BIOENERGY'S ROLE IN SOIL CARBON STORAGE WORKSHOP

Argonne NATIONAL LABORATORY

Soil Organic Carbon Modeling to Support a Feedstock-level Biofuel LCA

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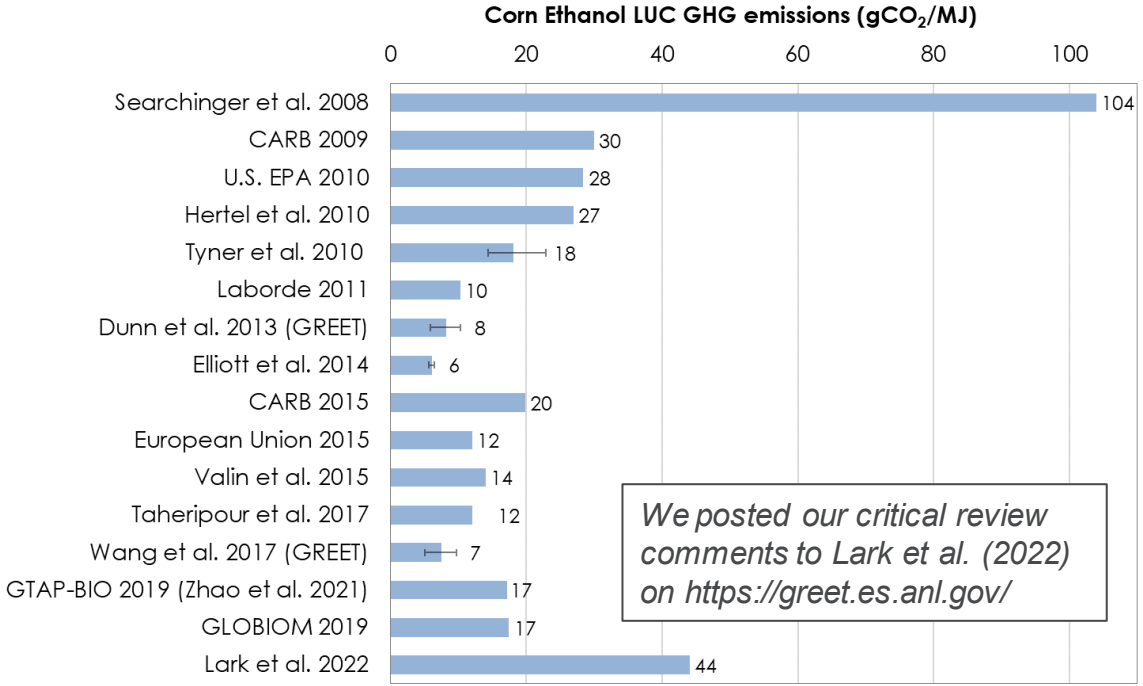
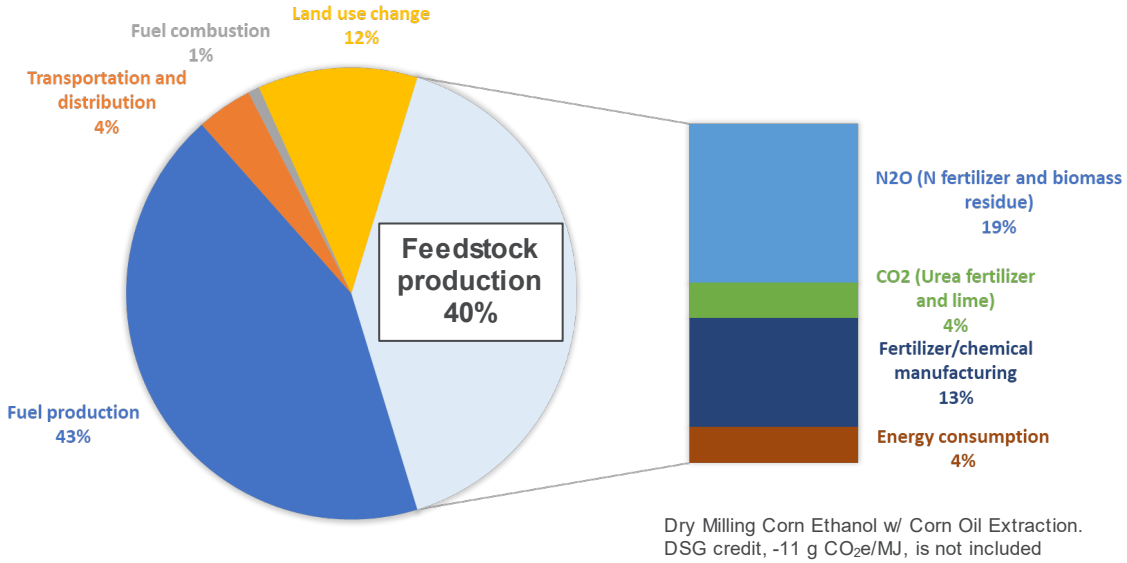
SOC changes from LUC for large-scale biofuel feedstock production have been incorporated into biofuel LCA

- The area of LUC driven by biofuel volume shocks is multiplied by "emission factors" (EF, CO_2e emitted per unit area)
  - EFs can be modeled using simple and/or sophisticated modeling frameworks
- The downtrends in estimated LUC emissions since 2008

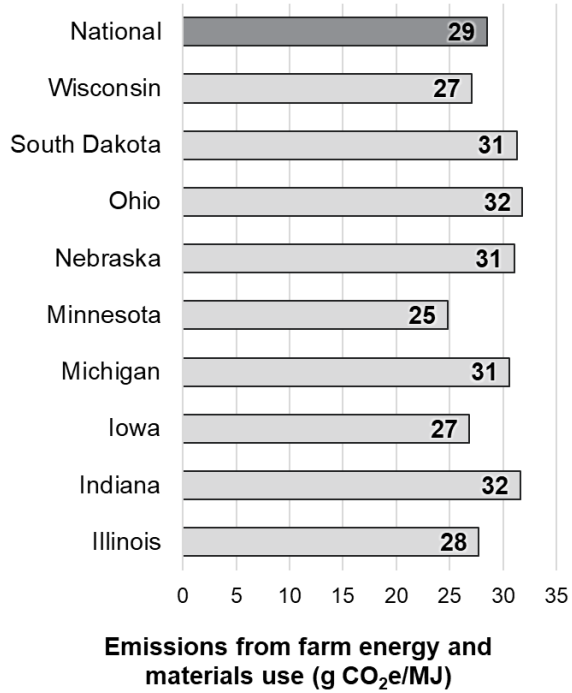


Modified fromLee et al 2021 Retrospective analysis of the U.S. corn ethanol industry for 2005–2019

The impacts of land management changes (LMC) on feedstock carbon intensity (CI) have received attention

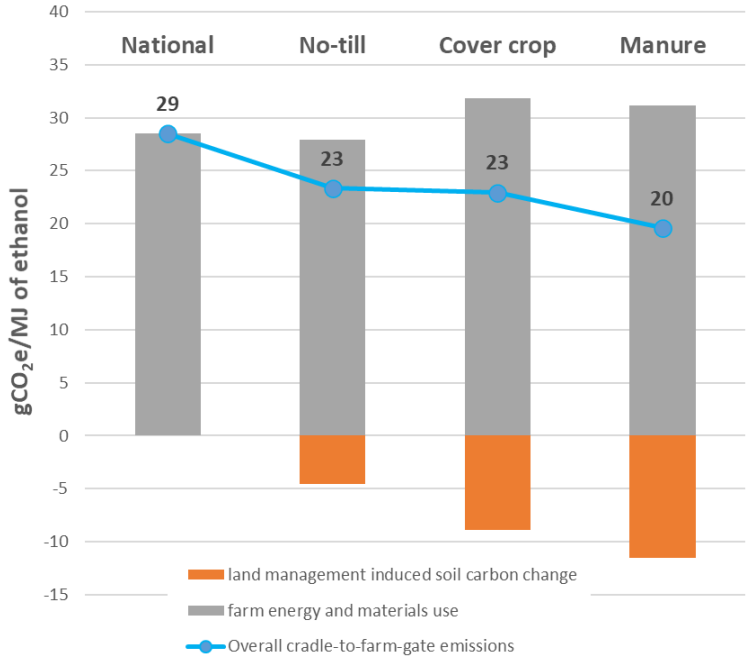


Dry Milling Corn Ethanol w/ Corn Oil Extraction.
DSG credit, -11 g CO_2e/MJ, is not included



- The feedstock CI variation reflects
  - Soil fertility, climate, and farming practices (e.g., tillage)

SOC changes from adopting various farming practices significantly affect the CI of feedstock production



Modified from Liu et al (2020) Shifting agricultural practices to produce sustainable, low carbon intensity feedstocks for biofuel production

- Both SOC change and energy/material inputs affect the cradle-to-farm gate GHG emissions
- Shifting current farming practices to no-till, cover crops, and manure application can produce low CI feedstocks for biofuel production

Sophisticated modeling frameworks have provided reliable and cost-effective estimates of SOC changes

- Simulate the dynamics of multiple SOC "pools"
  - Active, slow, and passive pools dependent on their decay rates
  - Model inputs include prior land-use history, various agronomic practices, and soil/climatic conditions
- CENTURY-derived models
  - US EPA uses DAYCENT (a daily time-step version of CENTURY) for national GHG inventory development
  - USDA NRCS embeds DAYCENT in COMET-Farm (its whole farm and ranch carbon and GHG accounting system)
  - Argonne developed a parameterized version of CENTURY to generate US county-level SOC changes

CENTURY-type model

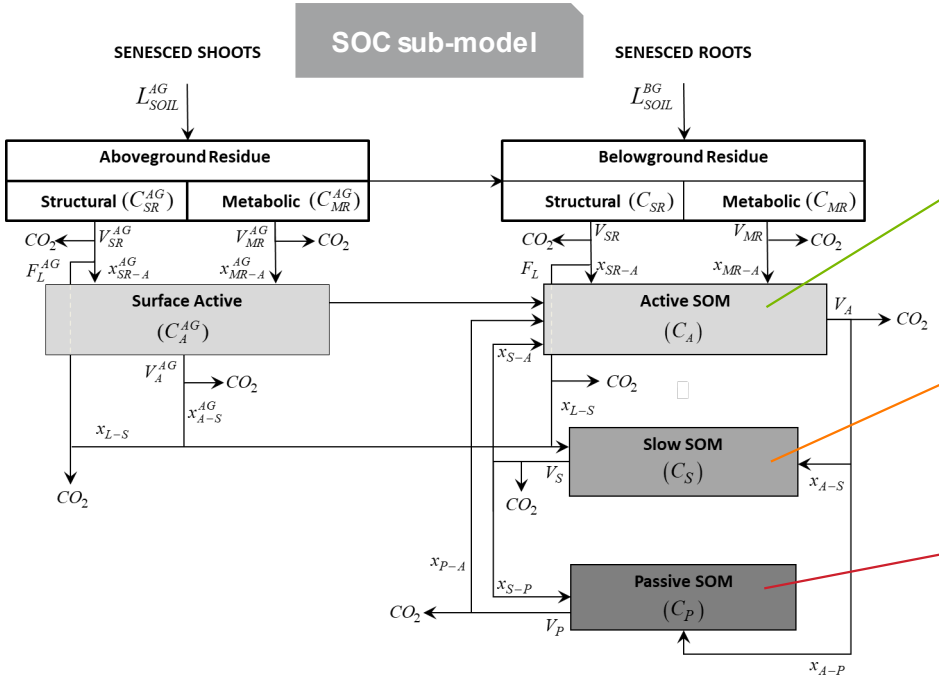
Soil | Climate | Farm management

Inputs

Plant growth sub-model

Nutrient cycling sub-model

Hydrology sub-model



Turnover time = days to years

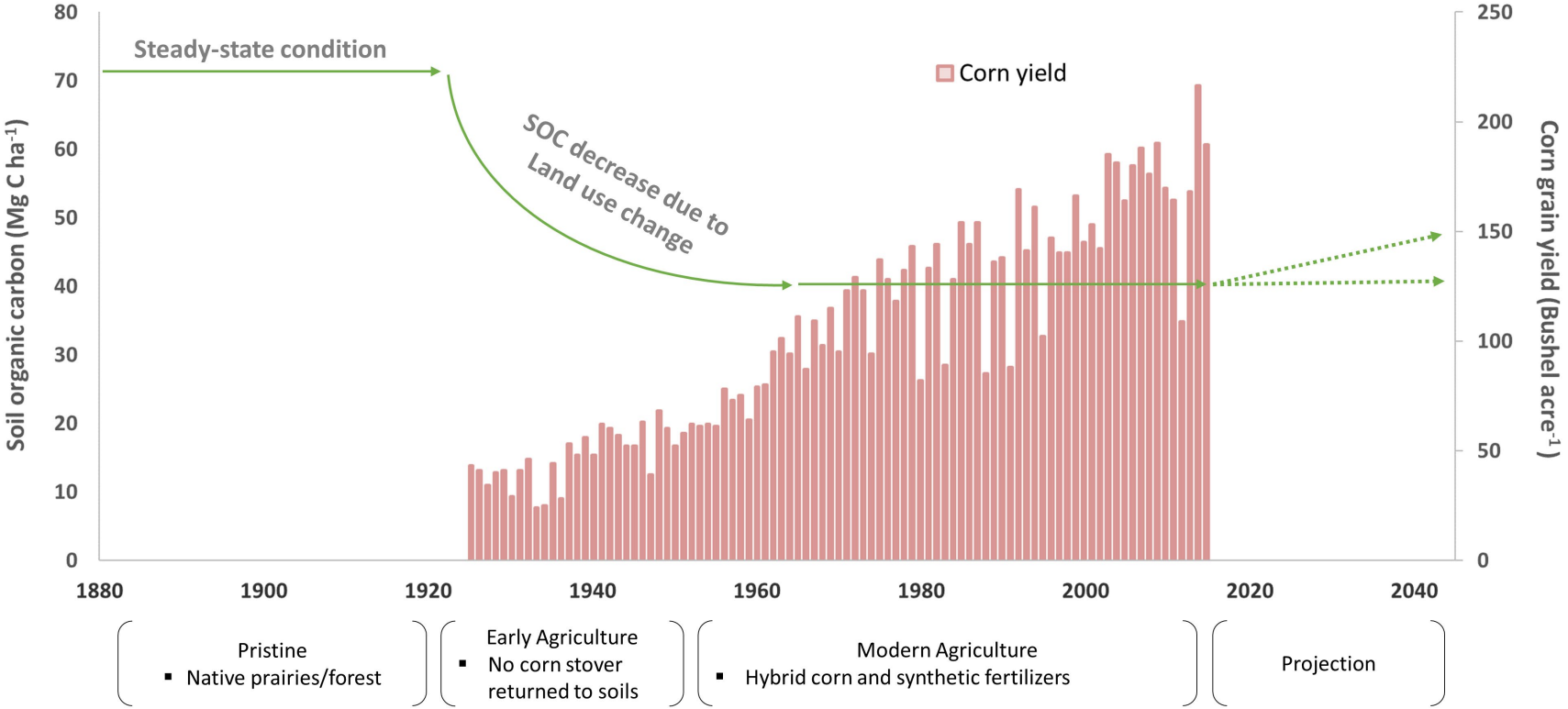
Turnover time = years to decades

Turnover time = decades to hundreds

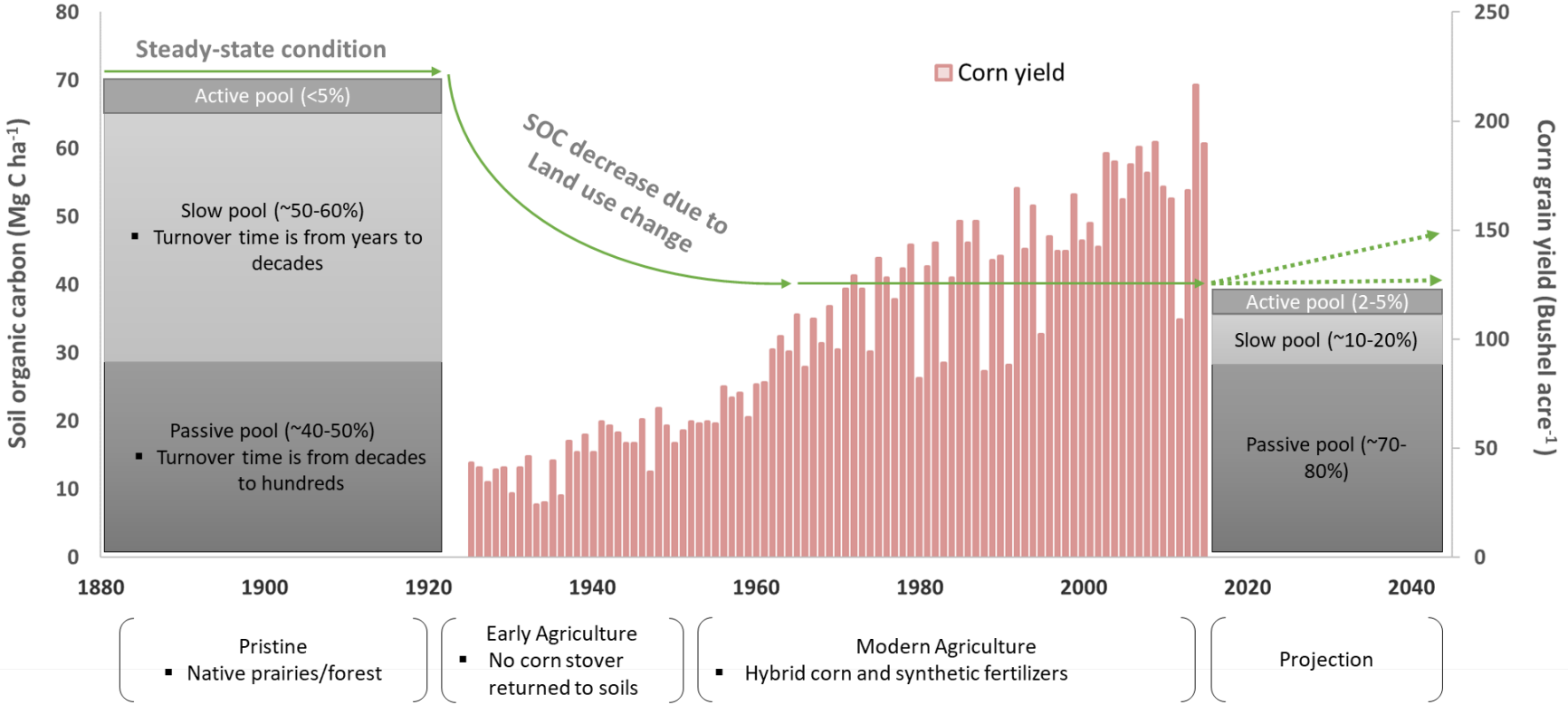
Outputs

Crop yield | SOC | N_2O

Long-term dynamics of SOC changes are simulated

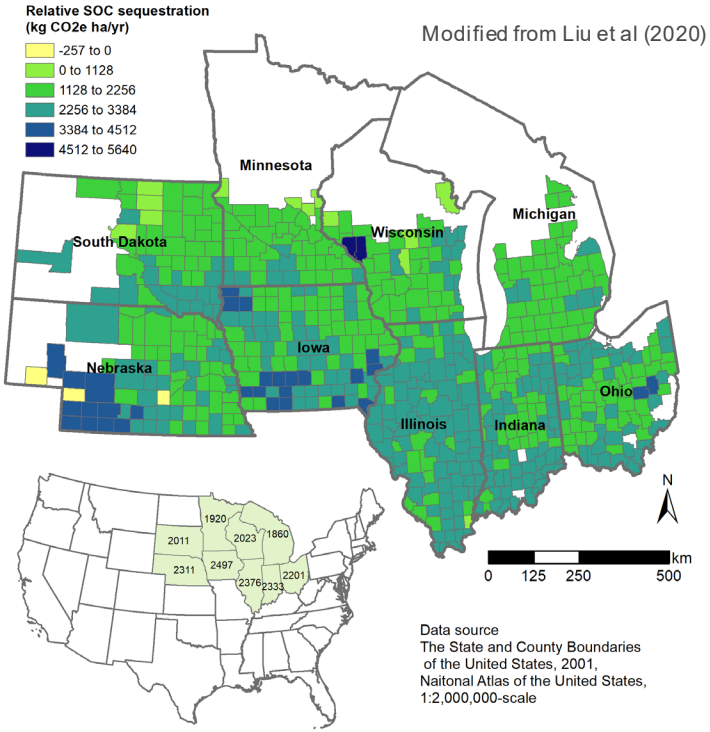


Initial status of SOC determine projecting SOC changes



Modeling of SOC changes continues to be improved and evolved

- Promote the certification of low-carbon feedstock production practices
  - Help certify monitoring, reporting, verification of lower CI farming practices by linking data, model, and in-situ sensing
- Communicate with broad science communities and stakeholders
  - Address a strong need for better, long-term data, uncertainties, and permanence (i.e., the longevity of the SOC sink)



ARGONNE'S SOC MODELING EFFORTS ARE SUPPORTED BY DOE'S EERE BETO & ARPA-E SMARTFARM PROGRAM