Climate Change, Carbon, and Sustainable Agriculture

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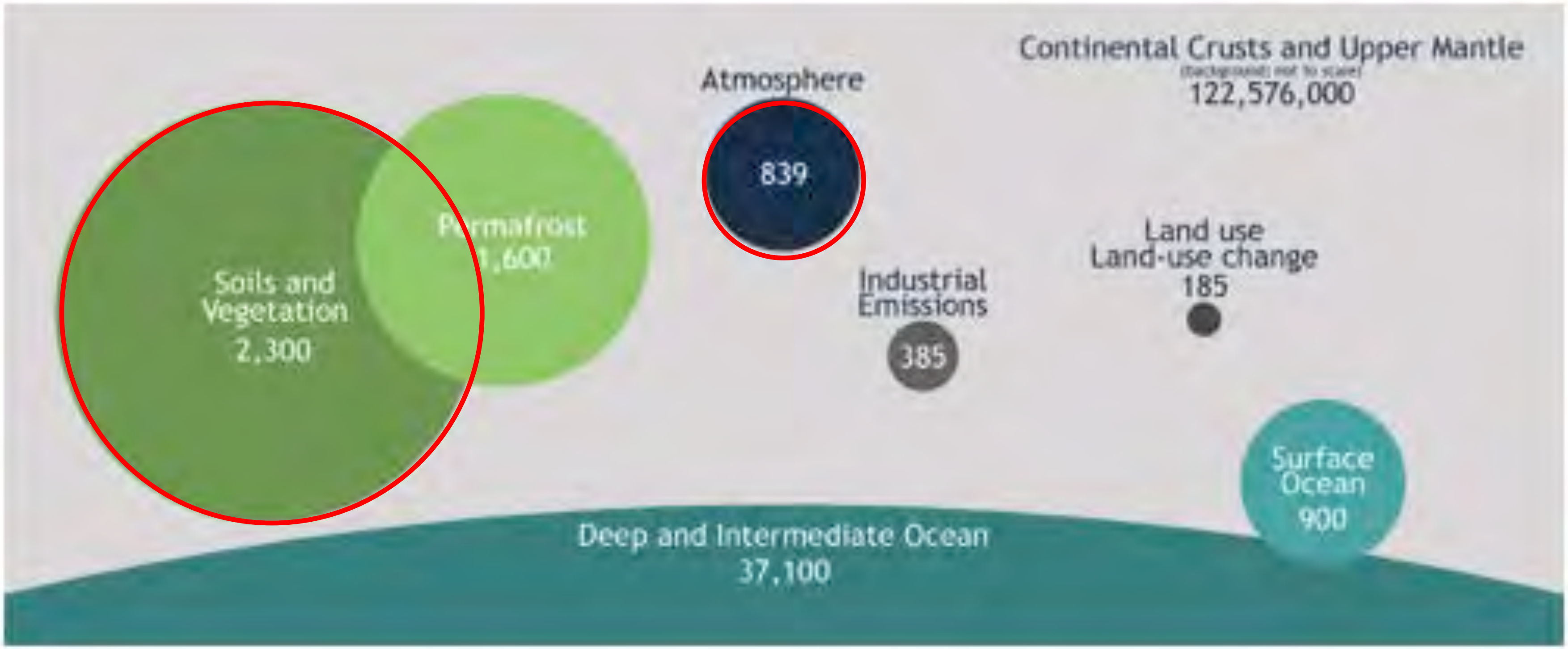
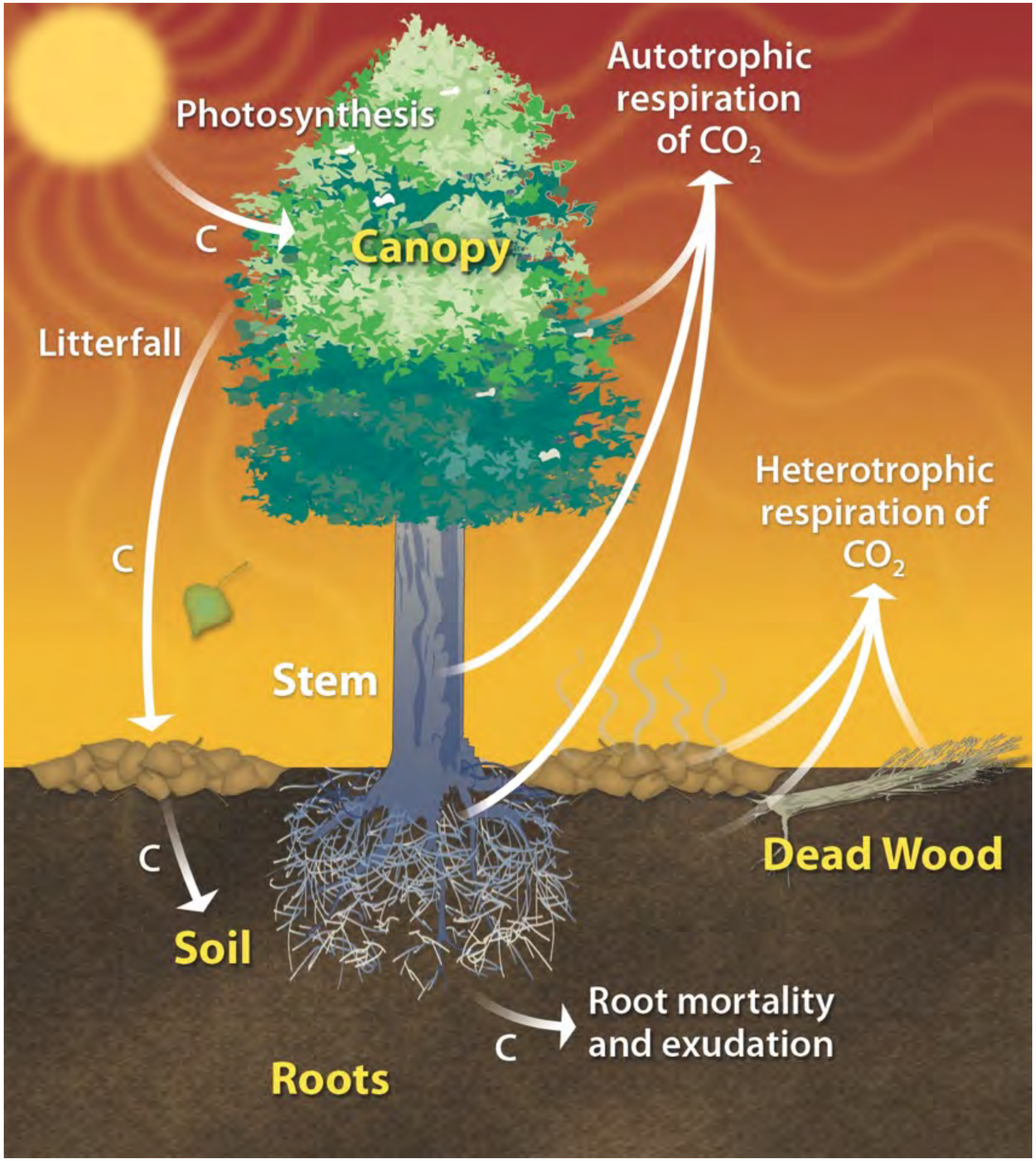
CIAS

NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

Carbon Pools



https://www.fs.usda.gov/ccrc/topics/global-carbon



Biomass and Soil Carbon

US **forests** store 600 to 700 MMT CO_2eq per year

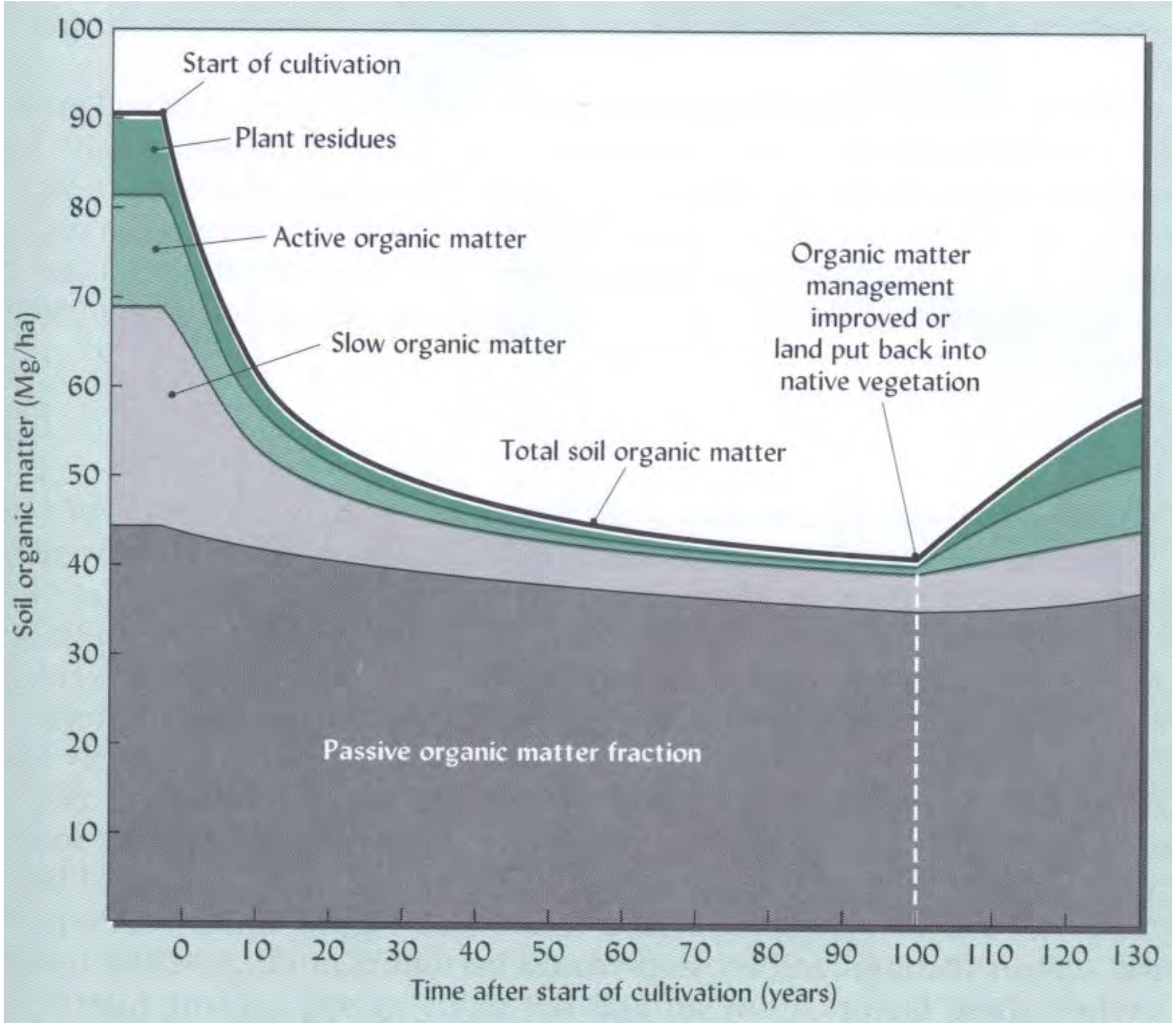
Urban forests store 90 MMT CO_2eq

US **agricultural land**: carbon equilibrium?? (Over 10,000 years global agriculture resulted in the loss of ~ 100 Gt C from soils)

Ch 2 North American Carbon Budget, *Second State of the Carbon Cycle Report*

DOE Genomic Science program https://genomicscience.energy.gov

Land Use Change and Soil Carbon



(Brady and Weil, 1999)

Ag. mitigation strategies for Wisconsin

Reduce Emissions

- Reduce nitrogen fertilizer applications
- Manage manure
- Enteric emissions?
- Energy efficiency, et al.

Increase Carbon Storage

- Build soil health
- Add trees
- Land use change (to diverse perennials)

Co-benefits:

- Water quality
- Biodiversity

Principles of soil health

- **Limit disturbance:** Protect soil structure by avoiding tillage and use of pesticides, insecticides, and synthetic fertilizers.
- **Armor:** Keep the soil covered at all times.
- **Diversity:** Strive for a healthy mix of plant and animal species.
- **Living Roots:** Maintain living roots in the soil as long as possible throughout the year.
- **Integrate Animals:** Manage livestock using regenerative strategies like adaptive multi-paddock grazing.

Limit disturbance

- No-till (usually relies on herbicides)
- Perennial crops

NRCS

Armor

- Crop residue
- mulch
- cover crops
- perennial crops

Mimi Broeske

Diversity

- Crop rotation
- Strip-cropping
- Cover crop cocktails
- STRIPS, buffers, etc.
- Diverse pastures
- Agroforestry

Living Roots Year-round

- Cover crops
- (STRIPS, windbreaks)
- Perennial pasture, agroforestry

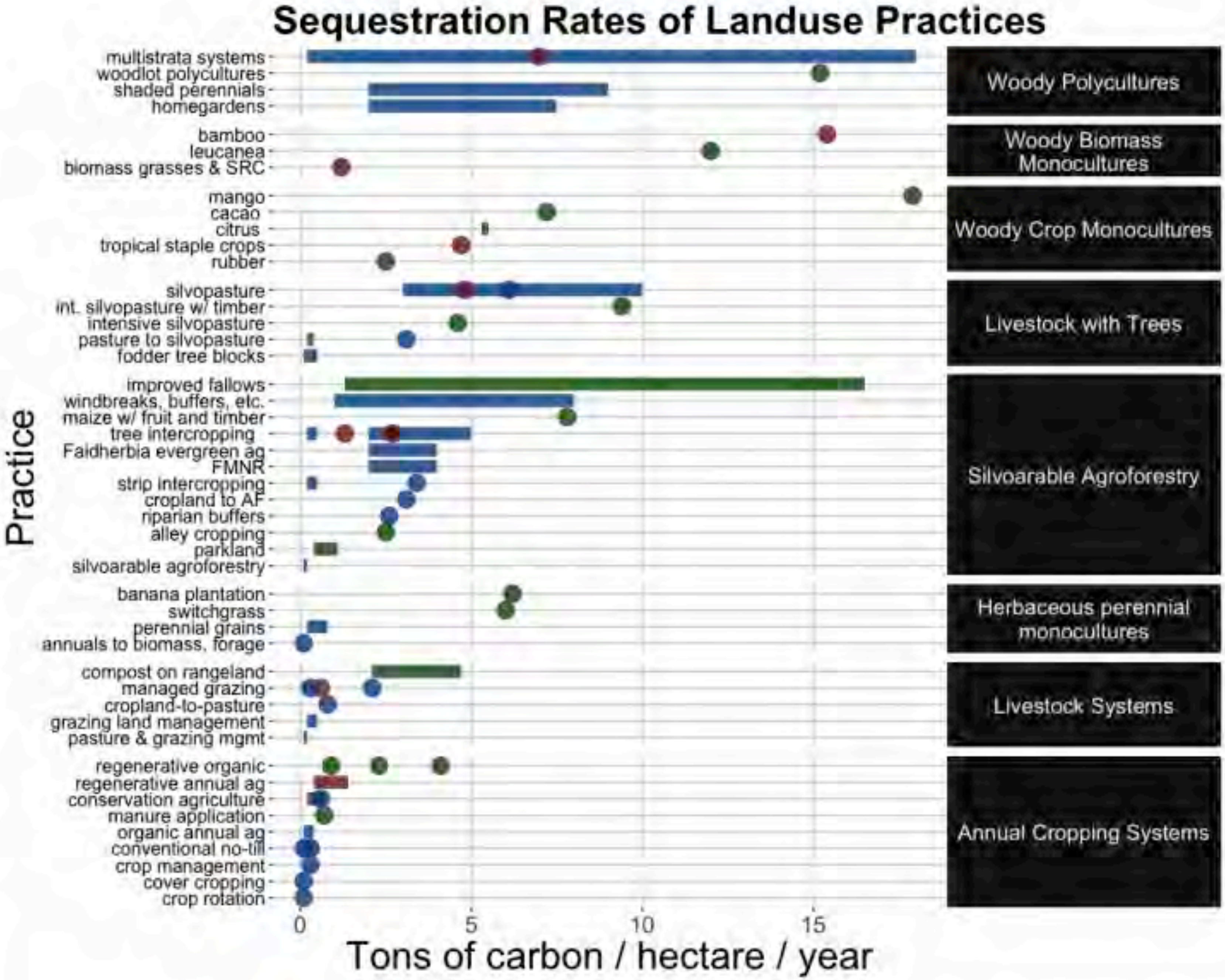
https://www.patagoniaprovisions.com/pages/why-beer

Integrate Animals

Ruth McNair

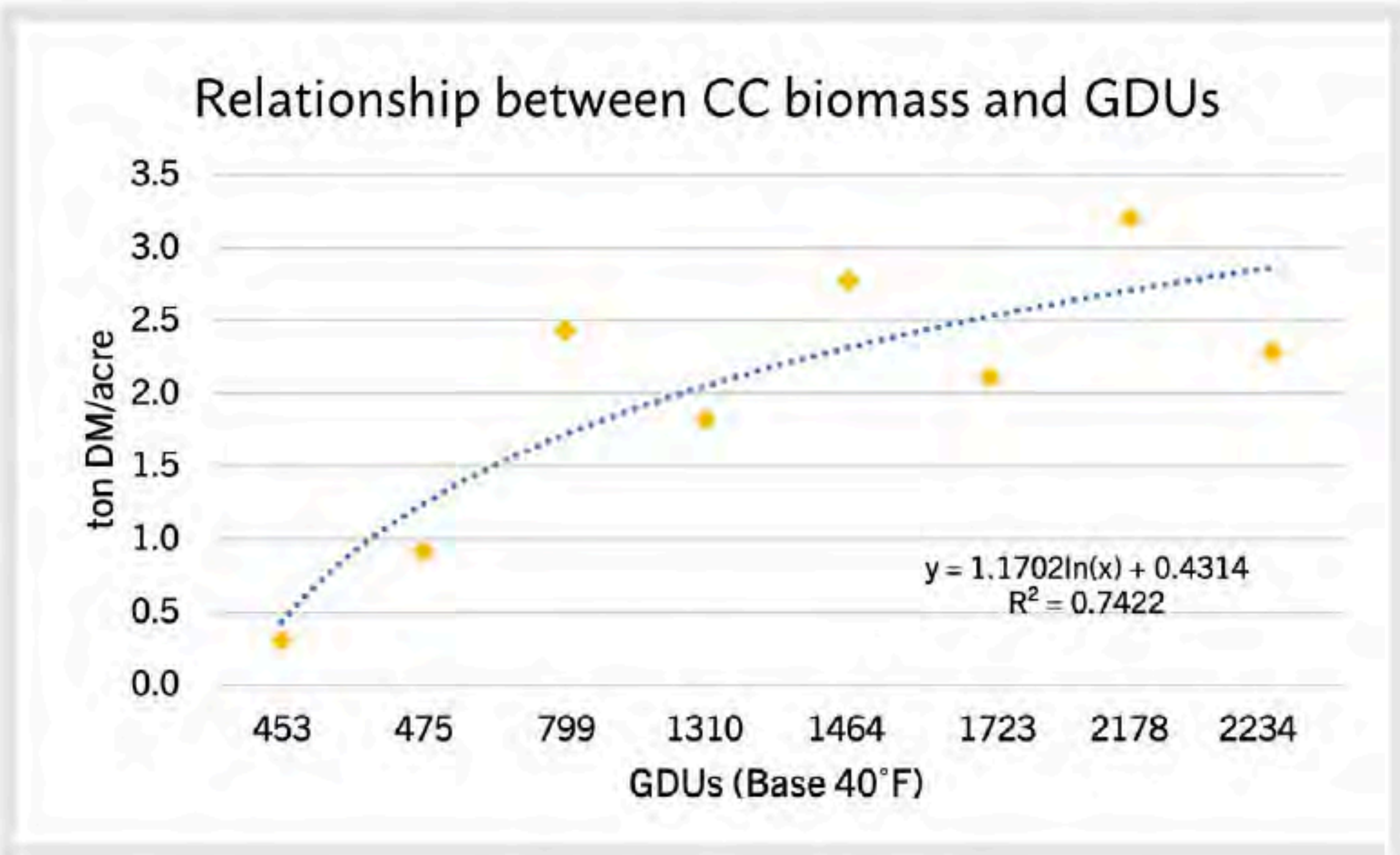
Challenges

- Results are very variable depending on soil, climate, management
- May cause more GHG emissions (N_2O, CH_4, CO_2) to put that C in the soil than the total stored
- Warming climate
- Reversable
- Time frames – C loss usually fast, while gains are slow
- Food production
- Who pays? Especially for land use change



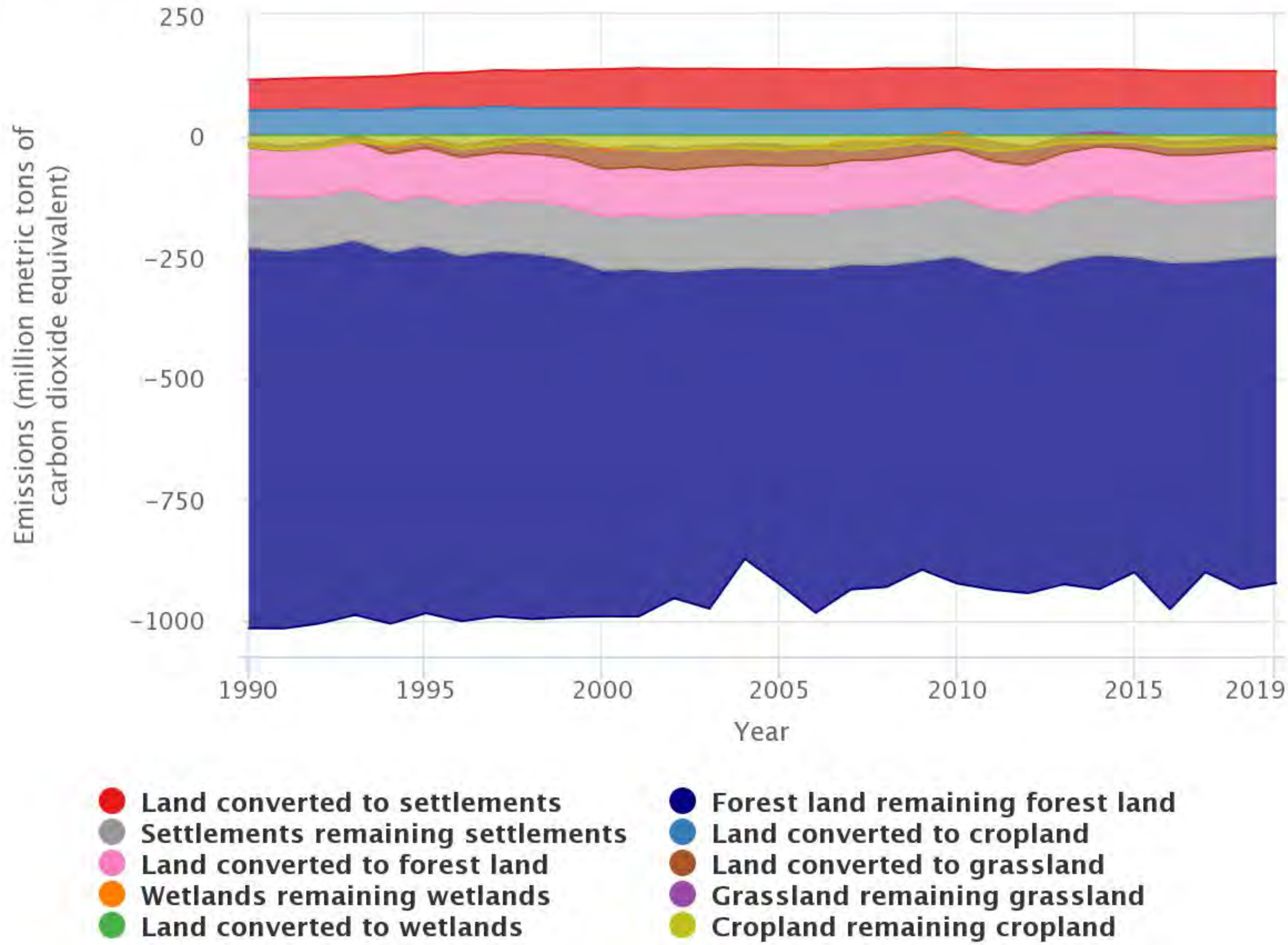
http://carbonfarmingsolution.com/carbon-sequestration-rates-and-stocks

Cover crops



Building Knowledge about Wisconsin's Cover Crops Farmer Research Project - 2020

U.S. Greenhouse Gas Emissions and Sinks from Land Use, Land-Use Change, and Forestry, by Category, 1990-2019



Source: U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019.
https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Policy ideas?

- Carbon payments?
- 30 x 30 goal: Land payments? Public lands?

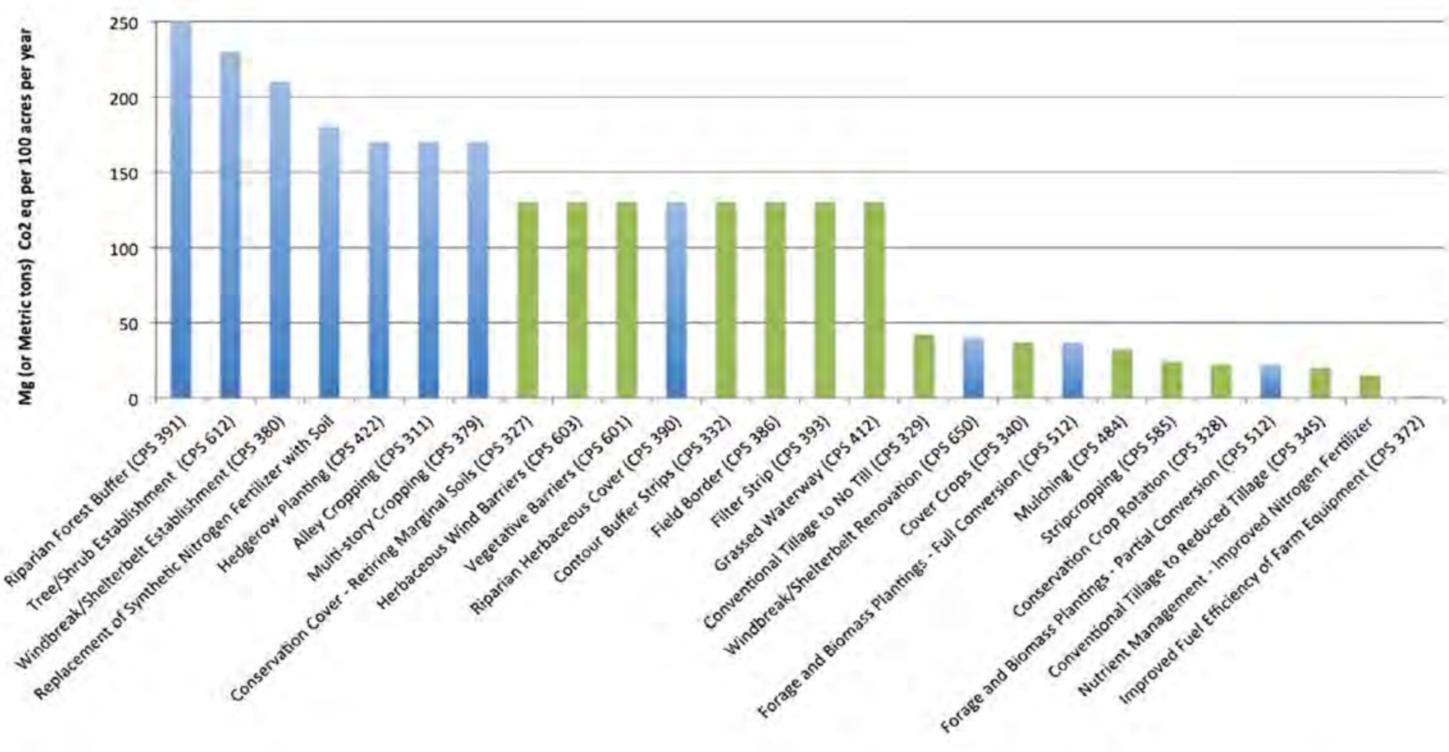


Figure 4. Soil Carbon Sequestration/Emissions Reduction Potential by Management Practice

Source: NRCS COMET-Planner (as excerpted from Biardeau et al., (2016).)


Questions? Comments?
Thank you!
Ruth McNair

Agriculture, Ecosystems and Environment

Soil carbon lost from Mollisols of the North Central U.S.A. with 20 years of agricultural best management practices

Gregg Sanford, Joshua Posner, Randall Jackson, Chris Kucharik, Janet Hedtcke, Ting-Li Lin

Carbon change 1989 - 2009

depth	Grazing	Forage system	No-till Corn-SB
0 - 15cm	6.5	−1.2	−2.7
15 - 30cm	−3.8	−1.9	−6.7
30 - 60cm	−1.1	−0.8	−1.9
60 - 90cm	−2.2	−2.9	−2.7
Total	**−0.6**	**−6.8**	**−14.0**

Opinion: Soil carbon sequestration is an elusive climate mitigation tool

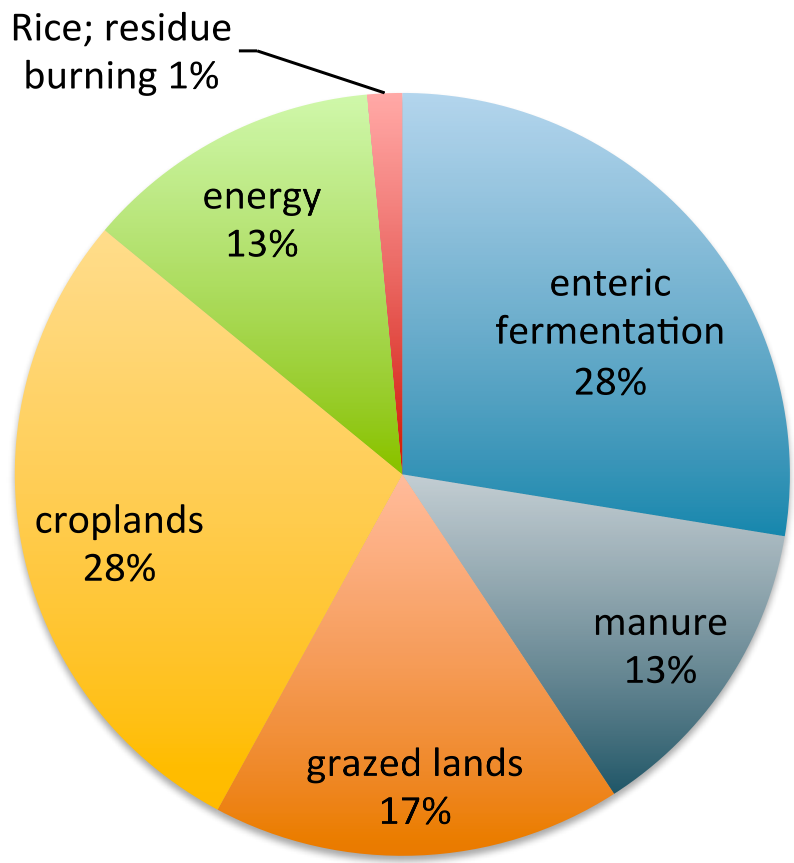
Ronald Amundson and Léopold Biardeau

PNAS November 13, 2018 115 (46) 11652-11656
https://doi.org/10.1073/pnas.1815901115

“We fully agree with soil carbon sequestration advocates that any carbon sequestered is a good thing, and soils can indeed regain some carbon. ***However, the promotion of this method to significantly alleviate our carbon dioxide imbalance is somewhat irresponsible and has political implications.*** The suggestion that soil carbon sequestration may be a “bridge” serves only as a reason to yet further delay action.”

Executive Order on Tackling the Climate Crisis at Home and Abroad

- Sec. 216. … the goal of conserving 30 percent of our lands and waters by 2030.
- Sec. 204. It is the policy of my Administration to lead the Nation's effort to combat the climate crisis by example — specifically, by aligning the management of Federal procurement and real property, public lands and waters, and financial programs to support robust climate action.



MMT CO_2 eq.			
		2000	2013
Grassland	Total	32.99	102.04
Grassland	CH_4	2.7	2.78
Grassland	N_2O	70.8	95.93
Grassland	CO_2	-40.51	3.33
Crops	Total	133.07	175.09
Cropland Soils	N_2O	141.8	167.78
Cropland Soils	CO_2	-18.76	-1.41

US Greenhouse Gas Emissions from Agriculture in 2013. Data from USDA

U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990–2013

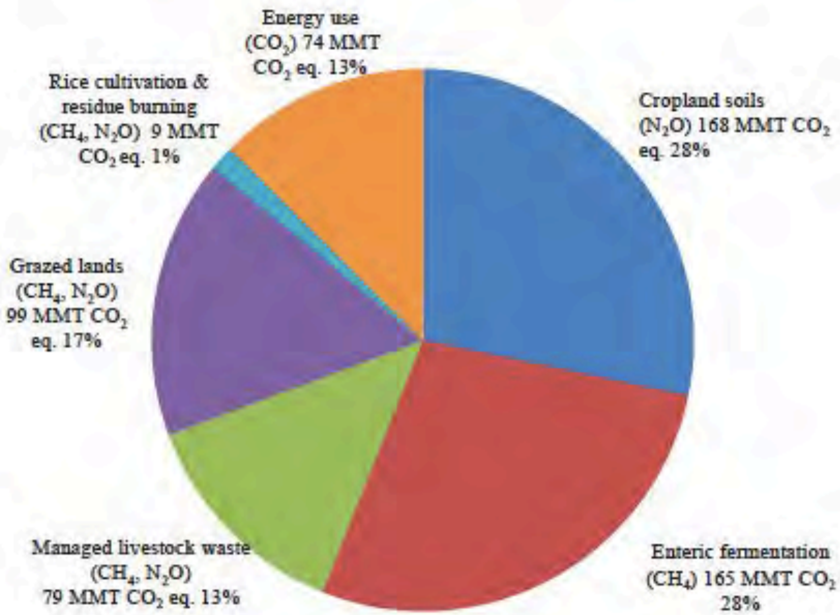


Figure 1-1 Agricultural Sources of Greenhouse Gas Emissions in 2013 *(CH_4 is methane; N_2O is nitrous oxide; CO_2 is carbon dioxide. MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)*

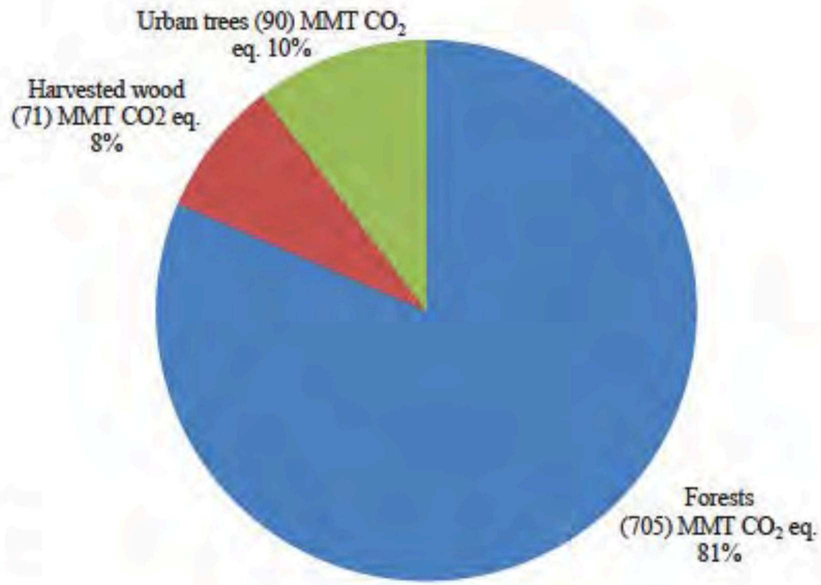


Figure 1-2 Agricultural and Forest Sinks of Carbon Dioxide in 2013 *(MMT CO_2 eq. is million metric tons of carbon dioxide equivalent)*

Net emissions from Agriculture ~ 418 MMT

Net C uptake from forests ~ 700+ MMT

US Agriculture and Forestry Greenhouse Gas Inventory 1990 – 2013

Necessary, but not sufficient

		1990	1995	2000	2005	2010	2011	2012	2013
Source		MMT CO2 ec	MMT CO2 ec	MMT CO2 ec	MMT CO2 ec	MMT CO2 ec	MMT CO2 ec	MMT CO2 ec	MMT CO2 eq
Livestock	Total	215.11	236.9	236.95	241.62	249.07	247.44	247.37	243.23
Enteric Ferm	CH4	164.15	178.65	170.59	168.87	171.1	168.74	166.34	164.53
Managed Wa	CH4	37.15	43.28	50.01	56.34	60.92	61.42	63.71	61.39
Managed Wa	N2O	13.8	14.96	16.34	16.41	17.05	17.27	17.33	17.31
Grassland	Total	73.94	93.62	32.99	82.94	101.55	101.36	100.7	102.04
Grassland	CH4	2.73	2.95	2.7	2.7	2.6	2.56	2.5	2.78
Grassland	N2O	80.53	90.33	70.8	85	96.15	95.99	95.45	95.93
Grassland	CO2	-9.32	0.34	-40.51	-4.77	2.8	2.81	2.75	3.33
Crops	Total	117.03	161.54	133.07	164	174.7	172.99	177.1	175.09
Cropland Soi	N2O	143.48	158.24	141.8	158.61	168.11	169.8	170.5	167.78
Cropland Soi	CO2	-36.03	-6.89	-18.76	-3.86	-4.89	-5.69	-3.1	-1.41
Rice Cultivati	CH4	9.16	9.81	9.62	8.95	11.1	8.47	9.29	8.3
Residue Burr	CH4	0.32	0.28	0.31	0.22	0.29	0.3	0.3	0.31
Residue Burr	N2O	0.1	0.09	0.1	0.08	0.1	0.1	0.1	0.1
Energy Use	CO2	73.92	73.92	73.92	69.85	72.71	73.28	73.85	74.42
Forestry	Total	-699.83	-728	-563.2	-887.6	-851.5	-856.13	-860.65	-865.18
Forests	CO2	-507.66	-542	-376	-704	-705	-704.91	-704.91	-704.91
Harvested W	CO2	-131.77	-118	-113	-103	-60.5	-63.92	-67.34	-70.77
Urban Trees	CO2	-60.4	-67.1	-73.8	-80.5	-86.1	-87.3	-88.4	-89.5
Net Emission	All GHGs	-219.83	-162	-86.2	-329.2	-253.5	-261.06	-261.63	-270.4

US Agriculture and Forestry Greenhouse Gas Inventory 1990 – 2013

Drawdown: Regenerative agriculture

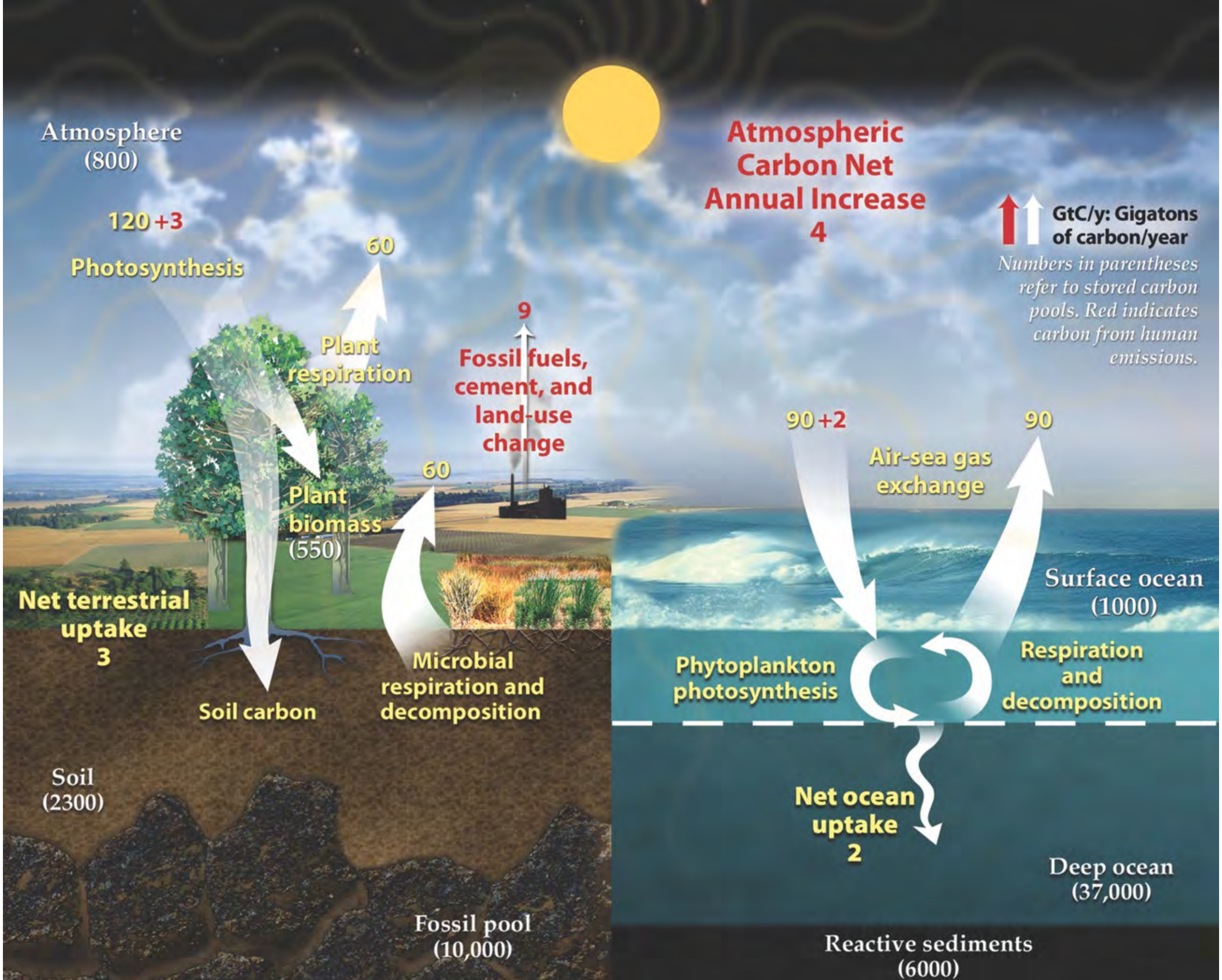
#11

RANK AND RESULTS BY 2050

23.15 GIGATONS
REDUCED CO_2

$57.22 BILLION
NET IMPLEMENTATION COST

$1.93 TRILLION
NET OPERATIONAL SAVINGS



DOE Genomic Science program https://genomicscience.energy.gov

Carbon sequestration in agricultural soils via cultivation of cover crops – A meta-analysis

Christopher Poeplau [a,b,*], Axel Don [a]

"The predicted new steady state was reached after 155 years of cover crop cultivation with a total mean SOC stock accumulation of 16.71.5Mg /ha for a soil depth of 22 cm. Thus, the C input driven SOC sequestration with the introduction of cover crops proved to be highly efficient. We estimated a potential global SOC sequestration of 0.120.03 Pg C/yr, which would compensate for 8% of the direct annual greenhouse gas emissions from agriculture."

Challenges

- Good management does not always increase carbon throughout soil profile
- May take more GHG emissions (N_2O, CH_4, CO_2) to put that C in the soil than the total stored
- Warming climate
- Reversable
- Time frames
- Food production
- People – who pays, especially for land use change

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https://www.agriculture.com/crops/conservation/how-to-tweak-a-long-term-no-till-system