

Benefits and Costs of Maine's Natural Climate Solutions Part 1: Agriculture

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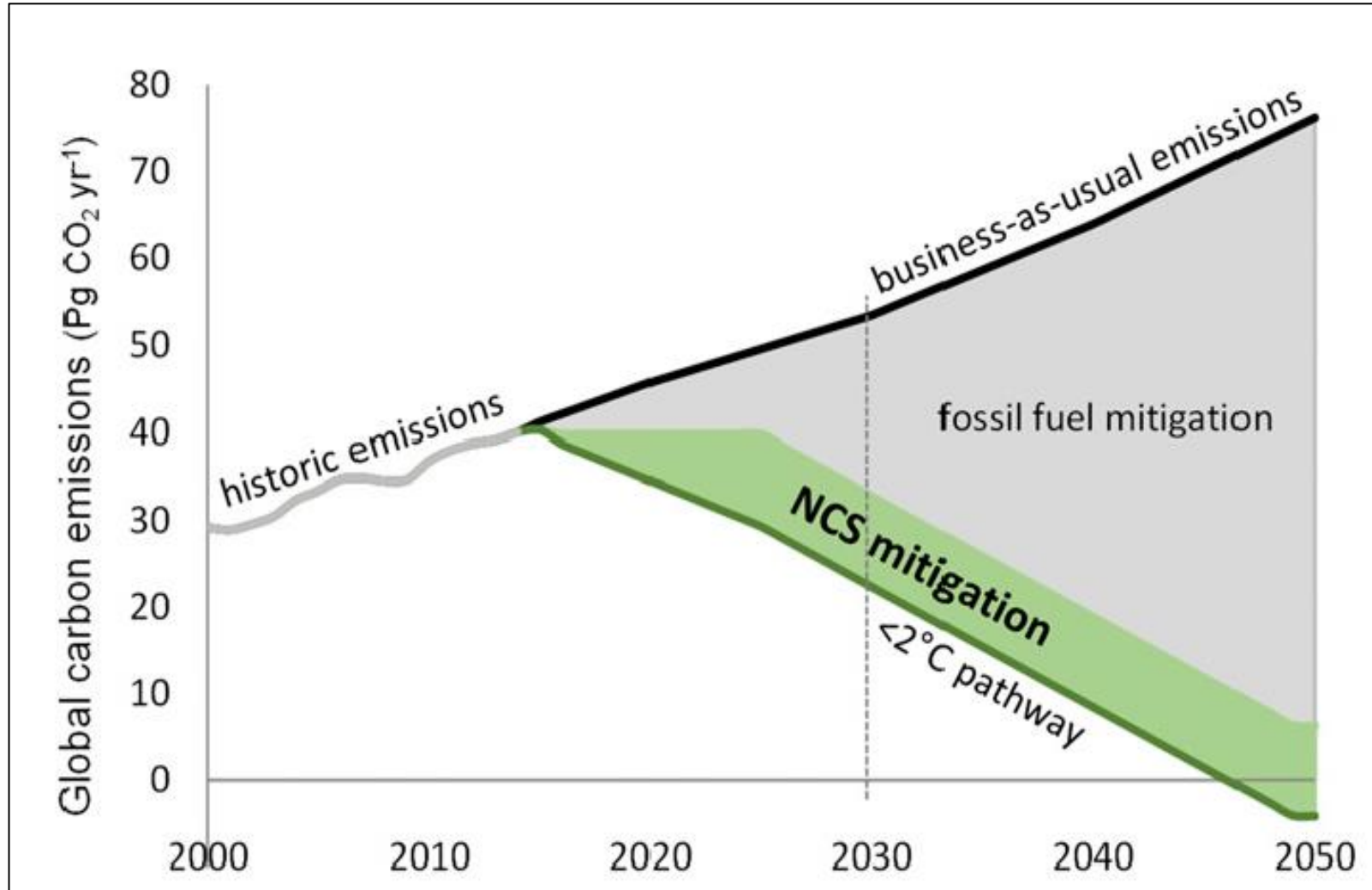


What are “Natural Climate Solutions”?

Any action that **conserves**, **restores** or improves the use or **management** of forests, wetlands, grasslands, and agricultural lands, while simultaneously **increasing carbon storage** or **avoiding greenhouse gas emissions**.

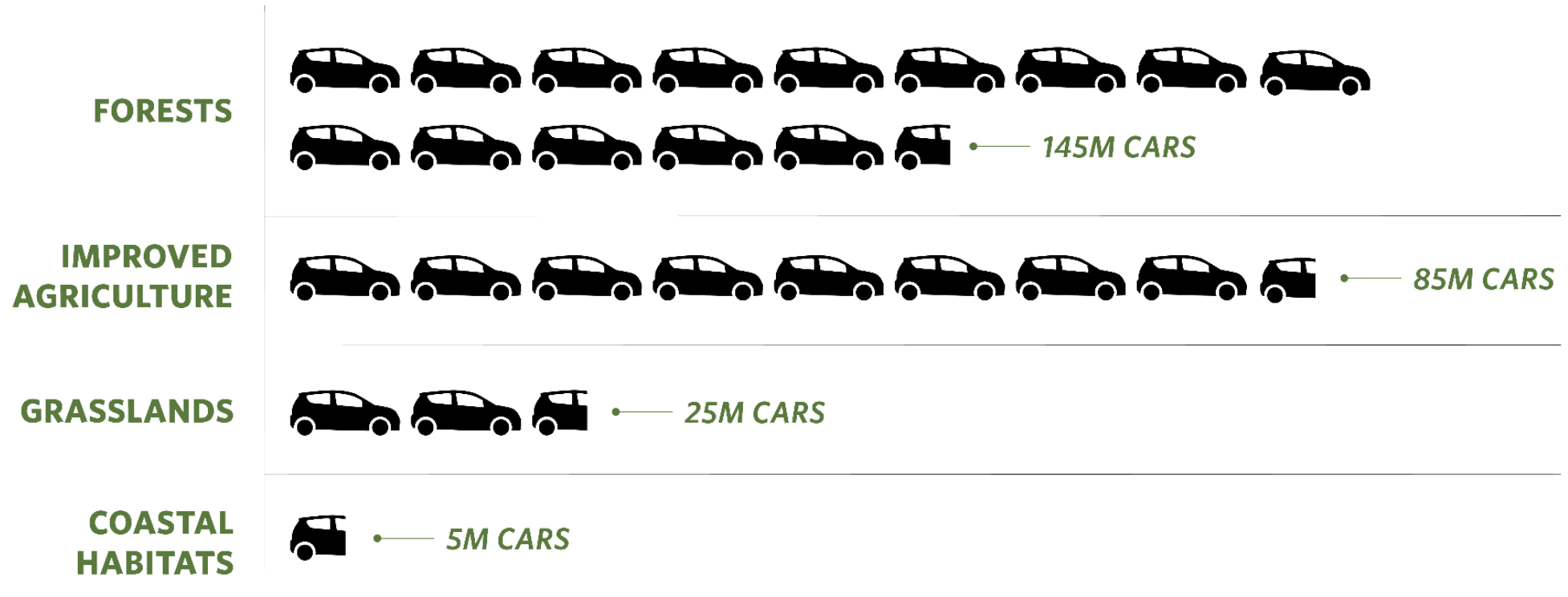


Globally, Natural Climate Solutions (NCS) are expected to contribute to at least 20% of the Paris Agreement's aggregate reduction target



NATURAL CLIMATE SOLUTIONS

In the U.S., nature has potential to remove **21% of the nation's carbon pollution**—equivalent to removing emissions from **ALL cars and trucks on the road**...and then some.

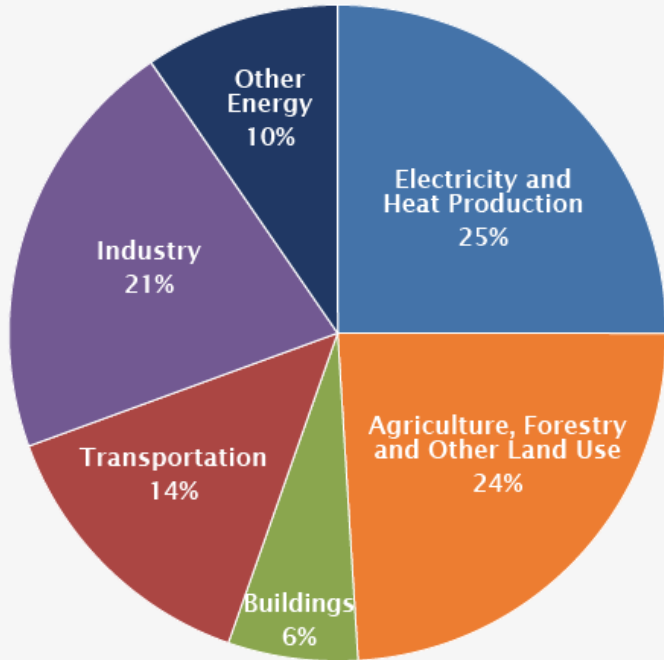


U.S. Mitigation Potential: Approximate Number of Cars Removed Each Year in Millions

 = 10M cars

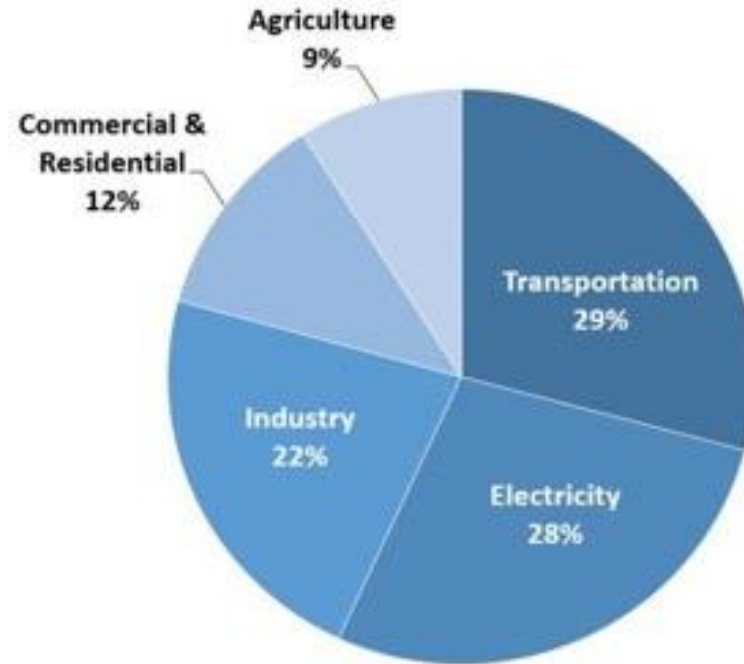
But, Agricultural and Land Use Greenhouse Gas (GHG) emissions vary depending on where and what you measure...

Total Global GHG Emissions by Economic Sector in 2014



Global: 24% total

Total Global GHG Emissions by Economic Sector in 2017



US: 9% total

Total Maine GHG Emissions by Source Category in 2017

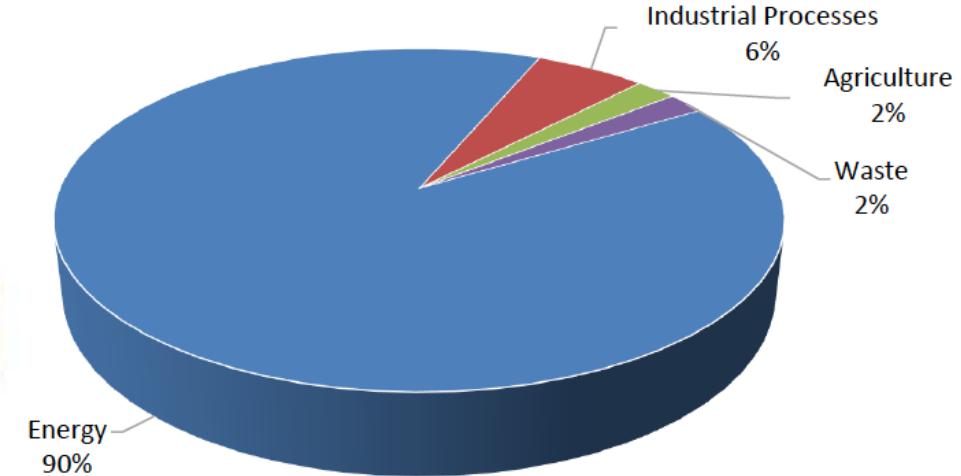


Figure 2. Emissions by source category for 2017 (data in Appendix A)

Maine: 2% total

Maine has seen 30% drop in agricultural GHG emissions since 2004...

Table A2. Maine's greenhouse gas emissions in MMTCO₂e (2004 - 2017)

Sector	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Energy	24.33	23.33	21.42	21.08	19.22	18.44	18.20	17.68	15.99	16.73	16.78	16.98	16.60	15.73
Industrial Processes	1.26	1.28	1.31	1.35	1.27	1.08	0.91	0.97	0.95	0.98	1.06	1.02	1.03	1.04
Agriculture	0.54	0.58	0.60	0.59	0.60	0.56	0.49	0.43	0.44	0.42	0.39	0.39	0.38	0.38
Waste	0.40	0.42	0.43	0.37	0.32	0.32	0.35	0.35	0.36	0.36	0.36	0.35	0.36	0.36
Gross Emissions	26.53	25.61	23.76	23.40	21.41	20.39	19.95	19.43	17.73	18.49	18.58	18.74	18.37	17.51

...and a 34% reduction in Gross GHGs

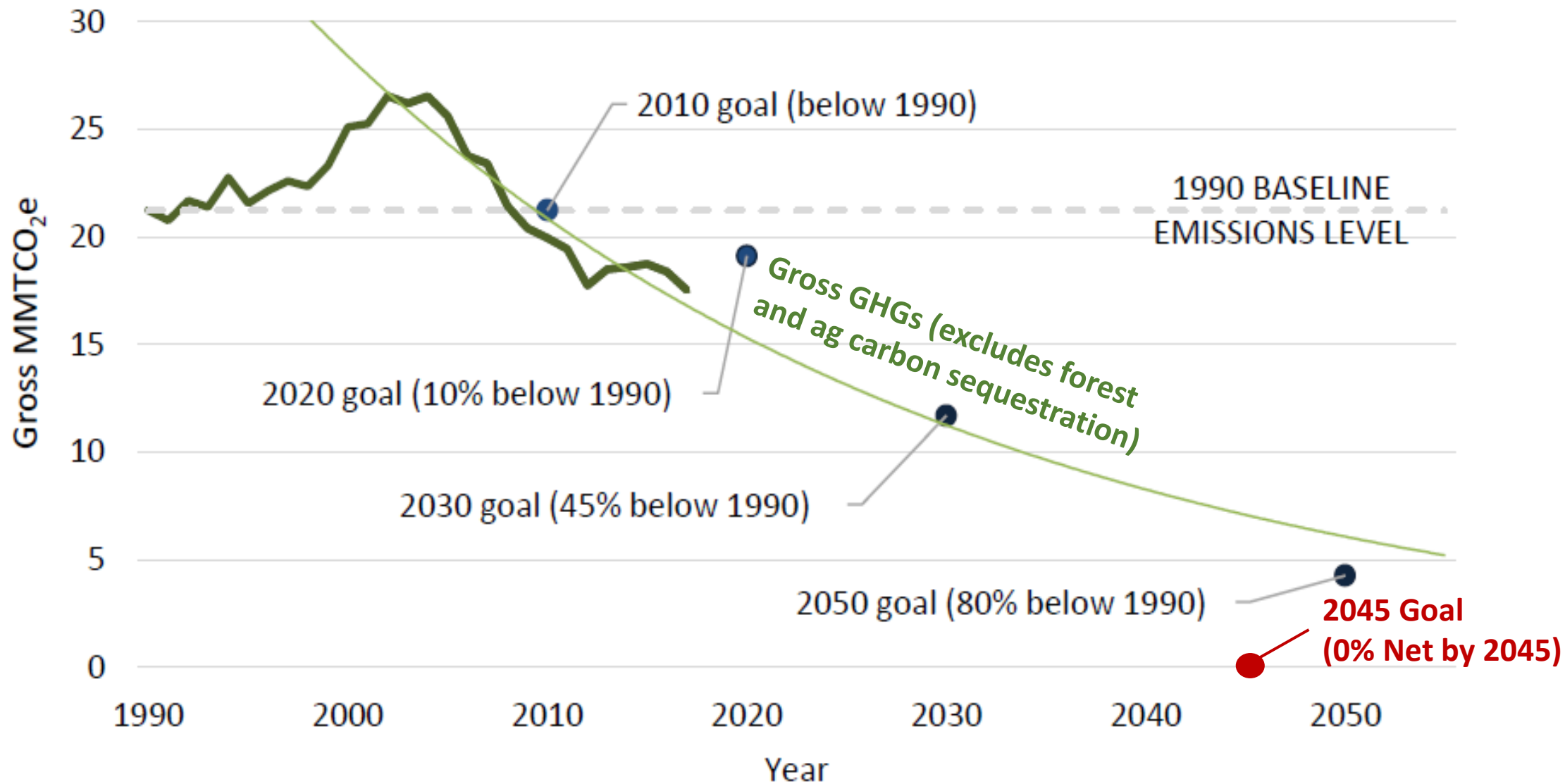
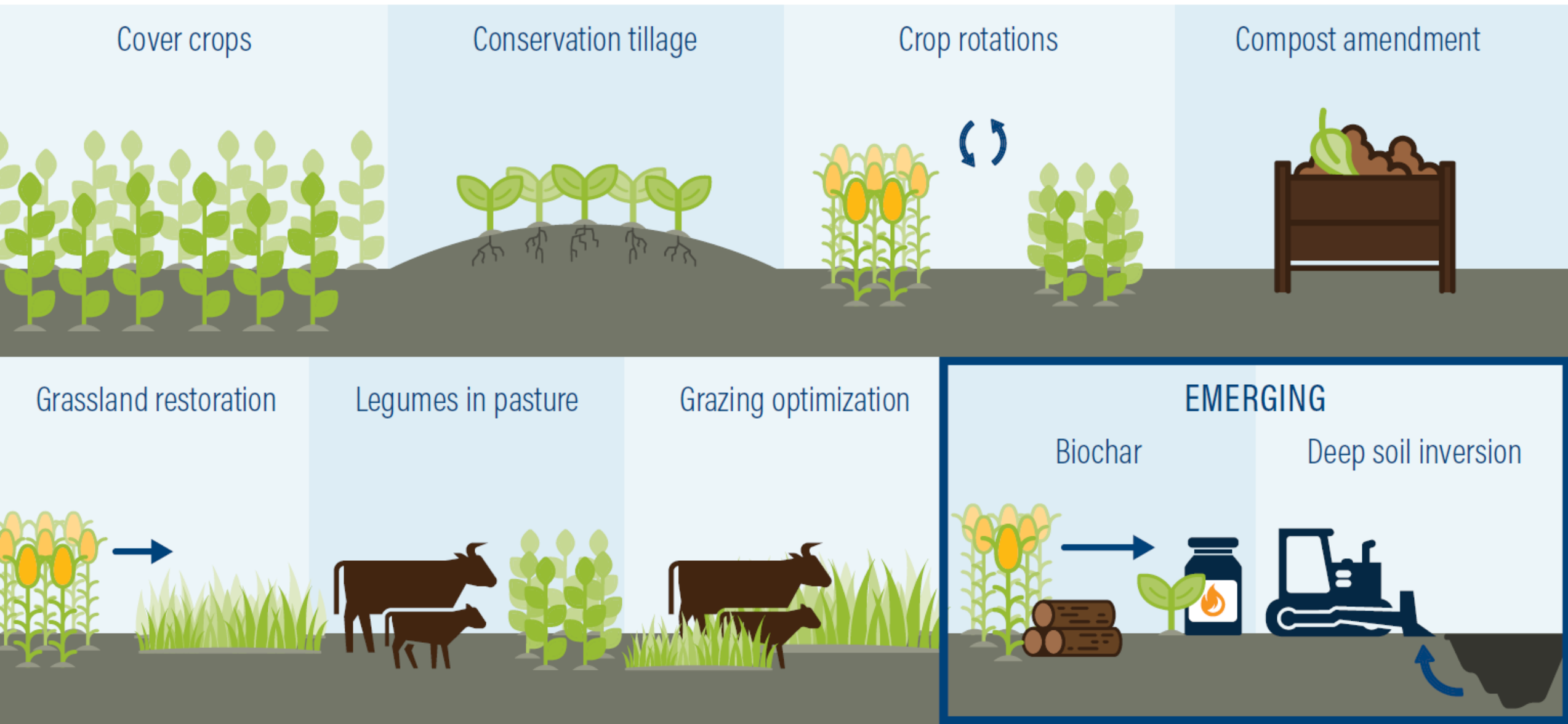


Figure 11. Maine's greenhouse gas emissions 1990-2017 with 2020, 2030, and 2050 reduction and emissions goals

Some agricultural practices to consider...



How do we estimate NCS mitigation benefits and costs?

1. Define 'baseline' or 'business as usual' pathway
 - Continuance of current policy and practices
 - Geographical boundary and temporal scale
2. Establish list of acceptable or appropriate mitigation practices
 - Debate about what mitigation should be included
 - Measurement, monitoring, verification
 - Permanence, additionality, leakage
3. Estimate 'cost' and 'effectiveness' of implementing practices
 - Typically done using a suite of models and assumptions
 - Mix of economic and biophysical modelling
 - Attempts to be empirically based, but can be complex due to nature of the sector
 - Can also identify additional non-financial barriers of adoption

Estimating Costs and Benefits

Costs

- Capital/equipment
- Labor
- Maintenance
- Opportunity
 - Yield reductions
 - Farmable area



Benefits

- Yield improvements
- Cost-savings
- Reduced GHGs
- Increased C sequestration
- Other environmental co-benefits

Net Costs and Benefits of Cover Cropping (Legumes)

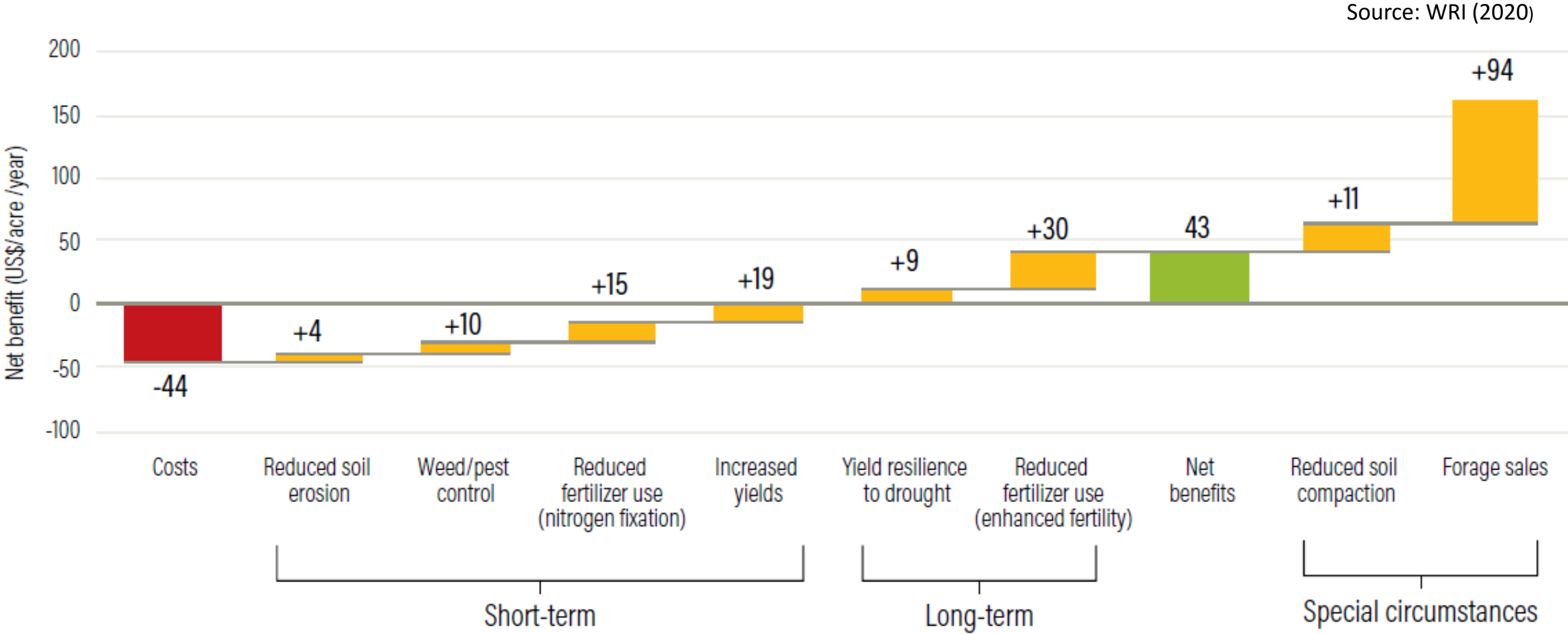
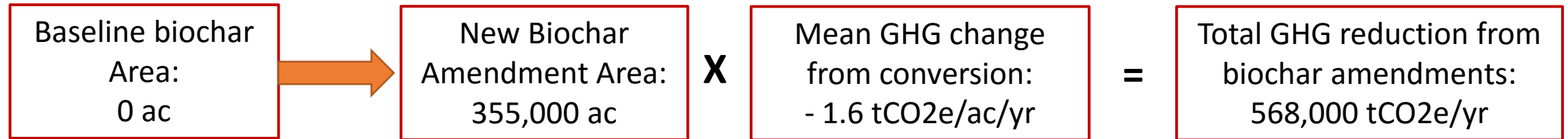


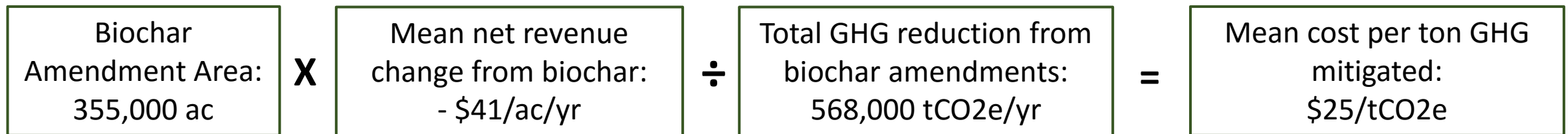
Figure shows detailed costs, but does not include mitigation potential

Example – Adding Biochar Amendments to Maine Crops

Technical/Physical Potential



Economic Cost



Other Barriers to Adoption

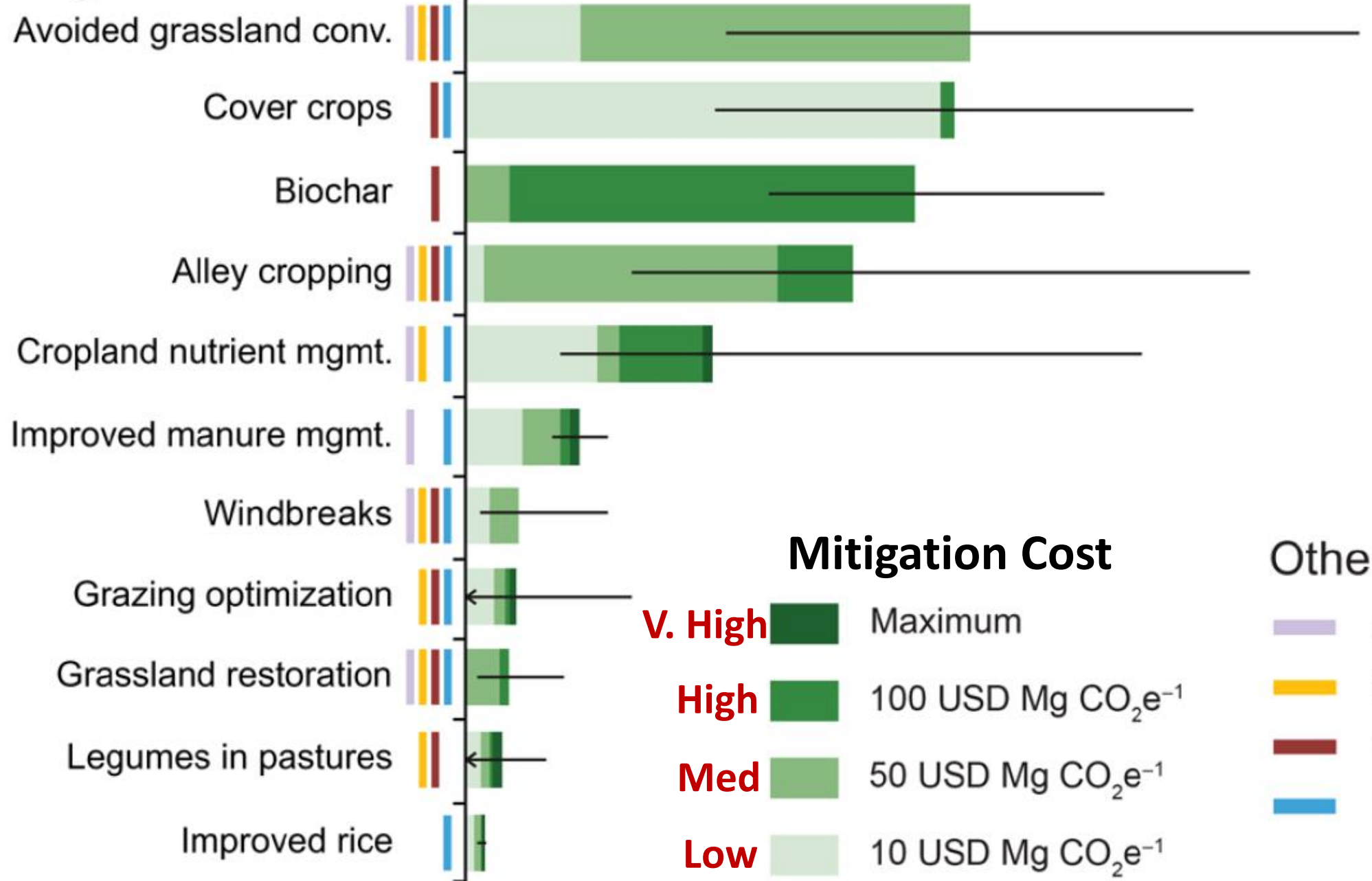
Perceived Risk

Technical Knowledge

Farm System Compatibility

Ag. & grasslands

US Ag GHG Mitigation Potential



Mitigation Cost

- V. High** Maximum
- High** 100 USD Mg CO₂e⁻¹
- Med** 50 USD Mg CO₂e⁻¹
- Low** 10 USD Mg CO₂e⁻¹

Other benefits

- Air
- Biodiversity
- Soil
- Water

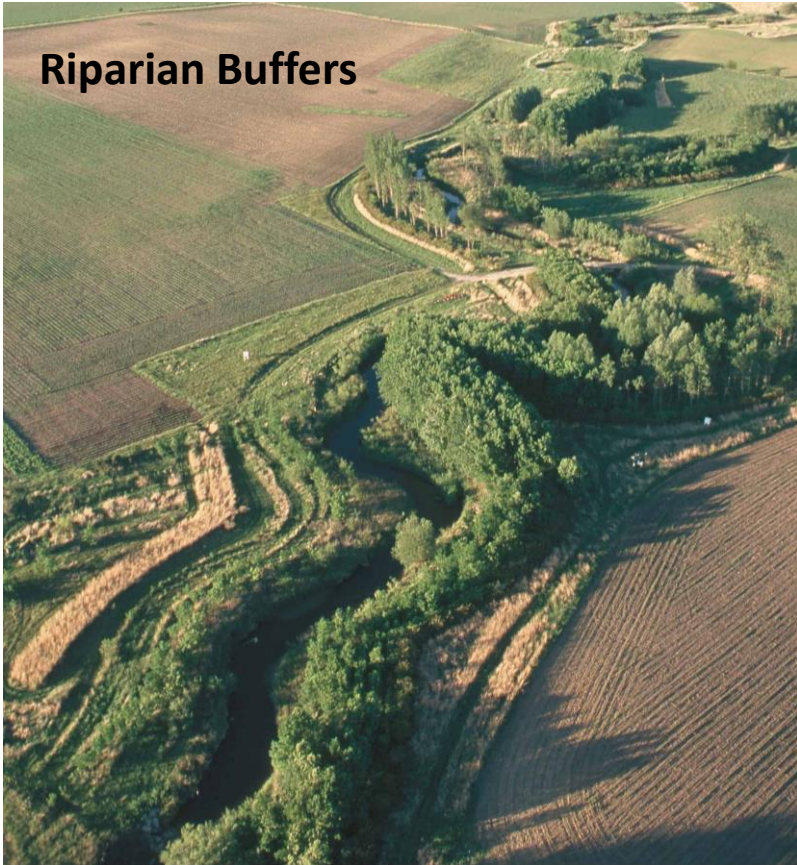
Source: Fargione et al (2018)

What about Maine?

- To date, most studies are global and national-scale
- State-level estimates often reliant on assumptions more applicable elsewhere
- Practices covered often typical of more conventional agricultural systems
- Specific implementation barriers?



Riparian Buffers



Convert to Perennials



**Biochar
Amendment**



Reduced Tillage



**Dairy Manure
Management**



Some agricultural NCS to consider...

Technical and Economic Potential of Agricultural NCS

Agricultural NCS Methodology

A green combine harvester is shown from a rear perspective, moving through a field of golden-brown crops. The harvester has a John Deere logo on its back. In the background, there are rolling green hills and mountains under a clear sky.

- **Approach: Financial and agronomic response analysis**
- **Geography: Current ‘major crop’ area and dairy farms across Maine (~400,000 acres)**
- **Timespan: 2017 to 2037**
- **Baseline: “Current” practice distribution and emissions by crop based on USDA Census**
- **NCS opportunities: cover crops, reduced-till, no-till, biochar, diversified rotations, manure management, set-asides**
- **Mitigation: emissions factors for abatement based on literature**

Maine Land Cover - 2019

Maine Land Use	Area (ac)
Forests	17,502,904
Potato	50,211
Lowbush blueberry	39,286
Hay & haylage	175,231
Grain & silage corn	29,286
Other grains	39,419
Apples & other perennial crops	6,814
All other crops	120,233



Land Cover Categories
(by decreasing acreage)

AGRICULTURE*

- Other Hay/Non Alfalfa
- Grass/Pasture
- Potatoes
- Blueberries
- Corn
- Oats
- Rye
- Clover/Wildflowers
- Barley
- Alfalfa
- Broccoli
- Apples
- Fallow/Idle Cropland
- Christmas Trees
- Hemp
- Spring Wheat

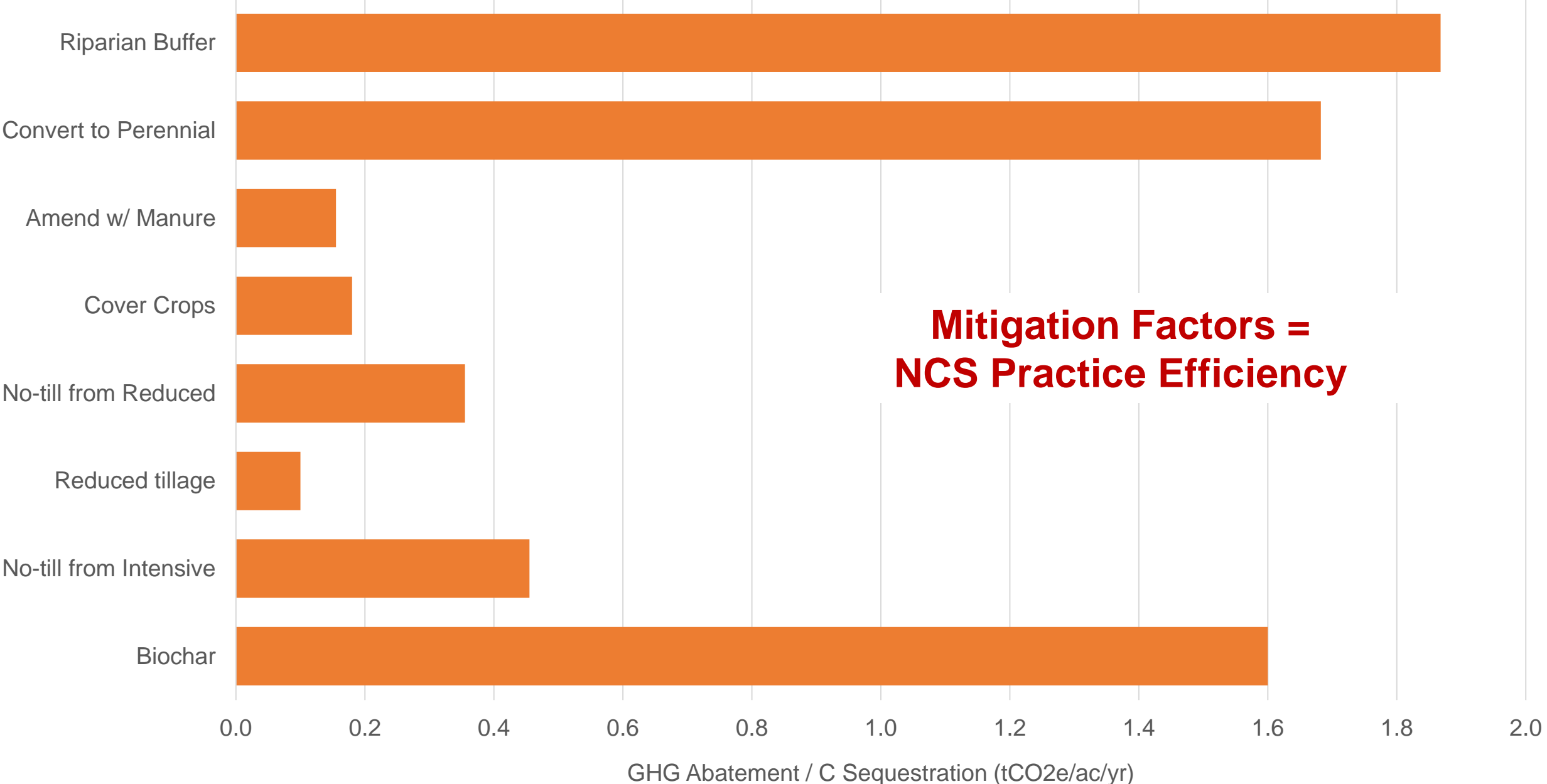
NON-AGRICULTURE**

- Mixed Forest
- Evergreen Forest
- Deciduous Forest
- Woody Wetlands
- Open Water
- Shrubland

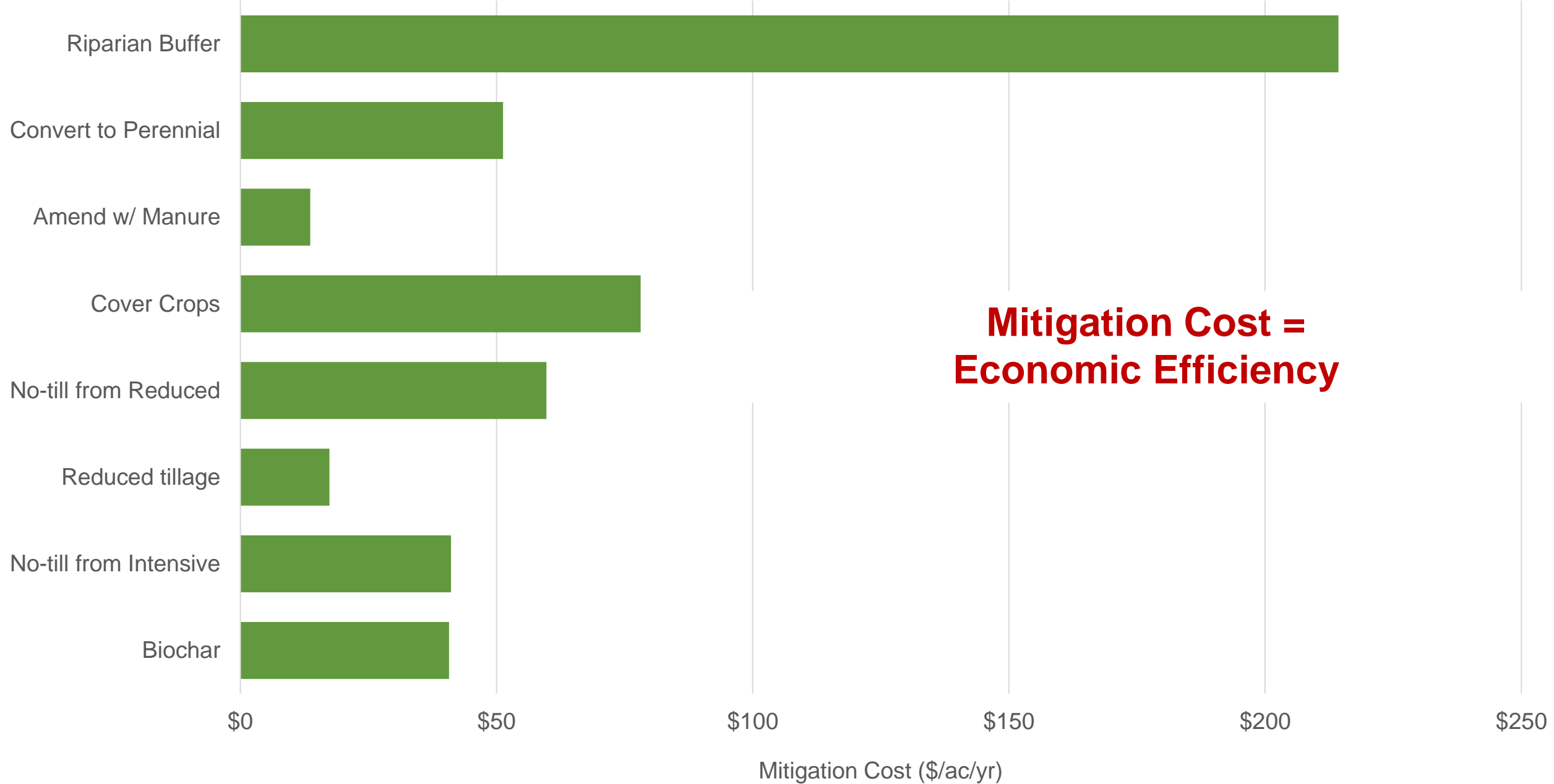
Source: USDA Crop Data Layer (2020)

Top 16 agriculture categories /
Top 6 non-agriculture categories listed

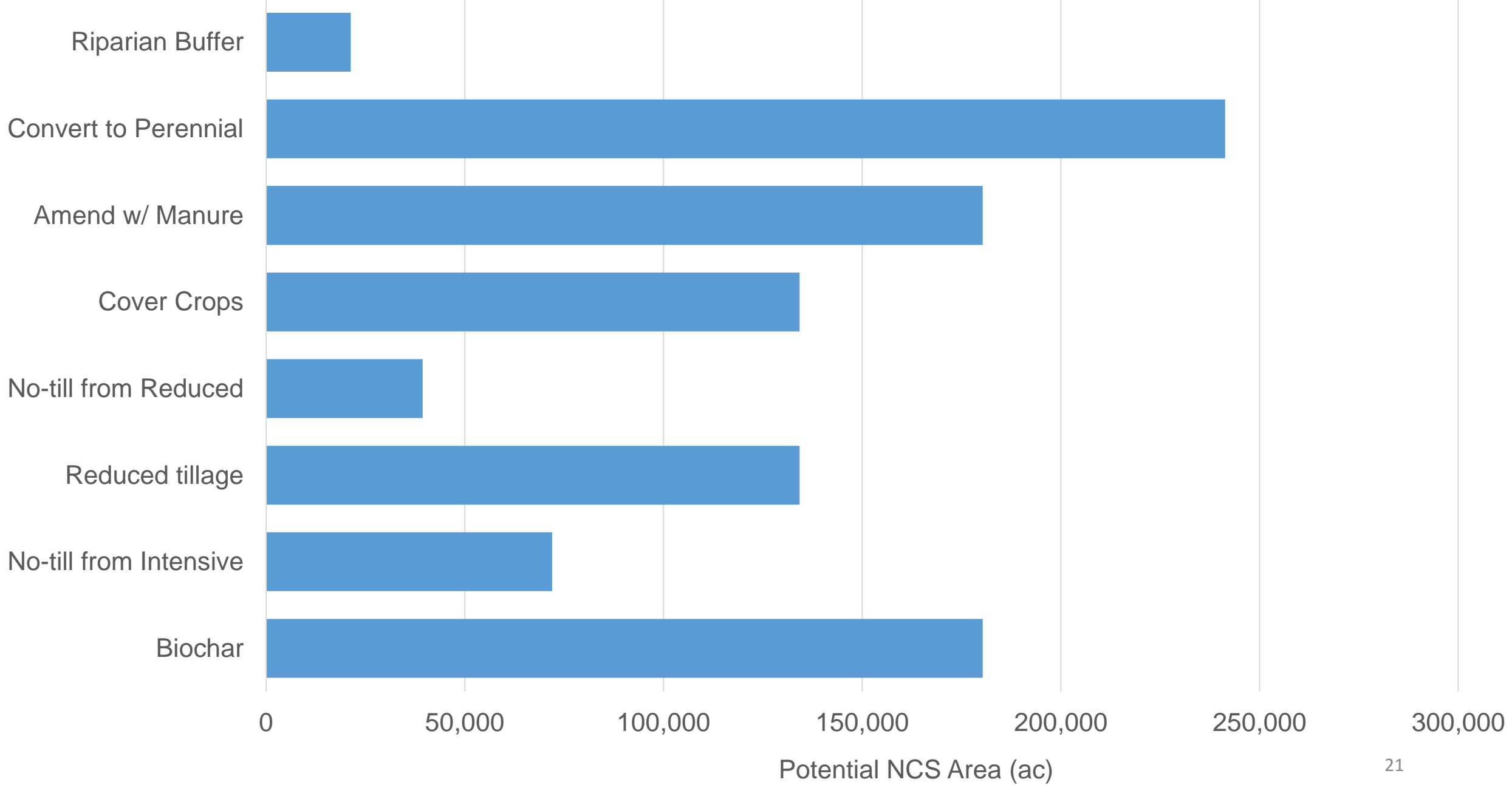
Maine Average Mitigation Factors by NCS Practice (tCO2e/ac/yr)



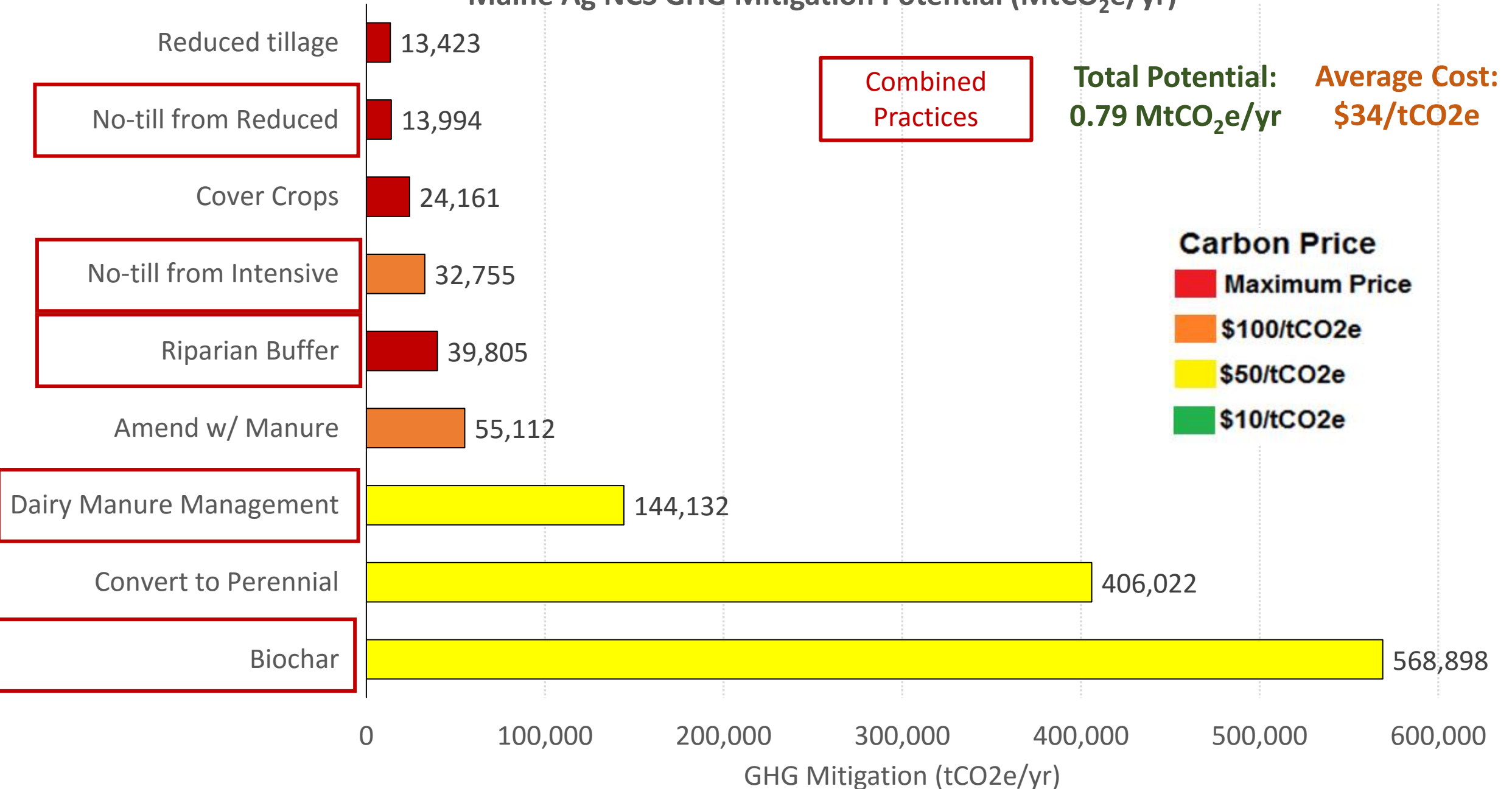
Mitigation Cost (\$/ac/yr)



Total Potential NCS Area (ac)

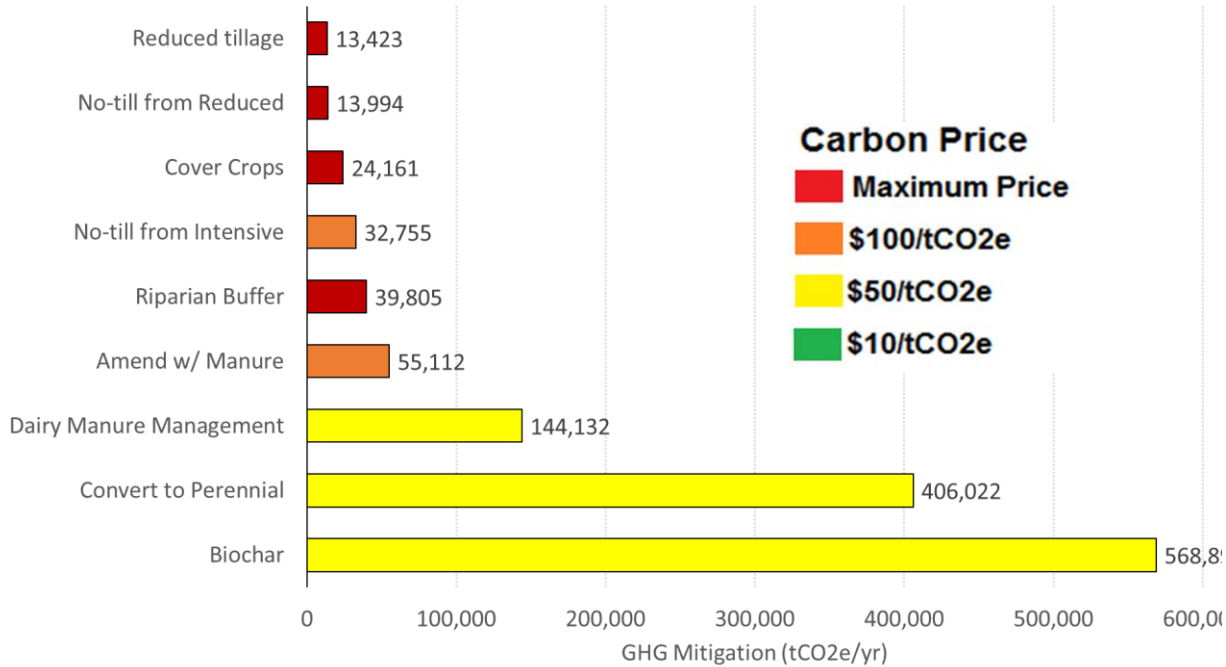


Maine Ag NCS GHG Mitigation Potential (MtCO₂e/yr)



Maine Ag NCS Mitigation Potential

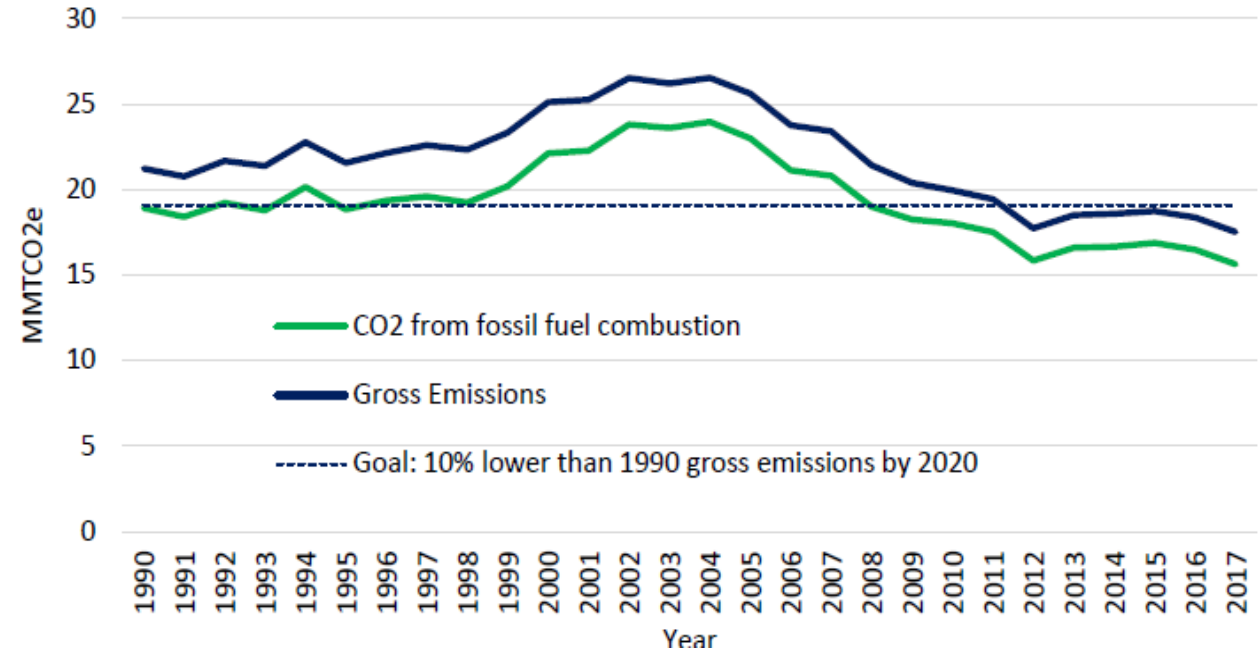
Maine Ag NCS GHG Mitigation Potential (MtCO₂e/yr)



**Agricultural Mitigation Potential:
<0.1 to 0.8 MtCO₂e/yr**

Source: own calcs

Maine GHG Emissions (MtCO₂e/yr)



Total Emissions: ~18 MtCO₂e/yr
**Agricultural GHG emissions:
 ~0.4 MtCO₂e/yr**

Source: Maine DEP (2020)

Barriers and Opportunities to Implementing NCS

Potato Focus Group

- Caribou, ME – January 2020
- 16 participants (2 organic, 4 crop advisers)
- **Barriers & Opportunities**
 - Longer rotations that include perennials, transitional payments and broadening forage market
 - Payments for cover crops seeded in fall, not “green”
 - Less bulky paperwork for reimbursement programs
 - Encouraging adoption of nurse crops, perhaps through cost-share
 - Encouraging tillage in spring rather than fall
 - Subsidizing biochar to make price point affordable/comparable to lime



Organic Vegetable Focus Group

- Falmouth, ME – February 2020
- 5 participants (all organic, 1 crop adviser)
- **Barriers & Opportunities**
 - High willingness to prioritize soil health, consider incentivizing
 - Cost of organic cover crop seed a barrier
 - Scale and appropriate equipment are barriers to further NT/RT adoption
 - Considerable interest in biochar, including making on farm, but many questions about the benefits and how it works on Maine soils
 - Agroforestry mentioned as an additional NCS practice



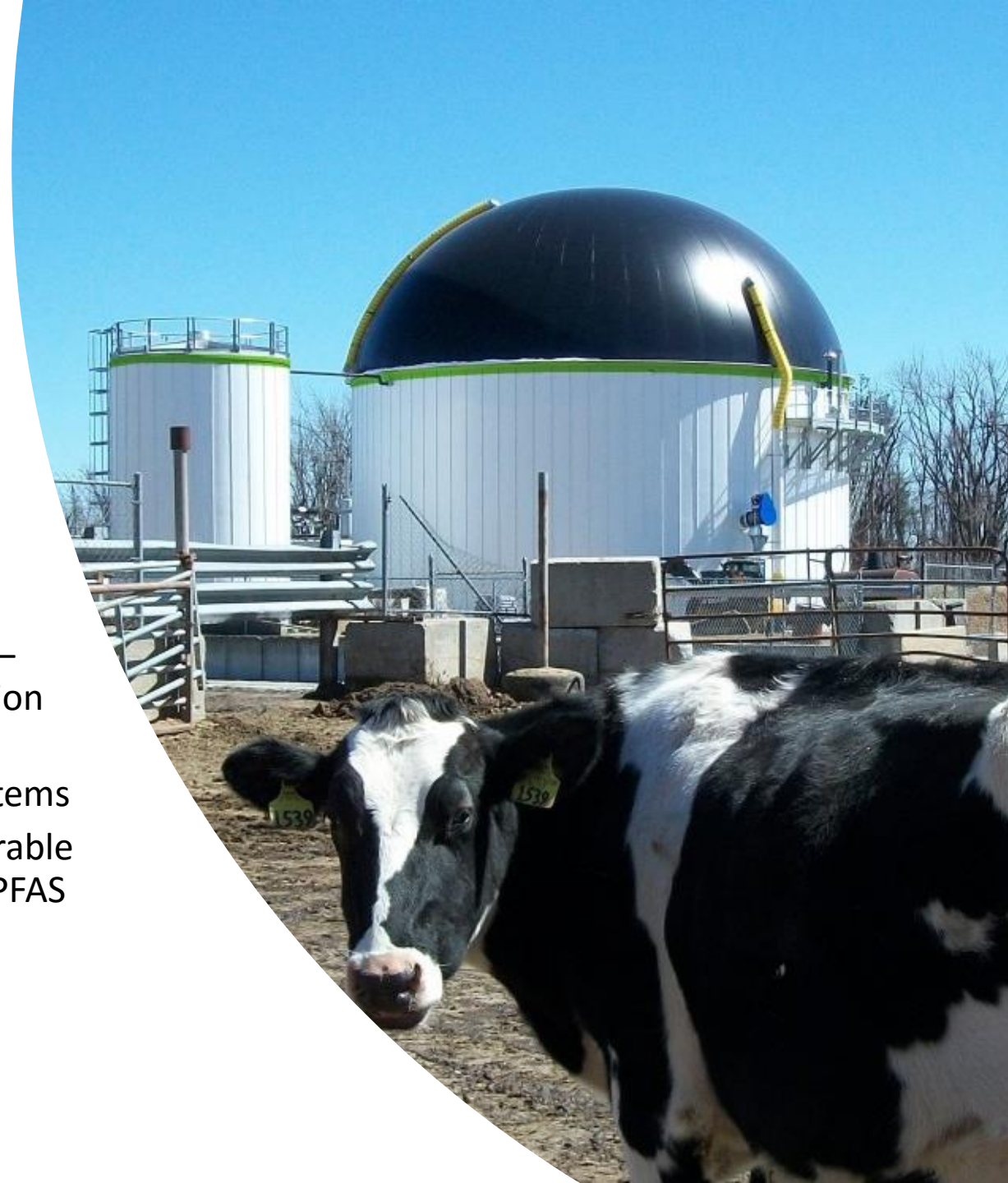
Blueberry Focus Group

- Zoom – January 2021
- 4 participants (3 organic)
- **Barriers & Opportunities**
 - Labor a key constraint in every aspect of management, including NCS
 - Potential to integrate acidic biochar with mulch application
 - Interest in biochar as a component of traditional burning practices
 - Not everyone has heard of biochar – opportunity for education
 - NOP approval important for organic growers



Dairy Focus Group


- Zoom – January 2021
- 11 participants (4 organic, 1 crop adviser)
- **Barriers & Opportunities**
 - Economics a key consideration for digester adoption – many would be willing to adopt, but need for education and logistical support
 - SLS is of interest but doesn't work for all bedding systems
 - Mixed views on biochar – some interest, but considerable resistance to inputs with unknown feedstock due to PFAS
 - Many have tried / are using NT
 - Seed price an important consideration in cover crop choice / adoption



ME Agriculture NCS Summary

- Top NCS for Maine: Mix of **biochar**, **manure management**, and **convert to perennials**
- Many NCS **limited by area extent** and/or **low GHG benefits** (e.g., no-till)
- Typically **more expensive than forestry** practices
- Ag sector could be **carbon neutral** if enough farmers adopt NCS
- **Financial and technical assistance** could accelerate implementation





Natural climate solutions (NCS), such as cropland nutrient management, planting trees, and conservation, that sequester carbon or limit GHG emissions can affect near-term GHG mitigation goals in cost-effective ways and enhance long-term ecosystem services.

Want to know more about Maine's Natural Climate Solutions?

Visit the UMaine Forest Climate Change Initiative's website for full report, fact sheets, and more!

<https://crsf.umaine.edu/forest-climate-change-initiative/ncs/>

Thanks to all our collaborators and funders...

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Dr. Ivan Fernandez
Ms. Jen Carroll



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