Vermont Agriculture & Soil Carbon Sequestration

Ryan Patch
Vermont Agency of Agriculture, Food and Markets
House Committee on Agriculture
January 25, 2022

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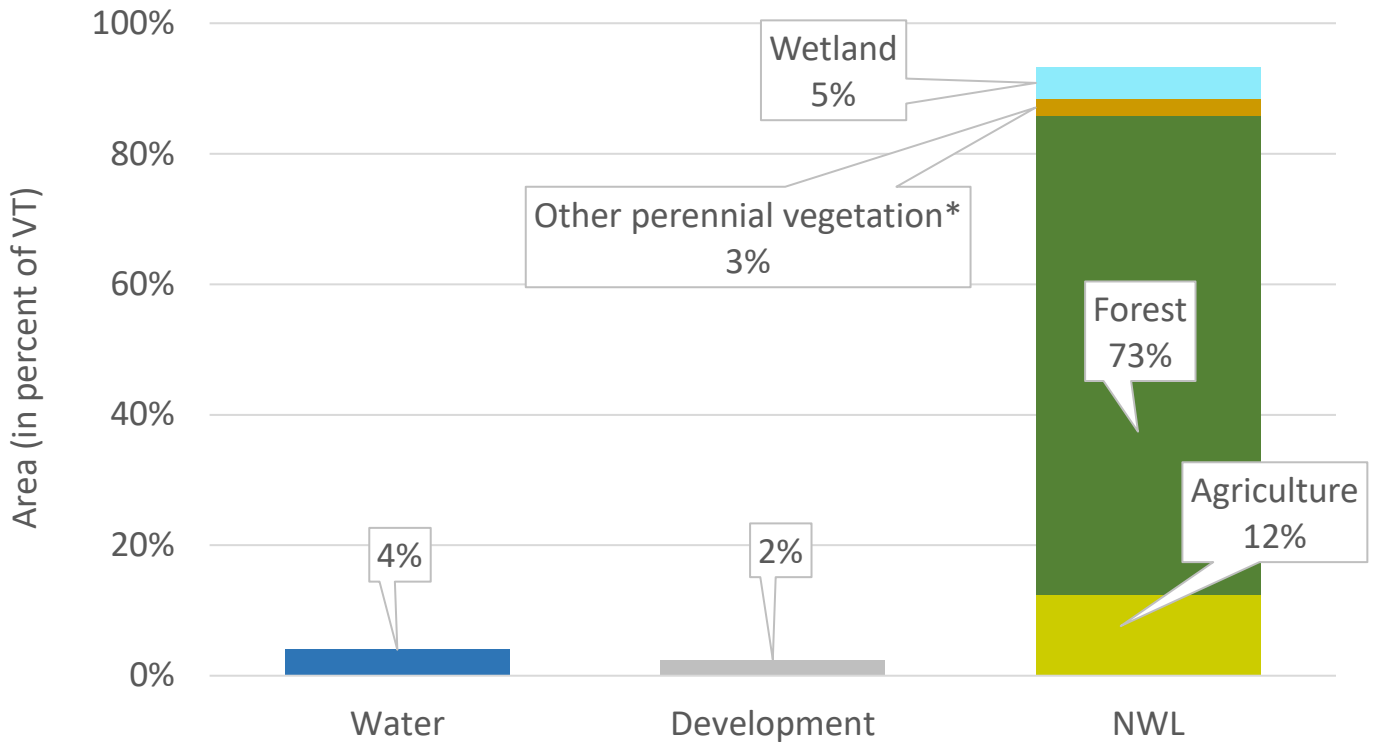
Natural & Working Lands (NWL) cover 94% of Vermont



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

Data source: 2016 National Land Cover Database; Images courtesy FPR

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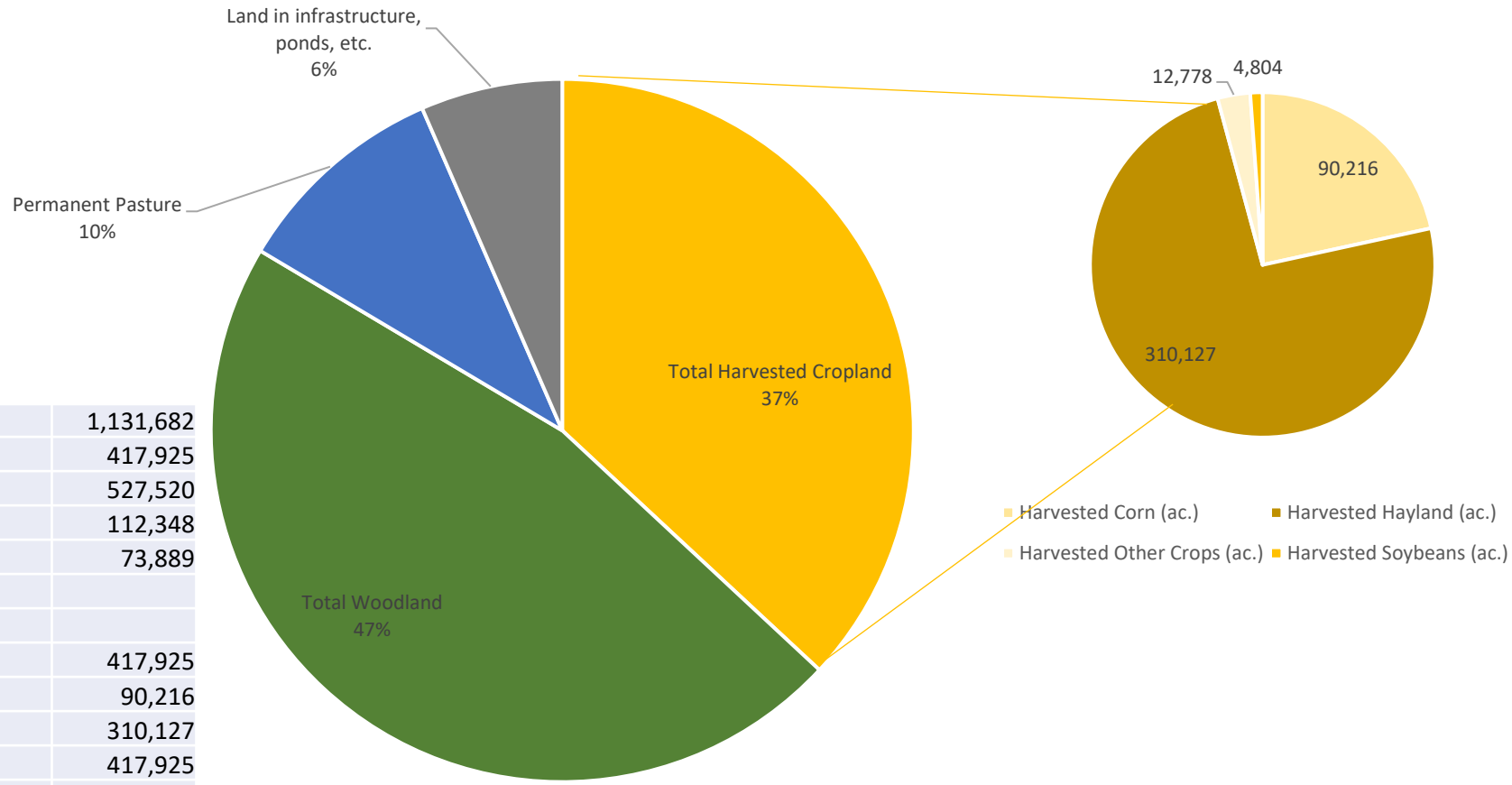
Land managed by farms in Vermont, 2017



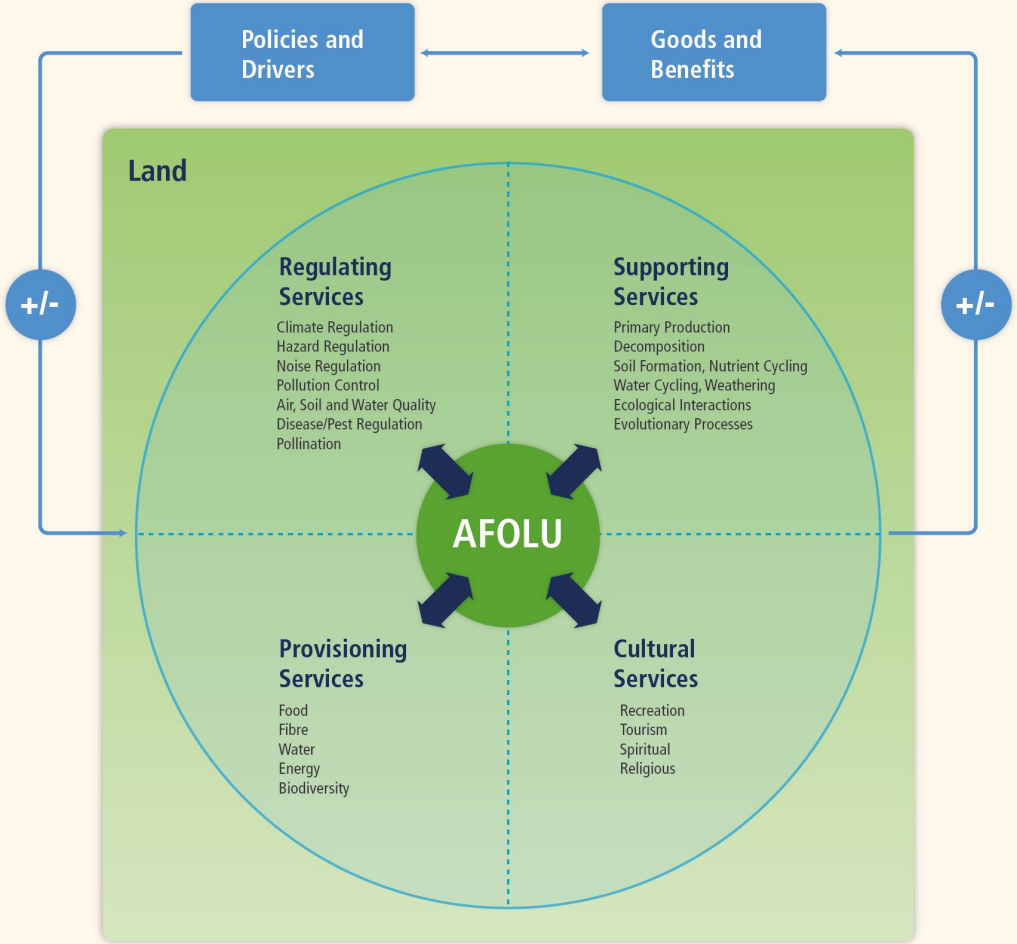
Land in Farms	1,131,682
Total Harvested Cropland	417,925
Total Woodland	527,520
Permanent Pasture	112,348
Land in infrastructure, ponds, etc.	73,889
Total Cropland Harvested	417,925
Total Corn in VT	90,216
Total Hayland in VT	310,127
Total Other in VT	417,925
Total Soybeans	4,804

Source: 2017 USDA NASS Ag Census

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

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Vermont is Getting Warmer and Wetter: Climate Change Study

The Green Mountain State has warmed nearly 2°F, with a 21% jump in precipitation

Key findings

Climate change is here – and impacting communities across Vermont.

Vermont is getting warmer. Winters are warming more quickly. Snow season is getting shorter.

Vermont is getting wett Heavy rain events happe more often, contributing more flooding and wate quality problems.

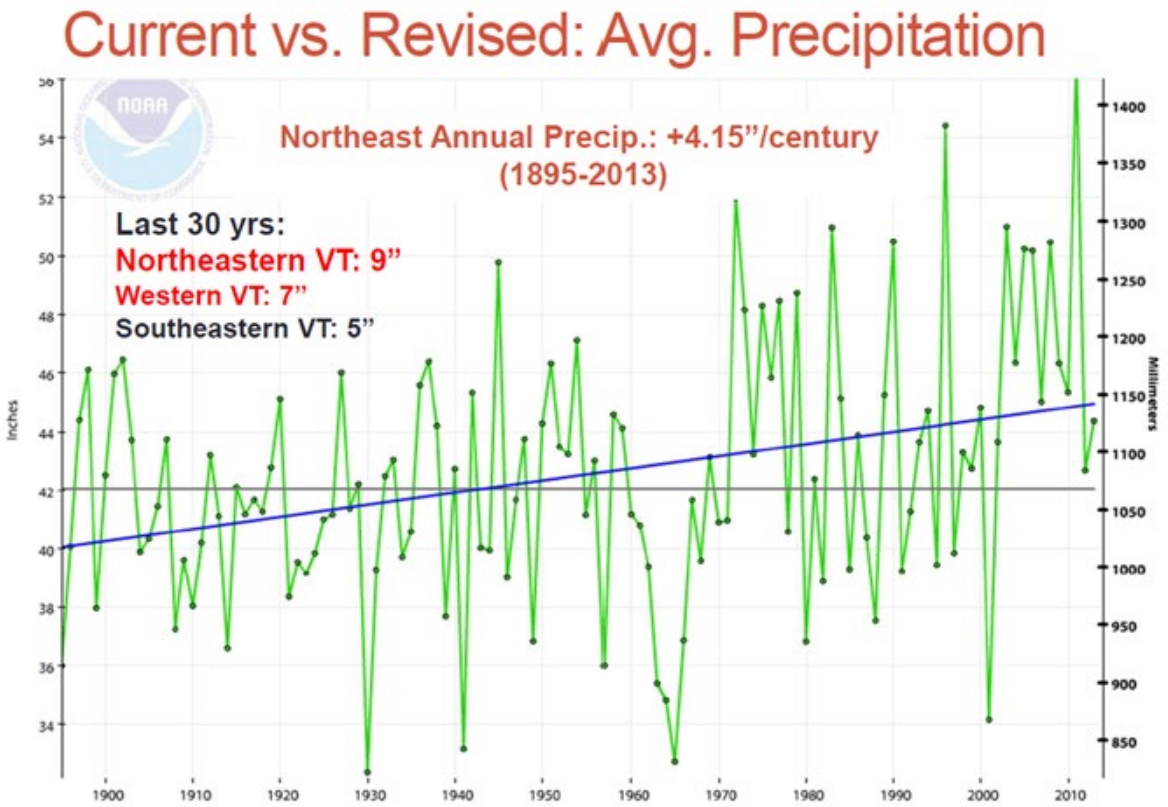
Multiple, complex impacts could lead to surprises.

Climate impacts and risks will increase without action.

Dig in to learn more...

Source: The Vermont Climate Assessment 2021. Burlington, Vermont: Gund Institute for Environment at the University of Vermont. On the web: https://vtclimate.org

Precipitation trends in Vermont



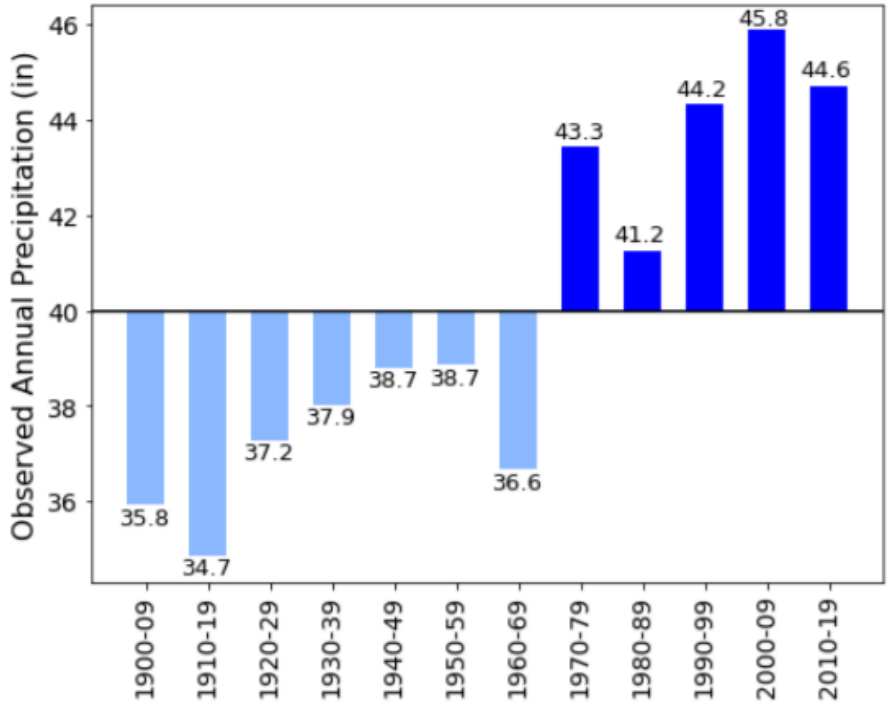


Figure 1-8: Decadal averages of observed annual precipitation in Vermont

Source: Joshua Faulkner: Agriculture, Climate Change & Water Quality Presentation. Gund Institute for Environment at UVM. https://www.youtube.com/watch?v=9uIzxc57n4w
Source: The Vermont Climate Assessment 2021. Burlington, Vermont: Gund Institute for Environment at the University of Vermont. On the web: https://vtclimate.org

Why Vermont Crops Fail; 2001 - 2021

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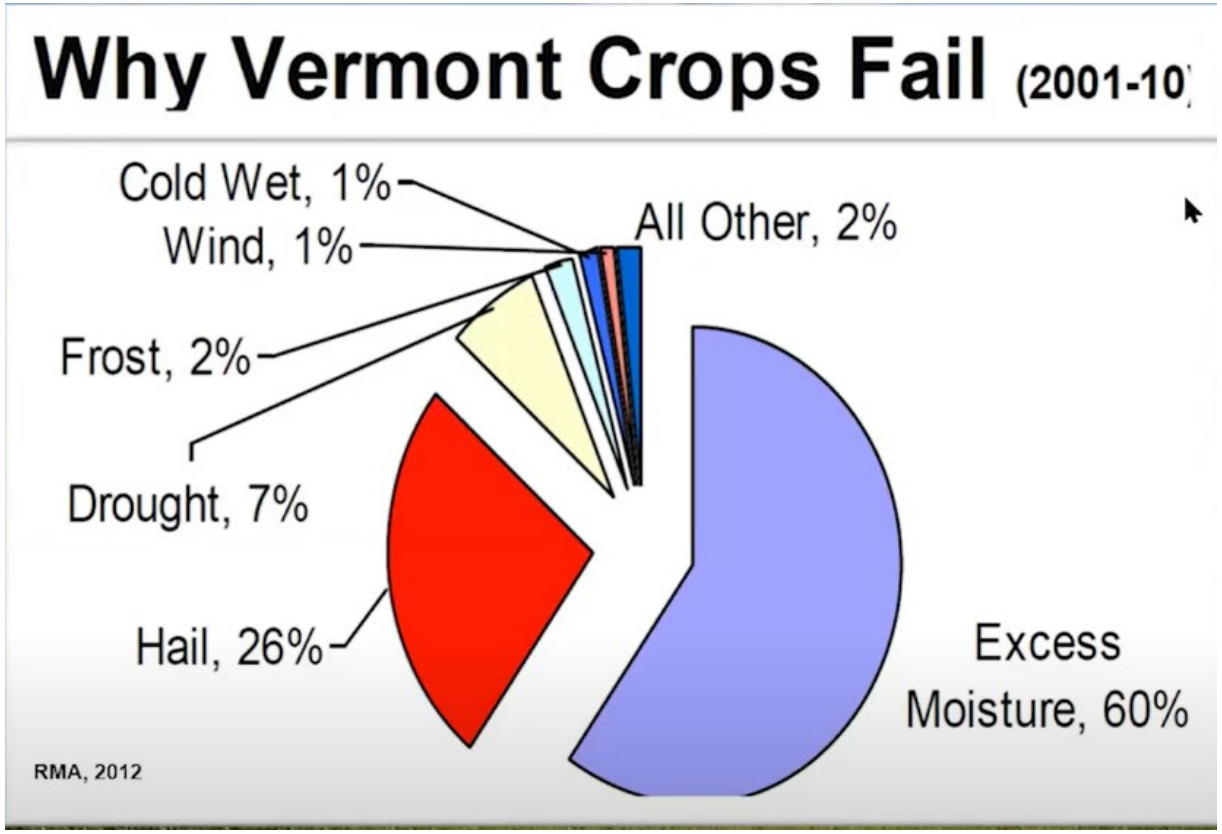

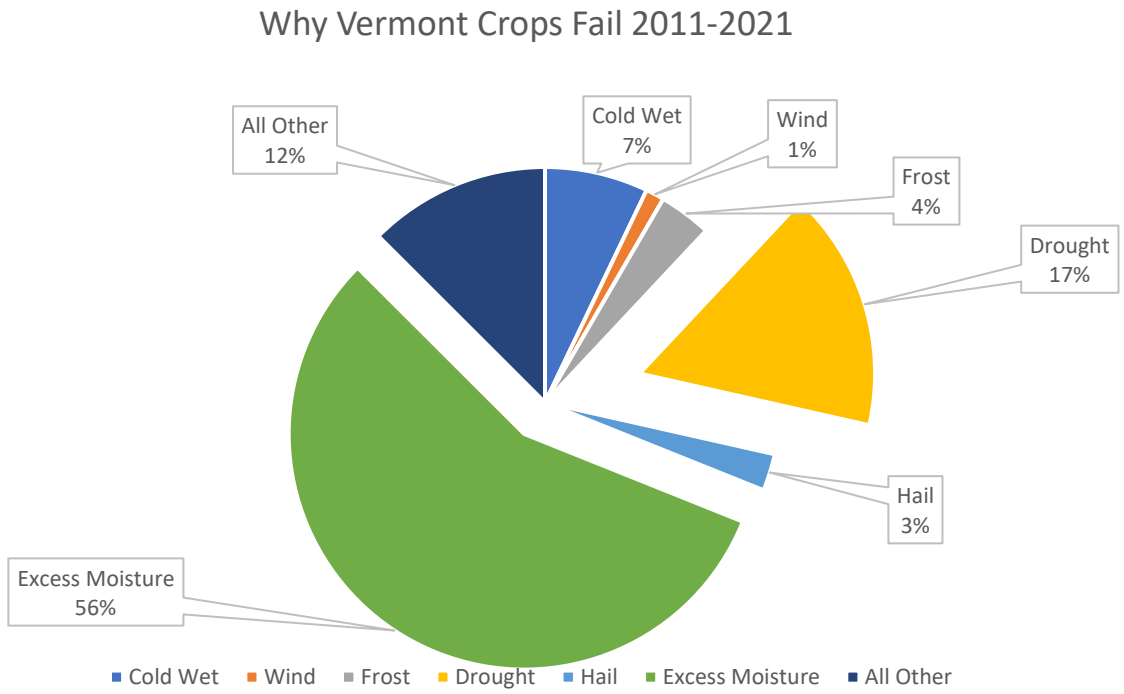

Source: Joshua Faulkner: Agriculture, Climate Change & Water Quality Presentation. Gund Institute for Environment at UVM. https://www.youtube.com/watch?v=9uIzxc57n4w
Source: USDA RMA, Cause of Loss Historical Data Files. Avaliable at: https://www.rma.usda.gov/Information-Tools/Summary-of-Business/Cause-of-Loss

VT Precipitation Projection

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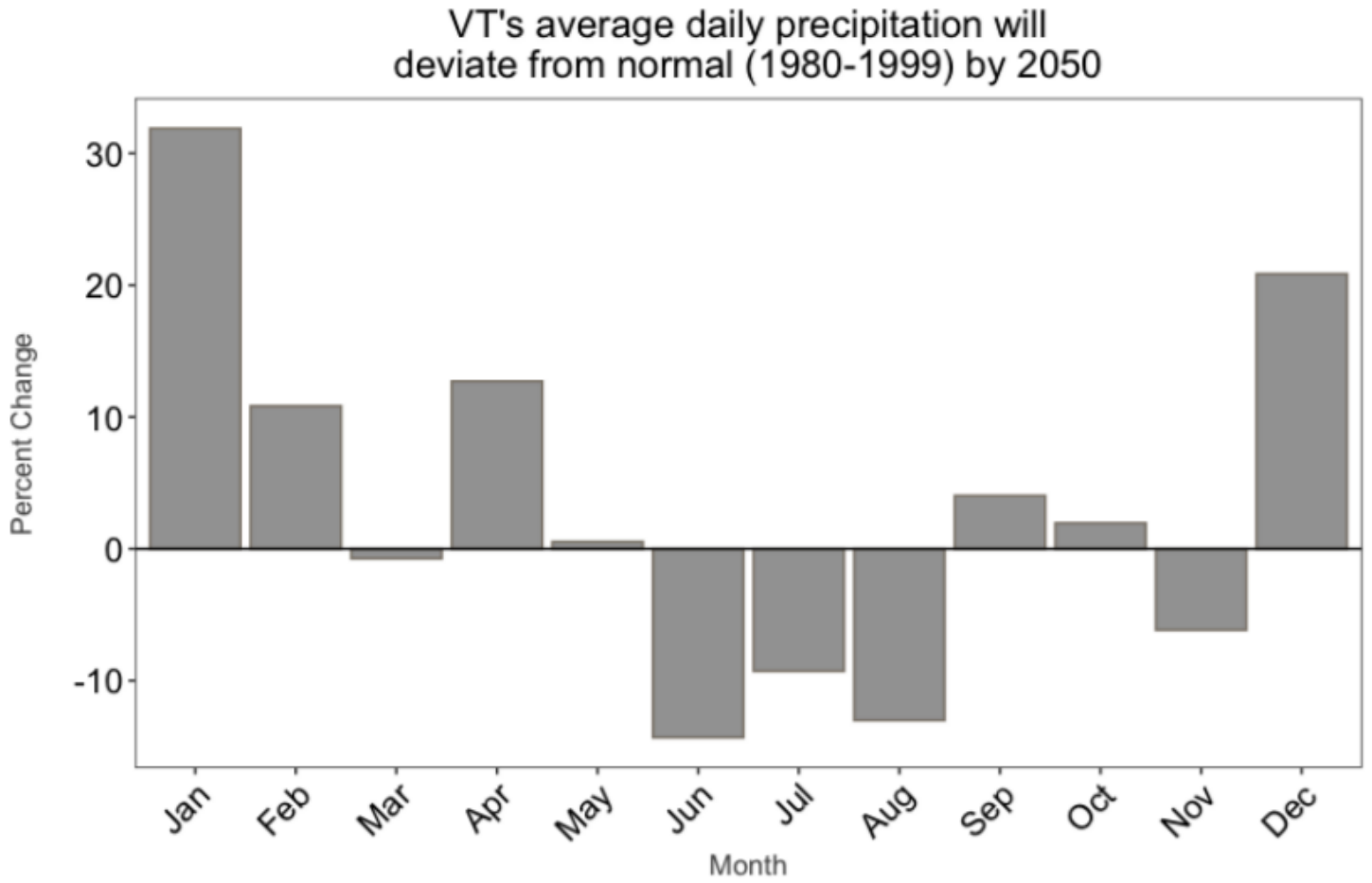

Figure 5-5: Projected daily mean precipitation in 2050 as percent deviation relative to 1980s–1990s shows lower summer growing season precipitation (USGS, 2021a)

Source: Claro, J., Faulkner, J., Isbell, C., Ruggiero, R., White, A., 2021. Agriculture and Food Systems. In Galford, G.L., Faulkner, J. et al. (Eds), The Vermont Climate Assessment 2021. Burlington, Vermont: Gund Institute for Environment at the University of Vermont. On the web: https://vtclimate.org

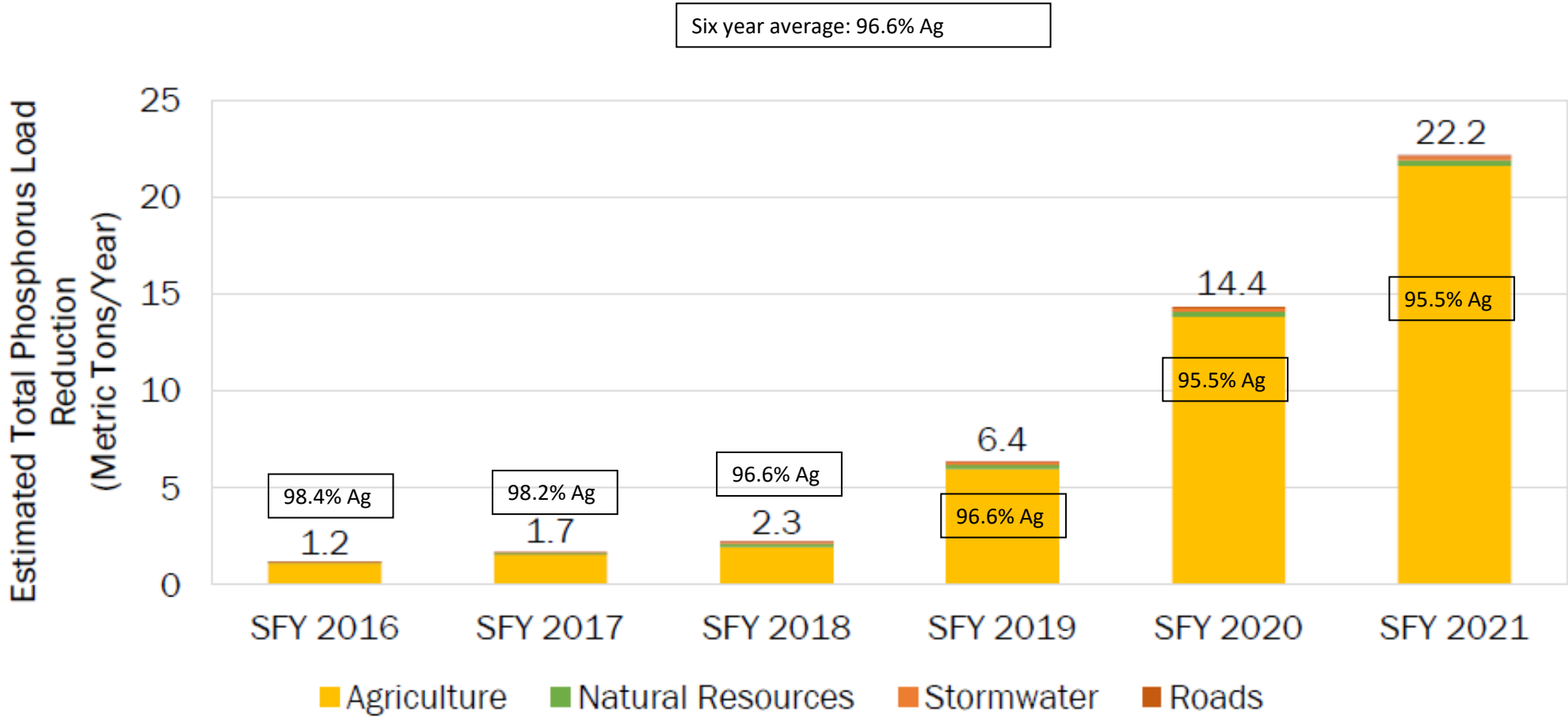

Figure 23. Annual estimated total phosphorus load reductions (metric tons per year) associated with state-funded clean water projects in the Lake Champlain and Lake Memphremagog basins by land use sector, SFY 2016-2021.[24]

Source: https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/Reports/2021CleanWaterInitiativePerformanceReport_FINAL_updated%201-20-2022.pdf (page 33)

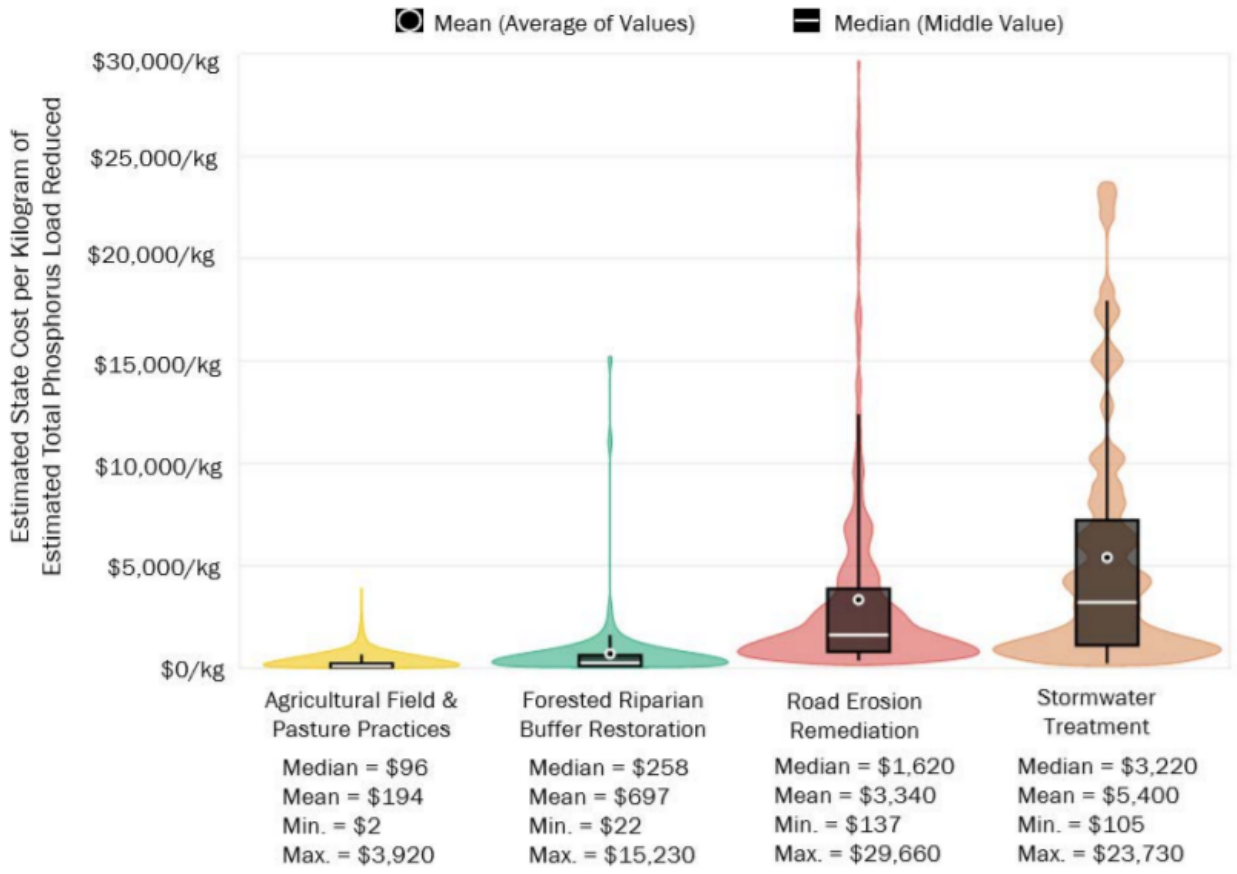

Figure 24. State investment per estimated kilogram of total phosphorus load reduced over the lifespan of each project type, based on clean water projects funded through State of Vermont agencies completed SFY 2016-2021 (excludes local and federal leveraged funds).[26]

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.

Source: https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/Reports/2021CleanWaterInitiativePerformanceReport_FINAL_updated%201-20-2022.pdf (page 34)

Agricultural conservation practice tracking

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(Sorted by Acreage)

Practice Code	Practice Name	TOTAL						
		2016	2017	2018	2019	2020	Total	Average
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
913VTAg	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
901VTAg	Manure Injection	0	0	0	2,247	3,787	6,034	1,207
911VTAg	Rotational Grazing	0	0	0	2,889	2,563	5,452	1,090
902VTAg	Aeration	433	475	2,023	572	1,797	5,300	1,060
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PAC	Production Area Compliance	0	792	540	1,185	1,385	3,902	780

Source: https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2021-01-15_CleanWaterPerformanceReport_SFY2020-FINA-PDF-A.pdf

IPCC Definition of Co-benefits

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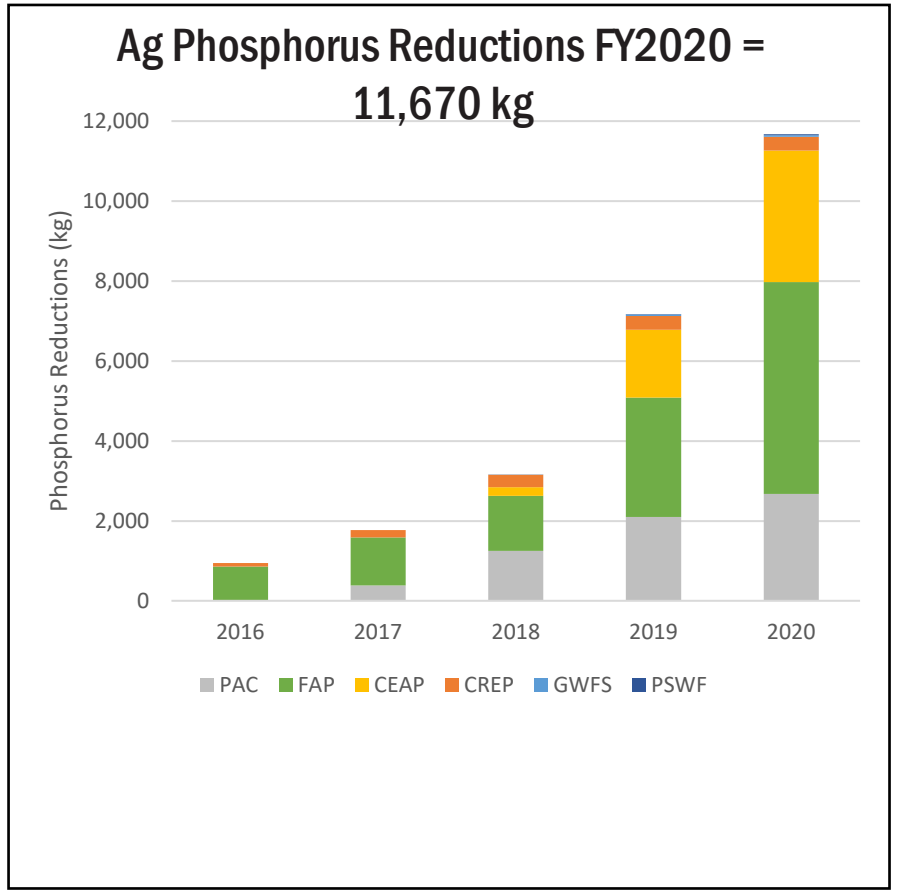
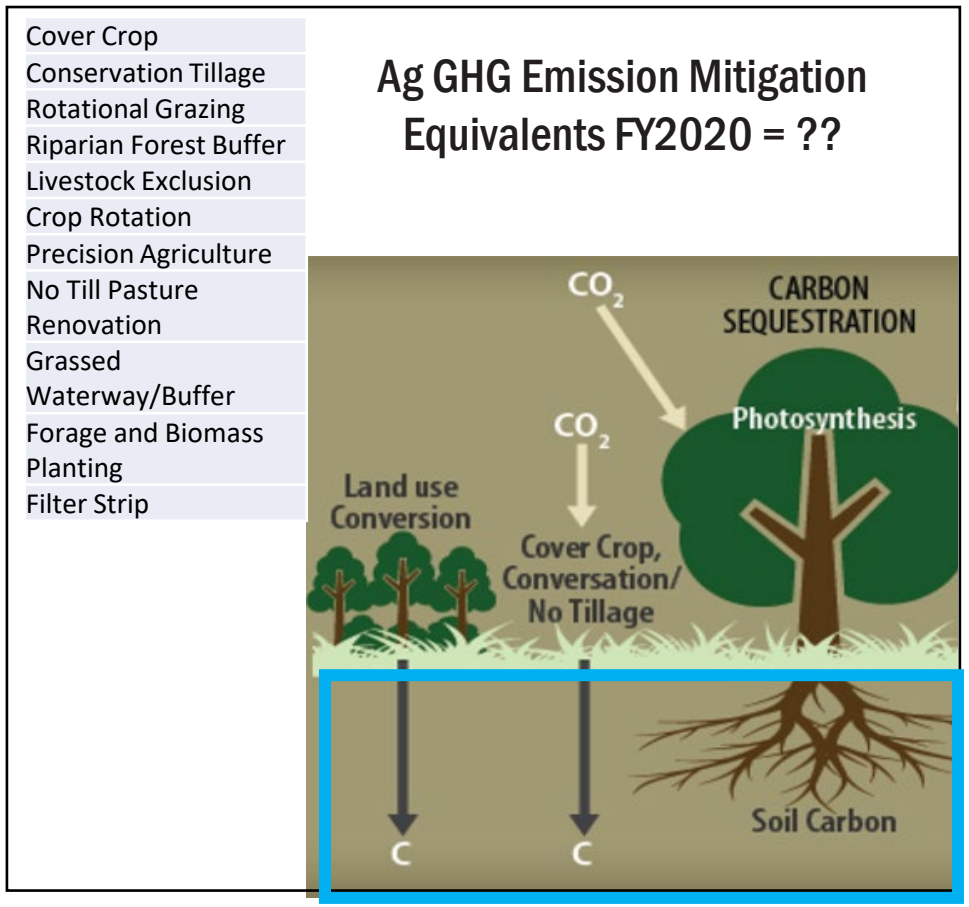
Co-benefits: The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors.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



Cover Crop
Conservation Tillage
Rotational Grazing
Riparian Forest Buffer
Livestock Exclusion
Crop Rotation
Precision Agriculture
No Till Pasture Renovation
Grassed Waterway/Buffer
Forage and Biomass Planting
Filter Strip



2. Task 5C Agriculture Strategy Matrix Document (excel spreadsheets)

						NRCS Practice Physical Effects		
Emissions + Sequestration + Storage	Emissions of GHGs	Organic Matter Depletion	Soil Organism Habitat Loss or Degradation	Aggregate Instability	Nutrients Transported to Surface Water	Ponding and Flooding	Terrestrial Habitat	Aquatic Habitat

Practice	NRCS Practice Code	Emissions + Sequestration + Storage	Emissions of GHGs	Organic Matter Depletion
			34	9
Conservation Cover	327	9	4	5
Tree/Shrub Establishment	612	8	4	4
Windbreak-Shelterbelt Establishment (ft)	380	8	4	4
Riparian Forest Buffer	391	7	3	4
Alley Cropping	311	7	2	5
Multi-Story Cropping	379	7	2	5
Cover Crop	340	6	4	2
No-Till	329	6	4	2
Nutrient Management	590	6	4	2
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Prescribed/Rotational Grazing	528	6	2	4

Agricultural conservation practice tracking

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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

Source: https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2021-01-15_CleanWaterPerformanceReport_SFY2020-FINA-PDF-A.pdf

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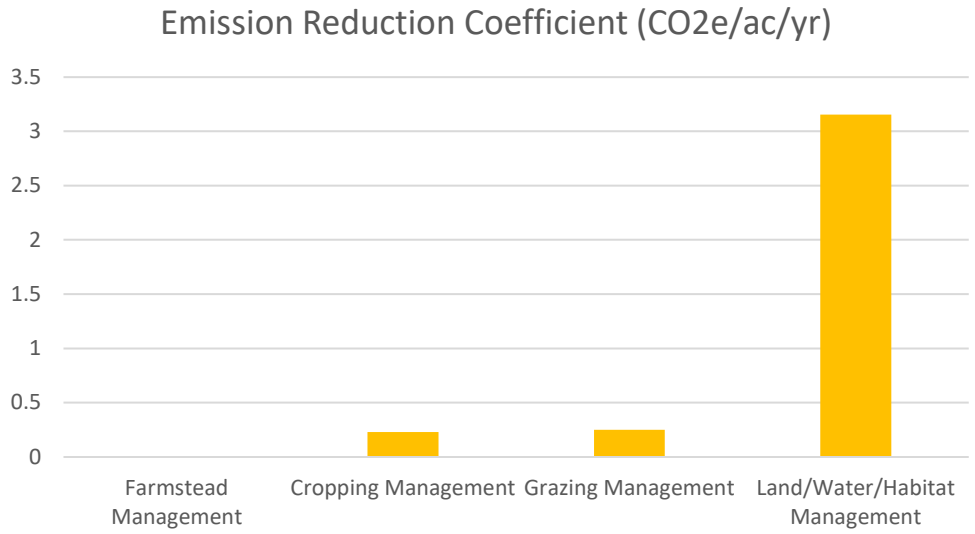

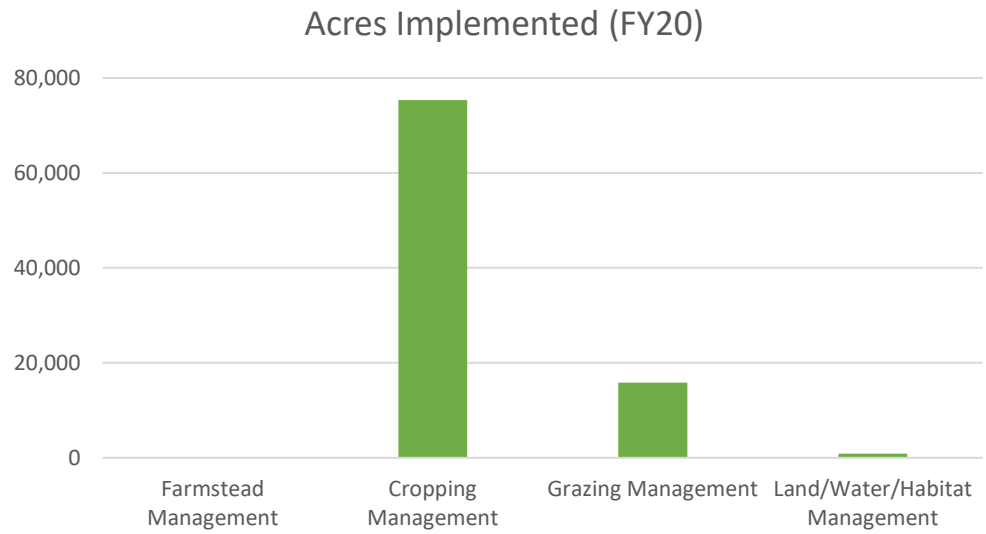

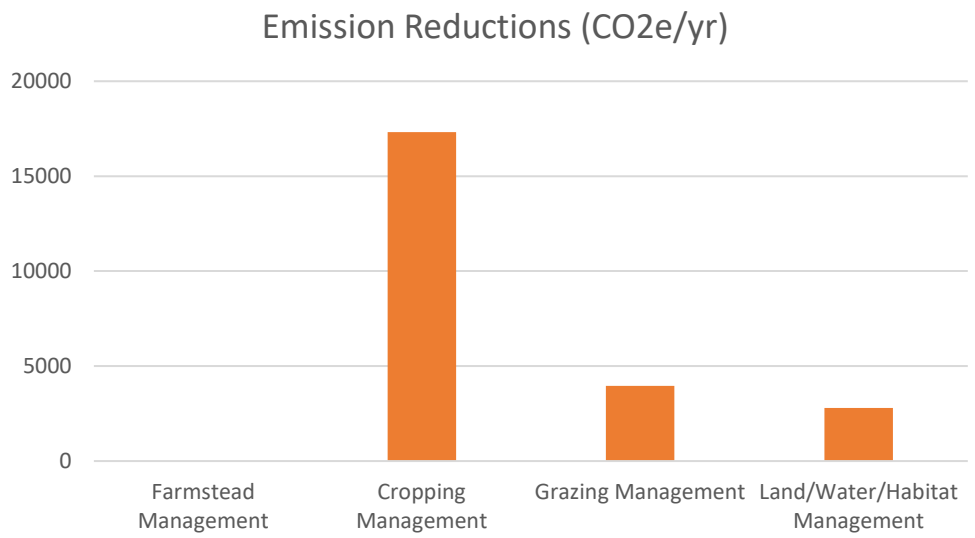

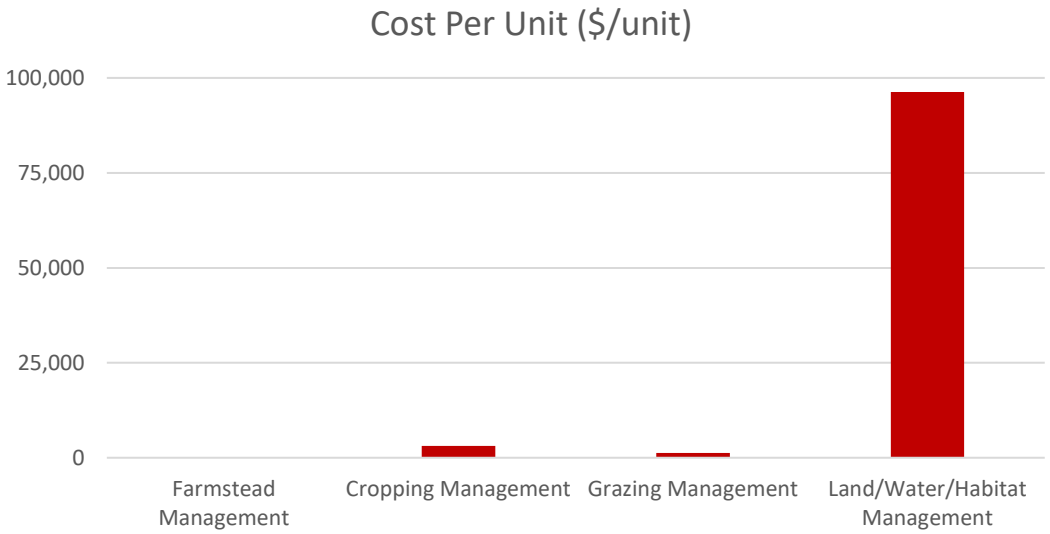

Carbon Inventory: Ex-Act

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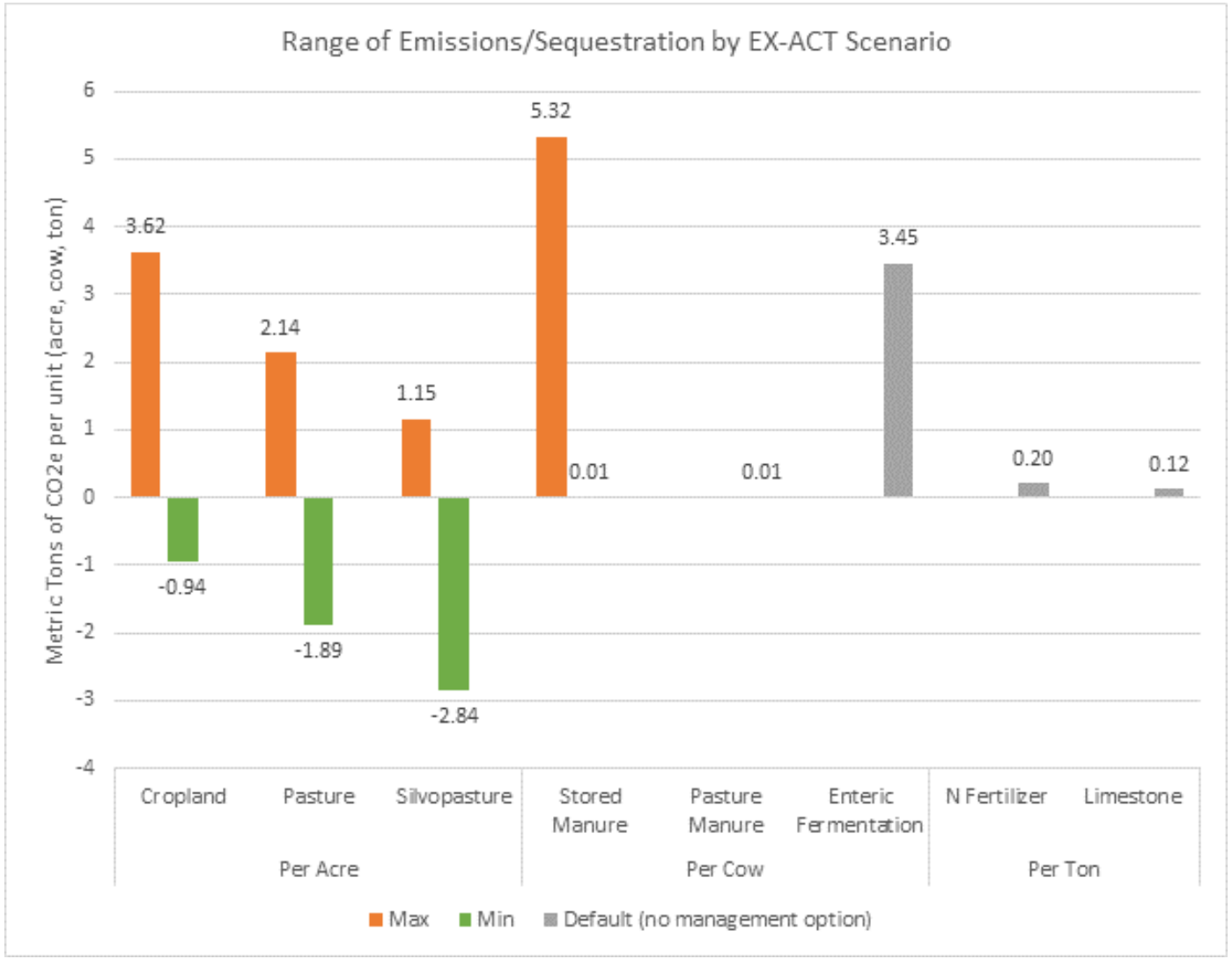

Source: https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-i.pdf
Source: https://aoa.vermont.gov/sites/aoa/files/Boards/VCC/ACT153%20As%20Enacted.pdf

TNC Canada: N&WL GHG Mitigation Opportunities

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Natural Climate Solutions are actions to **protect, better manage and restore nature** to reduce greenhouse gas emissions. Combined with cutting fossil-fuel use, boosting energy efficiency and accelerating clean-energy innovation, Natural Climate Solutions offer powerful and cost-effective ways to tackle the climate crisis.

New science led by Nature United with 16 other research institutions shows that Natural Climate Solutions can reduce Canada's emissions by up to **78 megatonnes of CO_2e annually in 2030.** The study was peer-reviewed and published in *Science Advances*.

Media Inquiries: (416) 526-7353 | jacqueline.nunes@natureunited.ca

Natural climate solution
Cover crops
Crop residue - biochar
Nutrient management
Tree intercropping (trees in agricultural lands pathway)
Manure Management
Silvopasture (trees in agricultural lands pathway)
Legume crops
Reduced tillage
Riparian tree planting (trees in agricultural lands pathway)
Legumes in pastures
Avoided conversion of shelterbelts (trees in agricultural lands pathway)
Avoided wetland conversion
Wetland restoration
Avoided grassland conversion
Riparian grassland restoration
Improved forest management
Avoided forest conversion
Restoration of forest cover
Urban canopy cover

Source: https://www.natureunited.ca/what-we-do/our-priorities/innovating-for-climate-change/natural-climate-solutions/

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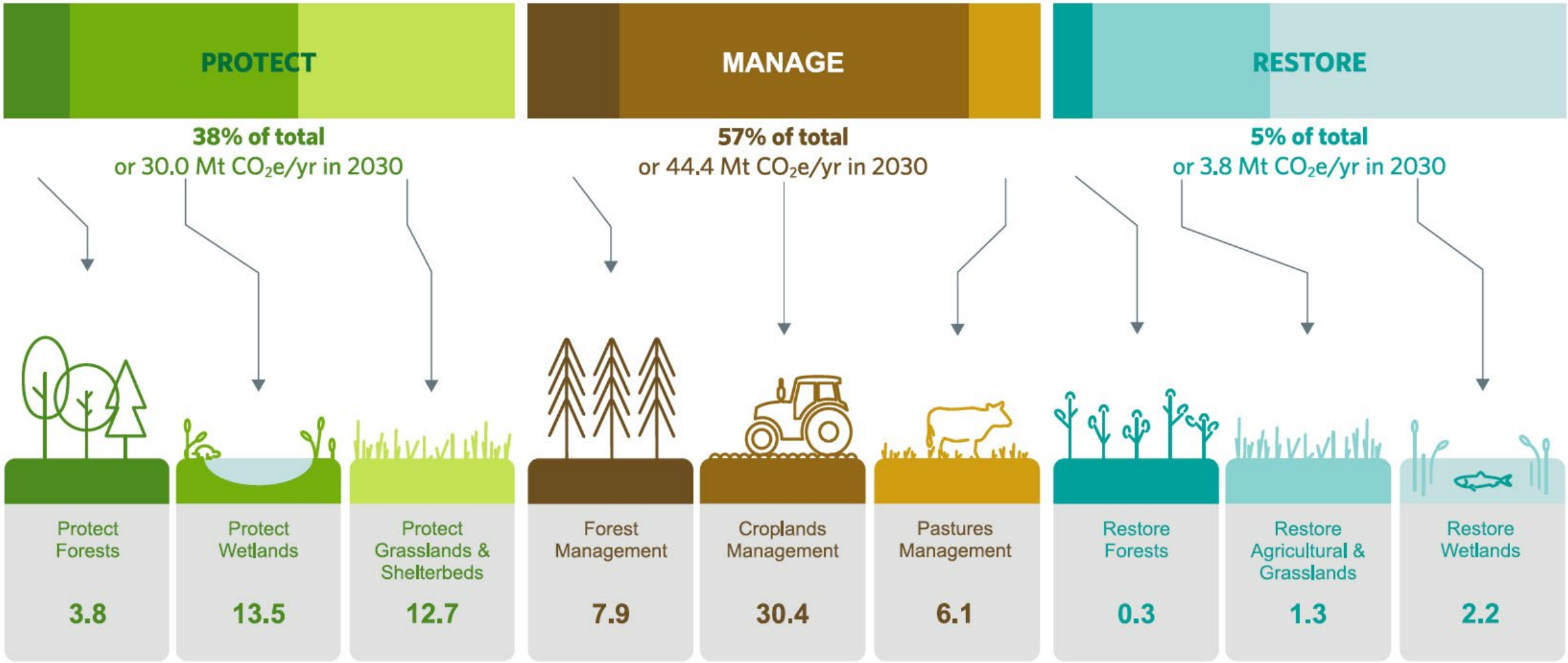

Source: https://www.natureunited.ca/content/dam/tnc/nature/en/documents/canada/natural-climate-solutions-infographic.pdf

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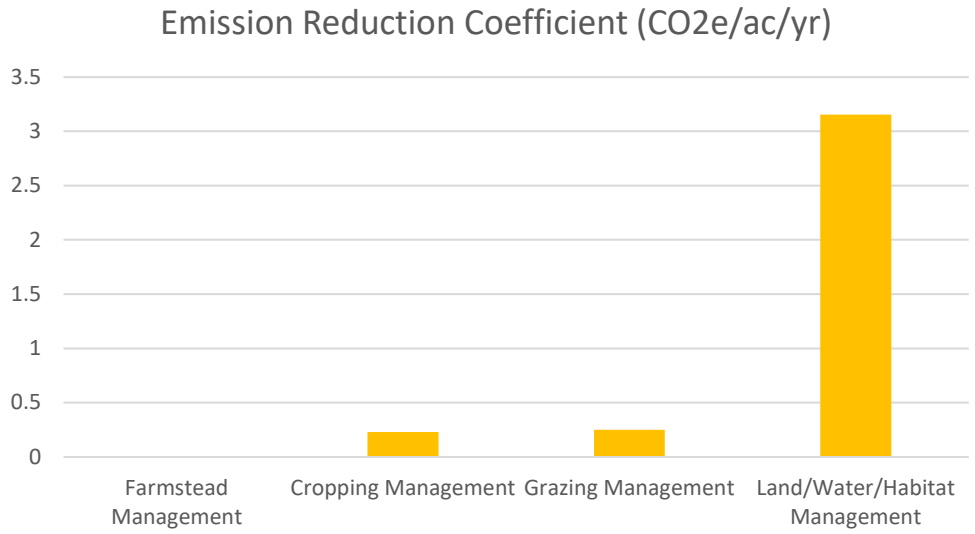
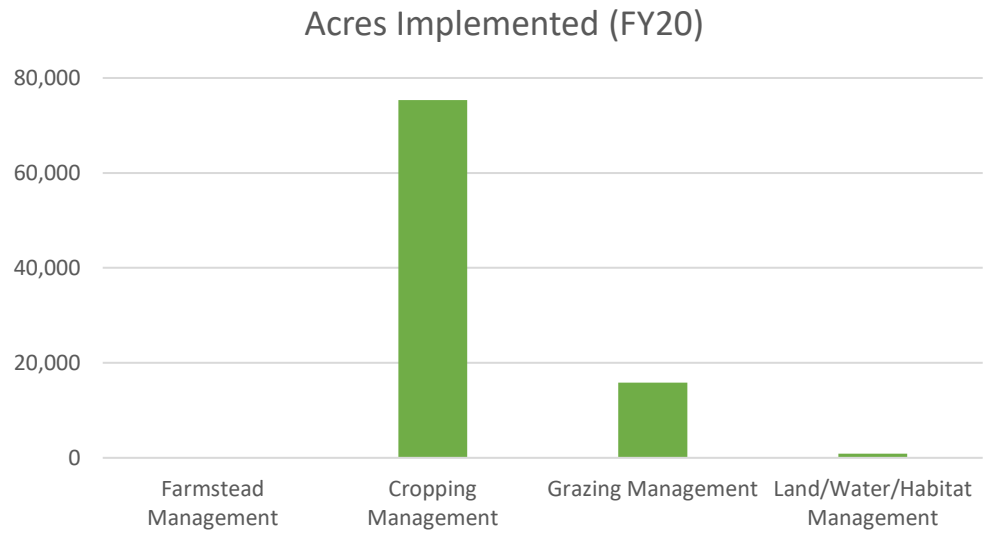
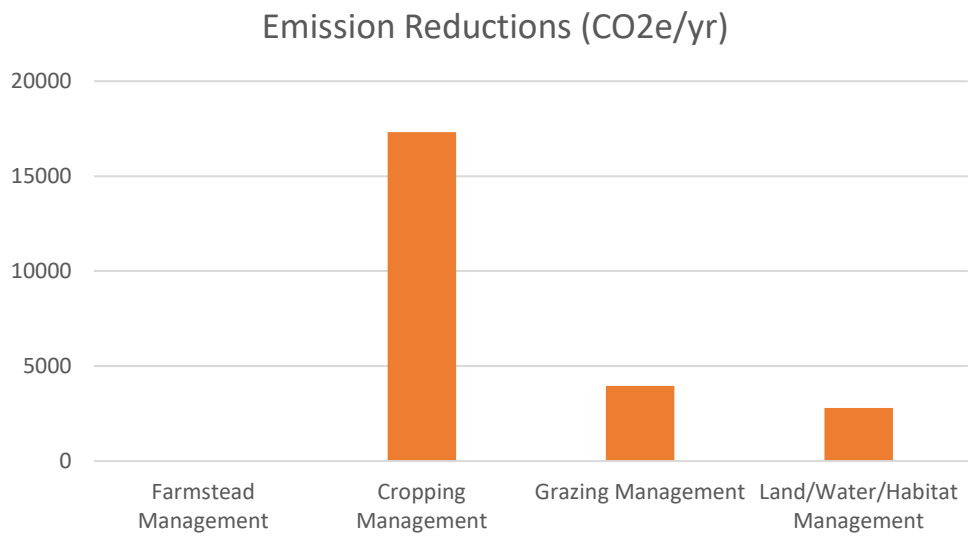
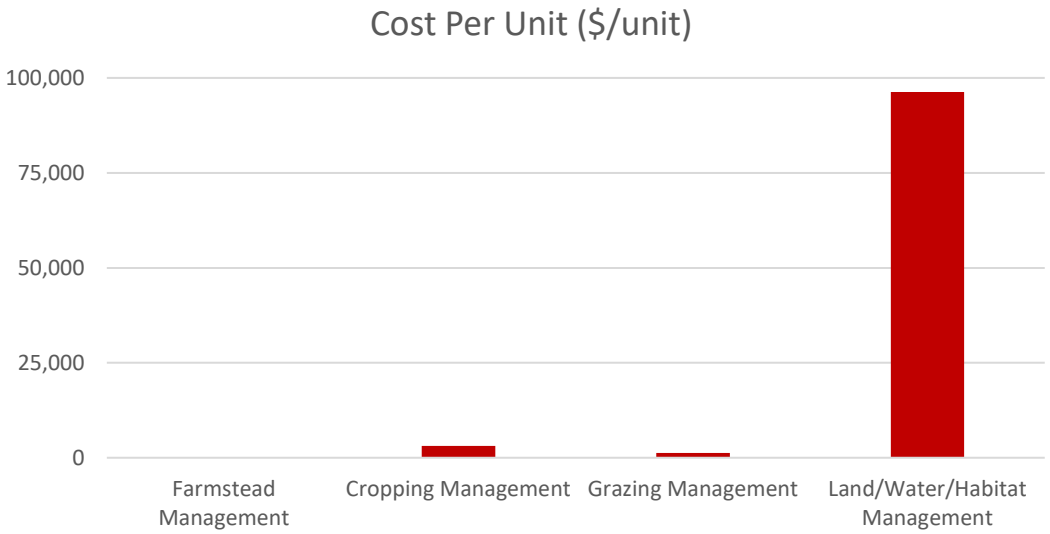








IPCC: Land management and Co-benefits

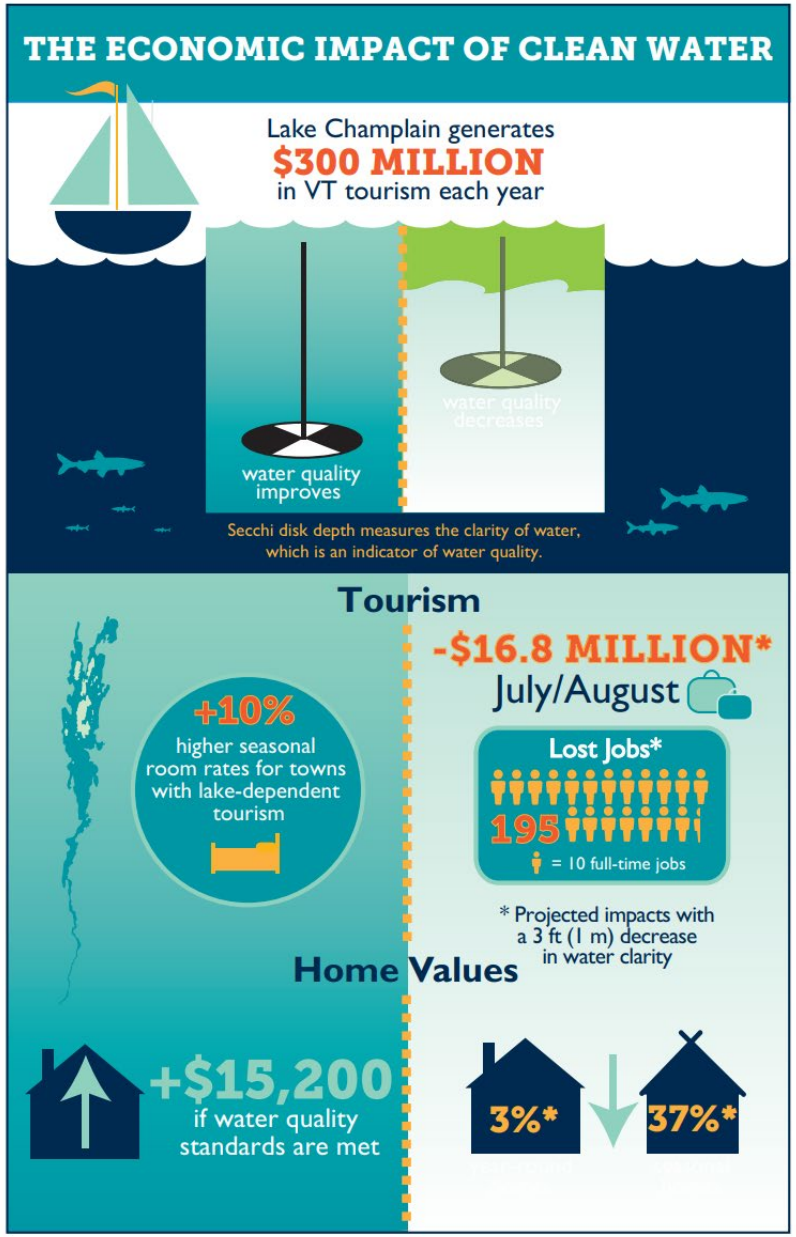
VERMONT
AGENCY OF AGRICULTURE, FOOD & MARKETS
WATER QUALITY DIVISION

Table 6.70 | Impacts on Nature's Contributions to People (NCP) of integrated response options based on land management.

Integrated response options based on land management	Habitat creation and maintenance	Pollination and dispersal of seeds and other propagules	Regulation of air quality	Regulation of climate	Regulation of ocean acidification	Regulation of freshwater quantity, flow and timing	Regulation of freshwater and coastal water quality	Formation, protection and decontamination of soils and sediments	Regulation of hazards and extreme events	Regulation of organisms detrimental to humans	Energy	Food and feed	Materials and assistance	Medicinal, biochemical and genetic resources	Learning and inspiration	Physical and psychological experiences	Supporting identities	Maintenance of options
Increased food productivity																		
Improved cropland management																		
Improved grazing land management																		
Improved livestock management																		
Agroforestry																		
Agricultural diversification																		
Avoidance of conversion of grassland to cropland																		
Integrated water management													+ or −					

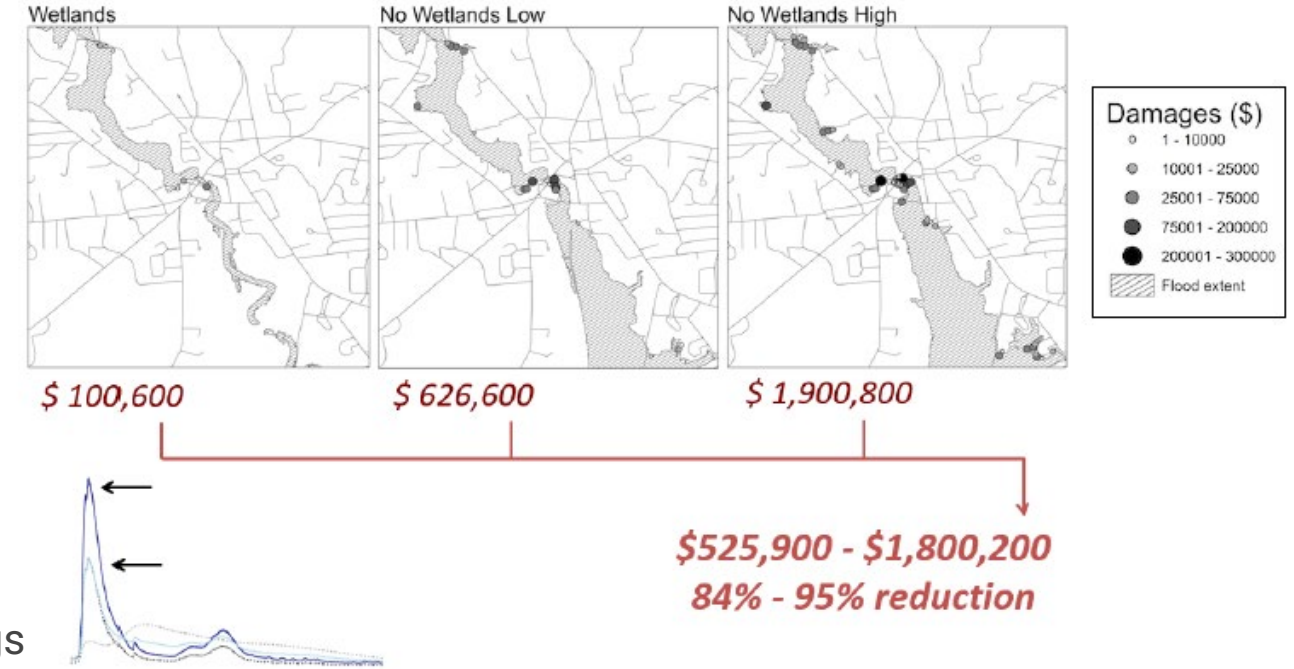
Large positive impacts, strong evidence
Medium positive impacts, some evidence
Small positive impacts or low evidence
Low negative impacts or low evidence
Medium negative impacts, medium evidence
Large negative impacts, high evidence

https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/09_Chapter-6.pdf



DATA SOURCE: *An Assessment of the Economic Value of Clean Water in Lake Champlain*. Brian Voigt, Julia Lees, Jon Erickson, University of Vermont, Gund Institute for Ecological Economics. September 2015.

Middlebury - economic damages



Key findings

•During Tropical Storm Irene in 2011, floodplains and wetlands diminished damages in Middlebury, VT, by 84 to 95 percent – saving potentially as much as $1.8 million in flood damages.

•Middlebury saves an annual average of $126,000 to $450,000 in damages due to the Otter Creek floodplain, which reduced damages by 54 to 78 percent, on average, across 10 flooding events.

Source: Keri Bryan Watson , Gund Institute, UVM

USDA NRCS Vermont: 68 wetland easements on 5,063 acres

VT-DEC River Corridor Easement Programs: 75 unique river corridor easements

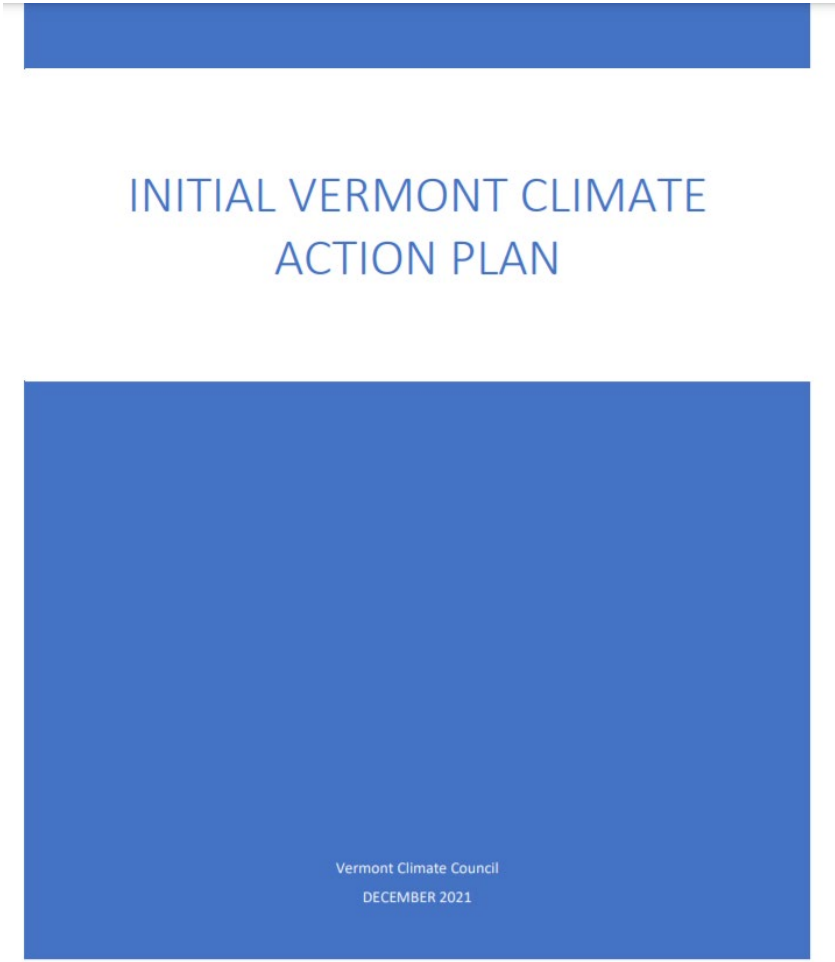
USDA/VAAFM Conservation Reserve Enhancement Program (CREP): 26 CREP Projects in Vermont are enrolled in the DEC River Corridor Easement Program

USDA/VAAFM CREP: Over 2,000 acres of agricultural land enrolled in the program

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)



Source: https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2021-12/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf#page=213&zoom=100,93,96

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Co-Chair: Billy Coster, ANR

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*Vermont Climate Councilor