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
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
The State of Soil Health in Vermont

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?

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 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
The State of Soil Health in Vermont
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- **Ecosystem Services**
  - Soil health
  - Resilience to extreme weather
  - Climate regulation

- **Biological community in soil**
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  - Niche partitioning and breadth

- **Carbon permanence**
Soil Carbon Stock Basics

- % 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

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

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.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>number of fields sampled</th>
<th>5 cm depth</th>
<th>30 cm depth</th>
<th>100 cm depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland</td>
<td>8</td>
<td>23.75</td>
<td>95.49</td>
<td>124.37</td>
</tr>
<tr>
<td>Forest</td>
<td>27</td>
<td>91.75</td>
<td>212.31</td>
<td>NA</td>
</tr>
<tr>
<td>Pasture and Hay</td>
<td>15</td>
<td>30.59</td>
<td>90.45</td>
<td>132.15</td>
</tr>
<tr>
<td>Wetland</td>
<td>3</td>
<td>82.93</td>
<td>456.50</td>
<td>1425.81</td>
</tr>
</tbody>
</table>
Soil Carbon Stocks in forest & wetland soils

- 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

Soil Carbon Stocks in forest & wetland soils

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

Soil Carbon Stocks in Vermont agricultural soils

**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

<table>
<thead>
<tr>
<th>Type</th>
<th>n</th>
<th>Min</th>
<th>Median</th>
<th>Mean</th>
<th>Max</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>96</td>
<td>33.35</td>
<td><strong>86.01</strong></td>
<td>85.52</td>
<td>143.95</td>
<td>21.68</td>
</tr>
<tr>
<td>Hay</td>
<td>24</td>
<td>59.64</td>
<td><strong>93.84</strong></td>
<td>99.65</td>
<td>164.56</td>
<td>28.34</td>
</tr>
<tr>
<td>Pasture</td>
<td>16</td>
<td>67.06</td>
<td><strong>80.18</strong></td>
<td>79.00</td>
<td>92.32</td>
<td>9.09</td>
</tr>
<tr>
<td>Veg</td>
<td>18</td>
<td>25.73</td>
<td><strong>76.75</strong></td>
<td>69.30</td>
<td>97.84</td>
<td>21.60</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Dataset</th>
<th>n</th>
<th>Average OM%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermont - UVM AETL data</td>
<td>9,415</td>
<td>5.3%</td>
</tr>
<tr>
<td>Vermont - USDA RaCA data</td>
<td>26</td>
<td>5.6%</td>
</tr>
<tr>
<td>Vermont - Cornell CASH data</td>
<td>622</td>
<td>4.8%</td>
</tr>
<tr>
<td>Vermont - State of Soil Health 2021 data</td>
<td>145</td>
<td>4.4%</td>
</tr>
<tr>
<td>USA - USDA RaCA data</td>
<td>6,236</td>
<td>3.2%</td>
</tr>
</tbody>
</table>
• 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
- N₂O 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
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
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?
Advice from Extension on Climate Change

“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.

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

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
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 of their farm operation, including crop insurance.
Soil health & cover crops

Already used by most growers for climate adaptation

<table>
<thead>
<tr>
<th>Adapting to</th>
<th>Cover crops</th>
<th>Soil health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Precipitation</td>
<td>74% of growers</td>
<td>74% of growers</td>
</tr>
<tr>
<td>Drought</td>
<td>66% of growers</td>
<td>72% of growers</td>
</tr>
</tbody>
</table>
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?
"Resiliency is not about bouncing back. It's about bouncing FORWARD!"

Eileen McDargh

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

Adaptive Capacity

- Peer-learning
- Extension support
- Cost sharing and grants
- Reliable local markets
- Vermont Farm Fund
- Community relationships
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.
Thank you!  Alissa.white@uvm.edu