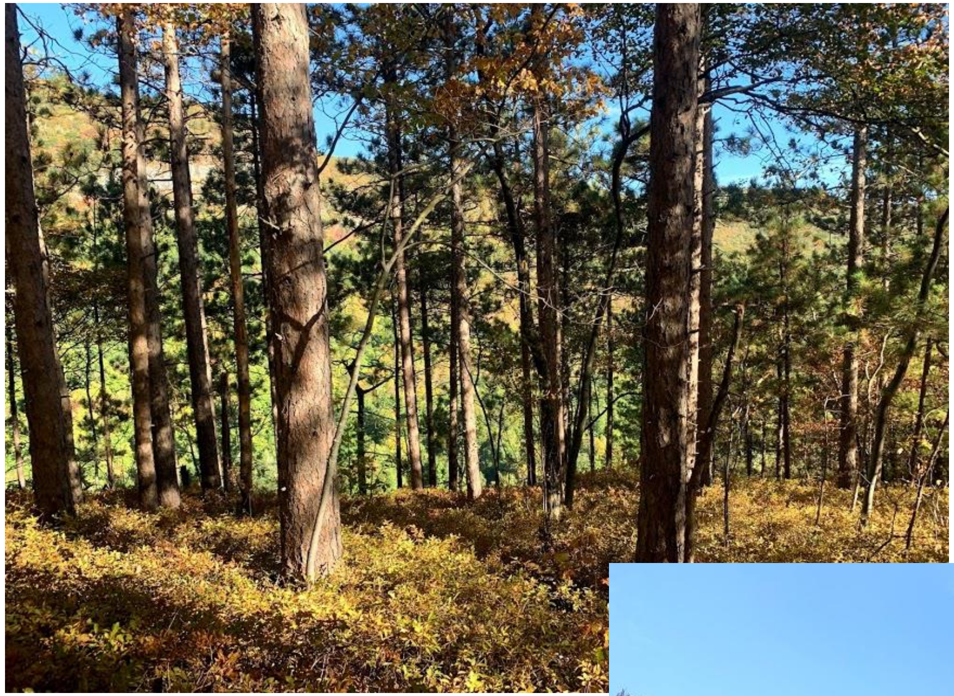


VERMONT AGENCY OF AGRICULTURE, FOOD & MARKETS AGENCY OF NATURAL RESOURCES

Climate Mitigation, Adaptation and Resilience on Natural & Working Lands

PRESENTATION TO THE CLIMATE COUNCIL

JANUARY 4, 2021

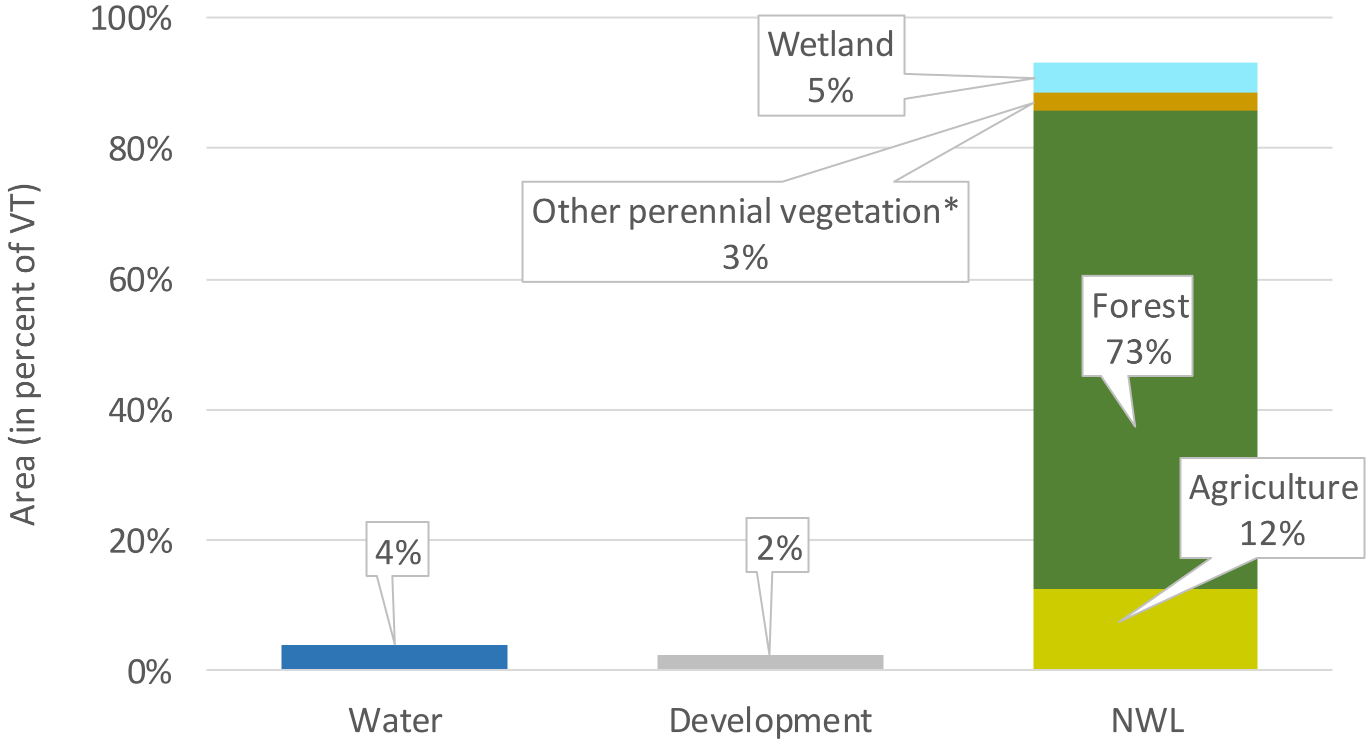
Dr. Alexandra Kosiba, Climate Forester, Dept. Forests, Parks and Recreation, Agency of Natural Resources

Ryan Patch, Water Quality Assistant Director, Agency of Agriculture, Food and Markets

Climate Mitigation, Adaptation and Resilience on Natural & Working Lands

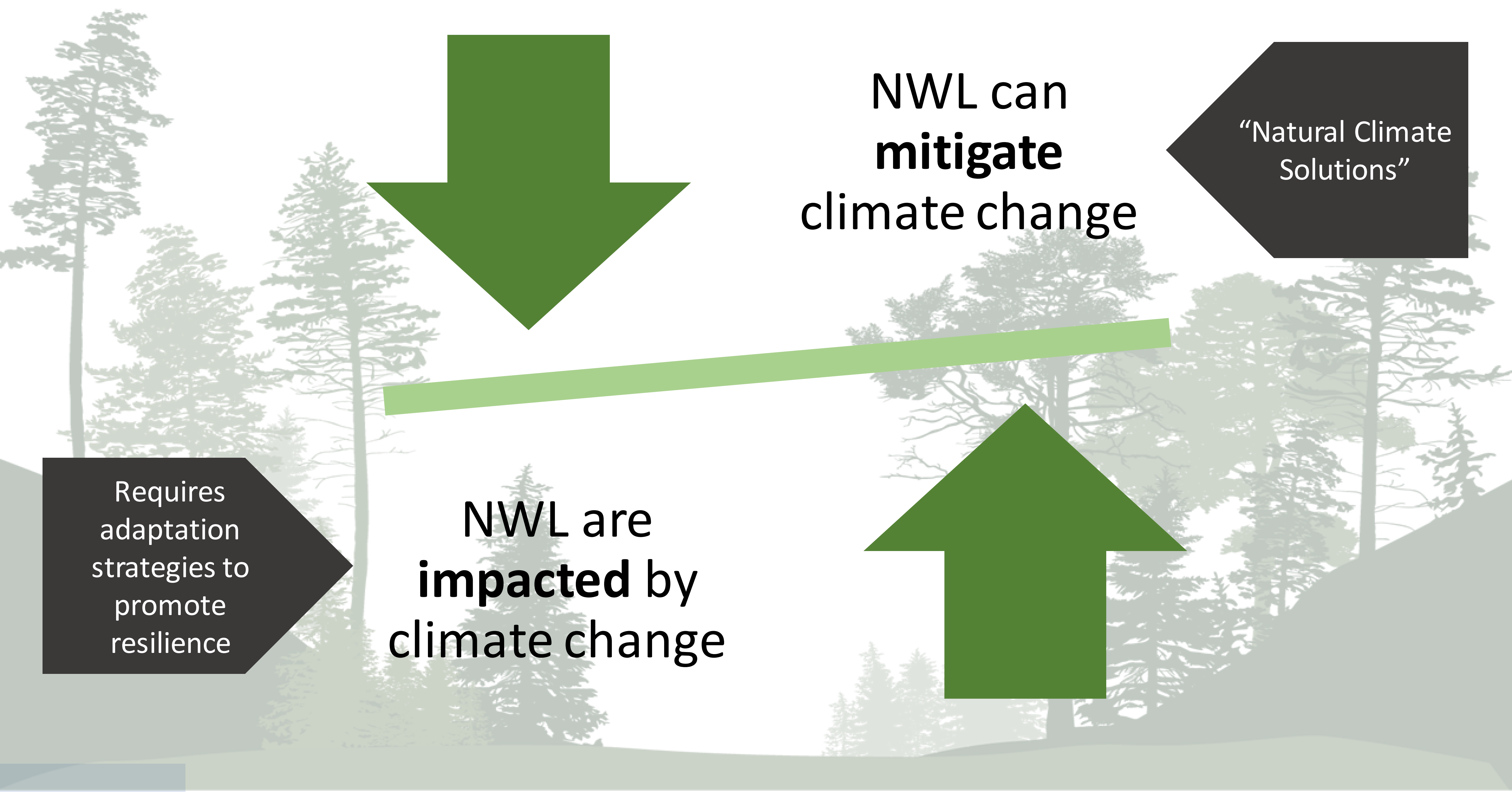
1. What are natural and working lands (NWL) and why are they important?
2. Terminology and concepts
3. The forest carbon cycle and its relevance to climate change
4. Forest sector carbon storage and fluxes
5. Opportunities and challenges for forest carbon mitigation and climate change adaptation
6. The importance of wetlands
7. Mitigation, adaptation, and resilience in agricultural systems

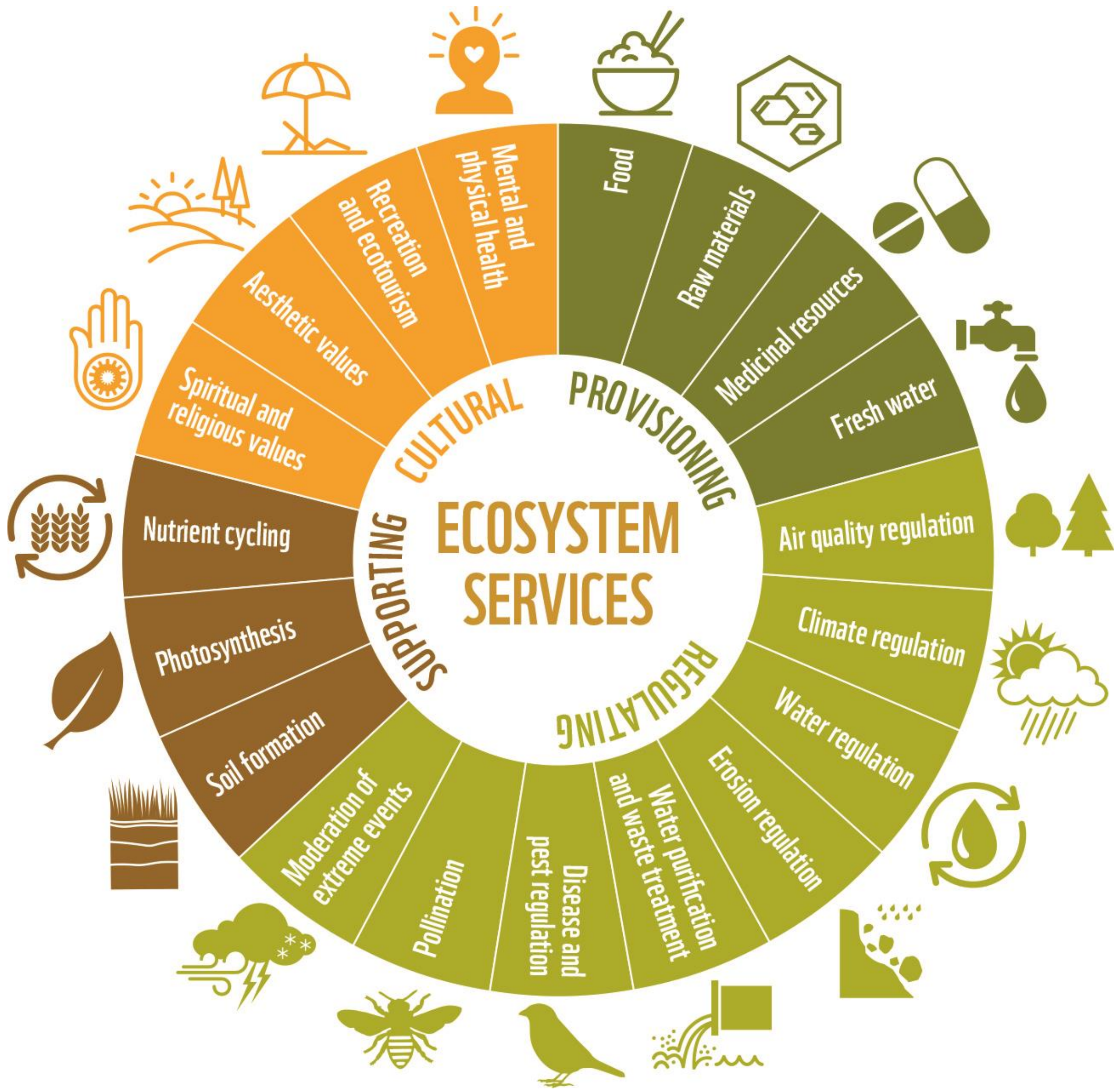
Natural & Working Lands (NWL) cover 94% of Vermont



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

Data source: 2016 National Land Cover Database

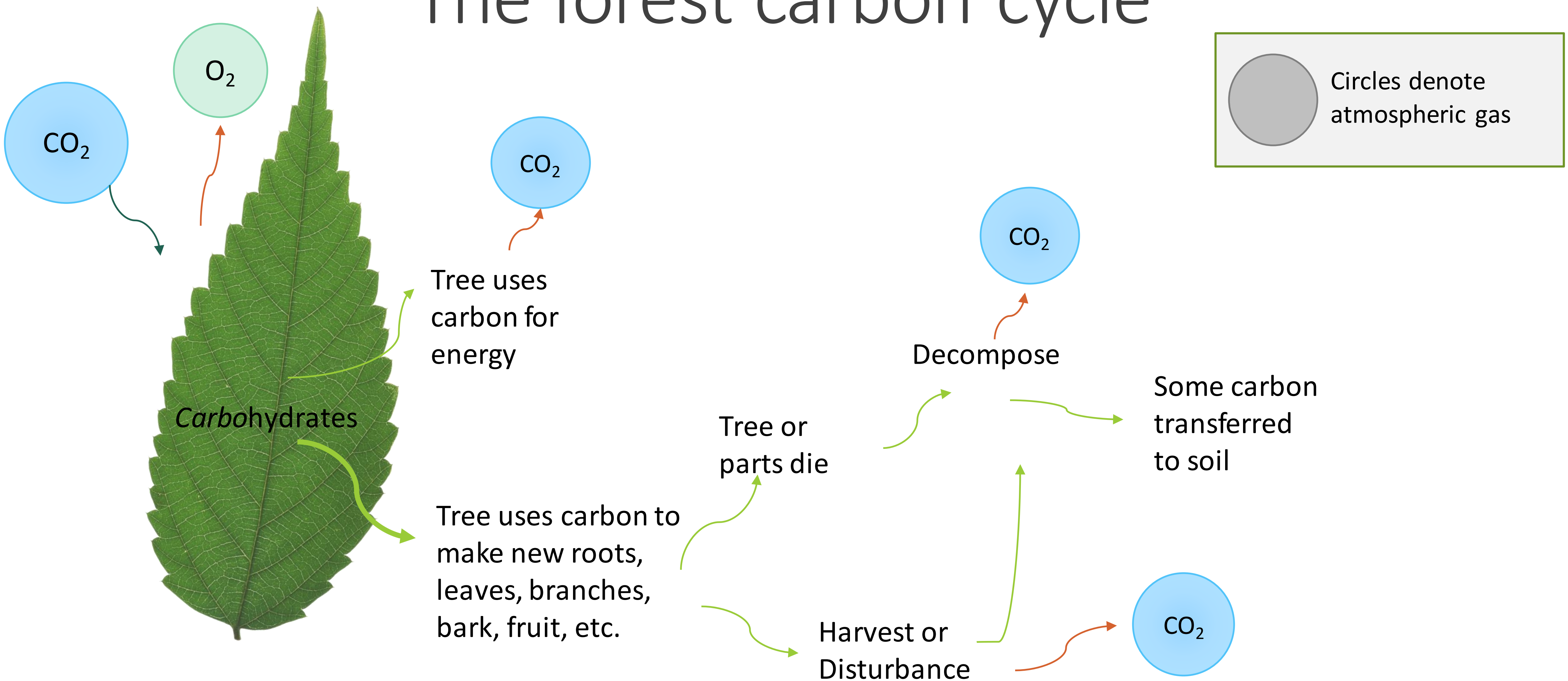

NWL can **mitigate** climate change
"Natural Climate Solutions"
Requires adaptation strategies to promote resilience
NWL are **impacted** by climate change



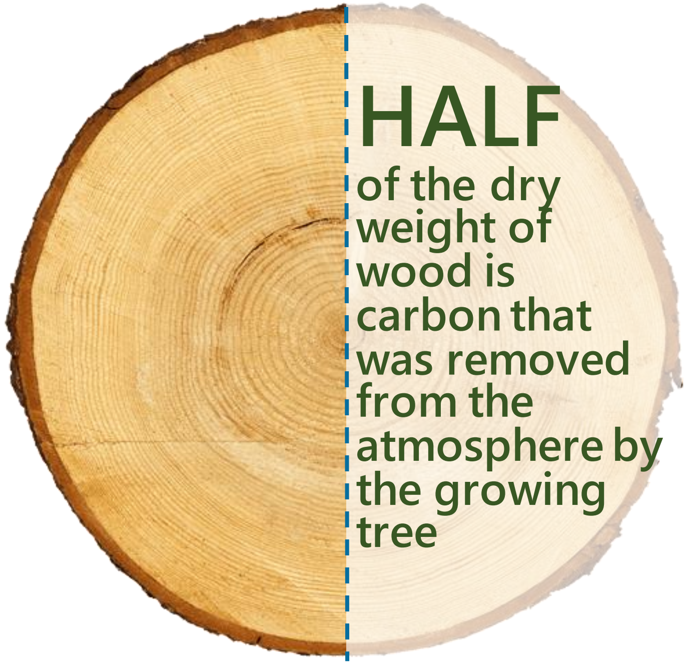
NWL provide vital ecosystem goods and services

Image source: WWF Living Planet Report 2016

The forest carbon cycle



Carbon vs. Carbon Dioxide



Plants use the carbon in CO_2 to make sugars. When a plant releases stored carbon through respiration, decomposition, or combustion, the carbon rejoins oxygen to make CO_2, which is released back to the atmosphere.

Carbon in living and dead plants and in soils are often expressed as **carbon dioxide equivalent (CO_2e)** for easier comparison to other sinks and sources of GHGs.

The CO_2 equivalent of wood is more than its weight:
1 MT of dry wood = 0.5 MT carbon = 1.8 MT carbon dioxide taken out of the atmosphere
CO_2 molecule is 3.7x heavier than a carbon atom

Forests and other NWL can mitigate climate change through the sequestration and storage of atmospheric CO_2

Carbon sequestration

The process of removing CO_2 from the atmosphere and storing it in another form that cannot immediately be released (like wood). Expressed as a negative value per unit time (MT CO_2e/year).

Carbon emission

CO_2 can be released to the atmosphere through decomposition, respiration, or combustion. Expressed as a positive value per unit time (MT CO_2e/year).

Net flux

The rate of change in stored carbon

Carbon storage

The total amount of carbon contained in a plant-based ecosystem or in a part of the system (trees, soil, leaf litter, dead wood).

Forests and other NWL can be carbon sinks or carbon sources depending on the balance between sequestration and emissions.

Carbon sink

Net flux < 0

The forest sequestered more CO_2 than it emitted.

The total carbon storage of the forest will increase by the amount sequestered.

Carbon source

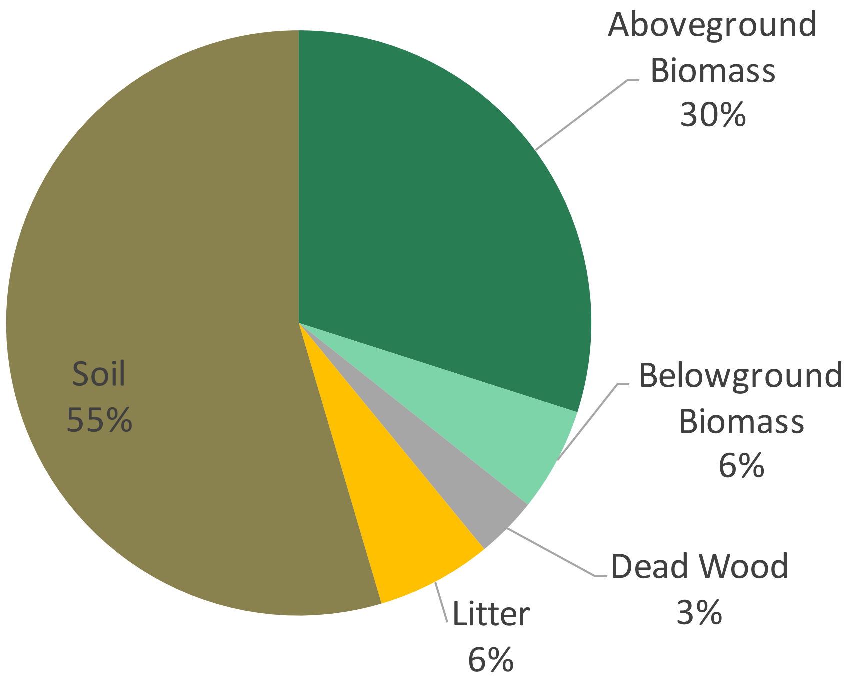
Net flux > 0

The forest emitted more CO_2 than it sequestered.

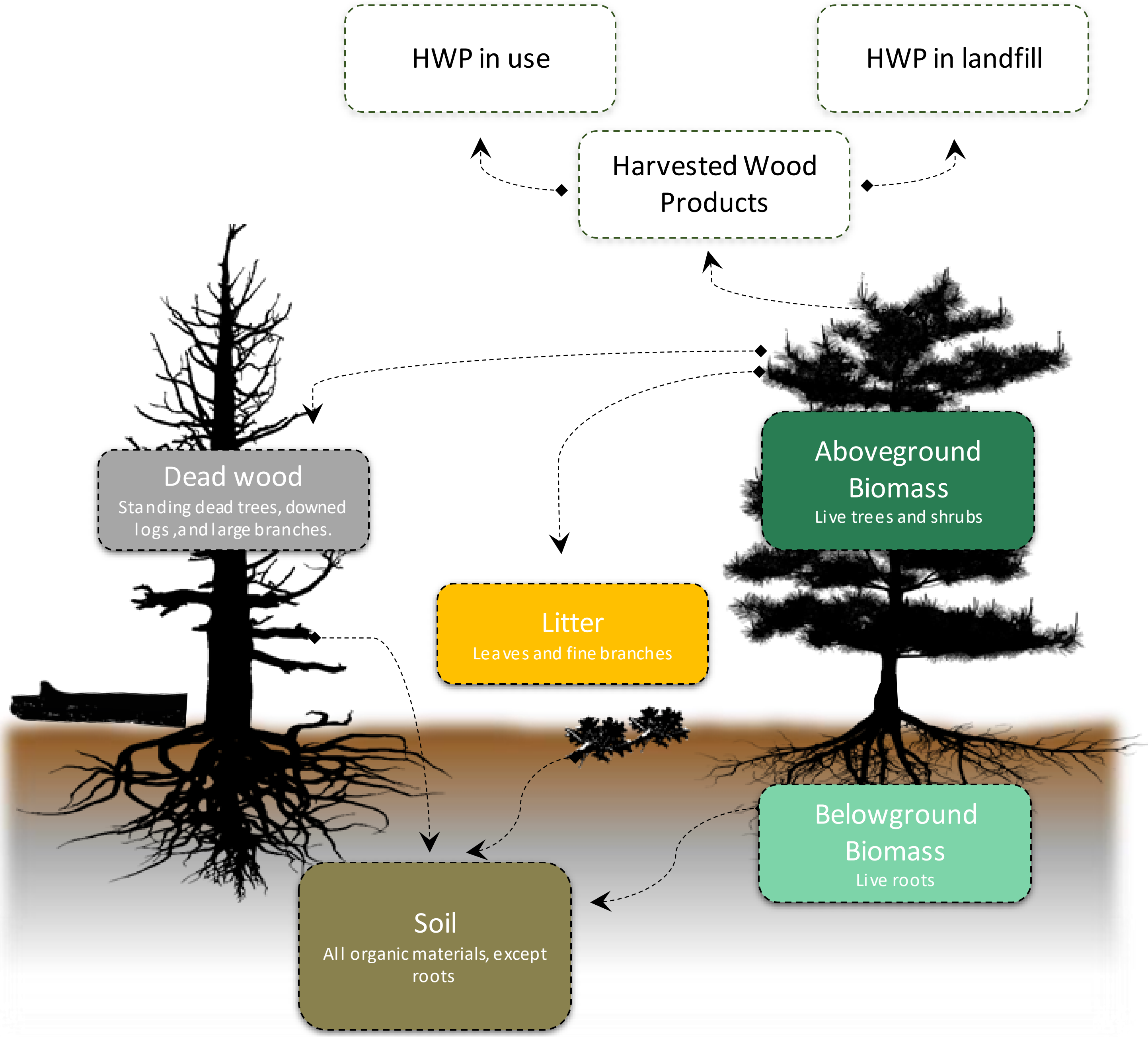
The total carbon storage of the forest will decrease by the amount emitted.

Image: Naveen Nkadalaveni

Forest carbon pools

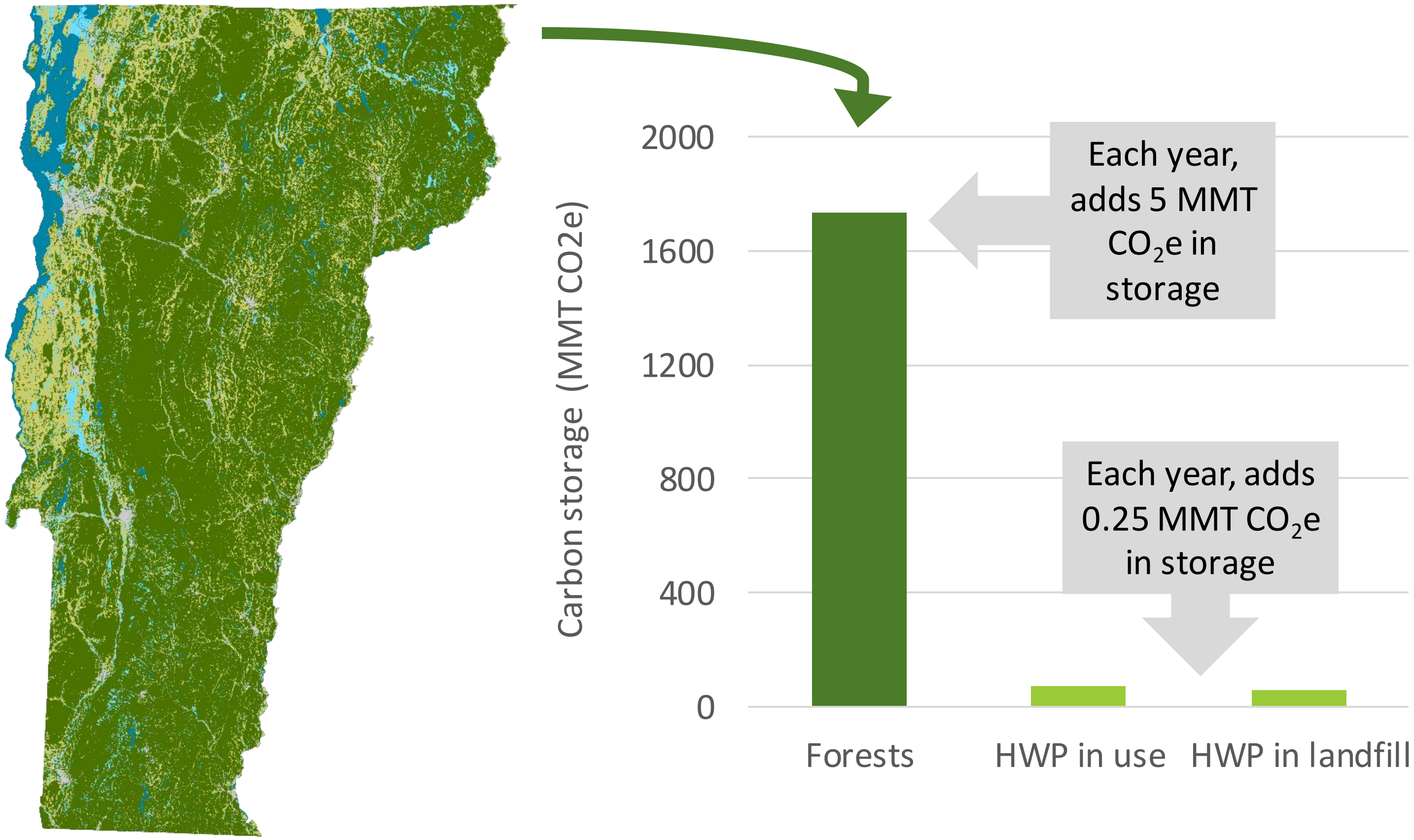


Vermont's Forest Carbon Storage Pools



Data source: Domke et al. (2020); data shown for 2018

Vermont's forests and HWP store about 1,920,000,000 MT CO_2e – if emitted, would be equivalent to 200X our current annual emissions



Harvested wood products (HWP) in use and in landfill are two additional carbon pools that add 125 MMT CO_2e to VT's forest carbon sink.

While VT's forest and HWP store a great deal of carbon, atmospheric CO_2 concentration is affected by *changes* in the size of the carbon pools.

Each year, Forests and HWP pools are **net sinks** – but that is not a guarantee.

Data sources: Domke et al. (2020) and Dugan et al. (2020); data shown for 2018

In addition to storing carbon in HWP, we can reduce emissions by substituting HWP for high emissions products, like fossil fuels, plastics, concrete, and steel

<u>Sawnwood</u>

Additional carbon storage pool

Substitution benefits: 1 MT avoids 0.54-0.8 MT CO_2 emissions compared to steel and concrete

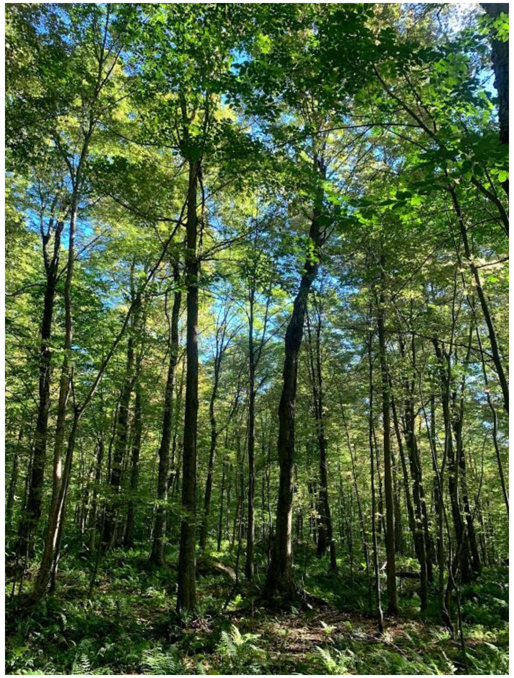
<u>Bioenergy</u>

Substitution benefits: 1 MT avoids 0.49-0.89 MT CO_2 emissions compared to fossil fuels

Substitution estimates: Sathre and O’Connor (2010) and Smyth et al. (2017)

Sources of annual forest carbon flux

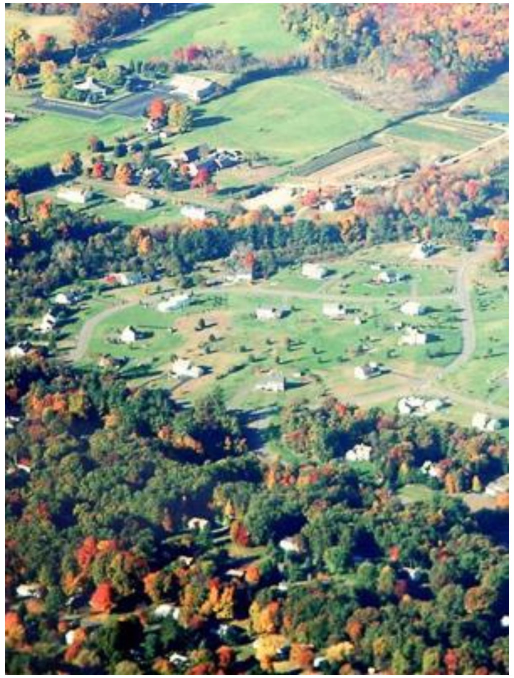
Recall that negative values indicate carbon sequestration (net carbon uptake = carbon sink) and positive values indicate carbon emissions (net carbon release = carbon source)



Forests

Harvested wood products

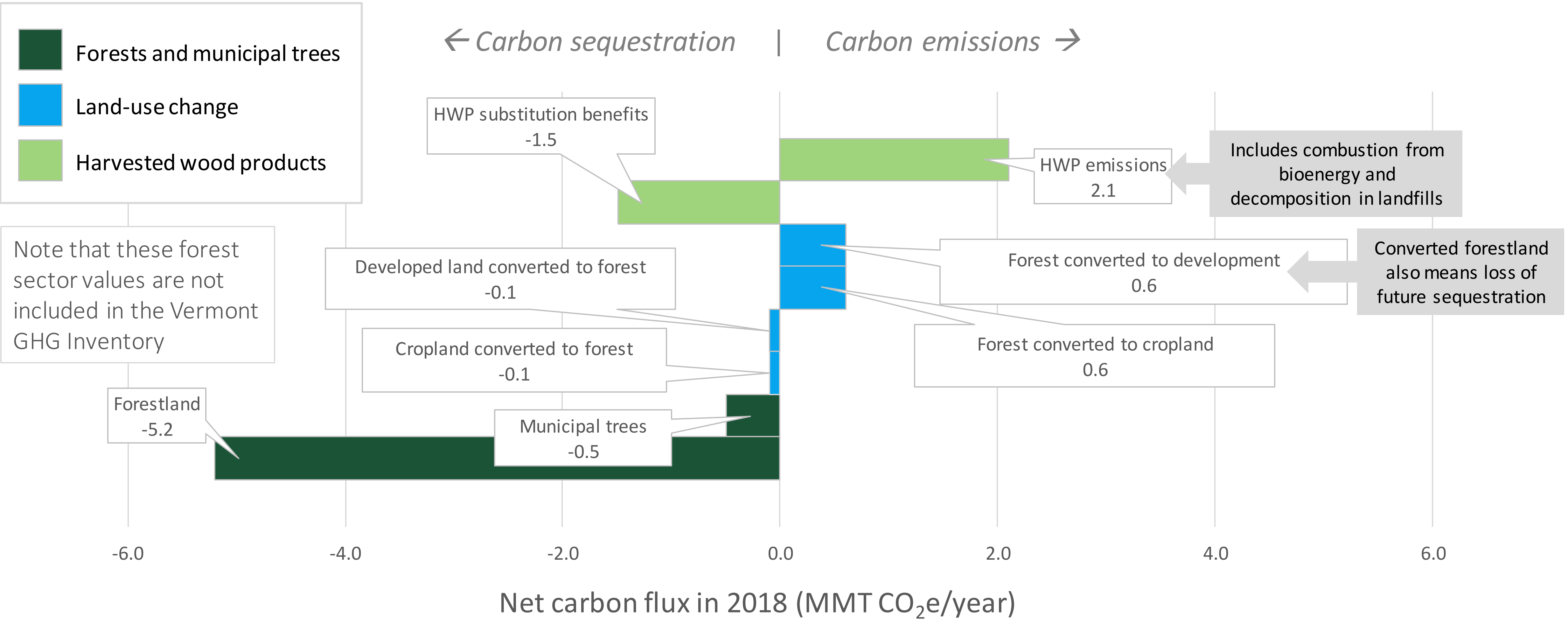
Trees in towns and cities



Land use conversion

Photos: Elm tree, Msact (2019); Development, Foster (2018)

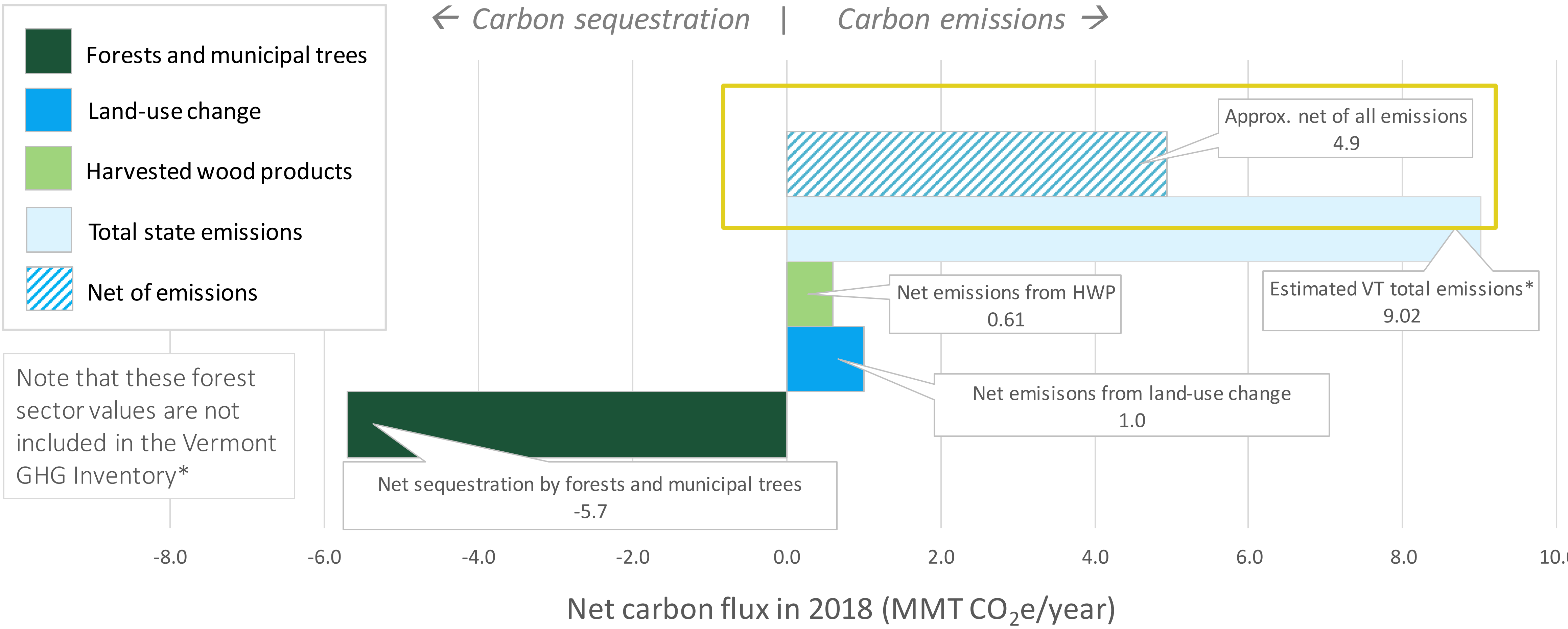
Across the VT forest sector in 2018, both carbon sinks and sources exist



Note that these forest sector values are not included in the Vermont GHG Inventory

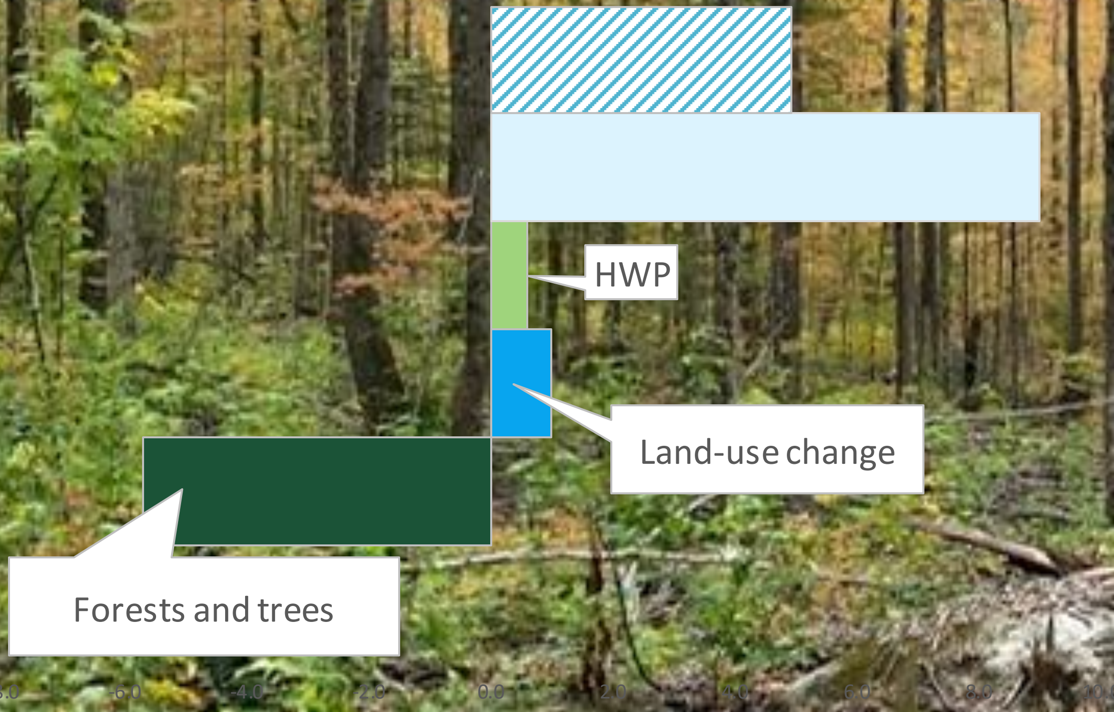
Data sources: Domke et al. (2020) forest and tree sequestration and land use change estimates; Dugan et al. (2020) HWP emissions and substitution estimates

When we combine the sinks and sources estimated for 2018, the forest sector took in ~45% of state annual emissions



*Data source for state emissions: VT ANR GHG Inventory (2020), estimate for 2018

Opportunities to maintain and increase the mitigation potential of the forest sector



1. Maintain or increase carbon sequestration of forests through good stewardship and ecological silviculture.
2. Maintain or increase carbon sequestration of municipal trees through good stewardship and additional tree planting
3. Reduce carbon emissions from land-use conversion
4. Decrease net HWP emissions by increasing use of wood as substitutes

Challenges to using forests to meet Vermont’s emission reduction goals

- Vermont’s forests are highly variable and dynamic
  - Difficult to estimate carbon fluxes without high costs
  - Remote sensing techniques developing
- 80% of forestland is privately owned
- Cannot double count forest carbon
  - Carbon offset projects in VT have already accounted for >20K acres
- Must also account for fluxes from other NWL
  - We have less data for wetlands, farmland, other types of NWL (shrublands, grasslands)
- Increasing carbon storage vs. avoiding carbon emissions

There are two types of climate change mitigation strategies for the forest sector and other NWL

Enhance the terrestrial carbon sink

= increase carbon storage through active sequestration of atmospheric CO_2 and storage in carbon pools

CO_2

Examples:

- Plant trees
- Use ecological silviculture
- Harvest and make durable wood products

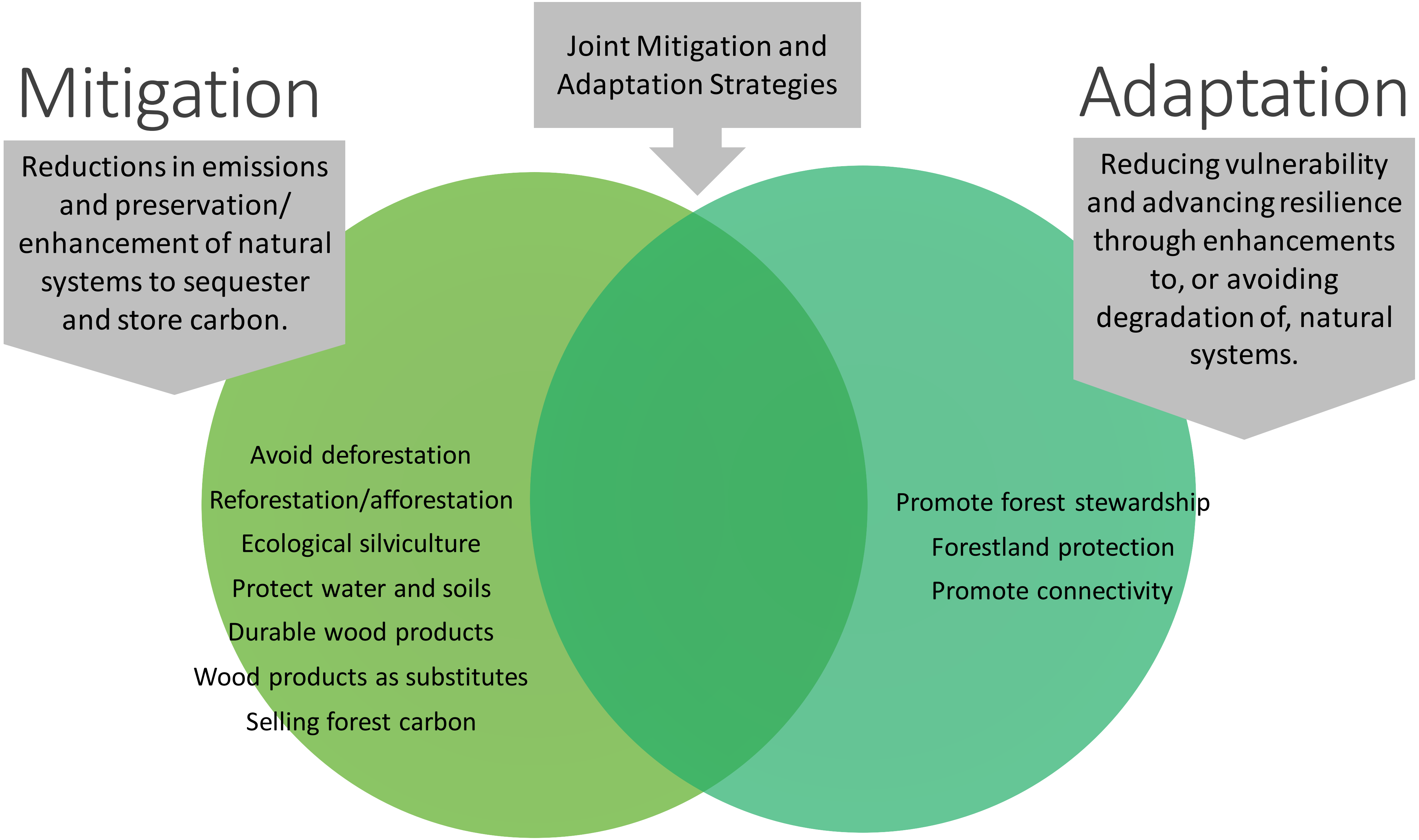
Reduce the source of atmospheric carbon

= avoid emitting additional CO_2 into the atmosphere

Examples:

- Keep forests as forests
- Substitute wood products for higher GHG products
- Reduce soil erosion

CO_2

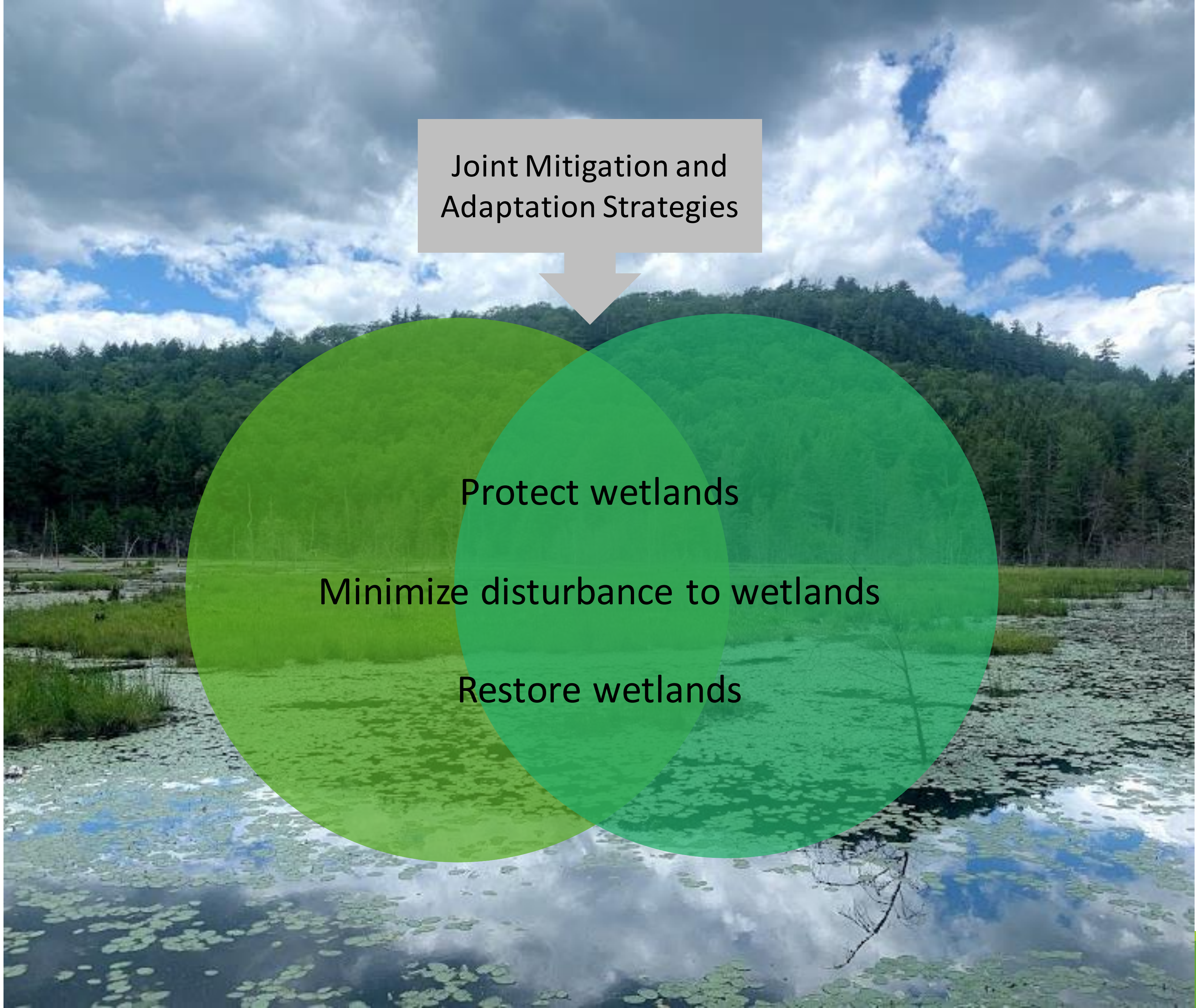

Mitigation
Reductions in emissions and preservation/ enhancement of natural systems to sequester and store carbon.
Joint Mitigation and Adaptation Strategies
Adaptation
Reducing vulnerability and advancing resilience through enhancements to, or avoiding degradation of, natural systems.
Avoid deforestation
Reforestation/afforestation
Ecological silviculture
Protect water and soils
Durable wood products
Wood products as substitutes
Selling forest carbon
Promote forest stewardship
Forestland protection
Promote connectivity

Strategies to promote the mitigation and adaptation potential of wetlands

Due to slow decomposition, wetland soils can contain **2-3 times more carbon than forest soils.**

And wetlands provide vital water filtration and flood control.

But we lack data on the fluxes in wetland carbon pools.



Vermont's Current Greenhouse Gas (GHG) Emissions Profile

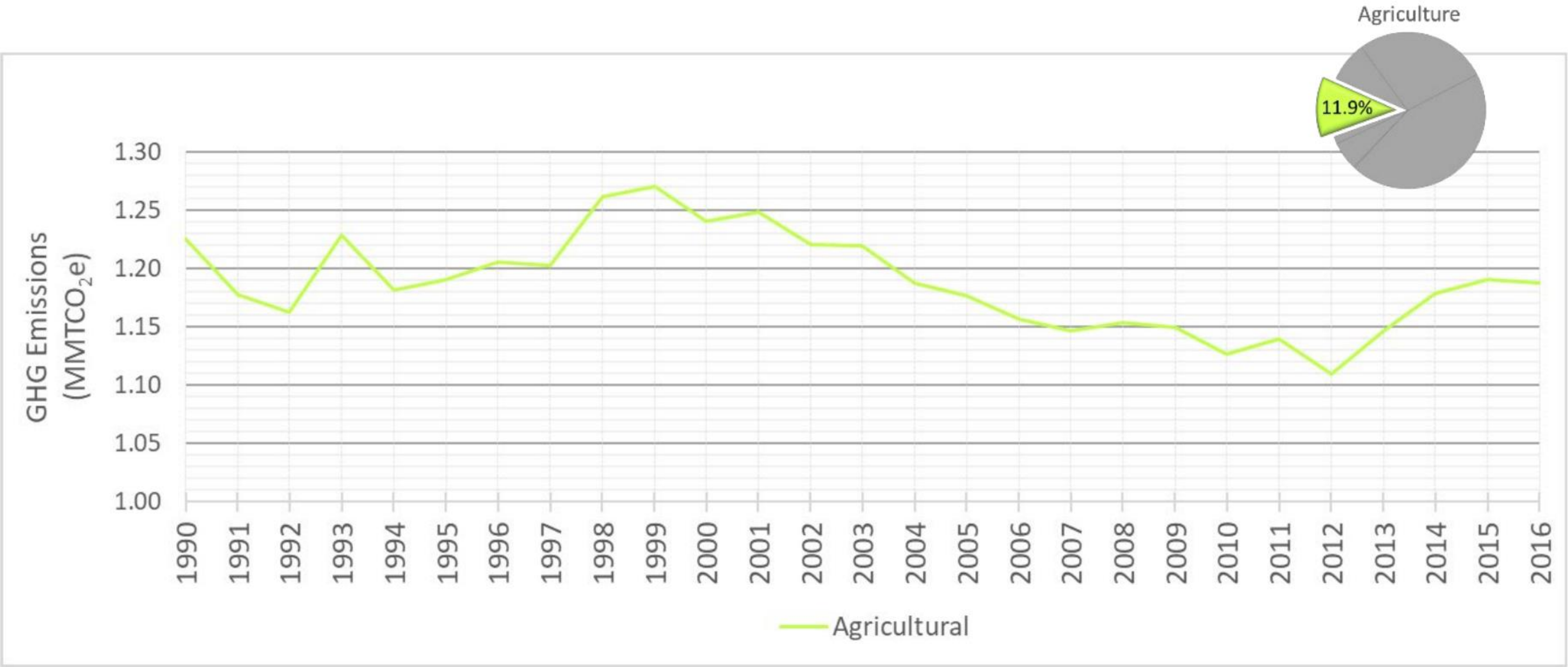
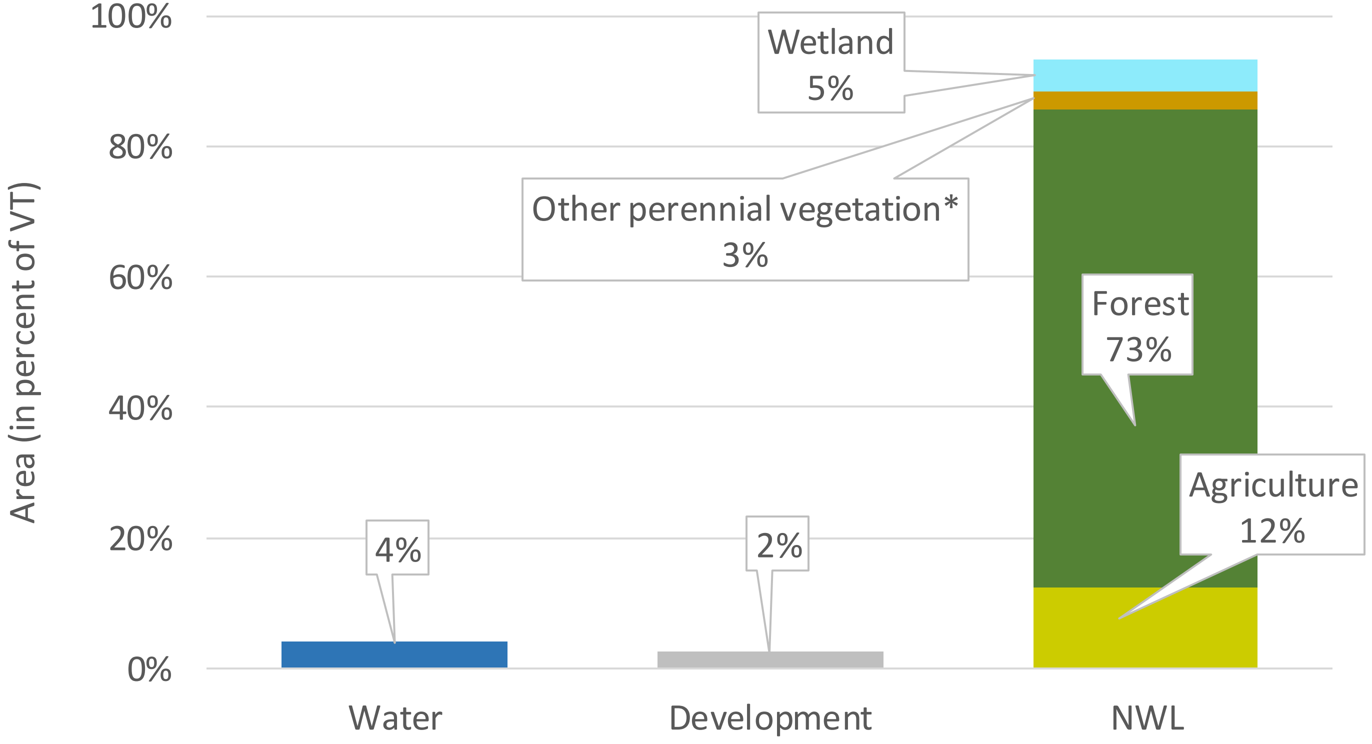


Figure 13: Vermont Agricultural Sector GHG Emissions (1990 – 2016).

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

-32%

Percentage decrease in total cropland in Vermont from 1987 to 2017

Census Category	1987	2017
Farms	5,877	6,808
Acres Land Managed by Farms	1,407,868	1,193,437
Total Cropland	707,970	479,680

Source: 1987 & 2017 USDA NASS Ag Census

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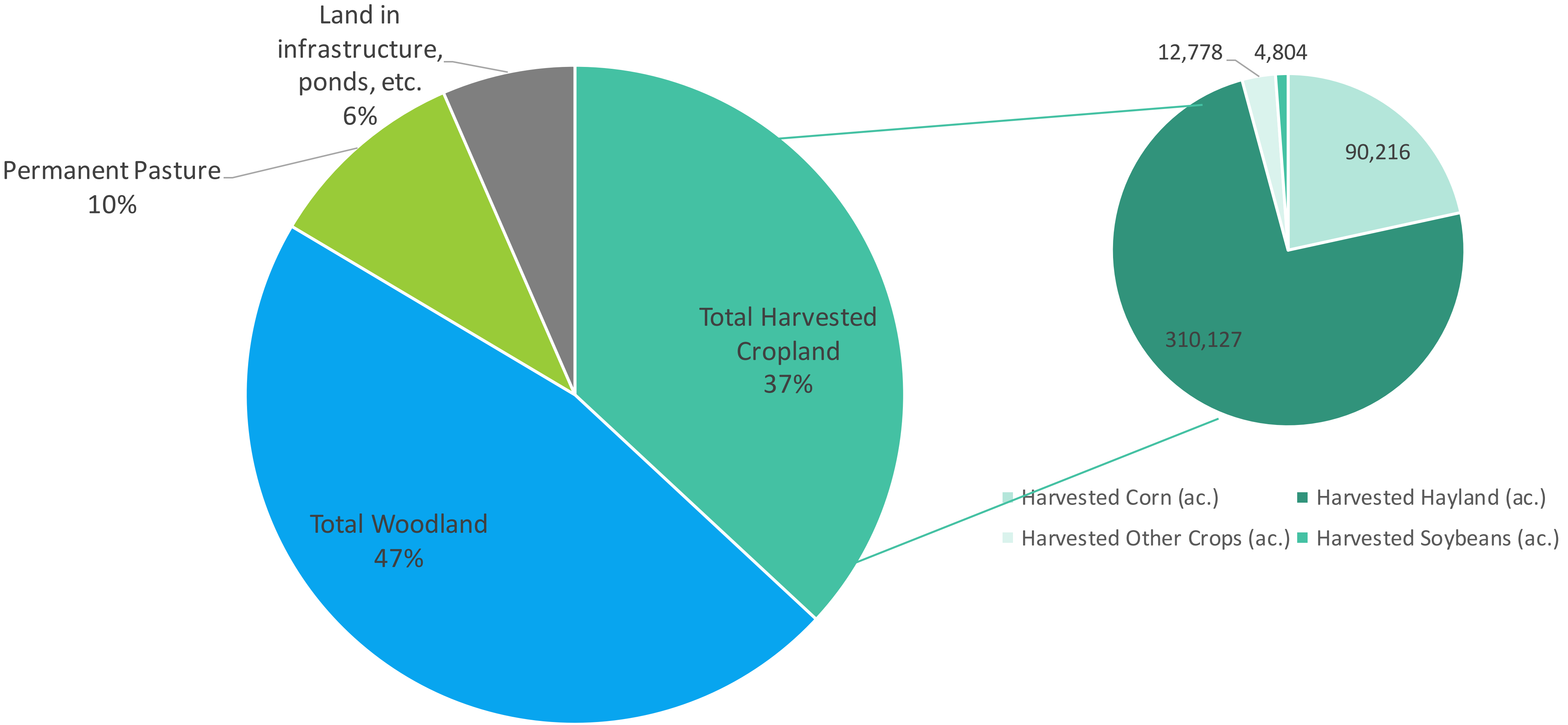
Land managed by farms in Vermont, 2017

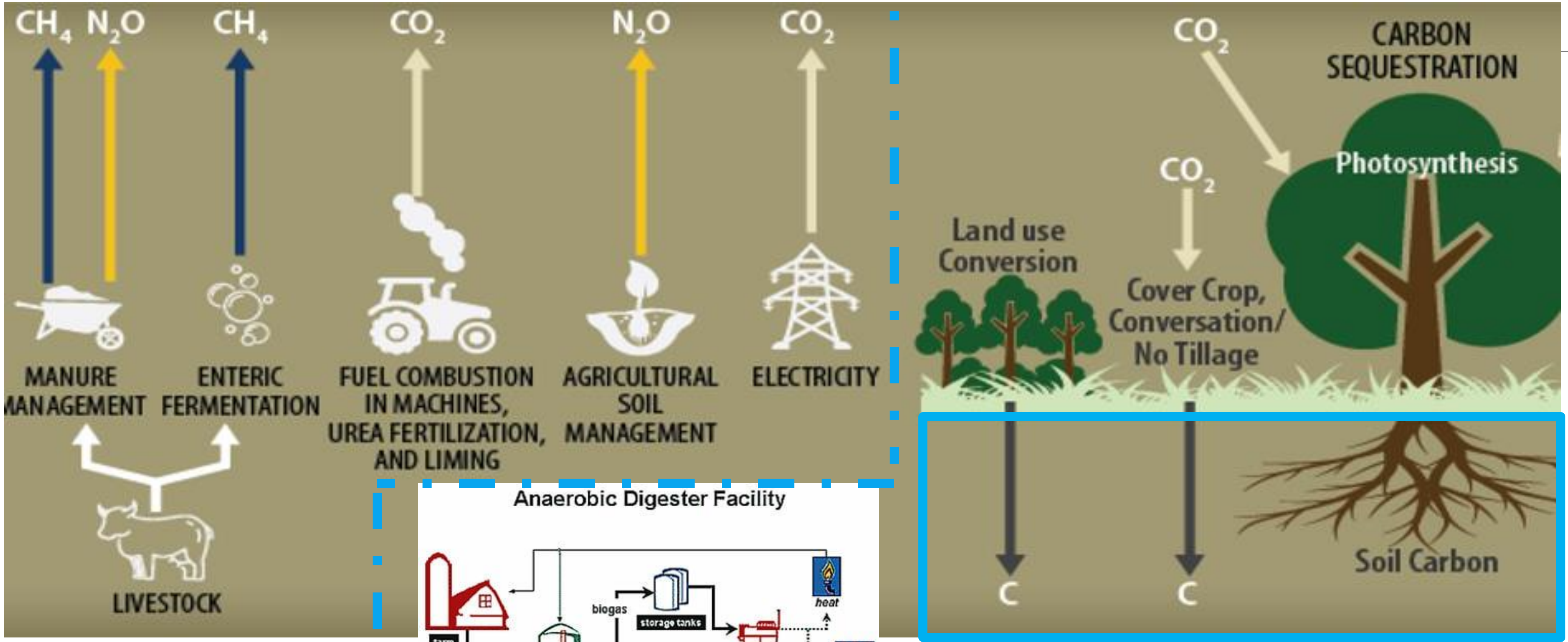


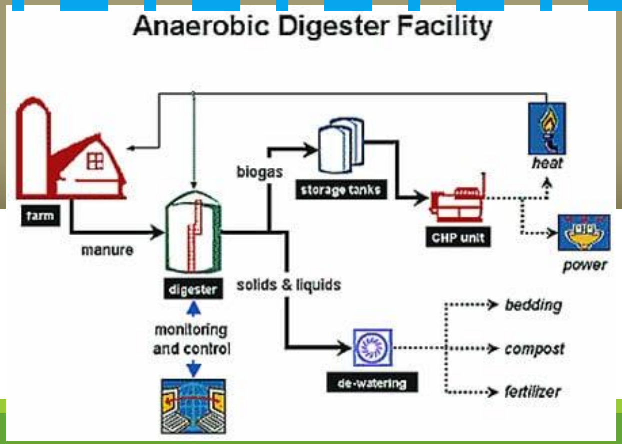
Source: 2017 USDA NASS Ag Census

Emissions Review

Emissions

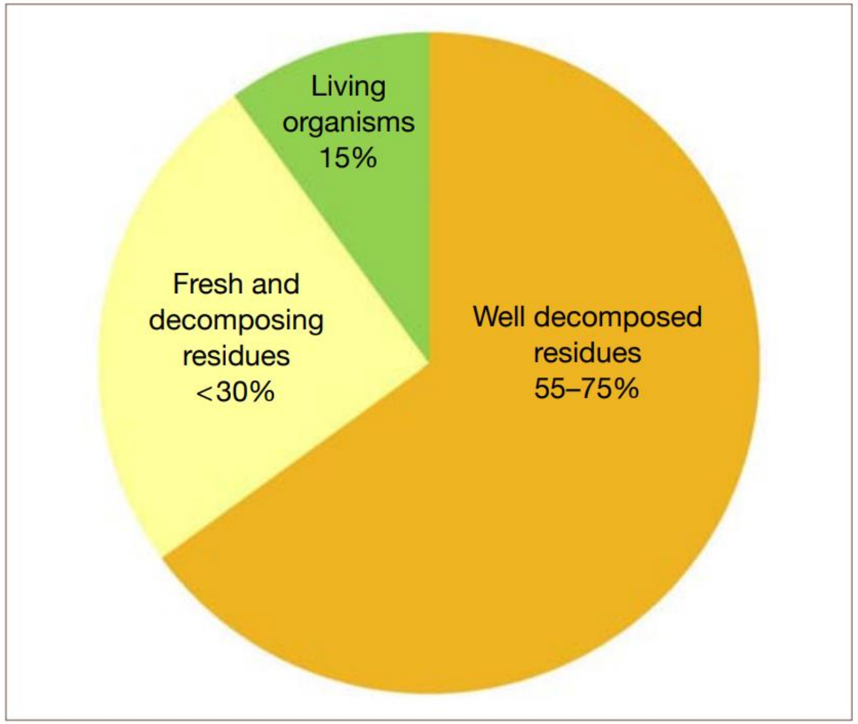
Mitigation



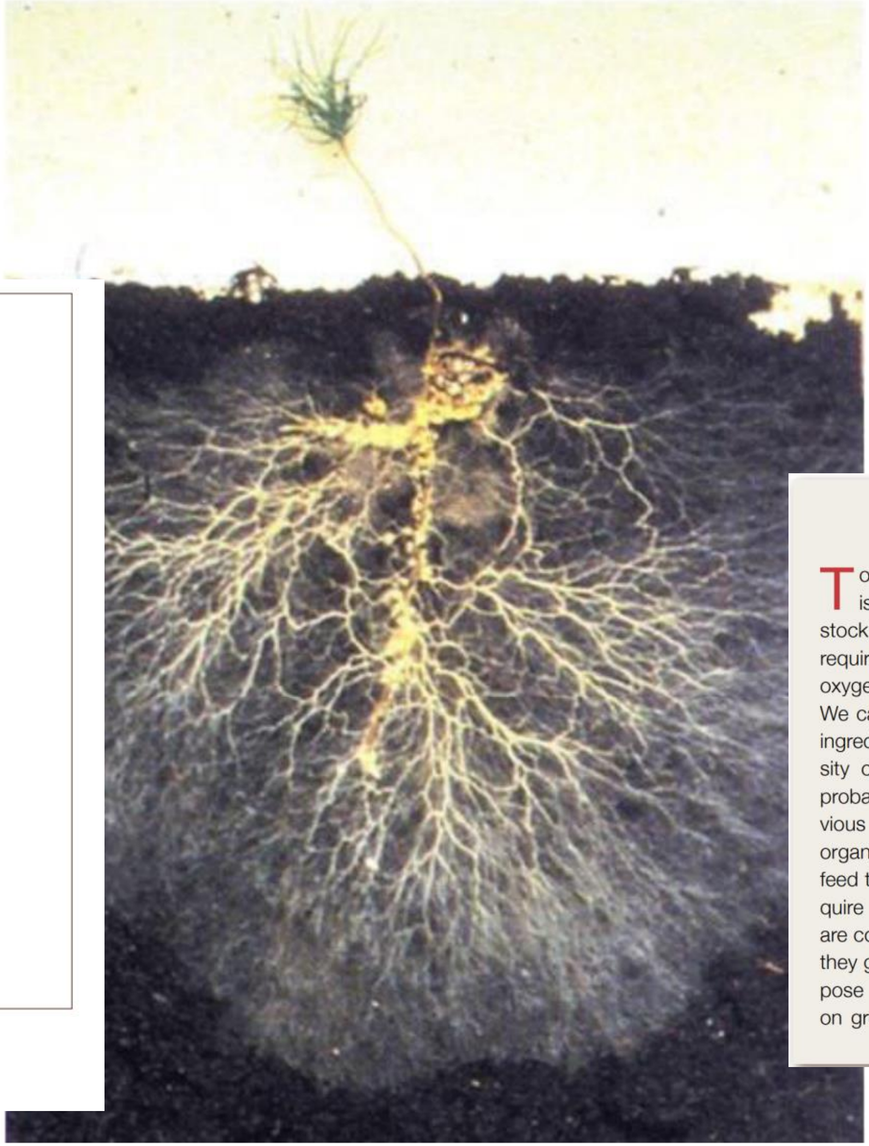


Source: Congressional Research Service: Greenhouse Gas Emissions and Sinks in U.S. Agriculture, September 17, 2018

Importance of Organic Matter



Composition of soil organic matter.



Mycorrhizae are symbiotic associations between fungi and plant roots. The mycorrhizal fungus colonizes plant roots and allows the plant access to more nutrients.

CARING FOR YOUR SOIL LIVESTOCK

To increase and maintain the diversity of organisms in the soil we must take care of the soil "livestock." Similar to feeding our cows, soil organisms require energy, protein, water, oxygen, and a proper habitat. We can provide these key diet ingredients by adding a diversity of organic residues. It is probably obvious from the previous section that adding fresh organic residues to the soil will feed the soil life. However, different soil organisms require slightly different foodstuffs. For example, fungi are common decomposers of plant residues because they generally have large amounts of hard-to-decompose carbon. Bacteria are generally more abundant on green litter of younger plants because they contain more simple carbon compounds. The b and fungi are only able to access plant residue shredder organisms, such as earthworms, brea dues into smaller chunks Oxygen and air space c provided by implementing tices that foster good til organisms do not grow compacted soils that c little air space. Growing ety of plants species ca create diversity of soil life. The plant roots of d organisms attract different microorganisms. Th home message is to treat your soil livestock li would your own animals. Think about what pra will not only provide adequate food, but a healthy for the animals that lie beneath your feet.

Earthworms are one of the most visible soil organisms and are often used as indicators of a healthy soil. Credit: US Composting Council

1. Disturb the soil as little as possible
2. Grow as many different species of plants as practical
3. Keep living plants in the soil as much as possible
4. Keep the soil covered year-round

Examples of Soil Health Practices - Mitigation

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What is it?		What does it do?	How does it help?
Conservation Crop Rotation Growing a diverse number of crops in a planned sequence in order to increase soil organic matter and biodiversity in the soil.		• Increases nutrient cycling • Manages plant pest (weeds, insects, and diseases) • Reduces sheet, rill, and wind erosion • Holds soil moisture • Adds diversity so soil microbes can thrive	• Maximize nutrients • Decreases use of pesticides • Improves water quality • Conserves water • Improves plant production
Cover Crop An un-harvested crop grown as part of planned rotation to provide conservation benefits to the soil.		• Increases soil organic matter • Prevents soil erosion • Conserves soil moisture • Increases nutrient cycling • Provides nitrogen for plant use • Suppresses weeds • Reduces compaction	• Improves crop production • Improves water quality • Conserves water • Maximize nutrients • Decreases use of pesticides • Improves water efficiency to crop
No Till A way of growing crops without disturbing the soil through tillage.		• Improves water holding capacity of soils • Increases organic matter • Reduces soil erosion • Reduces energy use • Decreases compaction	• Improves water efficiency • Conserves water • Improves crop production • Improves water quality • Saves renewable resources • Improves air quality • Increases productivity

Source: USDA NRCS

Examples of Soil Health Practices - Mitigation

Mulch Tillage

Using tillage methods where the soil surface is disturbed but maintains a high level of crop residue on the surface.

- Reduces soil erosion from wind and rain
- Increases soil moisture for plants
- Reduces energy use
- Increases soil organic matter

- Improves water quality
- Conserves water
- Saves renewable resources
- Improves air quality
- Improves crop production

Mulching

Applying plant residues or other suitable materials to the soil surface to compensate for loss of residue due to excessive tillage.

- Reduces erosion from wind and rain
- Moderates soil temperatures
- Increases soil organic matter
- Controls weeds
- Conserves soil moisture
- Reduces dust

- Improves water quality
- Improves plant productivity
- Increases crop production
- Reduces pesticide usage
- Conserves water
- Improves air quality

Nutrient Management

Managing soil nutrients to meet crop needs while minimizing the impact on the environment and the soil.

- Increases plant nutrient uptake
- Improves the physical, chemical, and biological properties of the soil
- Budgets, supplies, and conserves nutrients for plant production
- Reduces odors and nitrogen emissions

- Improves water quality
- Improves plant production
- Improves air quality

Source: USDA NRCS

Importance of Organic Matter – Mitigation, Adaptation, Resilience

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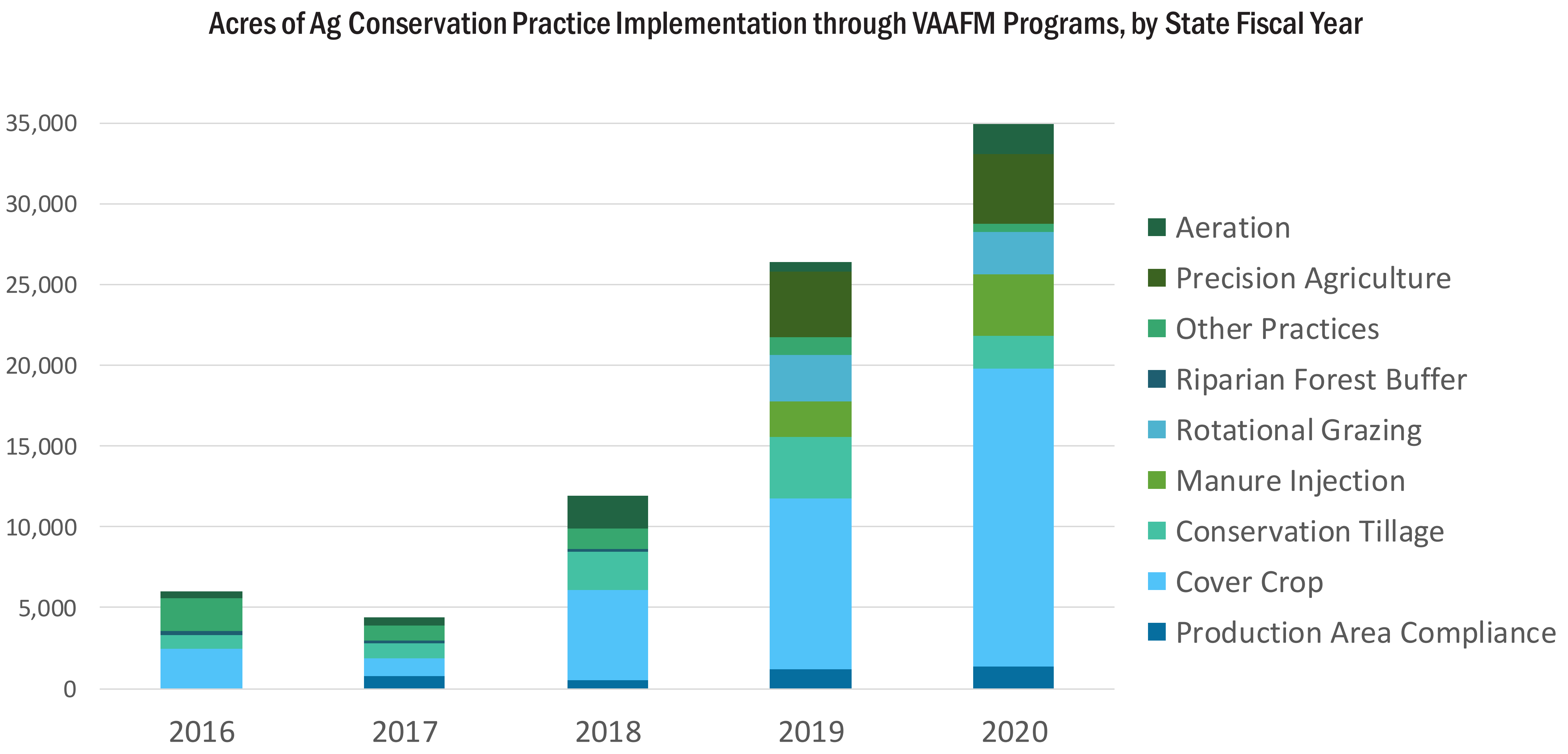
Source: USDA NRCS
Source: North Dakota State University, Soil Health Minute: Rainfall Simulator; https://youtu.be/Y4pwNIPX4AA

Results of Ag Nonpoint Source Program



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6 V.S.A. § 4962(2) "**Regenerative farming**" means a series of cropland management practices that:

(A) contributes to generating or building soils and soil fertility and health;

(B) increases water percolation, increases water retention, and increases the amount of clean water running off farms;

(C) increases biodiversity and ecosystem health and resiliency; and

(D) sequesters carbon in agricultural soils.

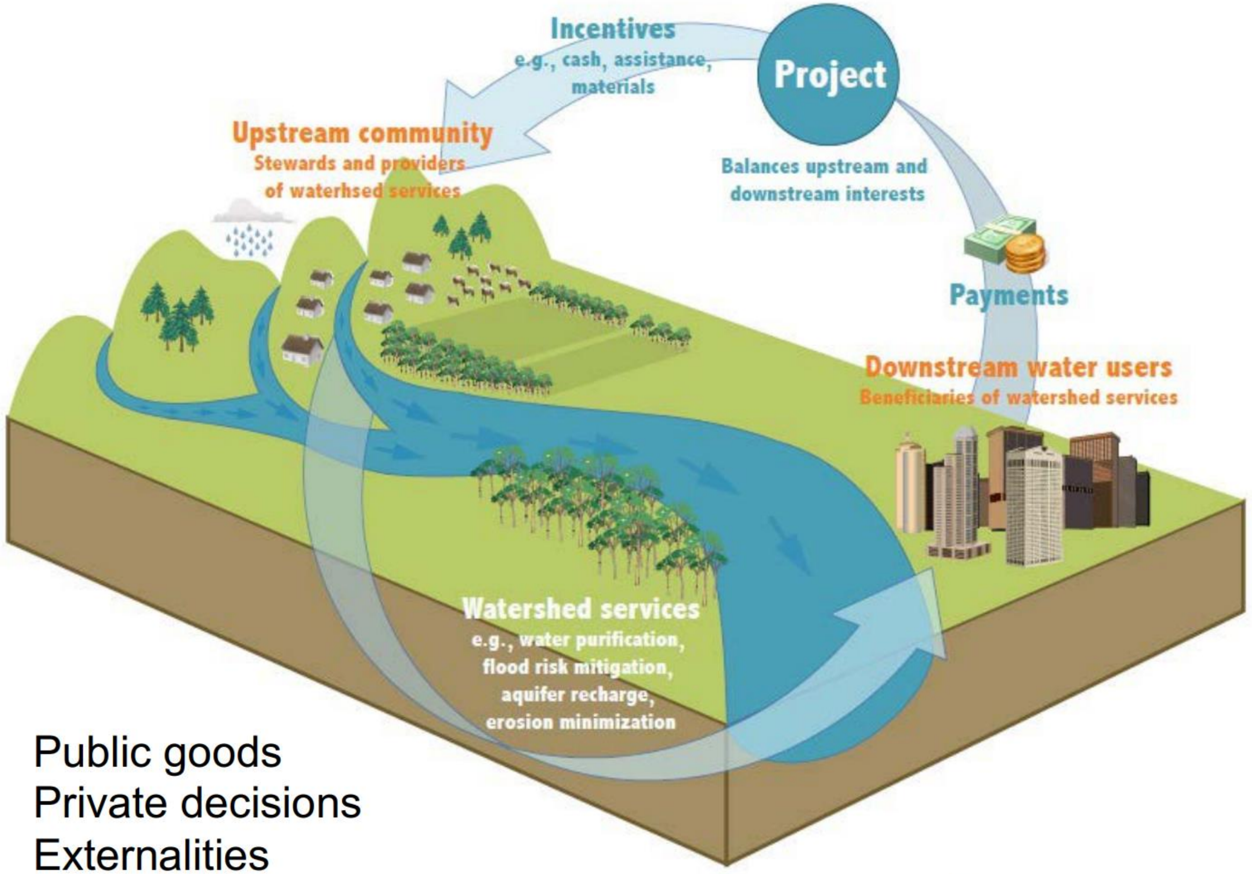
6 V.S.A. § 4802(4) "**Healthy soil**" means soil that has a well-developed, porous structure, is chemically balanced, supports diverse microbial communities, and has abundant organic matter.

* * * Soil Conservation * * *

Sec. 3. SOIL CONSERVATION PRACTICE AND PAYMENT FOR ECOSYSTEM SERVICES WORKING GROUP

(a) The Secretary of Agriculture, Food and Markets shall convene a Soil Conservation Practice and Payment for Ecosystem Services Working Group to recommend financial incentives designed to encourage farmers in Vermont to implement agricultural practices that exceed the requirements of 6 V.S.A. chapter 215 and that improve soil health, enhance crop resilience, increase carbon storage and stormwater storage capacity, and reduce agricultural runoff to waters. The Working Group shall:

VT LEG #342623 v.1



Public goods
Private decisions
Externalities

Mongabay.com

Mitigation Summary

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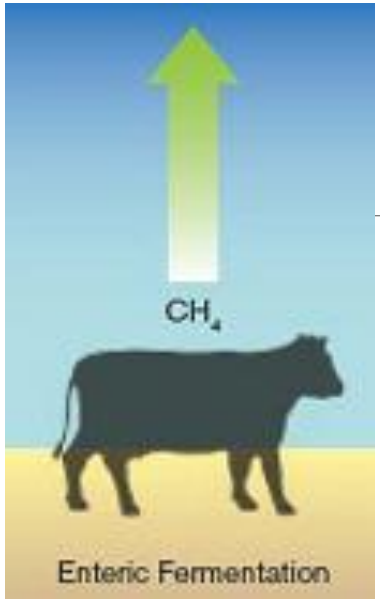
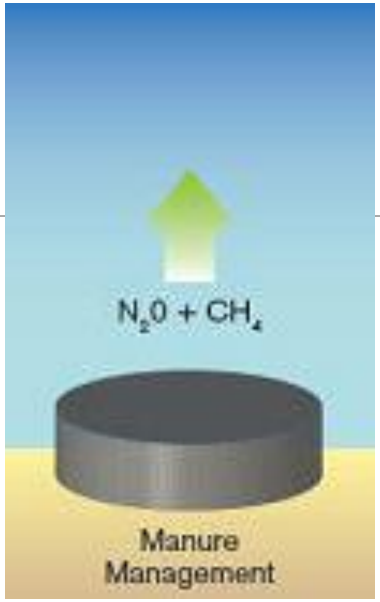


Example Mitigation Strategies:

1. Dietary adjustments
2. Improved genetics
3. Improving reproductive performance

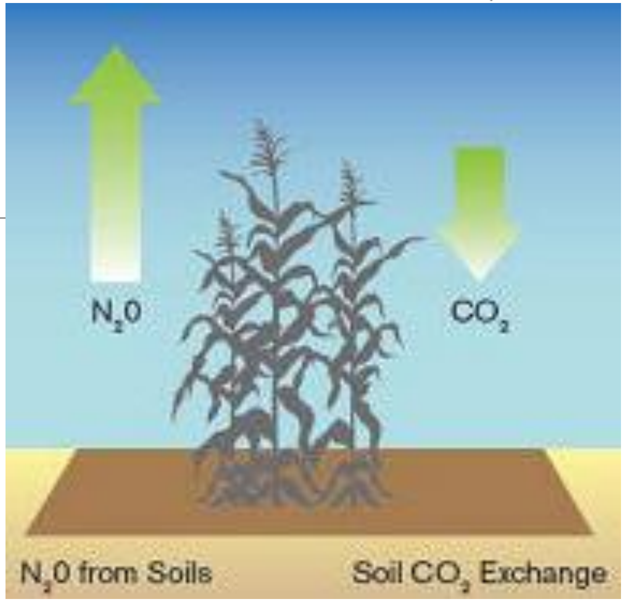

Source: Kuhn



Example Mitigation Strategies:

1. Manure Injection
2. Waste Storage Digestion / Energy Production
3. Covering Waste Storage Facilities


Source: VT-DEC



Example Mitigation Strategies:

1. Reduced Tillage
2. Cover Crop
3. Crop Rotation


Source: VAAFM

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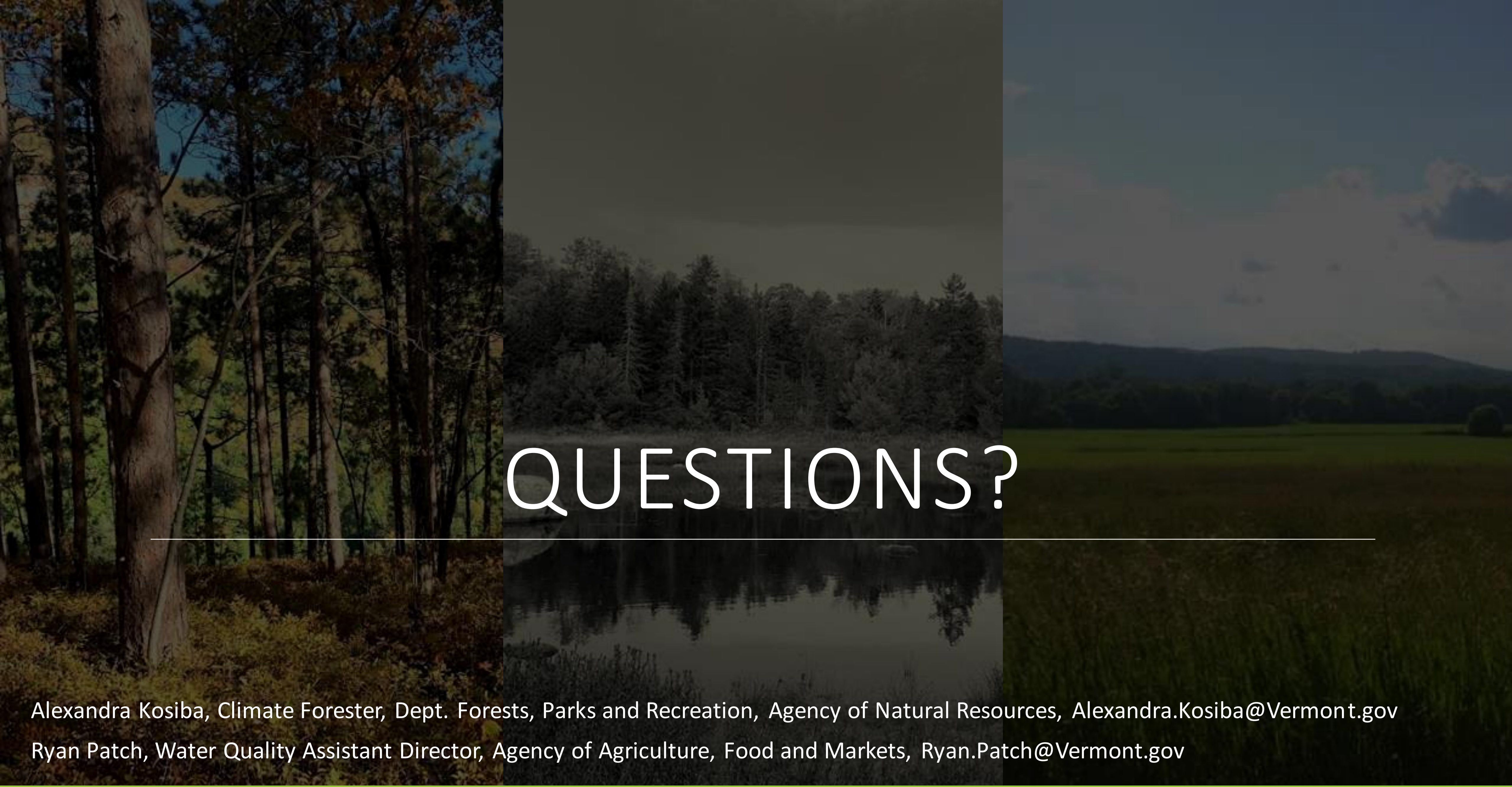
Conservation Practices can Influence Soil Carbon Levels
Agricultural land stores carbon in soils, and farmers can apply practices which can increase soil carbon levels in soils (cover cropping, no-till, management intensive grazing are examples of practices which can achieve this),

Technologies
Technologies can – and have been – applied to farms in Vermont to convert methane emissions from farms into energy through anerobic digestion, and

Whole Farm Considerations
Farms in Vermont manage significant tracts of forest in addition to cropland: According to the 2017 USDA NASS Ag Census, farms in Vermont manage 479,680 acres of total cropland and 503,496 acres of woodland that is not pastured. Land conservation programs are important to conserve land in agriculture.

Summary

- Vermont's Natural and Working lands can help us mitigate climate change, but they are also impacted by climate change.
- Currently, the forest sector provides a substantial carbon benefit, but this is not a guarantee in the future.
- Increasing the organic matter content of agricultural soils offers important agronomic benefits, in addition to the carbon benefit.
- To account for the NWL carbon sink we need to be able to measure it and manage it well.
- NWL present opportunities for joint mitigation and adaptation that can increase the resilience of natural and built systems.



QUESTIONS?

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