Transitioning Cereal Systems to Adapt to Climate Change

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Greenhouse Gas Mitigation Potential of Dryland Cropping Systems in the U.S. Great Plains

Mark Liebig
USDA-ARS
Mandan, ND

Presentation Overview

Great Plains Cropping Systems

- Region description
- Historical SOC trend
- Synthesis of ΔSOC and N_2O flux

The Future

- NCA Projections for the U.S. Great Plains

GHG Mitigation Options

Research Gaps/Activities

U.S. Great Plains: Description

Geography

- Large area, encompassing ≈150 Mha, 10 states, and multiple ecoregions

Climate

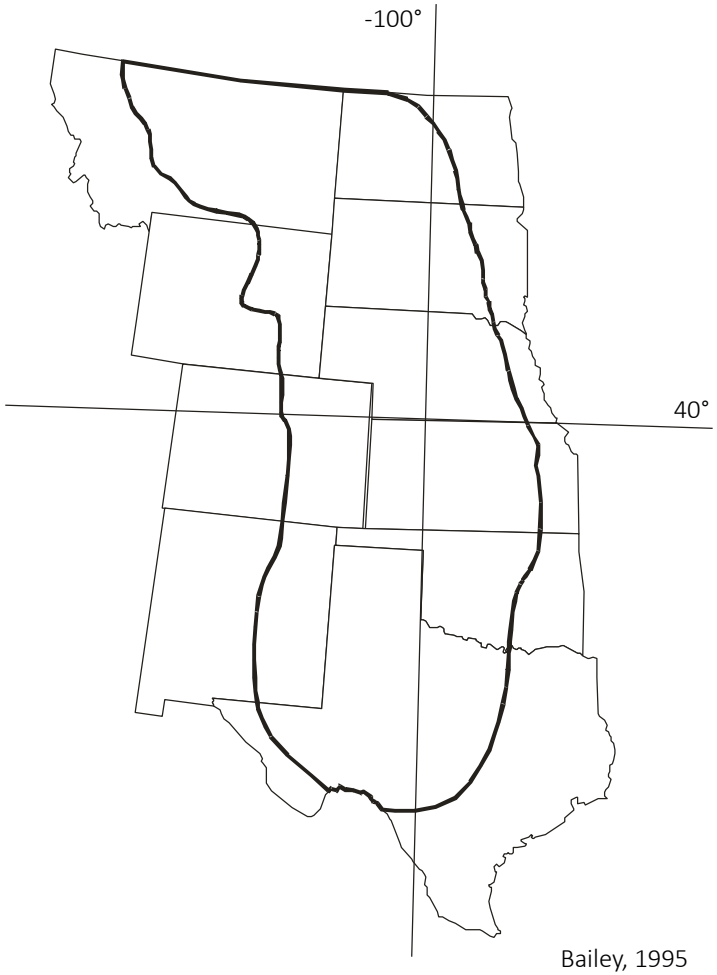
- 200-750 mm MAP (W➔E)
- 4-20°C MAT (N➔S)
- 1100-1750 PET (N➔S)

Native Vegetation, Soil

- Mixed-, short-grass
- SOC accumulation; Calcification

Land use

- 90% agriculture
- ≈45 Mha cropland (≈75% dryland)



Bailey, 1995

U.S. Great Plains: Conversion and Soil C

Conversion of native vegetation to dryland cropping

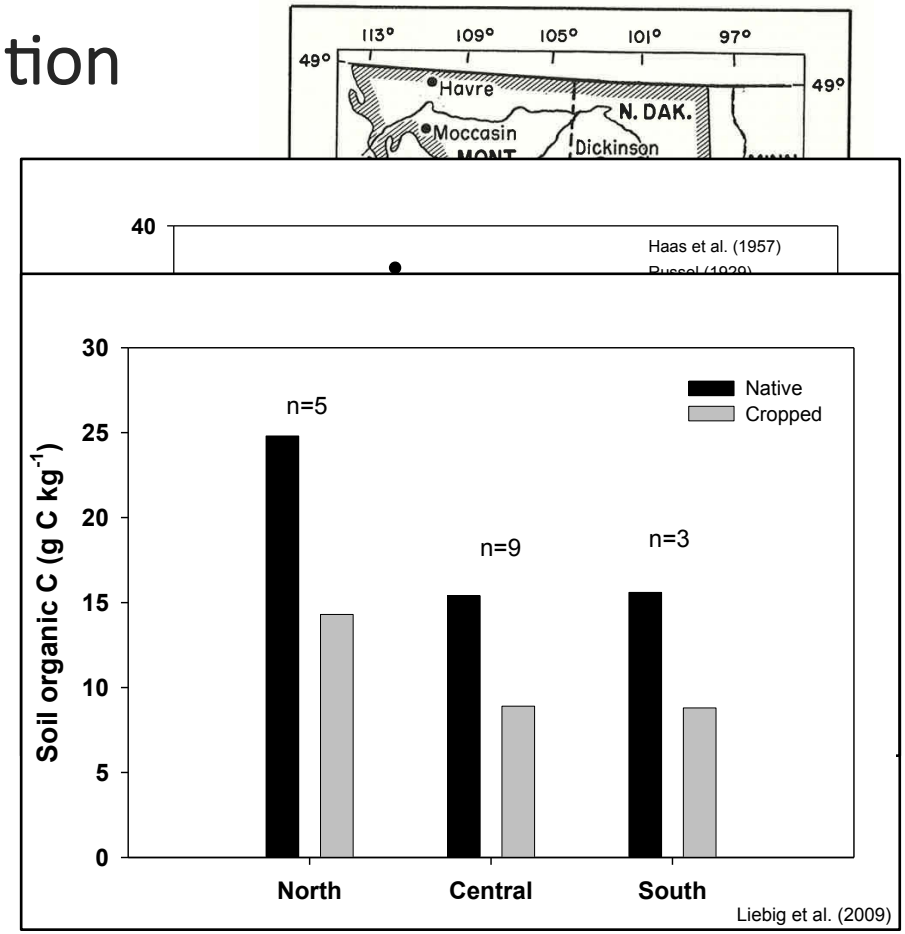
17 sites (MT to TX), surface 30.5 cm

Mean SOC loss:

- 42±11%
- 7.7±5.2 g C kg^{-1}

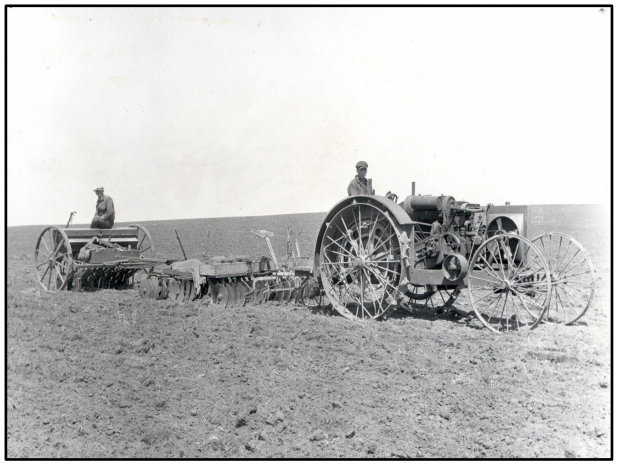
SOC loss by sub-region:

- 39-43%
- 6.5-10.5 g C kg^{-1}



Cropping System Evolution in Great Plains

- Conventional tillage
- Frequent use of fallow

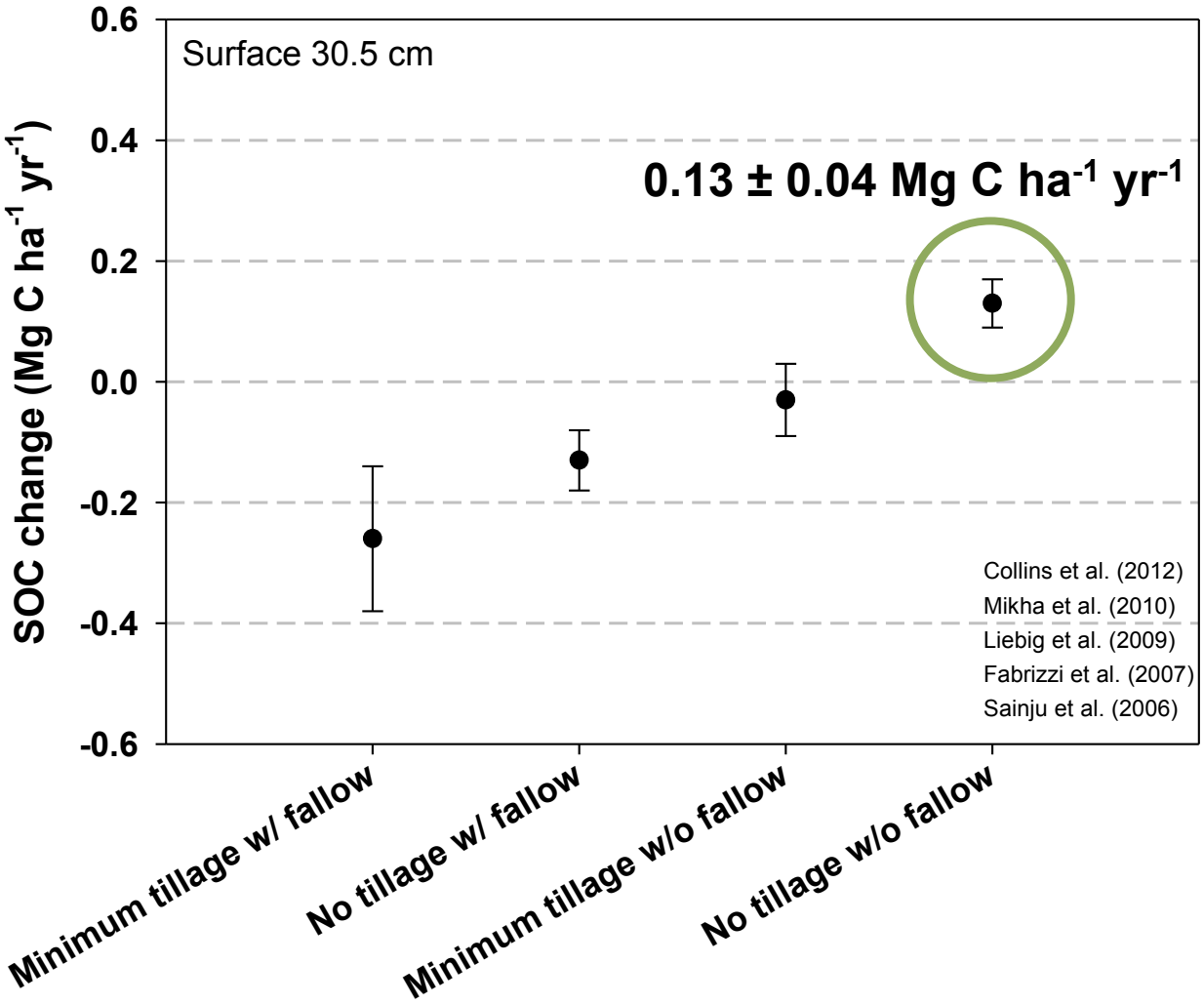


- - Weed and Residue Management Technology - -

- Reduced- and No-tillage
- Flex/Annual crop rotations

Reversing SOC Decline on Cropland?

Dryland Cropping Systems

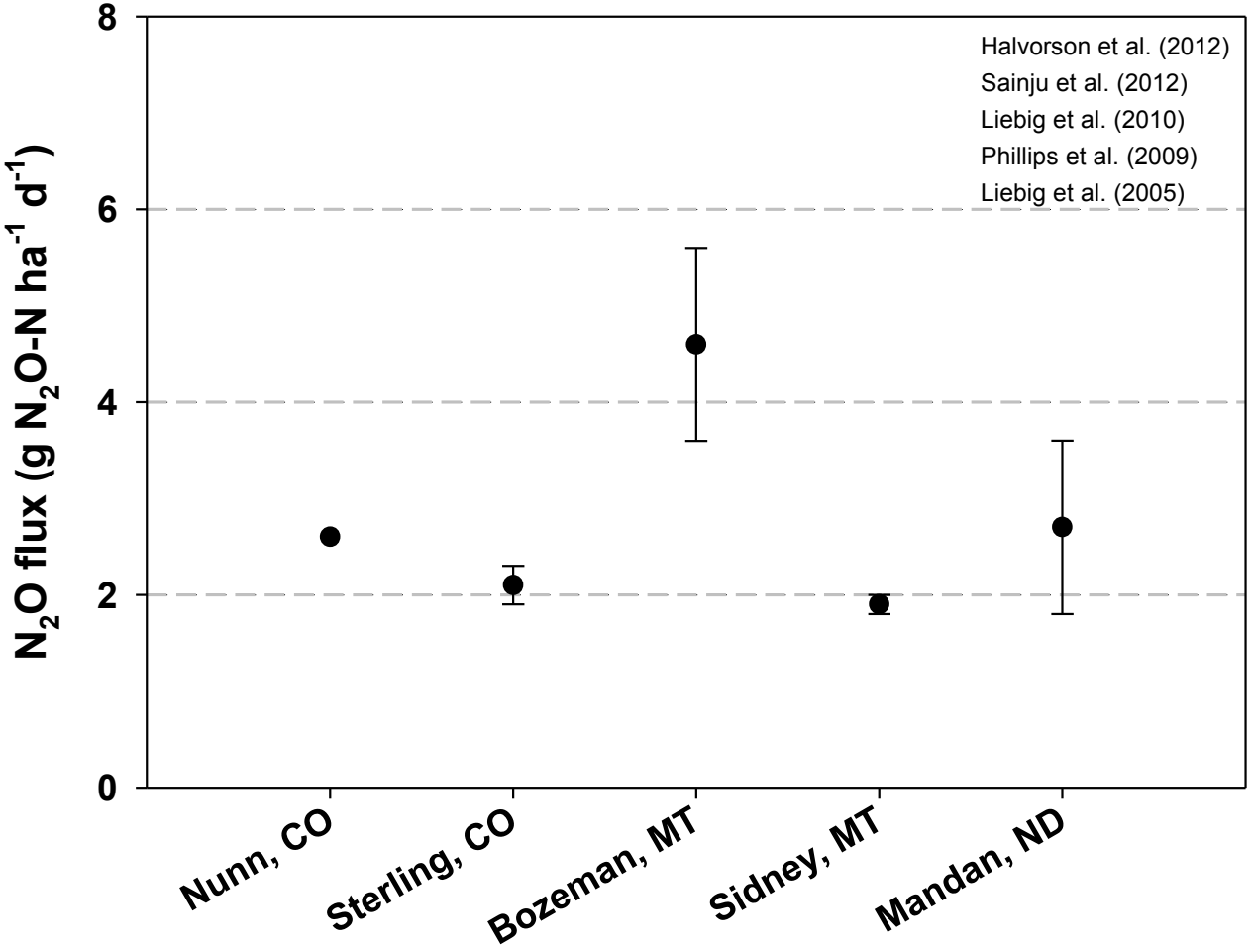


Achieving Neutral GWP
No-tillage, Continuous Cropping

Location	SOC accrual	CH_4 uptake	N fertilizer production/ application	Farm operations	Calculated N_2O emission to achieve neutral GWP	
	---------- kg CO_2 equiv. ha^{-1} yr^{-1} ----------					g N ha^{-1} d^{-1}
Mandan, ND	-843	-21	247	85	532	3.1
Sterling, CO	-440	-25	383	85	-3	--
Temple, TX	-587	-46	298	85	250	1.5

Adapted from Liebig et al. (2009)

N_2O flux
No-tillage, Continuous Cropping



U.S. Great Plains (looking forward)

Climate Change Impacts in the United States

CHAPTER 19
GREAT PLAINS

Convening Lead Authors

Dennis Ojima, Colorado State University

Mark Shafer, Oklahoma Climatological Survey

Lead Authors

John M. Antle, Oregon State University

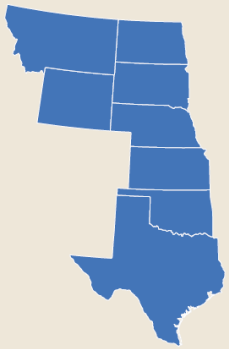
Doug Kluck, National Oceanic and Atmospheric Administration

Renee A. McPherson, University of Oklahoma

Sascha Petersen, Adaptation International

Bridget Scanlon, University of Texas

Kathleen Sherman, Colorado State University



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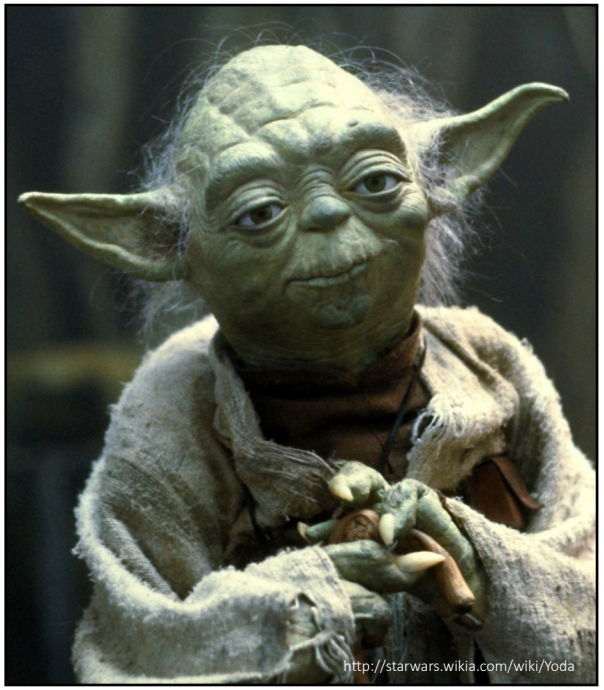


"Always in motion is the future."

Yoda

Precipitation Projections

- **Seasonal change**

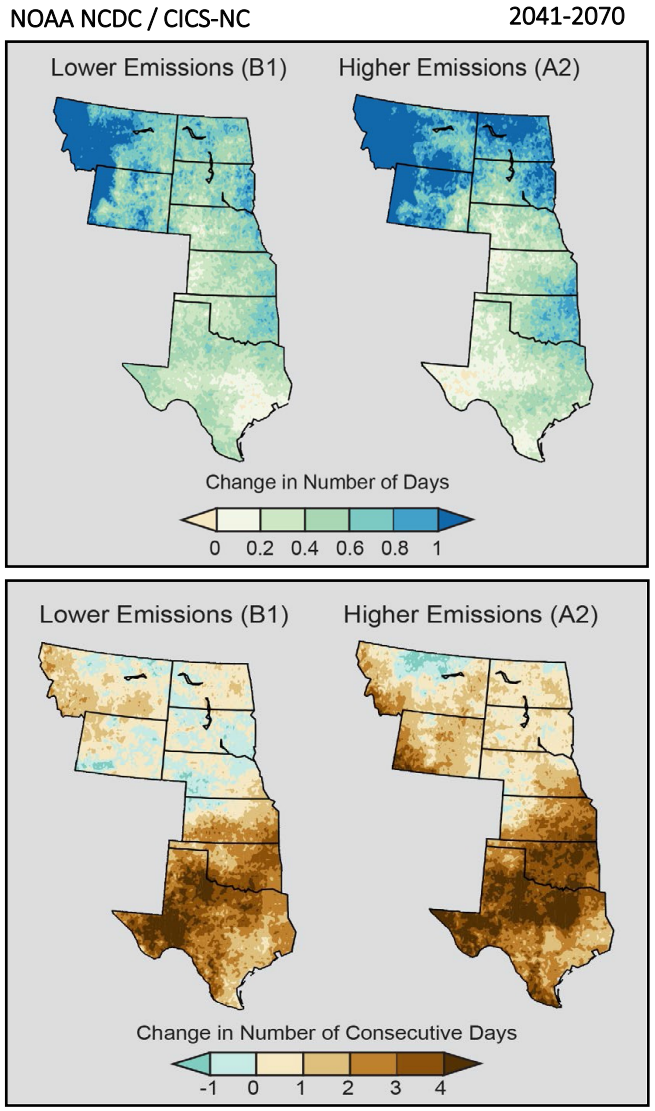
  Winter/spring precipitation projected to increase in the north

  Days with heavy precipitation to increase in north

- **Dry spells**

  Minimal change in north

  Longer in south

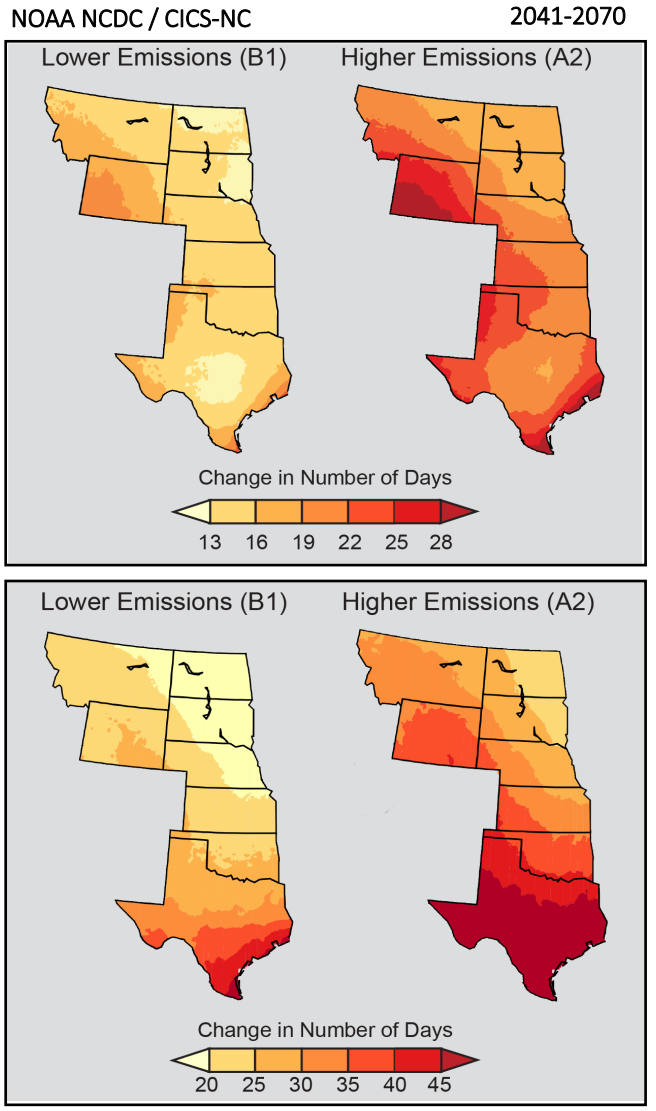


Shafer et al. (2014); P. 445

Temperature Projections

- Days >38°C (100°F)
  2x in the north
  4x in the south

- Nights >16°C (60°F)
  2x in the north
  24 d increase in growing season
- Nights >27°C (80°F)
  4x in the south



Shafer et al. (2014); P. 444

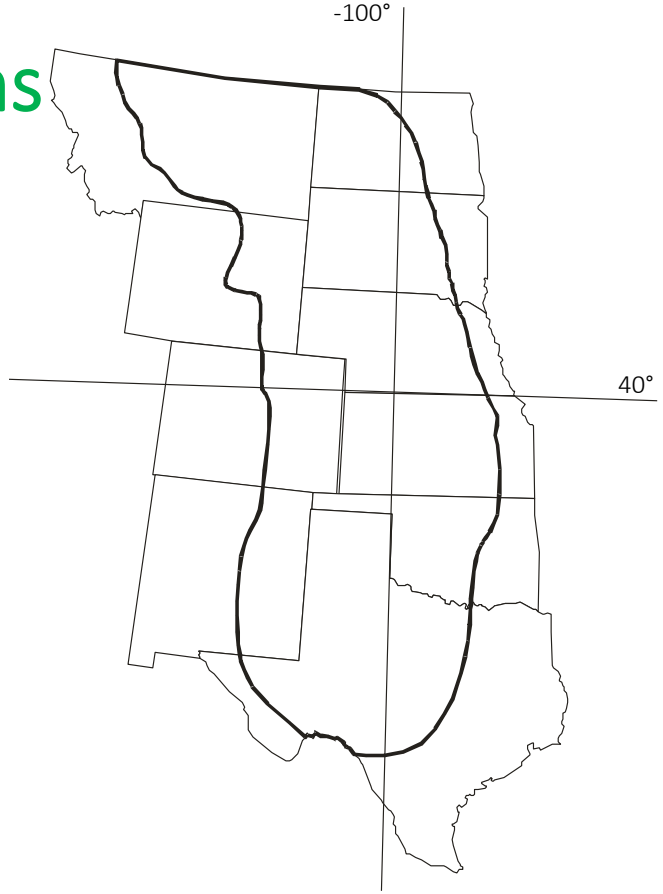
Projections suggest potential for greater…

…denitrification in Northern Plains

- Improve NUE through breeding and management
- Cropping interventions
- Nitrification/Urease inhibitors
- Reduce proportion of high N-demanding crops

…SOC Loss in Central and Southern Plains

- Increase root/residue input through breeding and management
- Increasing permanent cover



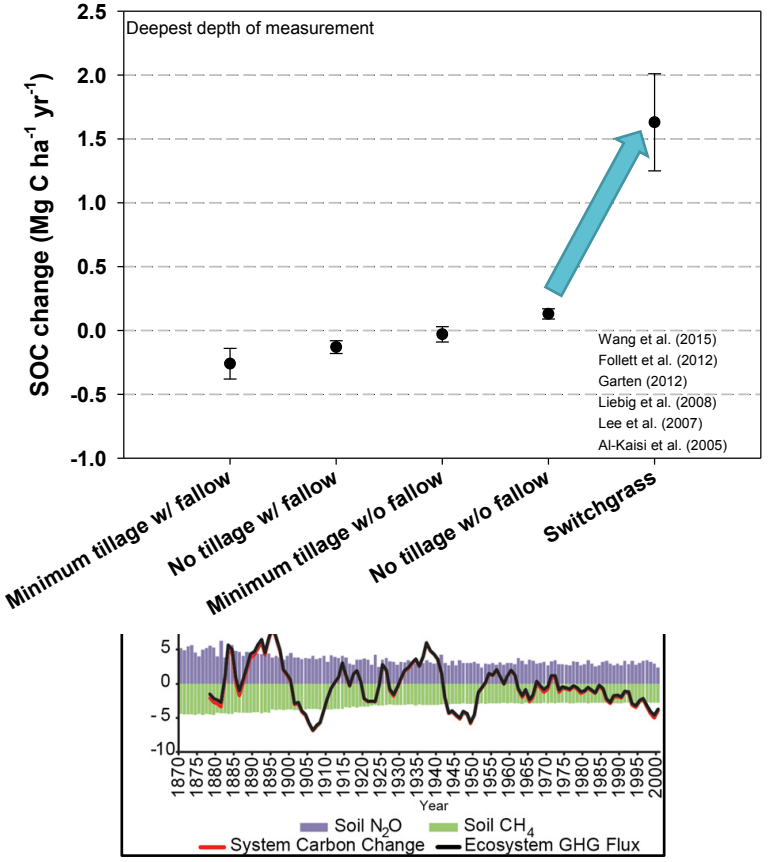
Bailey, 1995


M. Schmer, USDA-ARS

(Re)Incorporation of Perennial Phases

Biofeedstock Production

- Large root biomass; Substantial SOC accrual
- Low- to moderate N_2O emission (though broad validation in region is lacking)
- Net negative GHG flux (Parton et al., 2015)
- Significant co-benefits:
  - Wildlife habitat
  - Water regulation/filtration
  - Erosion protection
  - Dynamic use (forage)

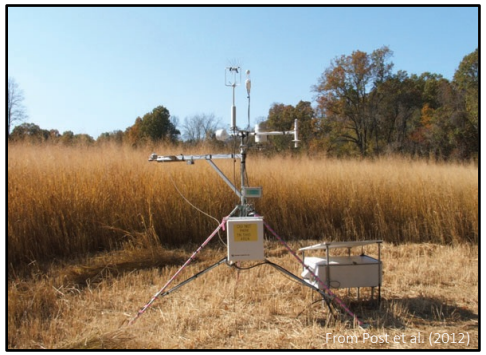


Parton et al. (2015)

GHG Mitigation: Research Gaps/Needs

Renewed look at herbaceous grass options for the Great Plains

- Feedstock candidates for sub-regional adaptation (e.g., Intermediate wheatgrass).
- Management strategies for transitioning between perennial/annual phases
- More intensive quantification of performance/attributes

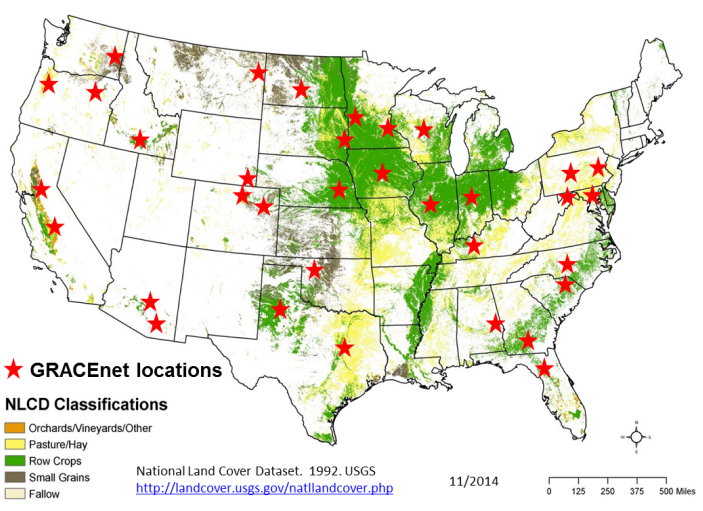


USDA-ARS Network Activities

Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACEnet)

Greenhouse Gas Reduction through Agricultural Carbon Enhancement

- **Goal:** Identify and develop agricultural strategies to enhance soil carbon storage, reduce greenhouse gas emission, and improve environmental quality
- 33 experimental sites, 27 states
- Common methods, treatment design, data management
- ARS Data Portal
- 2002-present



USDA-ARS Network Activities

Resilient Economic Agricultural Practices (REAP)

Vibrant Economies Depend on Healthy Landscapes Built on Healthy Soils

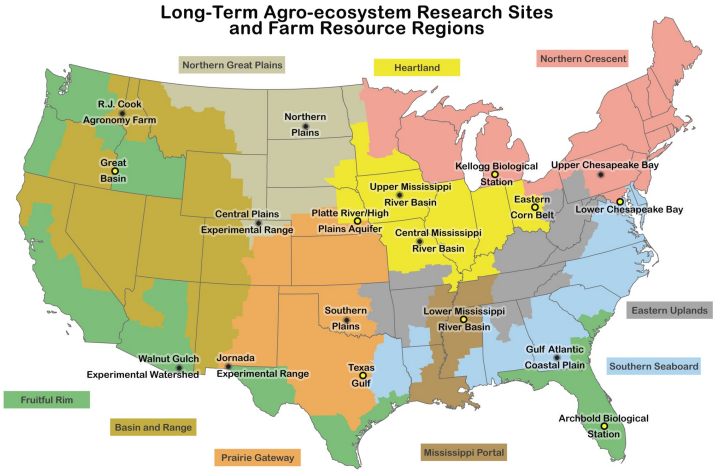
- **Goal:** Increase stakeholder awareness of soil health through research
- 36 experimental sites, 7 states
- Cross-location research
  - Stewardship of soil resources
  - Managing nutrients
- ARS Data Portal
- 2006-present

USDA-ARS Network Activities

Long-term Agroecosystem Network (LTAR)

Long-term, Trans-disciplinary Science for Agriculture

- **Goal:** Ensure sustained production and ecosystem services from agro-ecosystems, and forecast and verify effects of environmental trends, public policies, and emerging technologies
- 18 experimental sites, 9 regions
- 'Common Experiment'
  - Agro-ecosystem productivity
  - Climate variability and change
  - Conservation & environmental quality
  - Socio-economic viability & opportunities
- 2012-present



www.ars.usda.gov/ltar

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REACCH
Regional Approaches to Climate Change –
PACIFIC NORTHWEST AGRICULTURE

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Thank you!

University of Idaho

Washington State University

USDA NIFA

United States Department of Agriculture
National Institute of Food and Agriculture

Oregon State University OSU

Pacific Northwest Farmers Cooperative

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