Soil Carbon Stocks in Vermont
& The State of Soil Health in Vermont Project

Presentation to Agriculture and Ecosystems Subcommittee of the Vermont Climate Council

Alissa White, Brenda Bergman & Heather Darby

7/9/2021

The Nature Conservancy Vermont

THE UNIVERSITY OF VERMONT EXTENSION

The State of Soil Health in Vermo

Project Goals:

- establish a **baseline of soil health** indicators, carbon stocks and associated ecosystem services in Vermont's agricultural landscapes
- create **standards for soil sampling** across management types and partners so that they will be comparable
- give farmers **contextualized information** about soil health on their farms
- support **collaboration** among the many organizations that work with farmers towards shared goals around soil health
- **build skills & capacity** for soil carbon assessments & measuring soil health

GUND INSTITUTE FOR ENVIRONMENT

THE UNIVERSITY OF VERMONT EXTENSION

DARTMOUTH

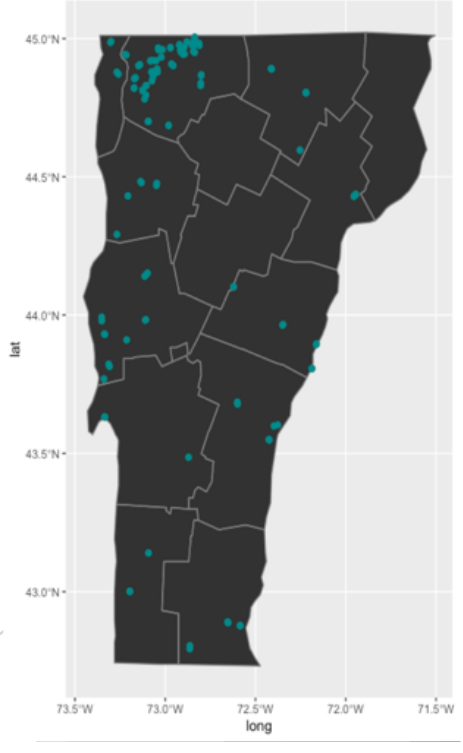
vermont environmental stewardship PROGRAM

The Nature Conservancy Vermont

BEN & JERRY'S

2021 Field Sampling

- 165+ fields sampled
- Convenience sample from existing research projects,
- Plus purposeful sampling to reach greater geographic extent of state



The State of Soil Health in Vermont

What are we measuring and what does it mean?

Soil Health (CASH)
- Available water capacity
- Aggregate stability
- Organic matter
- ACE soil protein index
- Soil respiration
- Active carbon
- Soil PH
- Extractable phosphorus
- Extractable potassium
- Minor elements

Soil Carbon Stocks to 30 cm depth
- Bulk density
- Soil Organic Carbon

Biological Functional Diversity
- Ecoplate carbon substrate test

Carbon fractions
- Particulate VS Mineral organic carbon

- Nutrient availability
- Ecosystem Services
  - Soil health
  - Resilience to extreme weather
  - Climate regulation
- Biological community in soil
  - Diversity richness
  - Niche partitioning and breadth
- Carbon permanence

The State of Soil Health in Vermont

What are we measuring and what does it mean?

Soil Health (CASH)
- Available water capacity
- Aggregate stability
- Organic matter
- ACE soil protein index
- Soil respiration
- Active carbon
- Soil PH
- Extractable phosphorus
- Extractable potassium
- Minor elements

Soil Carbon Stocks to 30 cm depth
- Bulk density
- Soil Organic Carbon

Biological Functional Diversity
- Ecoplate carbon substrate test

Carbon fractions
- Particulate VS Mineral organic carbon

- Nutrient availability
- Ecosystem Services
  - Soil health
  - Resilience to extreme weather
  - Climate regulation
- Biological community in soil
  - Diversity richness
  - Niche partitioning and breadth
- Carbon permanence

Soil Carbon Stock Basics

The University of Vermont

- % carbon content
- bulk density
- depth of measurement
- area

Carbon stock: amount of carbon in a volume of soil

MTC/ha to 30 cm depth

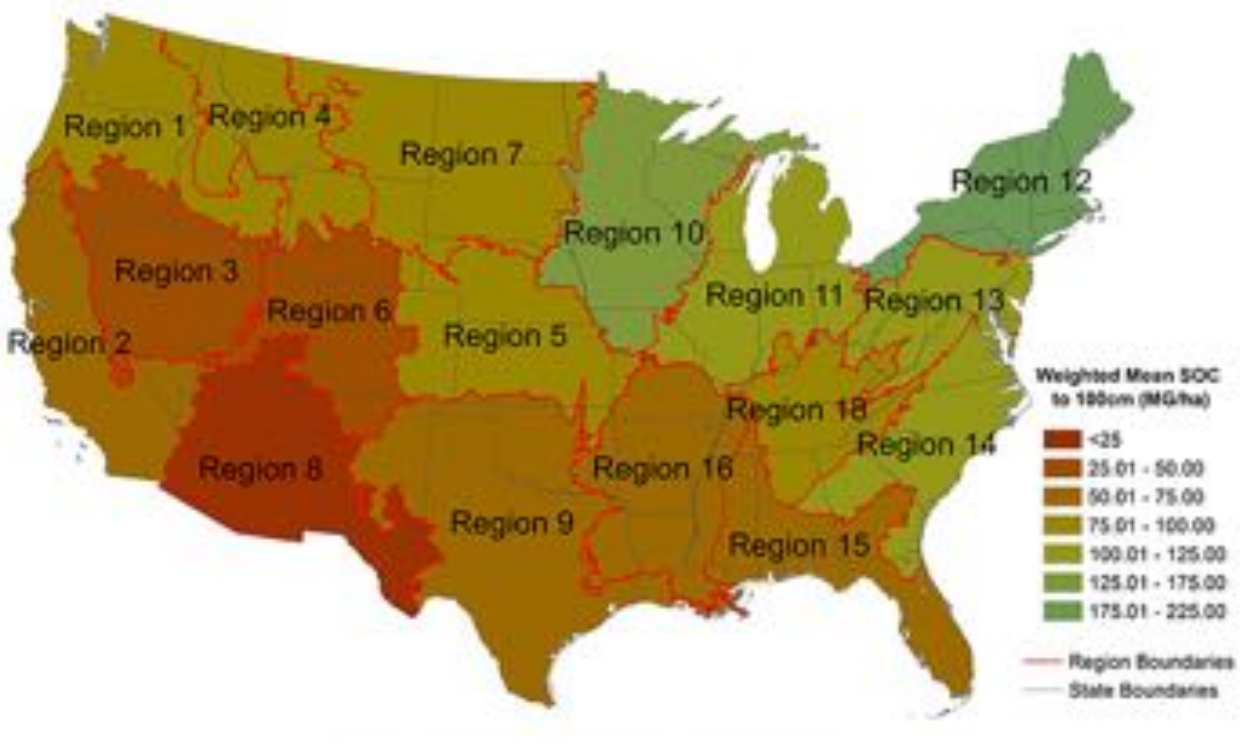
Soil Carbon Stocks nationally

The University of Vermont

Existing data:

The NRCS Rapid Carbon Assessment (RaCA)

- National baseline inventory of soil carbon stocks conducted in 2010
- Measured soil carbon and bulk density to calculate carbon stocks at 3 depths
- Most soil carbon occurs within 5-30 cm depth
- Wetlands have highest soil carbon stocks
- Northeast region has largest soil carbon stocks

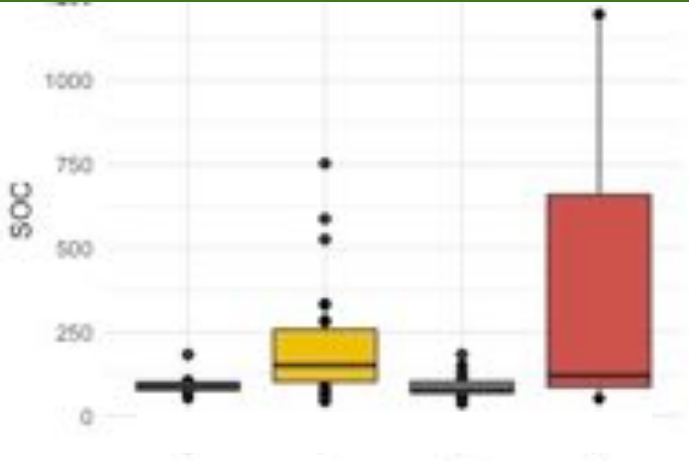


Soil Carbon Stocks in Vermont

The University of Vermont

NRCS RaCa soil carbon stock data in Vermont

- 53 sites in Vermont
- Mean values are skewed by high outliers
- Wetland and forest soils have highest soil carbon content in Vermont.
- Agricultural soils are an opportunity to enhance soil carbon content.

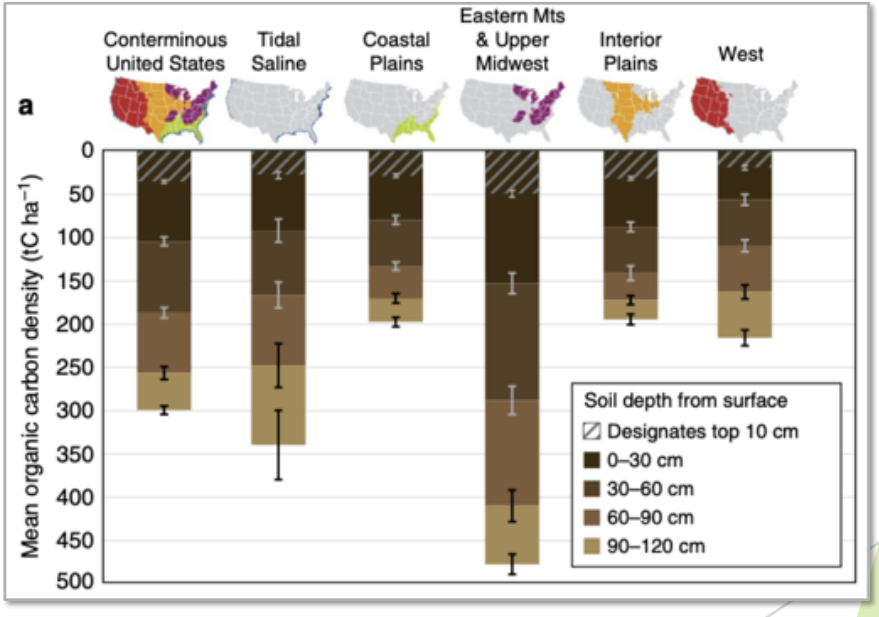


Land Use	number of fields sampled	mean SOC stock		
		5 cm depth	**30 cm depth**	100 cm depth
Cropland	8	23.75	**95.49**	124.37
	15			132.15
Wetland	3	82.93	**456.50**	1425.81

Soil Carbon Stocks in forest & wetland soils

The University of Vermont

- Wetland soils are anoxic, which slows decomposition.
- Wetland soils in the Eastern Mountains and Upper Midwest region, store an average of 539±47 tC /ha in the top 100 cm of soil



Nahlik, A. M., & Fennessy, M. S. (2016). Carbon storage in US wetlands. *Nature Communications*, *7*(1), 1-9.

Soil Carbon Stocks in forest & wetland soils

The University of Vermont

- Based on this 2017 ANR report, Vermont forests soils hold 152.95 t C/ha, and are the largest carbon pool n in our forest ecosystems.

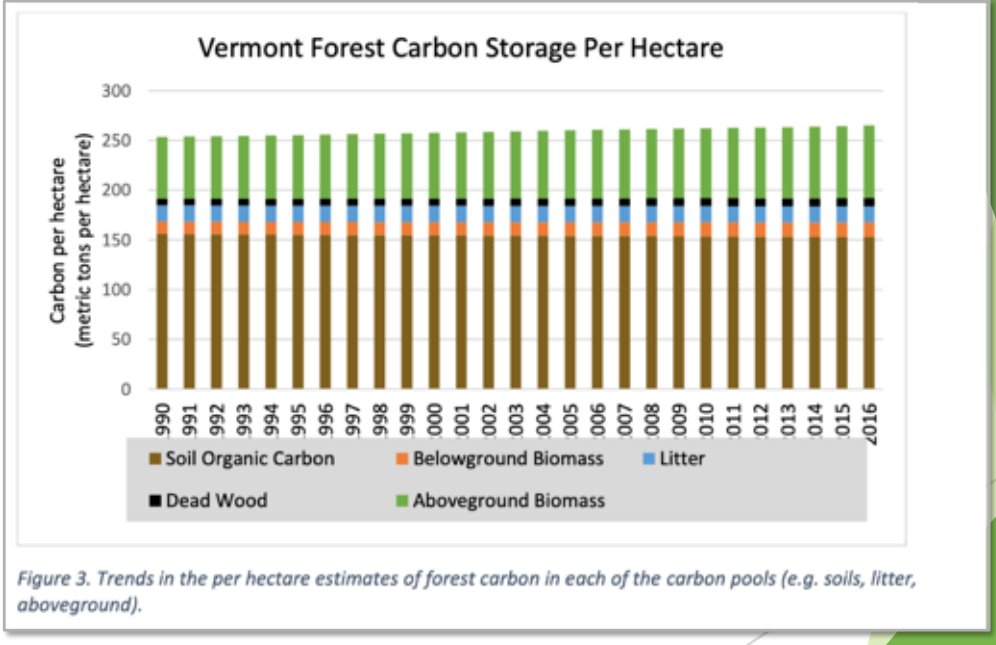


Figure 3. Trends in the per hectare estimates of forest carbon in each of the carbon pools (e.g. soils, litter, aboveground).

Schultz, B., Hanson, T., Halman, J., Wilmot, S., Spinney, E., & T. Greaves. 2017. Vermont Forest Carbon Assessment, IN: Forest Insect and Disease Conditions in Vermont, 2016. Agency of Natural Resources, Department of Forests, Parks & Recreation, Montpelier, VT.

Soil Carbon Stocks in Vermont agricultural soils

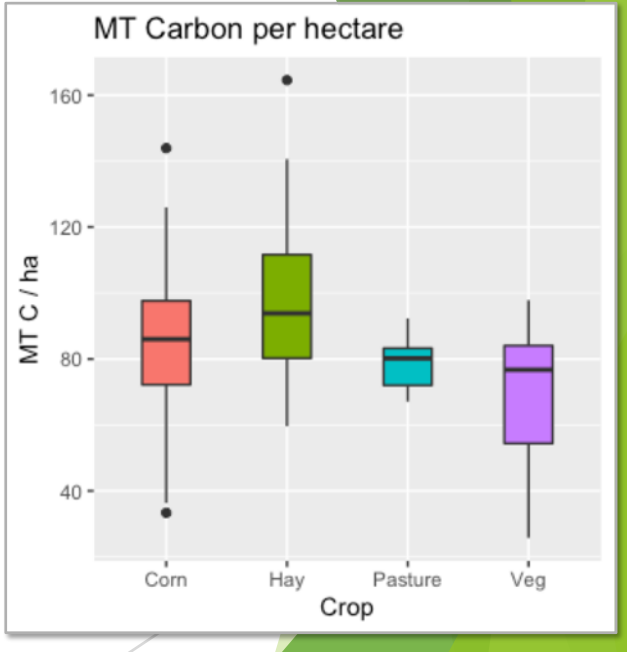
The University of Vermont

Preliminary results from the State of Soil Health 2021 data

- Hay fields have the greatest agricultural soil carbon stocks
- Corn fields may have higher soil carbon stocks than pasture and vegetable fields
- Vegetable fields have lowest soil carbon stocks
- Management and soil texture also have a strong effect

Soil Carbon Stocks in Vermont Agriculture
MT C/ha to 30 cm depth

Type	n	Min	*Median*	Mean	Max	Standard deviation
Corn	96	33.35	***86.01***	85.52	143.95	21.68
Hay	24	59.64	***93.84***	99.65	164.56	28.34
Pasture	16	67.06	***80.18***	79.00	92.32	9.09
Veg	18	25.73	***76.75***	69.30	97.84	21.60



Soil Organic Carbon in Vermont

The University of Vermont

Comparing existing data on agricultural soils

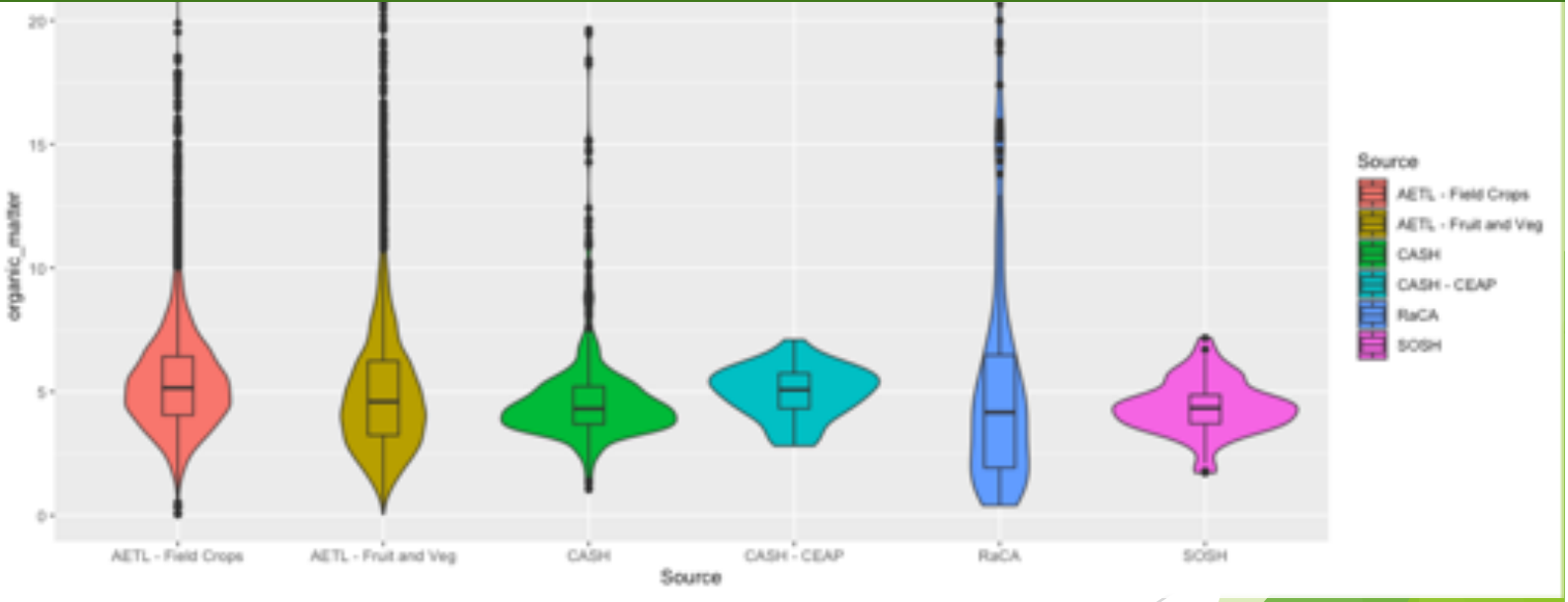
- Organic matter content in Vermont agricultural soils are outstanding
- Climate, soil texture and **management** contribute to high organic matter levels

Soil organic matter levels in hay, pasture and crop fields from available data

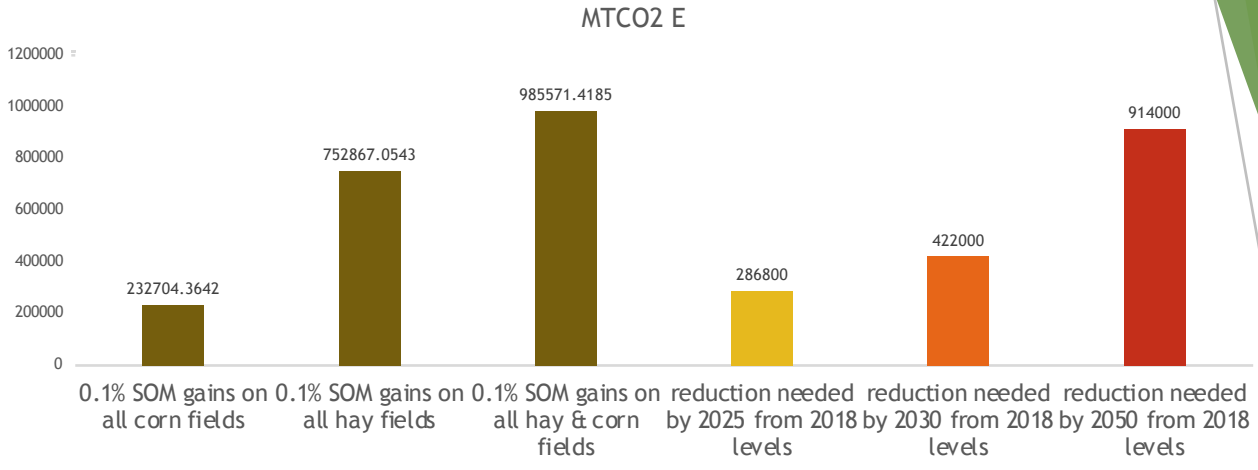
Dataset	n	Average OM%
Vermont - **UVM AETL data**	9,415	5.3%
Vermont - **USDA RaCA data**	26	5.6%
Vermont - **Cornell CASH data**	622	4.8%
Vermont - **State of Soil Health 2021 data**	145	4.4%
USA - **USDA RaCA data**	6,236	3.2%

Soil Organic Carbon in Vermont

The University of Vermont



- Organic matter content in Vermont agricultural soils from over 26,000 samples in multiple datasets corroborate that the **median and mean organic matter content are over 4%**
- Greater gains are possible. The high end of the interquartile range (Q3) for soil testing data from Vermont is **6.4% organic matter.**



By rough estimates, a 0.1% increase in soil organic matter content in the top 30 cm of corn and hay fields **can help Vermont meet its agriculture sector emissions reduction goals.**

But….

- gains would need to be sustained annually to offset emissions
- N_20 and other soil surface GHG emissions are not included in this picture, and have been shown to offset soil carbon gains in some soil and nutrient management systems in Vermont

The University of Vermont




Agricultural Resilience & Adaptation to Climate Change in the Northeast

Presentation to Agriculture and Ecosystems Subcommittee of the Vermont Climate Council
7/9/2021, Alissa White PhD

GUND INSTITUTE FOR ENVIRONMENT

Center for Sustainable Agriculture

ALC AGROECOLOGY & LIVELIHOODS COLLABORATIVE

The University of Vermont

NORTHEAST SARE Sustainable Agriculture Research & Education

USDA

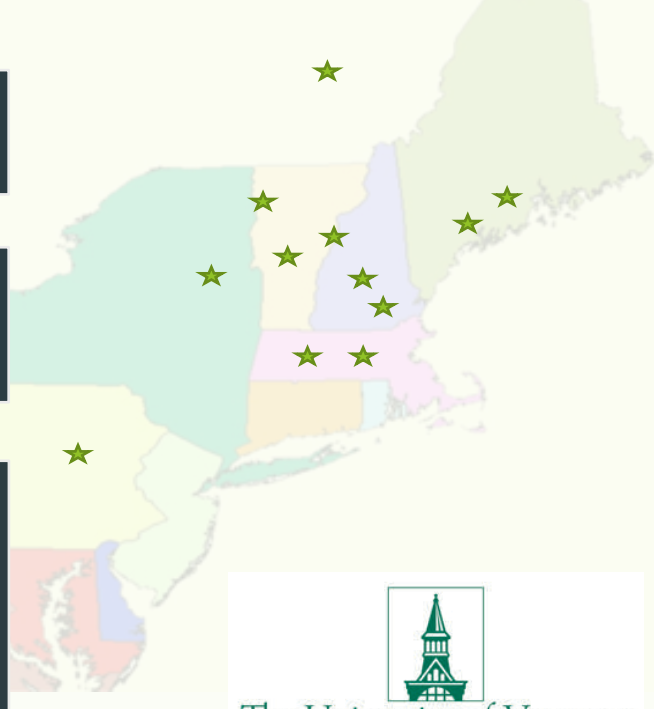
United States Department of Agriculture
Northeast Climate Hub

Regional research on climate resilience

Interviews with Agricultural Advisors
2017-2018

Farmer Survey
Winter 2017-2018

Focus Groups & Farmer-to-Farmer Sessions
Winter 2018-2019



The University of Vermont

Regional research on climate resilience

How to we bridge the climate information gap?

How are farmers adapting?

What resources support farm resilience to climate change?

The University of Vermont

Advice from Extension on Climate Change

Interviews with 17 Extension Professionals in the northeast about **climate change outreach**

"One level down." Information is more tangible and usable if it is tied to climate impacts, rather than climate change

Context specific. Information is more useful when it is tailored to unique operating contexts

The University of Vermont

Weather related crop loss in the Northeastern US 2013-2016

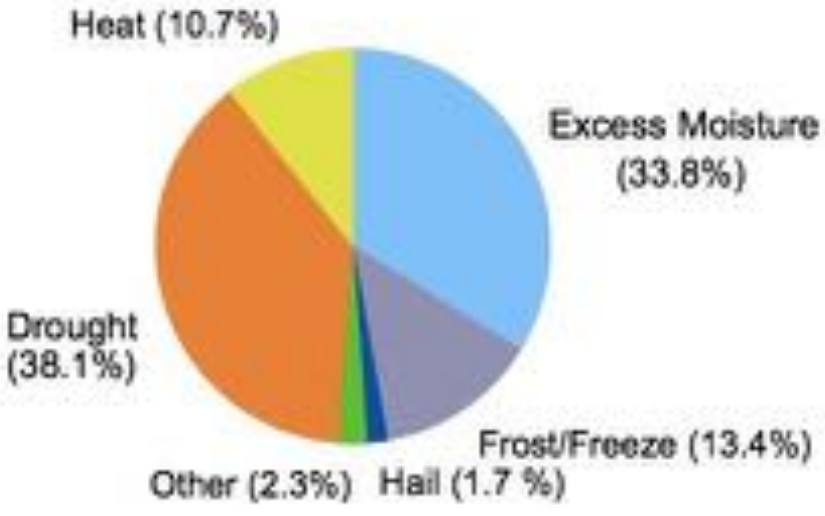
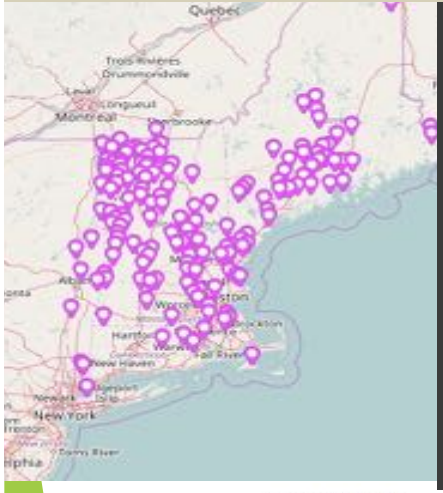


Image adapted from Wolfe et al., 2018

Regional Survey with Vegetable and Fruit Growers

- How are farmers adapting to extreme precipitation patterns?
- Which strategies are considered innovative and promising?



193 respondents, Canada to Pennsylvania

November 2017 April 2018

77 questions

Partnered with farmer organizations

NORTHEAST SARE Sustainable Agriculture Research & Education

USDA United States Department of Agriculture Northeast Climate Hub

The University of Vermont

76% of survey respondents agree or strongly agree that they **understand their vulnerability to weather-related risks.**

37% of respondents agree or strongly agree that they have the **knowledge or technical skill to respond.**

18% of respondents agree or strongly agree that they have the **financial capacity to deal with weather-related threats to the viability their farm operation, including crop insurance.**

Soil health & cover crops

Already used by most growers for climate adaptation

	Cover crops	Soil health
Adapting to Heavy Precipitation	**74%** of growers	**74%** of growers
Adapting to Drought	**66%** of growers	**72%** of growers

The University of Vermont

No-till & soils health are considered among the most innovative and promising strategies for adaptation

"Deep healthy porous soil absorbs, moves and stores water"

"No till system with cover cropping to reduce erosion"

"No-till, increase organic matter, avoid bare soil at all costs"

"Better quality soil is more resilient"

"Better deeper soil with more organic matter and biology performs better in drought conditions"

"Improve soil quality/drainage"

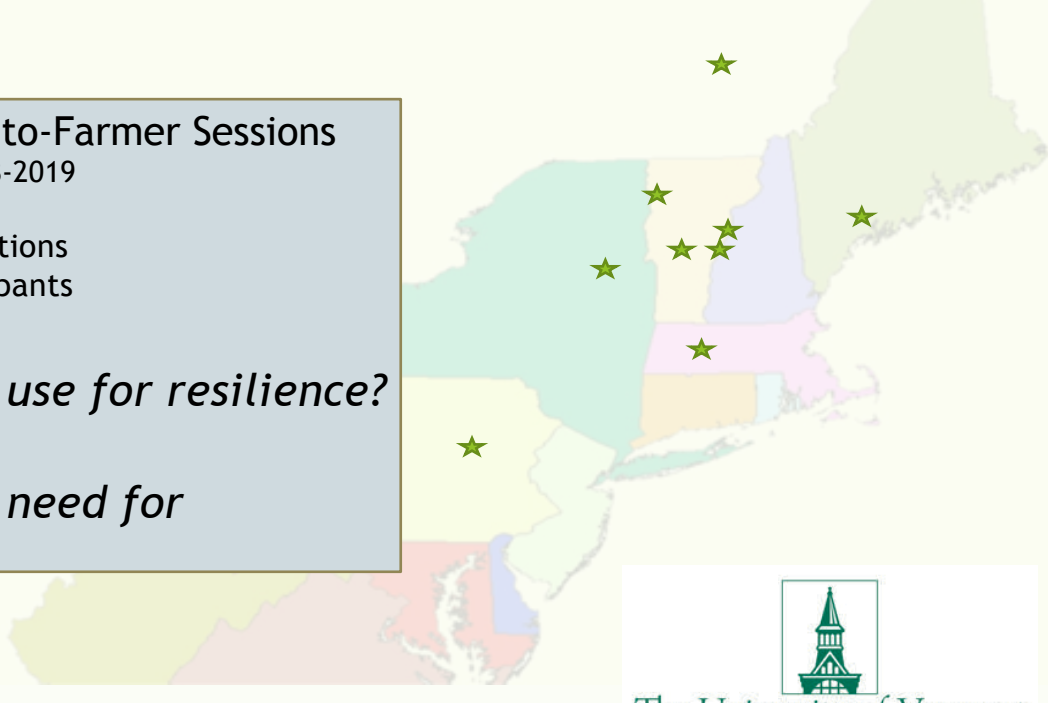
Resources for Resilience Listening Tour

Focus Groups & Farmer-to-Farmer Sessions
Winter 2018-2019

9 conversations
173 participants

What resources do you use for resilience?

What resources do you need for resilience?



The University of Vermont

"Resiliency is not about bouncing back.
It's about bouncing FORWARD!"

Eileen McDargh

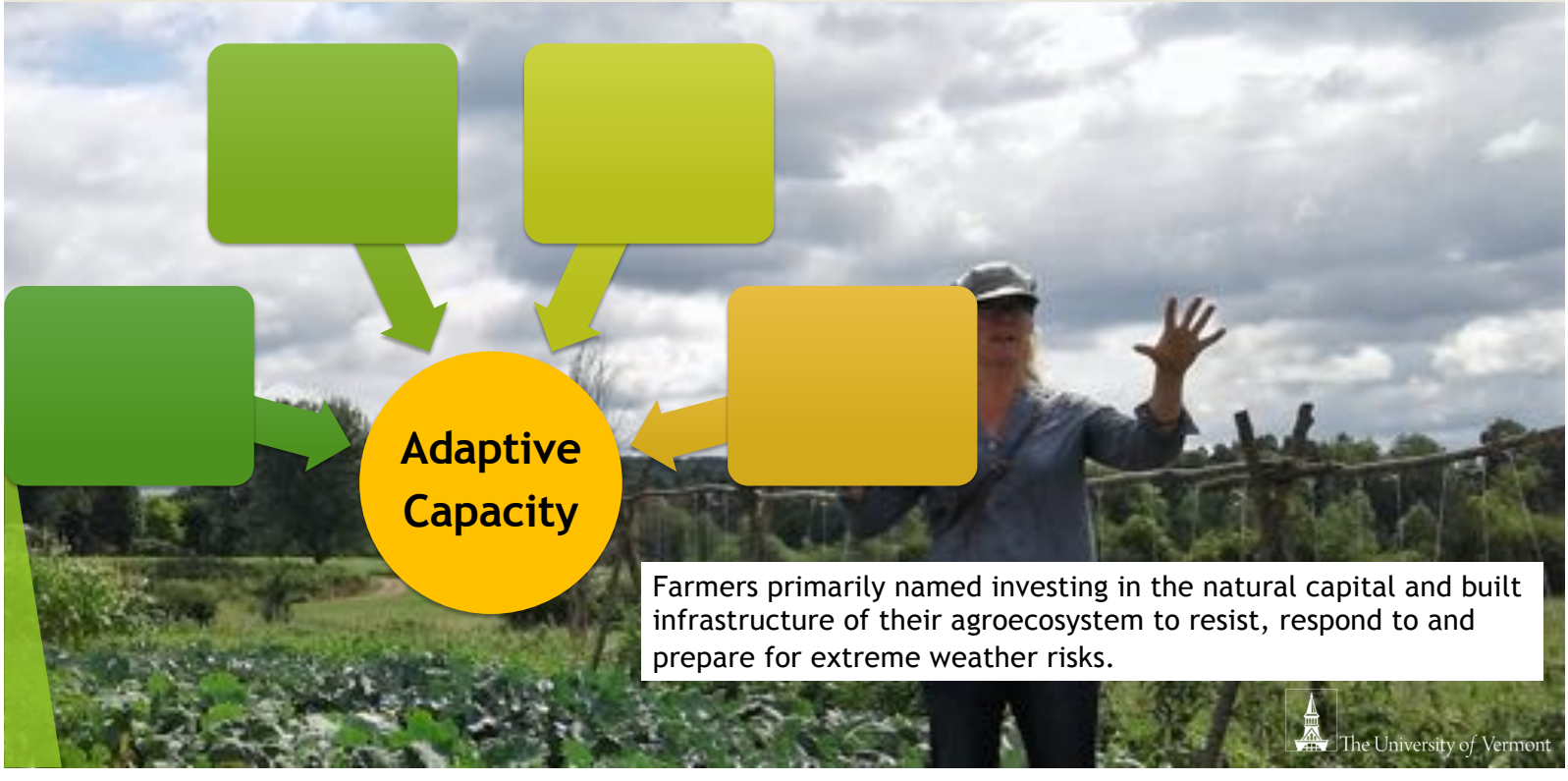
https://wisdomprimus.com/bounce-forward/

The University of Vermont

What are RESOURCES FOR RESILIENCE ?

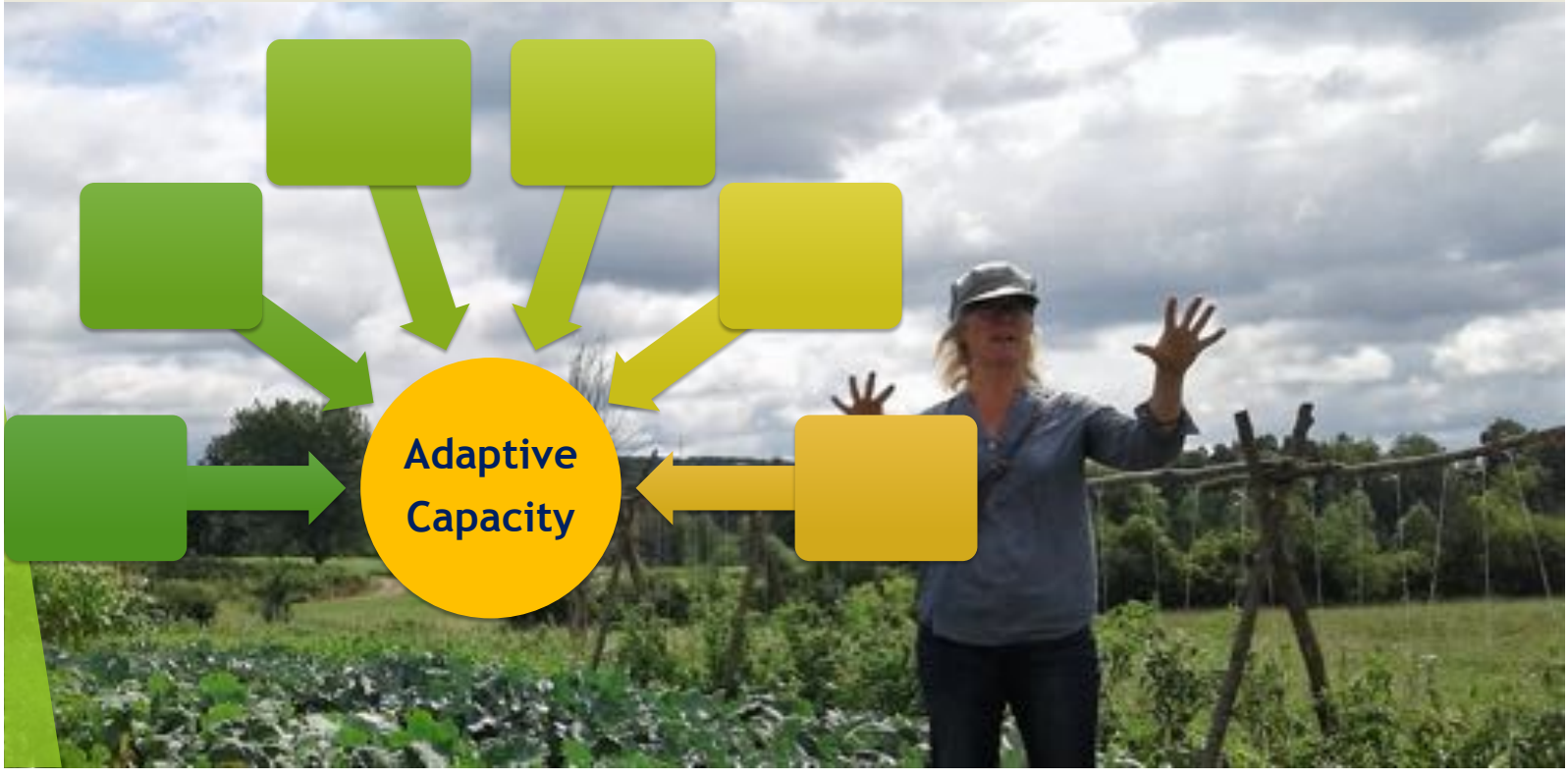
- **Natural:** soil, biodiversity
- **Physical:** pond, hoop house
- **Information**: growing degree days, farm map
- **Financial:** grants, insurance, markets
- **Educational:** workshops, technical assistance, planning support
- **Human:** skills, confidence
- **Equipment:** seed drill, bed hiller
- **Relationships:** other farmers, CSA members

Resources for Resilience: Visible

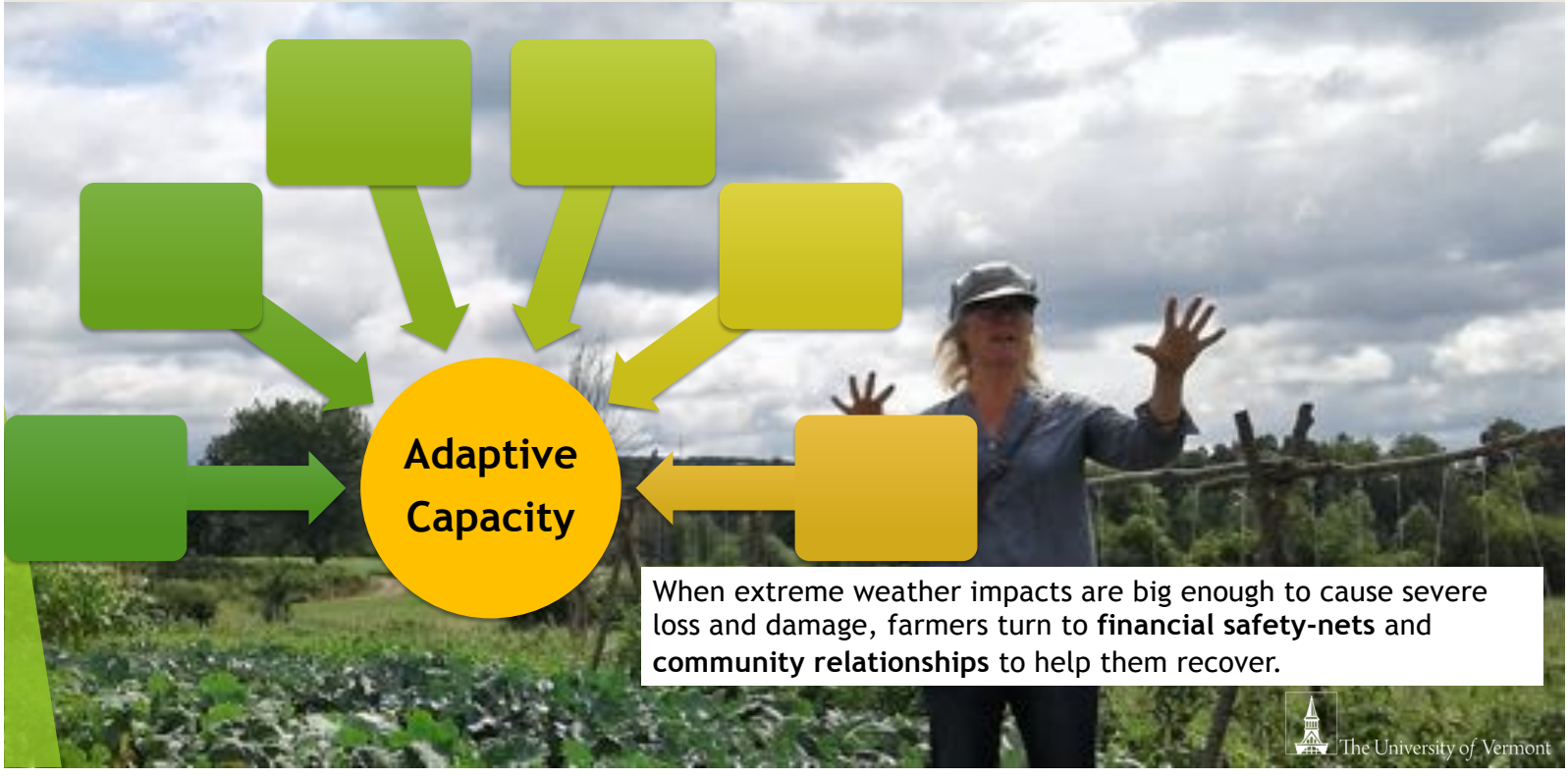


Farmers primarily named investing in the natural capital and built infrastructure of their agroecosystem to resist, respond to and prepare for extreme weather risks.

Resources for Resilience: Invisible



Resources for Resilience: Invisible



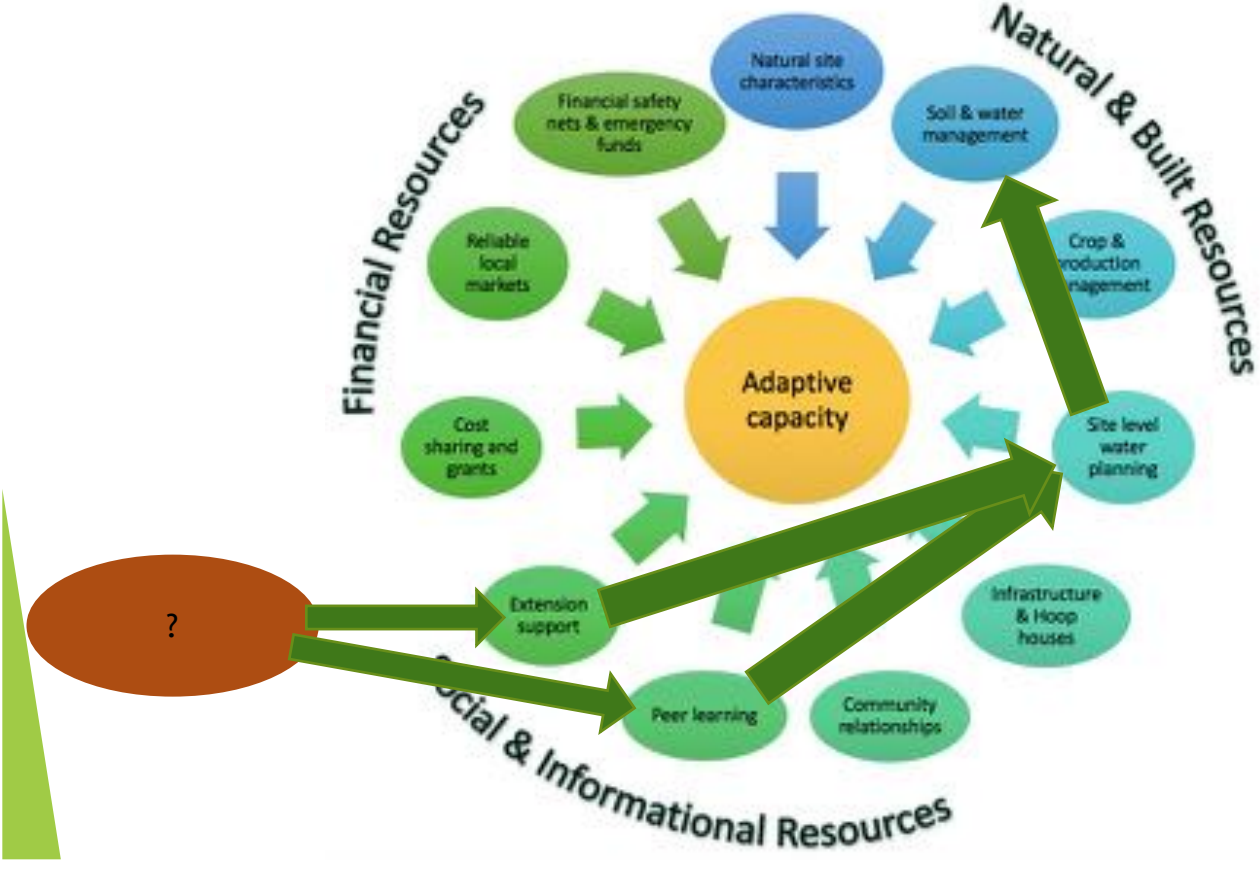
When extreme weather impacts are big enough to cause severe loss and damage, farmers turn to **financial safety-nets** and **community relationships** to help them recover.

The University of Vermont

The University of Vermont


Natural & Built Resources
Financial Resources
Social & Informational Resources
Natural site characteristics
Soil & water management
Financial safety nets & emergency funds
Reliable local markets
Crop & production Management
Adaptive capacity
Cost sharing and grants
Site level water planning
Extension support
Infrastructure & Hoop houses
Peer learning
Community relationships

The University of Vermont



The University of Vermont

Thank you!

Alissa.white@uvm.edu

The University of Vermont