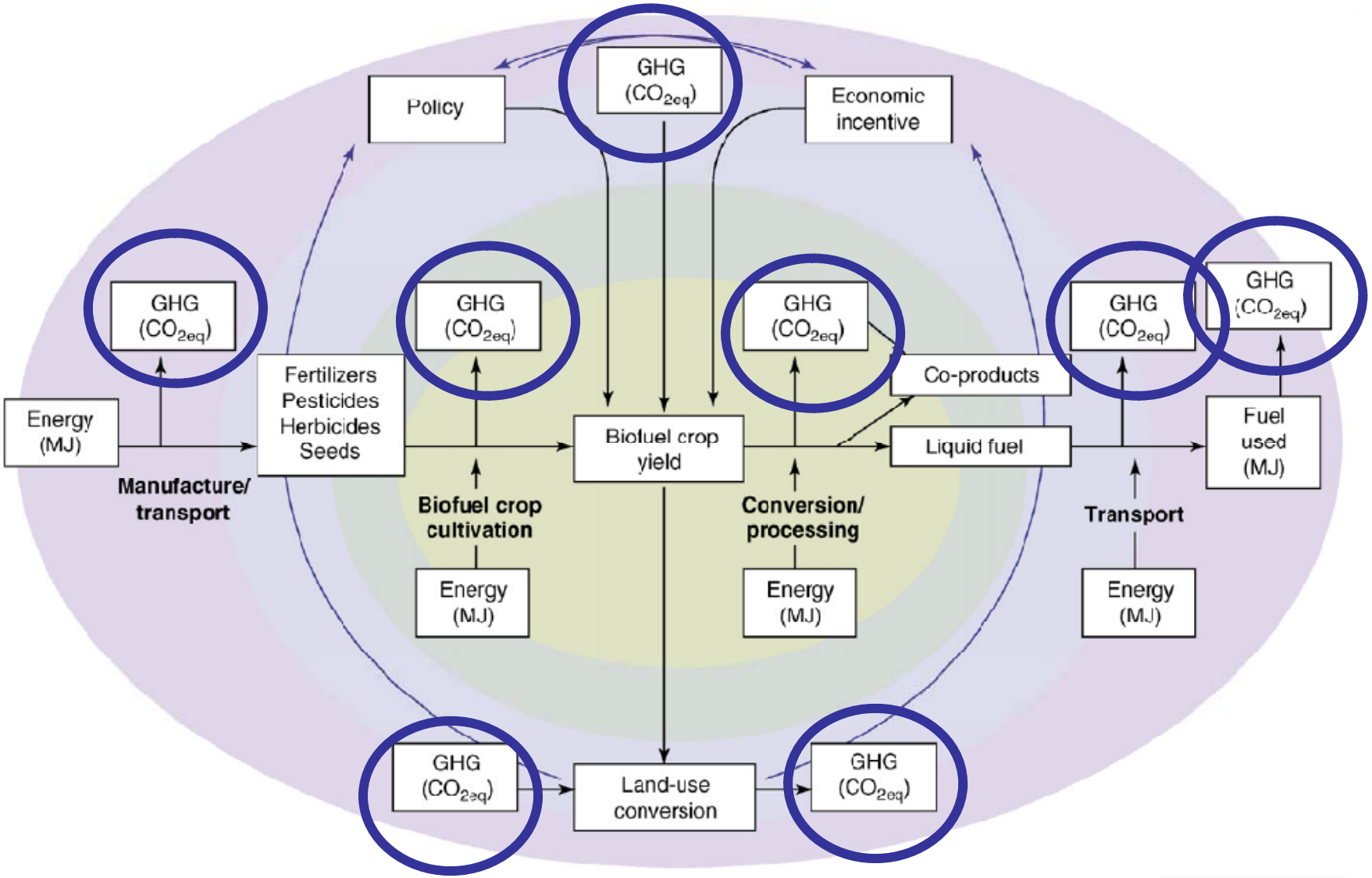
Contribuição das Mudanças da Terra ao Balanço dos Gases de Efeito Estufa dos Biocombustiveis

Contributions of Land Use Change to the Greenhouse Gas Budget of Biofuels

Kristina J. Anderson-Teixeira

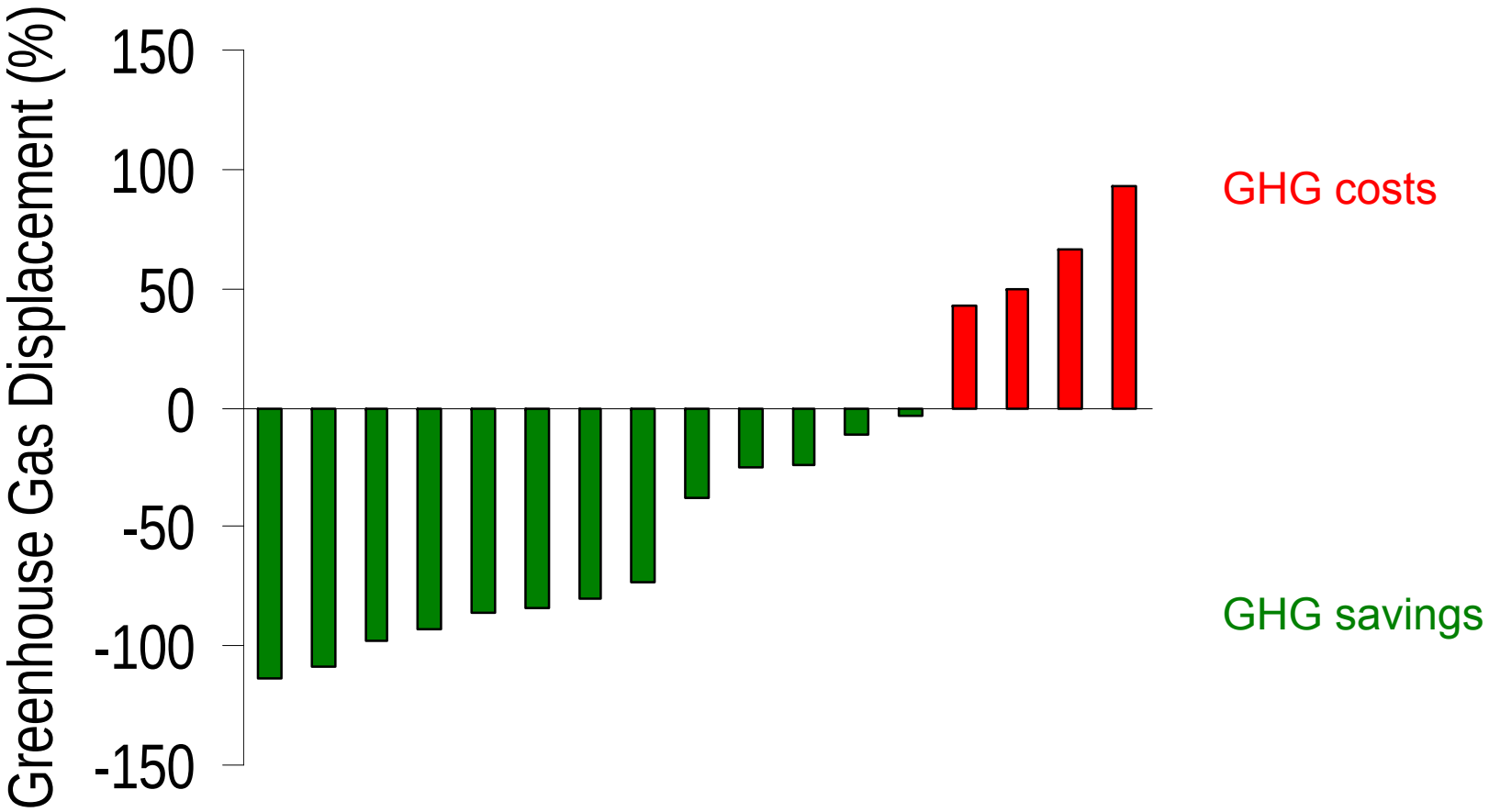
June 16, 2009

Life Cycle Analysis for Greenhouse Gases (GHG)



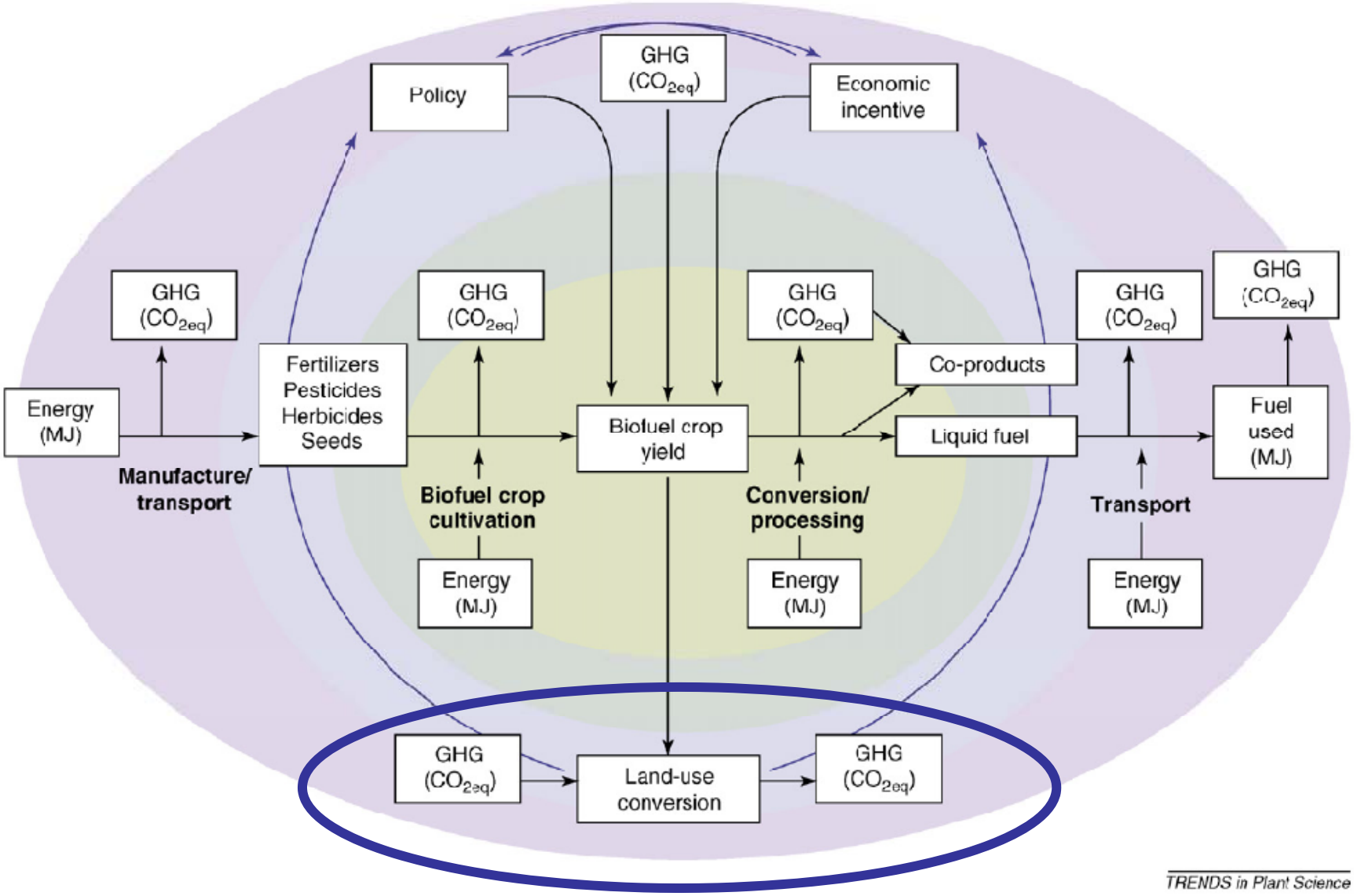
Davis, **Anderson-Teixeira**, & DeLucia (2009)

Estimates of Greenhouse Gas Displacement by Biofuels



Davis, **Anderson-Teixeira**, & DeLucia (2009)

Life Cycle Analysis



Davis, **Anderson-Teixeira**, & DeLucia (2009)

Outline

1. Changes in soil carbon under biofuel crops
2. Quantifying the full GHG effects of land use change

GCB Bioenergy (2009) **1**, 75–96, doi: 10.1111/j.1757-1707.2008.01001.x

Changes in soil organic carbon under biofuel crops

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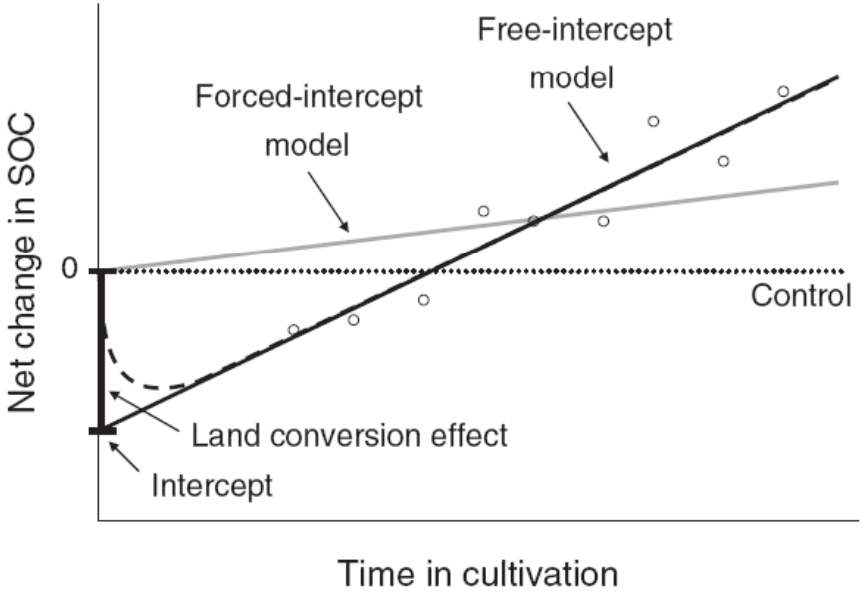
Conceptual Approach

Land conversion effect Biofuel crop effect



Maize residue

Sugarcane

Miscanthus

Switchgrass

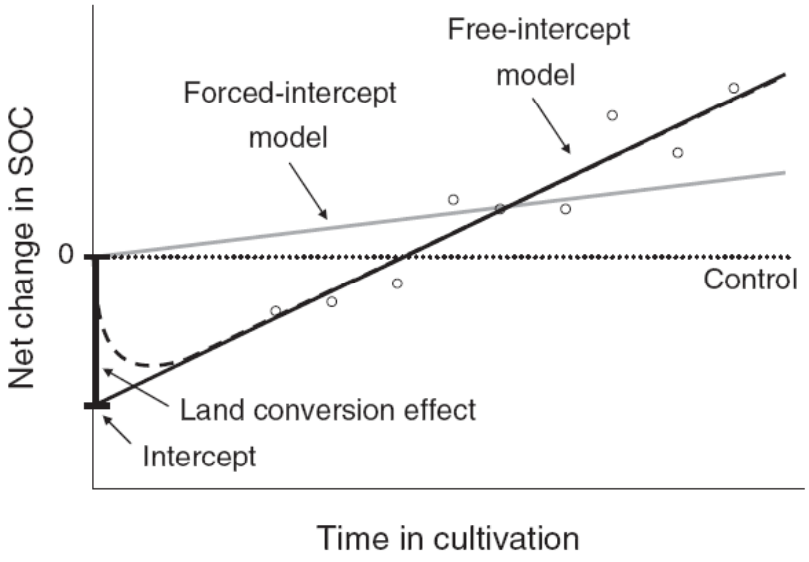
Mixed native/ prairie

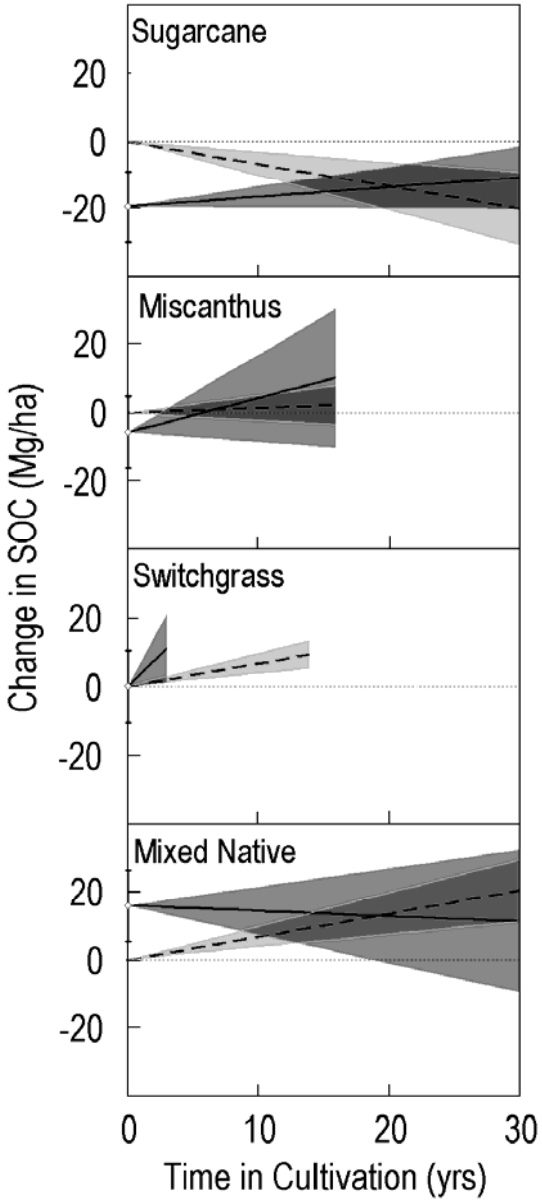
Methods

- Data compiled from published studies
  - Various ages, depths measured, previous land uses, harvest practices, etc.
- SOC measured in sites of ≥ 2 known ages (one control)
- Units
  - SOC_c (g C/kg soil) – SOC concentration for a certain depth increment
  - SOC_a (Mg C ha^{-1})- SOC per hectare, measured to various depths
    - When not reported, calculated from SOC_c and estimated bulk density

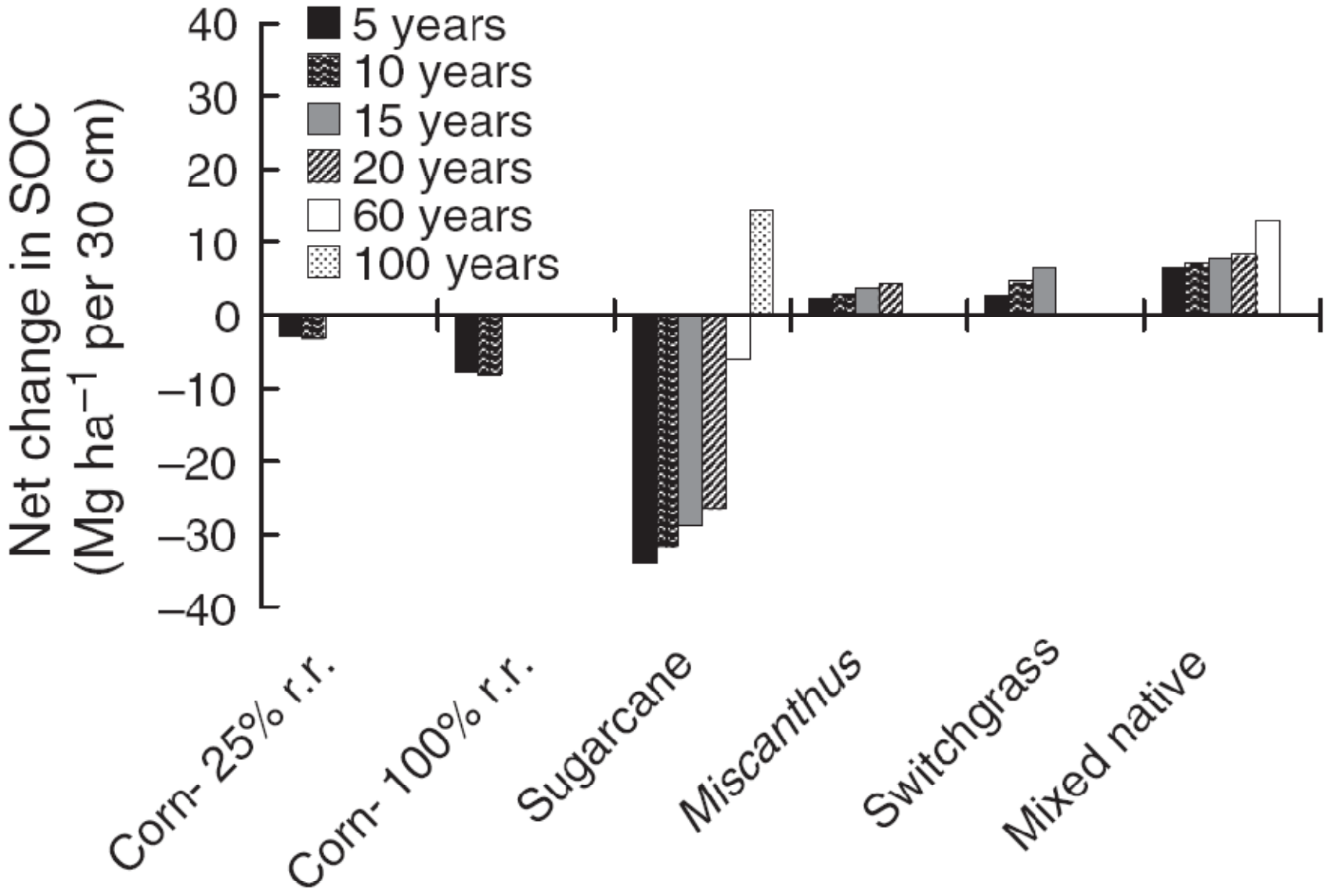
Forced- and Free- Intercept Models

- Forced-intercept (time 0 = control)
  - SOC decreases under sugarcane
- Free-intercept
  - Land conversion loss in sugarcane followed by SOC increase





Estimated net SOC change: area basis



Percent Change in SOC_c (Concentration Basis) by Depth

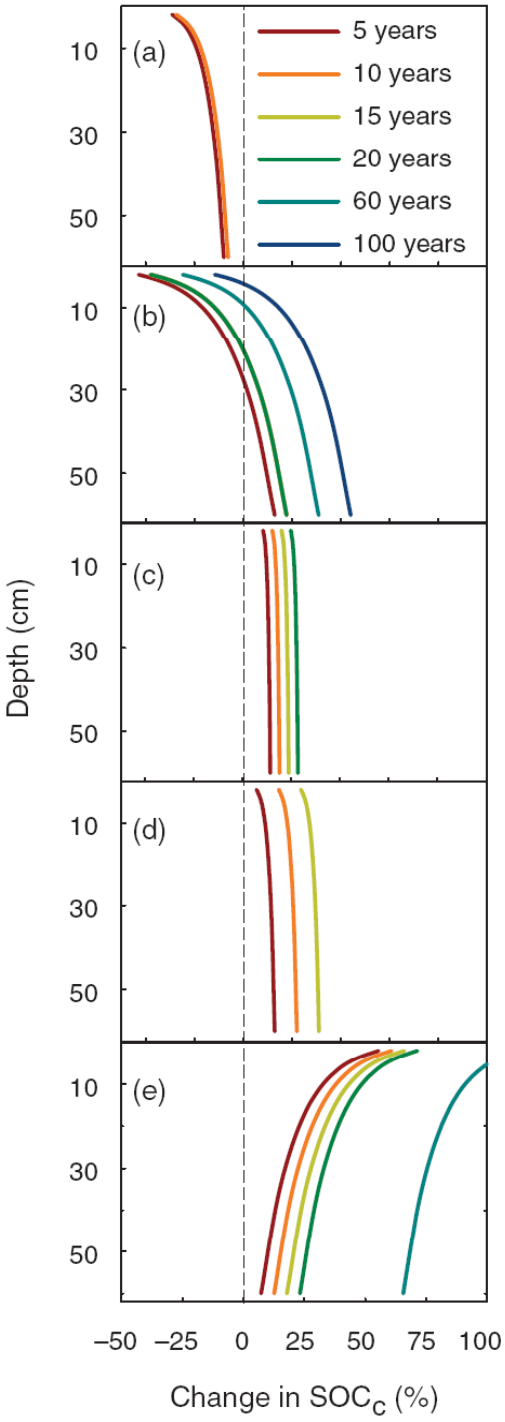
A) Maize with residue removal- C loss at all depths

B) Sugarcane- C loss in shallow soils, gain in deeper soils. Gain through time.

C) Miscanthus- C gains through time at all depths

D) Switchgrass- C gains through time at all depts

E) Mixed Native (Prairie)- C gains through time at all depths, particularly shallow



Sugarcane Data

- Locations
  - South Africa (n=6)
  - Australia (n=4)
  - **Brazil (n=2)**
    - **Alagoas**
    - **São Paulo**
  - Papua New Guinea (n=2)
  - Belize (n=2)
  - Hawaii (n=2)
  - Ecuador (n=1)
- Previous land use
  - Grass (n=10)
  - Forest (n=8)
  - Other (n=2)

Data is not representative of situation in São Paulo.

Quantifying the full GHG effects of land use change

GHG Effects of Land Use Change

- Define GHG Value (GHGV) of ecosystems

- GHG effect of land use change = $GHGV_{new}$ - $GHGV_{old}$

Greenhouse Gas Value of Land (GHGV)

Total greenhouse gas benefits of maintaining an ecosystem.

Includes both biomass storage and GHG flux

Greenhouse Gas Value of an Ecosystem (GHGV)

$$GHGV = S_{GHG} - \int_0^t F_{GHG}$$

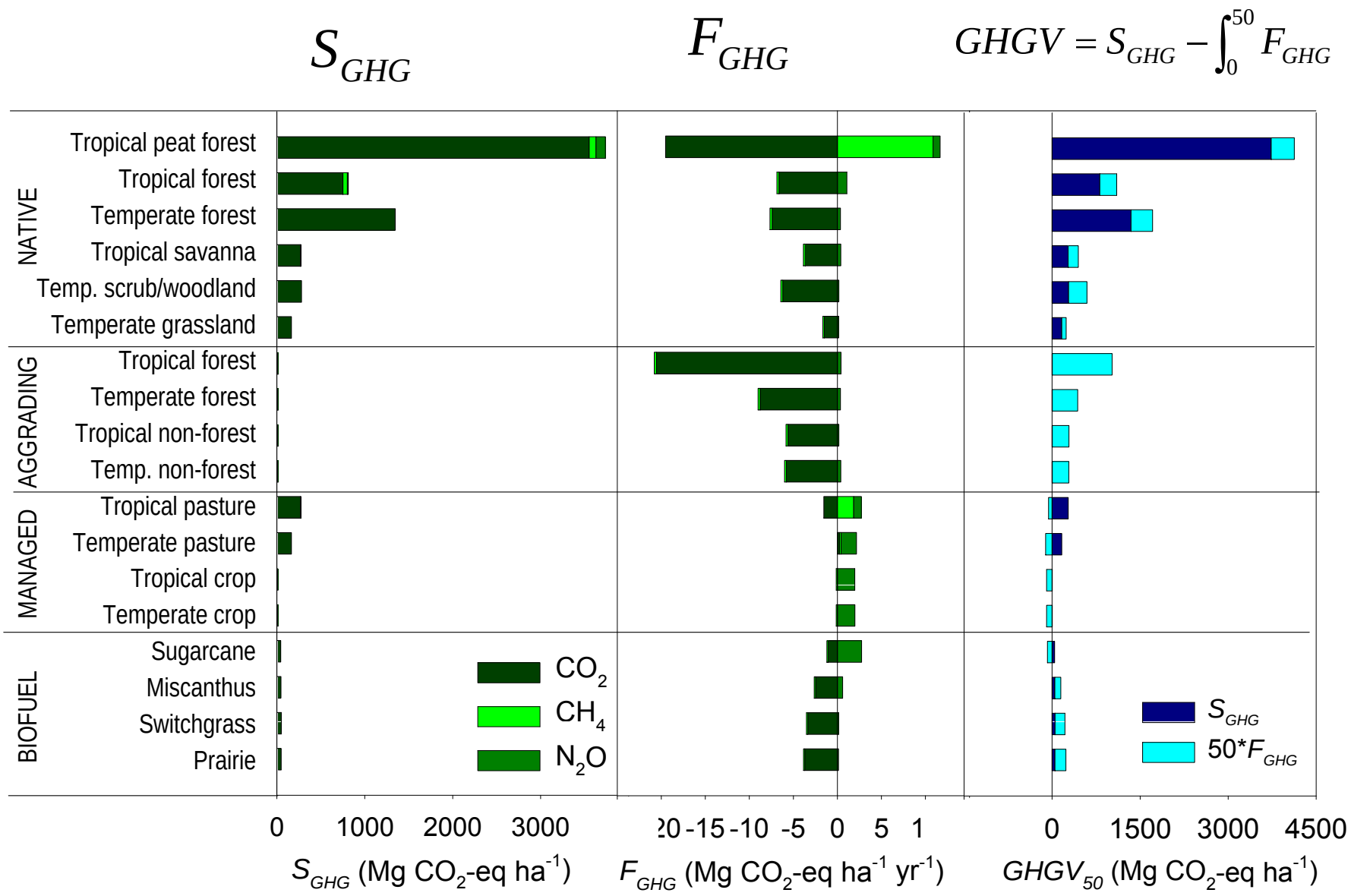
Storage of materials vulnerable to release as GHG's upon disturbance.

Mg CO_2-eq. ha^{-1}

Cumulative flux of GHG's (Mg CO_2-eq. ha^{-1} yr^{-1}), integrated over time span of interest (yr).

Mg CO_2-eq. ha^{-1}

- Includes CO_2, CH_4, N_2O
- Positive values indicate GHG benefit.


S_{GHG}
F_{GHG}
$GHGV = S_{GHG} - \int_0^{50} F_{GHG}$
NATIVE
Tropical peat forest
Tropical forest
Temperate forest
Tropical savanna
Temp. scrub/woodland
Temperate grassland
AGGRADING
Tropical forest
Temperate forest
Tropical non-forest
Temp. non-forest
MANAGED
Tropical pasture
Temperate pasture
Tropical crop
Temperate crop
BIOFUEL
Sugarcane
Miscanthus
Switchgrass
Prairie
CO_2
CH_4
N_2O
S_{GHG}
$50*F_{GHG}$
0 1000 2000 3000
-20 -15 -10 -5 0 5 1
0 1500 3000 4500
S_{GHG} (Mg CO_2-eq ha^{-1})
F_{GHG} (Mg CO_2-eq ha^{-1} yr^{-1})
$GHGV_{50}$ (Mg CO_2-eq ha^{-1})

Direct LUC

$$\Delta GHG^{D}_{LUC} = -(GHGV_{biofuel} - GHGV^{D}_{displaced}) / t$$

GHG value of displaced ecosystem

GHG value of biofuel ecosystem

Time scale of interest

Indirect LUC

$$\Delta GHG^{I}_{LUC} = -f \cdot (GHGV_{displacing\_ag} - GHGV^{I}_{displaced}) / t$$

ILUC/ DLUC

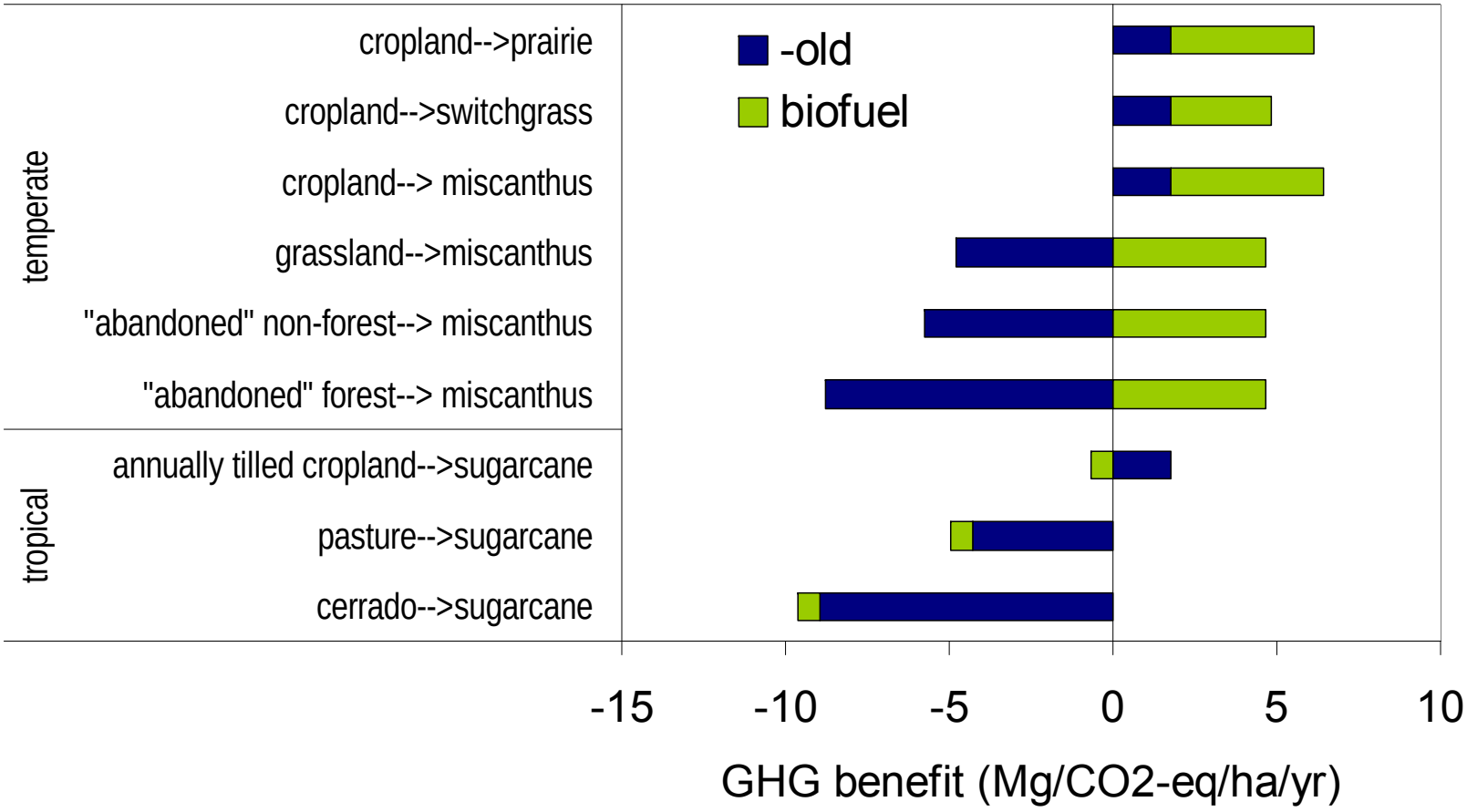
GHG value of displaced ecosystem

GHG value of displacing agriculture

Time scale of interest

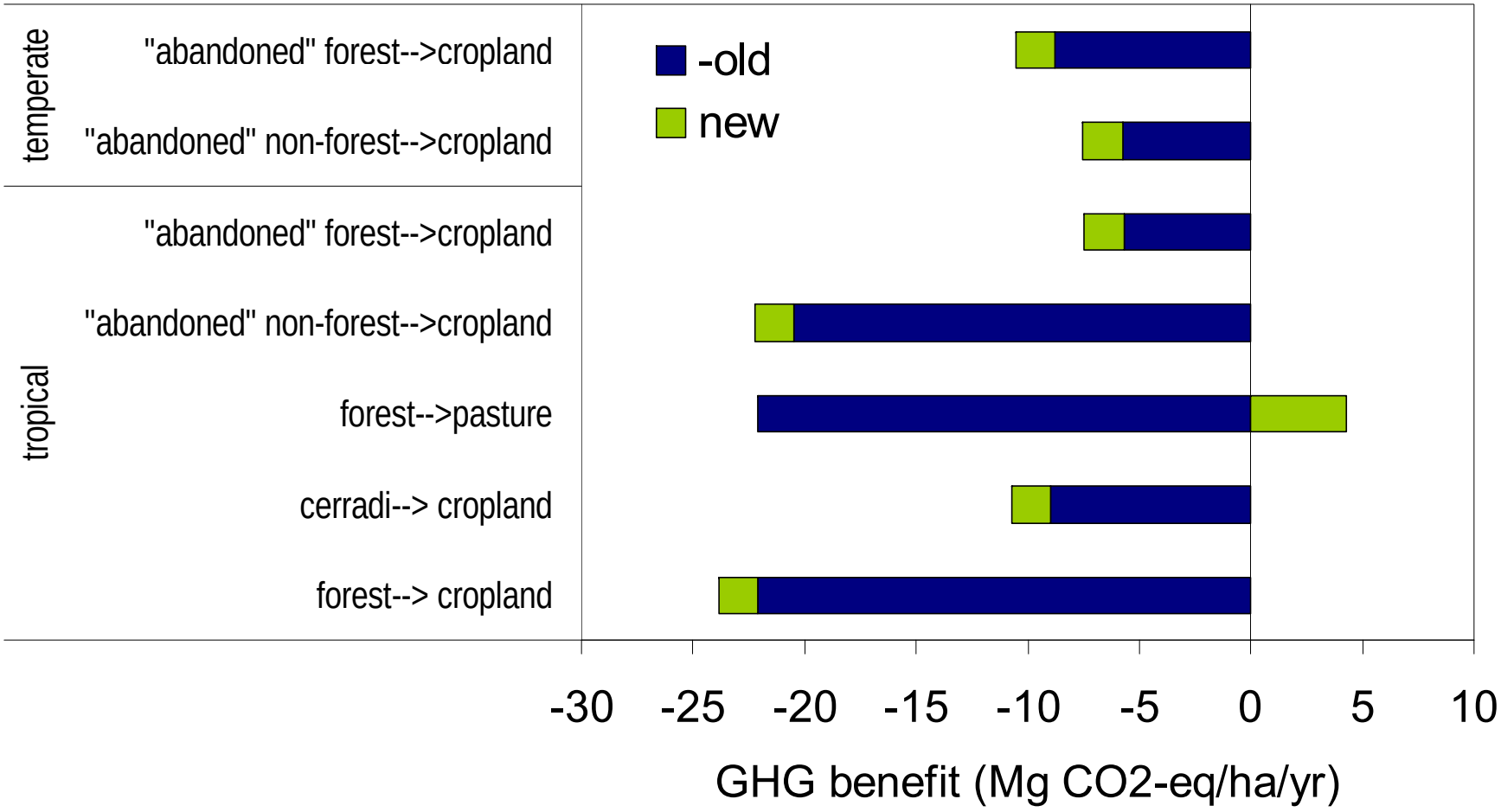
GHG effects of Direct Land Use Change

$$\Delta GHG_{LUC}^{D} = -(GHGV_{biofuel} - GHGV_{displaced}^{D}) / t$$



GHG effects of Indirect Land Use Change

$$\Delta GHG^{I}_{LUC} = -f \cdot (GHGV_{displacing\_ag} - GHGV^{I}_{displaced}) / t$$



What LCA's are Missing: DLUC

$$\Delta GHG^{D}_{LUC} = -(GHGV_{biofuel} - GHGV^{D}_{displaced}) / t$$

- Substantial benefit to replacing agricultural land (benefit of >2 Mg CO_2-eq/ha/yr)
  - Reduced N_2O emissions
  - Cessation of tillage→ increased SOC

- Full cost of clearing native ecosystems for biofuel crops
  - Displaced carbon sequestration
  - Emissions from land clearing

- Substantial costs to growing biofuels on "abandoned" land that would otherwise become forest (8-13 Mg CO_2-eq/ha/yr).
  - Displaced carbon sequestration

What LCA's are Missing: ILUC

$$\Delta GHG^{I}_{LUC} = -f \cdot (GHGV_{displacing\_ag} - GHGV^{I}_{displaced}) / t$$

- Full cost of displacing native ecosystems by biofuels
  - Emissions from burning
  - Displaced carbon sequestration
  - Negative GHGV of cropland
- Amazon replaced by crop:
  - 23.8 Mg CO_2-eq/ha/yr for 50 yr. time frame
  - Almost doubled from previous estimate.
- Depends on value of *f*

Conclusions

- At present, LCA's do not adequately account for GHG contributions from land use change.
- GHG contributions from land use change can be substantial.

Acknowledgements

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- Sarah Davis
- Mike Masters


Obrigada!