

Using the DayCent Model to Estimate Soil Carbon and GHG Fluxes for Bioenergy Assessments and the Annual U.S. GHG Emissions inventory

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Colorado State University

N R
E L



Overview

- Assessing agricultural GHGs @ CSU-NREL
 - DayCent model
- EPA National GHG inventory
 - National-scale assessment
- Bioenergy landscape design case study
 - Landscape-scale assessment

Overview

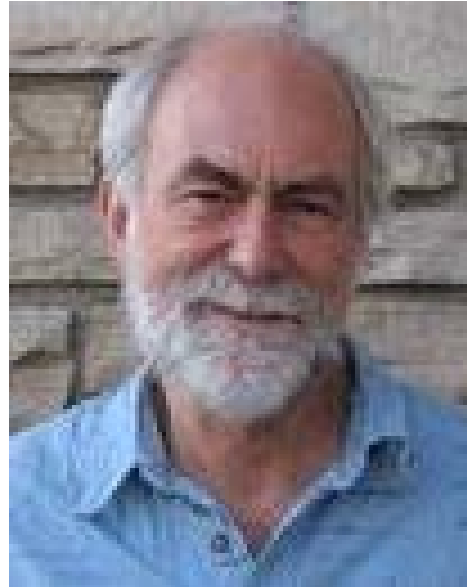
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Acknowledgements

- The CSU-NREL DayCent model & agricultural Inventory team



Steve Ogle



Bill Parton



Steve Del Grosso

Cody Alsaker
Guhan Dheenadayan
Chris Dorich
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Ken Killian
Ernie Marx
Shannon Spencer
Amy Swan
Steve Williams
Yao Zhang

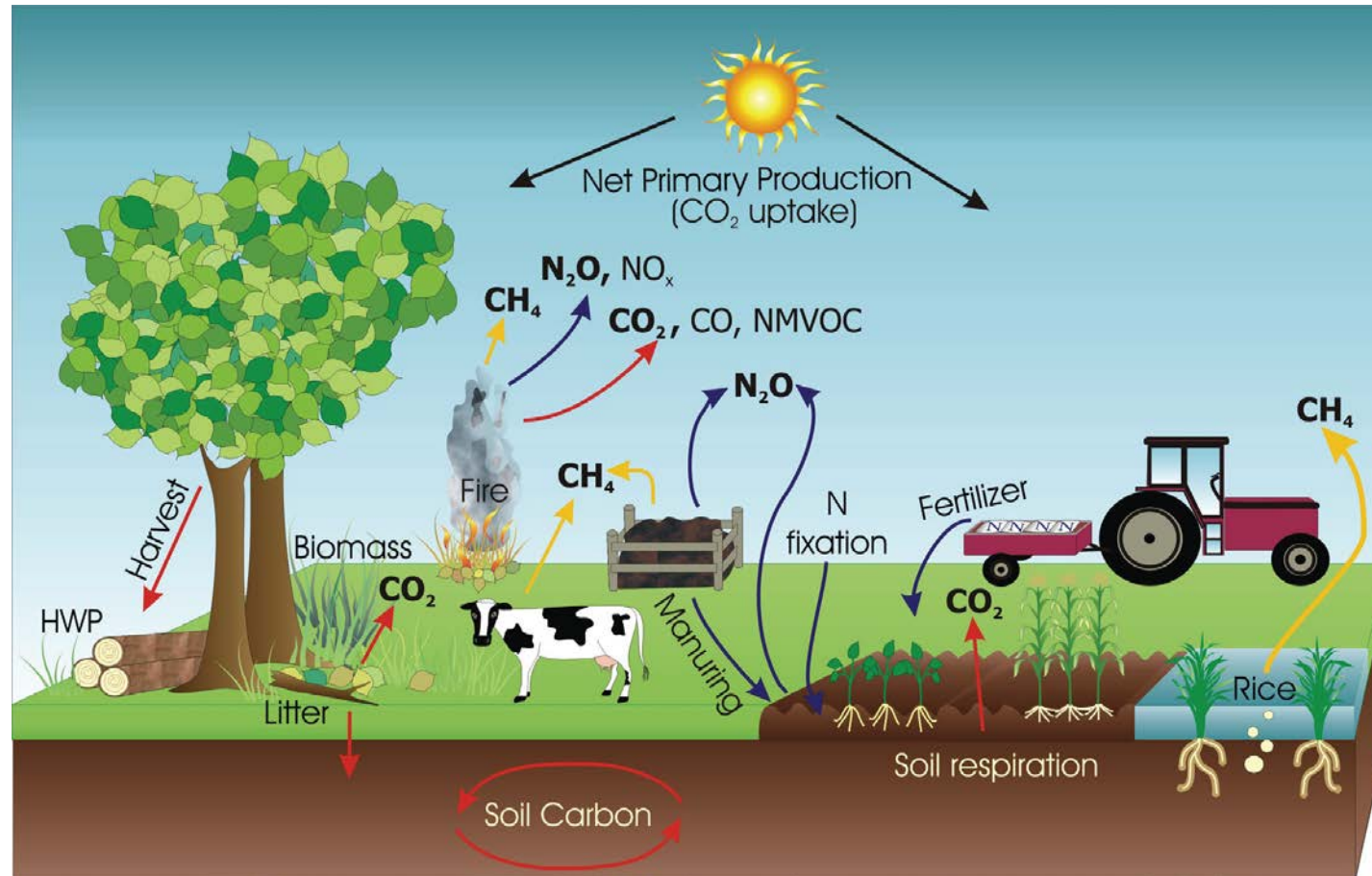
GHGs in the AFOLU sector

Biomass C Stock
Changes

Non-CO₂ GHG
Emissions
from Burning

Enteric Methane

CH₄ and N₂O
from Manure



Soil N₂O
Emissions

Rice Methane

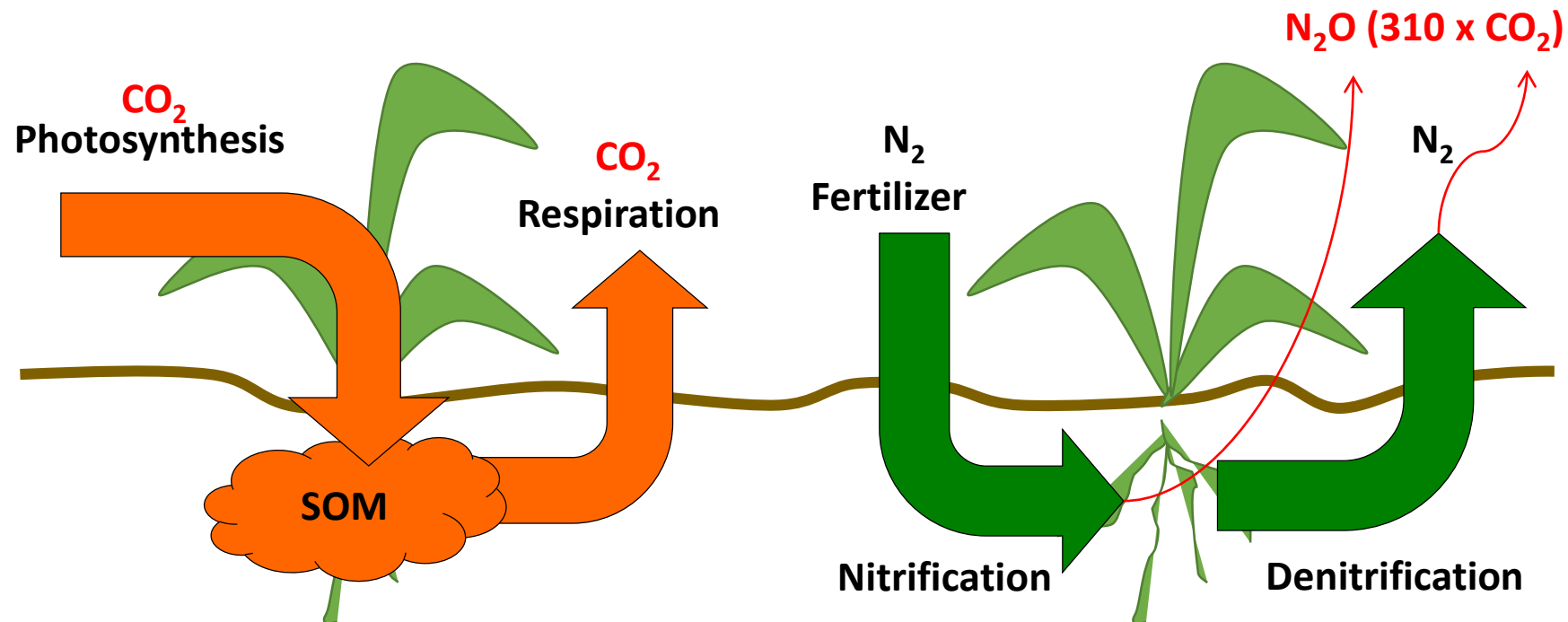
Soil C Stock
Changes

Urea and Liming
CO₂ Emissions

From 2006 IPCC Guidelines

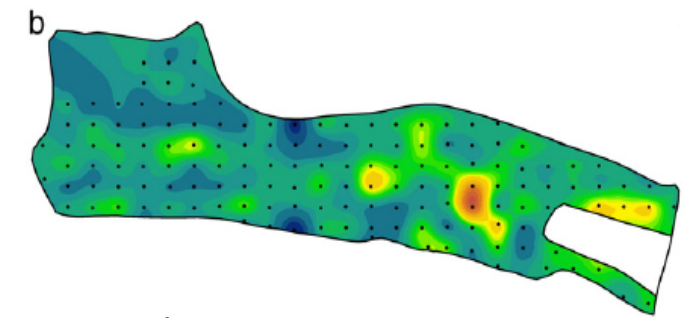
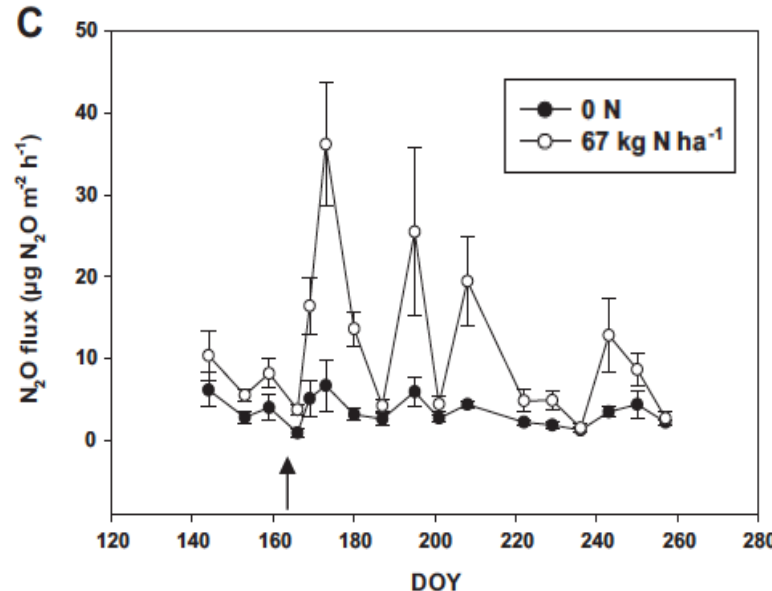
Agroecosystem biogeochemistry

- Cycling of C & N w/ associated GHG fluxes

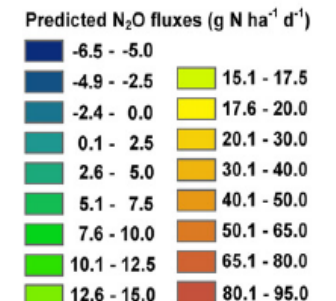


Measurement challenges

- Measurements of SOC, N₂O are difficult & labor-intensive
- Huge spatial and temporal variability

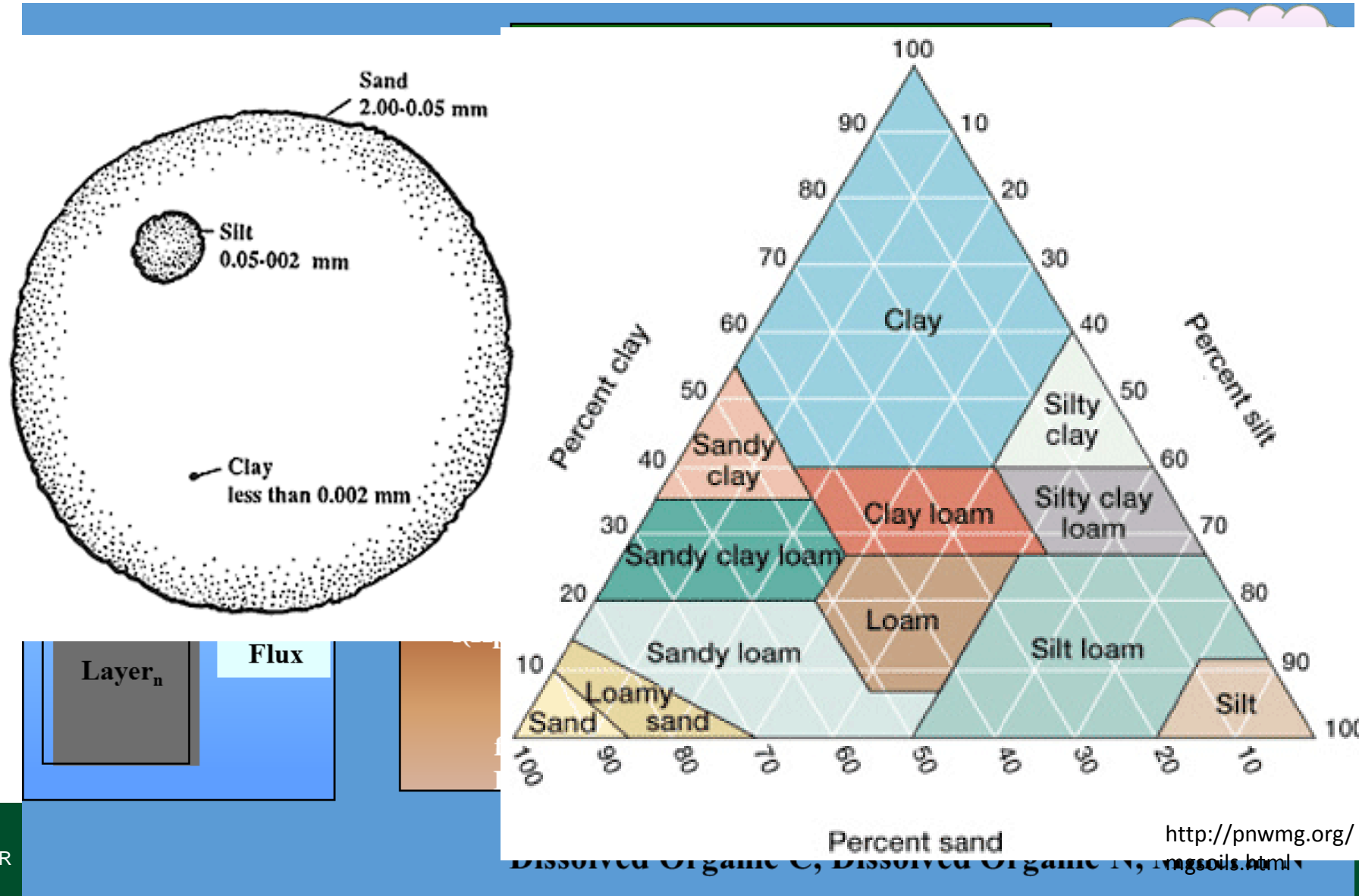


Li et al.
(2013).
Geoderma,
193–194, 1–
12.



Schmer et al. (2012). *Biomass and Bioenergy*, 45, 315–319.

DayCent ecosystem model



Overview

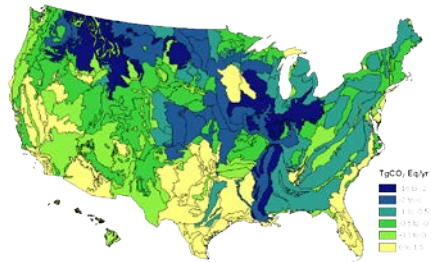
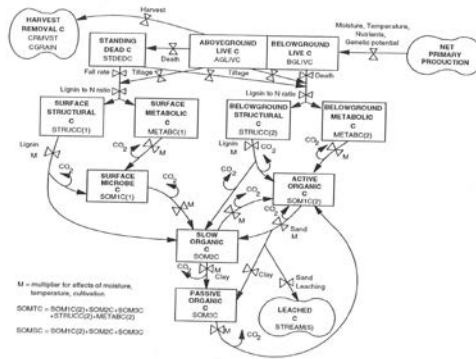
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National GHG Emissions Inventory-Monitoring System

- Annual reporting of GHG emissions to UNFCCC
- Comply with IPCC guidelines and good practice
- Support analyses of GHG mitigation potentials for development of domestic policy

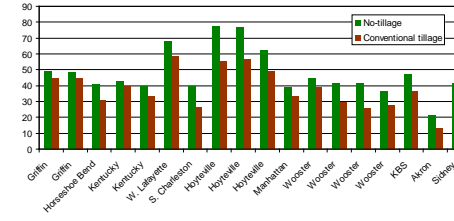


Model Development /Selection

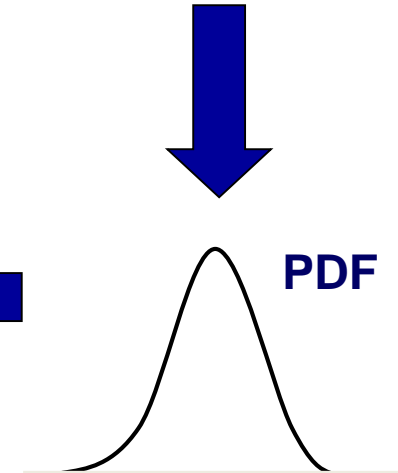
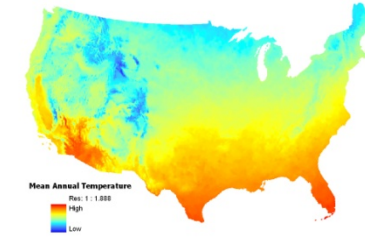


Evaluation of Model Results

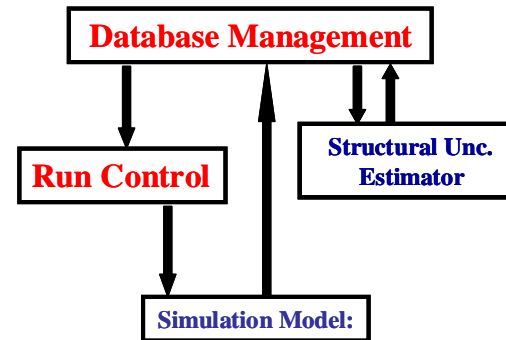
Model Testing/ Parameterization



Identify Model Inputs

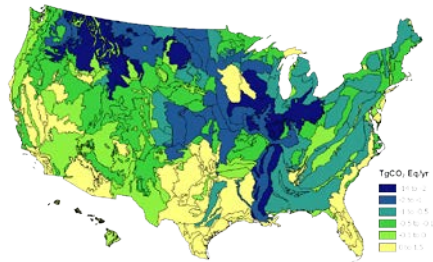


Assess Uncertainties



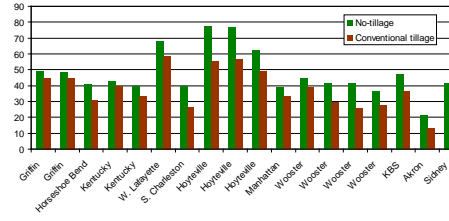
Implement Simulations

Adapted from 2006 IPCC Guidelines

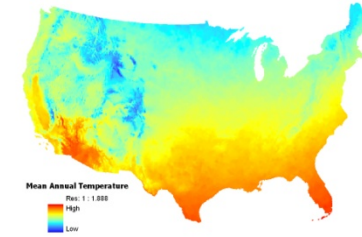
[illegible]

Evaluation of Model Results

Model Testing/ Parameterization

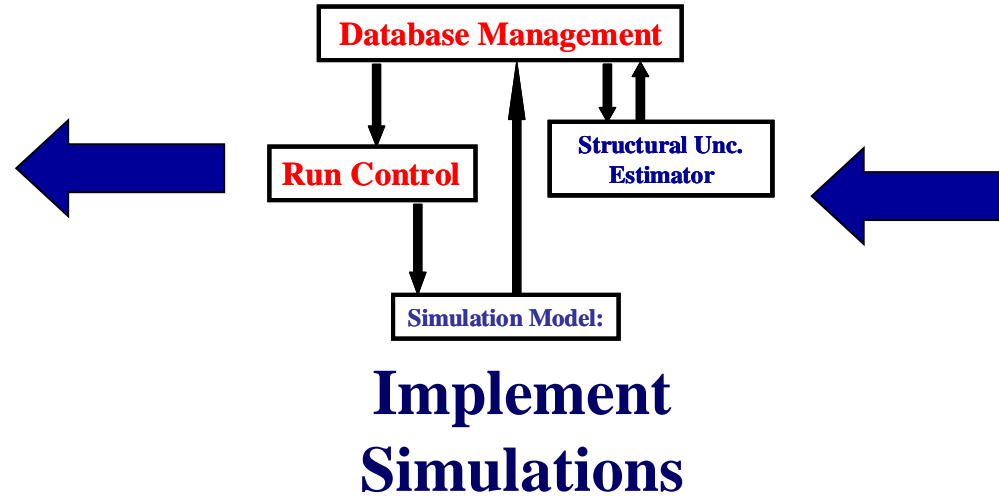


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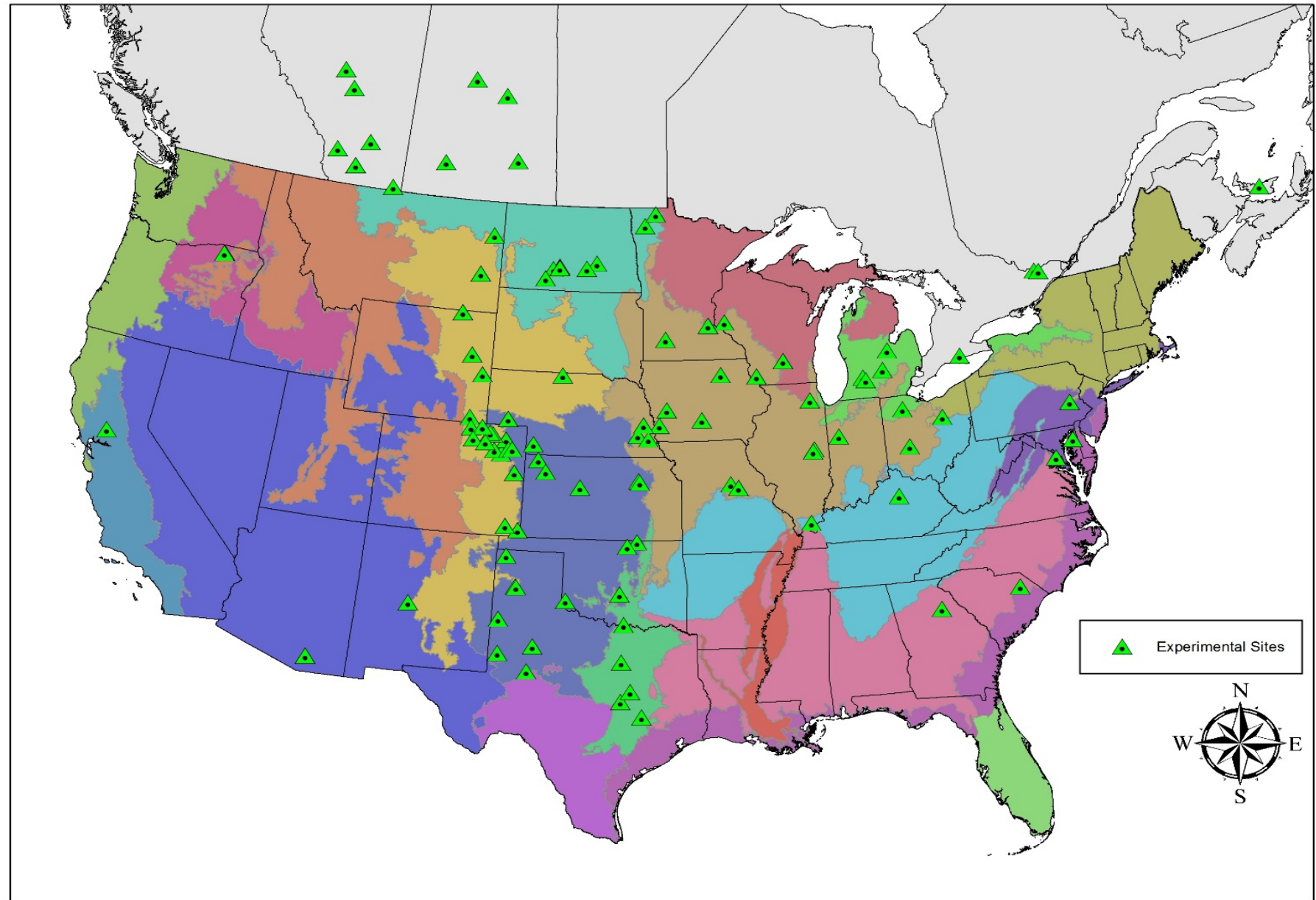


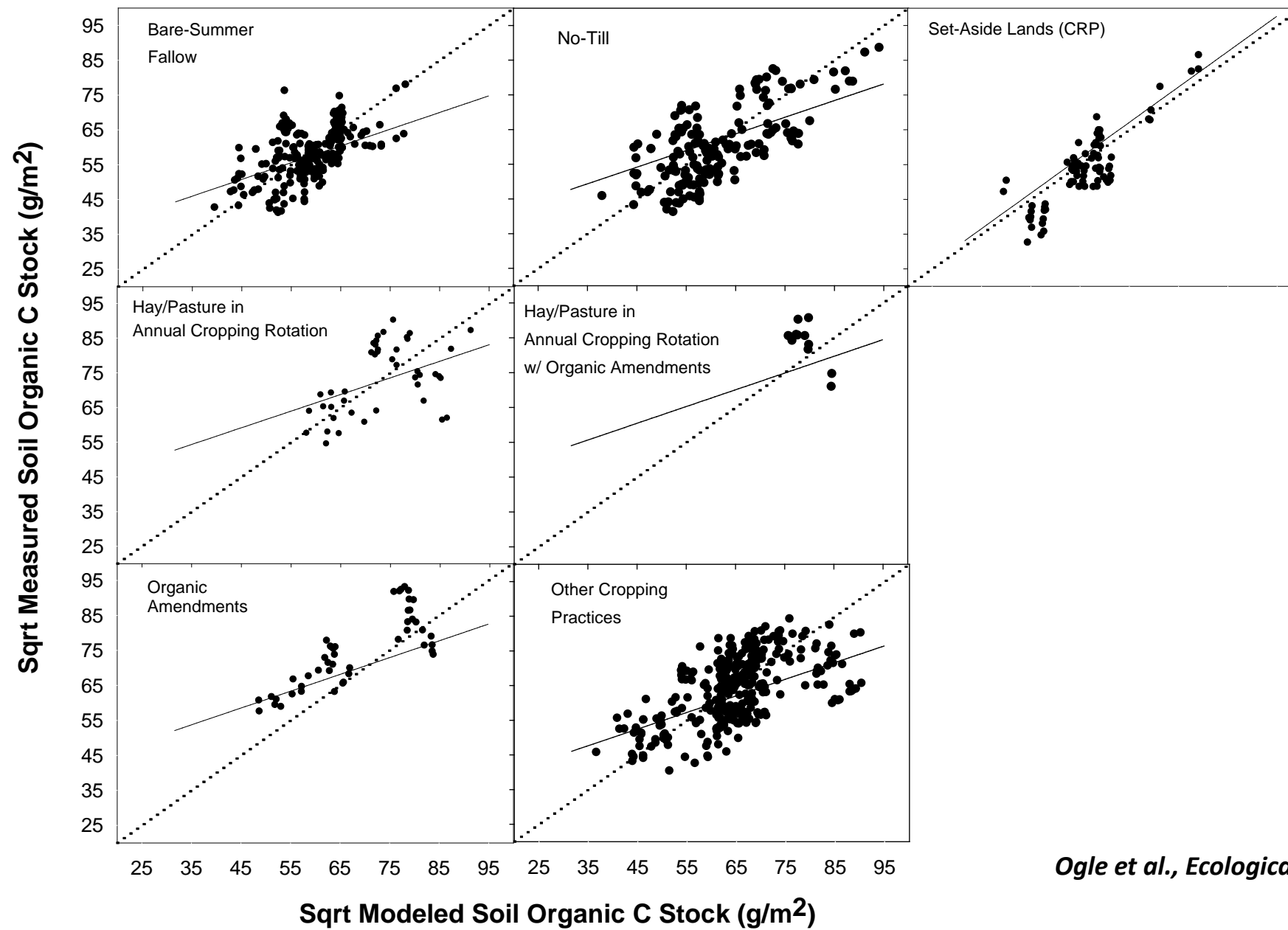
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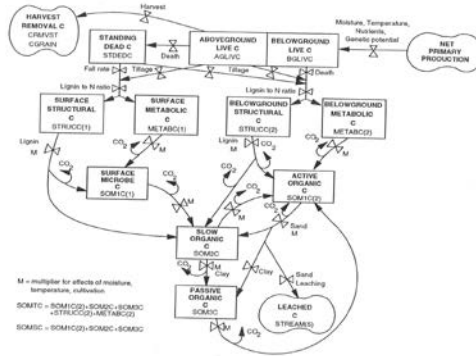
Experimental Sites



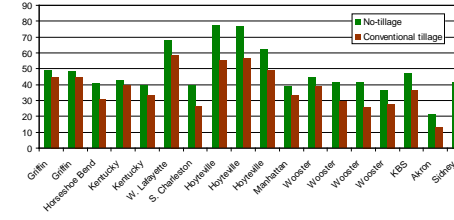


Ogle et al., Ecological Modelling, 2007

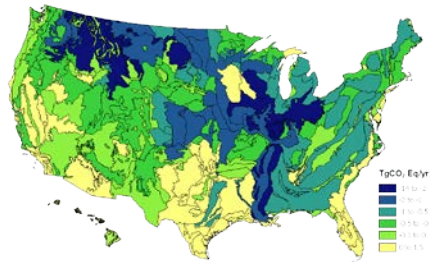
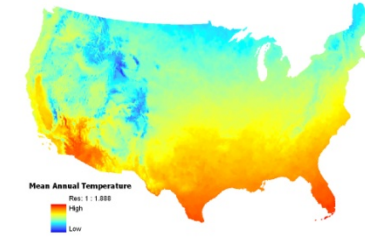
Model Development /Selection



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Identify Model Inputs



Evaluation of Model Results

Database Management

Run Control

Structural Unc.
Estimator

Simulation Model:

Implement Simulations

PDF

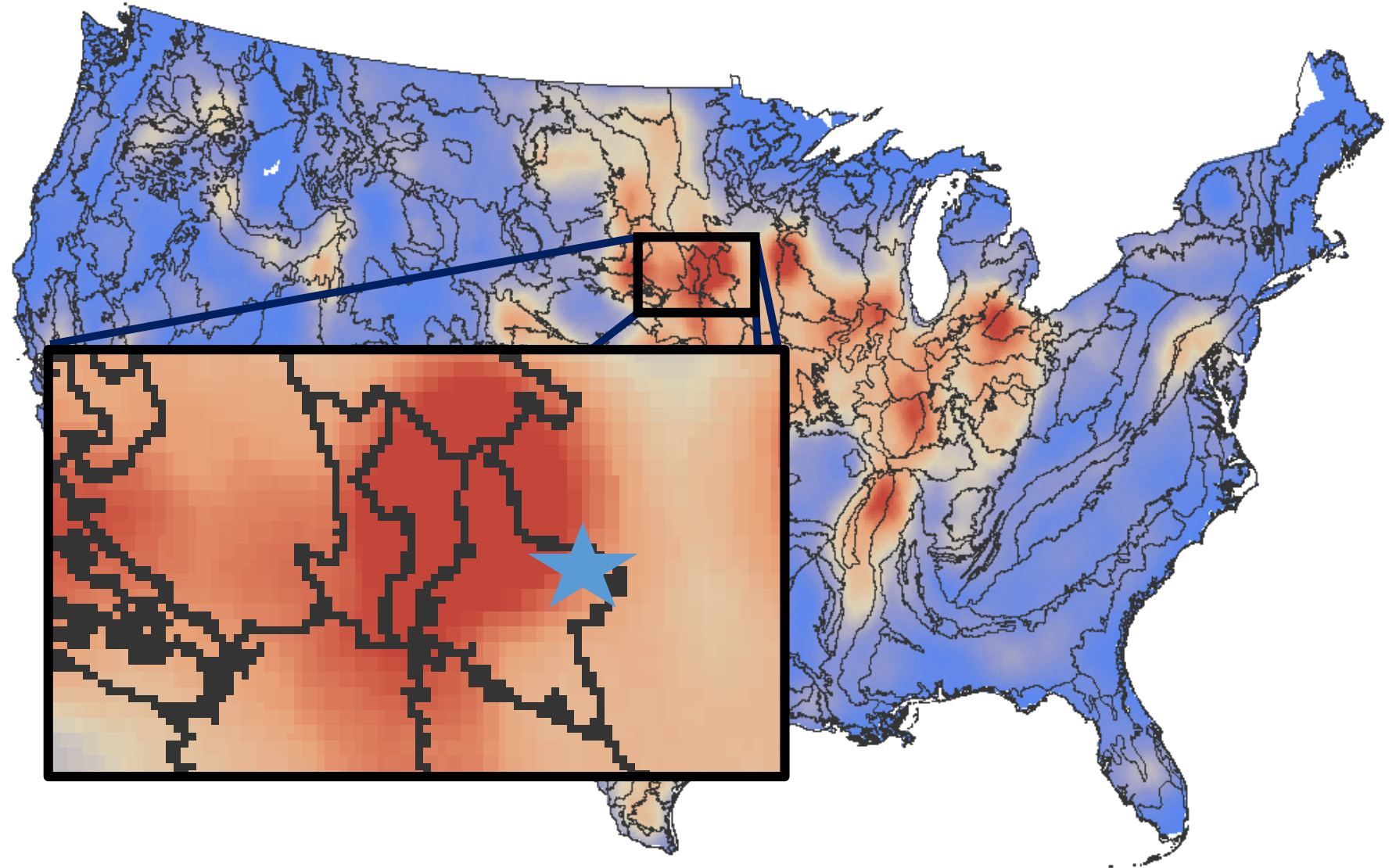
Assess Uncertainties

Adapted from 2006 IPCC Guidelines

Input data requirements

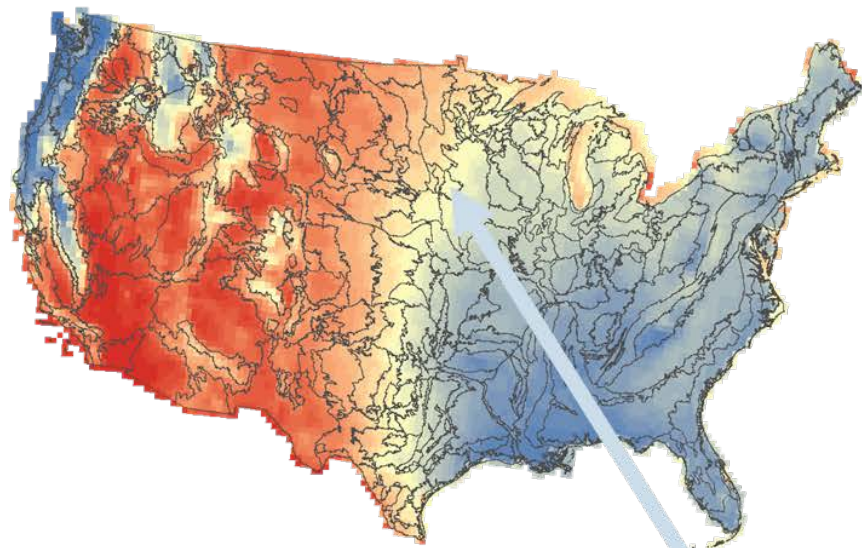
- Site latitude/longitude
- Climate (daily temp & precip data)
- Soil properties
 - Texture, depth profile
- MANAGEMENT
 - Crop rotation, tillage, fertilizer, organic matter, irrigation
- Productivity (EVI)

USDA National Resources Inventory

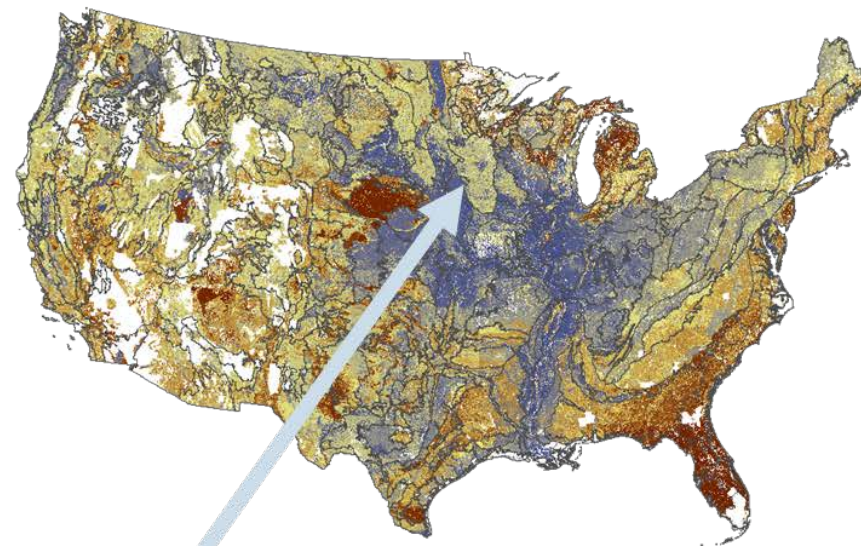


Ogle et al., 2010, Global Change Biology

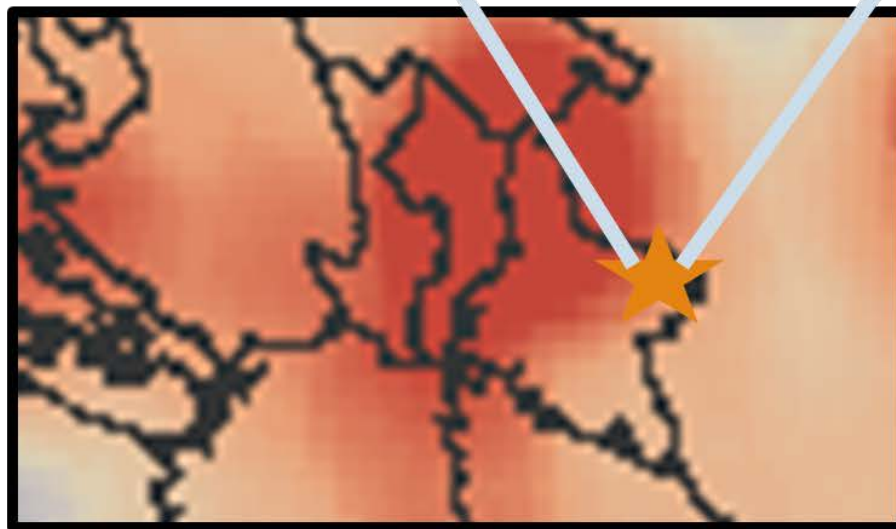
PRISM
Daily
Weather
Data



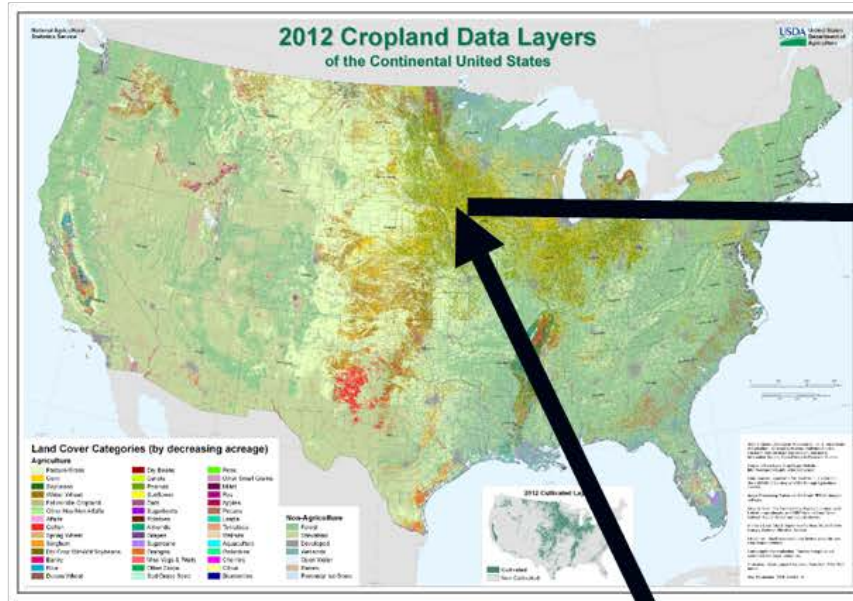
USDA-
NRCS
SSURGO
Soils Data



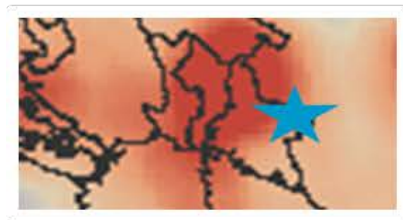
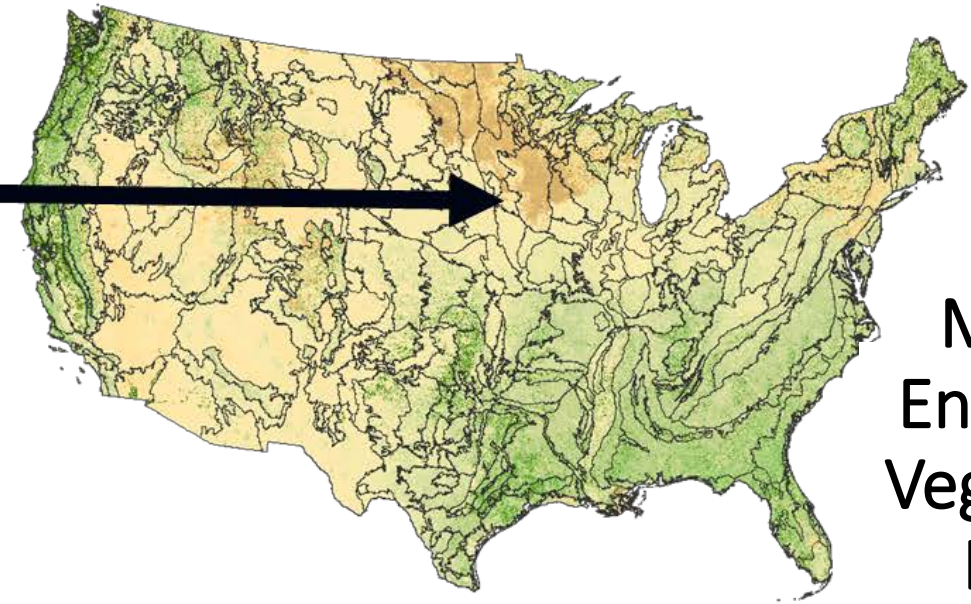
NRI Survey
Location



USDA-
NASS
Crop Data
Layer



MODIS Enhanced Vegetation Index



Tillage

~~Fertilizer~~

Planting

Harvest

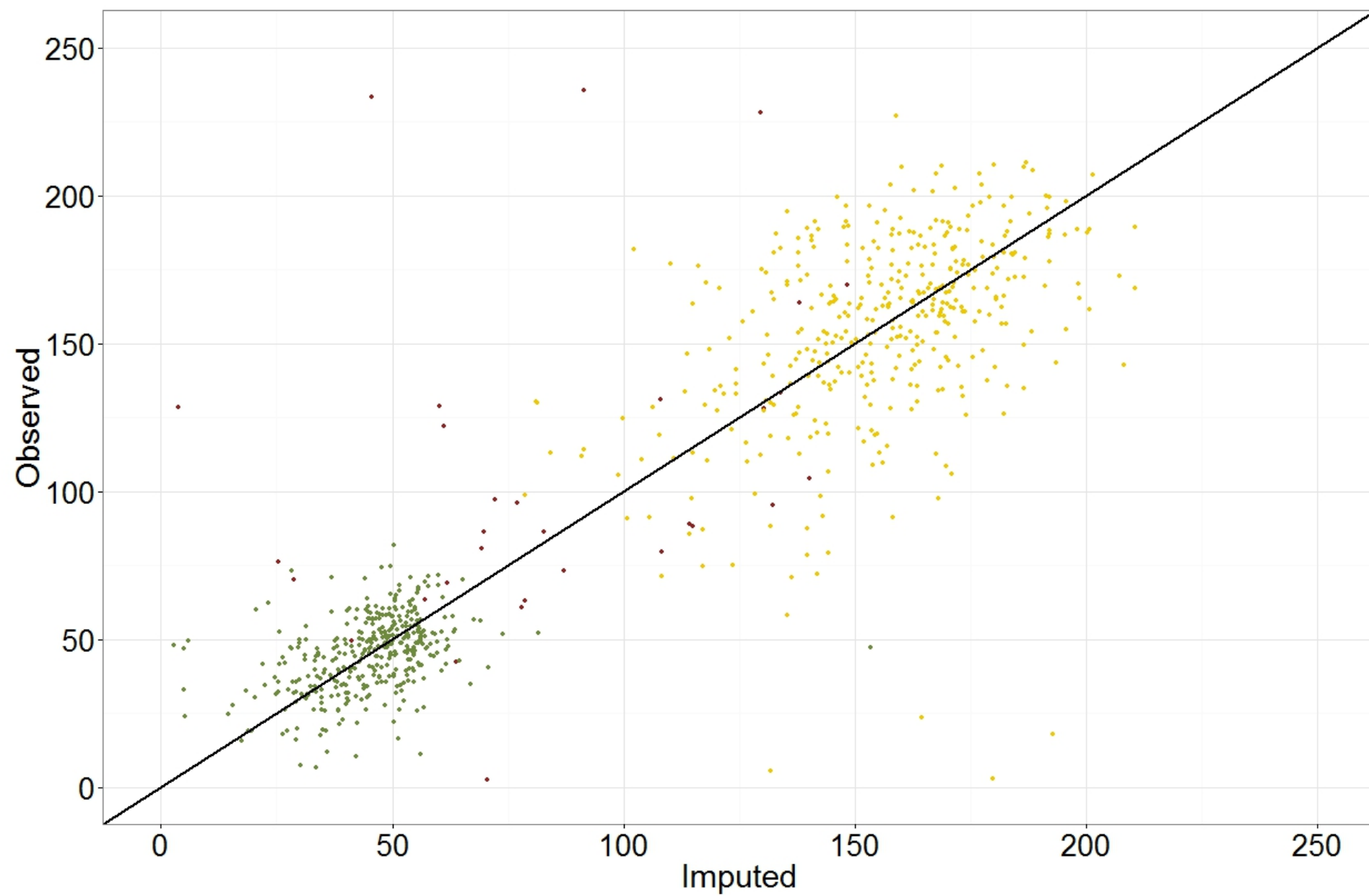
CORN

365

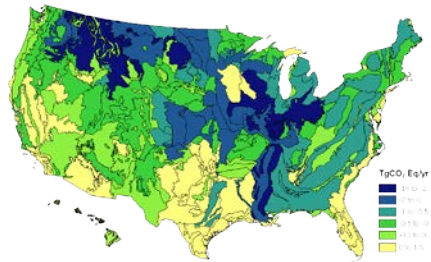
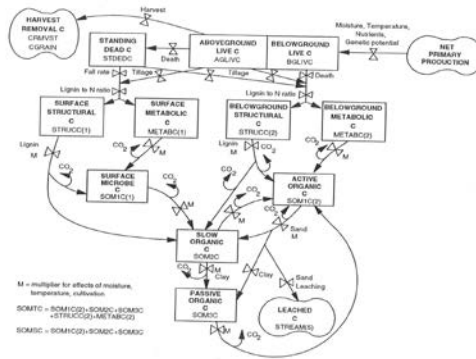
Management via Conservation Effects Assessment Project (CEAP)

- Survey of management practices on NRI subsample
- Information such as tillage practices, fertilizer management, manure/organic amendments, cover crops, and residue management
- We use machine learning (neural network) to impute management data from CEAP to rest of the NRI points



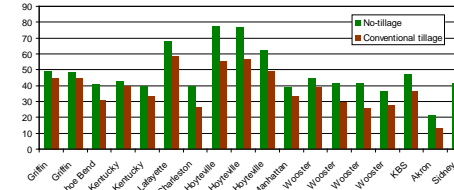


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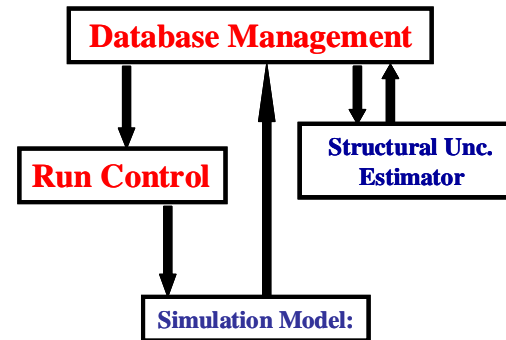
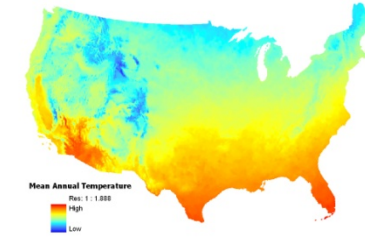


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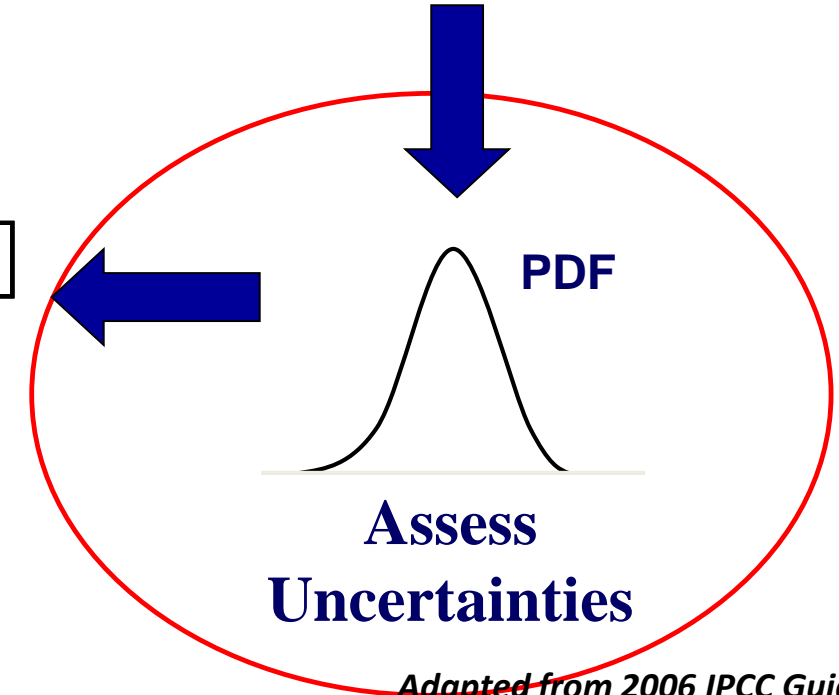
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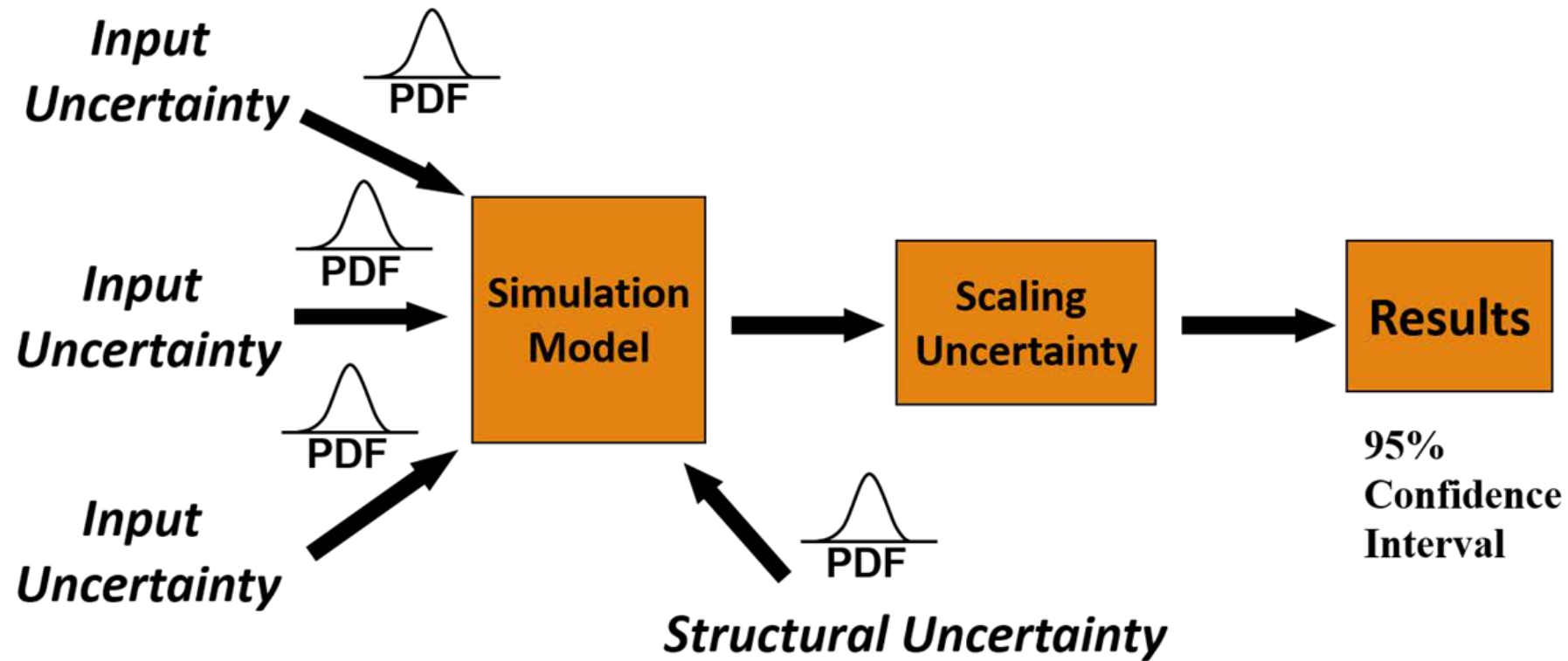
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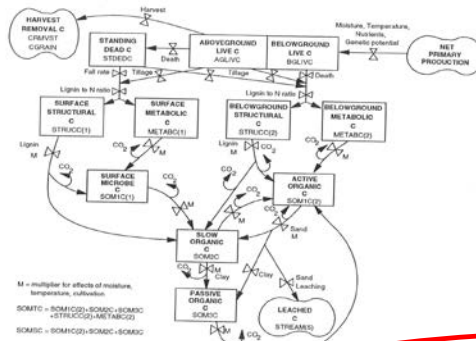
Adapted from 2006 IPCC Guidelines



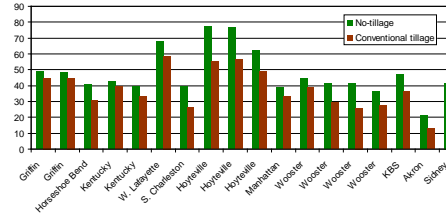
Empirical Approach: $SOC = \beta_o + \beta_1 X_1 + \dots + \beta_p X_p + \gamma_{mlra} + \gamma_{site} + \gamma_{year*site} + \varepsilon$

Ogle et al., 2010, Global Change Biology

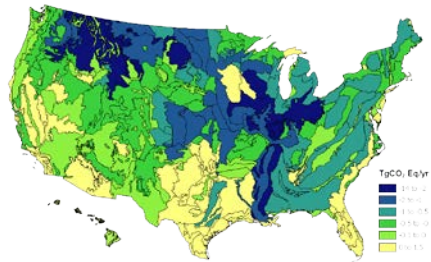
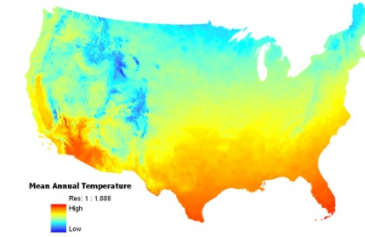
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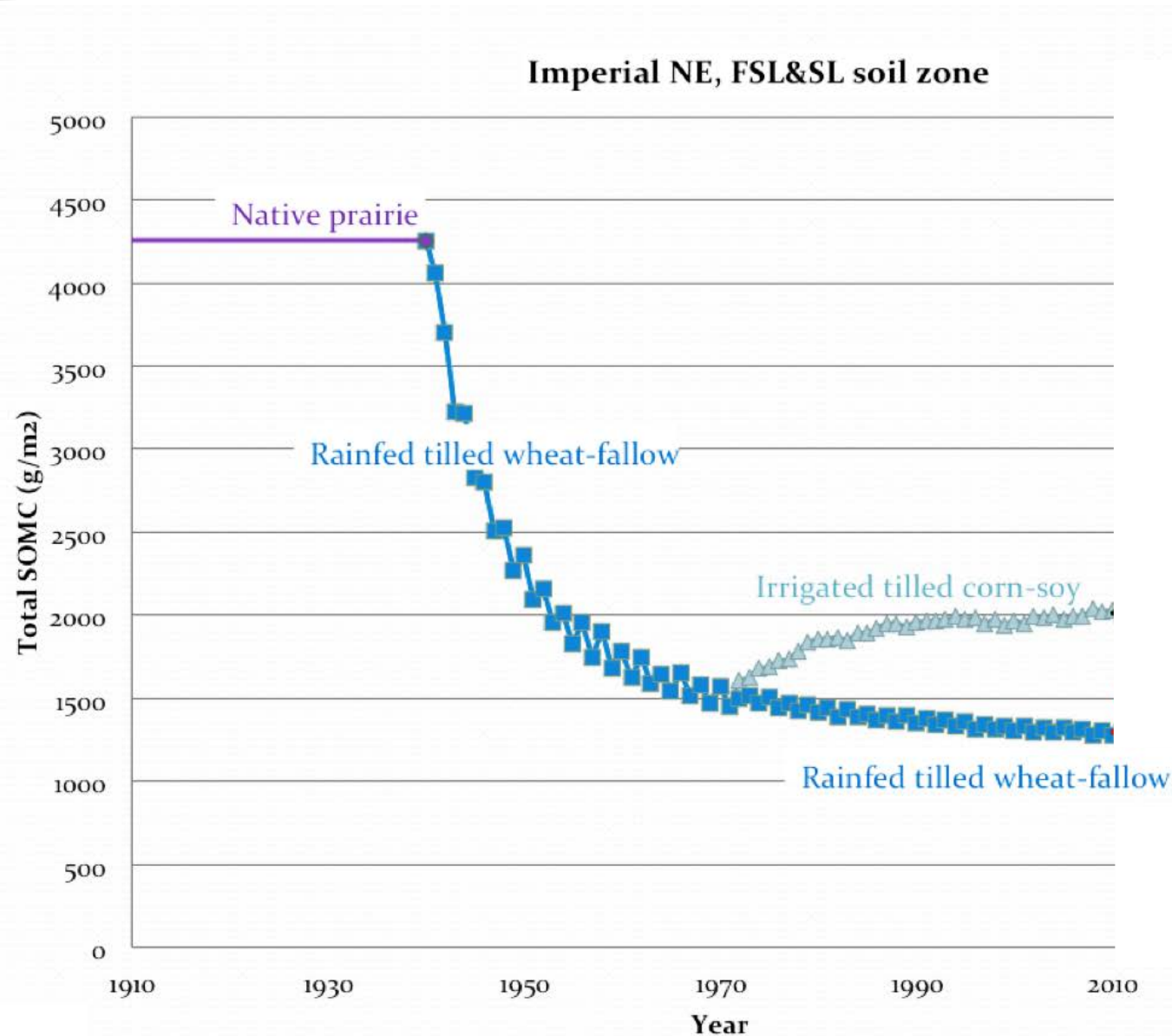
Implement Simulations

PDF

Assess Uncertainties

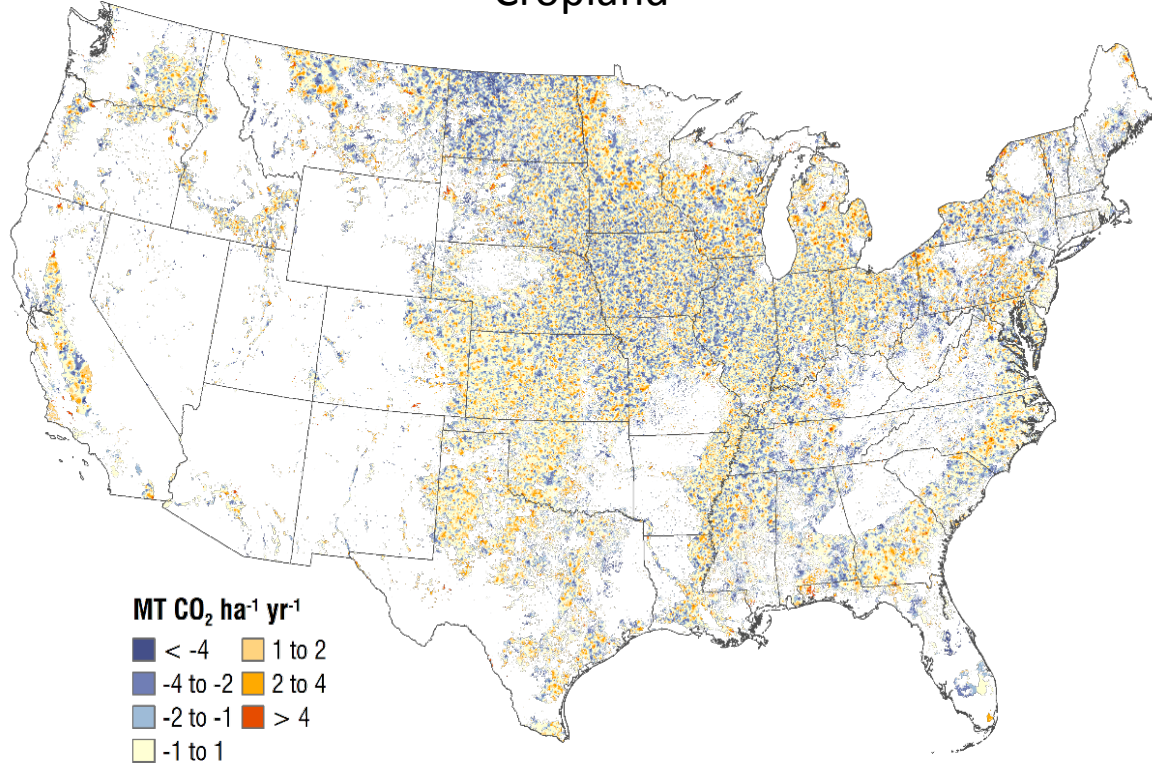
Adapted from 2006 IPCC Guidelines

Typical point-level results

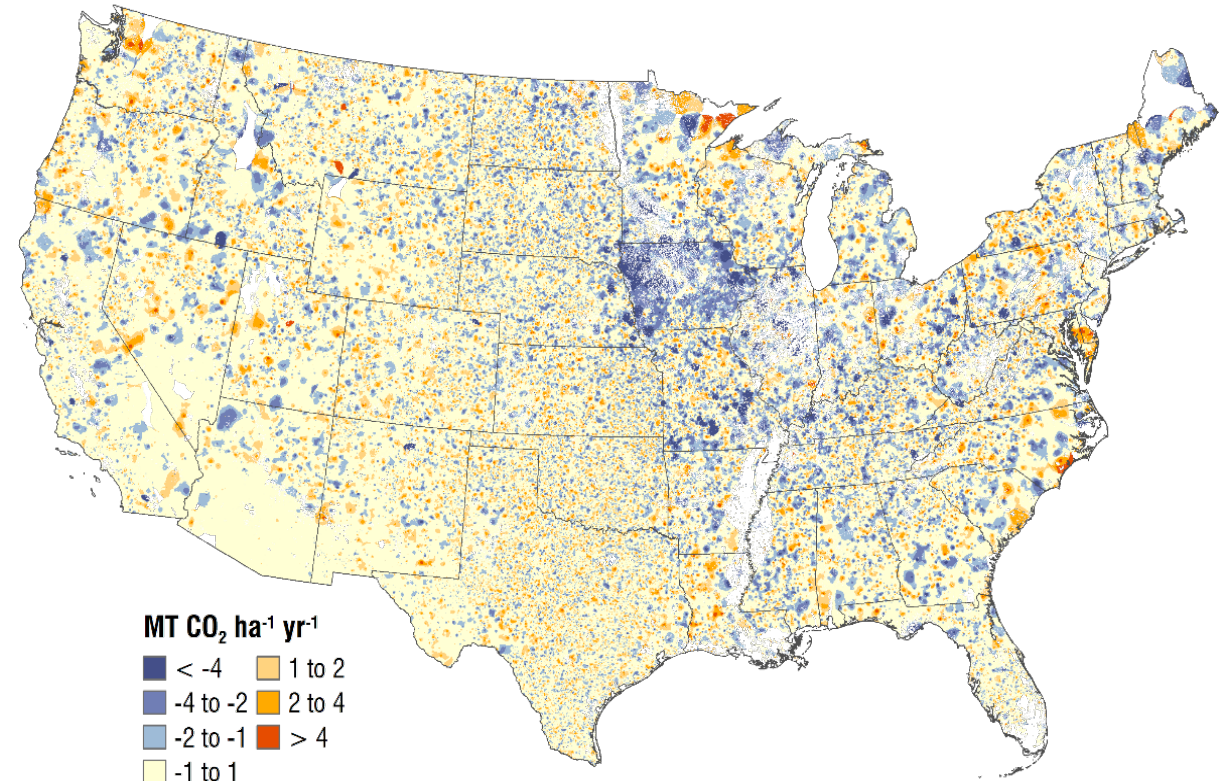


Soil C Stock Changes – Mineral Soils (2012)

Cropland

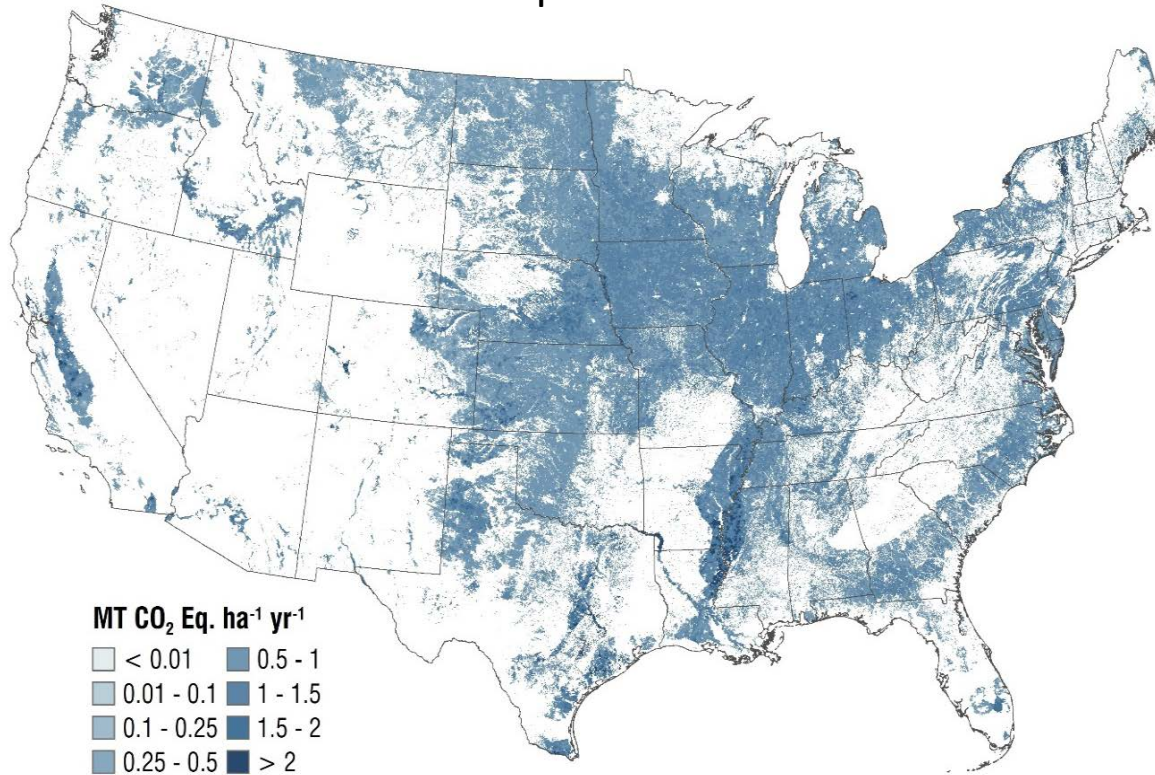


Grassland

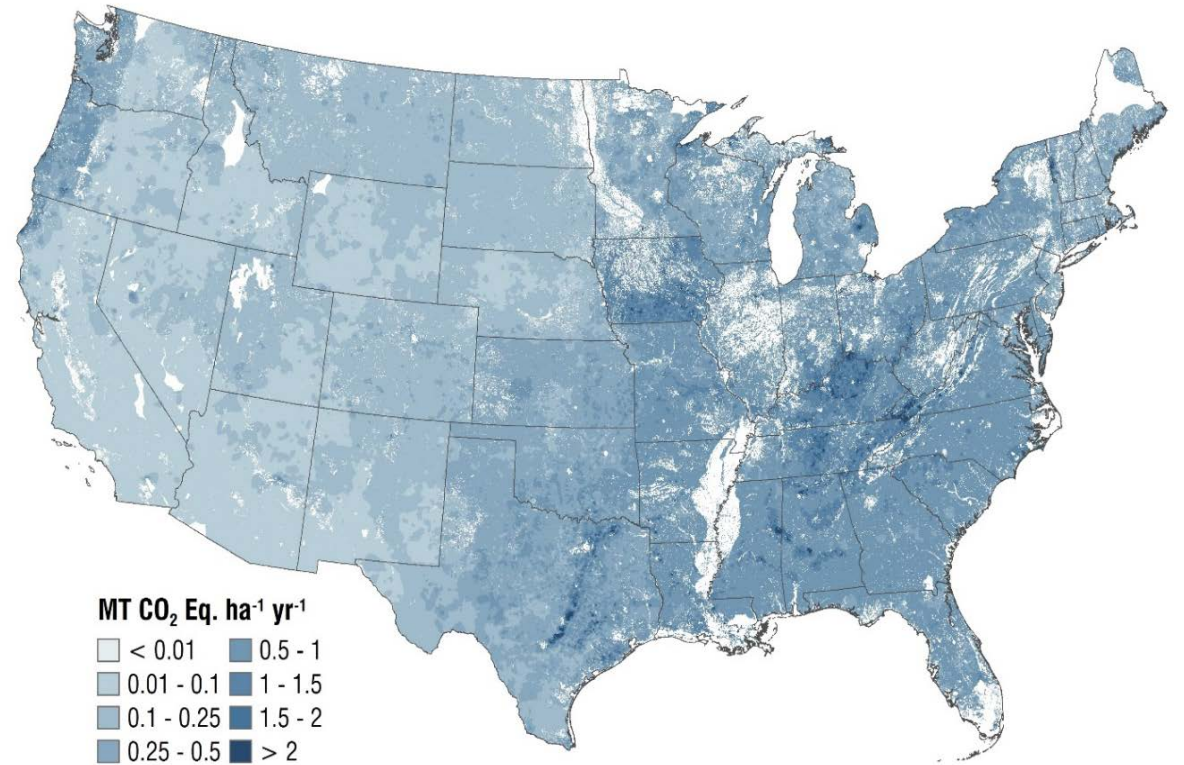


Soil N₂O emissions (2012)

Cropland



Grassland



Final reported result

Table 7-20: Net CO₂ Flux from Soil C Stock Changes in *Cropland Remaining Cropland* (Tg CO₂ Eq.)

Soil Type	1990		2005		2008	2009	2010	2011	2012
Mineral Soils	(75.9)		(51.5)		(52.0)	(51.4)	(49.8)	(49.7)	(48.6)
Organic Soils	24.0		22.4		22.1	22.1	22.1	22.1	22.1
Total Net Flux	(51.9)		(29.1)		(29.8)	(29.2)	(27.6)	(27.5)	(26.5)

Note: Totals may not sum due to independent rounding.

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- **Bioenergy landscape design case study**
 - **Landscape-scale assessment**

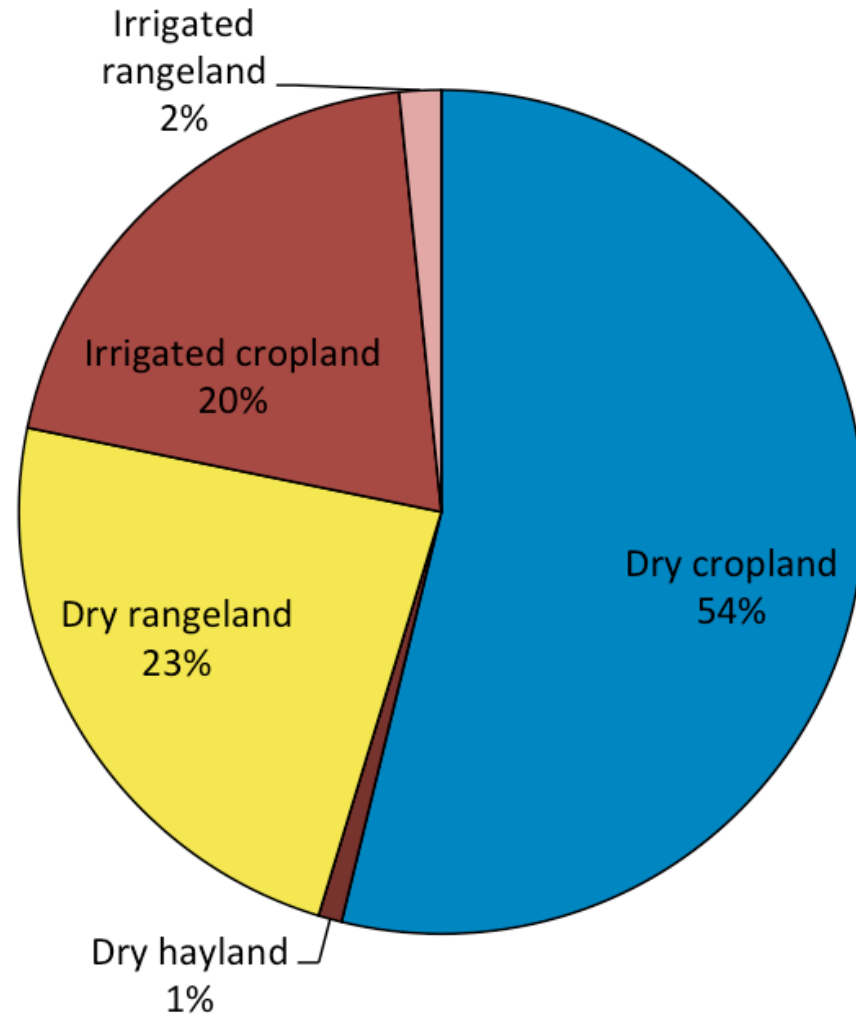
Landscape design case study

- Abengoa 25 MGY cellulosic EtOH biorefinery (biochem.)
- BCAP site, ~4000 acres switchgrass
- 7-county case study area

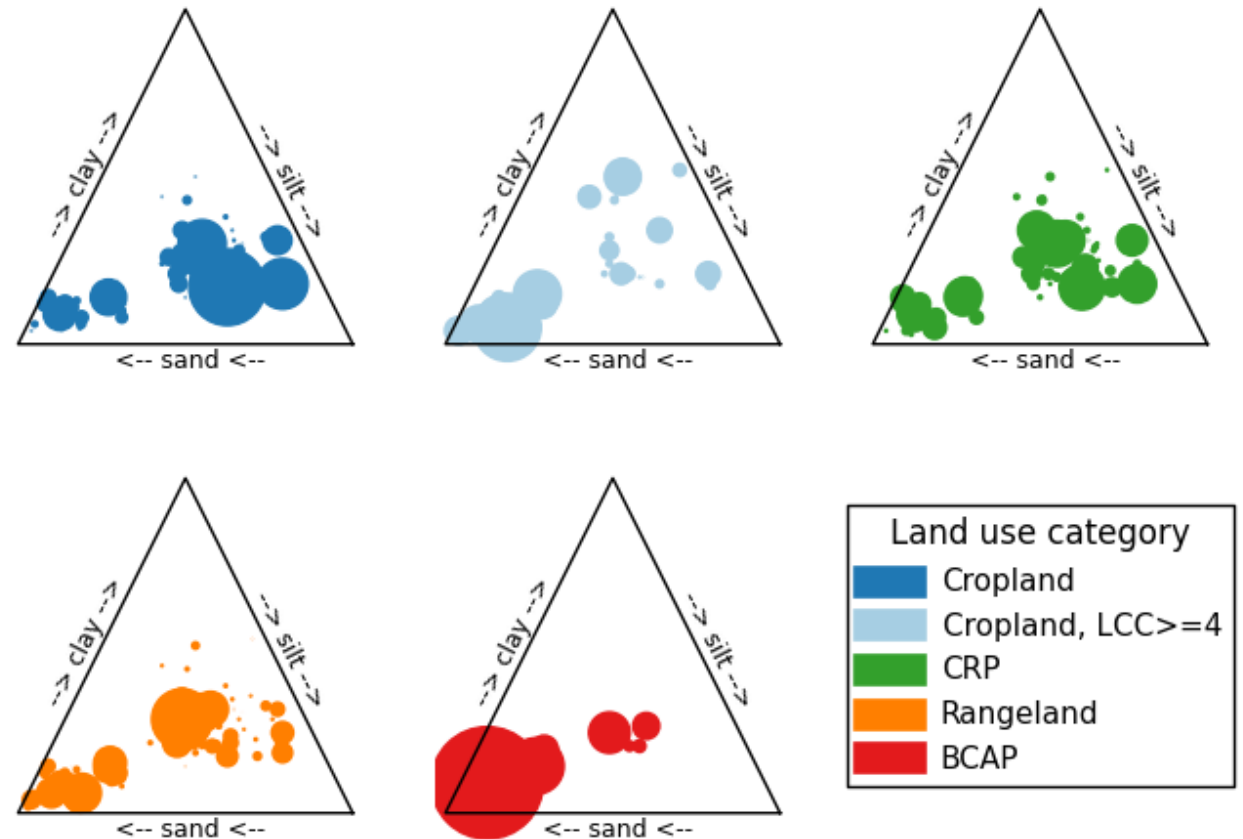
Field *et al.* High resolution techno-ecological modeling of a bioenergy landscape to identify climate mitigation opportunities in cellulosic ethanol production. *Accepted pending final revisions at Nature Energy.*



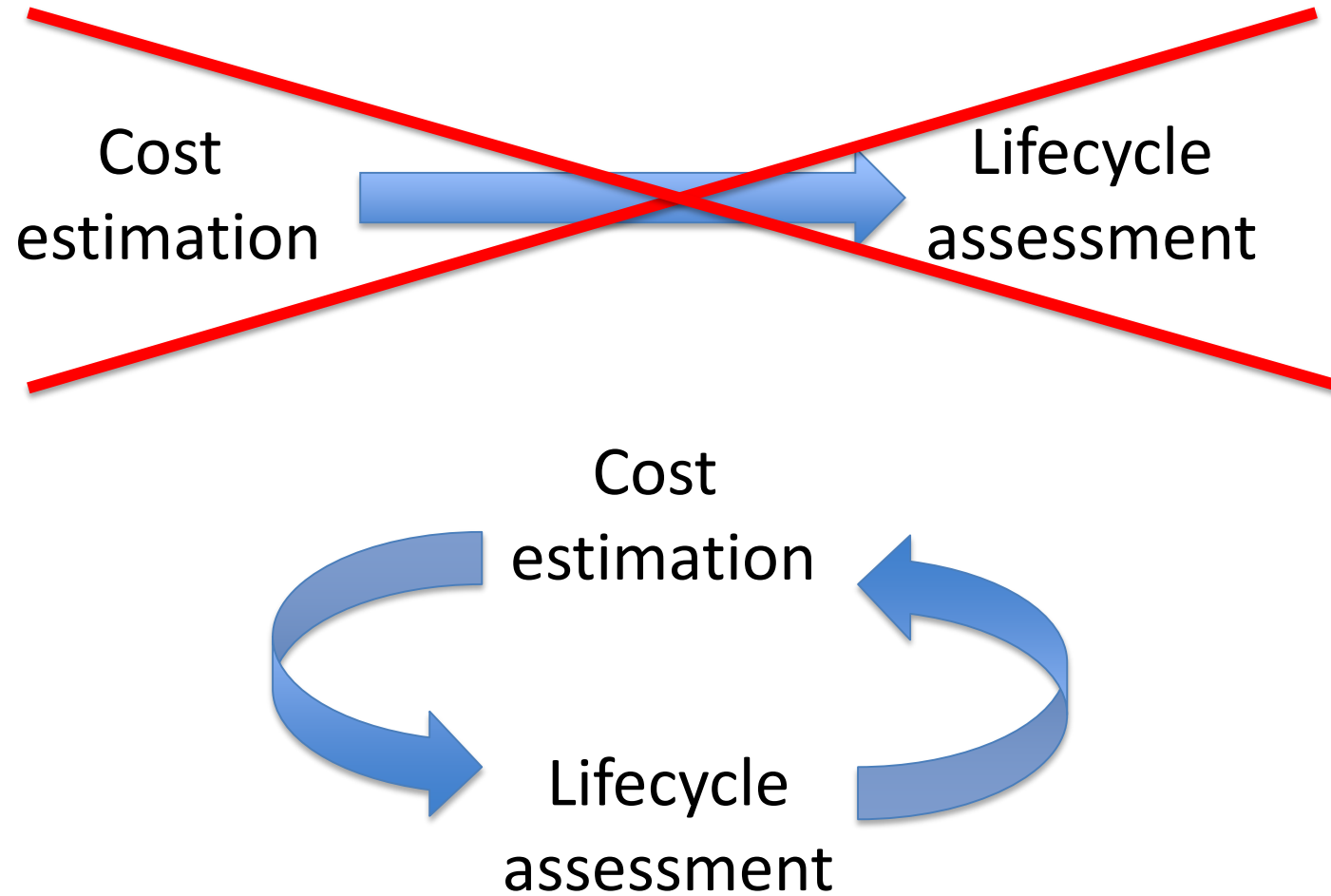
Landscape design case study



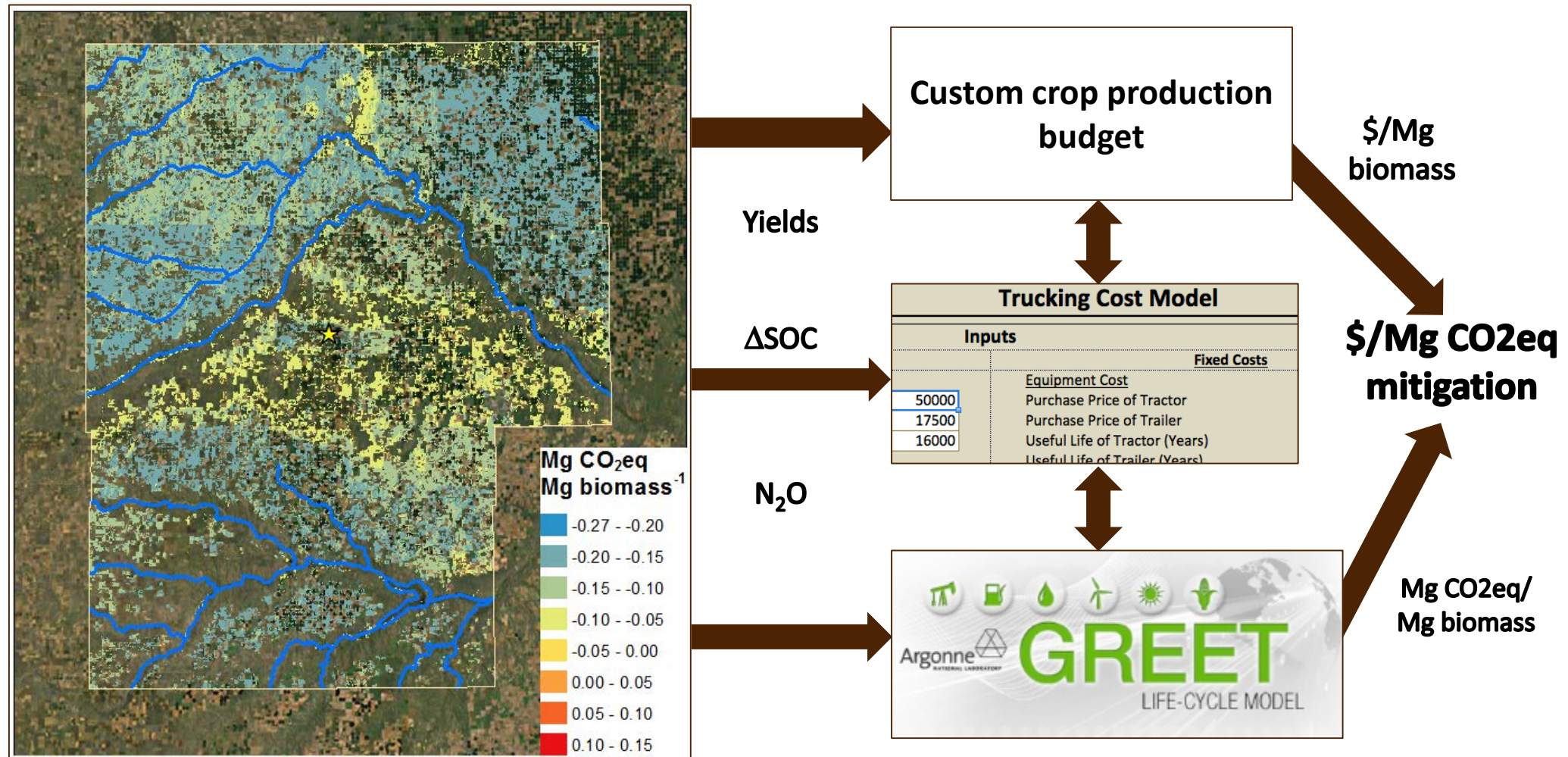
Area-weighted soil surface texture distribution by land use class



Integrated assessment

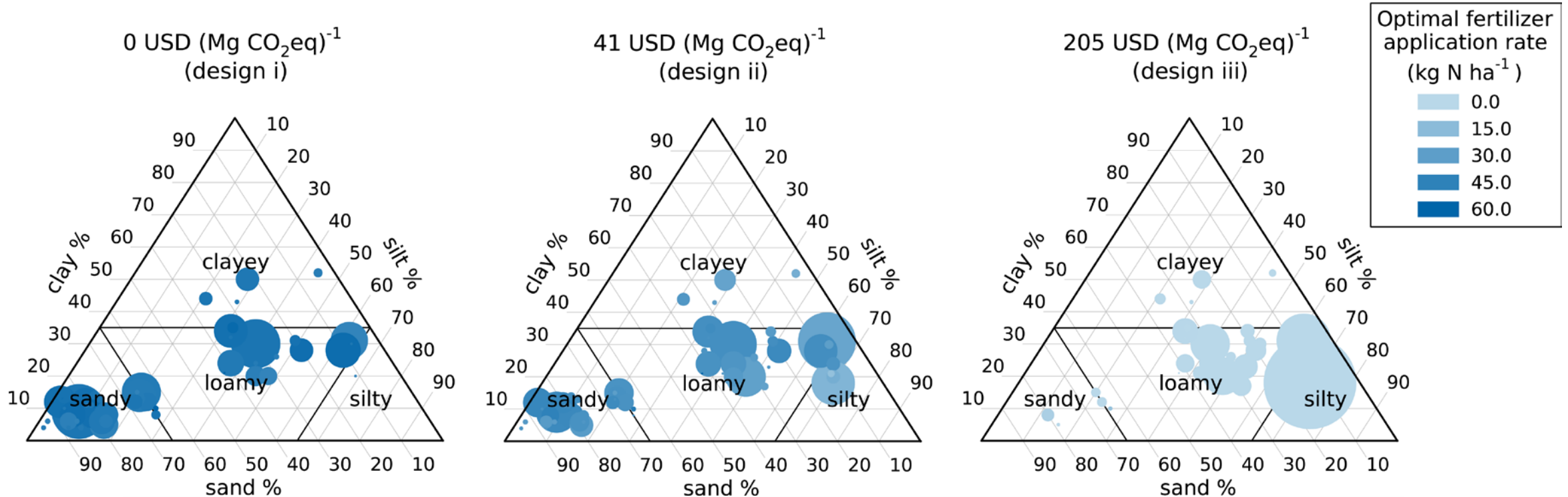


Integrated assessment

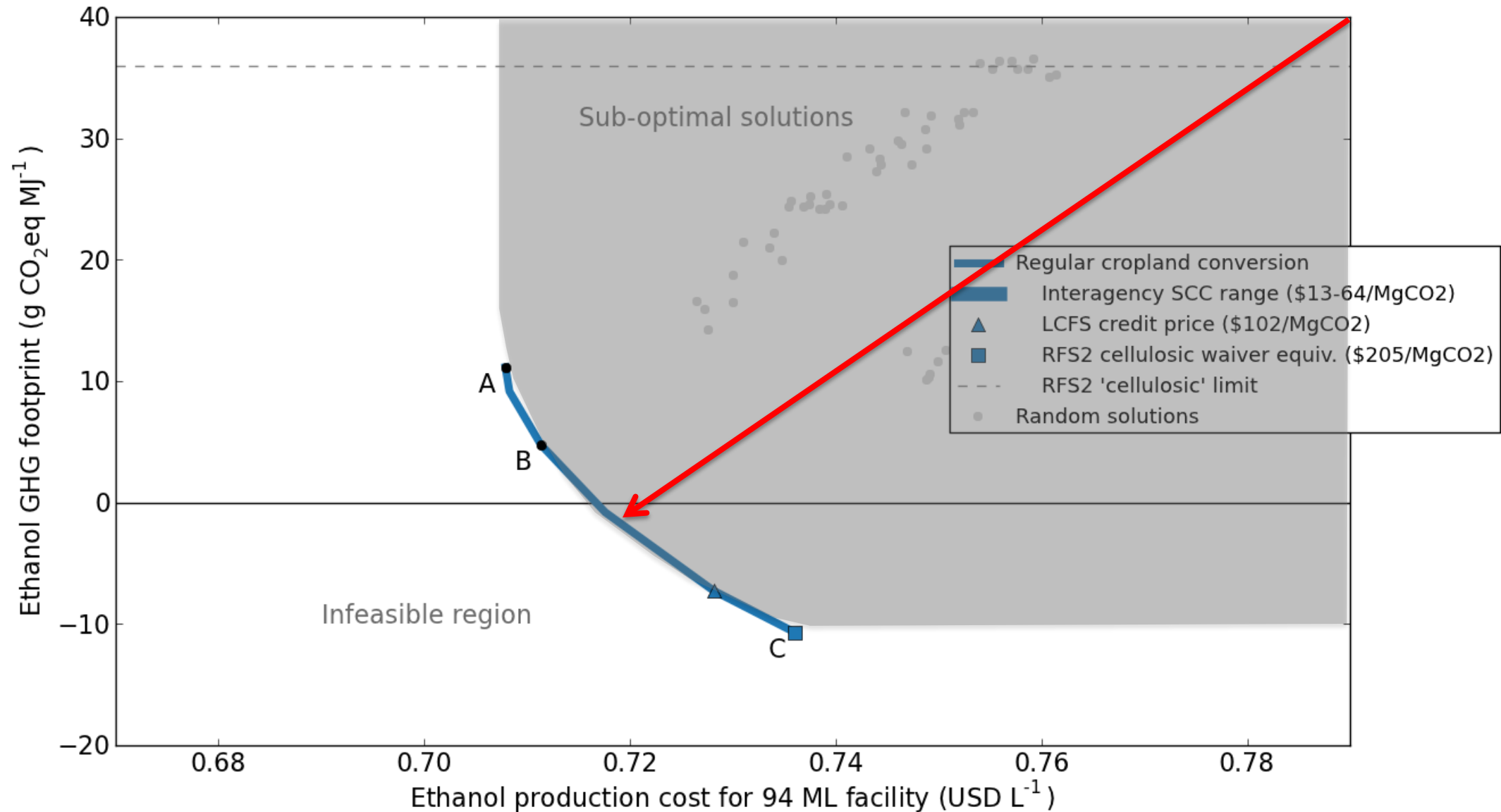


Landscape scale trade-offs

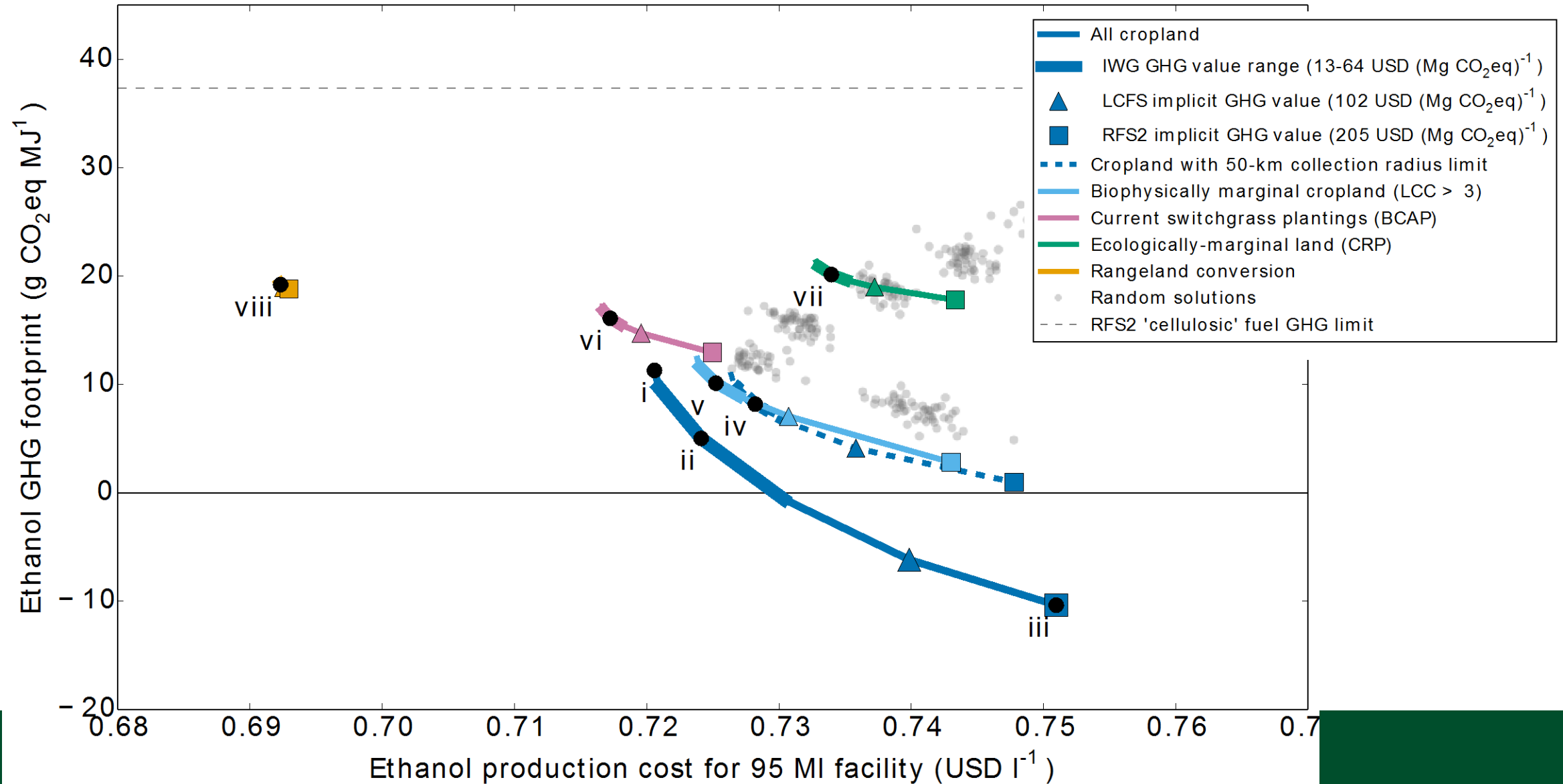
- Total social cost = production cost + monetized GHGs @ carbon price of 0, 41, and 204 USD (Mg CO₂eq)⁻¹



Landscape optimization



Landscape scale trade-offs



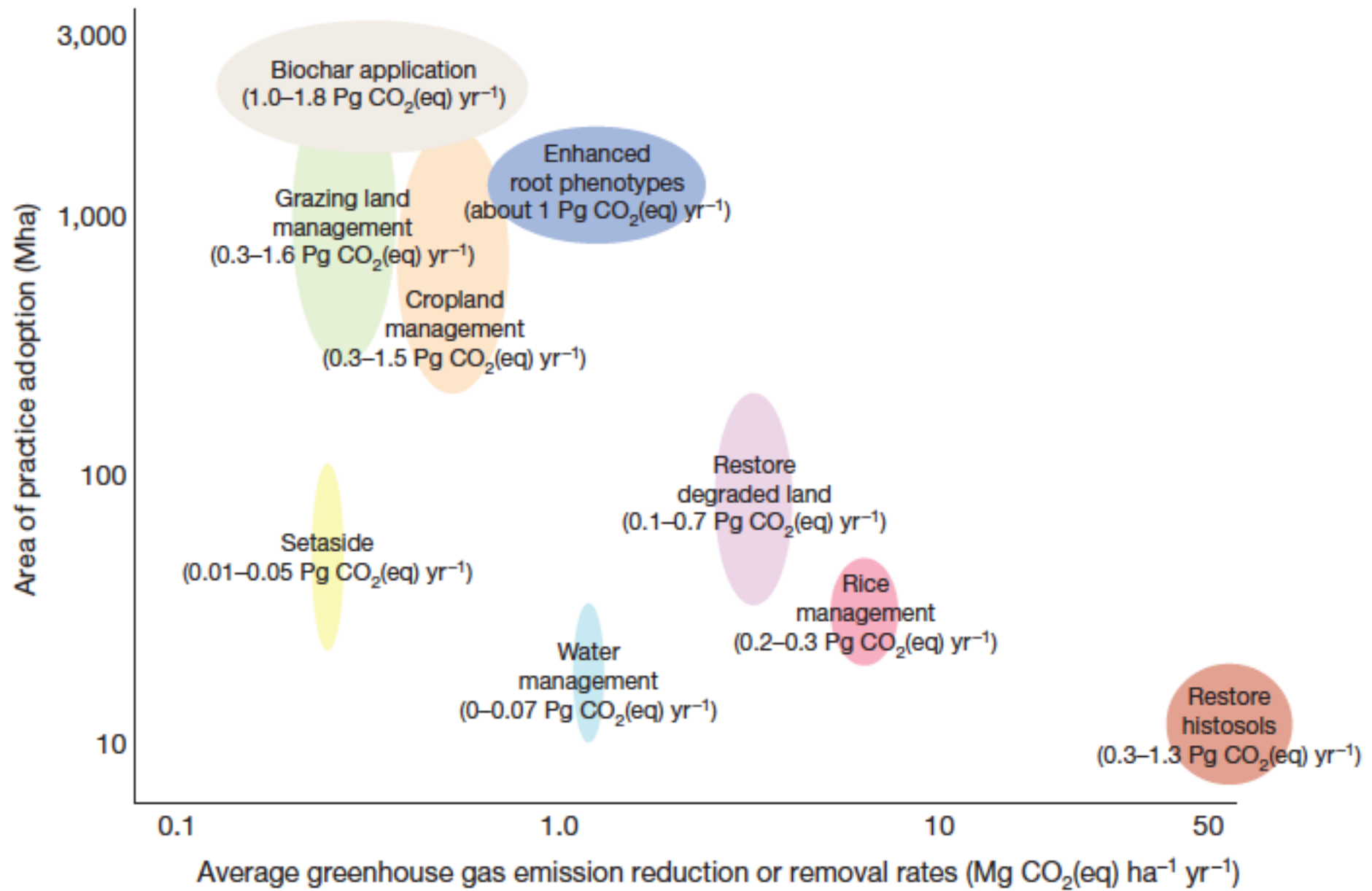


N A T U R A L R E S O U R C E E C O L O G Y L A B O R A T O R Y

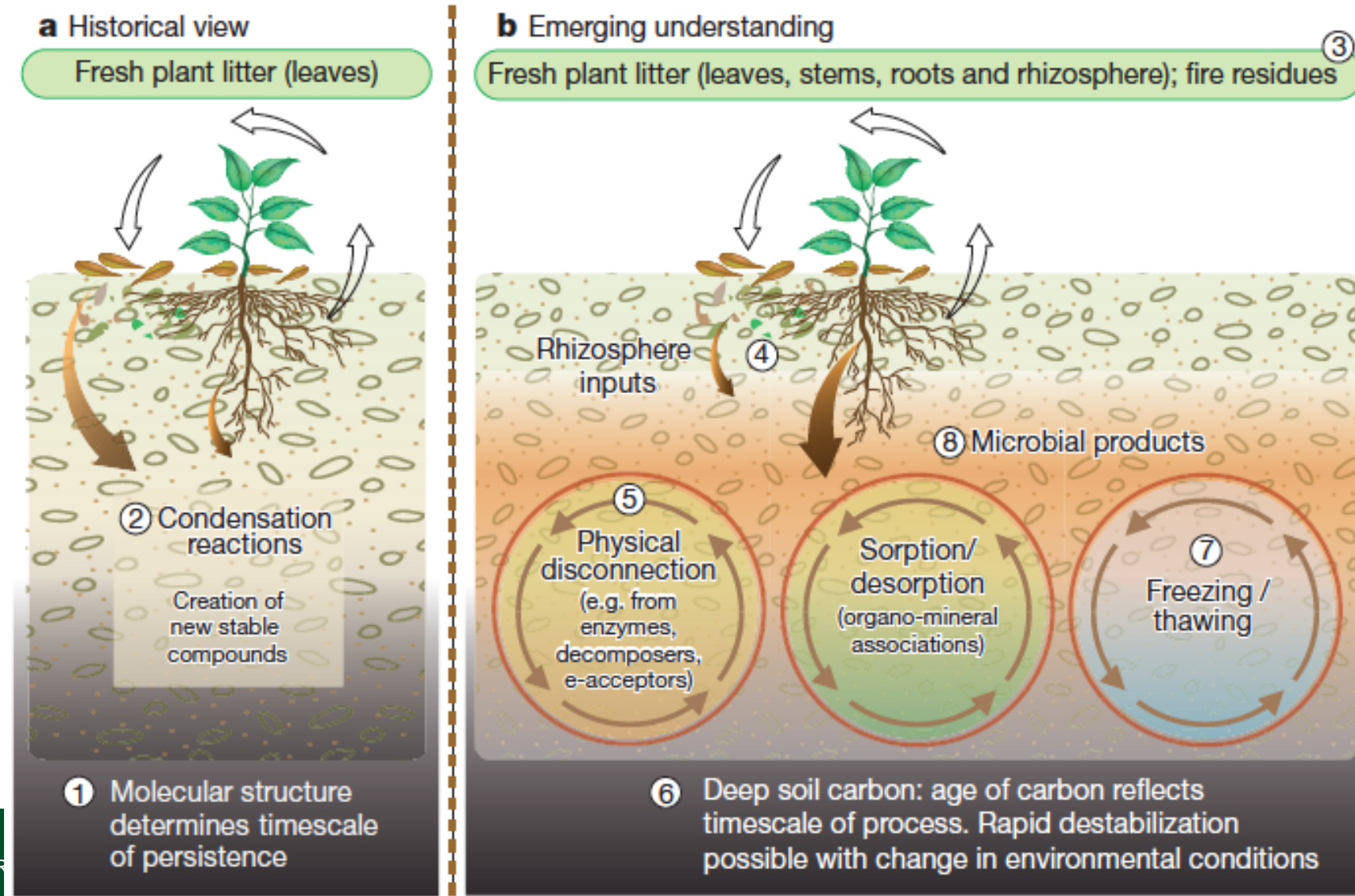
**Acknowledgements: Steve Del Grosso, Bill Parton,
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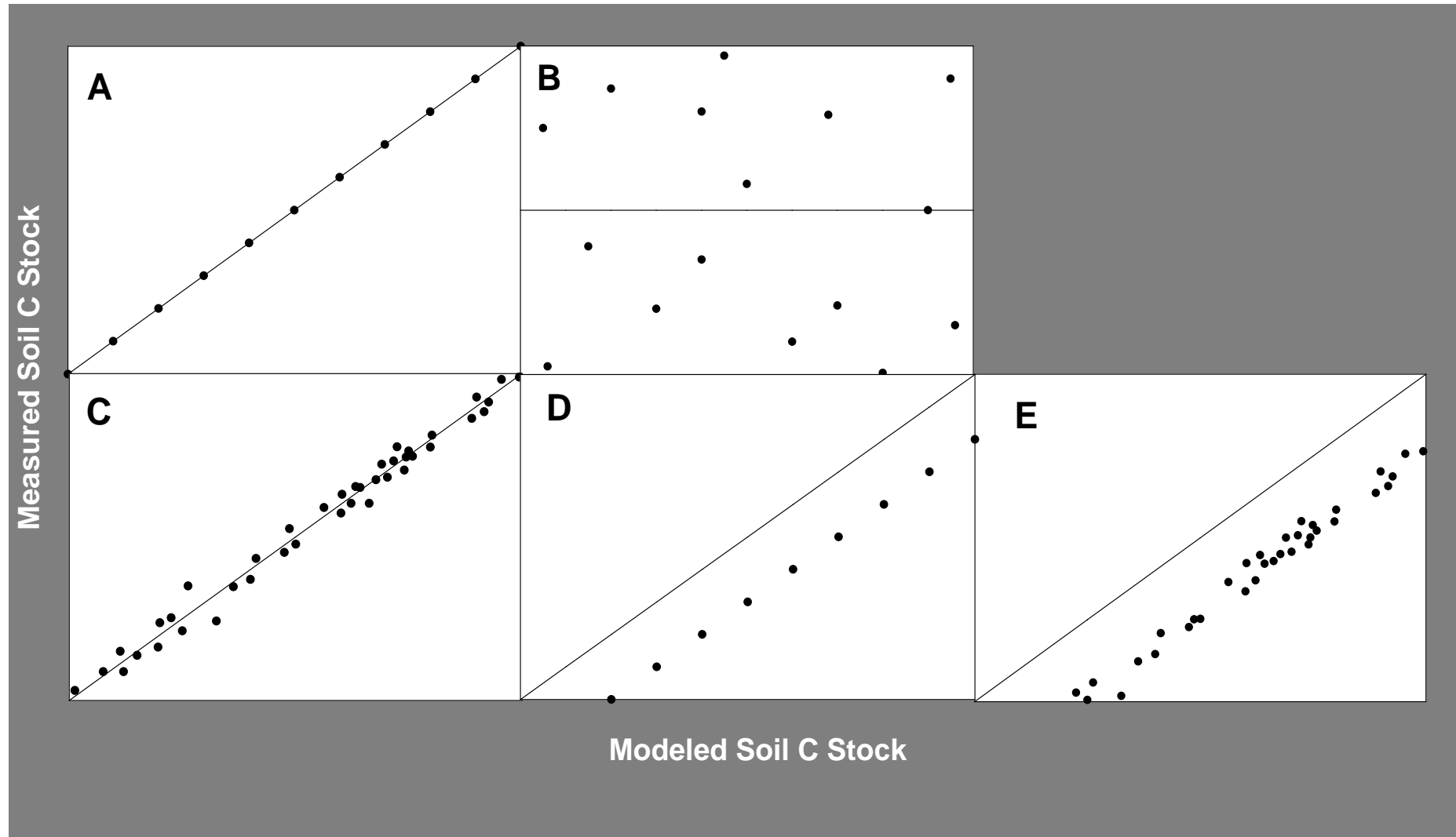


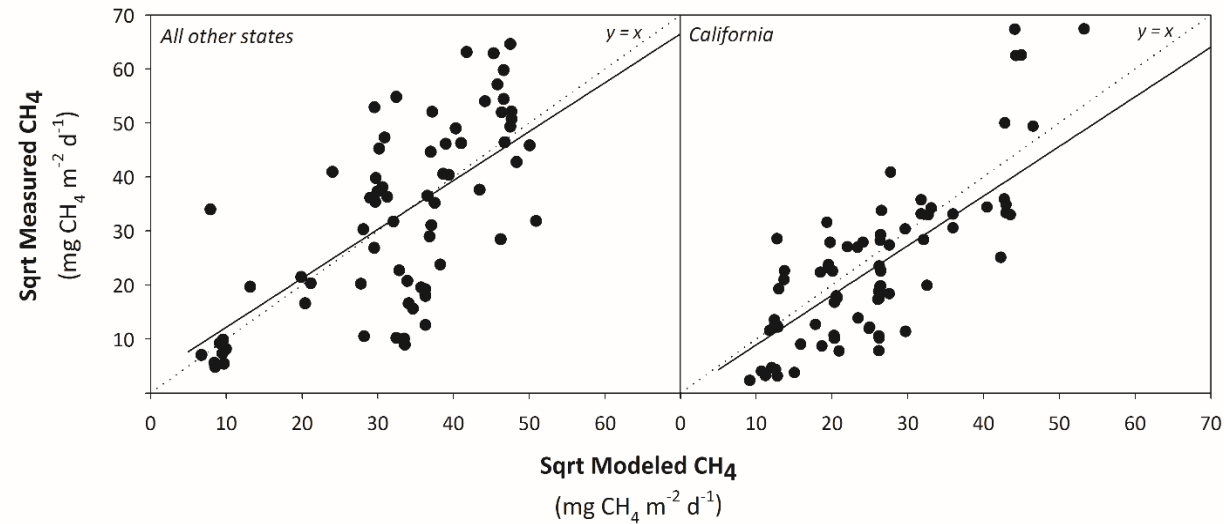
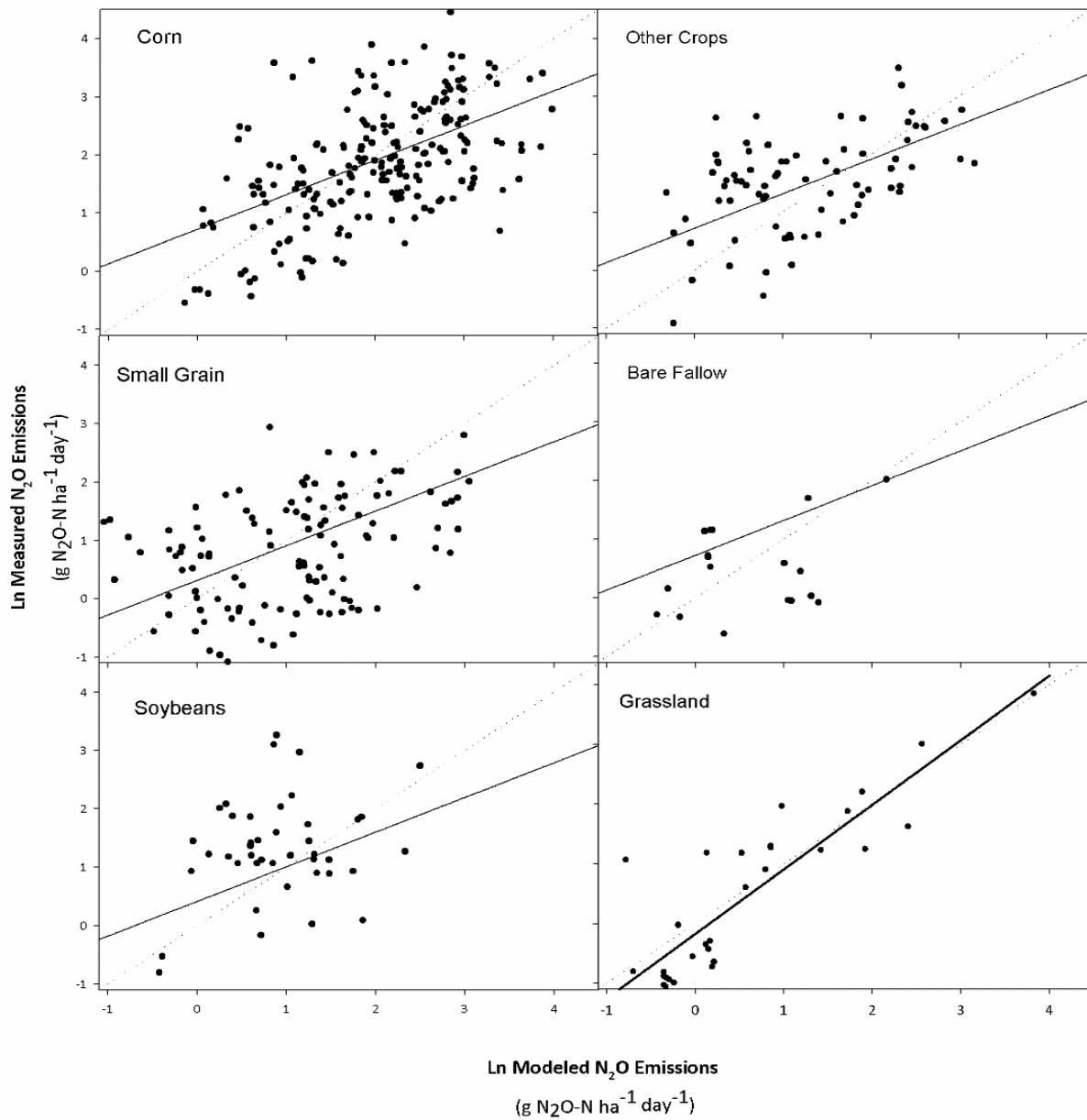
Modeling soil C dynamics



Schmidt et al. (2011) Persistence of soil organic Matter as an ecosystem property. *Nature*

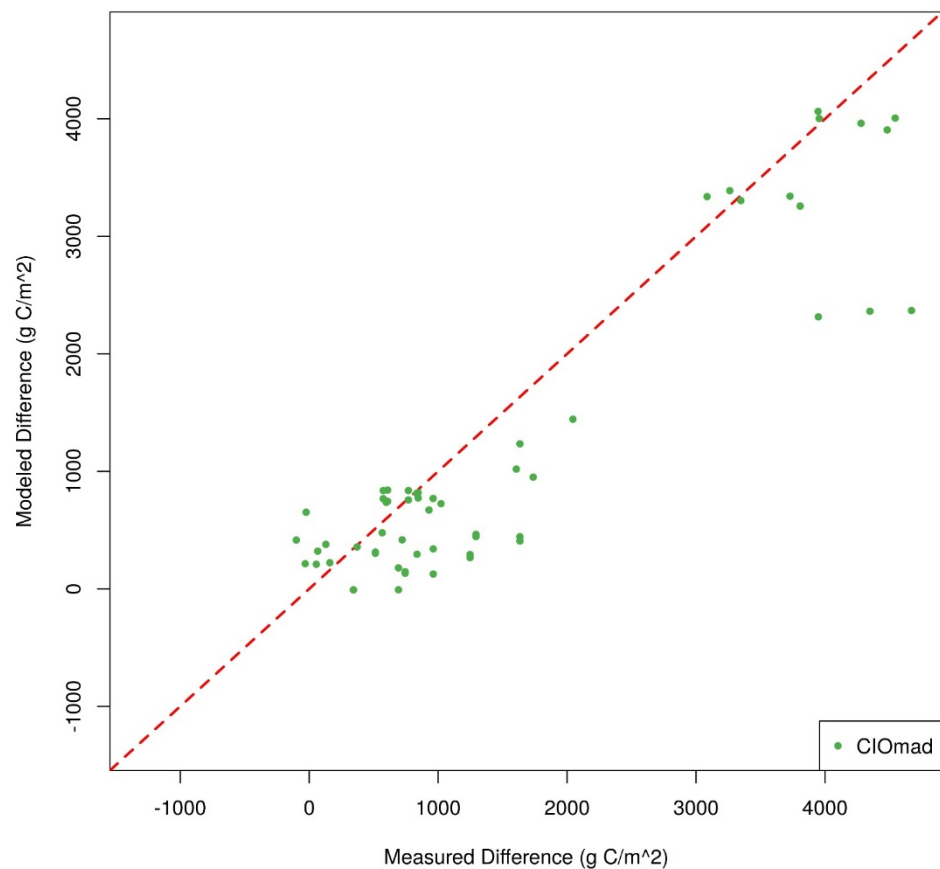
Uncertainty in Model Structure





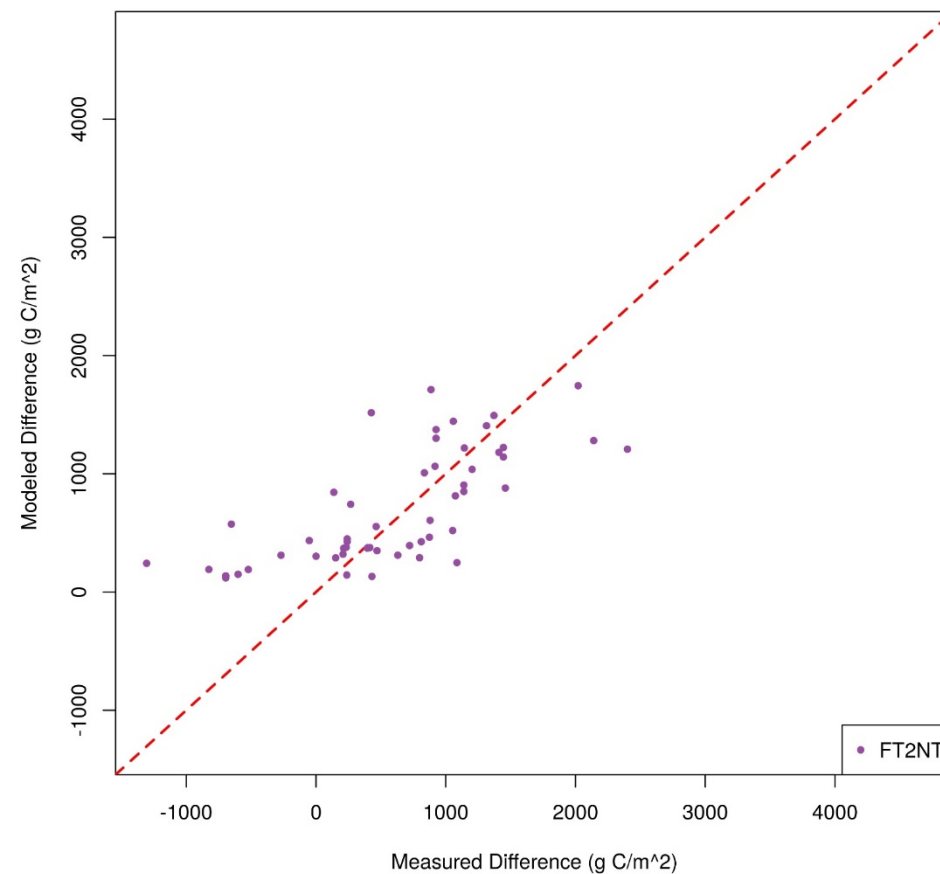
Manure Amendments

Treatment differences (Best)



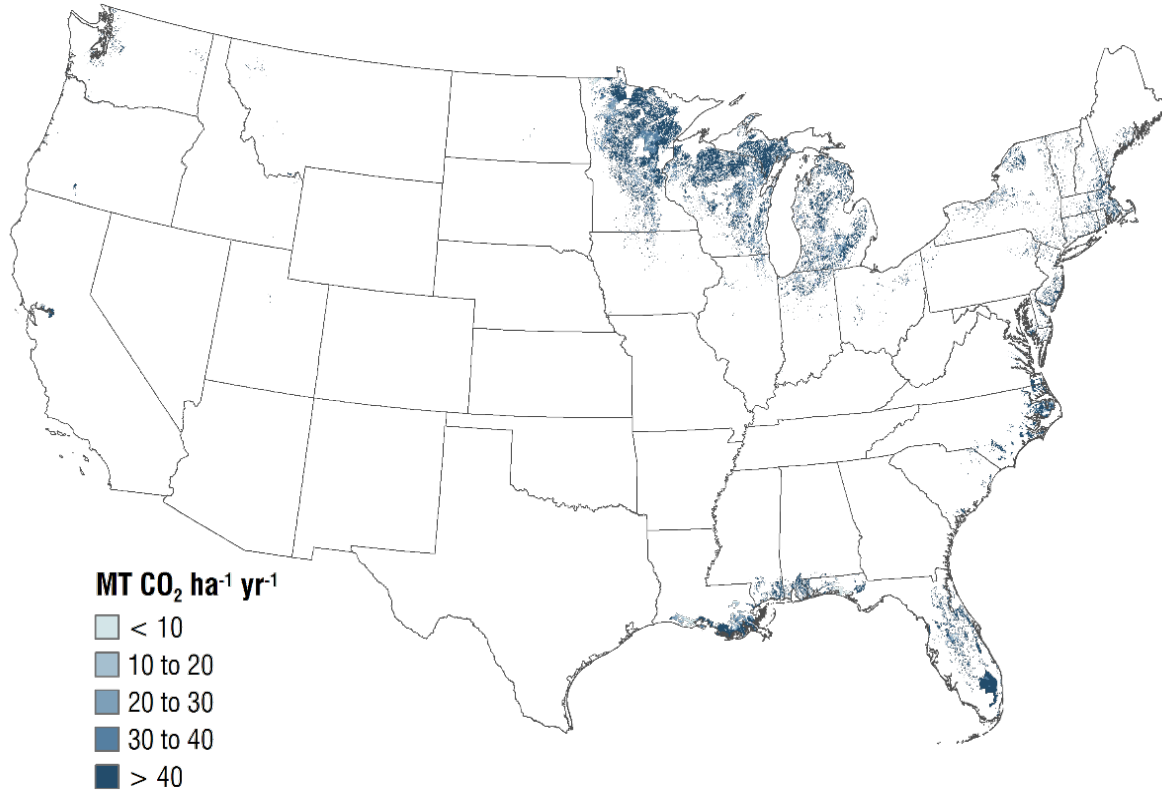
Tillage Change – Full Till to No-Till

Treatment differences (Best)



Soil C Stock Changes – Organic Soils (2012)

Cropland



Grassland

