Working Group Topic: Agricultural and Forestry Sequestration

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I. Agricultural Sequestration

Vermont farms have an opportunity contribute to meeting the state's climate goals by increasing the levels of carbon stored in soils—a process known as sequestration. Importantly, many of the agricultural management strategies which are known to sequester carbon also impart multiple benefits to farmers, the environment, and the working landscape which Vermonters hold so dear. We seek to reward and encourage farmers for being part of the climate solution and ensure that this climate friendly management allows them to stay in business while improving the environment.

Background

Primarily composed of carbon, the organic matter in soils plays a role in four important ecosystem services: resistance to soil erosion, soil water-holding capacity, soil fertility for plants, and soil biodiversity. Even small changes in the soil carbon pool have large-scale effects both on agricultural productivity and on the greenhouse gas balance. Maintaining carbon-rich soils, restoring and improving degraded agricultural lands and, more generally, increasing soil carbon, play an important role in addressing the three-fold challenge of food security, adaptation of food systems and people to climate change, and mitigation of anthropogenic emissions. According to the "4 by 1000" initiative—launched by participants during the 2015 COP 21 in Paris-- an annual growth rate of 0.4% in the soil carbon stocks, or 4‰ per year, would halt the increase in atmospheric CO2 concentration stemming from human activities.

Growing plants and trees are the most fundamental way we "capture" CO_2 from our atmosphere. Plants breathe in carbon dioxide and through photosynthesis, convert a portion of the carbon to plant biomass, both above and below ground. The science around carbon sequestration in soils is complex, yet research points clearly to two important principals. First, reducing soil disturbance keeps existing soil carbon in the soil. Second, while we have lost much of our agricultural soil carbon through 100 years of cropping, that loss can be reversed by adopting a reasonable set of conservation practices. In the temperate regions, estimates suggest such practices can add a ton of sequestered carbon per acre per year, on the average, for 10 to 20 years. Some soils can add more, and some have a lower sequestration potential. Generally, the moist soils of the northeast are better able to sequester carbon than the arid conditions of the west. With an estimated one-third of the arable land in agriculture globally, it is critical that we find ways to increase soil carbon in agricultural systems. Around the world, efforts are being targeted at decreasing soil disturbance, reducing erosion, increasing organic matter inputs to soil through crop residues and organic nutrient sources, and maintaining continuous living plant cover as much as possible throughout the year.

Farmers in Vermont manage 1.25 million acres of land, impacting 20% of the total land in the state. About half of that land is in active crop production including nearly 100,000 acres of corn, soybeans, cereal grains and vegetables; 338,000 acres of hay for livestock feed and biomass crops for bedding and mulch; 139,000 acres of permanent pasture. The rest is over 500,000 acres of farmer woodlots plus farmsteads and undeveloped land (USDA NASS, 2016). In 2016, a total of $776 M of all agriculture products were sold including $505 M from milk sales.

Over the past decade, educators, service providers, and partners in the agricultural community have worked closely with farmers to increase the use of conservation practices largely for their

water quality benefits.[1] Cover cropping helps keep soil in place, reduces moisture stress, increases soil organic matter, and adds nitrogen and other nutrients. Pasture management, including rotational grazing and adding compost, increases productivity, soil carbon and plant diversity. Careful nutrient management reduces run-off and fertilizer expense and can curb GHG emissions from soils in the form of nitrous oxide, while also reducing costs. Beside the water quality benefits, these practices increase soil resilience, maintain or enhance productivity, sequester carbon in soil, and in many cases, reduce the emission of greenhouse gasses.

Existing Condition and Trajectory

Over the last decade, adoption by Vermont farmers of these practices has resulted in the rebuilding of soil health. As importantly, these soil health improvements have the co-benefits of improving water quality and enhancing flood resiliency while increasing sequestered carbon in the soil and decreasing greenhouse gas (GHG) emissions from agricultural lands. New regulations (Vermont Clean Water Act) have promoted these practices for their water quality value and increased funding for implementation and education. Vermont farmers also lead in trying innovative practices like a roller crimper that increases the return of organic matter in cover crop residues to a field, with lower chemical inputs.

These practices also provide longer term benefits to farmers by enhancing productivity, decreasing fertilizer costs, and reducing volatility of weather-related yield swings--essentially creating cropping systems that are more resilient to the impacts of climate change. Many farmers have adopted these practices voluntarily, but there is still a financial cost to farm businesses. It is critical that these practices continue, once implemented, as research shows reverting to previous conditions can quickly reverse nearly all the prior gains. Since the potential for capturing annual CO_2 emissions, both locally and globally, through agriculture is high, and so clearly connected to other co-benefits, it is critical to recognize the value of enhancing these practices through future policies. Education and demonstration of such conservation practices that allow for farmer-to-farmer communication are also critical for increased adoption, and have been shown to one of the most effective means of changing management. Recent studies (Galik, et al., 2018) have suggested that policies that promote early action can promote innovation and reduce the lags in benefit outcomes compared to inaction.

Goal:

The goals stated in the CEP include reducing GHGs within the state and from outside the state's boundaries caused by the use of energy within the state by 50% by 2028 and 75% by 2050. Sequestration is an important and overlooked strategy to reduce atmospheric carbon dioxide. The CEP mentions carbon sequestration mainly in the context of forests. Soil sequestration is not mentioned and agricultural citations mention the potential for energy generation (and emission reductions) from anaerobic digestion. Agricultural practices that can increase carbon sequestration in soils can be significant, as can the contribution of both forestry and agriculture to our climate goals, especially given the many co-benefits. Our recommendations identify key

[1] Cover crops are grass or grain seeded either during the growing season or after harvesting of an annual crop, usually corn. Cover crops decrease the potential for erosion of bare soil during the non-growing months, while increasing soil health, organic matter and nutrients. Reduced tillage is a practice that minimizes soil disturbance and allows crop residue or stubble to stay on the soil. The cover residues (often in conjunction with a cover crop) protect the soil from erosion, and the soil structure and health are improved by avoiding annual plowing and heavy machinery. Cover crops are now used on about a third of the corn acres, and are required on some fields as part of the state's Required Agricultural Practices.

leverage points and policy actions needed to systematically recognize and advance the existing and potential contributions of agriculture to achieving the state's climate goals.

Potential impact
Extrapolating under reasonable assumptions[2], practices that promote carbon storage in agricultural soils have the potential to offset 2% of our annual state emissions.

II. Forest Sequestration

Background, Condition and Trajectory
Forest cover roughly 78% of the land area of state. They are also a major carbon store or "sink"—both above and below ground. Estimates suggest more than half our state's annual CO_2 emissions are being absorbed by the annual growth of these forests, and over 200 years of emissions are stored there. Recent data suggest our net annual sequestration is declining slightly, and—for the first time in over 100 years--our forested land base is declining (Morin, et al. 2017). While these data demonstrate changes in the state of our forests, the reasons for it are complex. One aspect of the future is relatively certain: climate change will increase management costs for forest landowners from a host of expected impacts including invasive plants and insect control, increased drainage and road infrastructure costs, storm damage, and potential reductions in health and productivity. To climate impacts add increasing property taxes, parcelization, weakening markets, and the shifting demographics of ownership and the stability of our future forest land base becomes tenuous. Already risky and marginal, the profitability of forest ownership is likely to decline, jeopardizing many of the benefits we have come to expect from our forests—benefits that include clean air, clean water, flood resilience, and carbon storage, along with more conventional forest products. Vermont has been proactive in informing both landowners and policy makers about this growing list of threats. Forest managers have access to regular reporting on forest health and markets. Planners have new legislative mandates requiring they consider the benefits of forest in regional and municipal plans. Workshops encouraging planning for ownership succession are ongoing. The Department of Forest, Parks, and Recreation has developed a suite of tools supporting the adaptation of management in the face of a changing climate. However, none of these laudable actions generate additional revenues to landowners.

One alternative revenue stream is gaining ground in much of the country: Programs that allow for forest landowners to monetize forest growth as carbon offsets—generating payments for some of the ecosystem services forests provide. Carbon offset programs not only promote additional sequestration, but by providing a new annual income stream to landowners may well play a role in keeping the major forest carbon sink intact. As with agriculture, co-benefits from habitat protection and sustainable management are additional dividends to the public. Yet, turning carbon in trees into a fungible "security" is far from simple. Program rules are complicated and the expertise required to develop forest carbon projects is expensive. Larger tracts (more carbon revenue) cover more of these fixed costs, which partially explains why most

[2] Our analysis assumes a 1% annual increase in organic matter per year across a distribution of soil types and practices. We also assumed these practices would be achieved on roughly one-third of agricultural acres and be sustained for a period of 20 years. Across all soils, this resulted in average carbon per acre changing from 25 to 30 tons over the 20-year period.

projects have occurred where parcel size is larger or growth is faster, compared to Vermont. Only one forest carbon project has been initiated in Vermont to date.

Managing forests for carbon sequestration is compatible with all other forms of responsible forest management. The potential for income from trading forest carbon offsets is likely to continue to generate interest, both from policy makers and landowners. Nationally, forest carbon offsets from across the country supply the bulk of traded offsets for the California Cap and Trade mechanism. Whether these programs will continue to grow is hotly debated, but of all the types of offsets available, forest-based offsets display substantial demand and some of the highest prices.

Goals:
The CEP recognizes the importance of intact forests and discusses the role of wood fuel for heat and energy. The CEP does not acknowledge the role of or the potential for sequestration in Vermont forests, though it does acknowledge the forests as a carbon sink. The Commission will identify actions the legislature and administration can undertake to support and promote additional sequestration in forests by landowners and communities. It will also consider recommendations that promote maintaining and enhancing the value of the large carbon sink represented by our current forests.

Potential impact
The carbon in our forest soils is relatively stable, presuming soil disturbance is minimized and the forest growing above remains reasonably intact. For decades, the "live" carbon in Vermont forests have seen a positive net change, that is, growth consistently exceeds losses from mortality and harvesting, consistently adding reservoir of carbon extracted from the atmosphere. Research is ongoing regarding optimal management strategies that balance both the preservation of the sink and sequestration from growth. In all likelihood, the introduction of offset trading will not have major effects on either the level of currently sequestered carbon or the accretion of additional carbon through growth. It does have potential to reward landowners for protecting the existing carbon and securing payments for new sequestration. We emphasize this point: *the potential loss of carbon from the loss of forestland is real and substantial*. Every acre of forest lost to development has the potential to release a hundred metric tons of carbon dioxide equivalent into the atmosphere—the equivalent emissions of twenty-five cars for a year.

Recommendation *Develop an accurate baseline of carbon sequestration in agricultural soils*	**GHG Impact** 	**Savings Impact** 	**Investment Needed** 	**Feasibility** 
Action Step(s)		Who's Responsible		
1 Convene relevant stakeholders		VT ANR Climate team		
2 Gather and make easily available existing data on soil carbon content in Vermont and the potential for soil carbon stocks to be increased through common agricultural practices.		NRCS, UVM, and AAFM		
3 Evaluate tradeoffs and co-benefits of Vermont-specific agricultural practices that sequester carbon.		ANR, NRCS, UVM, and AAFM		

***Rationale**: The phosphorus reduction value of various agricultural practices has been quantified, however, no baseline has been set for the sequestration value of these same practices. Until this is done, quantifying the value of future implementation opportunities is challenging. Based on the modeling estimates of the Lake Champlain TMDL and estimates by USDA/Natural Resources Conservation Service sub-watershed planning, it is reasonable to assume the potential for a minimum 40-50% increase in water-quality and carbon friendly practices over the next ten years. Various UVM departments are involved in research related to the current stocks and stability of those stocks in both agricultural and forest soils, yet this research has yet to provide estimates of where the greatest potential to add carbon can be found, and what land use practices are most likely to return the greatest benefits. We envision this research coming together in a tool that integrates soil science and economics (that is, costs to implement) to support better farmer decision making. For that to happen we need a consistent and expanded accounting system to identify and track benefits. The State of Vermont should lead in the development and funding of an evaluation of the tradeoffs and co-benefits associated with different adaptation and mitigation actions and agricultural practices, specific to Vermont soils, crops, and weather to ensure that decision makers, from policy leaders to farmers, have a comprehensive perspective on their options for responding to climate change.*

Recommendation	**GHG Impact**	**Savings Impact**	**Investment Needed**	**Feasibility**
Develop and use consistent messaging to farmers about the carbon-capturing co-benefits of the water quality improvements, including the cost-benefit to the farmer				

Action Step(s)	Who's Responsible
1 Develop messaging to incorporate into ongoing partner outreach/education/implementation efforts	NRCS, ANR, AAFM, UVM
2 Summarize and determine applicability of existing work on costs and returns of carbon-friendly practices.	UVM
3 Create outreach materials and a distribution plan of the costs and benefits of carbon-friendly practices that also improve water quality.	AAFM, UVM, ANR
4 Identify gaps in knowledge and propose research to fill the gaps.	UVM

***Rationale:** The University of Vermont Extension System has done extensive work to quantify the financial costs and returns to farmers for implementation of these carbon-friendly practices, but the sequestration benefits have not been as widely shared with the agricultural community as the water quality benefits. A priority should be on systematically sharing with farmers a comprehensive package of costs and benefits to each practice to help influence implementation and quantify the cost-benefit to the State. In addition to spreading the word to farmers, further and on-going research is needed to confirm and quantify how advocated management changes actually impact soil carbon storage and GHG emissions. Farmers who value mitigation benefits are willing to invest financial capital towards adaptive and mitigating practices when their farm is economically successful. However, when finances are tight, investments are not made toward mitigation. Economic and livelihood analysis of how financial and other livelihood assets drive and limit investment into resilience and mitigation on farms will be crucial to policy makers who wish to encourage mitigation.*

Recommendation	GHG Impact	Savings Impact	Investment Needed	Feasibility
Document goals and mitigation contributions from agricultural sequestration and create a best practice guide for farmers.				

Action Step(s)	Who's Responsible
1 Add a sequestration component to the triennial Vermont Comprehensive Energy Plan	PSD, with help from ANR, AAFM, and land-use planners.
2 Incorporate sequestration as a type of mitigation within the goals set forth in the Climate Change Adaptation Framework.	ANR
3 Revise and expand the AAFM publication *Potential Impacts of Climate Change on Agriculture in Vermont (2010) to reflect new science and new recommendations for farmer planning for the impacts of climate change. This becomes* best-practices guide for farmers demonstrating the sequestration potential and potential for reducing N2O emissions from soils using carbon-friendly practices. Explore opportunities to incorporate sequestration potential into ongoing outreach efforts	UVM and AAFM, NRCS, ANR

Rationale: *Documenting the value of agricultural contributions to climate change mitigation is necessary to ensure the continued support for implementation. Vermont is one of the few states that targets agriculture with its* Potential Impacts of Climate Change on Agriculture in Vermont (2010), yet neither the Comprehensive Energy Plan nor Vermont's Climate Change Adaptation Framework *(2013)* include substantial recommendations for agriculture. These guiding documents need to be expanded and brought up-to-date to include the substantial contributions of agriculture, including the multiple benefits, to help ensure the continuation of critical funding and support to the farming community. In particular, a document that can act as a guide to expected threats and potential mitigating activities can be a tool not only for farmers, but also for state, regional and municipal planners.

Recommendation	GHG Impact	Savings Impact	Investment Needed	Feasibility
Design and implement a way to track the sequestration benefits of water-quality practices that are being tracked through ANR's reporting to EPA. Determine levels of adoption and the additional, voluntary practices occurring.				

Action Step(s)	Who's Responsible

1 Convene stakeholders to identify reporting methodology and ways sequestration could be added to existing program tracking.	NRCS, AAFM, ANR, EPA
2 Propose an effective way to account for sequestration associated with water quality improvements that are being reported to EPA. Estimate additional cost and propose funding mechanisms.	NRCS, AAFM, ANR
3 Propose an effective way to account for sequestration associated with water quality improvements that are NOT being reported to EPA. Estimate additional cost, if any.	NRCS, AAFM, ANR, watershed groups

Rationale: *An important part of messaging to farmers is also the benefit of the practices they install to the public and the state. VT DEC is required to provide regular documentation to the EPA regarding progress in meeting the state's water quality goals through the Lake Champlain TMDL and the state Act 64, Vermont's Clean Water Act. The practices tracked in this effort are the same as those proposed as carbon-friendly, and the state must provide the resources to include the sequestration benefits of these practices. This includes not only practices implemented with the assistance of state or federal dollars, but also those done voluntarily by farmers around the state. An alignment of practice adoption levels for water quality goals with those for climate change mitigation goals will demonstrate additional value of investments in related programs.*

Recommendation *Incorporate land transfer and changes in parcel sizes and boundaries into ANR's environmental mapping tool.*	**GHG Impact** 	**Savings Impact** 	**Investment Needed** 	**Feasibility** 
Action Step(s)		Who's Responsible		
1 Convene stakeholders and agree on overall objective. Begin visualizing or sketching an end-user interface.		ANR (various), ACCD (various)		
2 Identify available data and data gaps. Identify resource needs		ANR (GIS), ACCD (GIS)		
3 Revisit objectives based on available data and funding and create project plan.		ANR, ACCD		
4 Launch work plan		ANR, ACCD		

Rationale: *Forested land provides significant long-term sequestration today with important potential for the future. Because forest land subdivision and conversion can threaten the economics of forest conservation and sequestration, better tracking and reporting of land use and development is essential. This reporting should be integrated into current, online tools designed to promote better land use decisions by local and regional planners and private landowners. The Department of Fish and Wildlife currently maintains the BioFinder website for this purpose. We suggest that better land transfer and parcelization reporting be incorporated into this tool.*

Recommendation	GHG Impact	Savings Impact	Investment Needed	Feasibility
Re-assess funding needed to continue agricultural practices, especially after 2019. Based on the Treasurer's report (January 2017) and subsequent information, recommend one or two secure and cost-effective ways to pay for continued water-quality improvements that also sequester carbon and lessen or avoid flood damage.				

Action Step(s)	Who's Responsible
1 Tabulate existing sources of funding.	ANR, AAFM, NRCS, Treasurer's office
2 Rank funding for effectiveness in improving water quality, sequestering carbon, and lessening or avoiding flood damage.	ANR, AAFM, NRCS, EPA
3 Recommend one or two secure ways to continue funding.	ANR, AAFM, NRCS, Treasurer's office

Rationale: Agricultural practices that improve water quality and store carbon have multiple benefits. Cover crops and reduced tillage decrease soil erosion, improve soil health and crop management, and increase flood resiliency by improving soil infiltration. The continued implementation may reduce some costs (for example, equipment fuel), but implementation likely comes at a net cost to the farmer--cover crop seeding, cover crop termination in the spring, and purchase of new equipment for changes in tillage practices are among the required investments. Funding for implementation of these practices is relatively robust through 2020, however, a precipitous drop is expected that will reduce not only the implementation of new practices, but also threaten the continuation of ones already in place. Dairy milk prices are volatile and at a dramatic low in 2018, with little improvement expected in 2019. During times when farm income is well below the cost of production, practices considered voluntary (not required by law or contributing a direct source of income) often cease—resulting in the potential loss of the benefits gained. Securing consistent and long-term funding for these multi-purpose practices is a priority recommendation, for installation of additional acres, but also for ongoing implementation of current practices. There are extensive opportunities to leverage funds that are available for water quality improvement efforts, and use these to also support the additional sequestration benefits.

Commented [RM1]: This has been done – the Treasurer's report from last year estimated the cost for ag practices needed to meet the TMDL and water quality.
The funding for this is an ongoing discussion and challenge. How to handle this should be discussed with the full group on Thurs.

Commented [RM2]: This has already been done, to the best of our knowledge, through the prior Treasurer's report

Commented [RM3R2]: I knew it's been done through "CLEAN WATER REPORT REQUIRED BY ACT 64 OF 2015" by the Treasurer, but that's now 1.5 years old (January 2017), based on even older information. Given all the discussion about funding, it's worth re-assessing where we stand.

Recommendation *Use the new "BMP Challenge" program as a pilot study for incorporating sequestration into water quality project prioritization and tracking*	**GHG Impact** 	**Savings Impact** 	**Investment Needed** 	**Feasibility** 
Action Step(s)		Who's Responsible		
1 Work with partners to incorporate the estimation or measurement of increases in soil organic matter through the BMP Challenge practices.		ANR, UVM, AAFM		
3 Publicize program launch, have field days, make payments, and get reporting. Evaluate after two years.		UVM, ANR, AAFM		

Rationale: The recently developed "BMP Challenge" program provides a safety net for farmers during a transition to new practices, increasing the likelihood of immediate implementation, but also the likelihood of long-term acceptance of a practice--critical to permanent carbon sequestration and water quality benefits. Carbon promotion and protection is not currently a component of this program, should be integrated into program funding priorities.

Recommendation *The State of Vermont should investigate opportunities for the sale of carbon offsets and other mechanisms that leverage private finance for conservation.*	**GHG Impact** 	**Savings Impact** 	**Investment Needed** 	**Feasibility** 
Action Step(s)		Who's Responsible		
1 Characterize carbon offset opportunities for forestry in Vermont, voluntary and compliance, existing and emerging. Identify active and likely private finance organizations.		UVM, FP&R, ACCD, Coalition for Green Capital		
2 Consolidate and summarize above characterization and recommend type of State of Vermont participation and/or next steps and person(s) responsible for those actions.		UVM, ANR (Air and Climate), AAFM, ACCD, Coalition for Green Capital		

Rationale: *Carbon offsets are emerging as a potential mechanism to reward landowners for activities that sequester carbon. There are options for both agricultural and forest lands, but the market for forest offsets is more mature and robust. An initiative led by the Vermont Land Trust and UVM's Rubenstein School is working to develop a "pilot" project to demonstrate the feasibility of carbon offsets trading for smaller private forest landowners in Vermont. There is considerable interest on the part of landowners, yet these carbon projects are complex. This pilot will inform the potential for the sale of offsets to increase landowner income, and its potential as a new conservation finance tool. This effort represents an opportunity for state land managers to participate and answer questions that affect the feasibility of similar projects, either on other private lands (for example, compatibility with the Current Use rules) or on state lands. As the trading of forest carbon offsets becomes more common, county foresters and state land managers will need to have the information and experience to interpret current rules and mandates for landowners. AAFM and DFPR along with the ACCD should evaluate the potential for a fund that would mitigate the risk of investments in these programs, in the hopes of attracting capital to support private efforts. The results of this review can become the basis for recommendations to the state legislature for targeted funding.*

Recommendation	**GHG Impact**	**Savings Impact**	**Investment Needed**	**Feasibility**
Continue funding the Vermont Housing and Conservation Board for conservation easement purchases on forestland; prioritize projects that emphasize aggregation to maximize conservation and set the stage for carbon offset projects.				

Action Step(s)	Who's Responsible
1 Review criteria (in any form) used to choose forestry conservation projects.	FP&R, AAFM, VHCB Legislature?
2 Draft recommended changes that would be incorporated as VHCB policy.	FP&R, AAFM, VHCB

Rationale; *Conservation easements are an important tool for keeping agricultural and forest land undeveloped. Funding for the Vermont Housing Conservation Board should be continued, with priority given to projects that emphasize the aggregation of like-minded and neighboring landowners to maximize the conservation values and set the stage for future aggregated forest carbon offset projects.*

Recommendation	**GHG Impact**	**Savings Impact**	**Investment Needed**	**Feasibility**
The State of Vermont should continue to provide administrative and agency support and consider RGGI funding for the Department of Forests Parks and Recreation's Energy Saving Trees program.				

Action Step(s)	Who's Responsible
1 Determine and/or disclose energy savings and carbon sequestration of the program.	UVM, FP&R, RGGI
2 Estimate benefit/cost ratio of carbon sequestration and energy savings.	UVM, FP&R, RGGI

Rationale:*Trees in urban and suburban environments provide well documented energy-saving and health benefits, in addition to removing atmospheric carbon. By supporting tree planting in specific environments, this program can provide the greatest net benefits for the most affected communities. These projects are visible and engaging, offering many opportunities for participants to learn about the benefits of trees and tree care.*