Texas Soil Health Workshop

Wichita Falls, TX

9 March 2023

Soil Carbon and Greenhouse Gas Emissions in Semi-arid Cropping Systems

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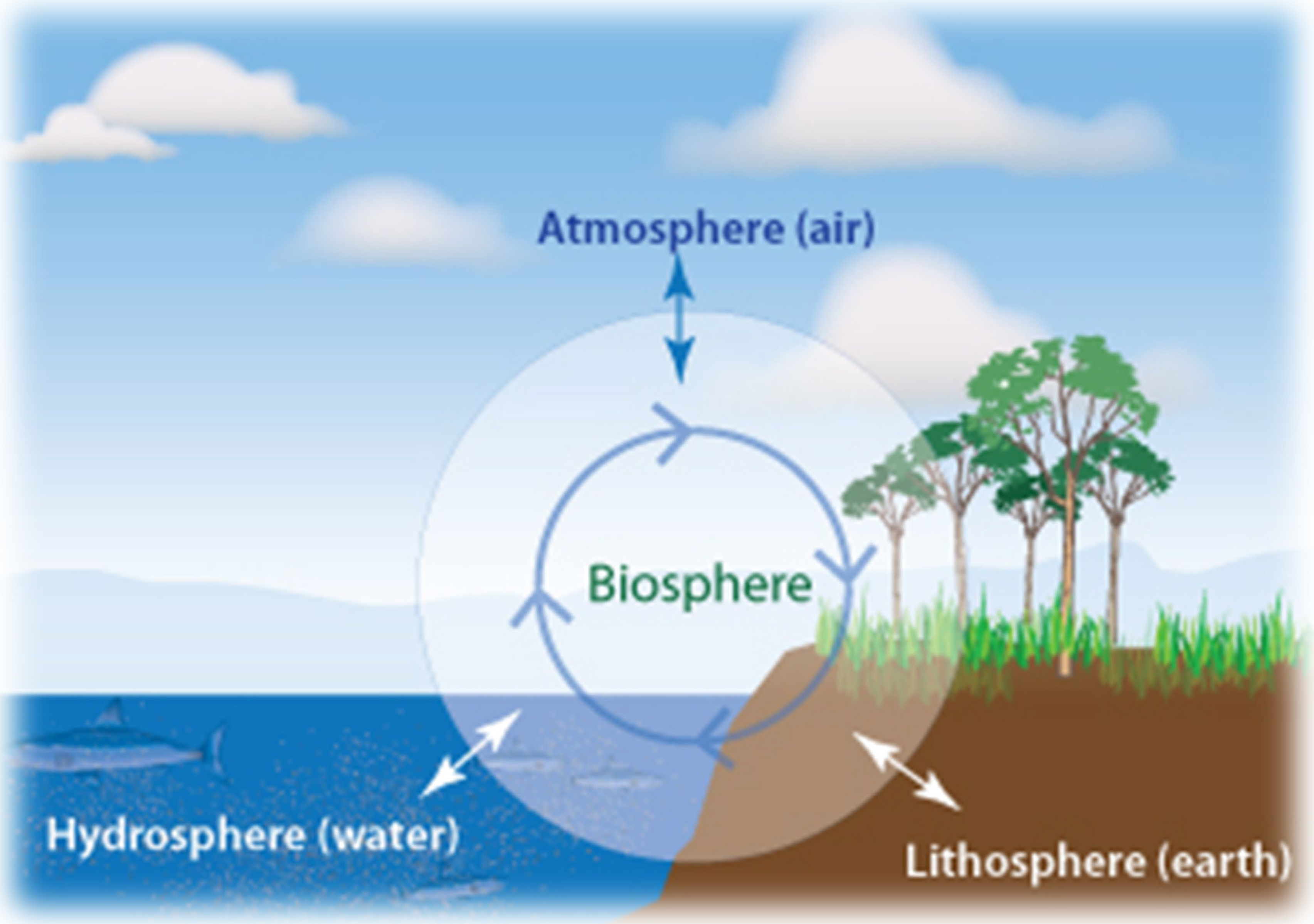
TEXAS A&M AGRILIFE RESEARCH

TEXAS TECH UNIVERSITY Department *of* Plant & Soil Science

Photo: Hector Valencia

Global Carbon Cycle

Biogeochemical cycle by which C is exchanged between the *biosphere*, *geosphere (lithosphere)*, *hydrosphere*, and *atmosphere*



Global Carbon Cycle

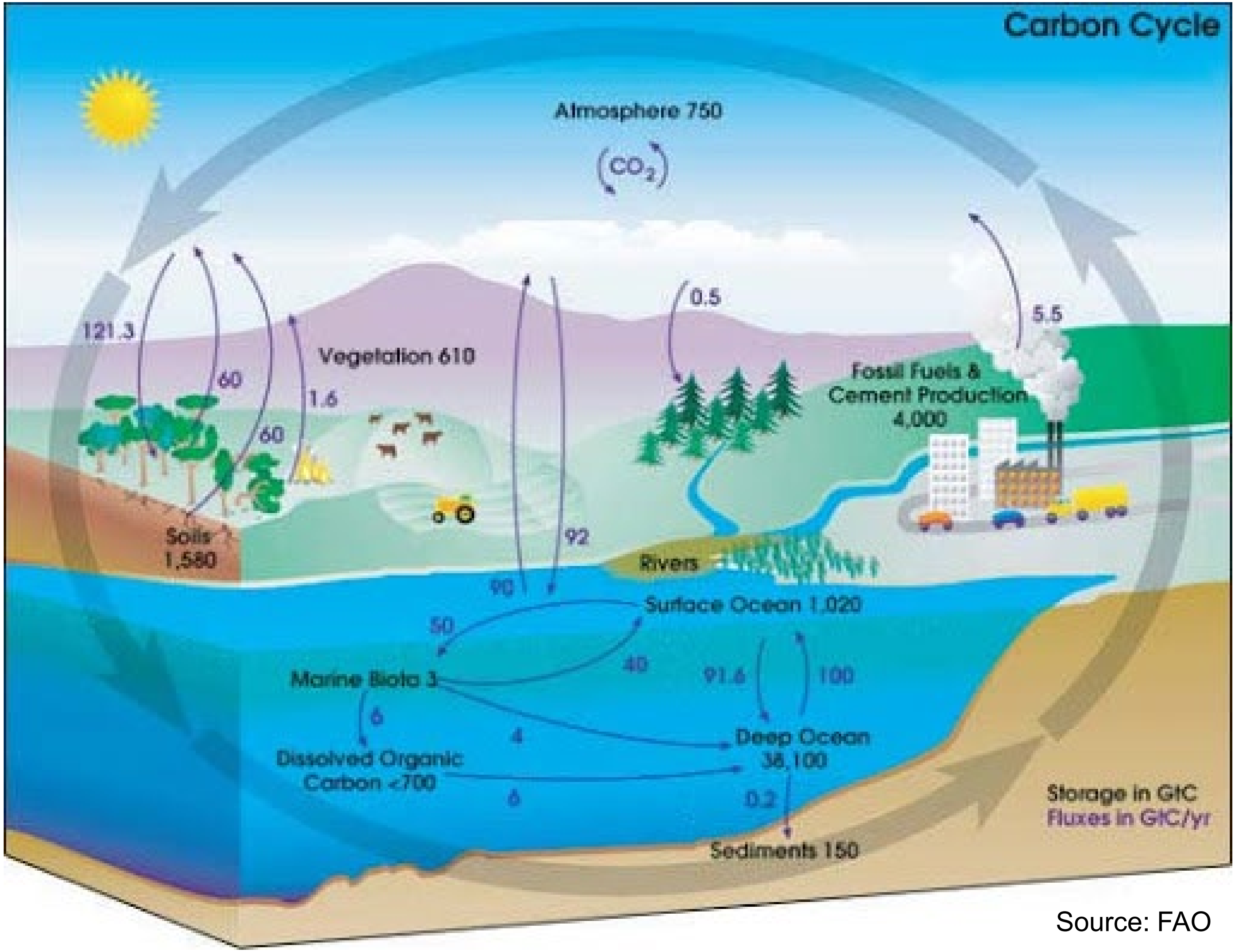
Sources (Gt C/year)

- Ocean release = 90
- Respiration = 60
- Decomposition = 60
- Fossil fuel = 9.3
- Deforestation = 1.0
- *TOTAL SOURCES* = 220.3

Sinks (Gt C/year)

- Photosynthesis = 120
- Ocean uptake = 92.7
- Soil = 0
- *TOTAL SINKS* = 212.7

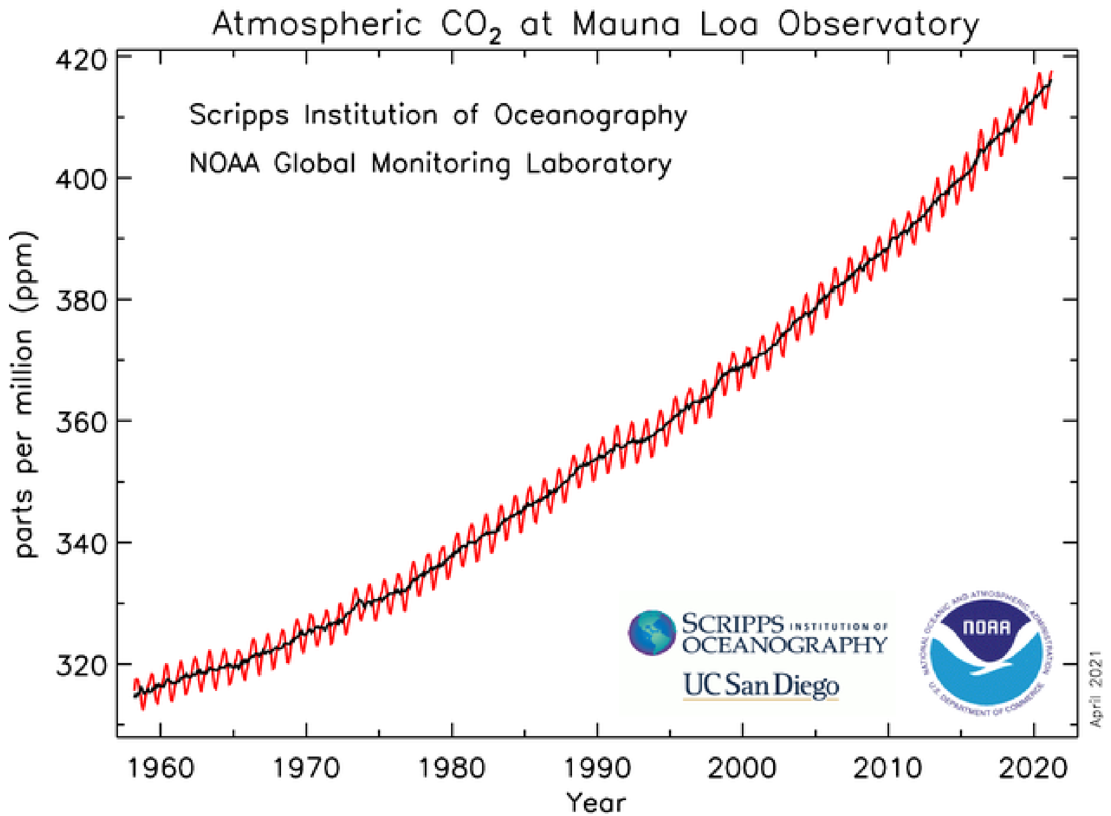
SOURCES – SINKS = 7.6 Gt C added to atmosphere annually



Source: FAO

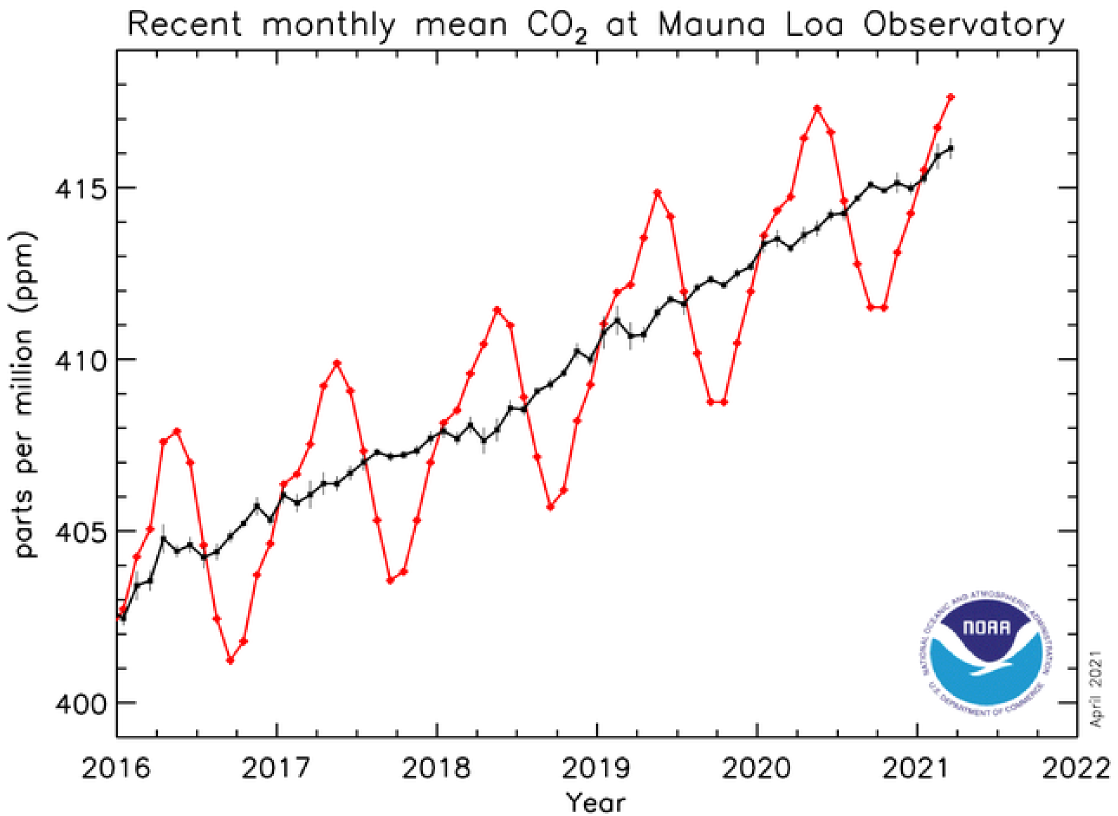
Global Carbon Cycle

- *SOURCES* – *SINKS* = 220.3 – 212.7 = 7.6 Gt C added to atmosphere annually
- Atmospheric pool increases by 4.5 Gt C annually


Atmospheric CO_2 at Mauna Loa Observatory

Scripps Institution of Oceanography

NOAA Global Monitoring Laboratory


Recent monthly mean CO_2 at Mauna Loa Observatory

January 2022: 419 ppm

January 2021: 416 ppm

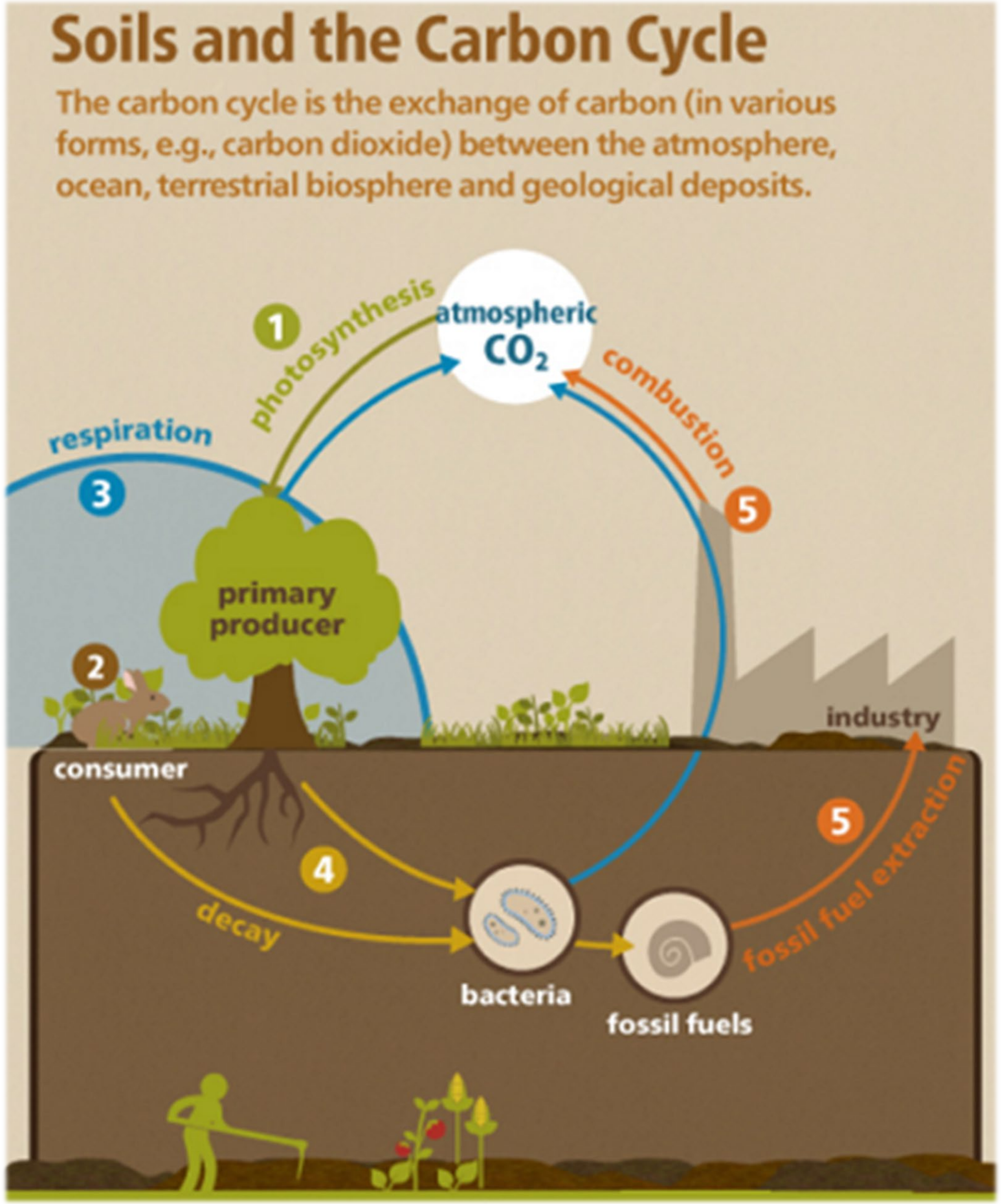
Global Carbon Cycle

- Soil is a major C reservoir, but it could have the potential to be (or may be) a sink
  - *Sink* is accumulating C
    (e.g., ocean or atmosphere)
  - *Reservoir (soil)* is not actively accumulating C

    Photosynthesis (120 Gt C/year) =

    Respiration (60 Gt C/year)
    \+
    Decomposition (60 Gt C/year)

- Soil organic C (OC) = 1500 Gt C
  - More C than the atmosphere
    (800 Gt C) and terrestrial vegetation (500 Gt C) combined



Source: FAO

Soil OC – Managing to Increase Stocks

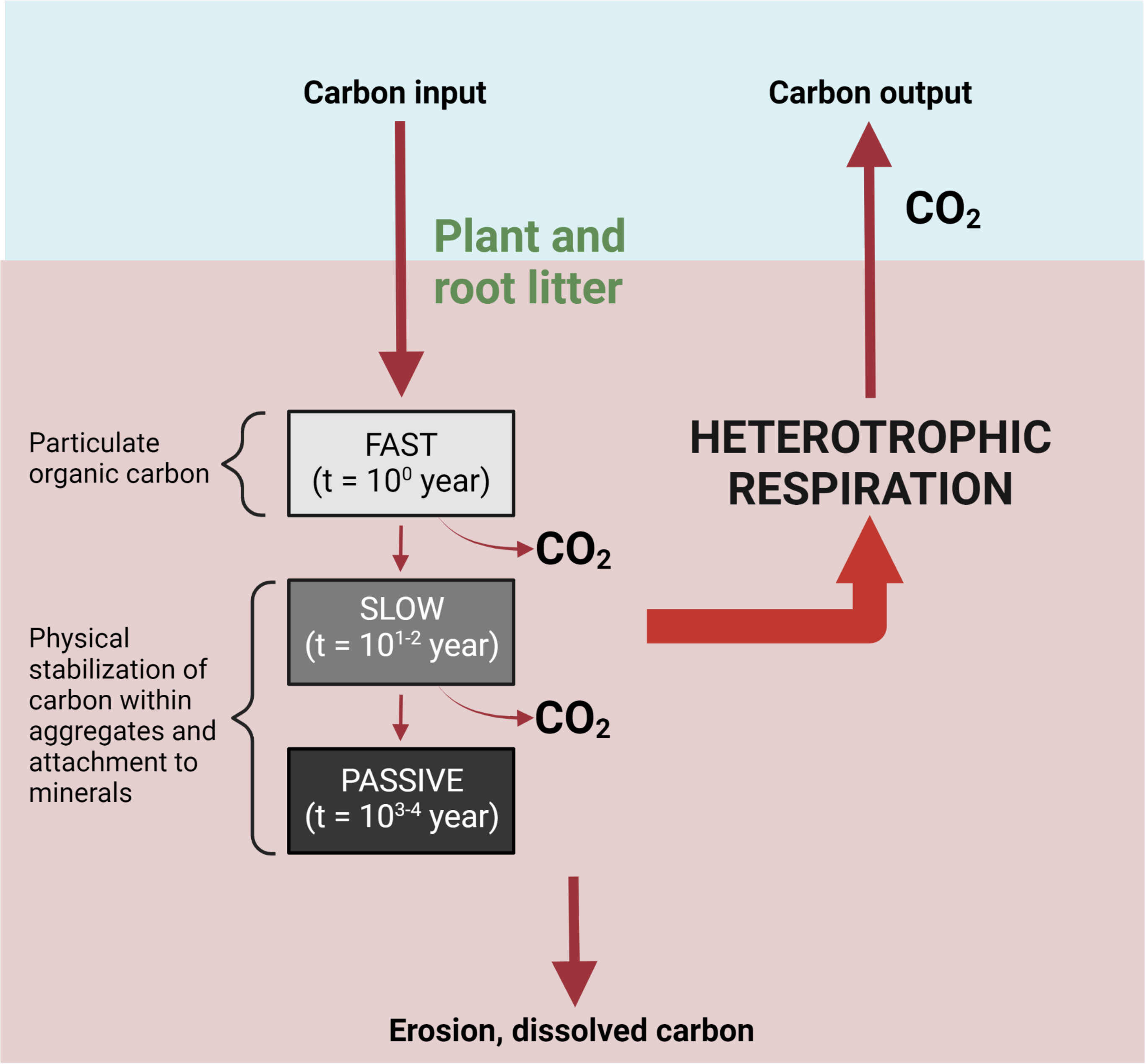
- Anthropogenic impacts on soil can turn it into either a net sink or net source (C lost as gas)
- C Source: greenhouse gases (GHG) including CO_2 and CH_4
  - CO_2 is most abundant C gas in atmosphere
    - Autotrophic and heterotrophic respiration of CO_2 is second largest terrestrial C flux
  - CH_4 is a 28x more potent GHG than CO_2
    - Released during decomposition of OM under anaerobic conditions (methanogensis)
- Sink or SOC storage in soil involves three stages:
  1. Removal of CO_2 from the atmosphere via plant photosynthesis
  2. Transfer of C from CO_2 to plant biomass
  3. Transfer of C from plant biomass to soil where it is stored as SOC in the most labile pool
- Managing to increase SOC stocks requires looking beyond just capturing atmospheric CO_2 – must find ways to retain C in the slow SOC pool

Soil OC – Cycling

- Dynamic reservoir – constantly changing due to microbial cycling of soil organic matter (C mineralization)

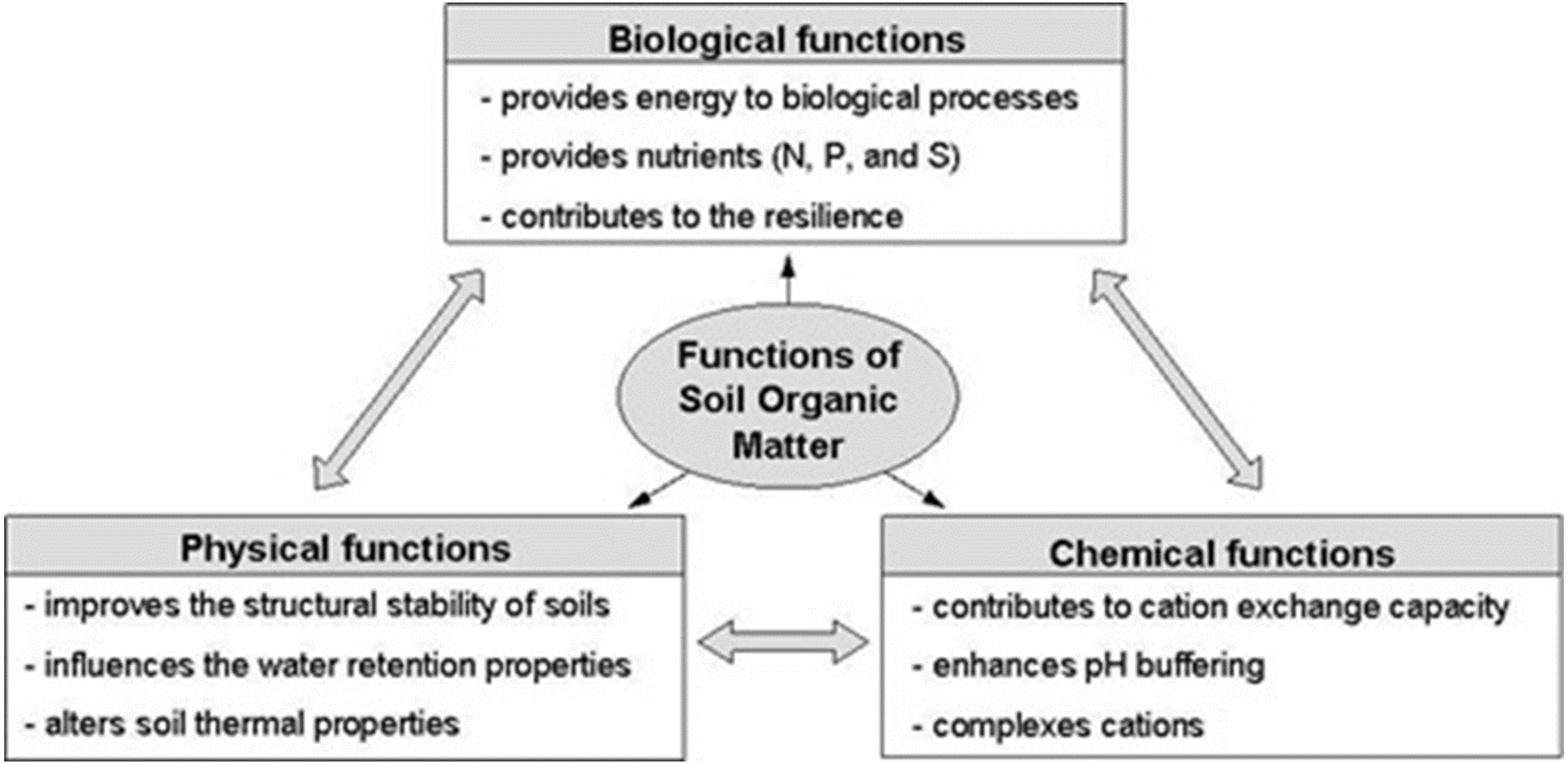
- Pools are not created equally
  - Particulate OC (checking account – quick to change)
  - Mineral-associated OM (saving account – slower to change)

- Functions/benefits are the result of SOM (and SOC) mineralization
  - Quantity added is not indicative of benefits



Soil OC – Ecosystem Services

- Functions/benefits are the result of SOM (and SOC) mineralization
  - Quantity added is not indicative of benefits



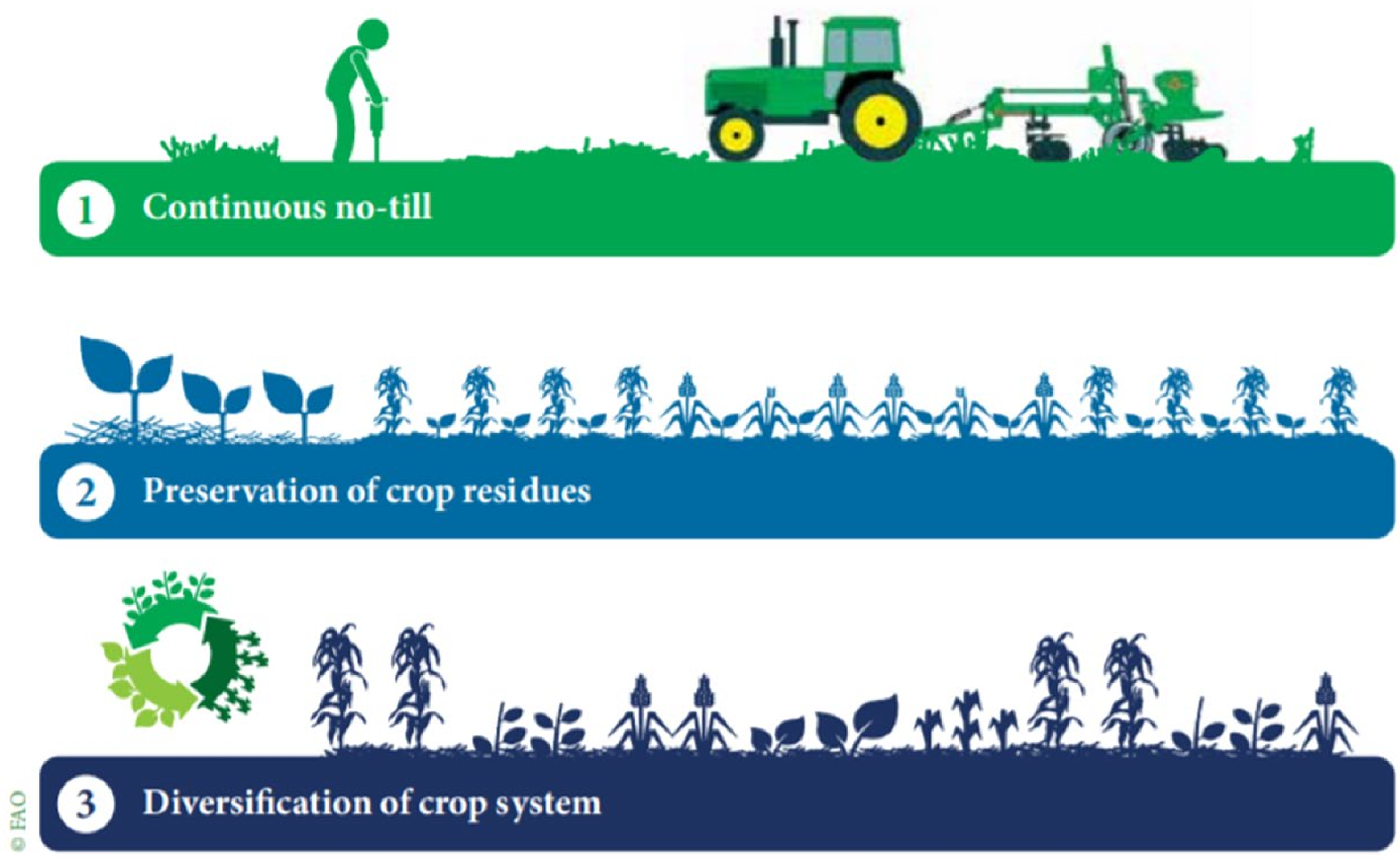
Functions of Soil Organic Matter

Biological functions
- provides energy to biological processes
- provides nutrients (N, P, and S)
- contributes to the resilience

Physical functions
- improves the structural stability of soils
- influences the water retention properties
- alters soil thermal properties

Chemical functions
- contributes to cation exchange capacity
- enhances pH buffering
- complexes cations

Soil OC – Managing to Increase Stocks



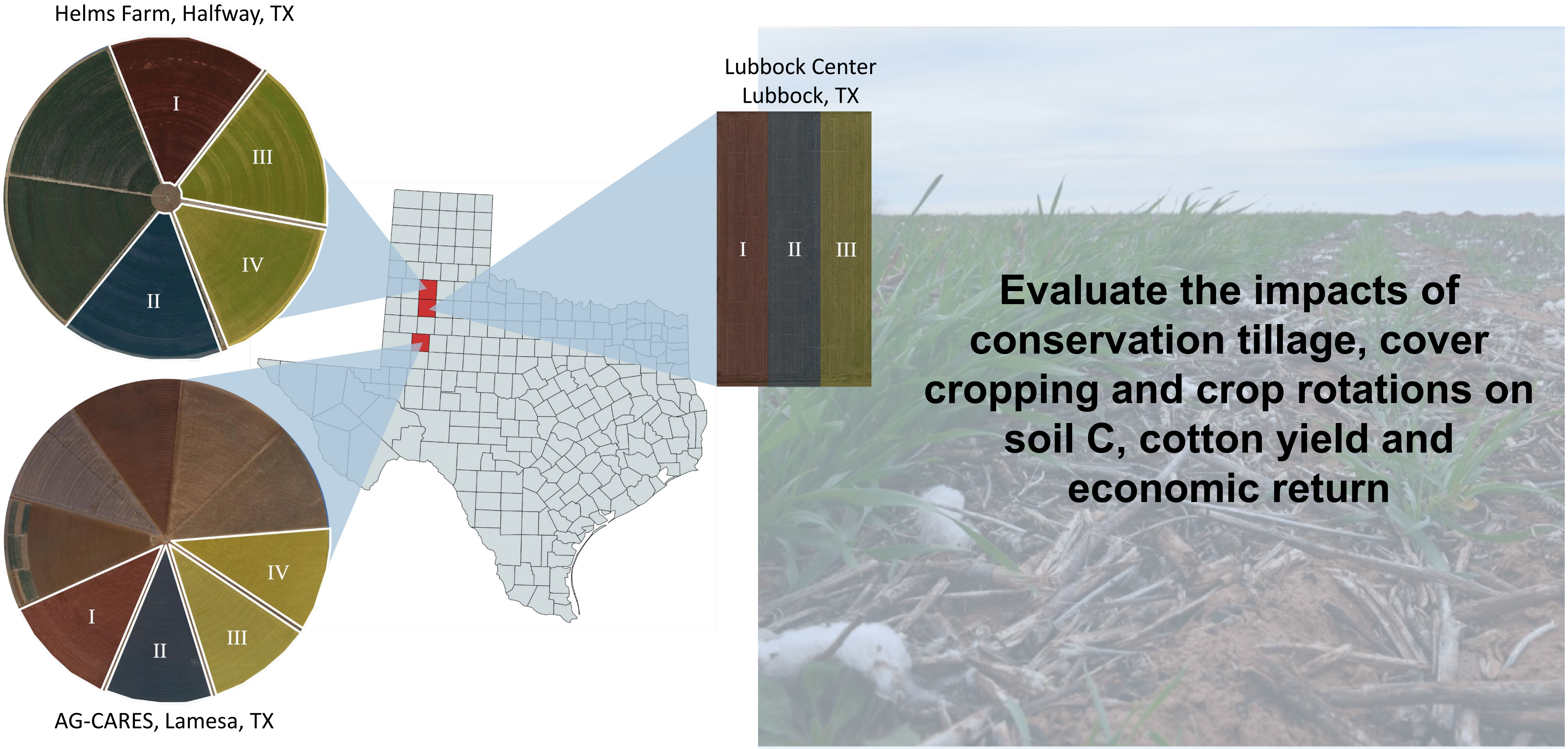
- Soils depleted of SOC have greatest potential to gain C
- Most soils are far from C saturation threshold
- Potential for increased C inputs and management that protects C stocks to maximize C storage

Carbon Storage Potential in Texas' High Plains

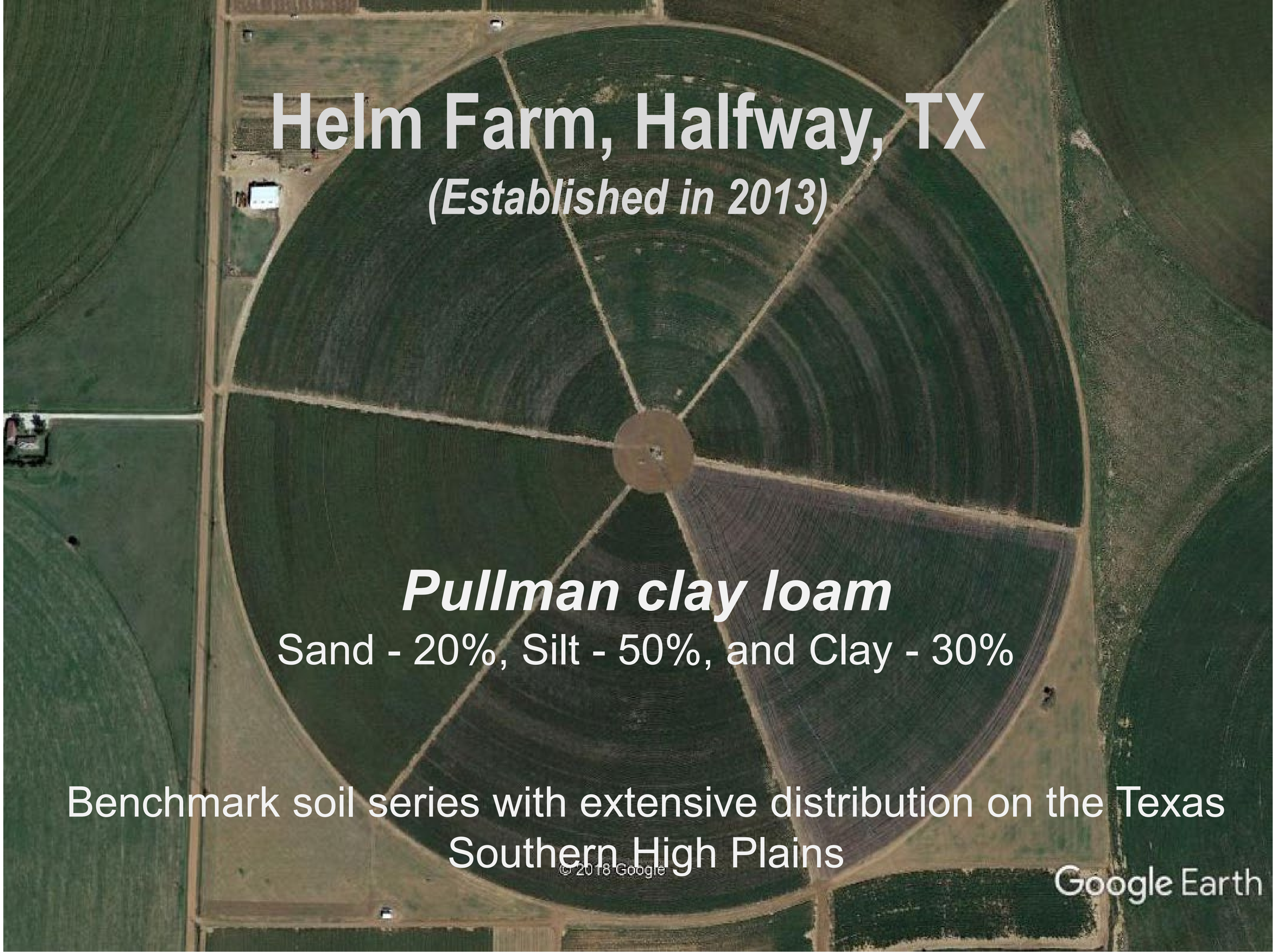
Katie Lewis, Associate Professor
Wayne Keeling and Paul DeLaune, Professors
Joseph Burke and Mark McDonald, GRA
Christopher Cobos, Research Associate

Texas A&M AgriLife Research

Conservation Management - Cotton Systems



Evaluate the impacts of conservation tillage, cover cropping and crop rotations on soil C, cotton yield and economic return



Helm Farm, Halfway, TX

(Established in 2013)

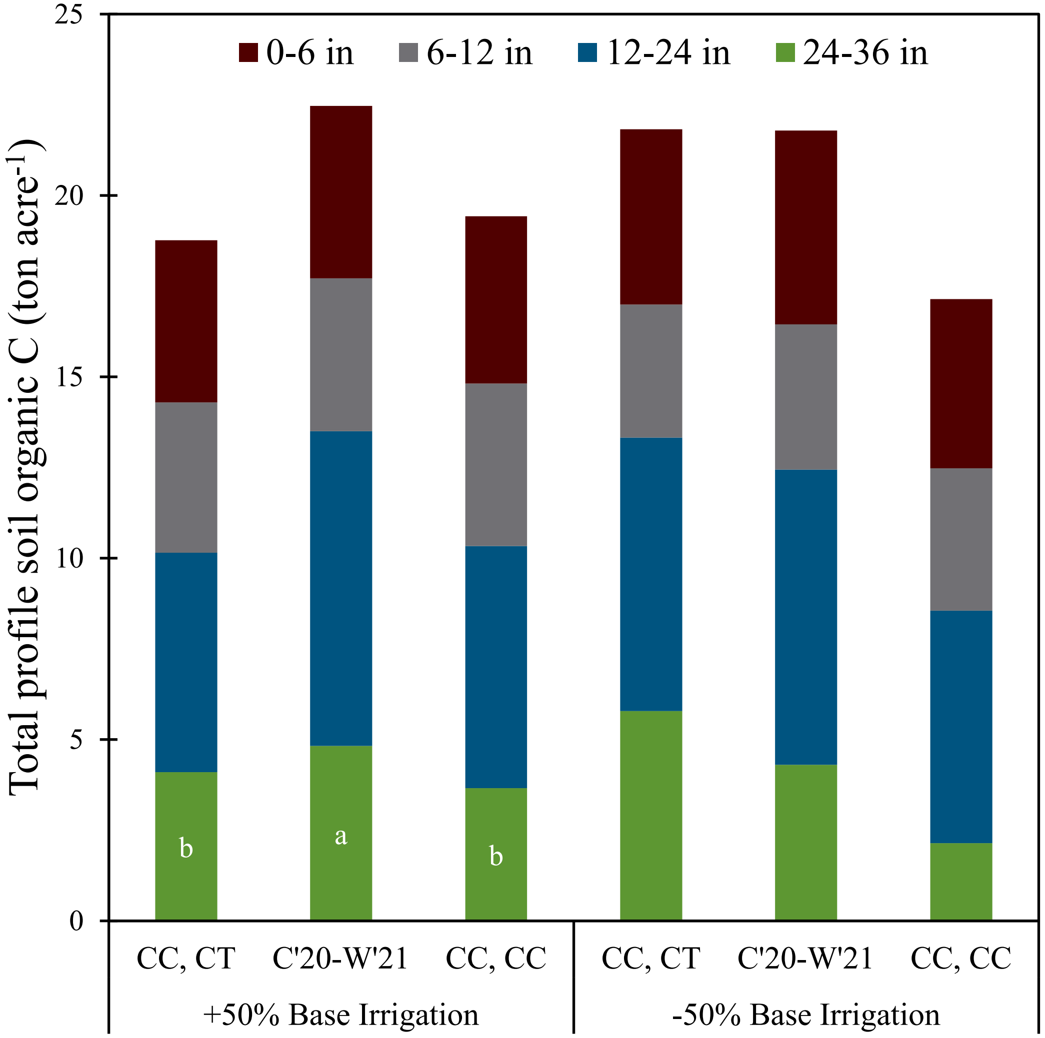
Pullman clay loam

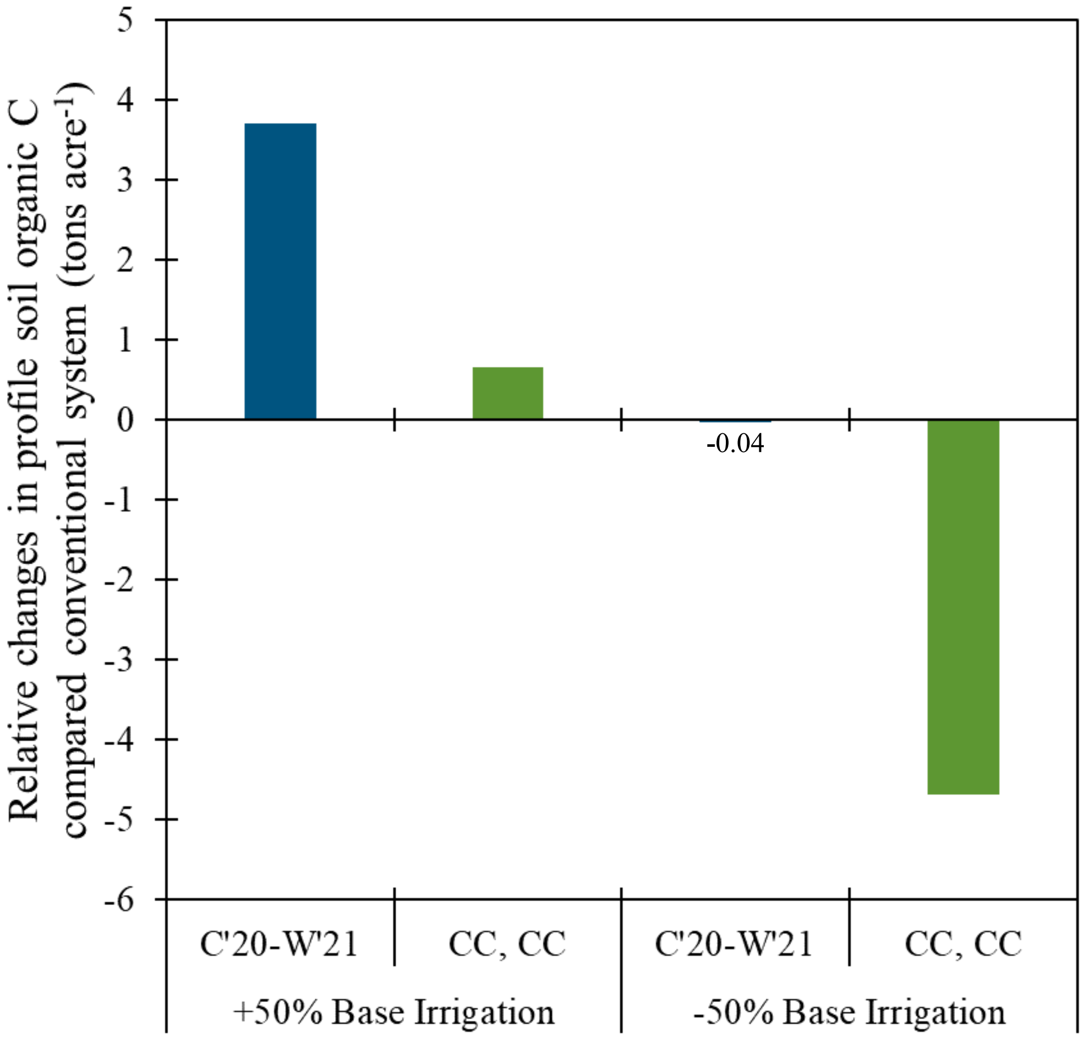
Sand - 20%, Silt - 50%, and Clay - 30%

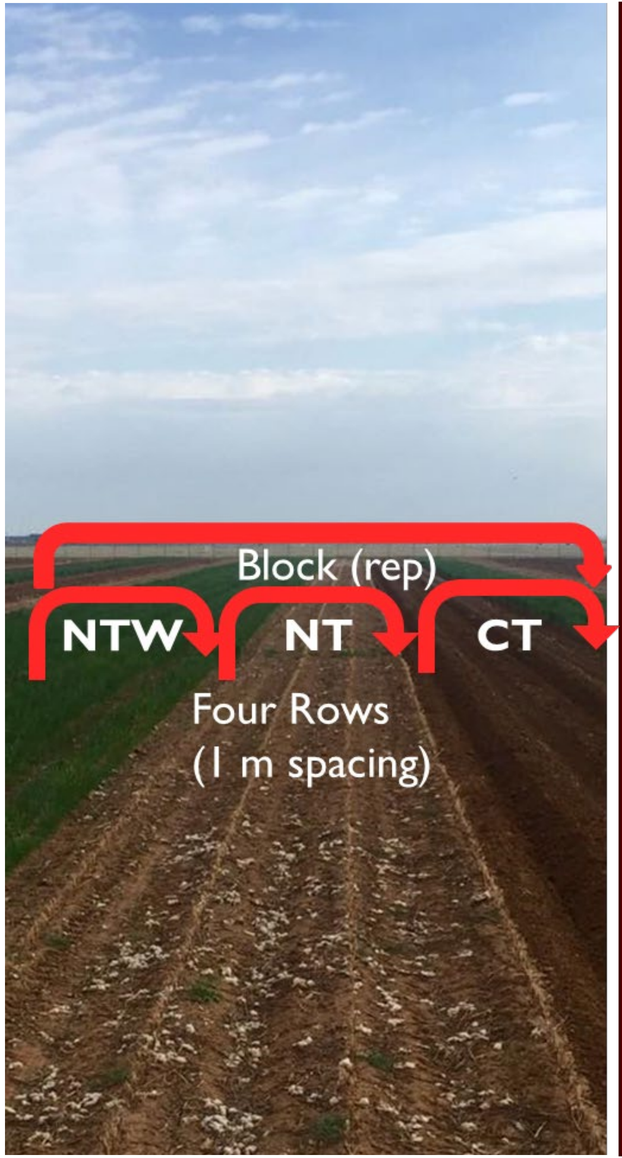
Benchmark soil series with extensive distribution on the Texas Southern High Plains

Soil Organic C (Helm Farm, est. 2013)

Soil samples collected prior to planting cotton in 2020 at 4 depths (0-6”, 6-12”, 12-24”, and 24-36”)



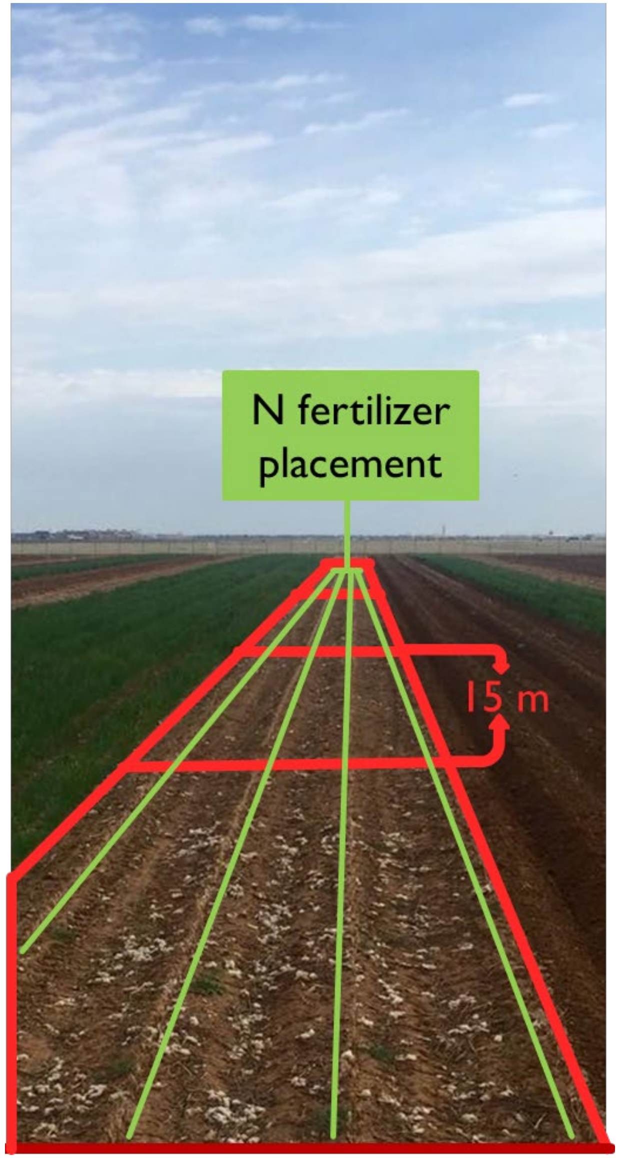




Research Center, Lubbock, TX

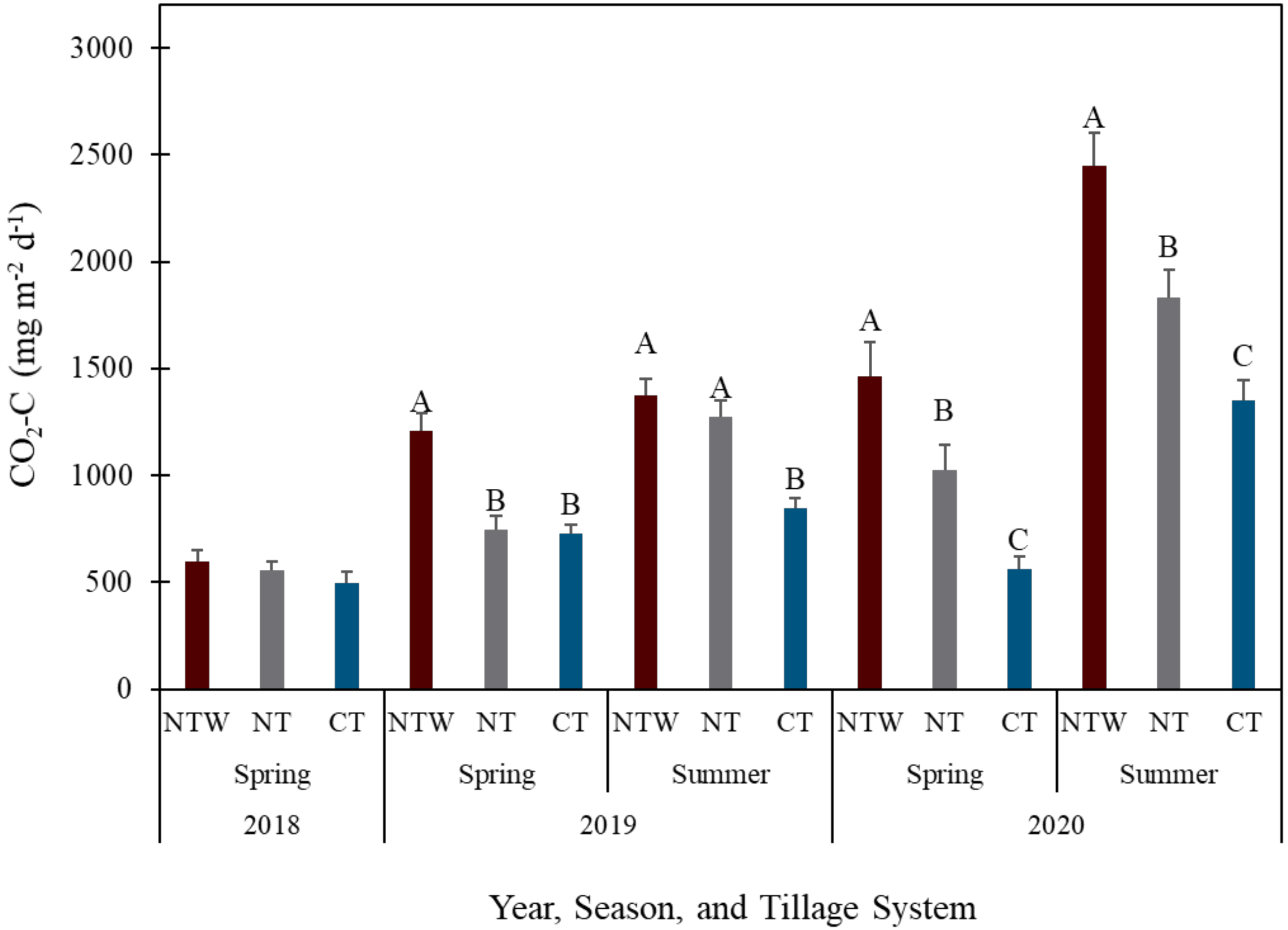
Est. 2015, Acuff loam

- Cover crops and no-tillage systems implemented in November of 2015
  - Site had been under conventional tillage for at least 60 years
- Study design – Split Plot (3 reps)
- Main plot: tillage systems
  - No-tillage with a winter wheat cover crop (NTW)
  - No-tillage winter fallow (NT)
  - Conventional tillage winter fallow (CT)
- Split Plot: nitrogen (N) treatments
  - 100% pre-plant (PP)
  - 40% pre-plant 60% side-dressed (SPLIT)
  - No-N control



Lubbock Research Center, Lubbock, TX

Est. 2015, Acuff loam



Conventional tillage CO_2-C emissions

- 0.87 tons C acre^{-1}

No-tillage with wheat cover <u>net</u> C flux

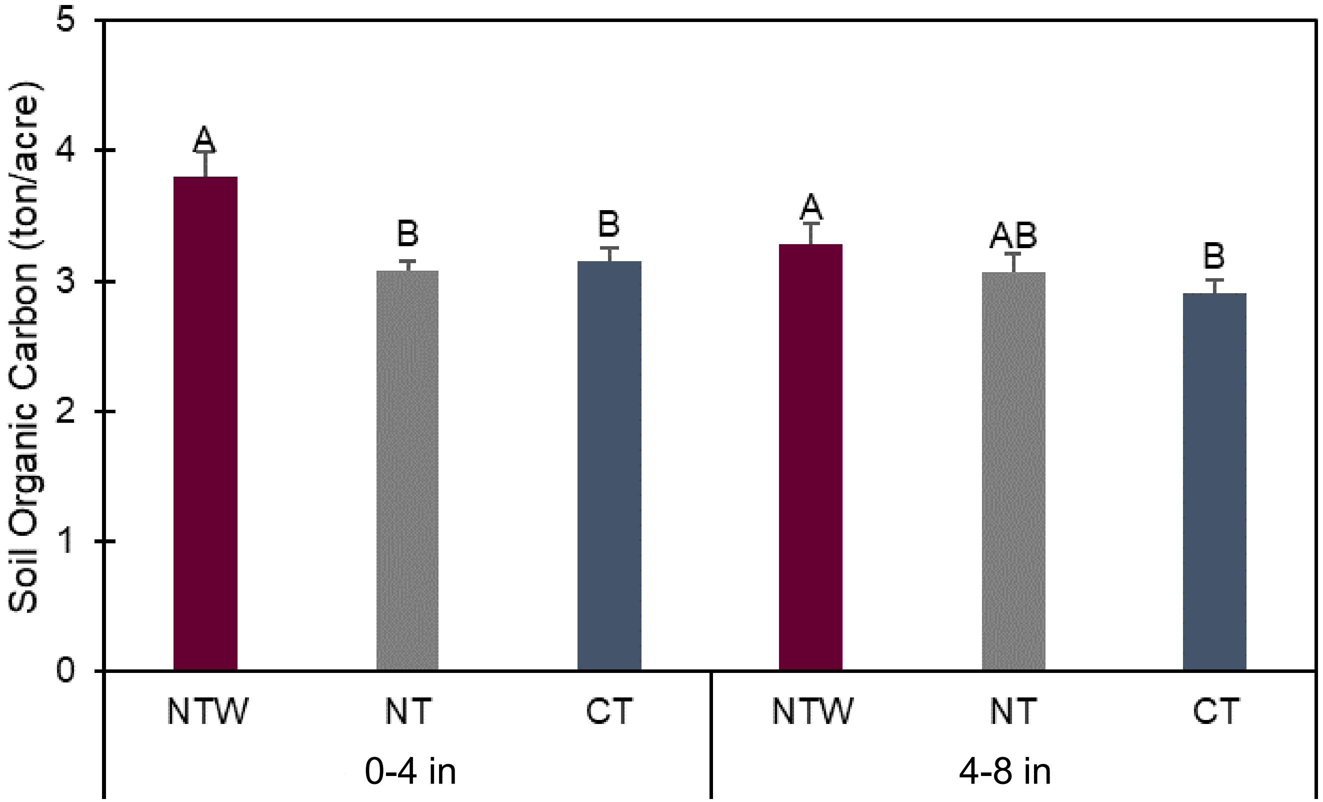
- 0.67 tons C acre^{-1}

Average decrease in CO_2-C emissions with the inclusion of wheat cover with no-tillage

- 22%
- 379 lb C acre^{-1}

Lubbock Research Center, Lubbock, TX

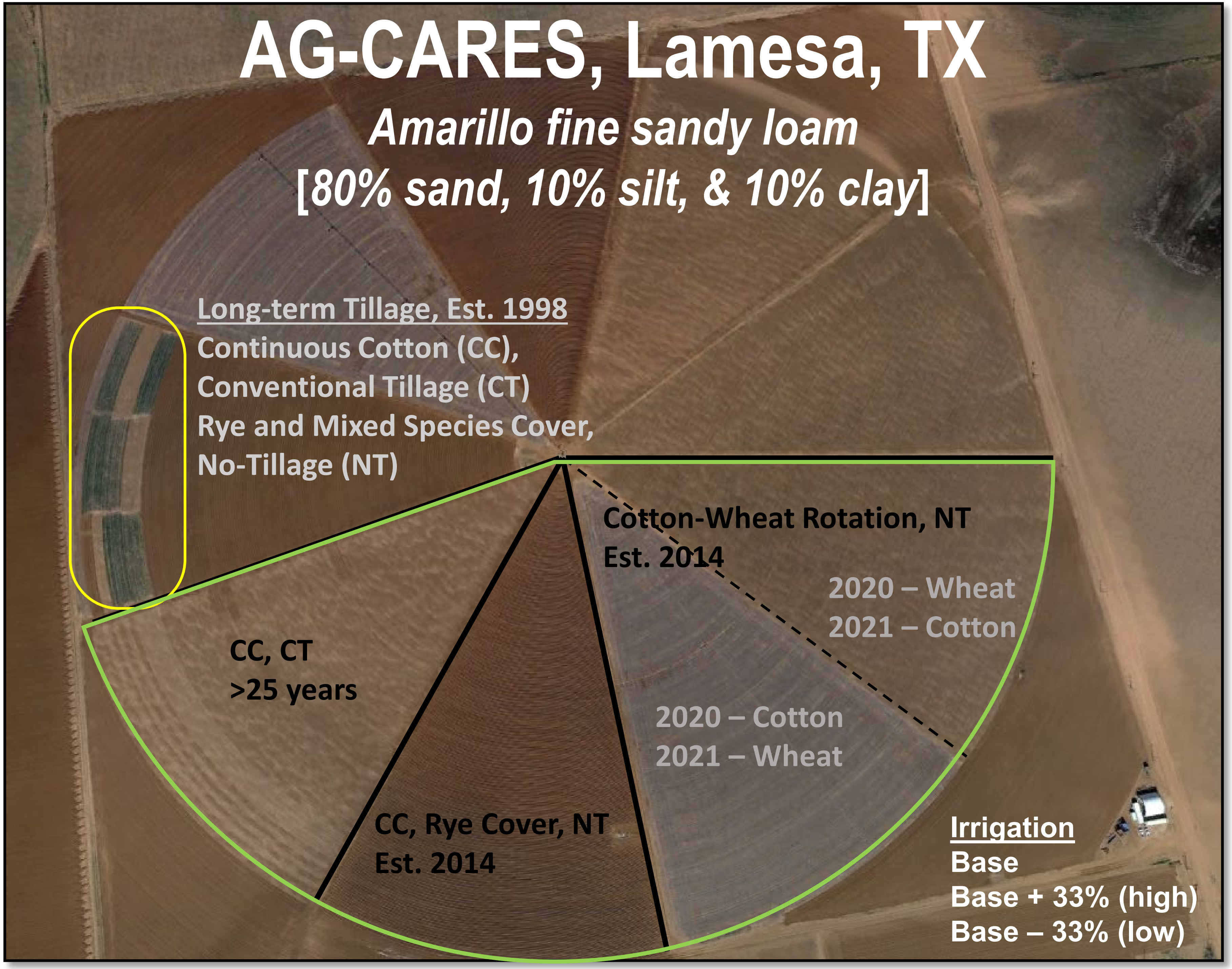
Est. 2015, Acuff loam



AG-CARES, Lamesa, TX

Amarillo fine sandy loam

[80% sand, 10% silt, & 10% clay]



<u>Long-term Tillage, Est. 1998</u>
Continuous Cotton (CC),
Conventional Tillage (CT)
Rye and Mixed Species Cover,
No-Tillage (NT)

CC, CT
>25 years

CC, Rye Cover, NT
Est. 2014

Cotton-Wheat Rotation, NT
Est. 2014

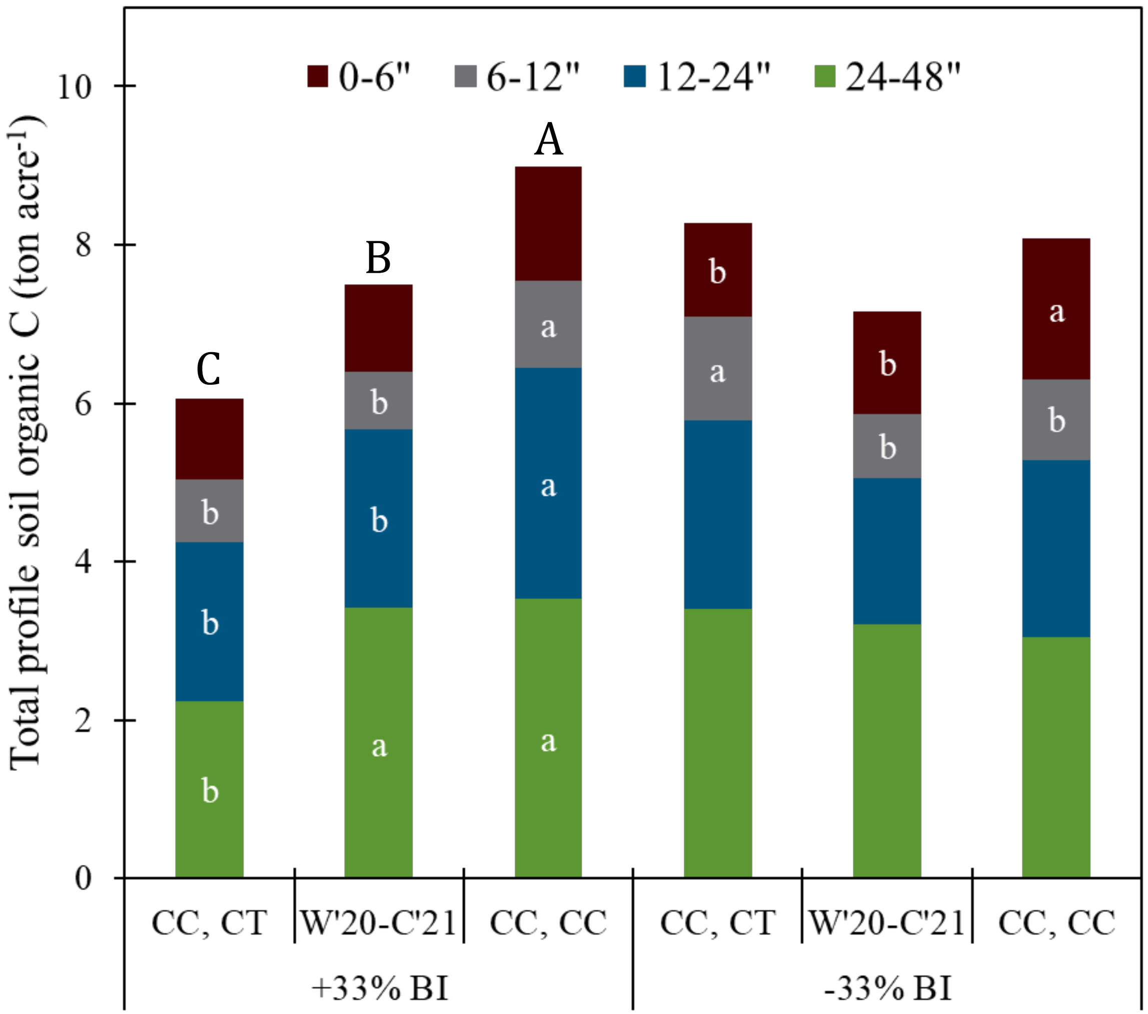
2020 – Wheat
2021 – Cotton

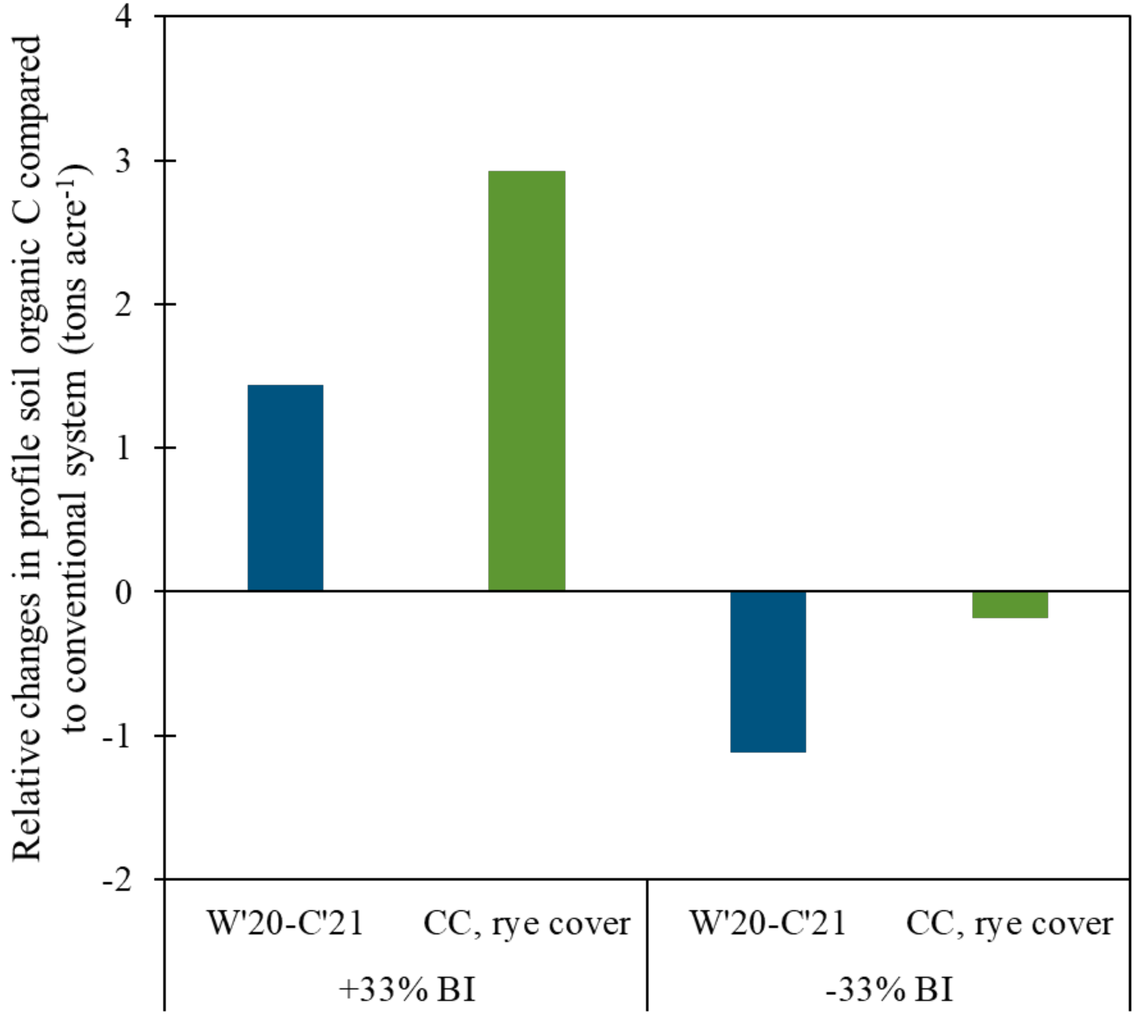
2020 – Cotton
2021 – Wheat

<u>Irrigation</u>
Base
Base + 33% (high)
Base – 33% (low)

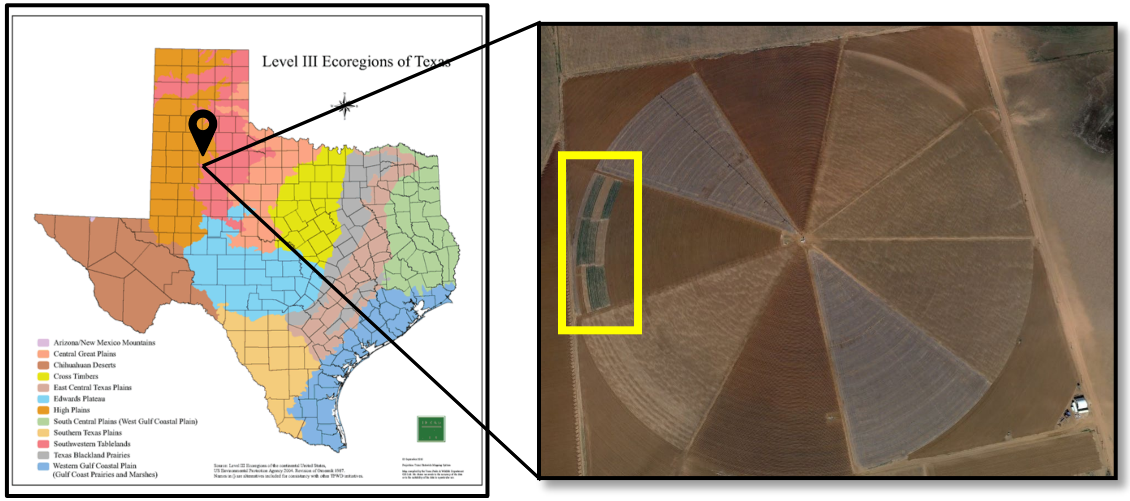
Soil organic C (AG-CARES, est. 2014)

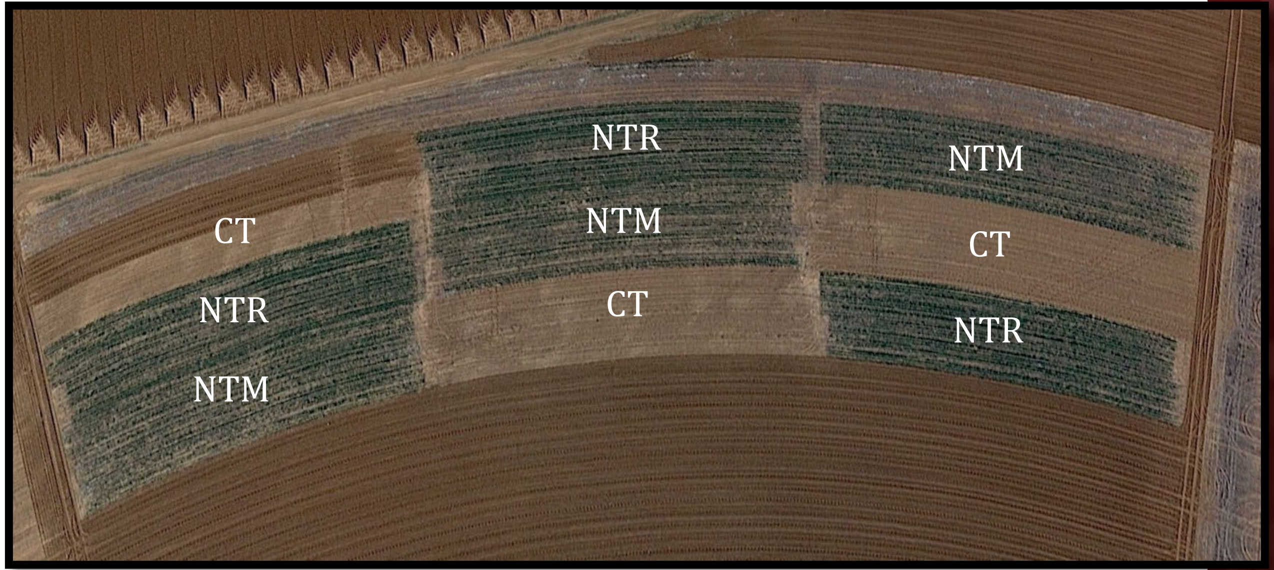
Soil samples collected prior to planting cotton in 2021 at 4 depths (0-6”, 6-12”, 12-24”, and 24-48”)





Longterm site





Research plot design at Ag-CARES in Lamesa, TX

Evaluated systems

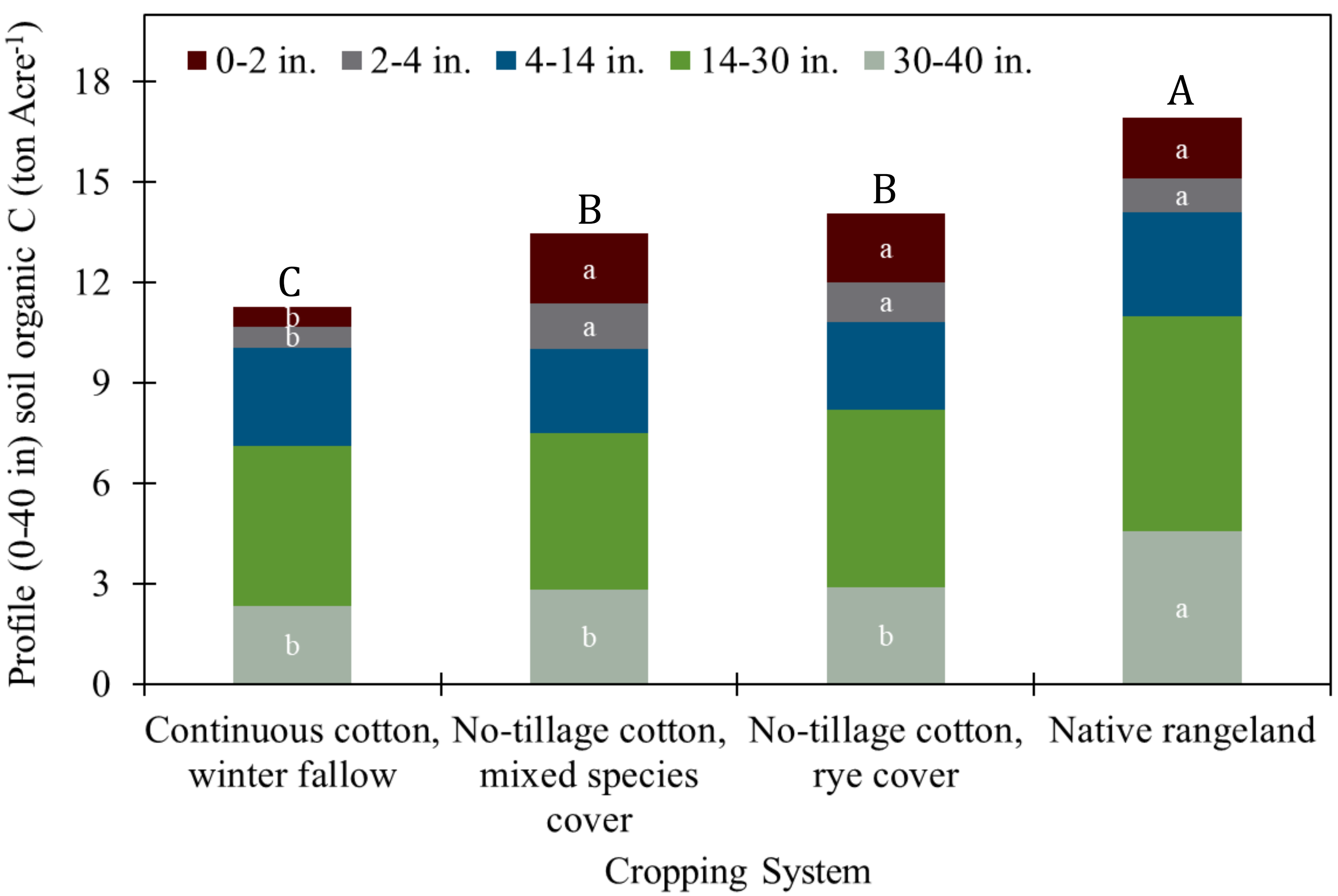
Continuous cotton systems – (est. 1998)

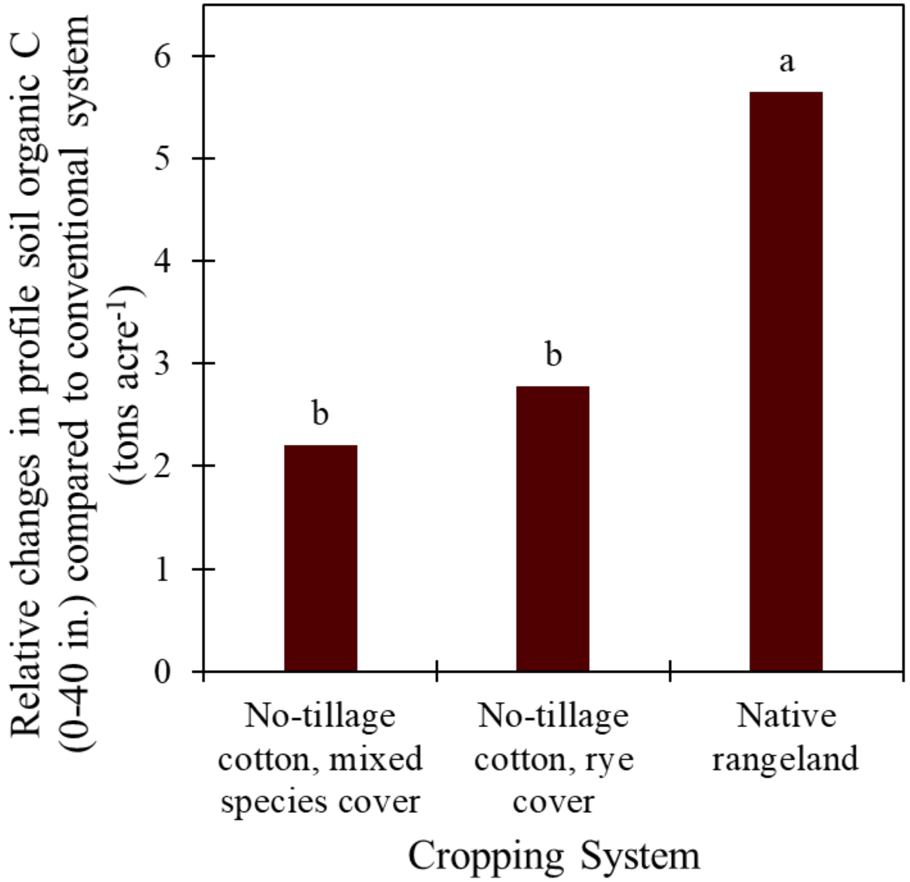
- Conventional tillage, winter fallow (CT)
- No-tillage, Rye cover (R-NT), 45 lb/acre
- No-tillage, Mixed cover (M-NT), 45 lb/acre
  - Rye (50%)
  - Austrian Winter Pea (33%)
  - Hairy Vetch (10%)
  - Radish (7%)
    - by weight
  - Established in November 2014
  - NRCS recommended mixture
- Native site with same soil texture (Wellman, TX)

Plot Size (AG-CARES) – 16 rows by 200 ft long

Soil organic C (AG-CARES, est. 1998)

Soil samples collected prior to planting cotton in 2018 at 5 depths (0-2”, 2-4”, 4-14”, 14-30” and 30-60”)

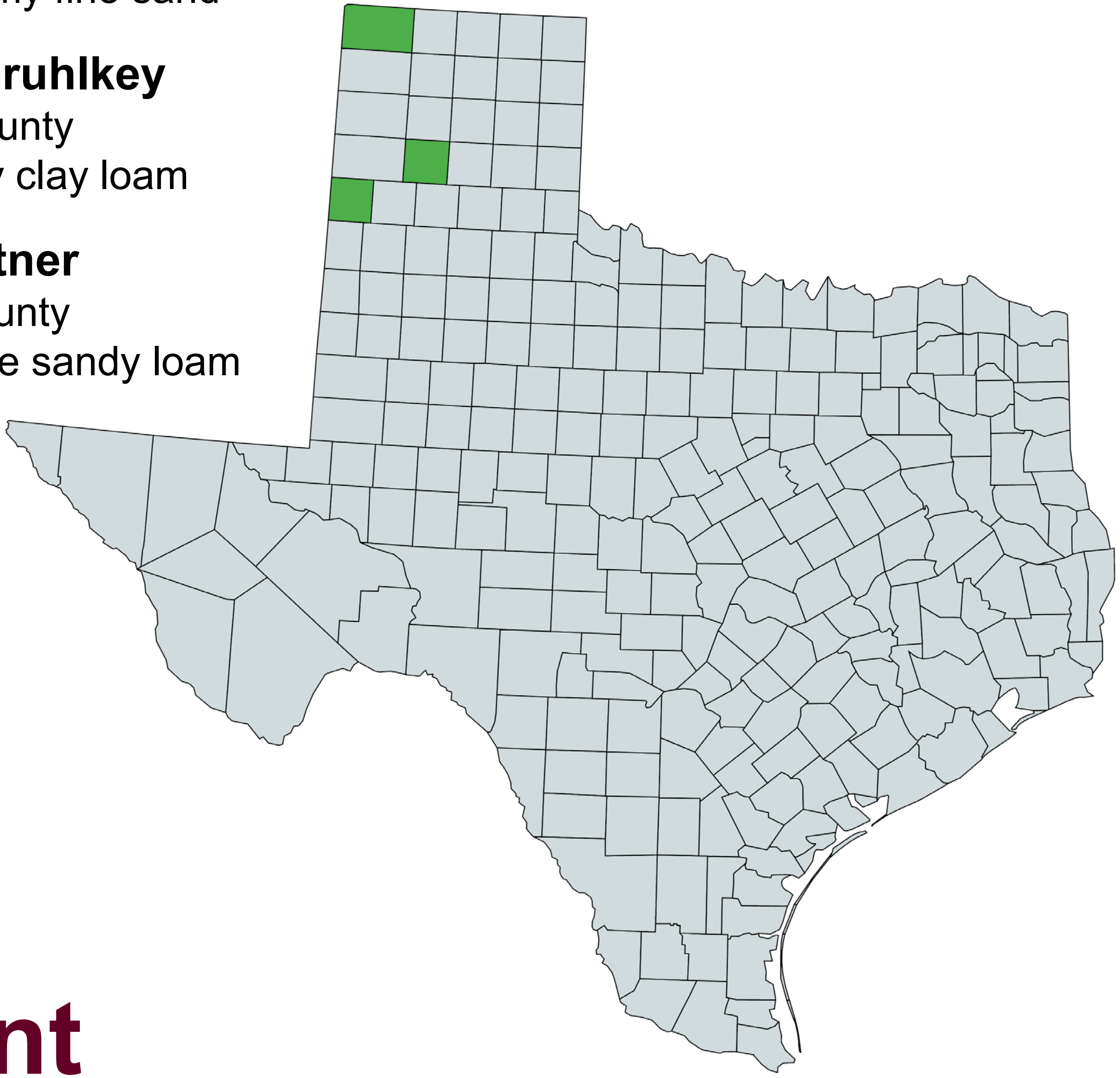




Steve and Zach Yoder
Dallam County
Dallam loamy fine sand

Braden Gruhlkey
Randall County
Pantex silty clay loam

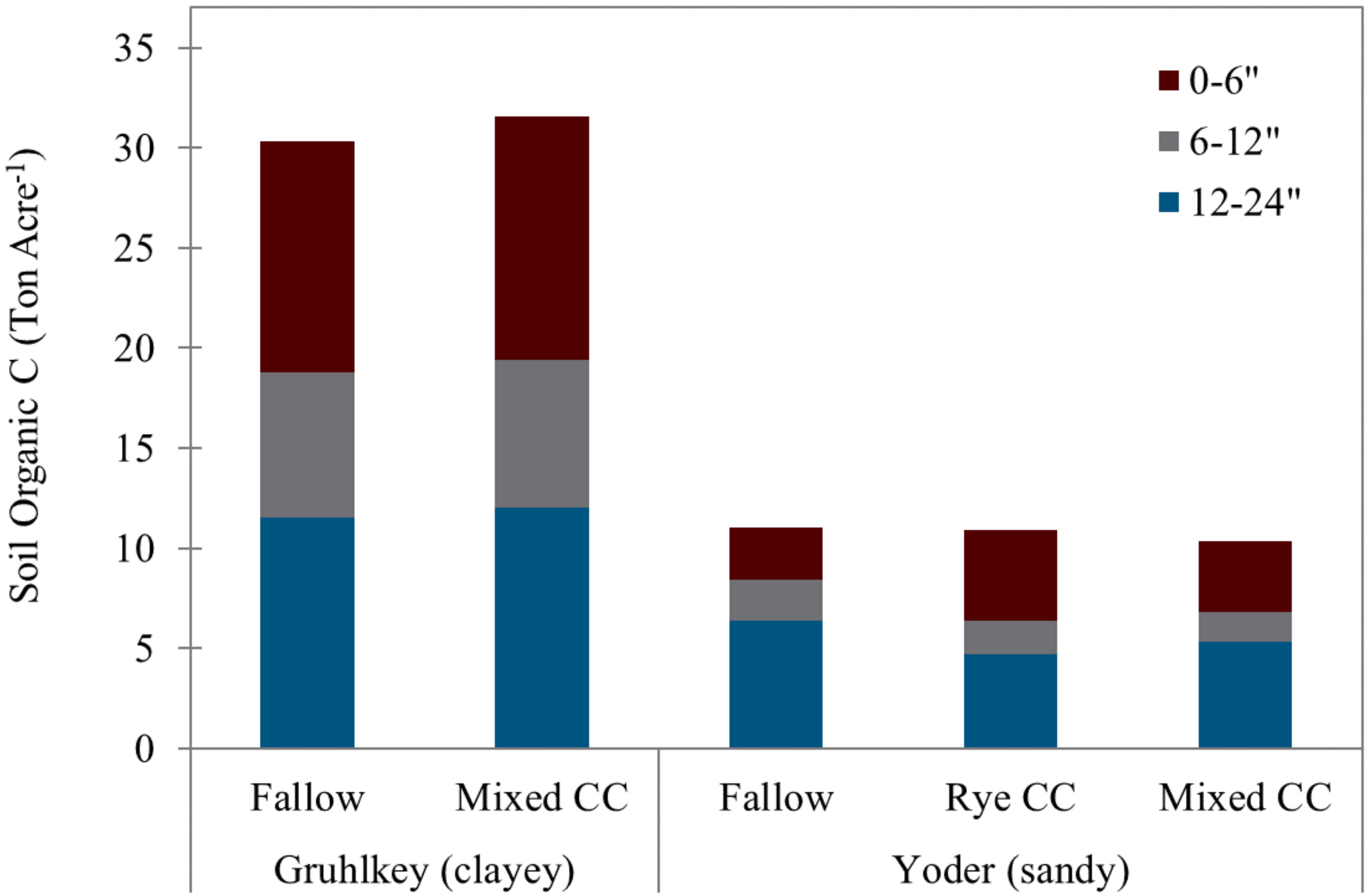
Kelly Kettner
Parmer County
Amarillo fine sandy loam



Conservation Management Corn Systems

Soil Organic C (est. 2017)

Samples collected in April 2020



Summary

- Conservation management practices have a variable effect on soil C storage
- Soil **texture** and **irrigation capacity/precipitation** have been identified as major drivers behind differences observed in soil C storage
- C storage was greater using cover crops in sandy soil and greater with rotation in clayey soil
- Potential to sequester 0.14 ton C/acre/year in sandy, semi-arid cotton system using cover crop and no-tillage (23-year system)
- While changes might be small, any amount of CO_2 kept in the soil and out of the atmosphere is going to be beneficial

Regenerative agriculture (#RegenAg)

Southern Great Plains
REGENAg

NIFA

Sustainable agricultural intensification and enhancement using regenerative agricultural practices

USDA Award Number: 2021-68012-35897

Our project goal is to intensify agricultural production in an environmentally sustainable manner that enhances the agronomic, economic, and community resiliency in the Southern Great Plains.

Collaborators -

Texas Water Resources Institute
make every drop count

Texas A&M AgriLife Research

Texas A&M AgriLife Extension

ATM

OSU

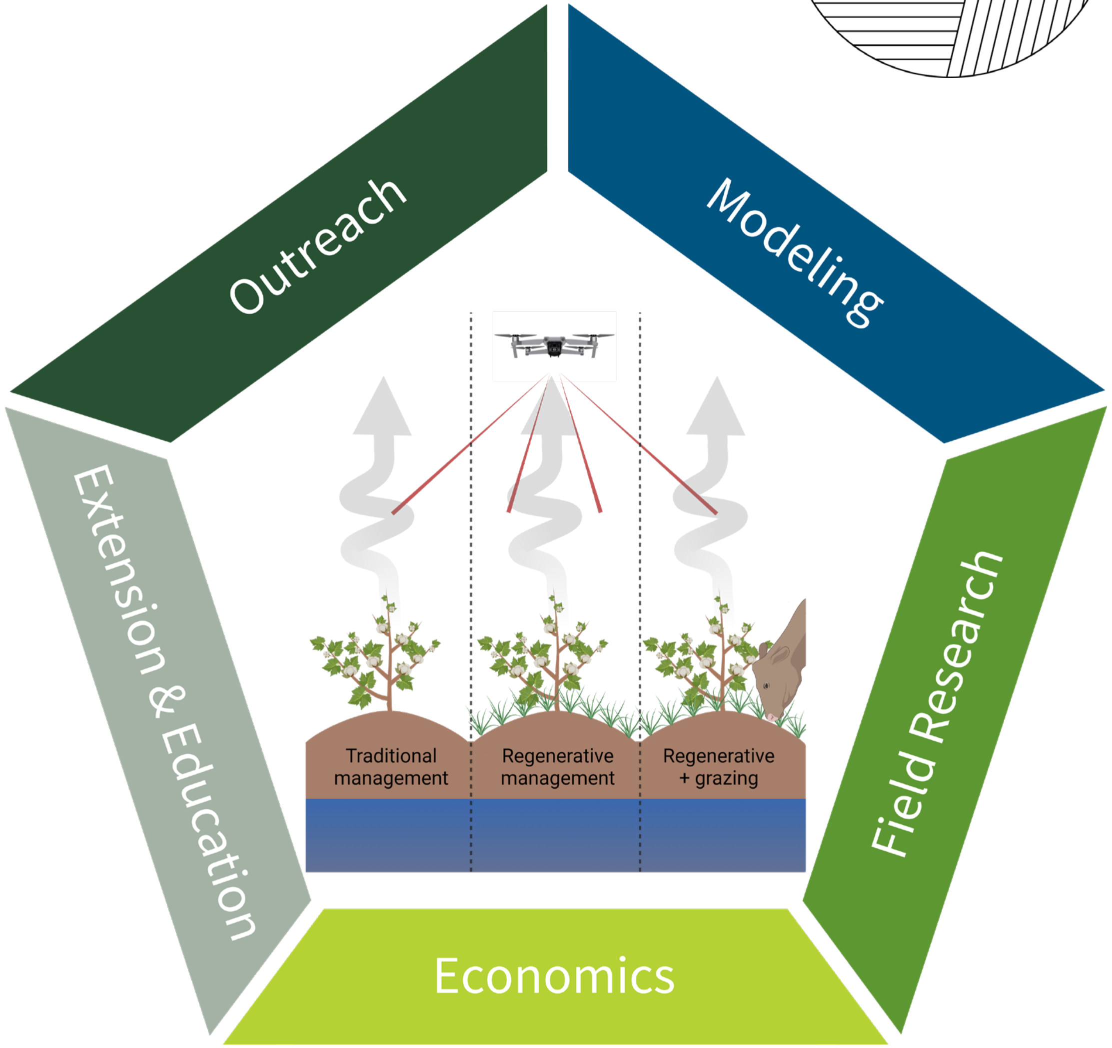
WT

Kansas State University

Regenerative agriculture (#RegenAg)

Select objectives -

- Develop and deliver *Master Soil Steward Program*
- Utilize models to assess soil and water quality impacts of regenerative practices
- Evaluate regenerative agricultural practices
- Develop and deliver transdisciplinary graduate and undergraduate curriculum
- Create farm budgets and determine potential impacts on rural communities



Regenerative agriculture (#RegenAg)

We need your help!

We are currently seeking livestock producers who graze cover crops or cotton-wheat rotations on the Texas High Plains

<ins>What we'll collect</ins>:

- Annual soil samples
  - 0-4, 4-12, 12-24, 24-48, and 48-60" depths
- Aboveground biomass
- Basic management information

Interested? Email ***katie.lewis@ag.tamu.edu*** *for more information*

<ins>What data we'll provide</ins>:

- Detailed soil analysis
  - Macro-/micronutrients, pH, EC
  - Soil organic C and total N
  - Microbial community structure and function
- Biomass characterization
  - Nutrient concentration and fiber characterization

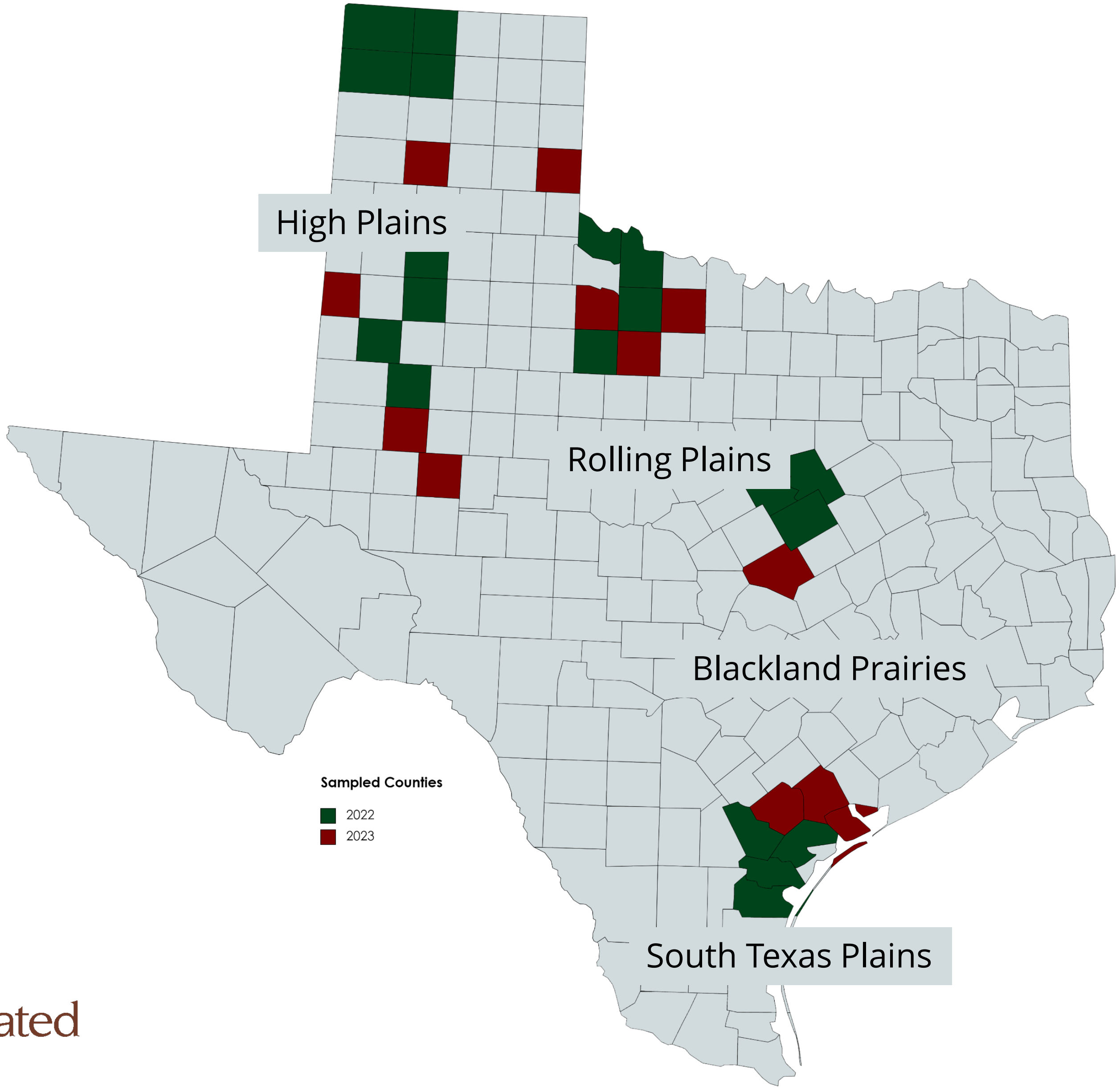
Carbon assessment in Texas cropping systems

Project specifics:

- Establish soil organic carbon baseline levels across Texas corn, cotton, and sorghum cropping systems
- Included conservation systems:
  - No-tillage, strip-tillage, conservation tillage, conservation irrigation, cover crops, crop rotations, integrated livestock grazing
- Soil sampling depths:
  - 0-15, 15-30, 30-45, 45-60, 60-75, 75-90 cm

Collaborators:

- Paul DeLaune
- Jamie Foster
- Jourdan Bell



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SORGHUM CHECKOFF

Cotton Incorporated

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TEXAS A&M AGRILIFE RESEARCH

TEXAS TECH UNIVERSITY
Department of Plant & Soil Science™

Dust mitigation on the Texas High Plains

Enhancing human health on the Texas High Plains with sustainable and resilient cropping systems that mitigate wind erosion and control dust

Project deliverables:

- Quantification of soil erosion and deposition
- Assess nutrient losses from wind erosion
- Determine the benefits of conservation agriculture to reduce wind erosion losses in the region
- Evaluate ecological and human health impacts of dust

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