# The Efficacy of Amelioration Practices for Crop Residue Removal in the Western Corn Belt

**Virginia L. Jin[1]*, Catherine E. Stewart[2], Marty R. Schmer[1], Aaron J. Sindelar[1,3], Brian J. Wienhold[1] *(retired)***

*[1]USDA-ARS Agroecosystem Management Research, Lincoln, NE*

*[2]USDA-ARS Soil Management and Sugarbeet Research, Fort Collins, CO*

*[3]Central Valley Ag Coop, Malcolm, NE*

***Correspondence*: Virginia.Jin@usda.gov**

*USDOE-BETO Bioenergy's Role in Soil Carbon Storage Workshop*

*Monday, March 28, 2022*

USDA United States Department of Agriculture
Agricultural Research Service

# Using Management to Ameliorate Stover Removal







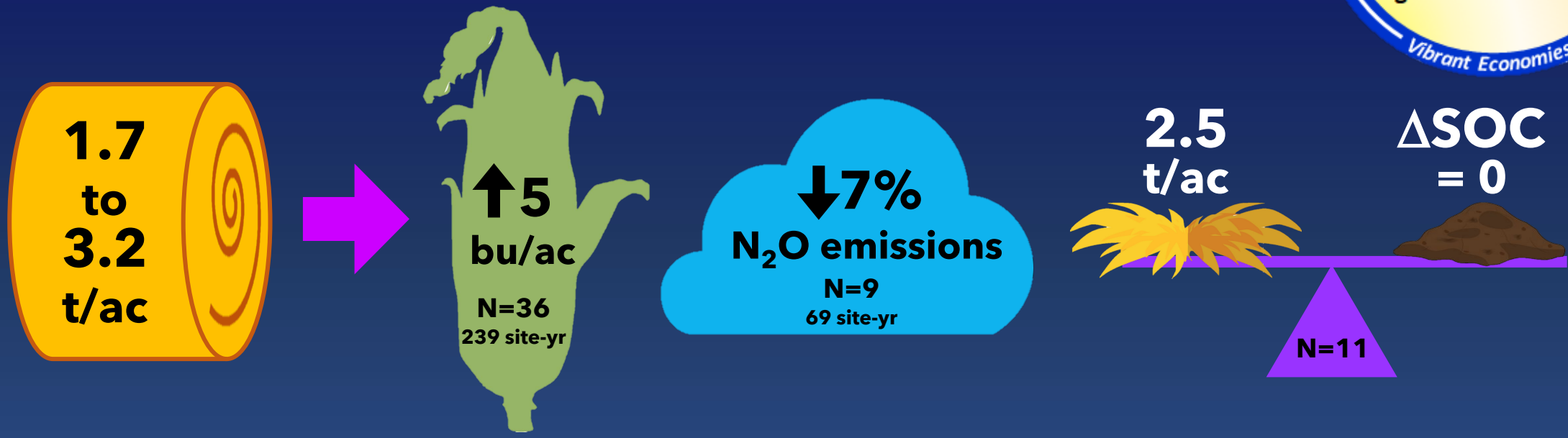

# A Closer Look: Stover Harvesting Practices

# USDA-ARS Research Questions & Approach

- **What are the impacts of corn stover removal on crops and soils?**
  - Agronomic metrics: Grain yield
  - Soil sustainability metrics: Soil organic carbon (SOC), Non-$CO_2$ gases ($N_2O$)
  - Soil health metrics: physical, chemical, biological properties (not presented)
- **How do these impacts differ between intensive production systems vs marginally productive systems?**
  - No-till vs tilled systems
  - Continuous monocropping vs crop rotations
  - Irrigated vs rainfed/dryland systems

# USDA-ARS REAP Project (early 2000s to mid-2010s)

- Sun Grant Regional Partnership: USDA-ARS, NIFA, USDOE-BETO, Universities, Industry partners
- 36 field sites across US; standard design, protocols




Karlen et al. 2014, BioEnergy Res 7: 528-539

Jin et al. 2014, BioEnergy Res 7: 517-527

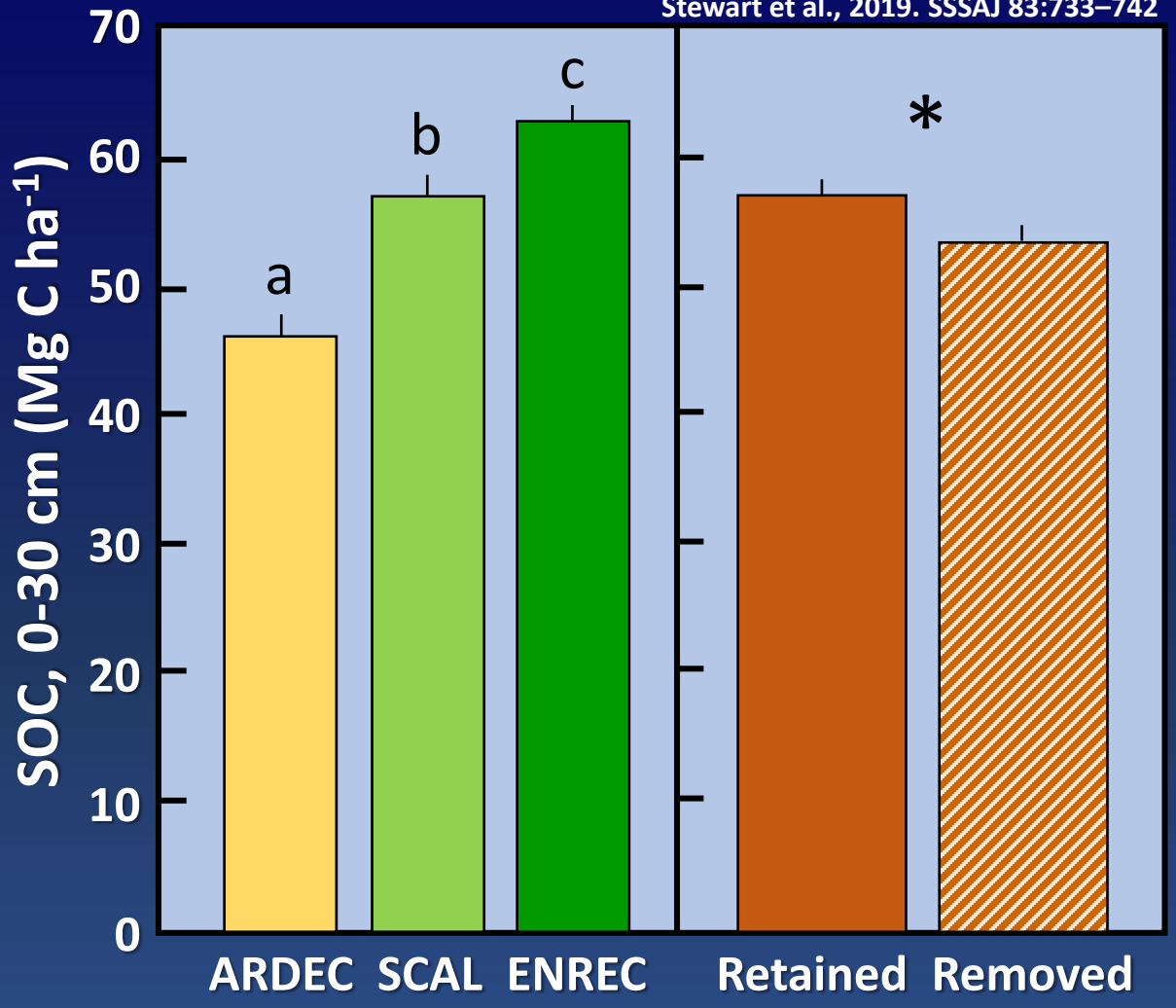
Johnson et al. 2014, BioEnergy Res 7: 481-490

- Led to $9M DOE-BETO Landscape Design Project (2015-2021)

# Does No-Till Mitigate Stover Removal Impacts?


- 2014 cross-site study
- Irrigated, no-till continuous corn
- Precipitation and SOC gradient

Stewart et al., 2019. SSSAJ 83:733–742




$\Delta SOC_{Removed-Retained}$ (t C $ac^{-1}$ $yr^{-1}$) = -0.24 -0.41 -0.15 -0.27

USDA United States Department of Agriculture
Agricultural Research Service

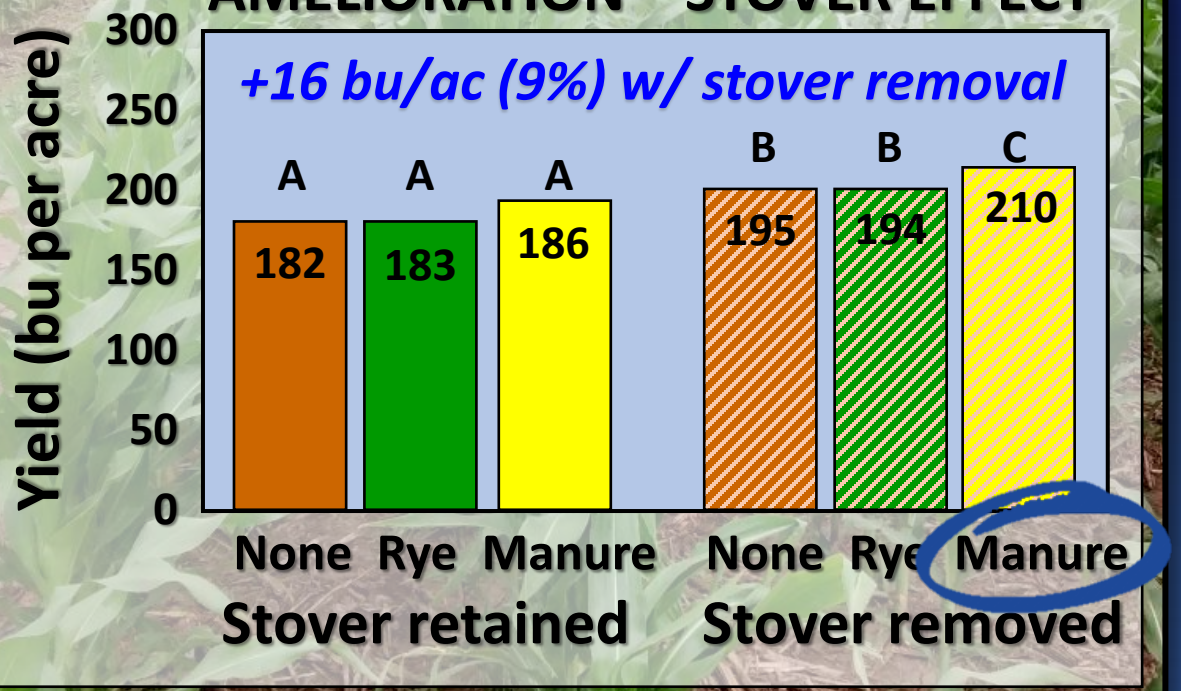
# How Long Does It Take for Soil Changes to Occur?

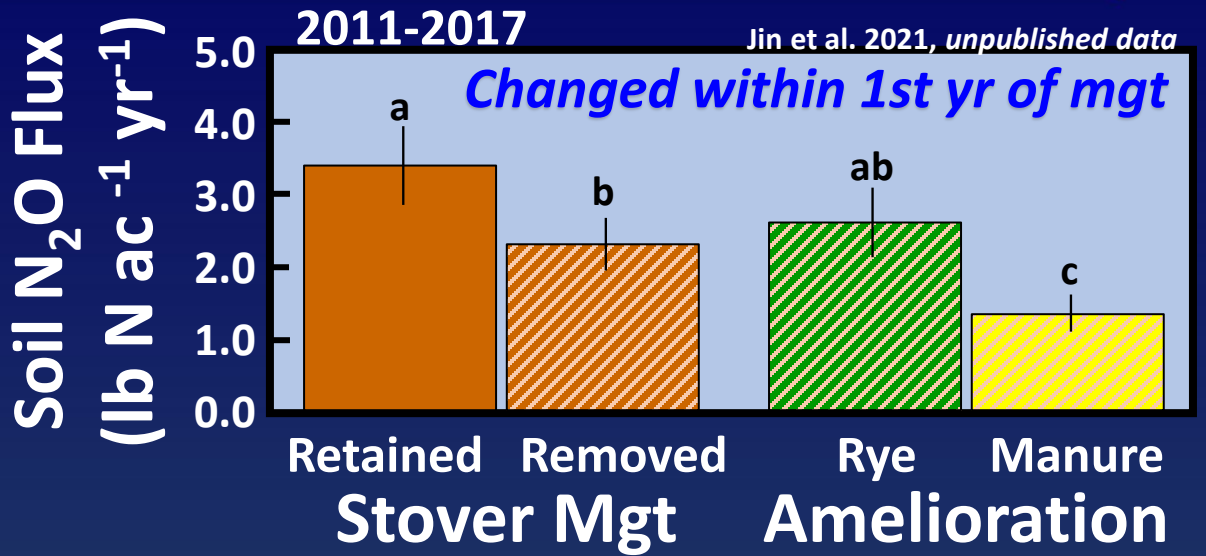
## SCAL Biomass Study: 2010-now
### Irrigated, no-till continous corn

Schmer et al. 2020, Agron J 112: 2506-2518

**2011-2018**

**AMELIORATION * STOVER EFFECT**




Blanco et al. 2014, SSSAJ 78: 1368-1377; Sindelar et al. 2019, SSSAJ 83: 221-231

| Soil Properties (0-12”) | Stover Removal | | Cover Crop | |
|---|---|---|---|---|
| | 3 yr | 6 yr | 3 yr | 6 yr |
| Water Infiltration | Ø | ↓ | Ø | Ø |
| Water Retention | Ø | ↓ | Ø | Ø |
| Available Water | Ø | ↓ | Ø | Ø |
| Wet Aggregate Stability | ↓ (0-1”) | ↓ (0-6”) | Ø | Ø |
| Soil Organic C | ↓ (0-1”) | ↓ (0-8”) | Ø | ↑ |


USDA United States Department of Agriculture
Agricultural Research Service

# Annual vs Perennial Feedstocks on Marginal Lands

## 9804 Bioenergy Study: 1998-now
### Rainfed marginal farmland

**Rates of SOC Change (0-30 cm), 1998-2014**

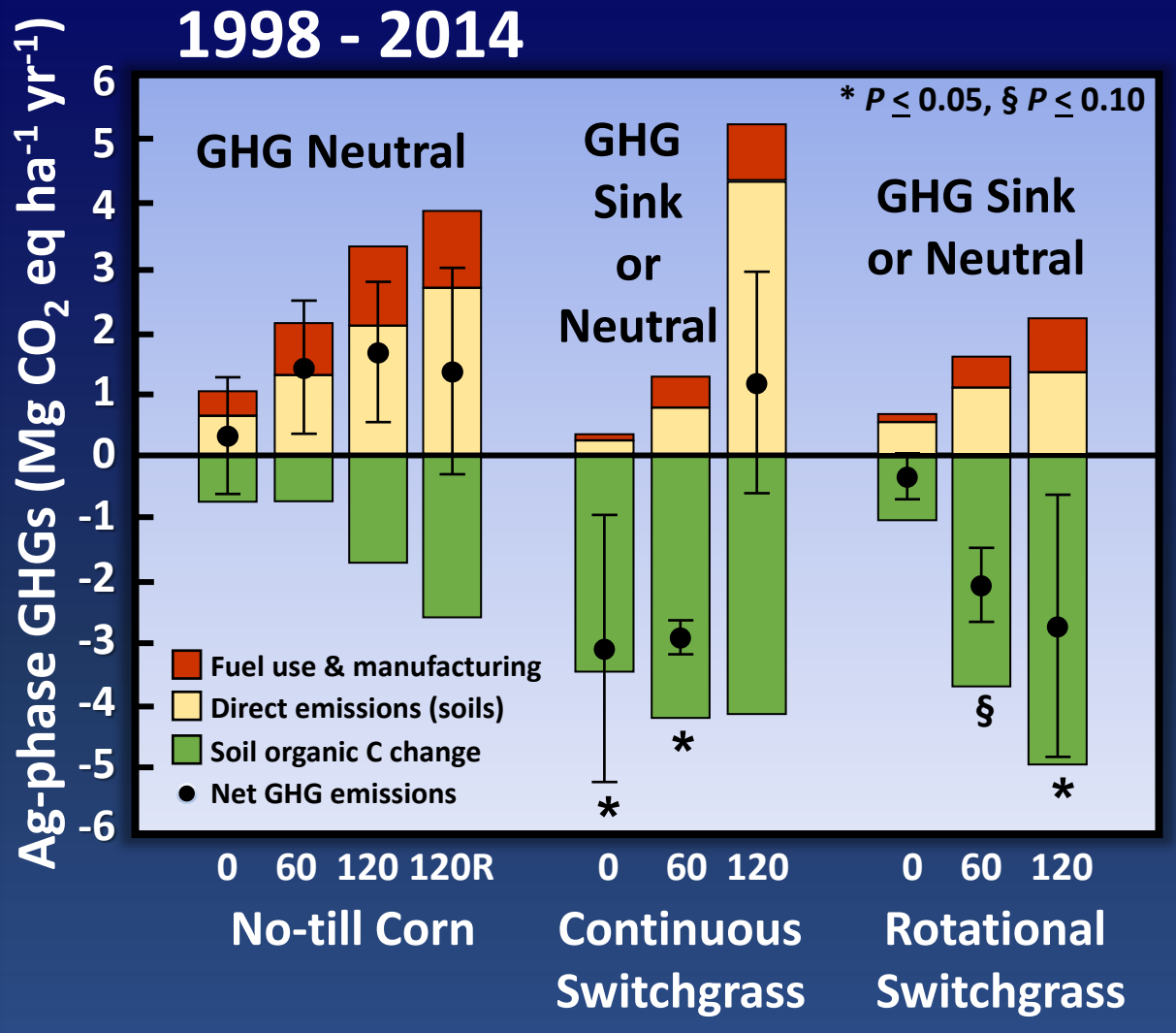
| Fertilizer N | NT Contin-uous Corn | Continuous Switchgrass | Rotational Switchgrass |
|---|---|---|---|
| lb ac$^{-1}$ yr$^{-1}$ | tons C ac$^{-1}$ yr$^{-1}$ | | |
| 0 | – | 0.40 ± 0.27 | 0.13 ± 0.04 |
| 60 | 0.09 ± 0.13 | 0.49 ± 0.04 | 0.45 ± 0.09 |
| 120 | 0.22 ± 0.13 | 0.49 ± 0.13 | 0.58 ± 0.22 |
| 120R* | 0.31 ± 0.18 | – | – |

*R = Residue retained

Corn stover removal rate = 1.7 ton ac$^{-1}$ (~60%)

ΔSOC > 0 ($P \leq 0.05$)

ΔSOC > 0 ($P \leq 0.10$)

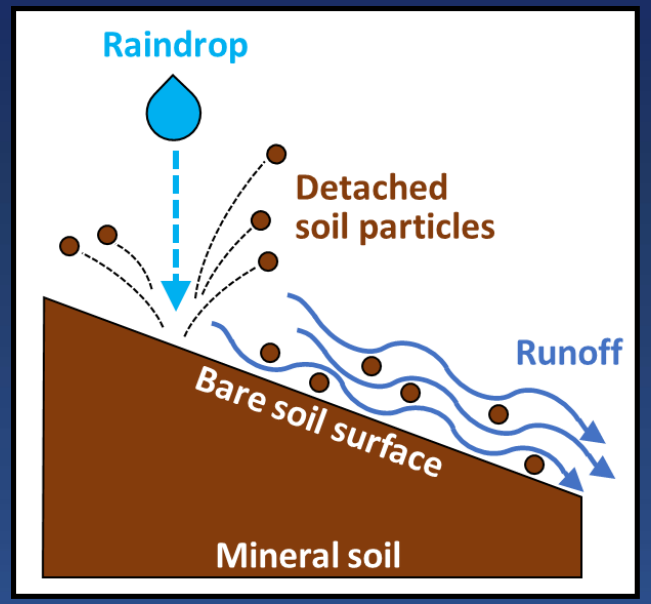


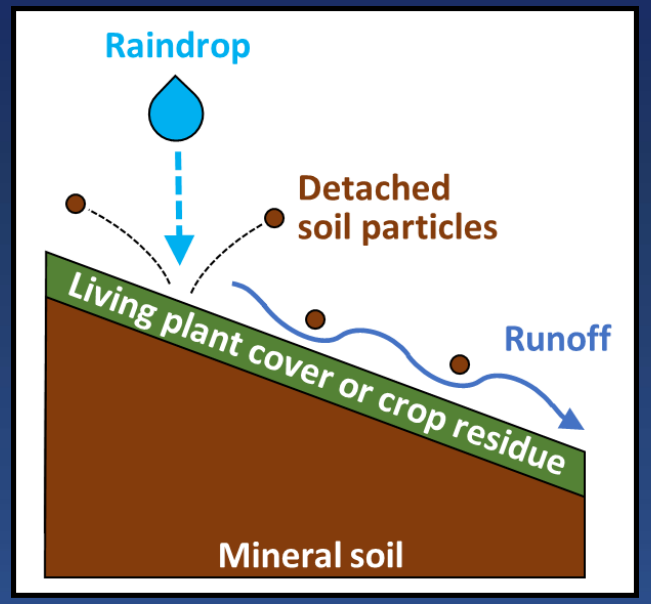

Jin et al. 2019, Sci Adv 5: eaav9318

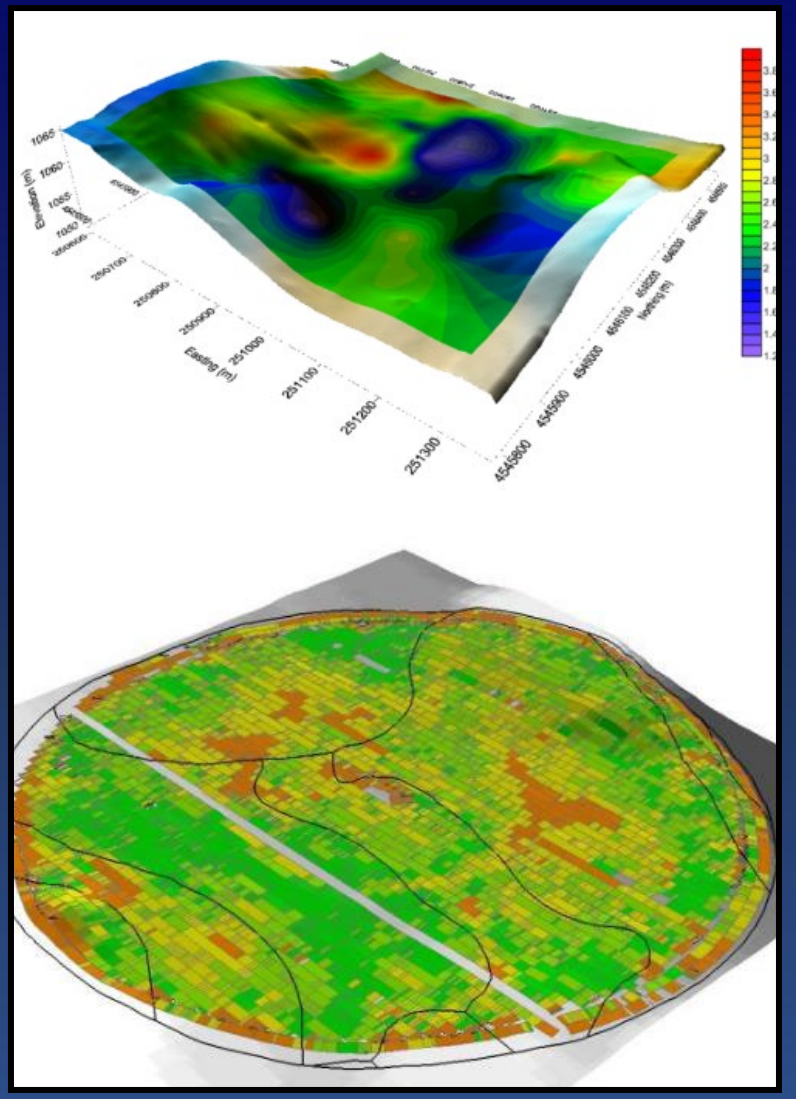
USDA United States Department of Agriculture
Agricultural Research Service

# Stover Harvest Guidelines

- ≥ 180 bushels/ac for adequate organic matter return and soil cover
- Target removing ≤ 2 tons/ac, alternating yrs
- Target slopes ≤ 4% to limit erosion risk
- Minimize stalk removal to limit erosion risk



# Stover Harvest Guidelines – Amelioration Practices

- Recommended practices to use with stover removal
  - No-till or other reduced tillage soil management practice, PLUS
  - Winter cover crop and/or manure to replace harvested stover, AND/OR
  - Periodic soil testing (SOM, pH, N, P, K, S) to evaluate soil status

- Efficacy of amelioration management depends on initial soil status, time
  - In the cross-site irrigated studies, all sites LOST SOC despite long-term no-till use
    → No-till alone does not fully offset the impacts of removing crop residue.
    → Adding a cover crops/animal manure further offsets, but still not completely.
  - In the marginally productive farmland study, all treatments GAINED SOC
    → Poor initial soil status responded positively to all conservation management, regardless whether feedstock system was annual row-crop or perennial grass.

# Acknowledgements

Many thanks to our agency, university, & industry collaborators.

Special thanks to the multitude of ARS support scientists, technicians, and student workers across the REAP Regional Partnership locations.

Funding through USDA-ARS as part of the USDA-ARS-REAP project.

Additional funding through the North Central Regional Sun Grant Center, South Dakota State University through USDOE – Office of Biomass Programs award number DE-FC36-05GO85041.