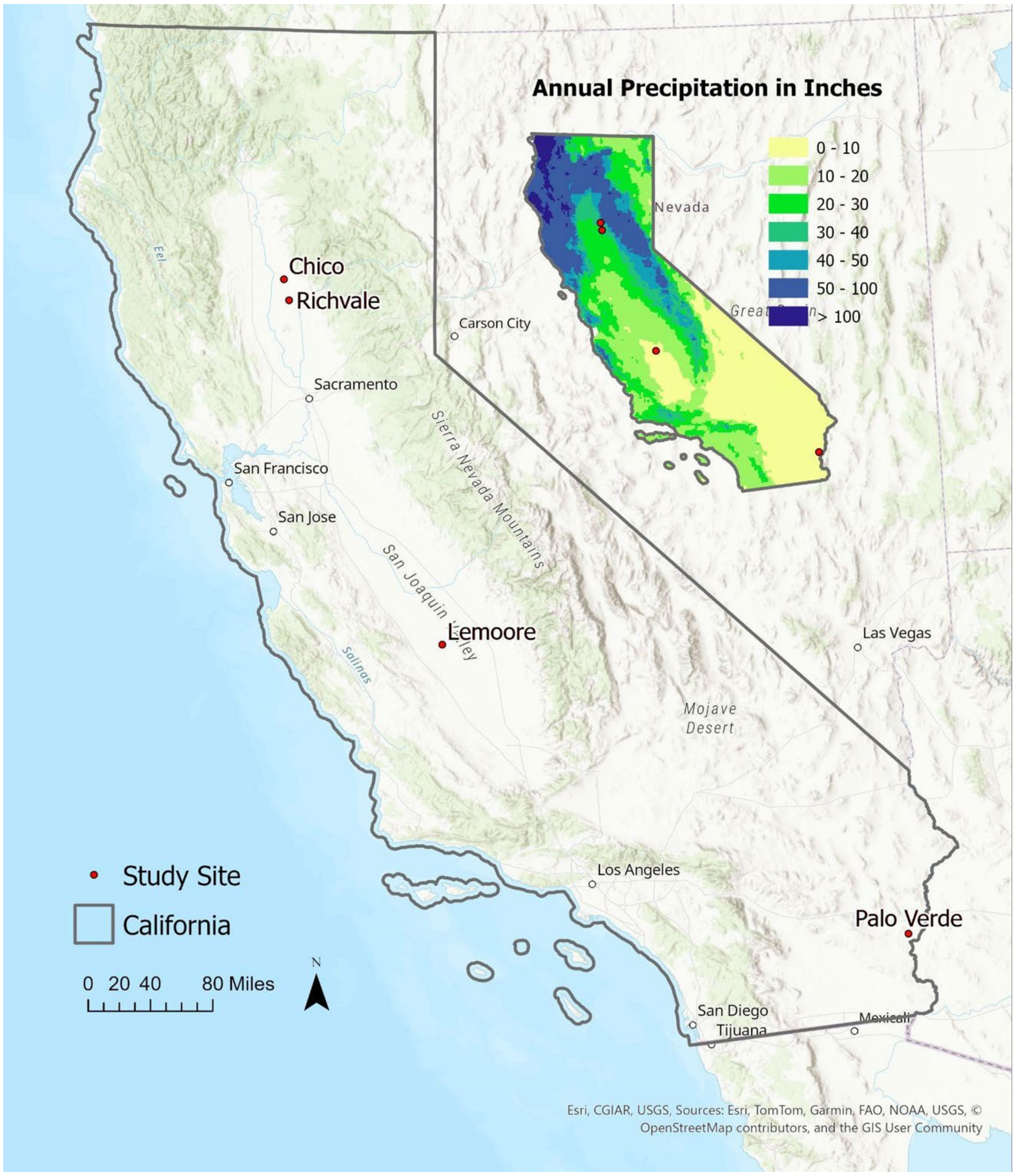


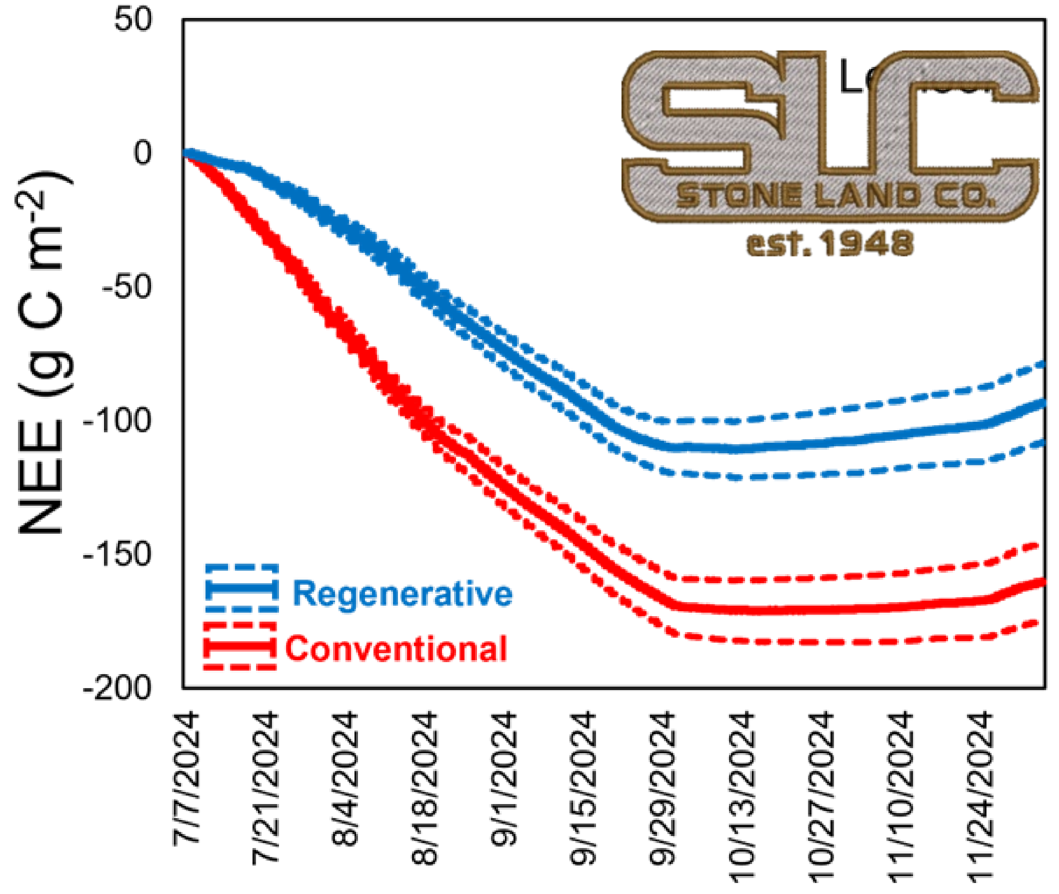
Regenerative
Conventional
Evapotranspiration (mm)
Plant Teff
Cut
Plant Cover crop
Combine
Fallow
2022-11
2023-01
2023-03
2023-05
2023-07
2023-09
2023-11
Year-month

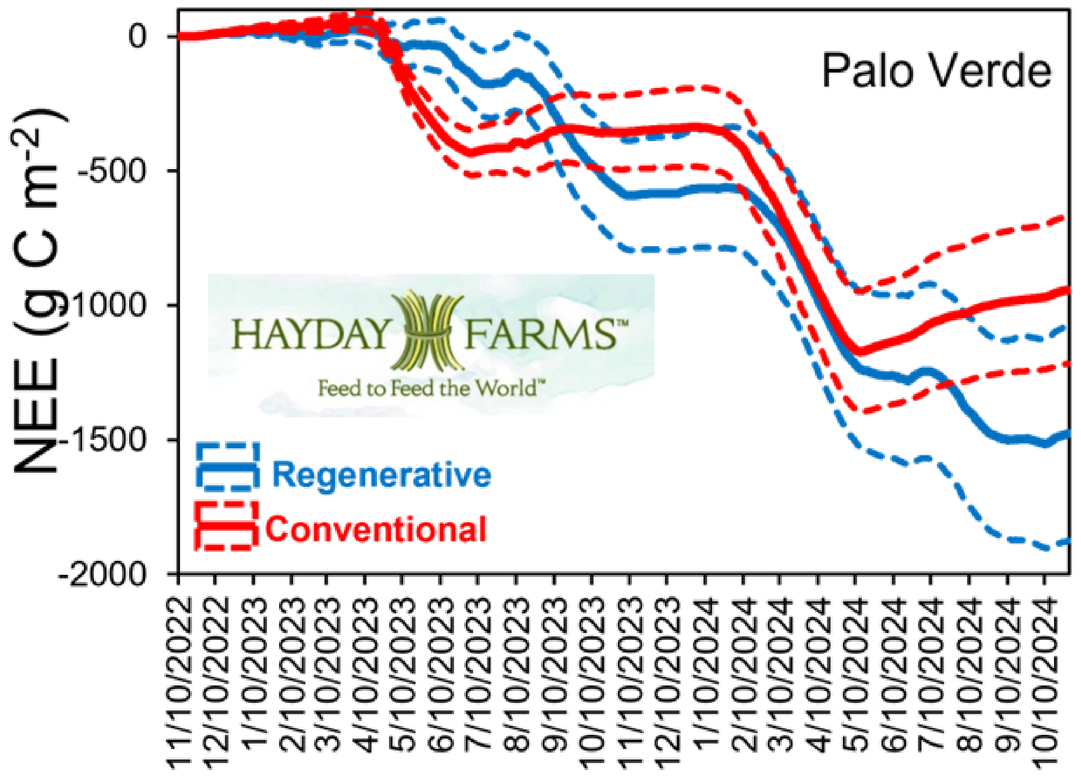
Net Ecosystem Exchange











PLFA data on SCAP PV Site - Year 1

	Regenerative	Standard
Total Fungi, PLFA ng/g	70.64 ± 14.27[a]	41.28 ± 6.4[b]
Total Fungi, % of Total Biomass	4.77 ± 1.25[a]	2.05 ± 0.28[b]
Arbuscular Mycorrhizal Fungi ng/g	35.83 ± 8.12[a]	17.76 ± 3.14[b]
AM, % of Total Biomass	2.61 ± 0.86[a]	0.88 ± 0.16[b]
Saprophytic Fungi ng/g	34.81 ± 7.93[a]	23.52 ± 3.47[b]
Saprophytic Fungi, % of Total Biomass	2.15 ± 0.48[a]	1.17 ± 0.15[b]

Regenerative Agriculture

- ➢RA improves all cropping systems
- ➢RA improves all management systems
- ➢It’s a proven Nature Based Solution to the Climate Crisis
- ➢RA as the new normal
- ➢The time is now

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