

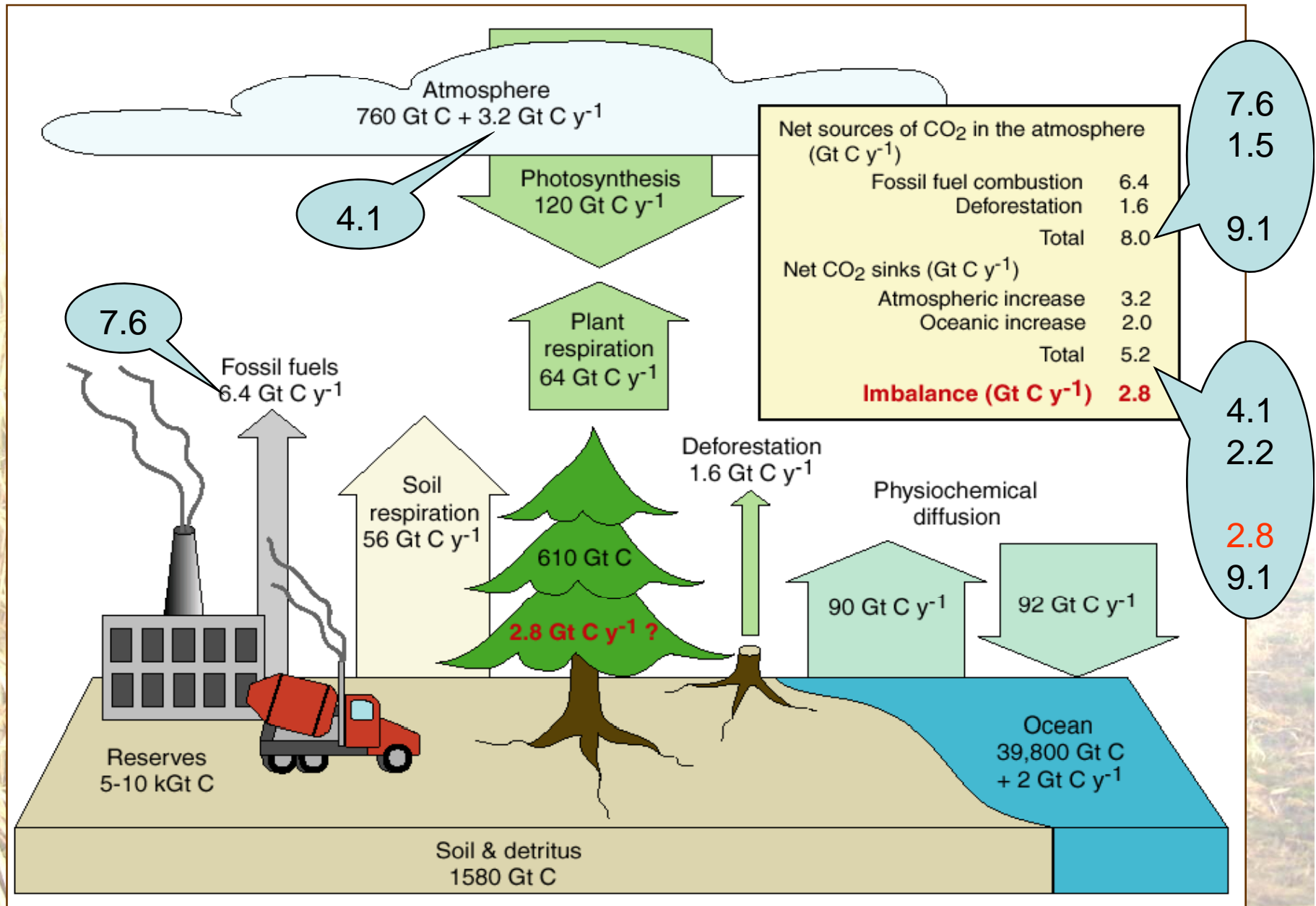
Ecological Sustainability of Biofuels: Savior or Satan?

Evan H. DeLucia

Department of Plant Biology
University of Illinois

<http://www.life.uiuc.edu/delucia/>





K.L. Griffin, Columbia U. 2002;

Canadell et al. 2007 PNAS



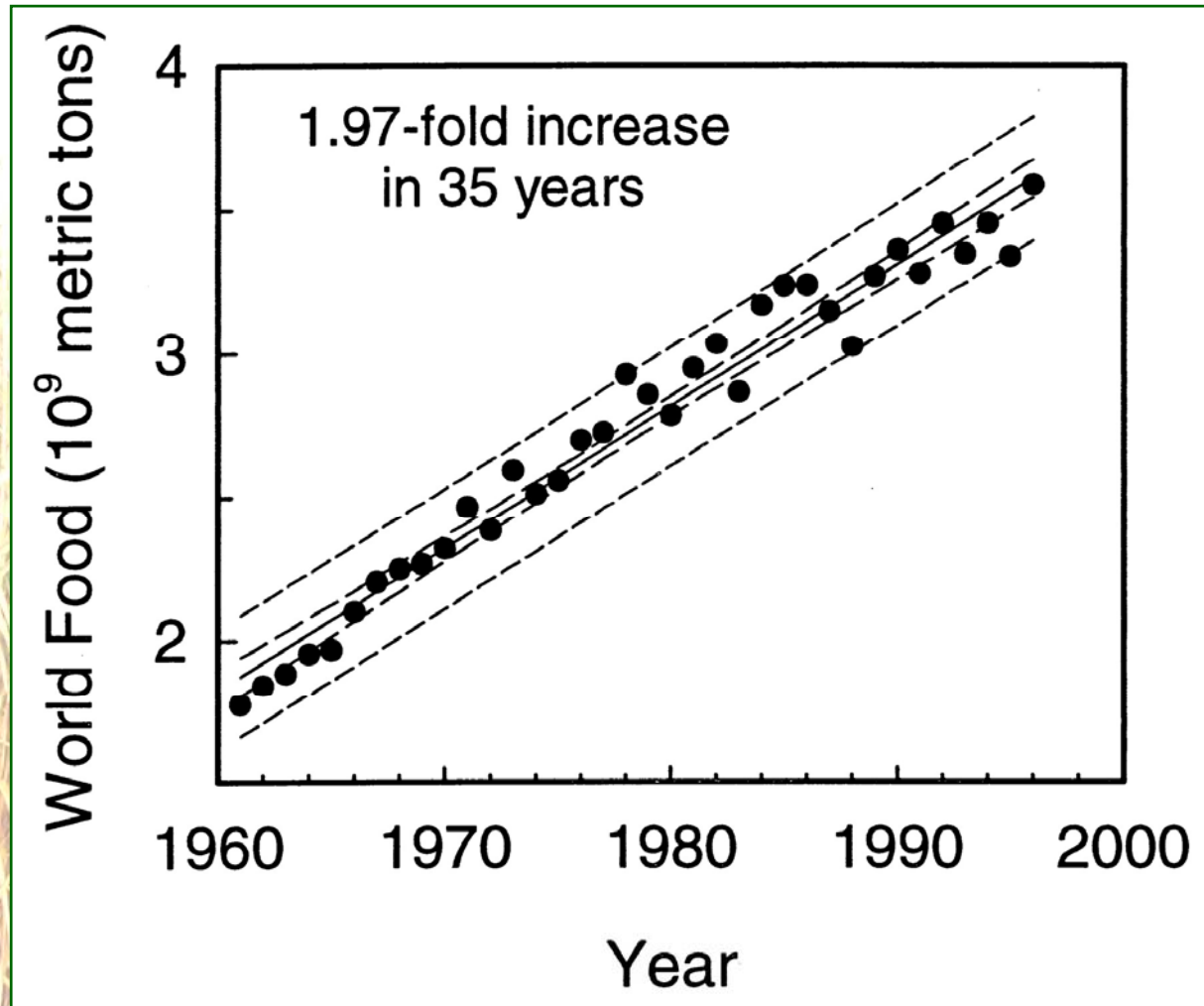
Atwood

Image © 2008 TerraMetrics
© 2008 TurnHere, Inc.
© 2008 Tele Atlas

Google

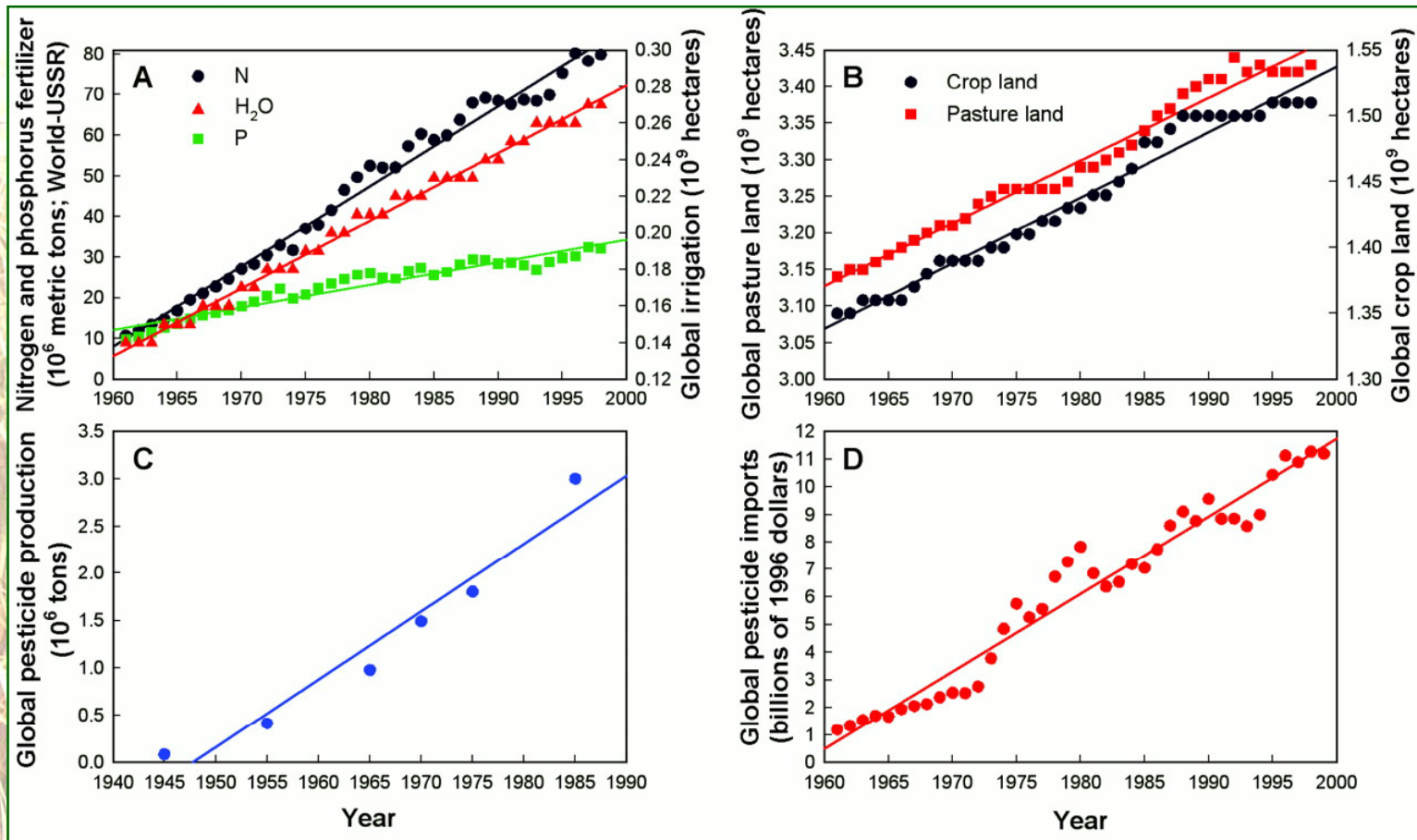
39°49'43.92" N 88°25'13.46" W elev 671 ft Eye alt 10.86 mi

The Green Revolution...



Tilman, David (1999) PNAS 96, 5995-6000

...was not without "bloodshed."



Tilman et al., Science 292, 281 -284 (2001)

The Energy Farm will feature side-by-side plots of

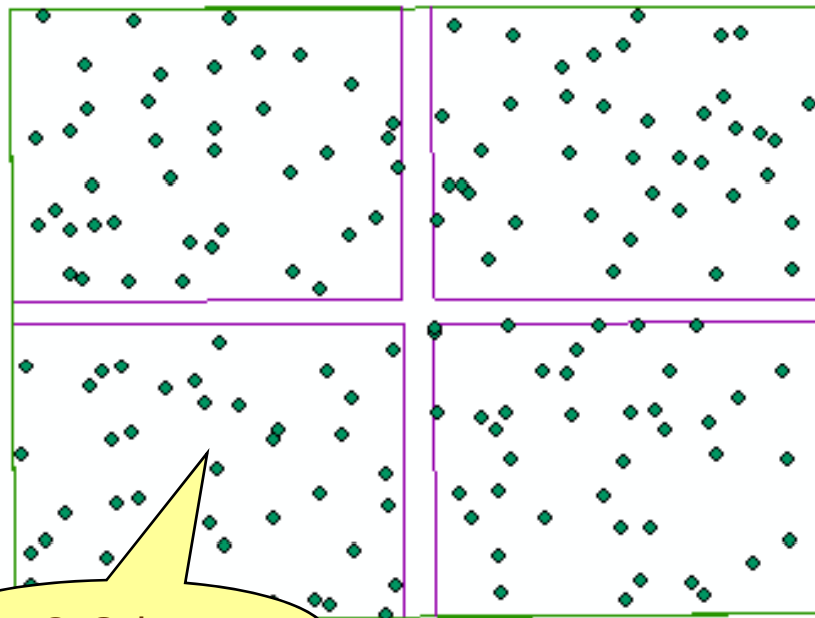


- Miscanthus
- Switchgrass
- Prairie
- Corn

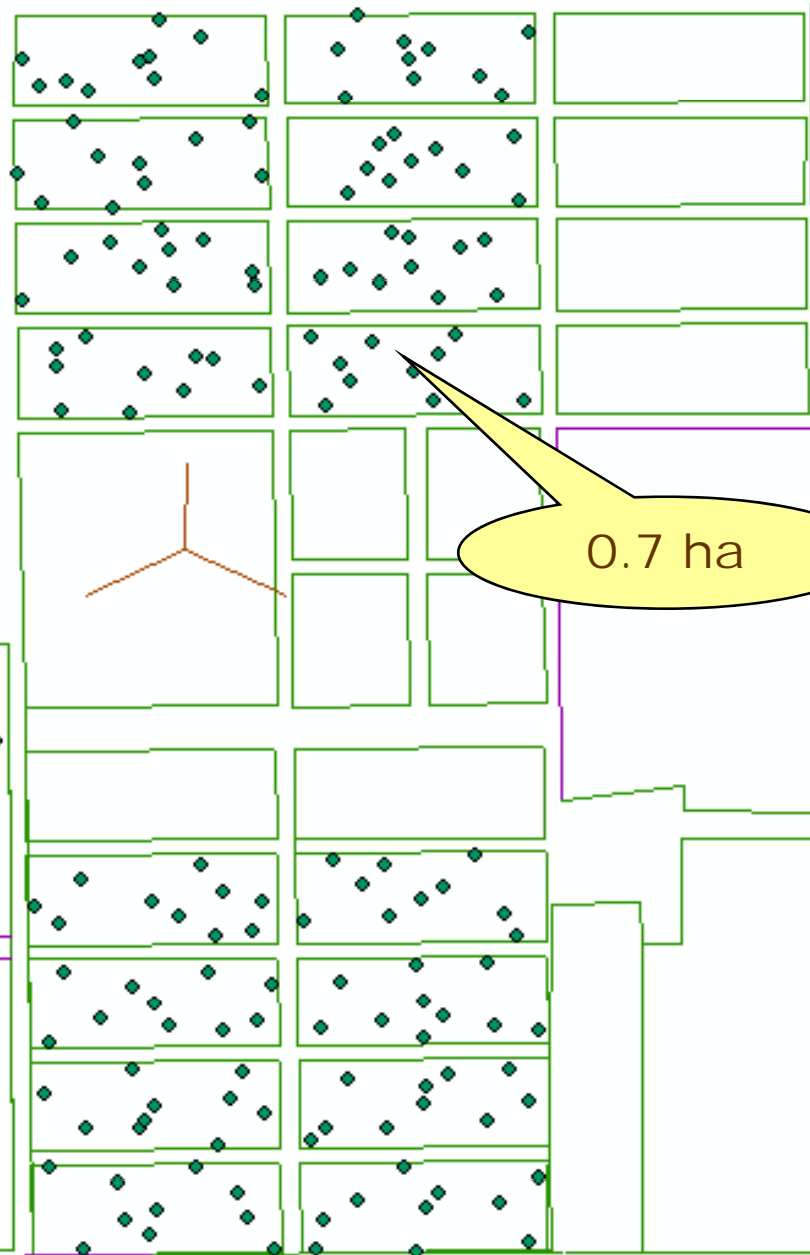


Pretreatment Soil Analysis

Soil cores were extracted to a depth of 1 m in 320 random locations.

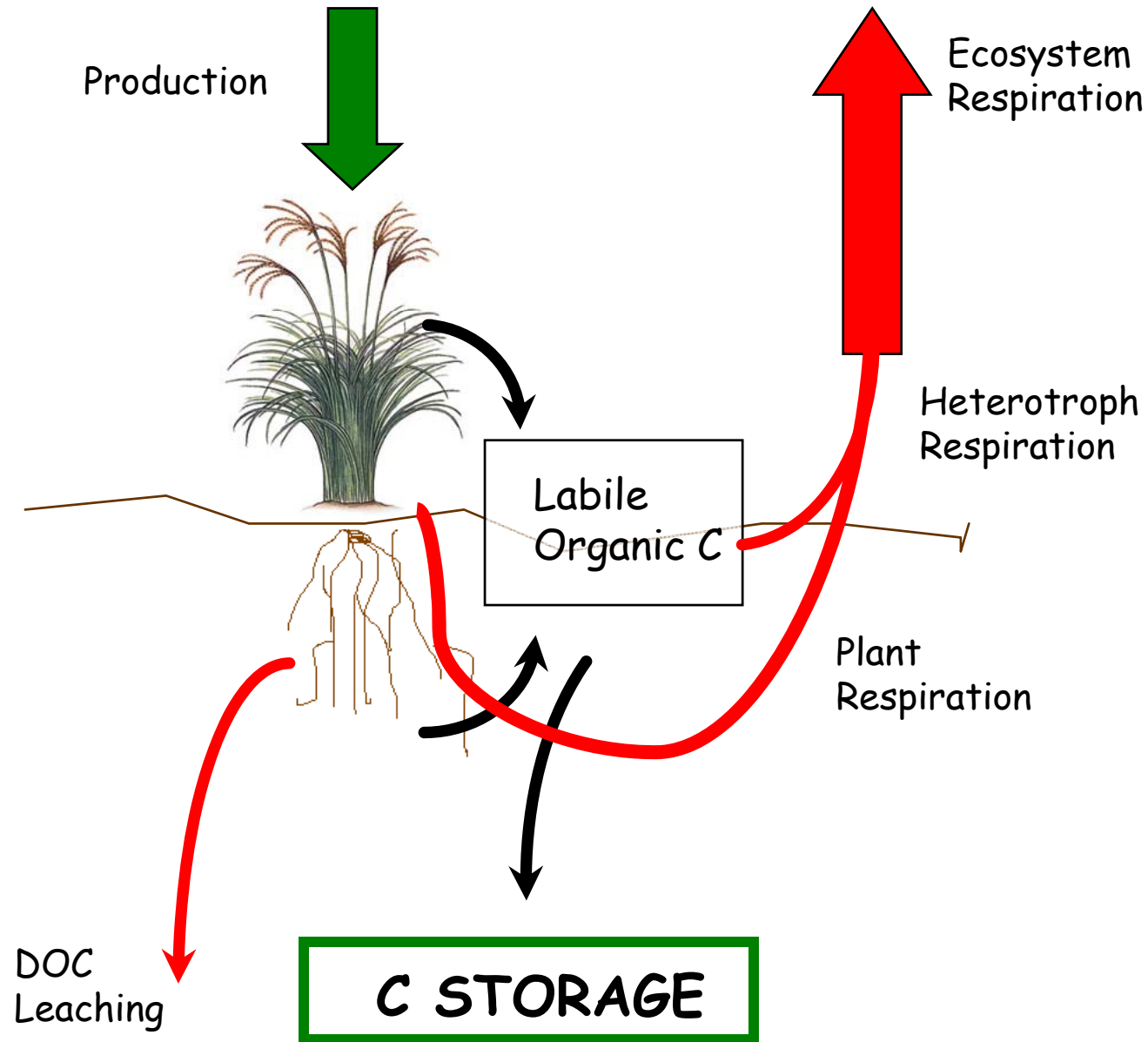


3.8 ha

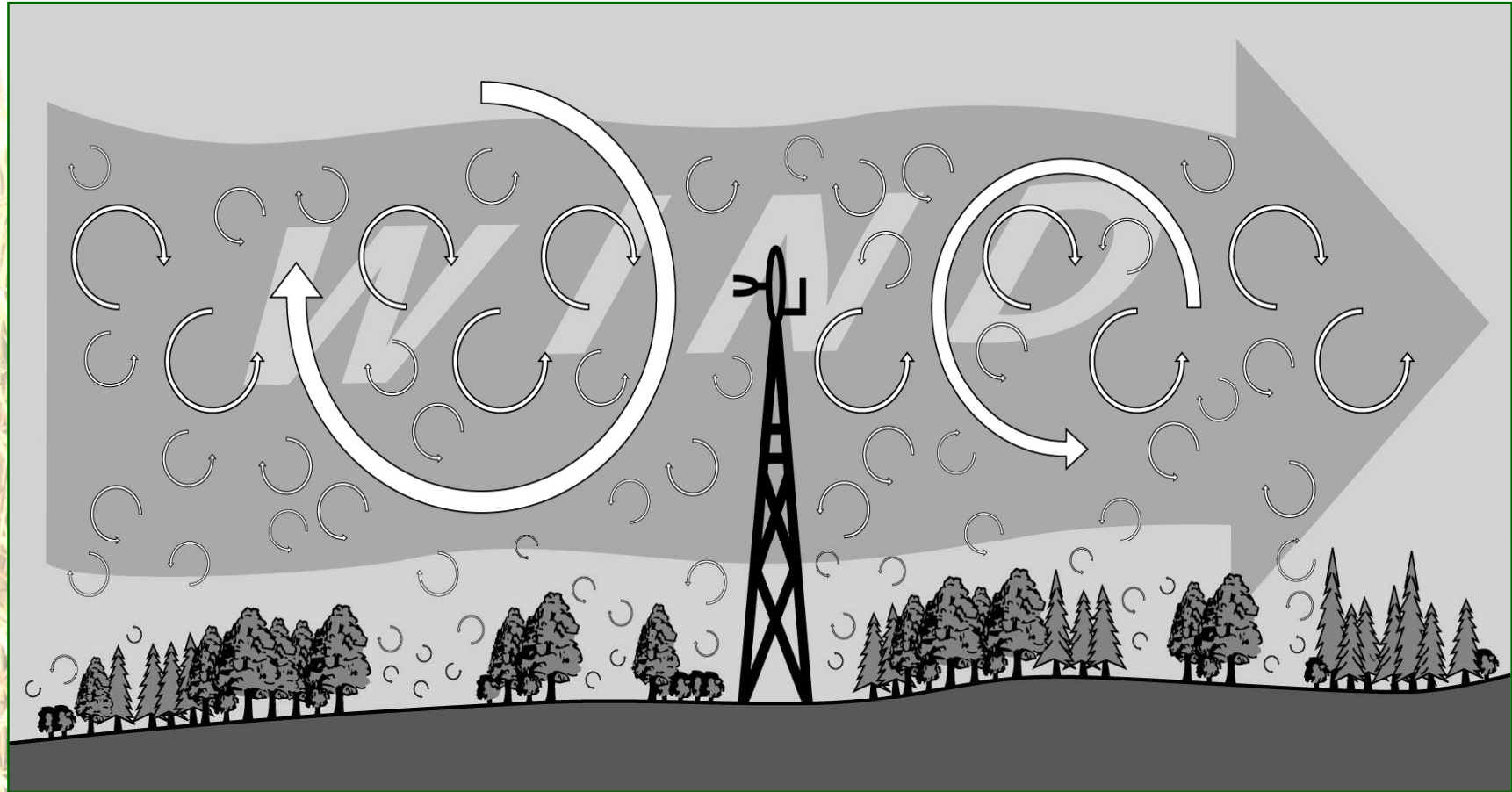


0.7 ha

Atmospheric CO₂



Measuring eddies



Fluxes:

N_2O
 CH_4
 CO_2

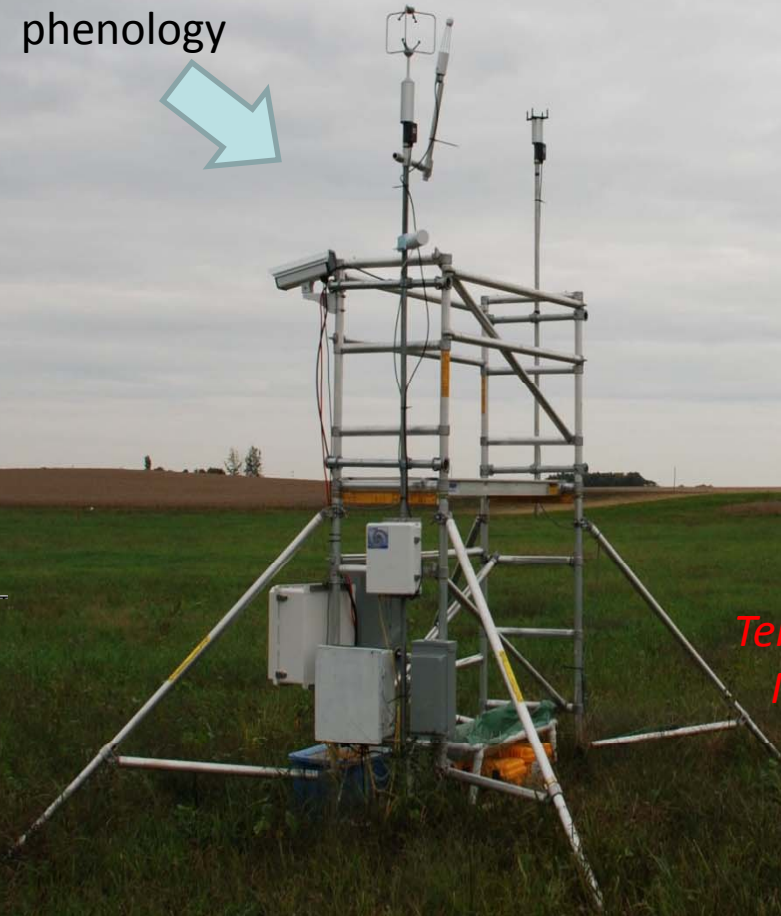


Photos:
phenology



Fluxes:

CO_2
 H_2O
S



Meteorology:

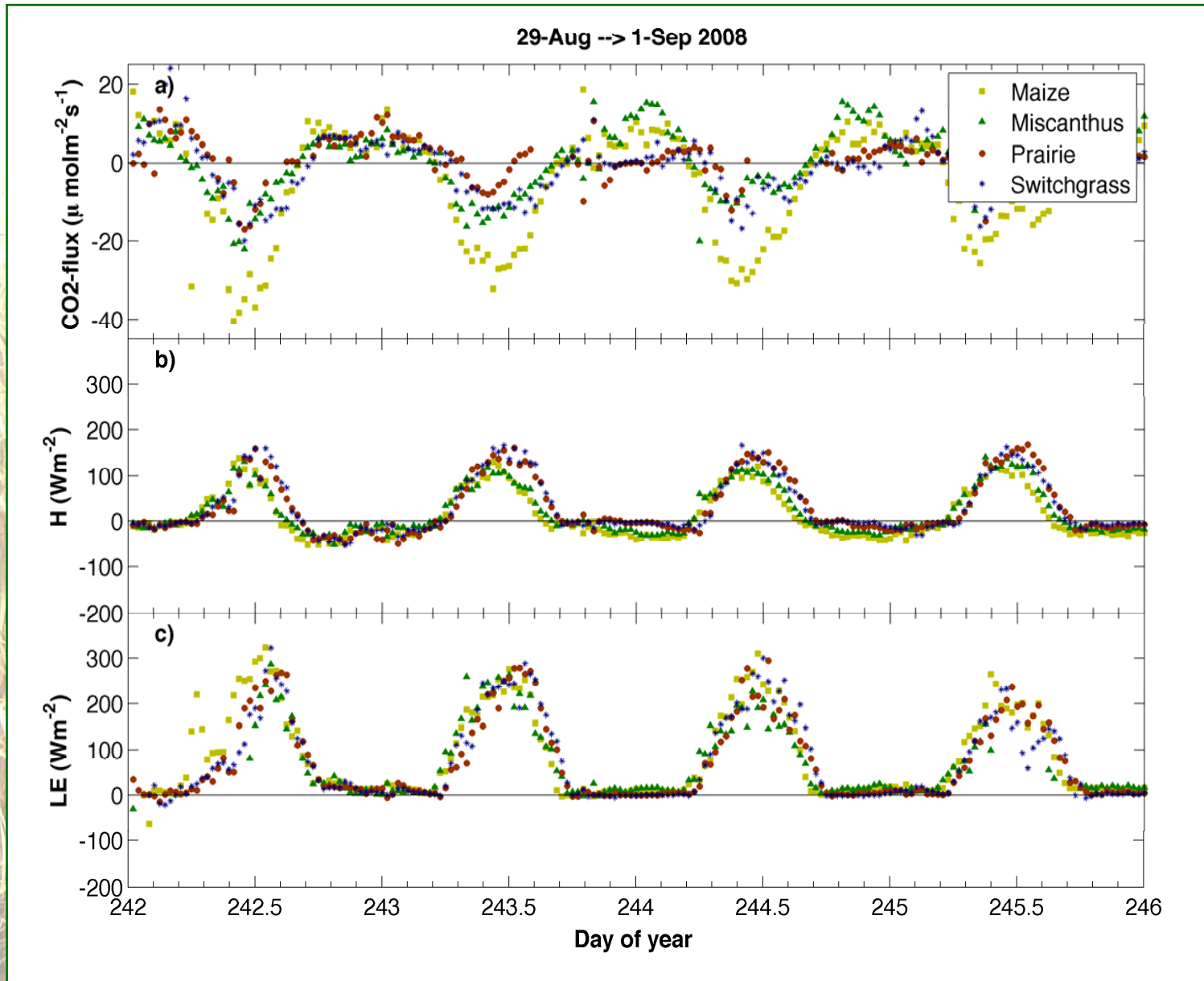
wind
Air Temperature
Net radiation
Humidity
Canopy Temp
PAR



Soil:
Heat flux
Temperature (to 1 m)
Moisture (to 1 m)



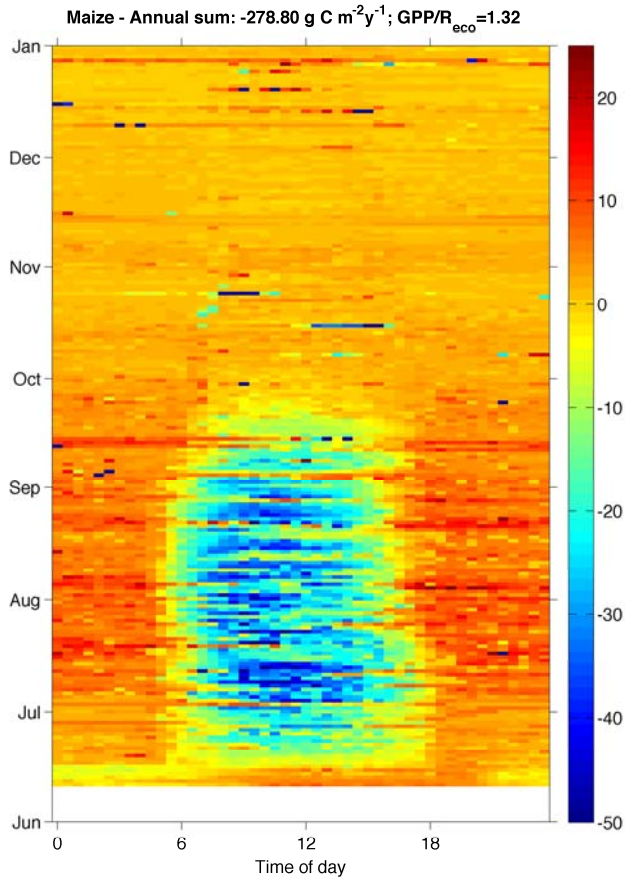
CO₂, energy and water fluxes



Check them online everyday at: http://www.flickr.com/photos/energy_farm/

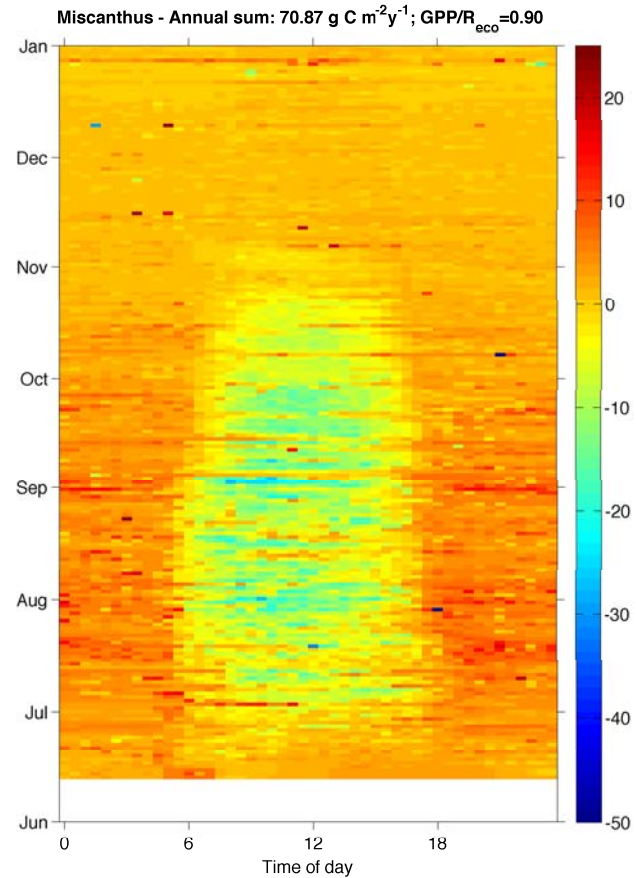
"Carbon footprints"

Maize



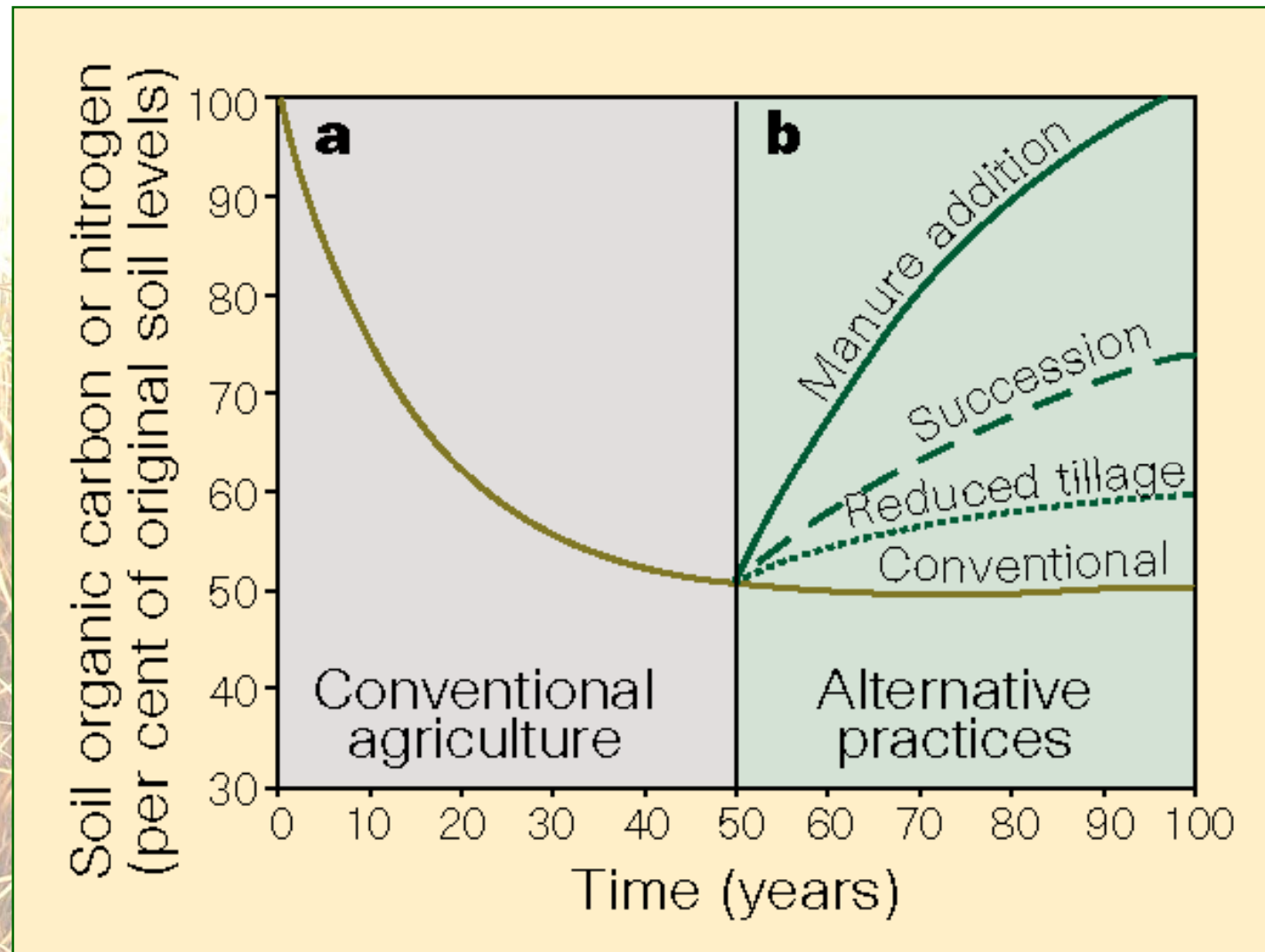
NEE: $-279 \text{ gC m}^{-2} \text{ y}^{-1}$
GPP/R: 1.3

Miscanthus



NEE: $71 \text{ gC m}^{-2} \text{ y}^{-1}$
GPP/R: 0.9

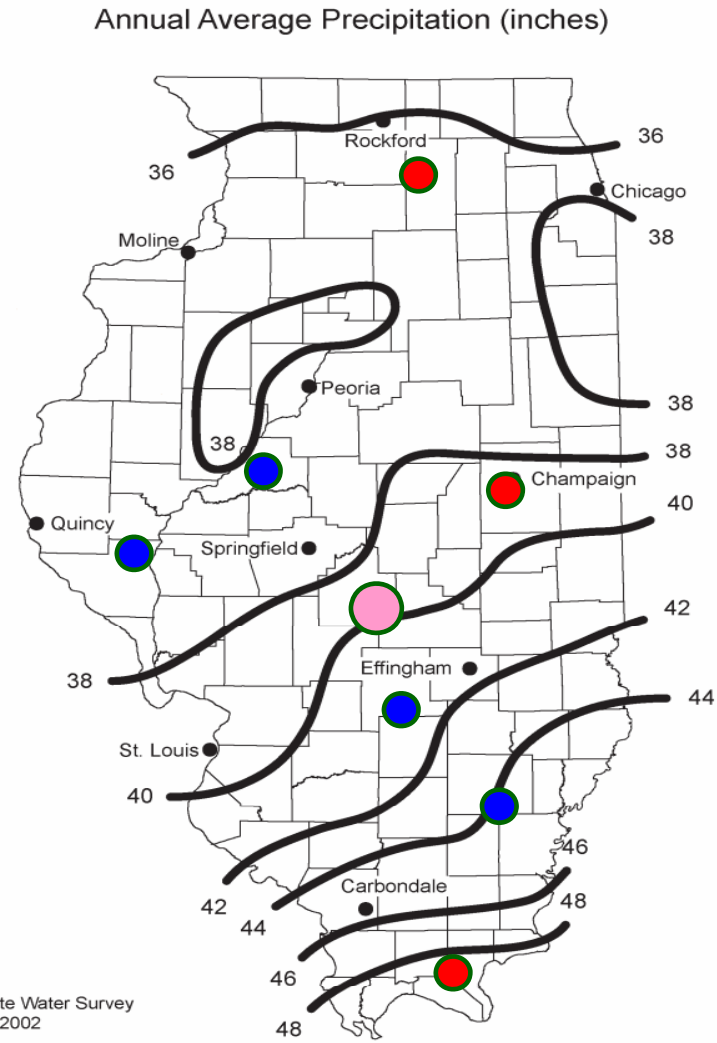
Land use and Soil Organic Carbon



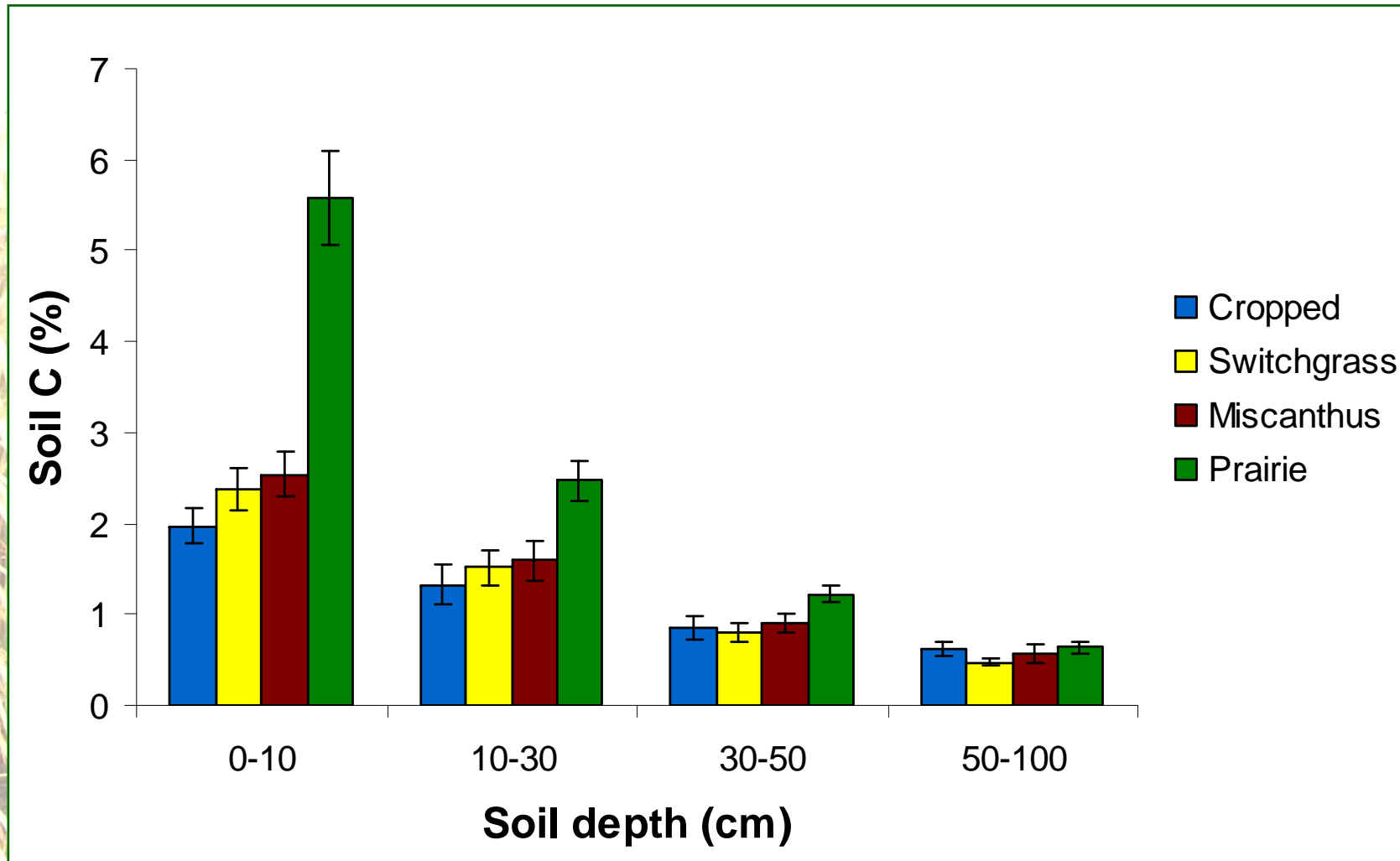
Tilman, Nature, 396, 211

Survey of Soil C Under Biofuel Crops

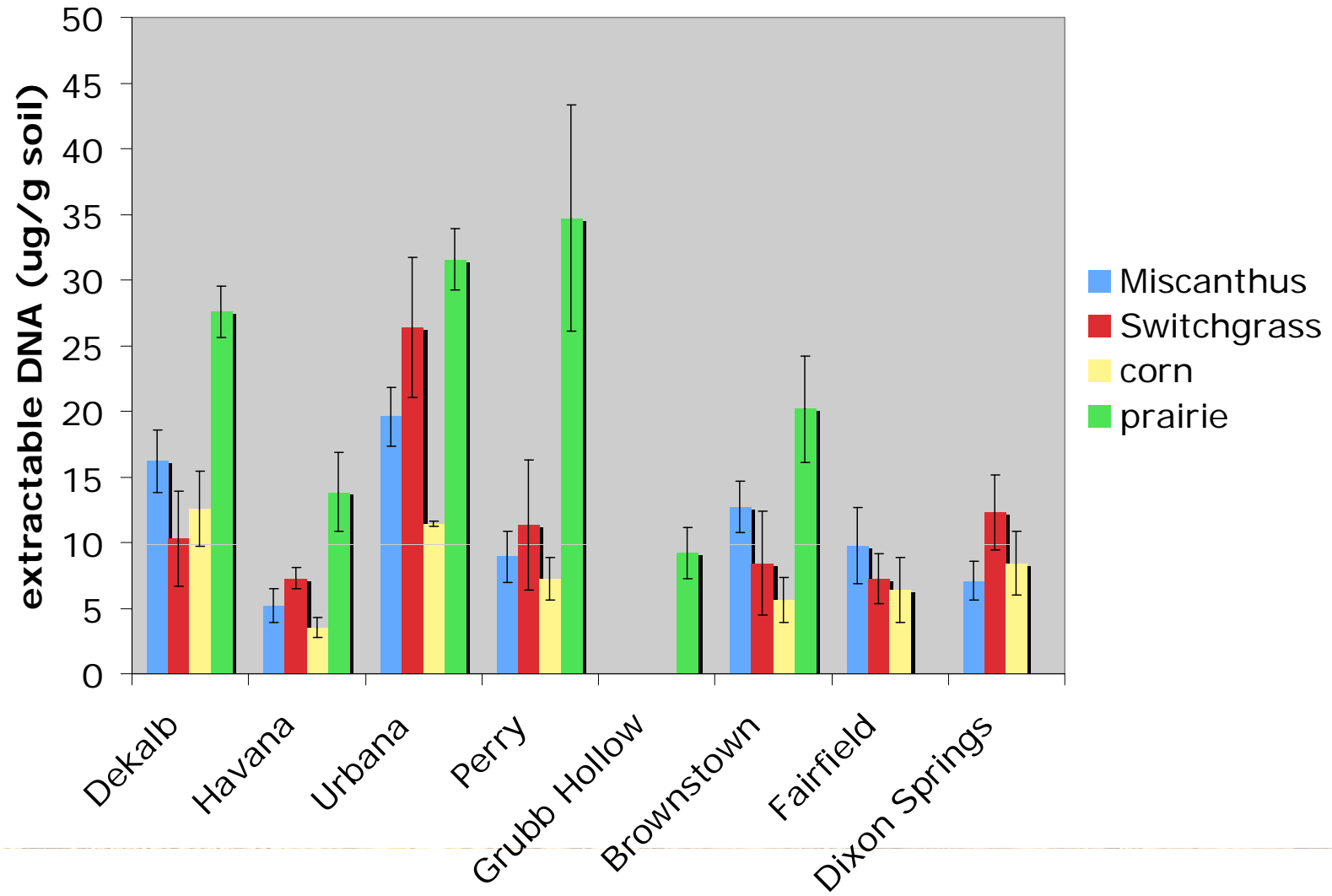
Miscanthus
Switchgrass
Maize
Native Prairie



Soil C of biofuel feedstocks



Soil microbial biomass



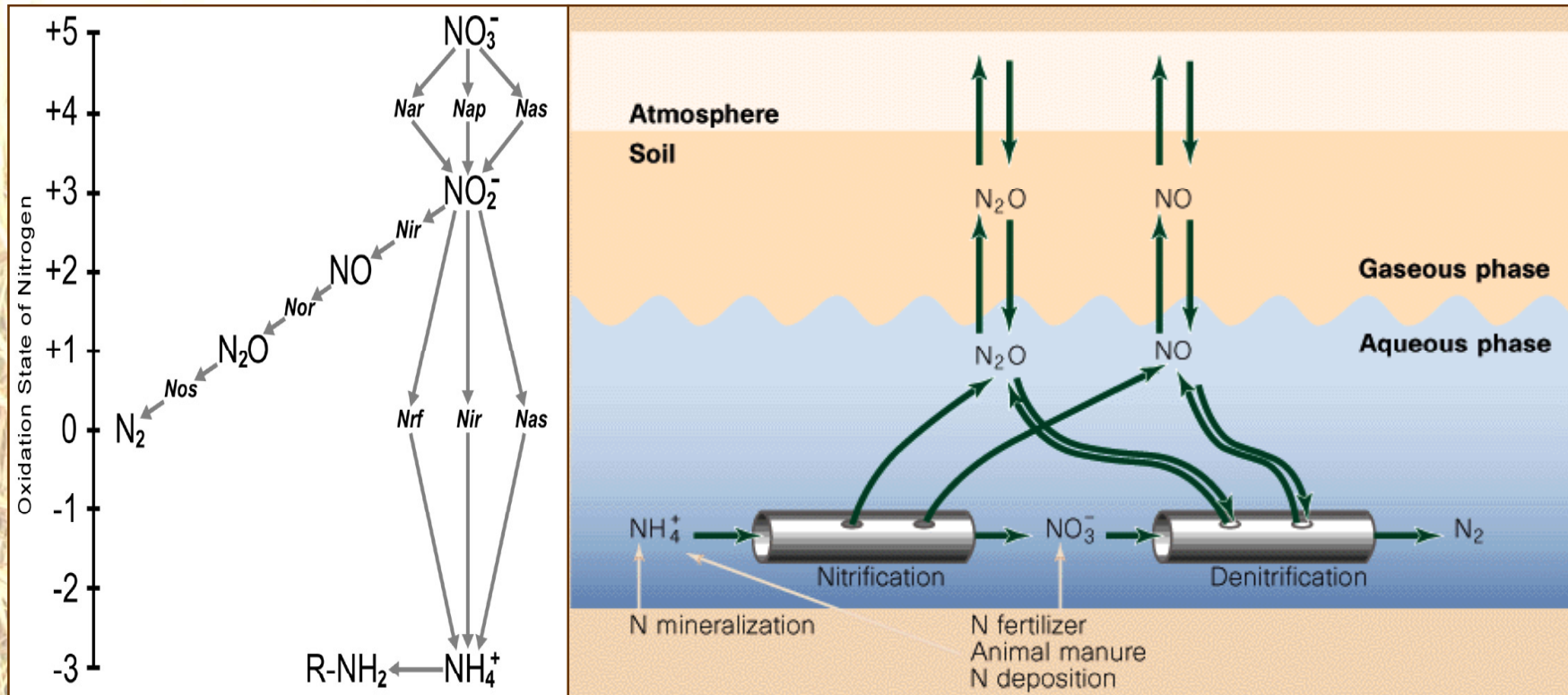


Drainage tiles
move N-laden
ground water to
rivers...



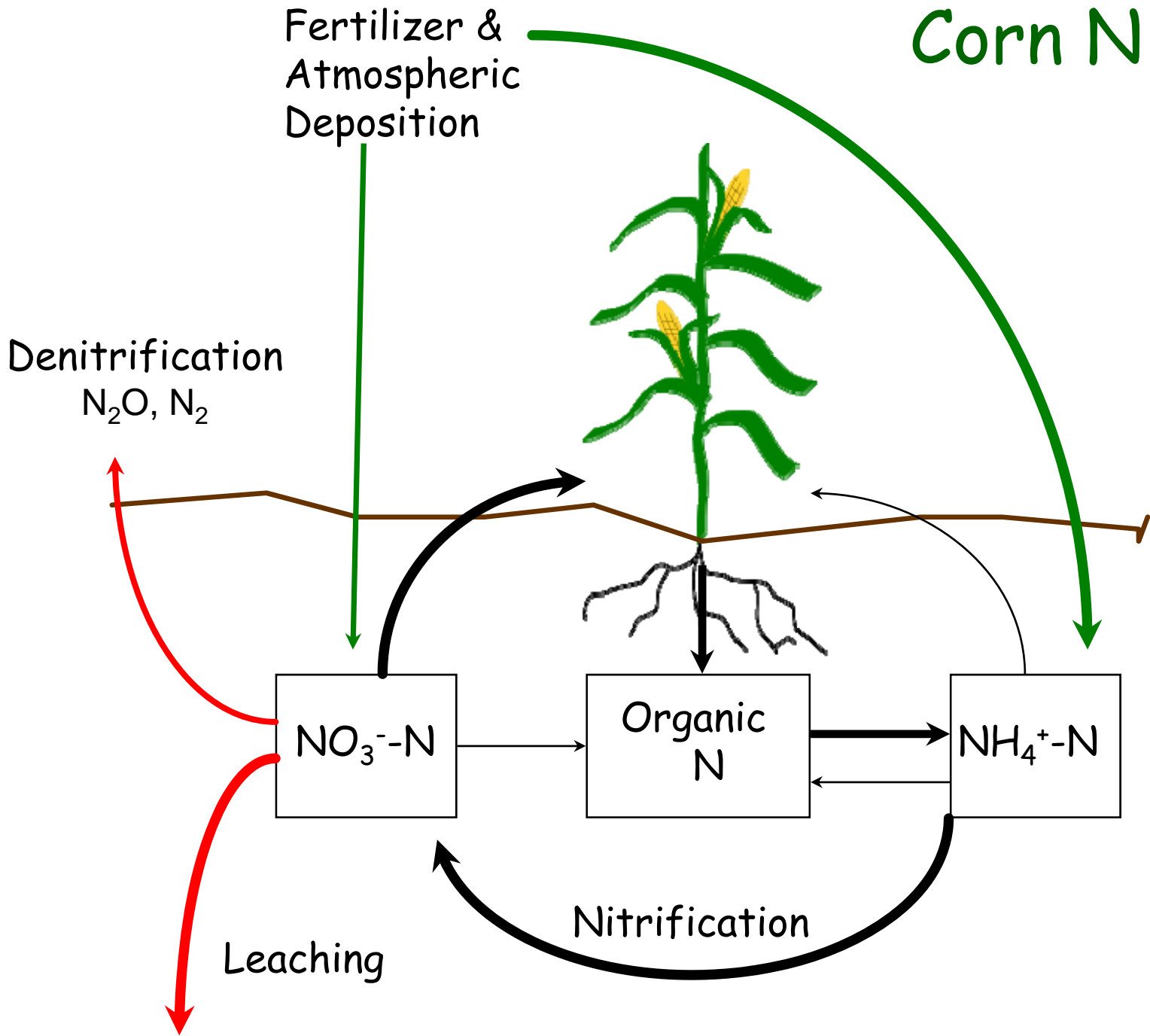
The infamous "dead zone" develops in the Gulf of Mexico each summer, threatening fisheries. ...excess nitrogen from farm fertilizers enters the gulf predominately via the Mississippi River.

Transformations of N and other elements in the soil are mediated by microorganisms

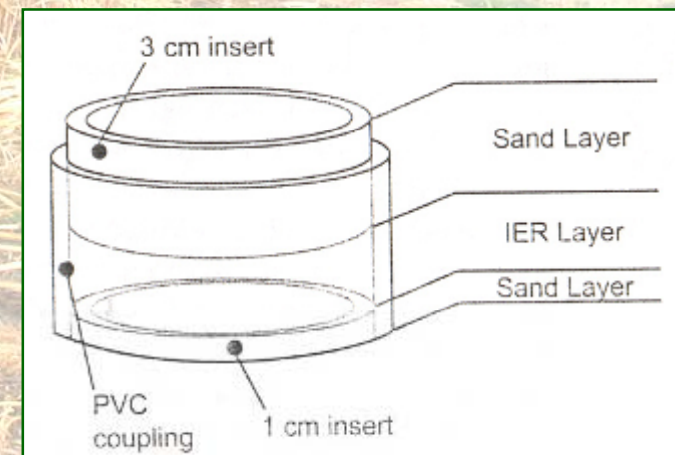


From Matt Cachmann, Pennsylvania State U.
Bouwman, Nature, 392, 866

Corn N Cycle



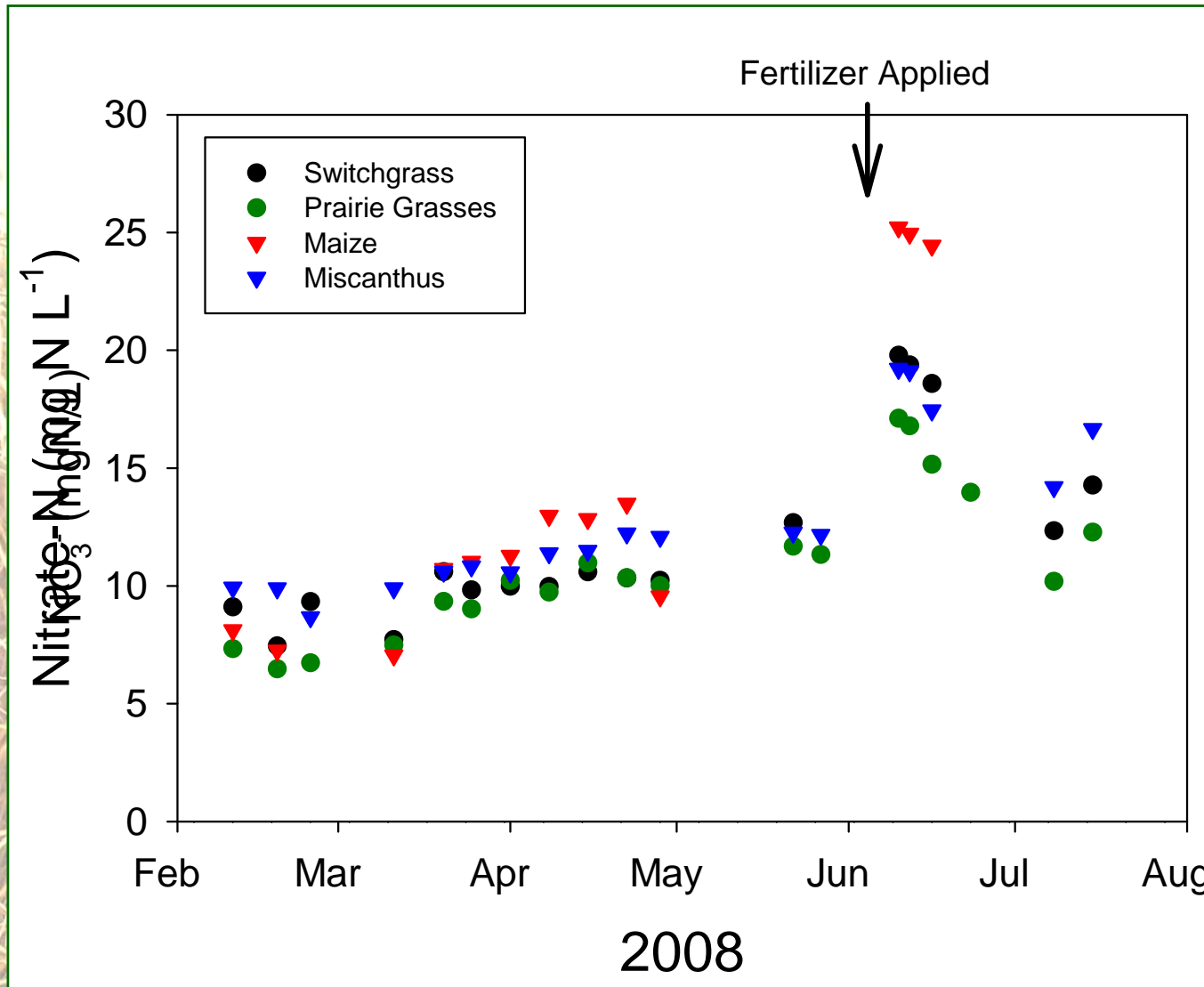
Measuring N fluxes in the soil



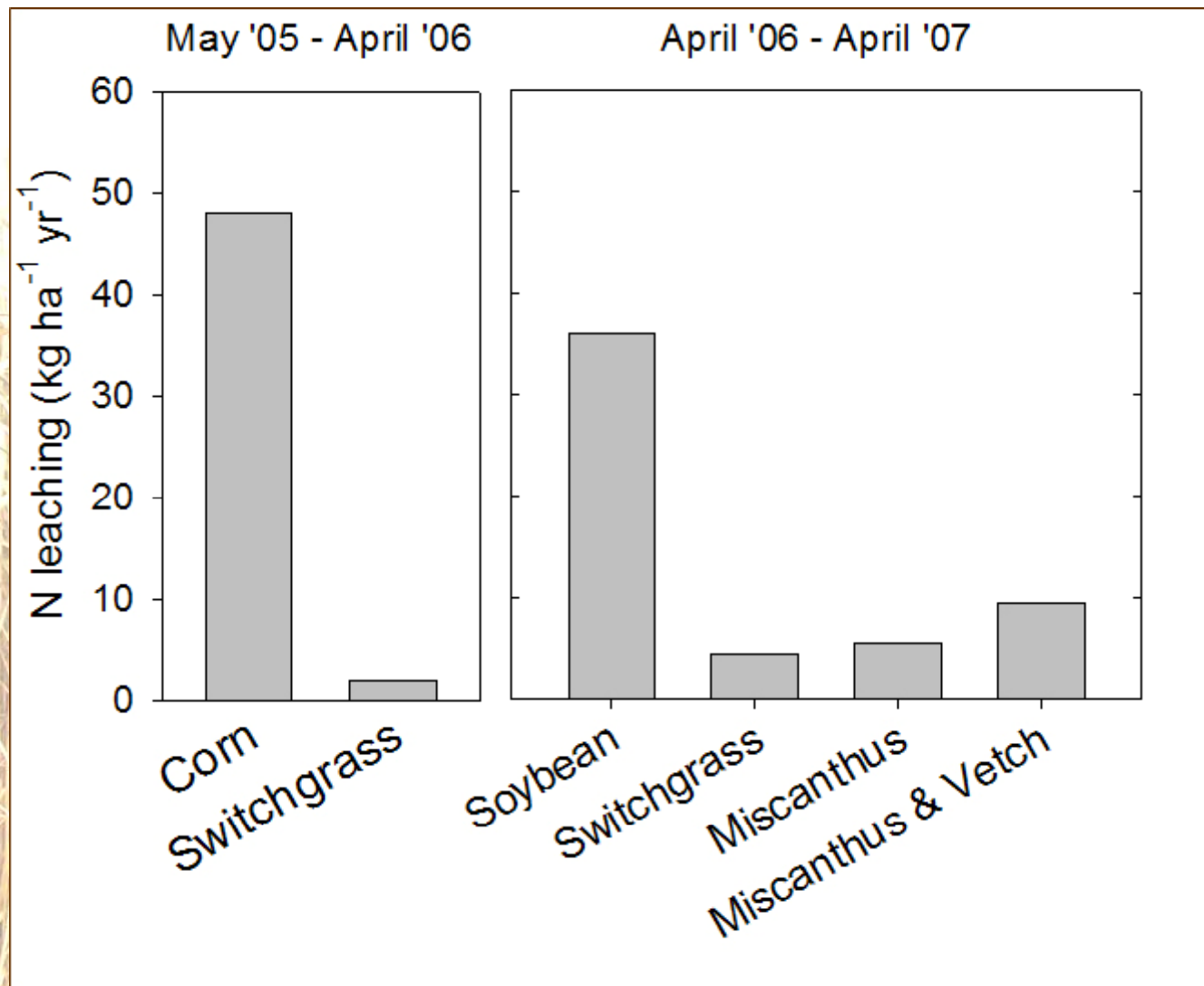
Tile monitoring equipment



Tile nitrate loss - 2008

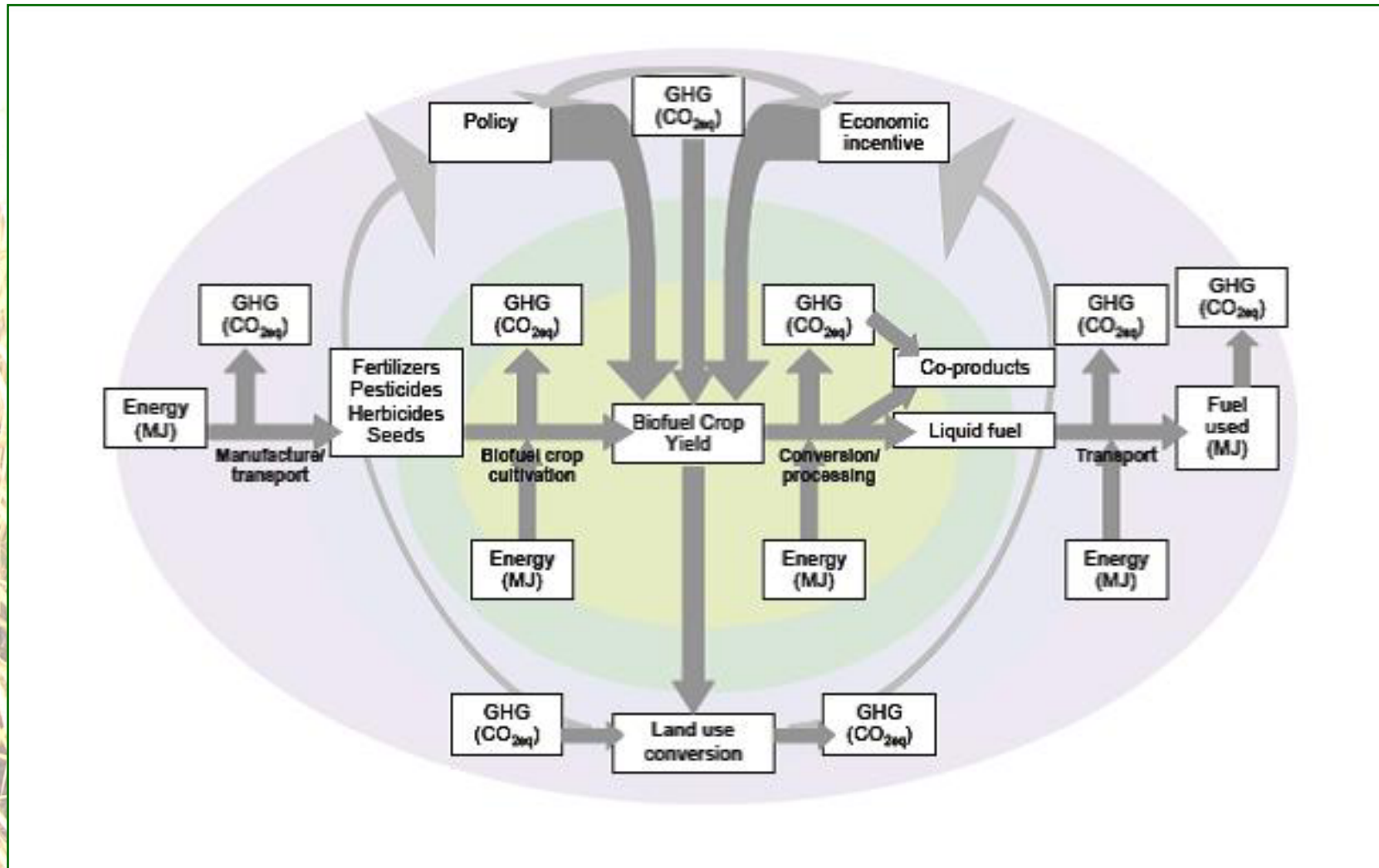


NO_3^- and NH_4^+ losses below the roots



G. McIsaac, M. David, C. Mitchell, unpublished

Life cycle analysis



Davis, S. et al. (2008) *Trends in Plant Science*, 14:140-146

Green house gas displacement

Biofuel crop	GHG displacement (%)	Refs.
Switchgrass	-114	[18]
Switchgrass combustion compared to coal combustion	-109	[26]
<i>Miscanthus</i> (gasi fication)	-98	[7]
Switchgrass	-93	[30]
Corn	-86	[36]
Reed canarygrass	-84	[18]
Cellulosic	-80	[33]
Switchgrass	-73	[39]
Corn-soy	-38	[18]
Corn	-25	[33]
Corn	-24	[39]
Switchgrass	-11	[40]
Corn	-3	[37]
Switchgrass	43	[22]
Switchgrass	50	[19]
Corn	66	[22]
Corn	93	[19]

Davis, S. et al. (2008) *Trends in Plant Science*,14:140-146



BIOENERGY CROPS, WHAT IS NOT REALISTIC



Use of land currently used for food and feed.



Irrigation with potable water



Net greenhouse gas balance little or no better than fossil fuels.



CURRENT BIOFUEL CROPS RIGHT?



Maize ✗



Soybean ✗



Palm oil ✗



Sugarcane ✓



THE BOTTOM LINE



Feedstock	Harvestable Biomass Dry (t/ha)	Ethanol (litres/ha)	Mha needed for 133 billion litres of ethanol	% 2006 harvested US cropland
Maize grain	10.1	3,830	35	24.4
Maize stover	6.71	2,554	52	37.2
Maize Total	17.5	6,640	20	14.8
Prairie mix	3.8	1,447	92	72.5
Switchgrass	12.5	4,767	28	22.0
Miscanthus	29.1	11,066	12	9.3

Source: Heaton, Dohleman & Long (2008) Global Change Biology 14, 2000–2014.

The "biofuels" group...

May R. Berenbaum
Carl J. Bernacchi
Mark B. David
Evan H. DeLucia
Roderick I. Mackie
Donald R. Ort
William Parton
Art Zangerl

Kristina Anderson-Teixeira
Sarah Davis
George Hickman
Michael Masters
Corey Mitchell
Candice Smith
Tony Yannarell
Marcelo Zeri

