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The benefits of carbon-farming and carbon market

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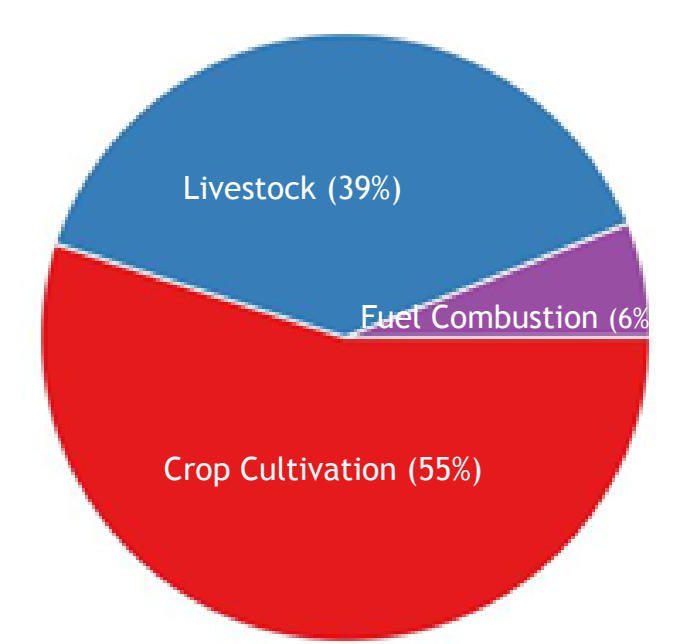
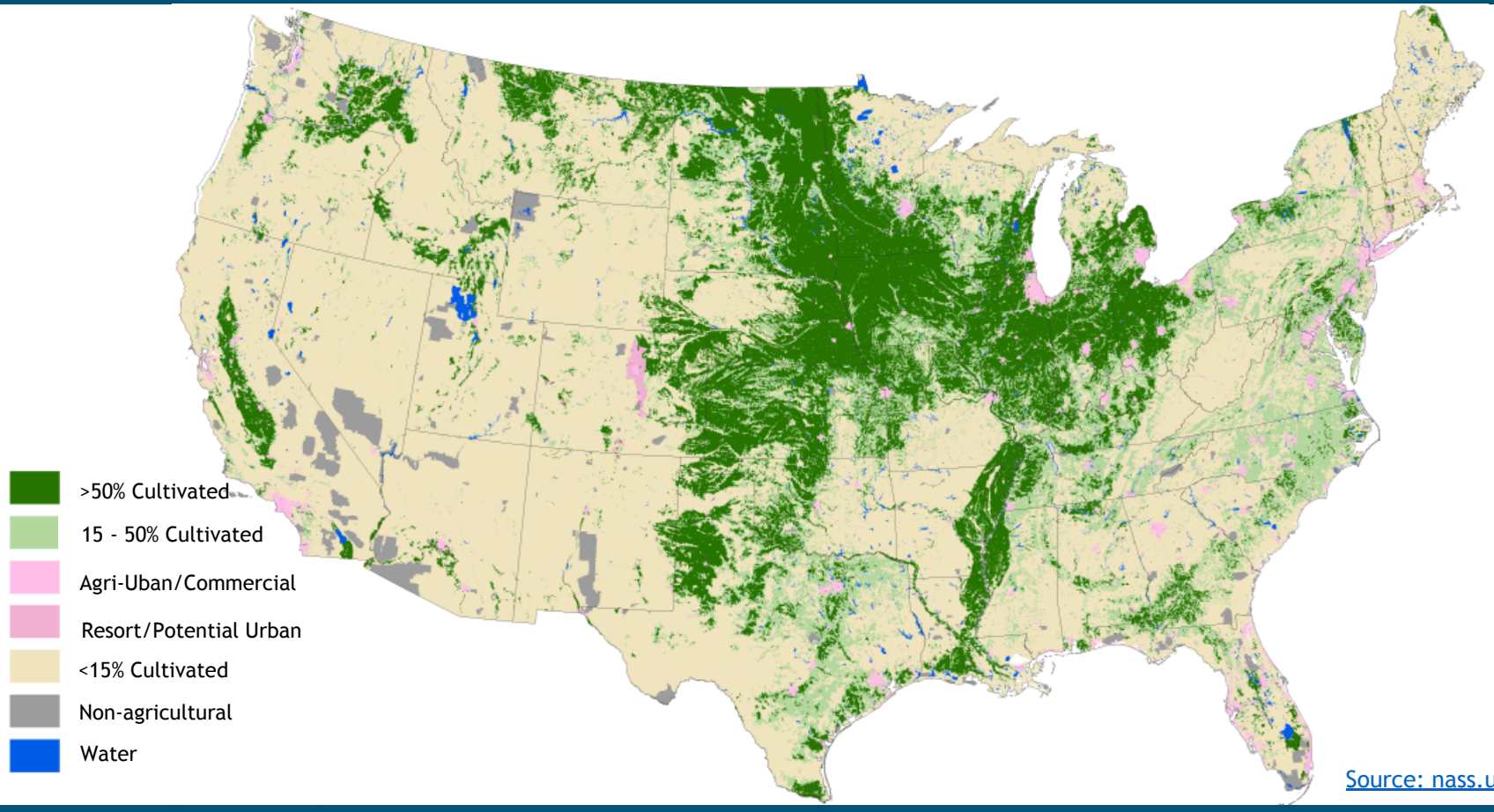
Background

- Global agriculture and land use emissions in 2018 was 9.3 Billion tons of CO_2e i.e. 17% of total GHG emissions(FAO, 2018)
- U.S. Agriculture –10% of total U.S. emissions of 6558 million Mtons. Agricultural emissions - approximately 655.8 million Mtons (EPA, 2019)



Source: (US EPA, 2019)

Background



Source: nass.usda.gov

- 922 million acres of cropland, pasture and range & 2 million farms in the U.S. (USDA).
- Carbon farming practices can sequester 0.3 to 2.8 MT CO_2e ha^{-1} yr^{-1} (based on 12 studies)
- Total mitigation potential of U.S. Agriculture: 105 $TgCO_2e$ at \$40/$MTCO_2e$ and 40$TgCO_2e$ at \$15/$MTCO_2e$ (Pape et al., 2016)
- Carbon-farming has potential for reducing GHG emissions and adapting to climate change (Bradford et al., 2019; Chenu et al., 2019; Paustian et al., 2019)

Carbon Farming Activities & Options

Crop Production Systems

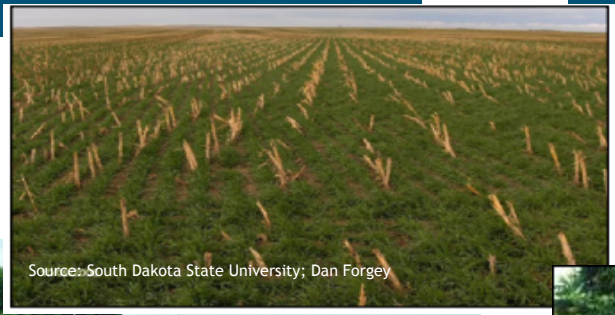
- Cover Crops
- Crop rotation
- Field Management practices
  - No Tillage
  - Fertilizer application rate, timing, inhibitor application, variable rate technology)

Animal Production Systems

- Anaerobic digester & biogas
- Lagoon
- Grazing Land Management
- Legume inter-seeding

Land Retirement Systems

- Cultivated land to conservation
- Marginal land to conservation or bioenergy crops
- Wetlands restoration
- Windbreaks
- Riparian forest buffers


Source: South Dakota State University; Dan Forgey


NRCS, USDA

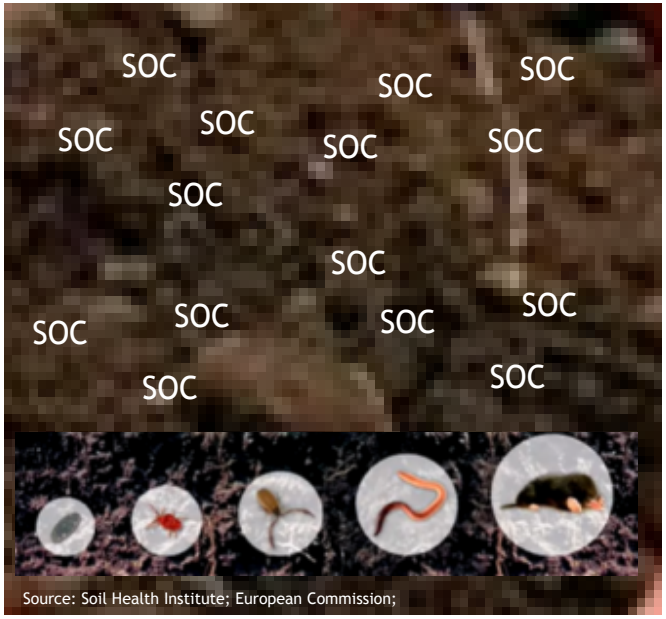

Source: USDA

Source: Built on ICF, 2013

Carbon Farming Pathways

Some generalized carbon pathways for cropland (Chenu et al., 2019; Paustian et al., 2019; Mattila et al., 2022)

i. Improving soil structure
ii. Increasing soil biological activities
iii. Increasing photosynthesis duration / intensity
iv. Managing organic soils for carbon storage



Carbon Market

Carbon market

- Potential value of carbon:$5.2 billion (Agribusiness Consulting, 2018)
- Potential volume of carbon:190 million MT. (AC, 2018)
- Total supply of carbon credits: 326 million MT CO_2e (AC, 2018)
- Marketing platforms NORI, Ecosystem Service Market Consortium

Carbon market : Demand and Supply of Carbon Credits

Demand

Potential Demand >100 companies

- Food and Beverage 57% of total demand
- Energy companies
- Industries
- Chemical, fertilizer and other materials
- Information and Telecommunications
- Utilities
- Financial
- Consumer discretionary

Supply

Potential supply

Field Crops:195 million MT CO_2 e

Fruits, Vegetables, Nuts : 13 million MT CO_2 e

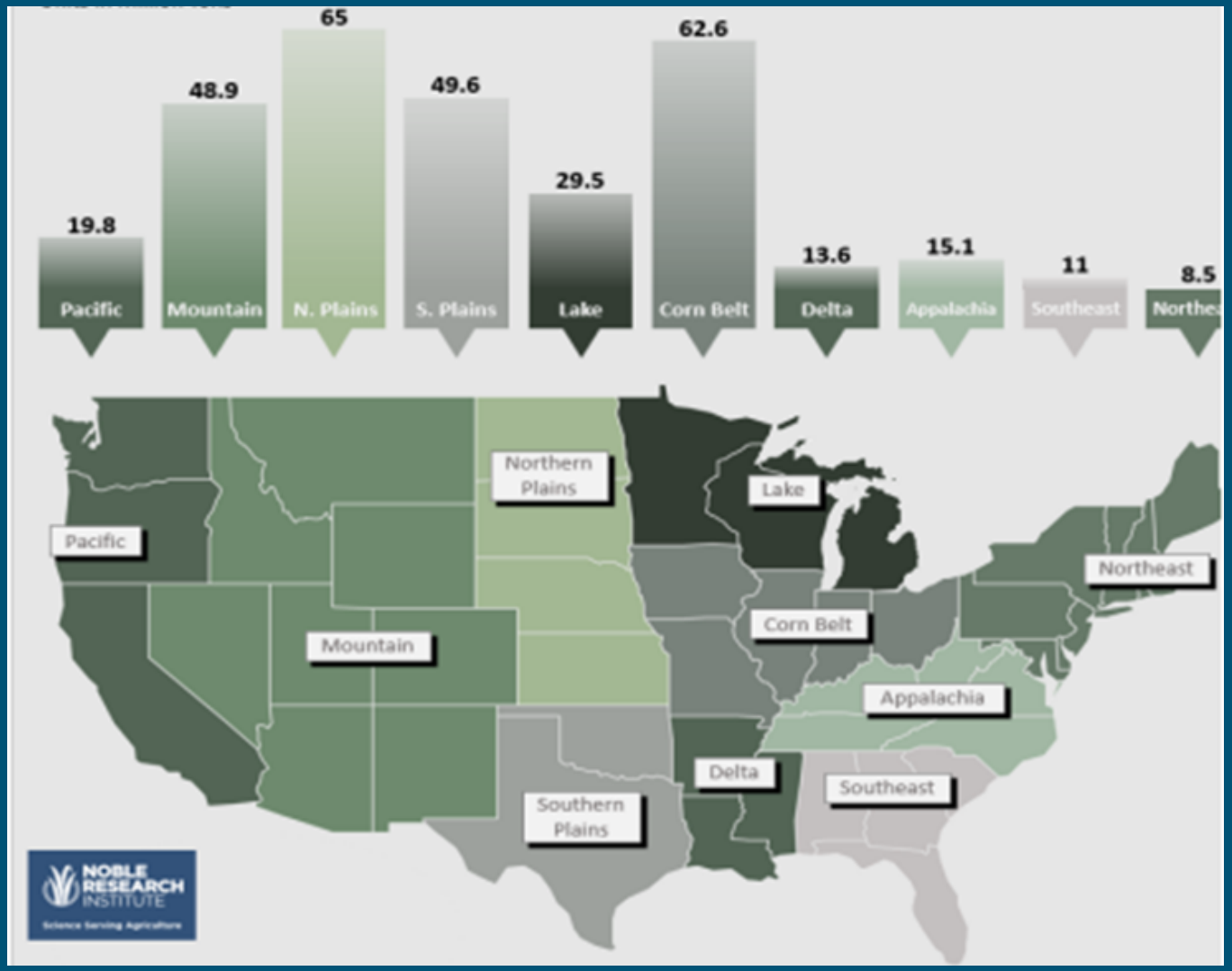
Pasture: 32 million MT CO_2 e

Rangeland: 84 million MT CO_2 e

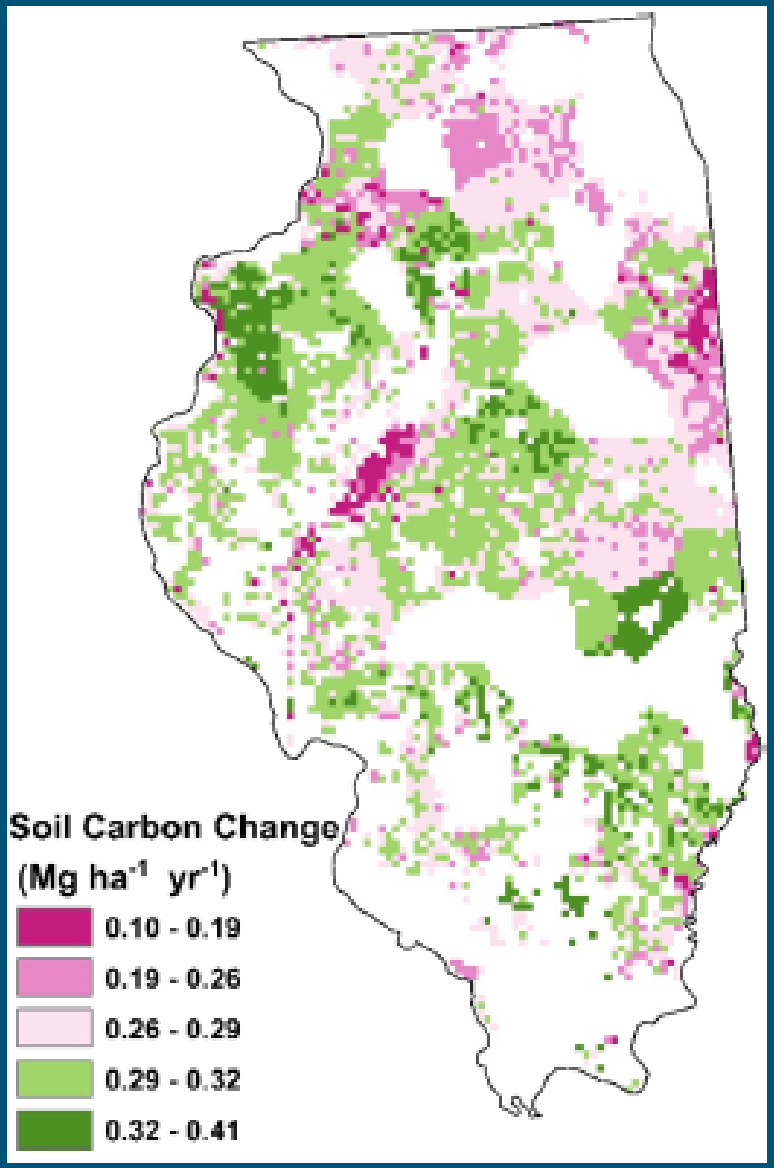
Total: 326 million MT CO_2 e

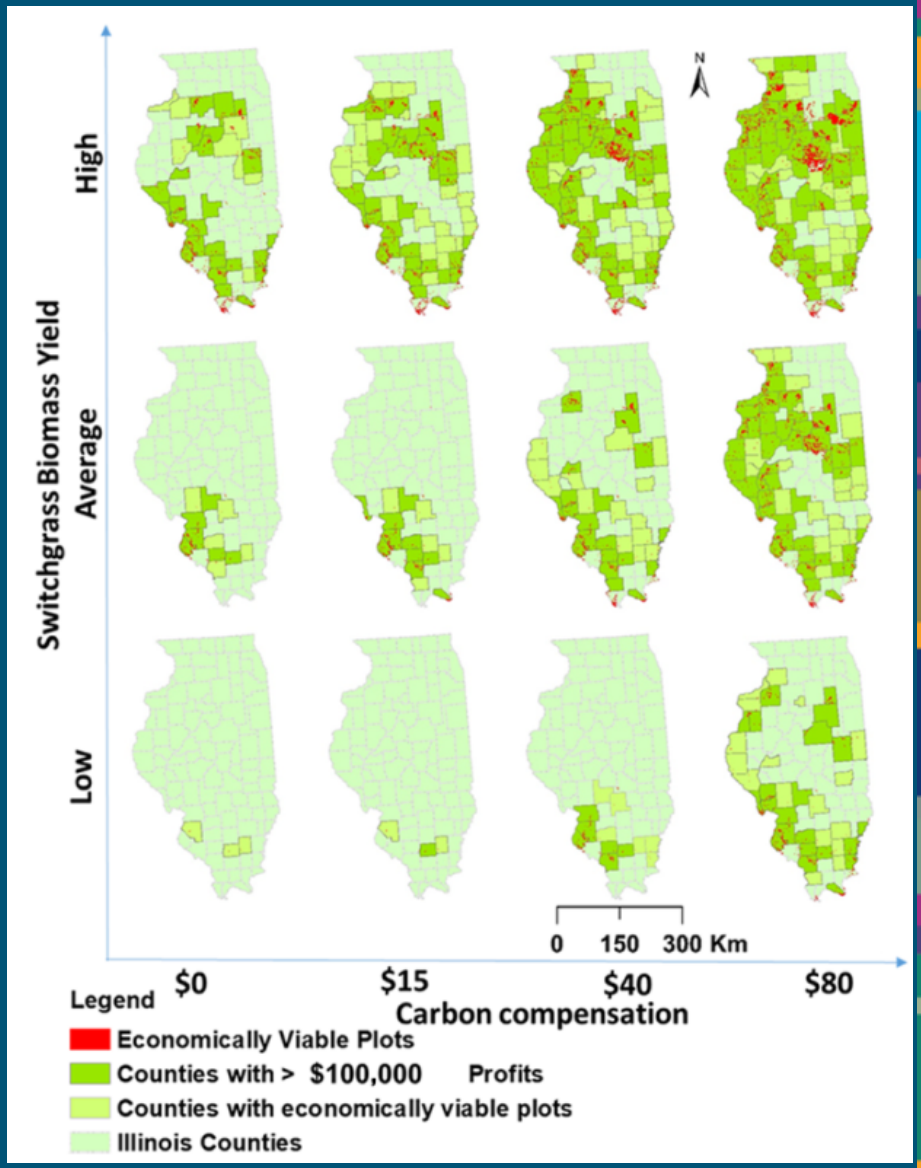
Source: Informa

Carbon Market: Potential Carbon Sequestration (million Metric Tons)



Carbon Sequestration Potential





$0: 3000 – 28,000 ha; $15: 6000 – 39,000 ha; $40 - $80: 13,000- 128,000 ha. (Source: Mishra et al. 2021)

Carbon Market: Potential Carbon Sequestration ('000 Metric Tons)

Region	Field Crops	Fruit, Vegetable & Tree Nuts	Pasture	Rangeland	Total
Northeast	5,581	1,204	1,743	0	8,528
Lake States	25,374	1,495	2,652	0	29,520
Corn Belt	56,446	344	5,799	13	62,602
Northern Plains	46,730	174	2,151	16,414	65,469
Appalachia	9,977	427	4,671	0	15,075
Southeast	5,501	2,050	2,809	686	11,046
Delta	10,561	129	2,852	60	13,603
Southern Plains	18,475	497	6,660	24,551	50,183
Mountain	11,798	754	1,982	35,474	50,008
Pacific	5,488	6,180	1,018	7,279	19,965
United States	**195,931**	**13,255**	**32,337**	**84,477**	**326,000**

Source: Informa Agribusiness consulting

Carbon market: Mechanisms for compensating farmers

- Carbon credits based on cap and trade
- Payment of carbon maintenance
- Payment for Ecosystem Services

Pricing Carbon : Breakeven prices

Potential breakeven prices for converting from conventional till to No-Till (in $/tCO$_2$e)

Crop	Northern Plains	Mountain	Southern Plains	Delta	Lake	Pacific	Corn Belt	Appalachia	Northeast
Soybeans	<$0		$3	$23	$17		$32	$114	$104
Corn	$18	$1	$14	$16	$22	$20	$34	$42	$44
Sorghum	$26	$18	$27	$27			$74		
Wheat	$39	$16	$44	$17	$47	$106	$57	$57	$58
Cotton		$136	$93	$141			$324		
Average	**$21**	**$43**	**$36**	**$45**	**$29**	**$63**	**$104**	**$71**	**$69**

Source: ICF International , NRCS/USDA Informa

Pricing Carbon : Breakeven prices

Potential breakeven prices for 10% reduction in nitrogen fertilizer application rate

Low Emissions Reduction Scenario		
Region	Crop Type	Break-Even Price (2010 $/ mt CO_2-eq)
Mountain	Corn	<$0[a]
Delta	Sorghum	<$0
Appalachia	Wheat	<$0
Northeast	Wheat	<$0
Corn Belt	Wheat	$17
Southeast	Corn	$64
Lake States	Corn	$124
Delta	Wheat	$133
Lake States	Wheat	$135
Southeast	Wheat	$135
Corn Belt	Corn	$174
Corn Belt	Sorghum	$175
Delta	Corn	$180
Northern Plains	Soybeans	$189
Appalachia	Corn	$194
Northeast	Corn	$215
Northern Plains	Wheat	$429
Southern Plains	Corn	$492
Southern Plains	Wheat	$545
Northern Plains	Corn	$652

High Emissions Reduction Scenario		
Region	Crop Type	Break-Even Price (2010 $/ mt CO_2-eq)
Mountain	Corn	<$0
Delta	Sorghum	<$0
Appalachia	Wheat	<$0
Northeast	Wheat	<$0
Corn Belt	Wheat	$2
Corn Belt	Sorghum	$11
Lake States	Corn	$17
Southeast	Corn	$17
Delta	Wheat	$18
Southeast	Wheat	$18
Lake States	Wheat	$18
Appalachia	Corn	$26
Northeast	Corn	$28
Corn Belt	Corn	$32
Delta	Corn	$48
Southern Plains	Corn	$65
Southern Plains	Wheat	$72
Southeast	Cotton	$126
Delta	Cotton	$295
Northern Plains	Wheat	$796

(Source: ICF, 2013)

Pricing Carbon : Breakeven prices

Breakeven prices for Land Retirement practices

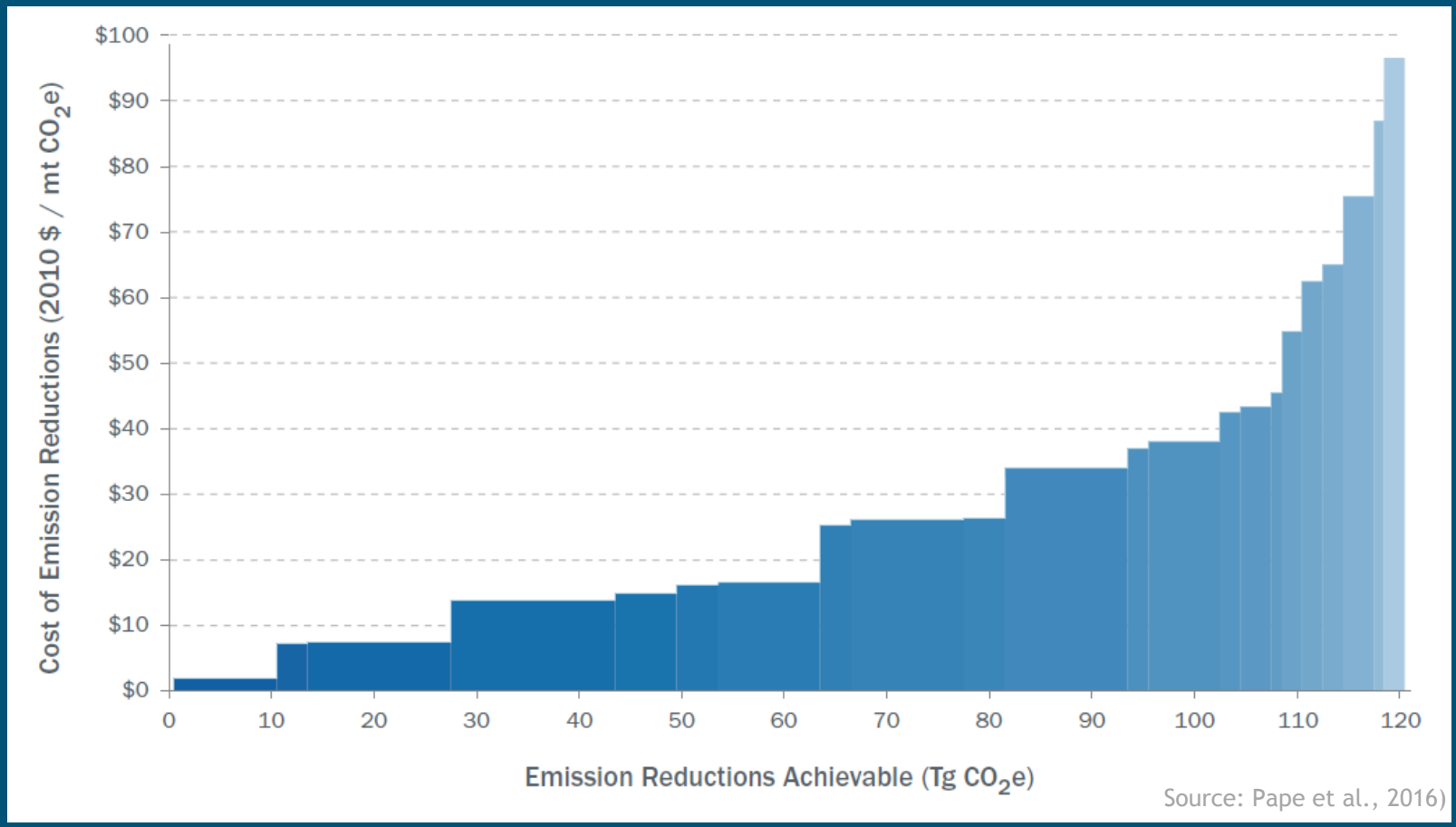
Practice	Crop Type	Breakeven Price (2010 $/mt CO_2-eq)
Retiring cultivated organic soils to permanent grassland[5,7]		$11
Retiring marginal soils to permanent grassland[5]		$24
Restoring forested wetlands[5]		$24
Restoring grassy wetlands[5]		$63
Establishment of wind breaks[5]		$17
Restoring riparian forest buffers[5]		$49
Retiring cultivated organic soils to permanent grassland[6,7]		$16
Retiring marginal soils to permanent grassland[6]		$144
Restoring forested wetlands[6]		$36
Restoring grassy wetlands[6]		$94
Establishment of wind breaks[6]		$97
Restoring riparian forest buffers[6]		$72

Source: UIUC, 2020; IFS, 2013

Costs per MT CO_2e . No Till - $33. Crop Rotation - $32. Cover Crops - $184 (ICF, 2013)

Marginal Abatement cost curve

(for breakeven prices less than $100/MTon$CO_2e$)



Source: Pape et al., 2016)

Carbon market : Pricing Carbon

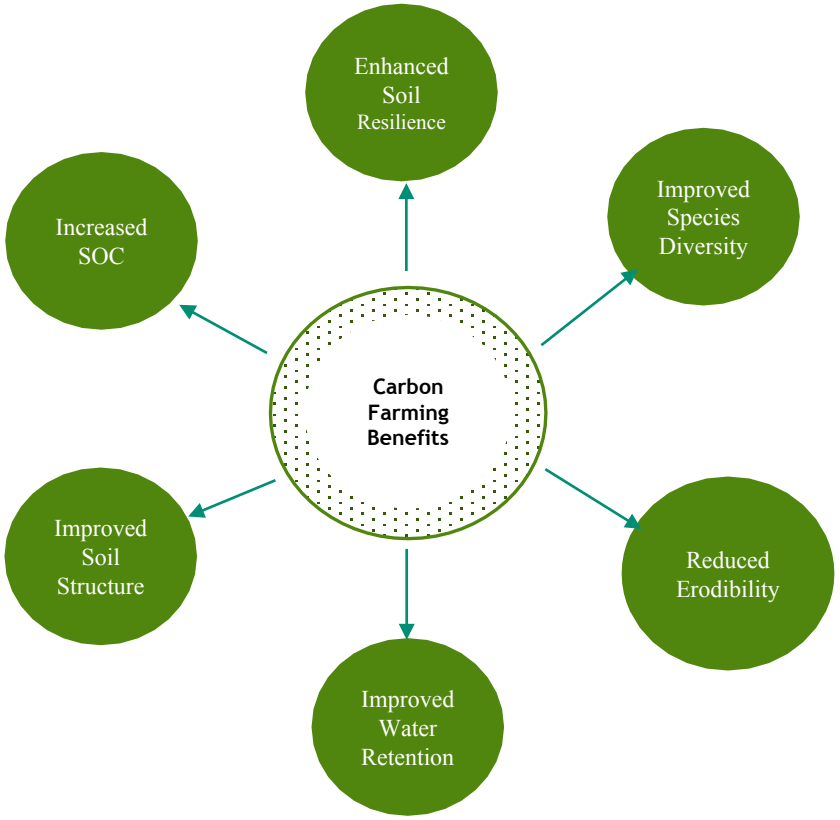
- Marginal abatement costs for all U.S. farms ranges from $1 to $ 100/Mton CO_2e (Pepe et al., 2018)
- Payment for carbon farming in the US - $12 to $500/Mton CO_2e(Antle et al., 2007)
  - Quantity of carbon sequestered,
  - Type of contract or payment mechanism used, and
  - Site specific characteristics of the areas.
- The high level commission of carbon prices estimated that the carbon prices be at least $40-80 per MT CO2e in 2020 and $50-$100 per MTCO_2e in 2030 in order to cost effectively reduce GHGs emissions (World Bank, 2020)
- There are more than 61 carbon pricing initiatives; Sweden and Switzerland @ >$100/MT CO_2e
- In the U.S., California's Low carbon fuel standard (LCFS) credit market @ $222/MT CO_2e, direct capture system @ $180/MT CO_2e (California Air Resource Board)
- The market price for carbon farming are @ $15/MT/$CO_2e$ (NORI)

Benefits of Carbon Farming

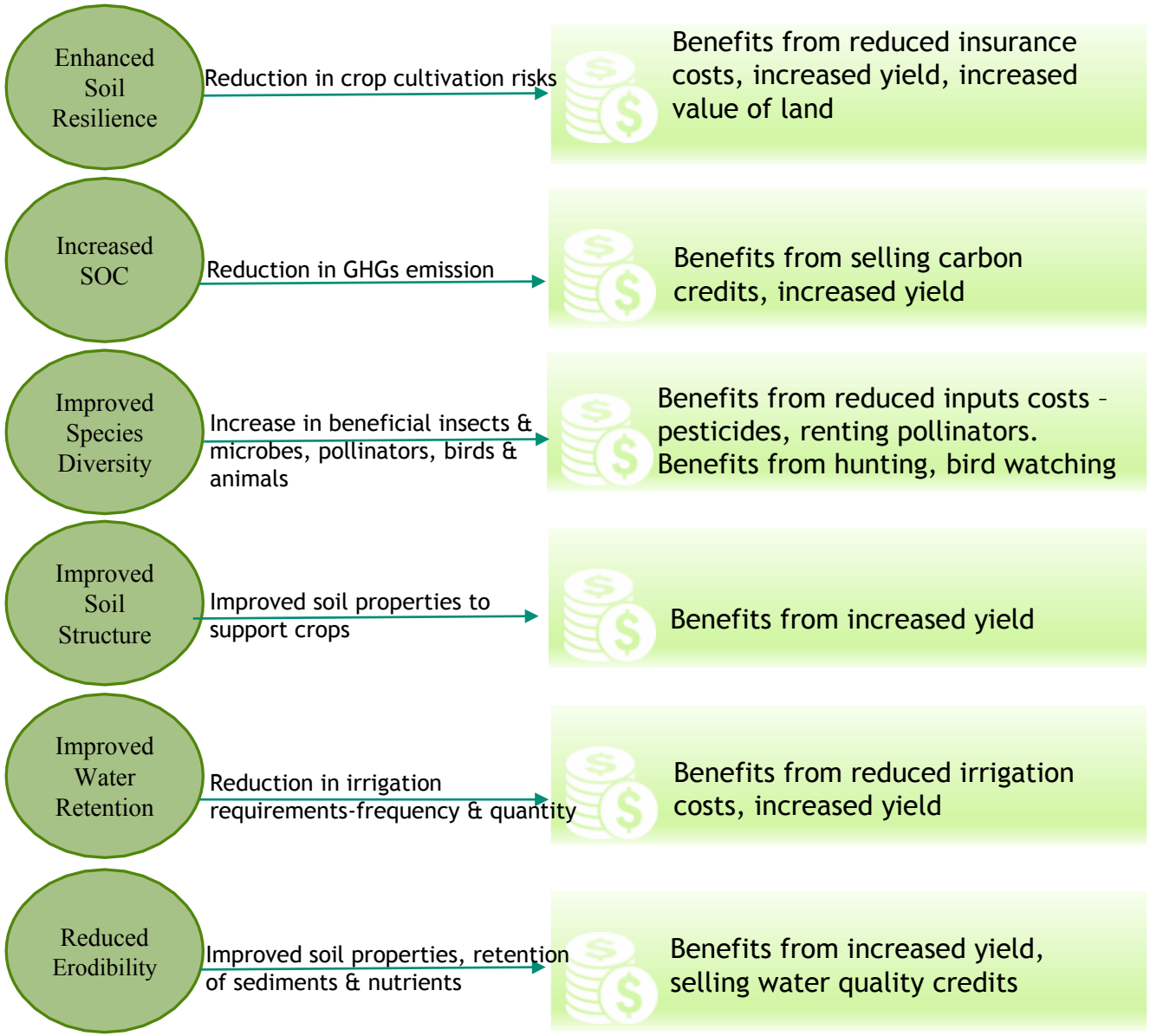
Threats to soil health

(Source: FAO and ITPS, 2015; World Bank, 2021)

Benefits to soil health



Valuation of Carbon Farming Benefits



Potential Welfare Implications

- Contribution to climate change mitigation
- Increased farmers' cash flow
- Increased surplus income for education, health & well being
- Increased food production & nutrition
- Decarbonization via bio-energy & bioproducts

Value of Ecosystem Services
Converting marginal land under corn/soy to switchgrass

Studies on Ecosystem Services valuation attributed to land use change										
Region of Studysite	Year	Soil carbon sequestration	Sediment reduction	Nitrate reduction	Water-based Recreation	Biodiversity				References
						Pollinators	Pest Control	Birds Watching	Hunting	
Chesapeake Bay	2018			$13.29 kg^{-1}						[37]
Chesapeake Bay	2019			$13-14/kg						[38]
US Northern Plains	2007	$12-500/MgC								[49]
Illinois	2019	$61.07/ha/ year	$4.35/Mg	$38.37/kg	$3.45-8.21/ha	NA		$42.36/ha	$9.97/ha	[8]
Dwight, Illinois	2020	$43-115/ha	$3-5/Mg	$13-30/kg	$6-8/ha	$24-85/ha	$46/ha	$11/ha	$10/ha	This study

(Baral et al., under internal review)

Value of Ecosystem Services

Converting marginal land under corn/soy to switchgrass

Ecosystem Service	2016 Dollars
Nitrate reduction	$38.37 per kg nitrate
Sediment reduction	$4.35 per Mg
Carbon dioxide emission reduction	$36.70 to $79.27[a] $61.07 per ha per year[b]
Recreational value	
Water-based recreation	$3.45 to $8.21 per ha
Wildlife viewing	$42.36 per ha
Pheasant hunting	$9.97 per ha

Mishra et al, 2019; Mishra et al., 2021

Carbon Market Challenges

Net profitability of carbon farming depends upon

- price of carbon,
- cost of implementation CF activities in the farm,
- loss of productivity,
- data costs for measuring carbon increment and
- transaction fees

<u>Some challenges include</u>

1. Accurate quantification of carbon credits generated
2. Carbon credits pricing
3. Trade barriers
4. Monitoring and verification

Source: ESMC Report, 2018

Summary

- Carbon market in the U.S. is valued at $5.2 billion U. S. dollars with a potential demand of 190 million MT and a potential supply 326 million MT CO_2e.
- U.S. Agriculture has total carbon mitigation potential of 105 $TgCO_2e$ at $\$40/CO_2e$. At $15/CO2e, it decreases to 40TgCO2e
- Challenges of carbon market quantification of carbon credits generated, pricing, trade barriers, monitoring and verification
- In order to attain decarbonization, the carbon prices should be at least $40-80 per MT CO_2e in 2020 and $50-$100 per MT CO_2e in 2030
- Carbon price in the existing market ranges from $5 to $15 per MT CO_2e.
- Carbon sequestration benefit is only one of the multiple benefits from carbon farming. Monetization and internalization of additional benefits of carbon farming:
  - increased yield,
  - increased value of land,
  - reduced insurance costs,
  - recreational benefits from hunting, bird watching,

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Acknowledgement

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