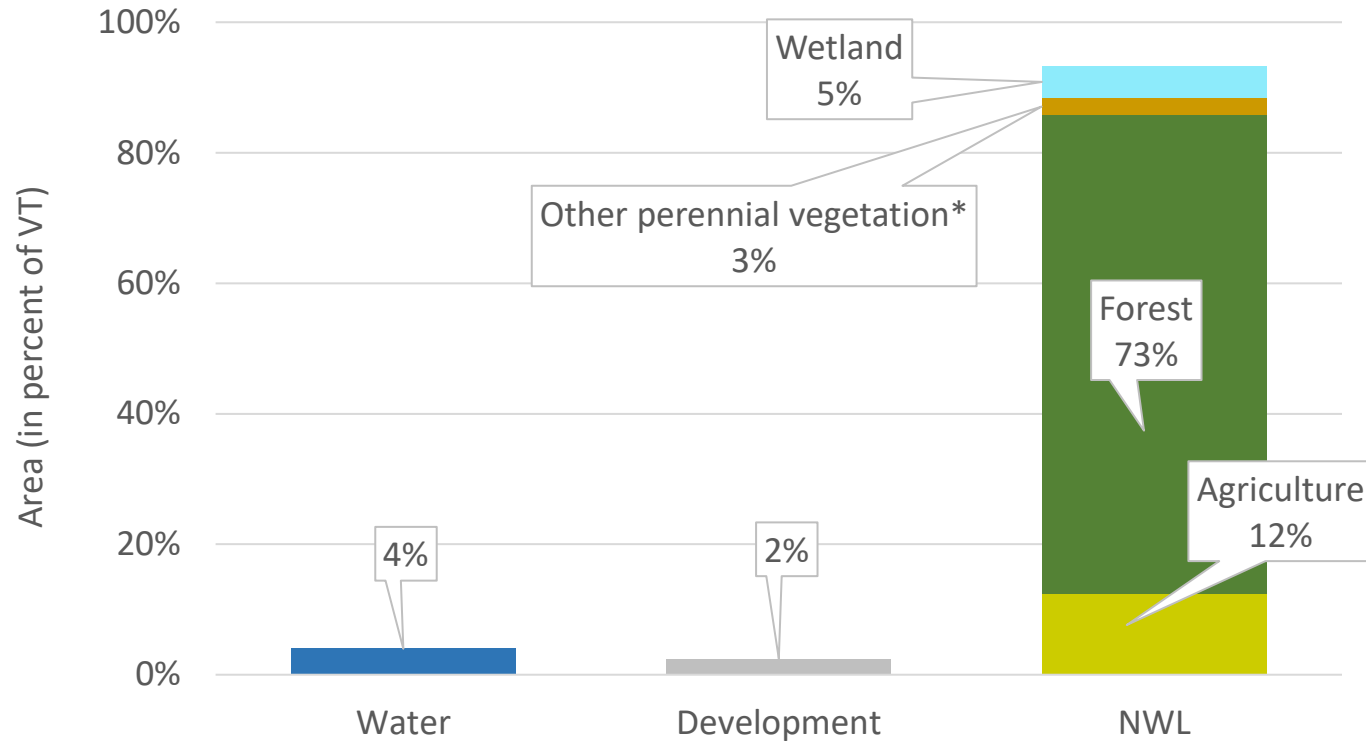


Vermont's Agricultural Mitigation Strategies

Ryan Patch
Agriculture Climate and Land Use Policy Manager
Vermont Agency of Agriculture, Food and Markets
Senate Committee on Agriculture
January 28, 2022

Natural & Working Lands (NWL) cover 94% of Vermont

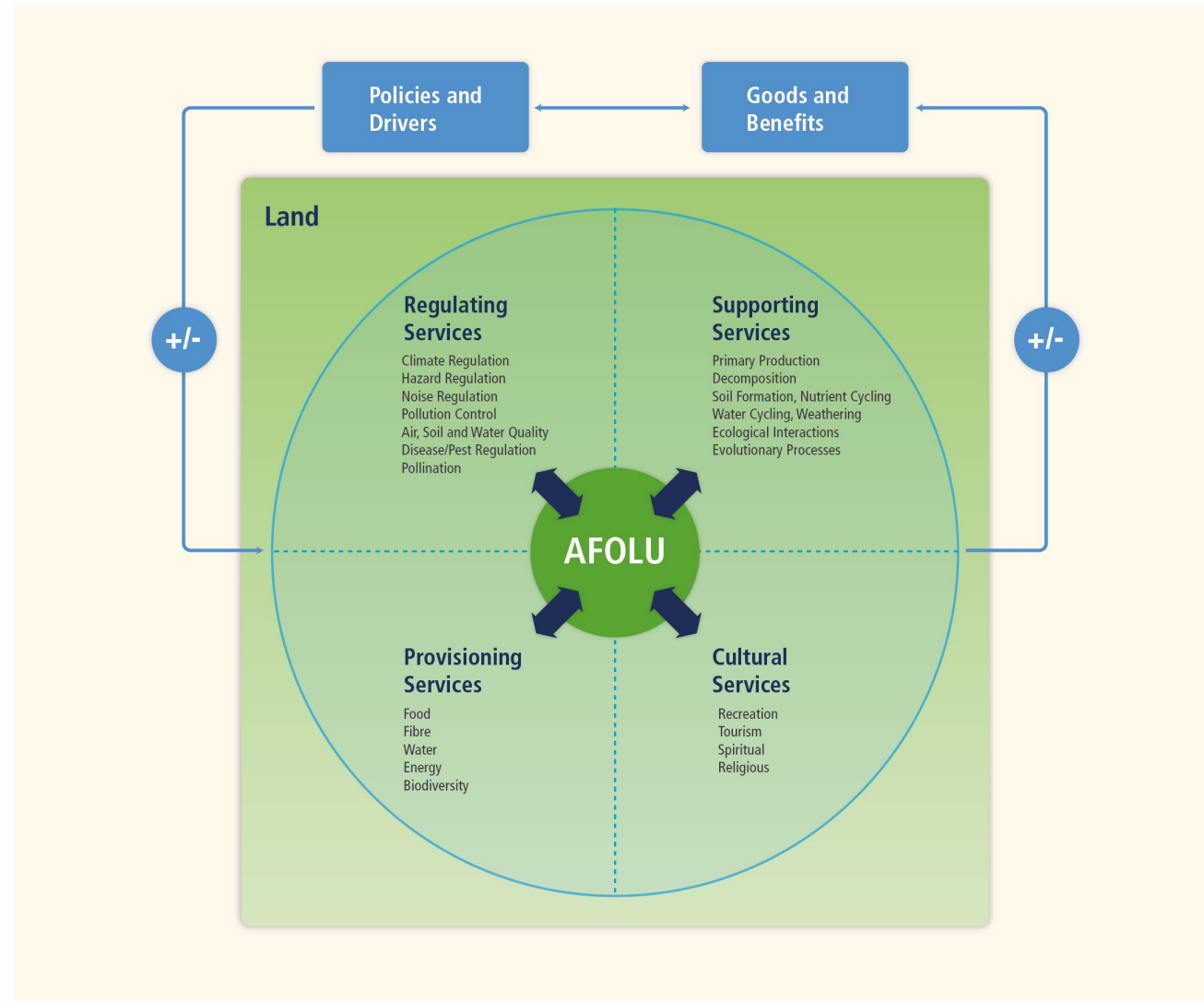


*Other perennial vegetation includes grasslands, shrub/scrublands, and turf

Agriculture, Forestry and Other Land Use (AFOLU)

Executive Summary

Agriculture, Forestry, and Other Land Use (AFOLU) is unique among the sectors considered in this volume, since the mitigation potential is derived from both an enhancement of removals of greenhouse gases (GHG), as well as reduction of emissions through management of land and livestock (*robust evidence; high agreement*). The land provides food that feeds the Earth’s human population of ca. 7 billion, fibre for a variety of purposes, livelihoods for billions of people worldwide, and is a critical resource for sustainable development in many regions. Agriculture is frequently central to the livelihoods of many social groups, especially in developing countries where it often accounts for a significant share of production. In addition to food and fibre, the land provides a multitude of ecosystem services; climate change mitigation is just one of many that are vital to human well-being (*robust evidence; high agreement*). Mitigation options in the AFOLU sector, therefore, need to be assessed, as far as possible, for their potential impact on all other services provided by land. [Section 11.1]



Source: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter11.pdf

Image Source: https://www.ipcc.ch/site/assets/uploads/2018/02/01_figure_11.1.png

Section 11.4: Agricultural Pathways for Mitigation (19 pages)

Section 13: Pathways for Adaptation and Building Resilience in Natural and Working Lands (38 pages)

Section 14: Pathways for Sequestration and Storing Carbon (13 pages)



INITIAL VERMONT CLIMATE
ACTION PLAN



Vermont Climate Council
DECEMBER 2021

§ 578. Greenhouse gas reduction requirements

(a) Greenhouse gas reduction requirements. Vermont shall reduce emissions of greenhouse gases from within the geographical boundaries of the State and those emissions outside the boundaries of the State that are caused by the use of energy in Vermont, as measured and inventoried pursuant to section 582 of this title, by:

(1) not less than 26 percent from 2005 greenhouse gas emissions by January 1, 2025 pursuant to the State's membership in the United States Climate Alliance and commitment to implement policies to achieve the objectives of the 2016 Paris Agreement;

(2) not less than 40 percent from 1990 greenhouse gas emissions by January 1, 2030 pursuant to the State's 2016 Comprehensive Energy Plan; and

(3) not less than 80 percent from 1990 greenhouse gas emissions by January 1, 2050 pursuant to the State's 2016 Comprehensive Energy Plan.

Vermont's Current Greenhouse Gas (GHG) Emissions Profile

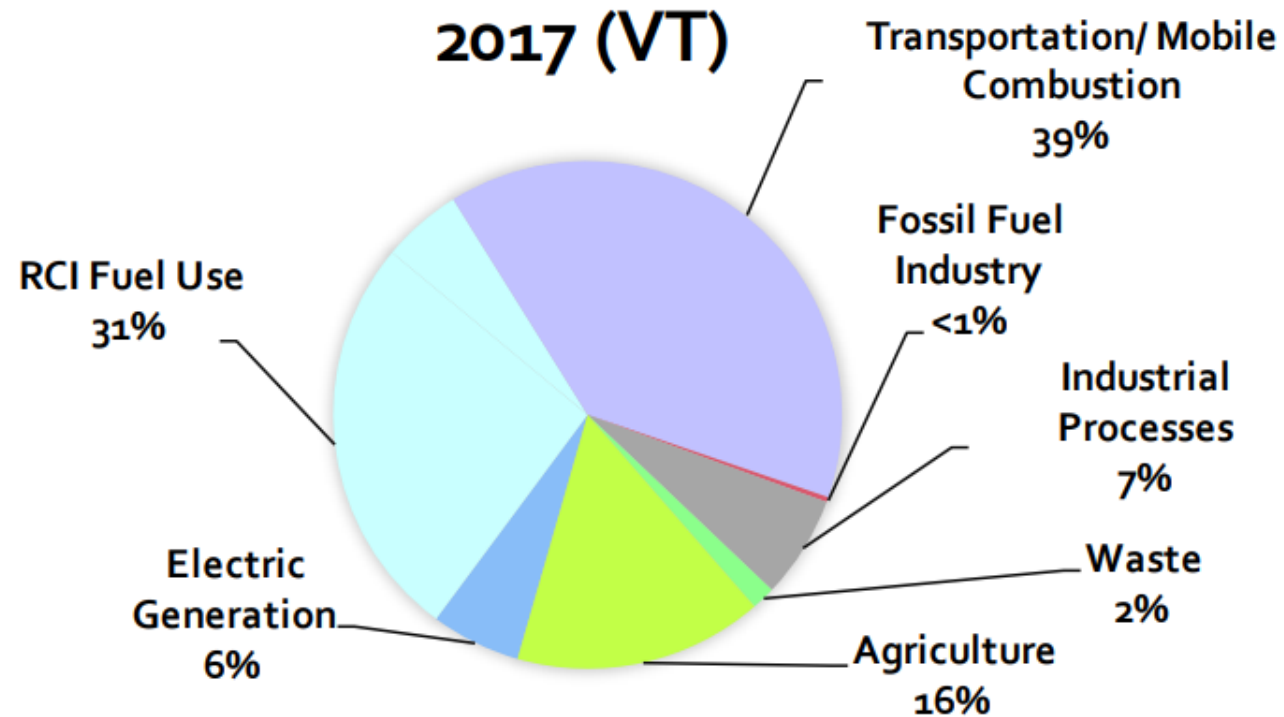
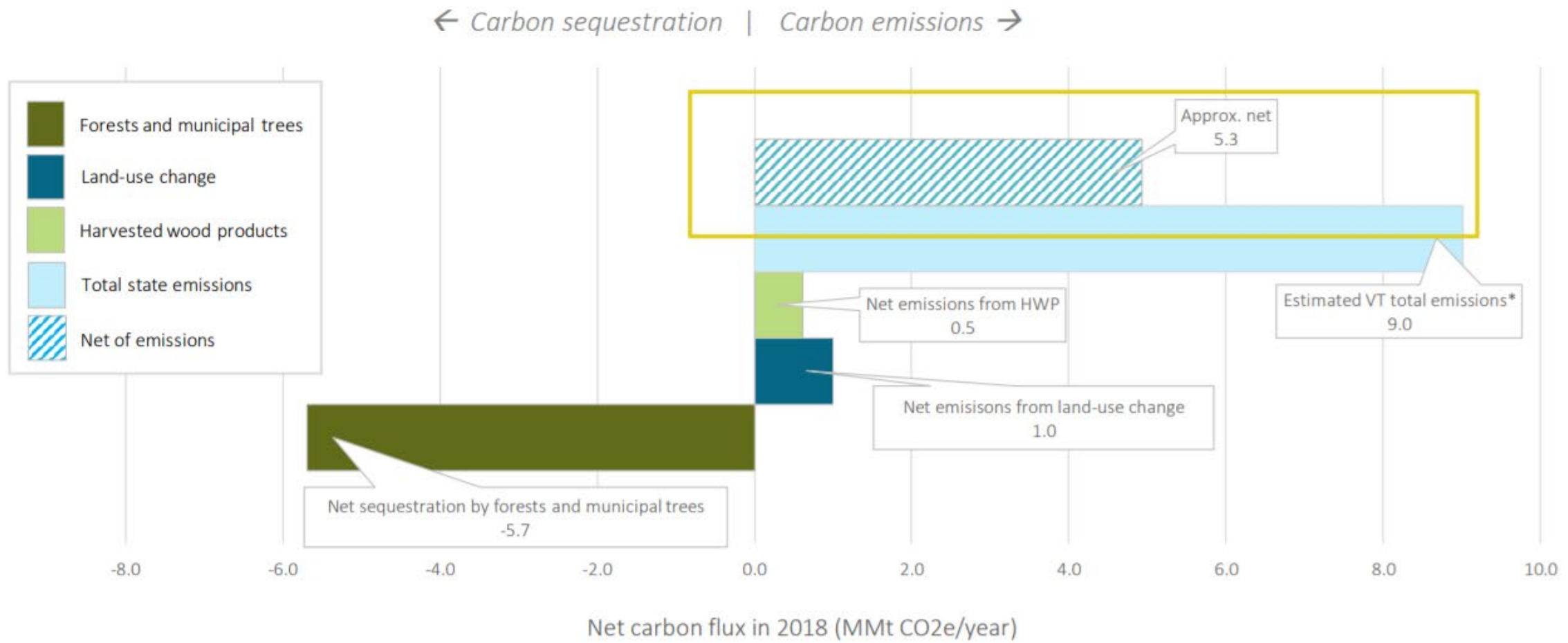


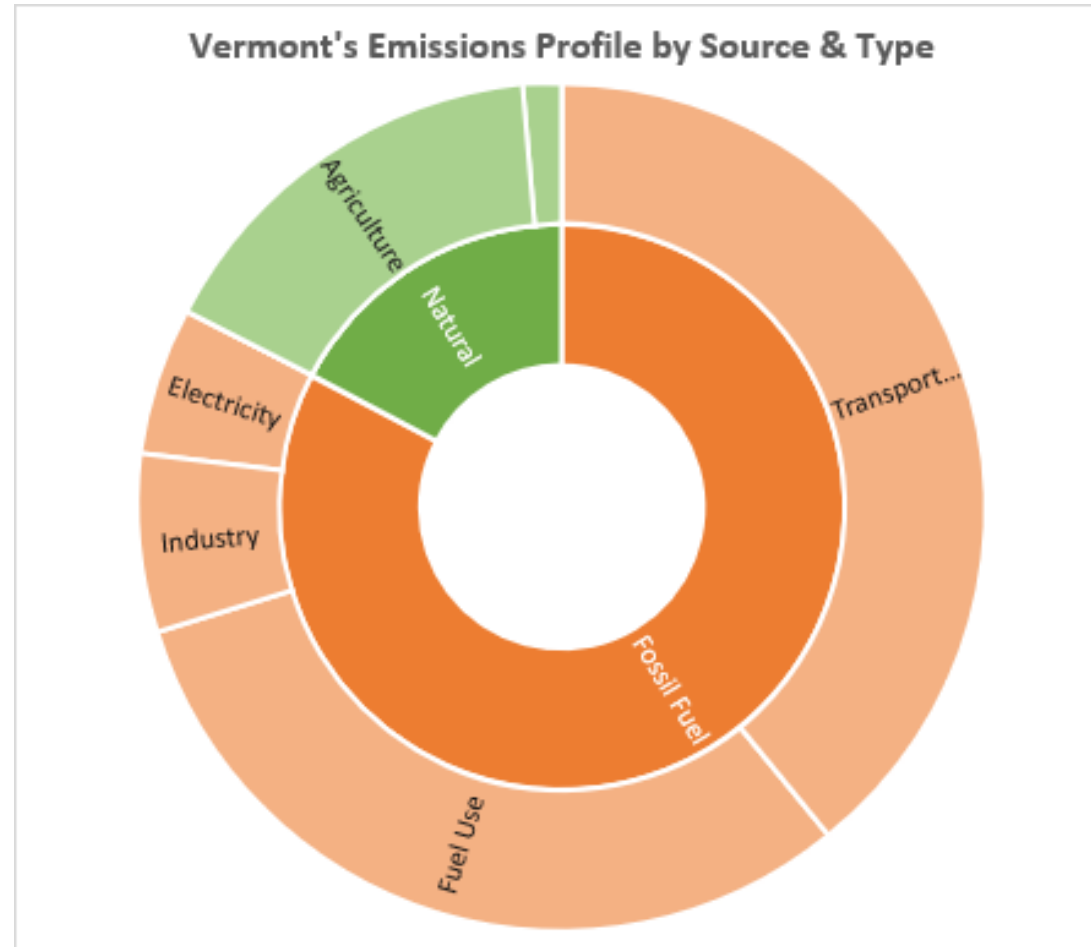
Figure 4: Vermont GHG percent contributions by sector.

When we combine the sinks and sources estimated for 2018, the forest sector took in ~42% of state annual emissions



Kosiba AM. 2021. Vermont Forest Carbon Inventory. Note that these forest sector values are not included in the Vermont GHG Inventory. Data source for state emissions: VT ANR GHG

Vermont's Current Greenhouse Gas (GHG) Emissions Profile

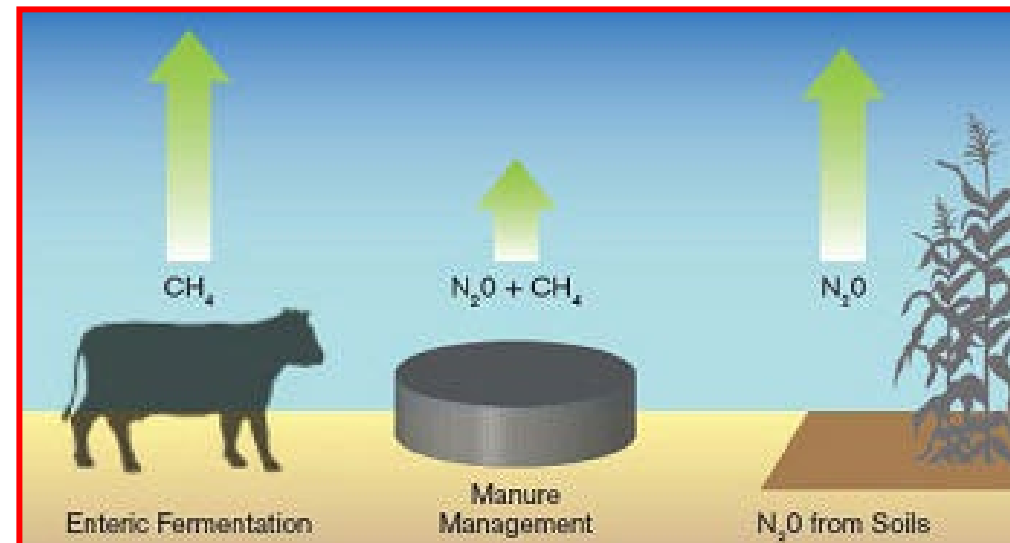


Source: https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

Source: <https://www.agr.gc.ca/eng/agriculture-and-the-environment/agricultural-practices/climate-change-and-agriculture/greenhouse-gases-and-agriculture/?id=1329321969842>

Vermont's Current Greenhouse Gas (GHG) Emissions Profile: Agriculture

Agriculture
Enteric Fermentation
Manure Management
Agricultural Soils
Liming and Urea Fertilization



Agriculture	1.23	1.19	1.30	1.32	1.30	1.32	1.29	1.29	1.28	1.38	1.29	1.29	1.26	1.28	1.25	1.29	1.31	1.35	1.38	1.37
Enteric Fermentation	0.70	0.67	0.69	0.68	0.67	0.66	0.65	0.63	0.63	0.64	0.64	0.64	0.62	0.63	0.62	0.64	0.64	0.63	0.64	0.64
Manure Management	0.18	0.19	0.26	0.29	0.30	0.32	0.31	0.33	0.32	0.33	0.34	0.33	0.33	0.33	0.32	0.32	0.32	0.34	0.36	0.35
Agricultural Soils	0.35	0.34	0.34	0.34	0.32	0.33	0.33	0.32	0.32	0.31	0.30	0.32	0.31	0.31	0.30	0.32	0.33	0.33	0.33	0.33
Liming and Urea Fertilization	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.01	0.01	0.00	0.00	0.01	0.03	0.05	0.05	0.05

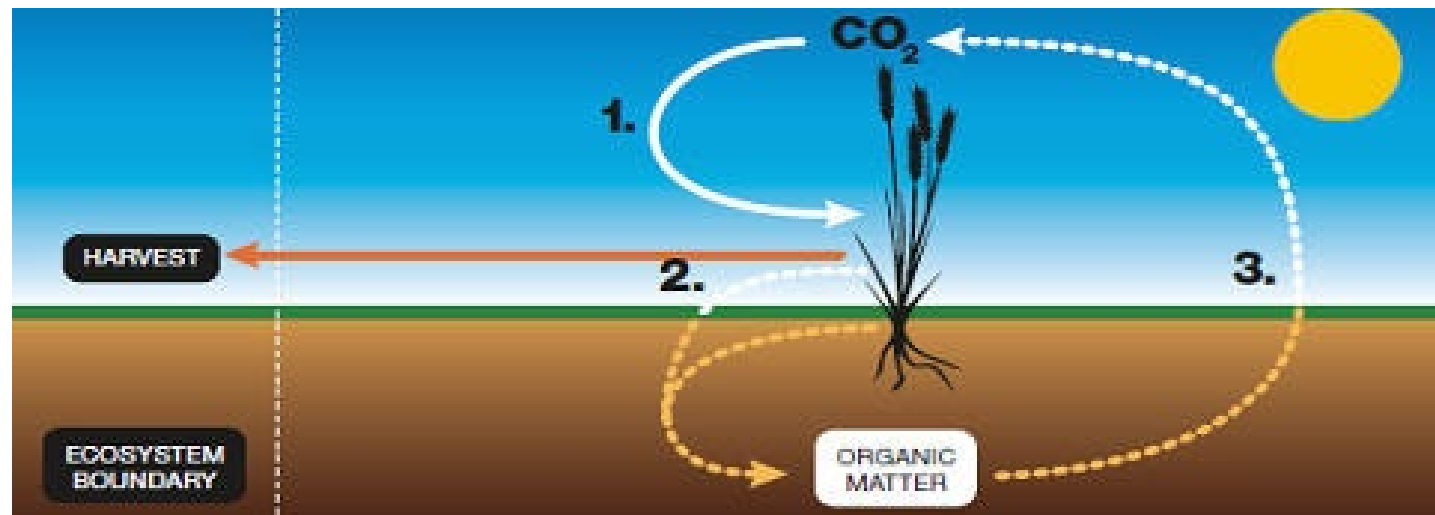
Source: https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/Vermont_Greenhouse_Gas_Emissions_Inventory_Update_1990-2017_Final.pdf

Source: <https://www.agr.gc.ca/eng/agriculture-and-the-environment/agricultural-practices/climate-change-and-agriculture/greenhouse-gases-and-agriculture/?id=1329321969842>

GHG Emissions & Sequestration



Carbon Cycle



Vermont Carbon Budget

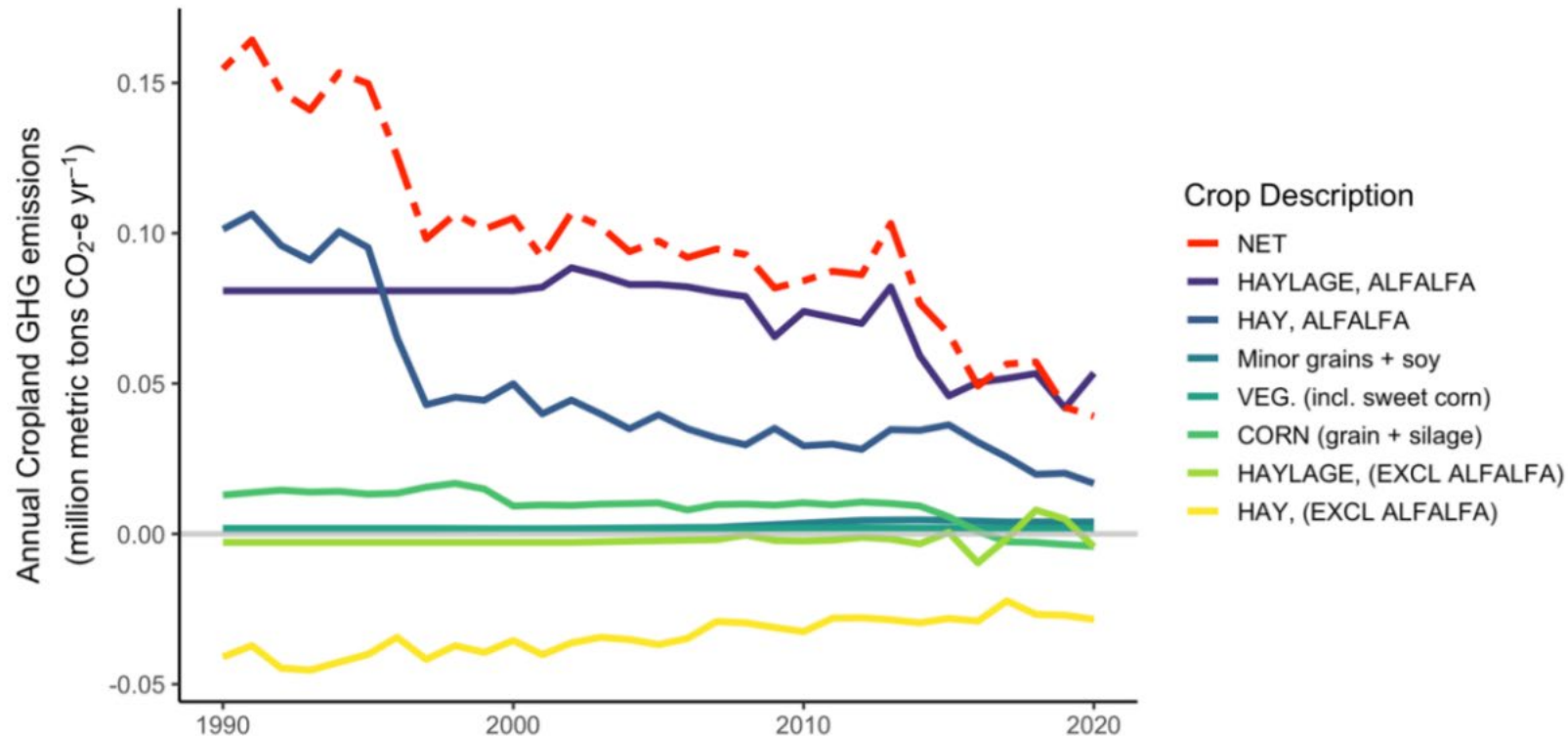


Figure 23: GHG emissions by crop type in Vermont 1990–2020 estimated with EX-ACT

EPA SIT & National Inventory Currently Two Chapters

SIT Chapter 5

EPA SIT	Category	GHG	VT	DEC
Agriculture (emissions)				
2	Enteric Fermentation	CH4	Yes	Yes
3	Manure Management	CH4, N2O	Yes	Yes
4	Agriculture Soils	N2O		
4a	Plant Residues & Legumes	N2O	Yes	Yes
	Histosols (conversion)	N2O	Yes	No
4b	Plant Fertilizers	N2O	Yes	Yes
4c	Animal Calculation Values	N2O	Yes	Yes
5	Rice Cultivation	CH4	No	No
6	Liming of Soils	CO2	Yes	Yes
7	Urea Fertilization	CO2	Yes	Yes
8	Ag Residue Burning	CH4, N2O	No	No

SIT Chapter 6

EPA SIT	Category	GHG	VT	DEC
Land Use, Land-Use Change, and Forestry (sequestration)				
7	Ag Soil Carbon Flux (Cropland and Grassland)		Yes	No
	Cropland Remaining Cropland			
	Land Converted to Cropland			
	Grassland Remaining Grassland			
	Land Converted to Grassland			
2	Forest Carbon Flux	flux	Yes	No
2a	Forest Remaining Forest			
	Land Converted to Forest			
	Forest Converted to Land			
3	C Storage in Urban Trees	storage	Yes	Yes
4	Settlement Soils (developed land)	N2O	Unknown	No
5	Forest Fires	CH4, N2O	No	No
6	Food Scraps & Yard Trimmings (land flux)		Unknown	No

EPA SIT vs. AFOLU

EPA SIT

- SIT Chapter 5 & Chapter 6
- EPA SIT continues to have the legacy split between Ag Emissions and LULUCF. This distinction was updated in 2006 by IPCC.
- VT Emission Inventory was passed 1 month before IPCC update combining Ag & LULUCF

IPCC AFOLU

- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories integrates previously separate Agriculture (Chapter 4) and the Land Use, Land-Use Change and Forestry (LULUCF) (Chapter 5) into a single comprehensive guidance section titled Agriculture, Forestry and other Land Use (AFOLU), noting: “This integration recognizes that the processes underlying greenhouse gas emissions and removals, as well as the different forms of terrestrial carbon stocks, can occur across all types of land and that often the same practices influence both Agriculture and Land Use, Land Use Change and Forestry”;

IPCC AR5 Revised Ag & LULUCF to a Single Chapter

IPCC AR4 (IPCC WGIII, 2007)
Agricultural and forestry mitigation were dealt with in separate chapters

IPCC AR5
First time - the terrestrial land surface, comprising agriculture, forestry and other land use (AFOLU), is considered together in a single chapter.



- Ensure all land based mitigation options can be considered together
- Minimise the risk of double counting or inconsistent treatment (e.g. different assumptions about available land)
- Consider systemic feedbacks between mitigation options related to the land surface

Working Group III contribution to the
IPCC Fifth Assessment Report

EPA SIT Tool Planned Updates (?)

- Planned updates to include the 2006 Intergovernmental Panel on Climate Change (IPCC) Updates
- Specifically, the Agriculture and LULUCF chapters were going to be combined, thereby accounting for GHG Flux from AFOLU

2006 IPCC Guidelines for National Greenhouse Gas Inventories

The release of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 GL) may bring some structural and organizational changes to the SIT LUCF and Agriculture modules as well as prompting updates to some emission and stock change factors. Nearly 140 scientists and national experts from more than thirty countries collaborated in the creation of the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* to ensure that the emission inventories submitted to the UNFCCC are consistent and comparable between nations. These guidelines were recently updated and revised to produce the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*.

When the organizational structure outlined in the 2006 IPCC Guidelines is fully implemented, the Agriculture and LULUCF chapters of the NIR will be combined into a single Agriculture, Forestry, and Other Land Uses (AFOLU) chapter covering six land-use categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, and Other Land). The Agriculture and LUCF modules of the SIT may be similarly combined and reorganized to maintain consistency with national and international inventory approaches. These changes will likely be incorporated in the next round of revisions to the SIT modules.

Methods for Growing Crops have different outcomes



Management:

- Full width tillage
- No Nutrient Management
- No Field specific conservation practices



Management:

- Cover crop
- Reduced and No-Till technology
- Nutrient Management
- Riparian Buffers
- Crop Rotation

USDA COMET ERCs:

- 0.15 tons CO₂e/ac/yr
- 0.19 tons CO₂e/ac/yr
- 0.37 tons CO₂e/ac/yr
- 0.74 tons CO₂e/ac/yr
- 0.22 tons CO₂e/ac/yr

1. Develop a methodology and protocol for quantifying climate mitigation, resilience, and adaptation impacts of existing state and federal water quality implementation programs as reported through the annual Clean Water Initiative Performance Report.

							(Sorted by Acreage)	
Practice Code	Practice Name	TOTAL					Total	Average
		2016	2017	2018	2019	2020		
340	Cover Crop	28,381	23,408	29,615	24,114	36,885	142,404	28,481
590	Nutrient Management	12,992	10,012	9,792	8,051	14,545	55,393	11,079
345	Conservation Tillage	8,940	9,506	10,703	12,143	8,142	49,434	9,887
328	Conservation Crop Rotation	10,516	11,709	13,156	4,632	2,181	42,194	8,439
329	Residue and Tillage Management, No Till	2,963	2,900	3,098	6,322	3,275	18,559	3,712
512	Pasture and Hay Planting	2,080	1,713	2,450	1,455	1,917	9,613	1,923
913VTA	Precision Agriculture	0	0	0	4,041	4,297	8,338	1,668
528	Prescribed Grazing	1,808	1,224	1,472	1,826	1,074	7,404	1,481
901VTA	Manure Injection	0	0	0	2,247	3,787	6,034	1,207
911VTA	Rotational Grazing	0	0	0	2,889	2,563	5,452	1,090
902VTA	Aeration	433	475	2,023	572	1,797	5,300	1,060
314	Brush Management	708	782	1,058	1,219	1,450	5,217	1,043
633	Waste Recycling	2,220	1,181	548	0	92	4,041	808
PAC	Production Area Compliance	0	792	540	1,185	1,385	3,902	780

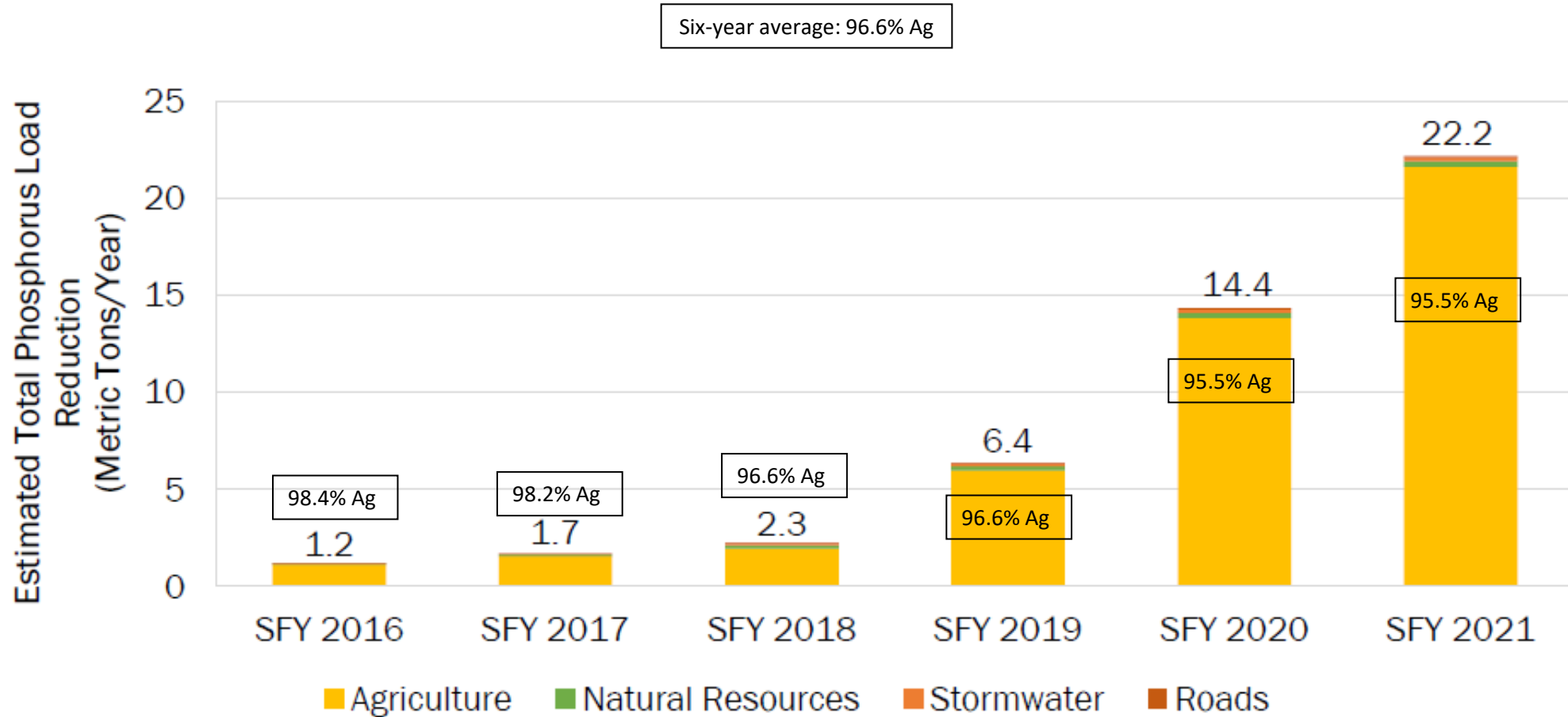


Figure 23. Annual estimated total phosphorus load reductions (metric tons per year) associated with state-funded clean water projects in the Lake Champlain and Lake Memphremagog basins by land use sector, SFY 2016-2021.²⁴

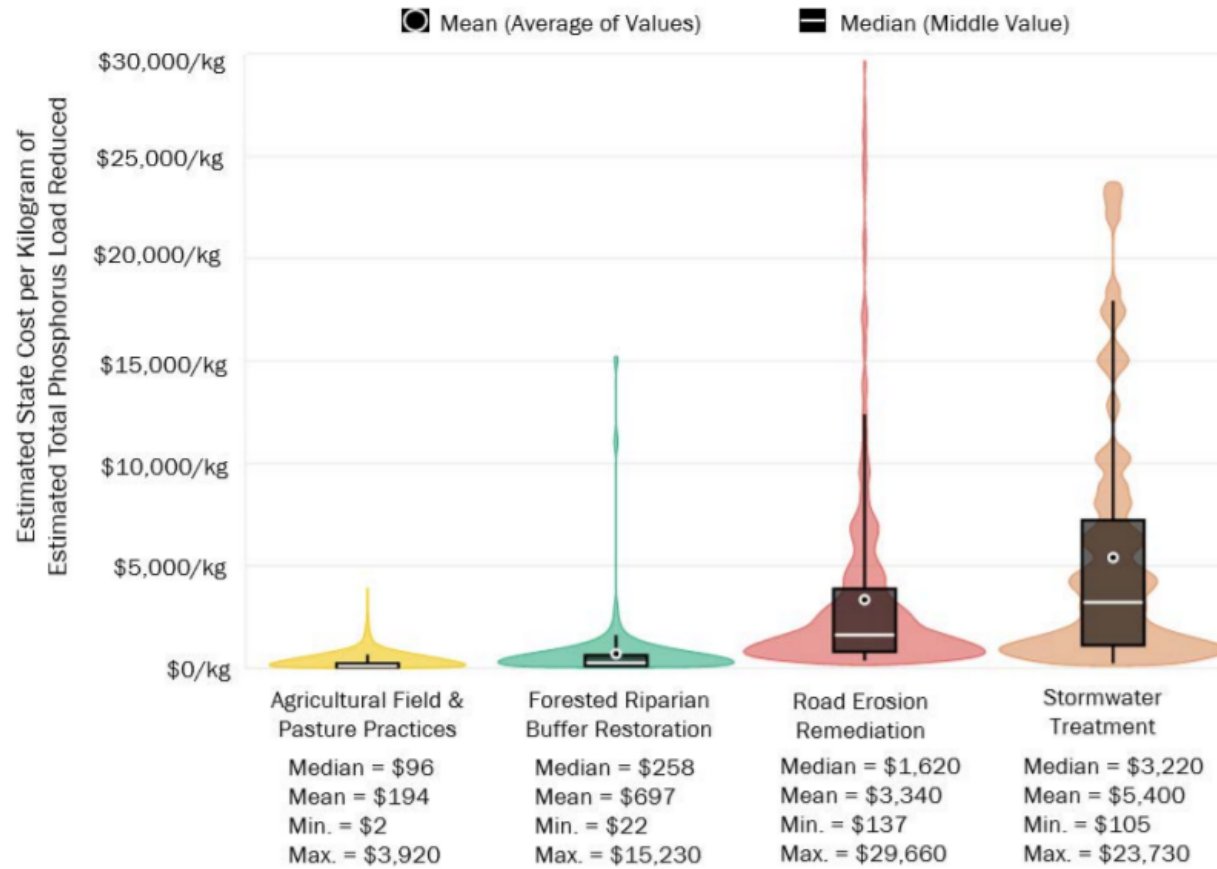


FIGURE GUIDE

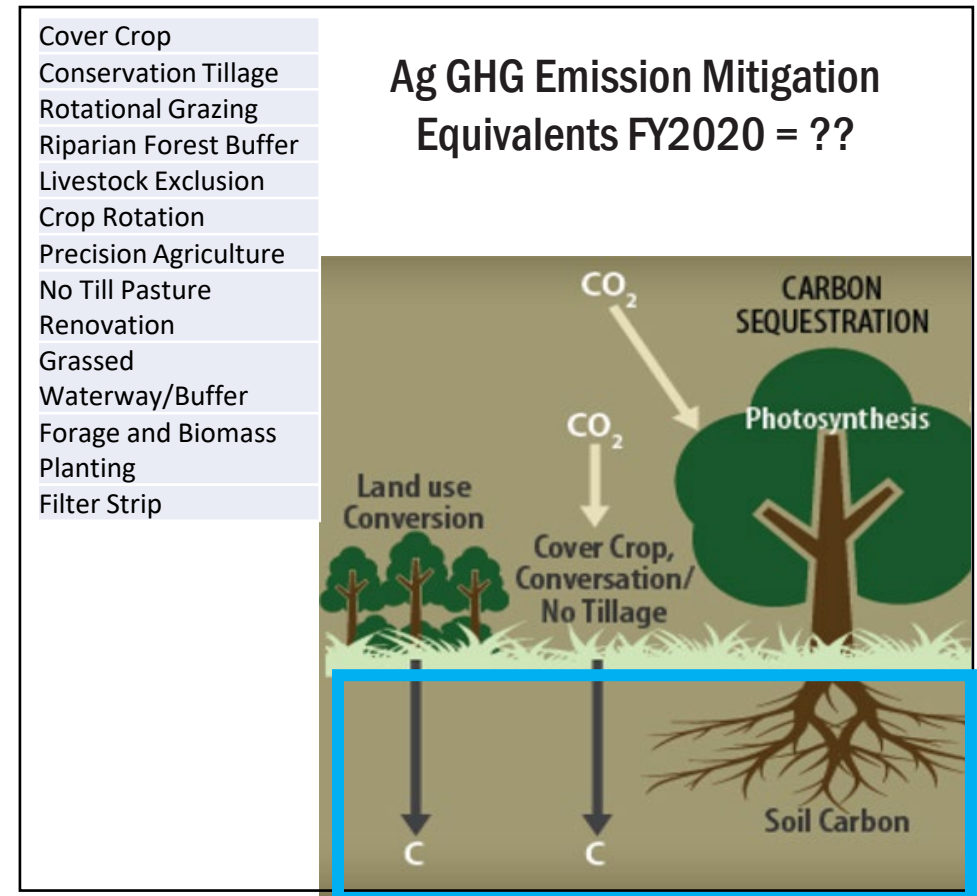
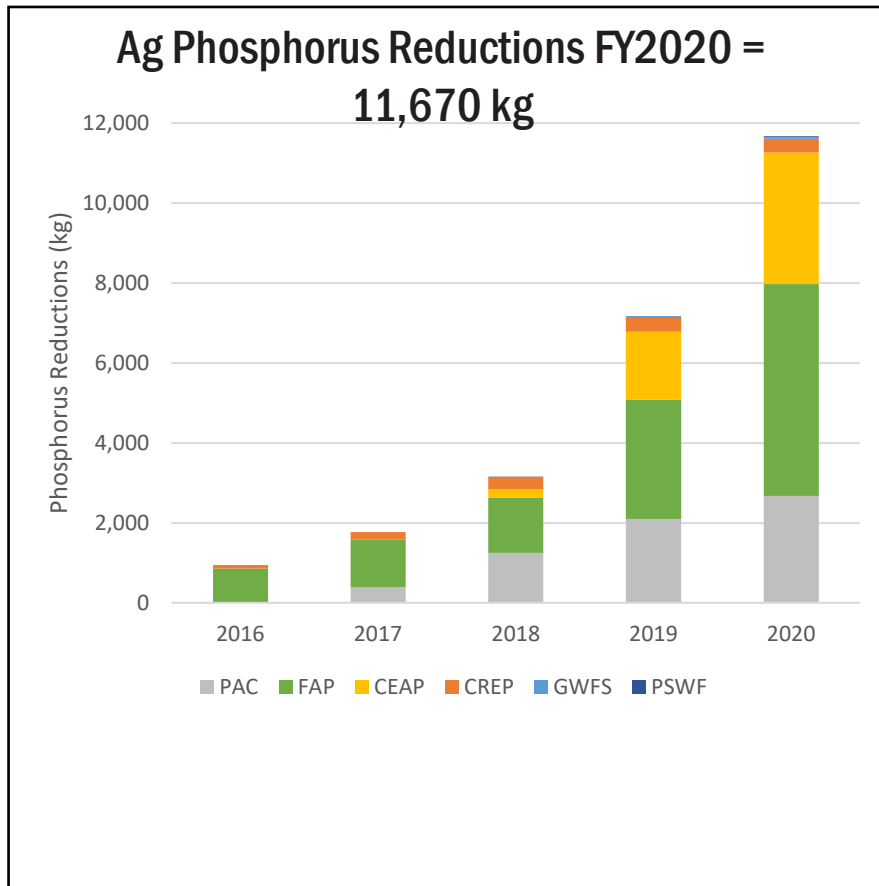
The violin plots, pictured at left, combine a box plot (see black rectangles/lines) and a density plot (see colored shapes).

A box plot shows the minimum, maximum, median, and average cost effectiveness values.

A density plot shows the relative number of projects falling into each range of cost effectiveness. Wider sections of the colored shapes represent more projects than thinner sections.

Figure 24. State investment per estimated kilogram of total phosphorus load reduced over the lifespan of each project type, based on clean water projects funded through State of Vermont agencies completed SFY 2016-2021 (excludes local and federal leveraged funds).²⁶

Co-benefits: The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits.

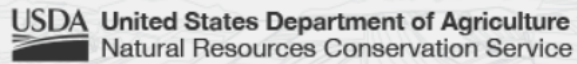


Agricultural conservation practice tracking

COMET-Planner Emission Reduction Coefficients (ERC)	Units: tons CO2e/ac/yr	CO2 Equivalents	Addison County	Vermont	Negative = Emissions				http://comet-planner.com/						
NRCS Conservation Practices	Soil Carbon	Biomass Carbon	Fossil CO2	Biomass Burning CO2	Biomass Burning N2O	Biomass Burning CH4	Liming	Total CO2	Direct Soil N2O	Indirect Soil N2O	Total N2O	Soil CH4	Total Emission Reductions	Minimum Total Emission Reductions*	Maximum Total Emission Reductions*
Crop Land															
Cover Crop (CPS 340) - Add Non-Legume Seasonal Cover Crop (with 25% Fertilizer N Reduction) to Non-Irrigated Cropland	0.16	0	0	0	0	0	0	0.16	-0.01	0	-0.01	0	0.15	-0.09	0.54
Cover Crop (CPS 340) - Add Legume Seasonal Cover Crop (with 50% Fertilizer N Reduction) to Non-Irrigated Cropland	0.39	0	0	0	0	0	0	0.39	-0.19	-0.04	-0.23	0	0.16	-0.15	0.84
Conservation Crop Rotation (CPS 328) - Decrease Fallow Frequency or Add Perennial Crops to Rotations	0.21	0	0	0	0	0	0	0.21	0.01	0	0.01	0	0.22	N.E. **	N.E. **
Residue and Tillage Management - Reduced Till (CPS 345) - Intensive Till to Reduced Till on Non-Irrigated Cropland	0.17	0	0	0	0	0	0	0.17	0.01	0	0.01	0	0.19	0.05	0.34
Residue and Tillage Management - No-Till (CPS 329) - Intensive Till to No Till or Strip Till on Non-Irrigated Cropland	0.5	0	0	0	0	0	0	0.5	0.04	0.01	0.05	0	0.56	0.29	0.77
Residue and Tillage Management - No-Till (CPS 329) - Reduced Till to No Till or Strip Till on Non-Irrigated Cropland	0.4	0	0	0	0	0	0	0.4	0.03	0.01	0.04	0	0.44	0.22	0.61
Nutrient Management (CPS 590) - Improved N Fertilizer Management on Non-Irrigated Croplands - Reduce Fertilizer Application Rate by 15%	-0.02	0	0	0	0	0	0	-0.02	0	0	0	0	-0.01	-0.17	0.13
Nutrient Management (CPS 590) - Replace Synthetic N Fertilizer with Compost (CN ratio 10) on Non-Irrigated Croplands	0.2	0	0	0	0	0	0	0.2	-0.15	-0.04	-0.19	0	0.01	-0.27	0.23
Nutrient Management (CPS 590) - Replace Synthetic N Fertilizer with Compost (CN ratio 25) on Non-Irrigated Croplands	0.49	0	0	0	0	0	0	0.49	-0.1	-0.02	-0.12	0	0.37	0.11	0.6
Nutrient Management (CPS 590) - Replace Synthetic N Fertilizer with Dairy Manure on Non-Irrigated Croplands	0.22	0	0	0	0	0	0	0.22	-0.13	-0.03	-0.16	0	0.06	-0.18	0.27

*Minimum and maximum emission reductions represent the minimum and maximum total emissions over a range of soil, climate and management conditions within multi-county regions. Min/Max emissions are not estimated for all practices, due to limitations in quantification methods

**Values were not estimated due to limited data on reductions of greenhouse gas emissions from this practice



Carbon and greenhouse gas evaluation
for NRCS conservation practice planning

[HOME](#) [HELP](#) [NRCS TOOL](#)

Recommended use of COMET-Planner CDFA HSP: *This evaluation tool is designed to provide estimates of the net greenhouse gas reductions for specific agricultural management conservation practices included in the California Department of Food and Agriculture (CDFA) Healthy Soils Program (HSP). This tool also helps estimate payments associated with implementing the practices under the HSP. Please note that a comprehensive assessment of site specific conditions may not be accounted with this tool.*

EVALUATE POTENTIAL CARBON SEQUESTRATION AND GREENHOUSE GAS REDUCTIONS FROM ADOPTING NRCS CONSERVATION PRACTICES

INTRODUCTION
VIDEO



COMET-Planner for the CDFA Healthy Soils Program estimates greenhouse gas reductions and approximates program payments associated with NRCS Conservation Practices included in the program. NRCS Conservation Practices included in COMET-Planner are only those that have been identified as having greenhouse gas mitigation and/or carbon sequestration benefits on farms and ranches. This list of conservation practices is [based on the qualitative greenhouse benefits ranking of practices prepared by NRCS](#).

This tool has been developed to support programs coordinated by the CDFA and the California Air Resources Board (CARB), and contains information on conservation practices eligible under the HSP. For information on an expanded list of conservation practices, see the [COMET-Planner tool](#).

Step 1: Begin by naming your project and selecting your state and county

Project Name:

County:

Source: <http://comet-planner-cdfahsp.com/>

Source: <https://www.cdfa.ca.gov/oefi/healthysoils/incentivesprogram.html>



The United States of America Nationally Determined Contribution

Reducing Greenhouse Gases in the United States:
A 2030 Emissions Target

After a careful process involving analysis and consultation across the United States federal government and with leaders in state, local, and tribal governments, **the United States is setting an economy-wide target of reducing its net greenhouse gas emissions by 50-52 percent below 2005 levels in 2030.** The National Climate Advisor developed this NDC in consultation with the Special Presidential Envoy for Climate, and it was approved by President Joseph R. Biden Jr..

Beyond the energy sector, the United States will also **reduce emissions from forests and agriculture** and enhance carbon sinks through a range of programs and measures for ecosystems ranging from our forests and agricultural soils to our rivers and coasts. Actions to be pursued include, for example:

- **Agriculture and lands:** America's vast lands provide opportunities to **both reduce emissions, and sequester more carbon dioxide.** The United States will support scaling of climate smart agricultural practices (including, for example, cover crops), reforestation, rotational grazing, and nutrient management practices. In addition, federal and state governments will invest in forest protection and forest management, and engage in intensive efforts to reduce the scope and intensity of catastrophic wildfires, and to restore fire-damaged forest lands. Alongside these efforts, the United States will support nature-based coastal resilience projects including pre-disaster planning as well as efforts to increase sequestration in waterways and oceans by pursuing "blue carbon."

1. Develop a methodology and protocol for quantifying climate mitigation, resilience, and adaptation impacts of existing state and federal water quality implementation programs as reported through the annual Clean Water Initiative Performance Report.
2. The Vermont Climate Council has recommended developing and issuing a Request for Proposals (RFP) that will review and analyze methodological gaps of emission inventory tools currently used by the State of Vermont to quantify greenhouse gas emissions for evaluating changes in the Agriculture, Forestry and Other Land Use (AFOLU) sector and the tools' alignment with the Intergovernmental Panel on Climate Change (IPCC), Environmental Protection Agency (EPA), and peer state methodologies and approaches. The specific recommendations for this RFP can be found in the Carbon Budget Report memo found in Appendix 10.
3. Based on the findings of the technical RFP mentioned in action step (b) of this strategy, the VCC should consider recommending that the State of Vermont GHG emissions inventory protocol established in 10 V.S.A. § 582 be amended to include an inventory of GHG emissions that align with the intent and standards of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories that will include a net GHG emission accounting for the agriculture, forestry and other land use (AFOLU) sector