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Natural Carbon Sequestration in the Commonwealth

Carbon Sequestration Task Force

Virginia Coastal Policy Center, William & Mary Law School

Virginia Institute of Marine Science

Natural Carbon Sequestration in the Commonwealth

A Report to the General Assembly

January 2022

Acknowledgements

The Virginia General Assembly created the Carbon Sequestration Task Force in 2021 to examine the feasibility and potential to increase carbon sequestration in the Commonwealth. Specifically, the Task Force must (i) consider possible methods of increasing carbon sequestration within the natural environment through state land and marine resources use policies; agricultural, aquacultural, and silvicultural practices; and other practices to achieve natural resources restoration and long-term conservation; (ii) recommend short-term and long-term benchmarks for increasing carbon sequestration; (iii) develop a standardized methodology to establish baseline carbon levels and account for increases in carbon sequestration over time; (iv) identify existing carbon markets and considerations relevant to potential participation by the Commonwealth; and (v) identify other potential funding mechanisms to encourage carbon sequestration practices in the Commonwealth.

The charge required input from both the public and private sector, including many entities that devote time, energy, and resources to achieving Virginia's clean energy goals for a safer, equitable climate future. The Deputy Secretary of Natural and Historic Resources and the Secretary of Agriculture and Forestry would like to thank the participants in the Carbon Sequestration Task Force for their contributions to a well-grounded, science-based understanding of the potential to increase carbon sequestration through a variety of policy and market strategies. The full list of Task Force members and meeting participants can be found in the appendices to this document.

The Virginia Coastal Policy Center and a team of students from William & Mary Law School and the Virginia Institute of Marine Science developed background research for this report and supported the work of the Carbon Sequestration Task Force.

Contents

Executive Summary

This report has been generated based on input received as part of a series of meetings of the Virginia Carbon Sequestration Task Force ("Task Force"). The Task Force was created by the Virginia General Assembly in 2021 pursuant to Senate Bill 1374, codified under Chapter 504 of the 2021 Special Session Acts of Assembly.[1] The formation of the Task Force represents Virginia's commitment to reducing climate pollution, improving air quality, and addressing climate change through increasing carbon sequestration in the natural environment.

The Task Force convened for two meetings in the fall of 2021 to review the General Assembly's charge and discuss ways to increase carbon sequestration in the Commonwealth. Membership in the Task Force included representatives from numerous state agencies and boards, academic institutions, and non-governmental organizations, as well as private industry. A full membership list and meeting minutes may be found in Appendices A and B. The Secretary of Agriculture and Forestry and the Deputy Secretary of Natural and Historic Resources facilitated the meetings.

Natural carbon sequestration contributes to environmental goals by capturing carbon dioxide from the atmosphere and providing long-term storage in oceans, soils, vegetation, and geological formations. The build-up of carbon dioxide and other greenhouse gases in the atmosphere contributes to global warming and exacerbates the climate crisis. Thus, by capturing and storing carbon, communities can help offset emissions and mitigate the effects of climate change such as increased severe weather, wildfires, dangerous heatwaves, sea level rise, and diminished air and water quality.

Incorporating carbon sequestration into Virginia's economy can realize benefits such as cost savings from improved community health and from reduced climate change impacts in addition to new business opportunities in ecosystem services and the bioeconomy. To capture these benefits, the Task Force offered (1) increasing support for existing programs with carbon sequestration co-benefits, and (2) exploring new programs to incentivize additional carbon sequestration. Co-benefits refers to projects that produce added benefits in addition to the primary carbon sequestration goal.

The below discussion of the topics studied by the Task Force and recommendations reflects the work of the task force, including meetings, and is not comprehensive. This report instead represents an initial effort at understanding the role carbon sequestration can play in meeting Virginia's climate goals and provides direction for future study. Reference materials contained in the appendices provide additional information on specific topics and avenues for future study.

[1] Chapter 504 of the 2021 Acts of Assembly (Special Session I).

Introduction

The Carbon Sequestration Task Force ("Task Force") brought together a diverse body of stakeholders and researchers working to understand the role carbon sequestration can play in achieving Virginia's climate and environmental goals. With support from the Virginia Coastal Policy Center and a student team, including students at the William & Mary Law School and the Virginia Institute of Marine Science, the Task Force studied five principal strategies for carbon sequestration. The Task Force also reviewed pioneering work by the Virginia Department of Environmental Quality to quantify carbon sequestration in Virginia tidal wetlands that forms a basis for developing a standardized methodology to understand baseline carbon levels and carbon sequestration over time. Finally, the Task Force reviewed information on carbon markets and other financial incentives to encourage carbon sequestration.

Formation and Actions of the Virginia Carbon Sequestration Task Force

The Task Force was created pursuant to Chapter 504 of the 2021 Special Session Virginia Acts of Assembly, directing the Secretary of Natural and Historic Resources and the Secretary of Agriculture and Forestry to convene a task force for the purpose of studying carbon sequestration in the Commonwealth.[2] The legislation called for the task force to be composed of representatives from the Department of Environmental Quality; the Department of Conservation and Recreation; the Department of Wildlife Resources; the Department of Agriculture and Consumer Services; the Virginia State Forester's office; the Marine Resources Commission; technical experts from the University of Virginia, Virginia Tech, the Virginia Institute of Marine Sciences, and Virginia State University; a representative from each of the Virginia Farm Bureau, the Virginia Agribusiness Council, the Virginia Association of Soil and Water Conservation Districts, the Virginia Forestry Association, the Virginia Cooperative Extension, the Chesapeake Bay Foundation, Shellfish Growers of Virginia, and the Nature Conservancy and other conservation organizations; and other technical experts. The Deputy Secretary of Natural and Historic Resources and the Secretary of Agriculture and Forestry served as co-chairs of the task force.

Detailed minutes of the Task Force proceedings are attached to this report as appendices, as well as a member list and as-written reproductions of member recommendations (Appendix B, A, and C respectively). Background research conducted by students under the supervision of the Virginia Coastal Policy Center are attached as Appendix D and E, and presentations provided to the Task Force by subject matter experts are attached as Appendix F.

[2] Chapter 504 of the 2021 Acts of Assembly (Special Session I).

Virginia Carbon Sequestration Task Force Objectives

The Task Force was charged with (i) considering possible methods of increasing carbon sequestration within the natural environment through state land and marine resources use policies; agricultural, aquacultural, and silvicultural practices; and other practices to achieve natural resources restoration and long-term conservation; (ii) recommending short-term and long-term benchmarks for increasing carbon sequestration; (iii) developing a standardized methodology to establish baseline carbon levels and account for increases in carbon sequestration over time; (iv) identifying existing carbon markets and considerations relevant to potential participation by the Commonwealth; and (v) identifying other potential funding mechanisms to encourage carbon sequestration practices in the Commonwealth.[3]

The Task Force was further instructed to submit this report of its findings to the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources before the first day of the 2022 Session of the General Assembly (scheduled for January 12, 2022).

Strategies for Carbon Sequestration

The Deputy Secretary of Natural and Historic Resources and the Secretary of Agriculture and Forestry recommended focusing attention on five principal methods of carbon sequestration for potential application in the Commonwealth.

Background research of the principal methods was compiled by the student team working under the direction of the Virginia Coastal Policy Center for this report. Their research is provided in Appendix C and D.

Recommendations from Carbon Sequestration Task Force Members

Members of the Task Force were encouraged to propose recommendations in the meetings and also to submit written recommendations via email. Recommendations were collected by Task Force staff and the student support team for reproduction in this report.

Summary of Task Force Discussions

[3] Chapter 504 of the 2021 Acts of Assembly (Special Session I).

The Task Force convened in two meetings that involved presentations by subject-matter experts and group discussions on two principal topics. First, the Task Force discussed carbon sequestration efforts that are either already underway in the Commonwealth or are co-benefits of other environmental quality improvement measures. Second, the Task Force discussed new opportunities to increase carbon sequestration in Virginia.

In both meetings, representatives of state agencies shared information about their work to increase healthy forests, soil carbon, and blue carbon. In one example, the Department of Wildlife Resources ("DWR") shared information about acquisitions of large tracts of forest land for preservation.[4]

James Martin presented the Department of Environmental Quality's ("DEQ") work on Phase III of the Chesapeake Bay TMDL Watershed Implementation Plan ("WIP") and the carbon sequestration co-benefits that had resulted from the best management practices ("BMPs") employed to reduce nitrogen and phosphorus deposited into the watershed. Tree and forest practices accounted for over half of the sequestered carbon under the WIP, despite only covering five percent of the acreage devoted to BMPs. Tilling, grazing, and planting cover crops were described as the most critical areas to engage in BMPs to increase soil carbon.[5] Erin Lasher presented her work on the methodology DEQ uses to calculate carbon emissions, using the EPA's State Inventory Tool and default data provided by the EPA. The land use, land use change, and forestry modules were used to calculate sequestration. The tool identified a decline in emissions in Virginia and a slight increase in carbon sequestration.[6] Corey Connors of the Virginia Forestry Association identified the U.S. Forest Service's Forest Inventory and Analysis dataset as another tool to capture forest growth and loss.[7]

In discussing modeling and calculations of sequestration, Dr. Mark Luckenbach of the Virginia Institute of Marine Science raised the point that a model showing net gain or loss of a particular type of environment may not tell the whole story. Based on his research, while the Chesapeake region has roughly the same amount of tidal wetlands now as 150 years ago, 100,000 acres had eroded, and 100,000 new acres had transgressed onto forest or agricultural lands.[8] This transition between habitats can lead to large pulse releases of carbon, even though net measures of carbon-sequestering habitats remain stable.[9] James Martin of DEQ agreed that the same transition can be seen where agricultural land is lost to

[4] Becky Gwynn, DEP. DIR., DEPT. OF WILDLIFE RESOURCES. Minutes from October 12, 2021 Task Force Meeting page 2. *Infra* Appendix B.

[5] James Martin, CHESAPEAKE BAY COORDINATOR, DEPT. OF ENV. QUALITY. Minutes from November 3, 2021 Task Force Meeting pages 4-5. *Infra* Appendix B.

[6] Erin Lasher, GREENHOUSE GAS INVENTORY SPECIALIST, DEPT. OF ENV. QUALITY. Minutes from November 3, 2021 Task Force Meeting page 3. *Infra* Appendix B.

[7] Corey Connors, EXEC. DIR., VIRGINIA FORESTRY ASS'N. Minutes from November 3, 2021 Task Force Meeting page 8. *Infra* Appendix B.

[8] Mark Luckenbach, ASSOC. DEAN OF RESEARCH AND ADVISORY SERVICES, VIRGINIA INSTITUTE OF MARINE SCIENCE (VIMS). Minutes from November 3, 2021 Task Force Meeting page 10. *Infra* Appendix B. *See also* zu Ermgassen, Philine & Spalding, Mark & Blake, Brady & Coen, Loren & Dumbauld, Brett & Geiger, Stephen & Grabowski, Jonathan & Grizzle, Raymond & Luckenbach, Mark & McGraw, Kay & Rodney, William & Ruesink, Jennifer & Powers, Sean & Brumbaugh, Robert. *Historical ecology with real numbers: Past and present extent and biomass of an imperiled estuarine habitat.* 279 PROC. BIOL. SCI. 1742 (2012).

[9] Mark Luckenbach, *supra* note 8 at 13.

development, and also reclaimed from forested land.[10] Dr. Karen McGlathery of the University of Virginia's Environmental Resilience Institute added that the difference in carbon sequestered between agricultural land and marshland was relatively small, but replacing forested land would have a much larger impact on sequestration.[11] Seagrass beds and wetlands sequester only one fifth of the carbon that forests do annually, and the benefits in carbon sequestration were an order of magnitude lower for blue carbon than terrestrial carbon.[12] Even globally, blue carbon offsets could account for about three percent of carbon emissions.[13] Corey Connors of the Virginia Forestry Association raised forest land use taxation as an existing program that incentivized better forest management, and Becky Gwynn of DWR cited the Virginia Pollinators Program and Virginia Native Seed Network as programs that would benefit from further support.[14]

In the second Task Force meeting, Pam Kiely, the Associate Vice President for U.S. Climate at the Environmental Defense Fund, presented about carbon markets, particularly the difference between mandatory and voluntary markets.[15] Offset markets could be a tool to reach Virginia's net-zero emissions goal, provided the legislature does not cap the amount of carbon sinks that could be considered in the equation[16] and accurate values can be established for crediting different types of carbon sinks.[17] Dr. McGlathery described her work with the Nature Conservancy to create a methodology for valuing blue carbon but stated that blue carbon modeling and valuation was not as well-developed as that for forestry.[18]

Several Task Force members agreed that the complexity of developing models for valuation could be a barrier to an offset program.[19] Another barrier described by those familiar with carbon registries was the widespread policy of disallowing aggregation in markets, which is beneficial for improving tracking and monitoring of carbon projects but effectively locks smaller landowners out of the market.[20] Task Force

[10] James Martin, *supra* note 5 at 11.
[11] Karen McGlathery, DIRECTOR, ENV. RES. INST. UNIVERSITY OF VIRGINIA, Minutes from November 3, 2021 Task Force Meeting page 12. *Infra* Appendix B.
[12] *Id.* at 11, *see also* Karen McGlathery, DIRECTOR, ENV. RES. INST. UNIVERSITY OF VIRGINIA, Minutes from October 12, 2021 Task Force Meeting, page 6. *Infra* Appendix B.
[13] *Id.* at 13.
[14] Becky Gwynn, *supra* note 4 at p 4. *See also* Corey Connors, EXEC. DIR., VIRGINIA FORESTRY ASS'N. Minutes from October 12, 2021 Task Force Meeting page 4.
[15] *See infra* Appendix F for copies of all meeting presentations.
[16] Chris Bast, DEPTY. DIR., DEPT. OF ENV. QUALITY, Minutes from November 3, 2021 Task Force Meeting page 15. *Infra* Appendix B.
[17] Chris Bast, DEPTY. DIR., DEPT. OF ENV. QUALITY, Minutes from October 12, 2021 Task Force Meeting page 5. *Infra* Appendix B.
[18] Karen McGlathery, DIR., ENV. RES. INST. UNIVERSITY OF VIRGINIA, Minutes from October 12, 2021 Task Force Meeting, page 6. *Infra* Appendix B. *See also* Needelman, Brian & Emmer, Igino & Emmett-Mattox, Stephen & Crooks, Stephen & Megonigal, Patrick & Myers, Doug & Oreska, Matthew & McGlathery, Karen. *The Science and Policy of the Verified Carbon Standard Methodology for Tidal Wetland and Seagrass Restoration*. 41 ESTUARIES AND COASTS. 2159 (2018).
[19] *E.g.*, Karen McGlathery, *supra* note 11.
[20] Chandler Van Voorhis, CO-FOUNDER, GREENTREES, LLC. Minutes from November 3, 2021 Task Force Meeting page 10. *Infra* Appendix B.

members also raised questions about accounting for durability in carbon markets.[21] [22] Many carbon markets use tools such as risk pools and default valuations to account for variations in durability and leakage.[23] [24]

Recommendations for Future Consideration

At the conclusion of the second Task Force Meeting, members were asked for recommendations as to how the Commonwealth might best move forward in improving carbon sequestration to meet overall environmental quality improvement goals and address climate change.

Following the general outcome of the meeting discussions, the Task Force offered (1) increasing support for existing environmental programs with carbon sequestration co-benefits, and (2) exploring new programs, such as carbon markets, to develop additional carbon sequestration benefits.

Increasing Support for Existing Programs

Several members of the task force representing agencies, non-governmental organizations, and subject-matter experts recommended increasing support for existing environmental programs.

Representatives from the Virginia State Forester's Office recommended identification of existing programs and renewed focus on enhancing those programs to conserve resources and work within existing capacity.[25] Ben Rowe of the Virginia Farm Bureau recommended that the Watershed Implementation Plan studies the Commonwealth had already completed should serve as a model for agriculture and forestry efforts to improve carbon sequestration.[26] Kyle Shreve of the Virginia Agribusiness Council recommended fully funding agriculture best management practices ("BMPs") that would meet Virginia's water quality goals while also sequestering carbon.[27] Jay Ford of the Chesapeake Bay Foundation and James Martin of DEQ agreed with funding BMPs and Mr. Ford additionally suggested prioritizing practices that maximized woody biomass, since in his opinion that method was most effective in sequestering carbon and reducing nutrient runoff.[28] Dr. McGlathery of the University of Virginia's

[21] Karen McGlathery, *supra* note 18 at 5.
[22] Jay Ford, VIRGINIA VOICES OUTREACH COORDINATOR, CHESAPEAKE BAY FOUNDATION, First, Minutes from October 12, 2021 Task Force Meeting, page 2. *Infra* Appendix B.
[23] *See infra* Carbon Markets, 14.
[24] Chandler Van Voorhis, *supra* note 20 at 8.
[25] Terry Lasher, ASST. STATE FORESTER, VIRGINIA DEPT. OF FORESTRY. Minutes from October 12, 2021 Task Force Meeting, pages 2 and 5. *Infra* Appendix B.
[26] Ben Rowe, NAT'L AFFAIRS COORDINATOR AT VIRGINIA FARM BUREAU FEDERATION. Minutes from October 12, 2021 Task Force Meeting page 8. *Infra* Appendix B.
[27] Kyle Shreve, EXEC. DIR. VIRGINIA AGRIBUSINESS COUNCIL, Minutes from November 3, 2021 Task Force Meeting page 16. *Infra* Appendix B.
[28] James Martin *supra* note 5 at 16. *See also* Jay Ford, VIRGINIA VOICES OUTREACH COORDINATOR, CHESAPEAKE BAY FOUNDATION, Minutes from November 3, 2021 Task Force Meeting page 16. *Infra* Appendix B.

Environmental Resilience Institute pointed out that the carbon sequestered in land devoted to agriculture and marshland was relatively similar, but forest land sequestered much more carbon and replacing it would have a much greater impact. [29]

Many members of the Task Force recommended prioritizing tree cover and healthy forests as a carbon sequestration method, with co-benefits including water quality improvements, expanded wildlife habitat, and urban heat mitigation.[30] The Forest Inventory and Analysis ("FIA") Program dataset for vegetation simulations[31]; COMET-VR, a tool for simulating land management practices and land use changes[32]; and i-Tree Eco for urban forest calculations were recommended as useful tools[33].

New Ideas

The Task Force generally agreed that durability, or permanence of carbon reductions, was an important consideration, with some cautions against over-emphasizing durability and discounting year-to-year benefits of sequestration. In particular, the effects of climate change on carbon storage, including increased temperatures and severe weather events, should be considered in developing new ideas to increase carbon sequestration. [34]

Dr. Mark Luckenbach of VIMS recommended identifying and prioritizing areas for marsh migration in the face of climate change, then determining how to protect those areas once they were identified.[35] James Martin of DEQ agreed, suggesting a general policy approach of moving land conservation from parcel scale to critical area scale. [36]

Mary Sketch-Bryant with the Virginia Soil Health Coalition recommended involving private landowners, and greatest number of stakeholders and acres possible.[37] Other Task Force members agreed, including Corey Connors of the Virginia Forestry Association, who emphasized the importance of considering how individual landowners would access new strategies for carbon sequestration. Chandler Van Voorhis of GreenTrees, LLC recommended ensuring that there is more equitable access to any carbon

[29] Karen McGlathery, *supra* note 11 at 7.
[30] Bettina Ring, SECT'Y OF AGRICULTURE AND FORESTRY, Minutes from November 3, 2021 Task Force Meeting page 9. *Infra* Appendix B. *See also* James Martin, *supra* note 5 at 9. *See also* Chris Bast, *supra* note 16 at 9.
[31] Chandler Van Voorhis, *supra* note 20 at 2-3.
[32] *Id.*
[33] Corey Conners, *supra* note 7 at 5.
[34] Jay Ford, *supra* note 22 at 6; *See also* Mark Luckenbach, ASSOC. DEAN OF RESEARCH AND ADVISORY SERVICES, VIRGINIA INSTITUTE OF MARINE SCIENCE (VIMS). Minutes from October 12, 2021 Task Force Meeting page 3; Karen McGlathery, *supra* note 11 at 15; Chandler Van Voorhis, CO-FOUNDER, GREENTREES, LLC. Minutes from October 12, 2021 Task Force Meeting page 7. *Infra* Appendix B.
[35] Mark Luckenbach, *supra* note 8 at 17.
[36] James Martin, *supra* note 5 at 17.
[37] Mary Sketch-Bryant, COORDINATOR, VIRGINIA SOIL HEALTH COALITION, Minutes from October 12, 2021 Task Force Meeting, page 8. *See also* Corey Connors, EXEC. DIR., VIRGINIA FORESTRY ASS'N. Minutes from October 12, 2021 Task Force Meeting page 4. *Infra* Appendix B.

market for small and medium-sized landowners, and to this end, pursuing a tradeable tax credit for sequestration.[38]

Finally, representatives of the Department of Environmental Quality highlighted the need to coordinate energy initiatives intended to reduce emissions with carbon sequestration activities.[39] Unless there exists a compelling reason to do otherwise, DEQ Chief Deputy Chris Bast recommended aligning the sequestration baseline with the emissions baseline.[40]

Conclusion

The Carbon Sequestration Task Force worked to understand the role carbon sequestration can play in achieving Virginia's climate policy goals. Presentations from subject-matter experts and robust discussions with stakeholders representing state agencies, industry groups, environmental advocates, and researchers informed the Task Force's understanding of this issue. The Task Force reviewed five principal strategies for carbon sequestration, work by the Virginia Department of Environmental Quality to develop methodologies for carbon sequestration accounting, and ideas to incentivize carbon sequestration such as carbon markets and tax credits.

The Task Force generally offered a bifurcated approach to improving carbon sequestration in Virginia. First, the Commonwealth could identify, evaluate, and support existing programming with carbon sequestration co-benefits. Second, Virginia could consider new ideas to specifically address carbon sequestration as a primary benefit, such as carbon markets or tax credits. Adapting the framework of current tax credits, such as for land conservation, job creation, and biofuels, to carbon sequestration may facilitate measures by government, industry, and landowners to reduce atmospheric carbon.

[38] Chandler Van Voorhis, *supra* note 20 at 10, 16.
[39] Chris Bast, *supra* note 17 at 4.
[40] Chris Bast, *supra* note 16 at 14.

Appendix A: Task Force Membership

Organization	Representative	Email	Title
Office of the Secretary of Natural & Historic Resources	Matt Strickler	matt.strickler@governor.virginia.gov	Secretary of Natural & Historic Resources
	Josh Saks	joshua.saks@governor.virginia.gov	Deputy Secretary
Secretary of Agriculture and Forestry	Bettina Ring	bettina.ring@governor.virginia.gov	Secretary of Agriculture
Department of Environmental Quality	David Paylor	david.paylor@deq.virginia.gov	DEQ Director
	Chris Bast	chris.bast@deq.virginia.gov	Deputy Director of DEQ
	James Martin	james.martin@deq.virginia.gov	Chesapeake Bay Coordinator, DEQ
Department of Conservation and Recreation	Clyde Cristman	clyde.cristman@dcr.virginia.gov	DCR Director
Department of Wildlife Resources	Becky Gwynn	becky.gwynn@dwr.virginia.gov	Assistant Director, Wildlife Diversity
Department of Agriculture and Consumer Services	Charles Green	charles.green@vdacs.virginia.gov	Deputy Commissioner
Virginia State Forester	Rob Farrell	rob.farrell@dof.virginia.gov	State Forester
Department of Forestry	Terry Lasher	terry.lasher@dof.virginia.gov	Assistant State Forester
Office of the Governor	Ellen Bolen	ellen.bolen@governor.virginia.gov	Senior Advisor
University of Virginia	Dr. Karen McGlathery	KJM4K@virginia.edu	Professor and PI, Virginia Coast Reserve, Eastern Shore, Director of the Environmental Resilience Institute
Virginia Tech	Wade Thomason	wthomaso@vt.edu	Grain Crops Extension Specialist
Virginia Institute of Marine Sciences	Dr. Mark Luckenbach	luck@vims.edu	Associate Dean
Virginia State University	Ron Howell	rhowell@vsu.edu	Director of Operations Management, Virginia Cooperative Extension
Virginia Tech	Dr. Rory Maguire	rmaguire@vt.edu	Professor
	Dr. Mark Reiter	mreiter@vt.edu	Director, Eastern Shore AREC

Virginia Farm Bureau	Ben Rowe	Ben.Rowe@vafb.com	Lobbyist
Virginia Agribusiness Council	Kyle Shreve	kyle@va-agribusiness.org	Executive Director
Virginia Association of Soil and Water Conservation Districts	Dr. Kendall Tyree	kendall.tyree@vaswcd.org	Executive Director
Virginia Forestry Association	Corey Connors	cconnors@vaforestry.org	Executive Director
Virginia Cooperative Extension	Jeremy Daubert	jdaubert@vt.edu	Extension Agent
Chesapeake Bay Foundation	Jay Ford	jford@cbf.org	Outreach Coordinator
Shellfish Growers of Virginia	Travis Croxton	travis@rroysters.com	Co-owner, Rappahannock Oyster Co.
The Nature Conservancy	Nikki Rovner	nrovner@tnc.org	Associate State Director
New Dominion Solutions, LLC (consultant to Aqua Fund)	Emily Francis	emily@newdominionsolutions.com	Lobbyist, associated with SELC
Virginia Soil Health Coalition	Mary Sketch- Bryant	msketch2@vt.edu	Coordinator
GreenTrees, LLC	Chandler Van Voorhis	chandler@acre-investment.com	Investment Broker
Science Museum of Virginia	Jeremy Hoffman	jhoffman@smv.org	Climate/Earth Science Specialist

Appendix B: Meeting Minutes

MINUTES
CARBON SEQUESTRATION TASK FORCE MEETING
Tuesday, October 12, 2021 9:00 A.M.
Patrick Henry Building, Richmond, Virginia

MEMBERS PRESENT

• Joshua Saks	Deputy Secretary of Natural and Historic Resources
• Bettina Ring	Secretary of Agriculture and Forestry
• Chris Bast	Deputy Director, Dept. of Environmental Quality (DEQ)
• James Martin	Chesapeake Bay Coordinator, DEQ
• Clyde Cristman	Director, Dept. of Conservation and Recreation (DCR)
• Becky Gwynn	Dept. of Wildlife Resources (DWR)
• Charles Green	Dept. of Agriculture and Consumer Services
• Rob Farrell	Virginia State Forester
• Terry Lasher	Assistant State Forester, Dept. of Forestry (DOF)
• Ellen Bolen	Office of the Governor
• Dr. Karen McGlathery	Virginia Coast Reserve, Eastern Shore, Univ. of Virginia
• Wade Thomason	Grain Crops Extension Specialist, Virginia Tech
• Dr. Mark Luckenbach	Associate Dean, Virginia Institute of Marine Science
• Ron Howell	Virginia State University
• Dr. Rory Maguire	Professor, Virginia Tech
• Dr. Mark Reiter	E. Shore Ag. Research and Extension Ctr., Virginia Tech
• Ben Rowe	Virginia Farm Bureau
• Kyle Shreve	Virginia Agribusiness Council
• Dr. Kendall Tyree	Exec. Dir., Va. Assn. Soil & Water Conservation Districts
• Corey Connors	Virginia Forestry Association
• Jeremy Daubert	Virginia Cooperative Extension Service
• Jay Ford	Chesapeake Bay Foundation
• Travis Croxton	Shellfish Growers of Virginia
• Nikki Rovner	The Nature Conservancy
• Emily Francis	Southern Environmental Law Center, AquaFund
• Mary Sketch	Virginia Soil Health Coalition
• Chandler Van Voorhis	GreenTrees, LLC

ATTENDEES

• Elizabeth Andrews	Virginia Coastal Policy Center (VCPC)
• Greg Fowler	William & Mary Law

• Taylor Walker	Virginia Institute of Marine Science
• Luke Miller	William & Mary Law
• Eleanor Kolb	William & Mary Law
• Haarika Reddy	William & Mary Law
• Graham Montrose	Virginia Coastal Policy Center

CALL TO ORDER AND INTRODUCTIONS

Deputy Secretary Saks called the meeting to order at 9:00 A.M.

PRESENTATION

After introductions, Deputy Secretary Josh Saks described that this meeting was the first of a three-meeting arc on carbon sequestration. That day's meeting would focus on identifying potential carbon sequestration approaches, the next meeting would focus on operationalizing those ideas, and the last would finalize the report to be sent to the General Assembly. He then gave a short presentation providing background on, and the five main categories or "buckets" of, carbon sequestration strategies. The methods were healthy forests, blue carbon, soils, bioeconomy, and green communities. The presentation concluded with a brief overview of potential policy mechanisms to implement carbon sequestration approaches.

DISCUSSION OF POTENTIAL CARBON SEQUESTRATION OPTIONS IN VIRGINIA

Josh Saks opened the discussion by stating that the task force's charge was to make recommendations to the General Assembly regarding potential carbon sequestration methods in Virginia and their implementation.

Ellen Bolen asked how carbon sequestration efforts are being accounted for and if the group was tackling new carbon being emitted or old carbon currently existing in the atmosphere.

Chris Bast replied that the topics to be discussed at the next meeting included carbon sequestration benchmarks. Ideally, the task force would recommend short- and long-term ideas for carbon sequestration benefits. James Martin and DEQ have been working on valuing wetlands, which will be investigated more next meeting. The task force would review a forthcoming DEQ report about how emissions and carbon sinks were calculated for wetlands. Part of the task force's mission was to talk about developing a carbon sequestration methodology.

James Martin stated that the work DEQ did focused on practices included in the Chesapeake Bay TMDL Watershed Implementation Plan (WIP) and NRCS' COMET model, the tool they used to calculate carbon sequestration best practices. Trees, wetlands, and agricultural methods were well-accounted for in this model, but not stormwater management, green roofs, or other methods that need further work to be quantified.

Jay Ford asked how the task force is going to handle the "durability" of carbon sequestration practices. Mr. Ford said that one of the big questions and one of the major benefits is "dampening the curve" for emissions so there is time to get emissions reductions in place so that carbon can be locked up for a number of years. There is wide variability in practices and how long they last, so that is something he would like to be a main consideration going forward.

Josh Saks asked if the task force identified any carbon sequestration methodologies in the presentation that could be areas of focus.

Becky Gwynn replied affirmatively that healthy forests, soil carbon, and blue carbon were things state agencies have already been working on. Those categories are less complicated than some of the others in terms of where the state was in the past and where it was presently. Her agency, DWR, has been working on acquiring large tracts of forest land and similar projects. She then asked how to marry formal acknowledgement of that issue and maximizing carbon sequestration with requirements from federal and other funding sources. She was unsure how those requirements might work with federal grant requirements and wondered if it was possible to add new metrics to state funding sources, like the Virginia Land Conservation Fund, to consider carbon sequestration.

Terry Lasher agreed with Chris Bast that the task force should identify short- and long-term benchmarks and wished to further emphasize already existing frameworks. The WIP and other efforts already encouraged cooperation. One of the task force's big challenges would be agreeing on terminology to ensure everyone was on the right page. A lot of programs already in existence addressed carbon sequestration. In his opinion, the task force should focus less on reinventing the wheel and more on enhancing current projects.

Josh Saks asked how and what would that look like?

Terry Lasher replied that the DOF's work on hardwoods was a good example. It could be possible to increase hardwood production and increase investment in existing timber management programs.

Chandler Van Voorhis asked about carbon reduction versus removal. He thought carbon mineralization and reforestation in Virginia were going to be important, and he described a project with Virginia Tech looking at miles of habitat along perennial streams that they flow through on the way to the Chesapeake Bay. There were 650,000 acres in some form of open space or agriculture along those streams that could be looked at for use as green corridors. Mr. Van Voorhis encouraged looking at carbon reductions and the 2021 Virginia Academy of Science, Engineering, and Medicine (VASEM) report that recommended nature-based solutions.

Chris Bast asked for clarification on reductions versus removal.

Chandler Van Voorhis replied that people have looked at using nature-based infrastructure as a bridge strategy for adjustment to a low carbon economy. Even wind and solar could contribute to carbon reduction, helping to repair what was already in the atmosphere. Mr. Van Voorhis described how Microsoft had been trying to remove all its emissions since it started in the 1970s, but there were currently huge price separations between reduction and removal efforts. Planting trees, wetland restoration, etc. all fit in with removal. Changes in practices were mostly all emissions reduction.

Josh Saks asked Mark Luckenbach if the state was in a position to do both removal and reduction.

Mark Luckenbach replied yes, and that the state must do both at the same time. Dr. Luckenbach added that Jay Ford made a good point when he said that the task force needed to think about the durability of removals. Removal rates could be fast in the short term but fail or slow in the long term. Things with high removal rates may have high turnover.

Emily Francis commented that she thought this idea was important, and the task force also needed to think about what other practices contribute to removal or not, like producing nitrogen fertilizer. The task force needed to think about practices that do both. There were some practices where incentivizing markets would have both benefits.

James Martin stated that as far as carbon reduction, there are many efforts now, like solar farms coming online, that reduce emissions but can have unintended consequences (like trees cut down for a solar farm). The task force had to consider methods that would avoid unintended consequences. Composts and manures are re-used but reuse of these products could result in unintended consequences that also needed to be considered. For instance, phosphorous often is a byproduct of producing carbon-rich compost and fertilizers which could find its way to the Bay and cause harmful algal blooms.

Corey Connors added that the Virginia Forestry Association had a discussion at their annual conference the week prior where they had a panel on solar with the Virginia Department of Energy. They found that 8-24 acres of solar panels were required to generate 1 MW of energy and there were energy interests and development pressures that affect the overall impacts of solar energy. With respect to forest ownership, there are 16.2 million acres in the state with 60% of that in private hands. The task force needed to think about individual landowners having access to the ideas it came up with. Only 29 counties had forest land-use taxation, so that was low-hanging fruit to support landowners to keep their land as forest.

Josh Saks asked for further clarification on forest land use taxation. Mr. Saks asked where the money from that tax goes and if it could be used for carbon sequestration efforts.

Corey Connors replied that a forest land use taxation program reduces property taxes for forest land in between harvests or thinning, which helped to reduce costs to landowners. He specified the reduction was for more than an acre here or there; there was a certain size requirement to qualify.

Josh Saks asked if it was appropriate to summarize forest land use taxation as a disincentive to development and incentive to management of the forest.

Corey Connors replied affirmatively and that it was an incentive to better management. Also, forest products sequester carbon.

Becky Gwynn commented that there were practices associated with solar that could help reduce impacts. The Virginia Pollinators Program and Virginia Native Seed Network could help support native plantings and would also benefit from further incentives and support. The task force should update and incentivize what is planted underneath solar panels. The infrastructure was there for solar energy and further incentivization could help develop it further.

Josh Saks asked if this was discussed in the Solar Permit By Rule development process.

Becky Gwynn replied that yes, but it was a very limited discussion. It needed more support.

Chris Bast stated that discussion of tradeoffs was really important and there were very few "constant goods." Solar energy, for example, should be looked at as inclusive of lifetime emissions versus natural gas. The task force also needed to figure out how to balance the Governor's energy initiatives with improving carbon sequestration. DEQ looked at lifetime emissions for solar versus gas which ranged between 3%-25% less, a massive carbon reduction. When the task force balances these things, it is important to consider the whole universe and not take an anti-solar position.

Nikki Rovner commented that she thought it was easy not to be anti-solar, but the task force can make recommendations about solar siting. She thought the task force should probably start by thinking about practices that were giving the state the biggest carbon benefits. With the short amount of time for its work, the task force needed to think about recommendations and then identify further research that needed to be done. That would be the best use of the group's time.

Jay Ford stated there were many existing programs where co-benefits could be easily identified. He asked the agencies in the room if there was a need to identify a baseline level of carbon emissions in the state agency portfolio, or if that was something agencies were doing individually.

Secretary Bettina Ring stated that agencies were doing this on the individual program level.

Terry Lasher commented that community tree planting programs offered an example of programs already counting and quantifying benefits. The task force should look at what was already happening and programs that already existed. Examples given were the pollinator program, native hardwoods, pine plantings, and state and local nurseries closing. Virginia has tried to put money toward some programs to support native species planting.

Chris Bast stated that when we are talking about existing practices and existing data, it sounded like there was a need to establish values for those resources, like valuing a tree or a fuel source. He described how California had been assigning carbon values to biofuels and natural gas when issuing permits for projects such as road building. There was a recent legislative effort to assign the social cost of carbon to utility projects. He asked if this could be applied to other projects, to quantify the reduction or removal benefits.

Karen McGlathery commented that the Virginia Coast Reserve had been working on evaluating Natural and Nature Based Features (NNBFs) for the Governor, but ran into the same challenges regarding durability. It was possible to obtain annual rates, but was the task force looking 30, 40, 50 years in the future? This was important for carbon offset markets. Also, how would the projects be verified or validated? There were lots of projects that were not properly validated, like the Philadelphia Eagles buying carbon credits that were not based on anything. The state needs to make sure any efforts undertaken are actually keeping carbon out of the atmosphere.

Terry Lasher agreed that the time frame was important, but verification in the voluntary versus regulated market was different. The standards were much more stringent in the regulated market. The methodology was there, but there was a question of which method the task force would recommend.

Chandler Van Voorhis stated that, on the issue of permanence and durability of carbon offsets, the methodologies were well-settled and usually done ex post facto, meaning that the asset matured before the credit was issued and standards had to be met. These verifications could take 9 months or more, were extensive in terms of reporting, and fairly rigorous. The challenge was how to aggregate small landowners' properties, and how to speed up verification without sacrificing integrity. The existing accounting tools were very robust.

Emily Francis wished to clarify if Mr. Van Voorhis was talking about forestry.

Chandler Van Voorhis answered yes, but added that it applied to anything with an approved methodology. There were methodologies for blue carbon and wetlands and agricultural carbon. Forestry was the most well-established. Agricultural carbon durability is a challenge because it is easily reversed. He wished to flag that there was a lot of contention around the accounting of biomass carbon. Some believe that the biomass causes a debt first and must be rebalanced in the forest over time. Others thought it was carbon neutral from the outset.

Karen McGlathery stated that she worked with the Nature Conservancy to write a methodology for blue carbon, and it was not as well-developed as forestry. Methodology was not as advanced in some areas as others. The task force should identify gaps in methodologies across areas.

Chris Bast stated that methodologies existed for a lot of strategies. There was a difference between carbon offset markets and applying value to, for example, a grant program. In that case, the Commonwealth would just be stating a preference that projects that use a more beneficial sequestration method compared to another one be prioritized.

Clyde Cristman stated he was not as familiar with blue carbon, but he found a website on it and thought the task force should delve into it. Coastal ecosystems were critical to climate impacts and carbon sequestration, so it seemed like a great opportunity for funding to combine efforts, like the Commonwealth Center for Recurrent Flooding Resiliency. Mr. Cristman asked what information was available to quantify blue carbon.

Mark Luckenbach requested that Karen McGlathery weigh in, but he first added that efforts to protect what is already there was a low-lying bucket and more easily implemented. Dr. Luckenbach referred to Dr. McGlathery's comment that there was not as much experience with verification and validation, in part due to environmental variability. If the task force was thinking about marshes, it must think about sea level rise and work to enhance existing resources. Coastal marshes and coastal forests could take generations to rebuild, so accounting for the carbon sequestration was difficult.

Karen McGlathery agreed with Dr. Luckenbach and added Virginia had some of the best data on marshes and seagrass in terms of carbon stocks and annual sequestration rates. In the next 20, 30, 40 years, the impacts of increasing climate stressors, like heatwaves and severe weather events, must be considered. There were great numbers for methane release, and they could be included, but the numbers from the Blue Carbon Initiative mentioned earlier by Mr. Cristman were not scientifically rigorous. Seagrass forests and wetlands sequester only 1/5th of the carbon that forests do annually. The Blue Carbon Initiative was only talking about ocean carbon burial, which was very different and its value should not be overstated.

Mark Luckenbach stated that Virginia had a lot of coastline, but it was not as large as the non-coastal land area that supports other carbon sequestration methods such as forest carbon. Dr. Luckenbach then asked if every possible acre of seagrass were recovered, how much would that cost and what would be the impact compared to forest restoration?

Jay Ford supported integrating carbon sequestration into grant programs as Mr. Cristman said, and really appreciated Mr. Van Voorhis' input. Mr. Ford was focused on the idea of "durability" benchmarks for the state and did not want to conflate the values calculated year-to-year with benchmarks. Mr. Ford expressed interest in how climate change impacts and other practice losses are accounted for and how those impact large objectives, like a wetland drowning or losing a forest, effects sometimes called "backsliding". Mr. Ford clarified that is what he meant by the term "durability." The task force needed to keep an eye on how that would impact Virginia's macro-goals with increased attention given to those projects that have permanence.

Josh Saks asked if the task force was only supporting projects that did not have backsliding risk.

Jay Ford clarified that the task force should prioritize, not just support specific measures, and added that projects with staying power should be prioritized.

Emily Francis agreed.

Chandler Van Voorhis commented that in carbon markets, the American Carbon Registry had a 40 year, and the California Air Resources Board had a 100-year requirement for durability, incorporating global warming scenarios. Just because a project's gains were reversed in year 10 did not mean it was a total loss; even though it was not 100 years, there was a risk-buffer analysis to shield projects from those "Act of God" risks. The task force needed to be careful about over-emphasizing durability. There was a year-over-year atmospheric benefit that should be considered. He agreed that the task force should look for the best return in terms of dollars and reduction rates.

Terry Lasher wanted to talk about decisions for landowners and participants. He said it was important that the task force realize that there were costs for verification of carbon reductions. Small landowners had small margins, so it was going to be important to incentivize that properly. It was also important to talk about backsliding in order to account for things fairly. When permanence and durability were discussed, forest preservation was not necessarily preventing backsliding because forests require management to maximize carbon sequestration. The ability to address Acts of God would be important to the longevity of carbon sequestration practices.

Clyde Cristman stated that a baseline was needed. For example, DCR looked at funding preservation of a forest parcel that included wetlands and it did not score enough because of the wetlands. The agency was not accounting for that added carbon value.

Josh Saks asked if there were any specific approaches or policies from the five "buckets" that should be focused on before the task force adjourned.

Secretary Bettina Ring asked the agricultural experts on the task force to speak up about soil health. Secretary Ring thought there was an opportunity to catch up on some of the methodologies.

Rory Maguire stated that blue carbon was limited to waterways but that there was a lot of acreage in Virginia able to capture more carbon. More work was being conducted with DCR to look at carbon sequestration opportunities in other areas and what could provide the most return on investment.

Chandler Van Voorhis responded in the virtual chat that, "For approaches, I would consider a tradeable and transferrable tax credit for carbon sequestration practices. There is a move to do something similar at the federal level by altering IRS 45Q: Carbon Sequestration Tax Credit. The effort is to incorporate biological carbon and make it tradable like VA does with conservation easement program."

Chris Bast requested the task force find some overarching framework. He asked how carbon sequestration could be applied to existing efforts and programs? Flood preparedness and the prioritization of preservation over recreation were given as two examples. He stated that it was more cost-effective to maintain an existing marsh than it was to build one, and expressed a desire to minimize "backsliding," especially from Act of God events like wildfires or hurricanes. Ideally, such a strategy or method could apply to all five "buckets". Mr. Bast then asked what the consensus was on those ideas.

Mary Sketch agreed with Dr. Maguire's comment of getting the best return on investment. The task force needed to recognize great work that had been done, but also look at missed opportunities like involving more private individuals. The task force needed to look for ways to engage the greatest number of stakeholders and acreage. Agricultural cost-share funding was an important part of that effort and an incentive to landowners to participate in conservation.

Ben Rowe agreed and summarized the discussion on existing frameworks as essentially saying "reduce carbon emissions." He directed attention to what was being done already. For example, the WIP had incentivized reductions for nitrogen and phosphorus, and these had co-benefits with carbon sequestration. The task force should address the low-hanging fruit of using what studies have shown about the carbon sequestration values of water quality projects. That, in turn, should be the model for agriculture and forestry. The task force should hear from agencies about how they have already looked at carbon co-benefits as part of the WIP effort. If soil health was already looked at as a co-benefit in another program, why not add carbon sequestration to that too?

Kendall Tyree agreed and asked how to connect that with the soil health work and how to tie funding and benefits to data.

James Martin replied that DEQ had some information on that issue but had not tied that information together as well as possible. The task force should also look at quantifiable co-benefits of agricultural practices and tree plantings. He offered to make a presentation on the WIP for the next meeting and then briefly explained that the implementation of the WIP was estimated to remove 2 million tons of carbon from agricultural practices and tree planting. He then asked if it were possible to quantify sequestering carbon and understanding public benefits if there was funding tied to it.

Secretary Bettina Ring stated that some Virginia counties that were considered most important in terms of agriculture have not adopted land use taxation and that is something the task force should look into. The task force could also look at how retaining farmlands and forest lands impact TMDLs.

James Martin noted that there are tens of thousands of pounds of carbon equivalents also affecting atmospheric carbon. Should we focus on carbon only? What about methane and nitrous oxide and ways to minimize that?

Chris Bast said that when the group is discussing atmospheric carbon and carbon sequestration, we are talking about methane and other carbon forms and converting them to CO2 equivalents. The unit is "CO2E," the conversion of greenhouse gases into a single unit. The last survey in 2018 said Virginia had 28 million tons of carbon emissions, -51 million tons in carbon sinks.

James Martin sought clarification that the task force was accounting for other greenhouse gases.

Chris Bast replied in the affirmative and asked for any final approaches to carbon sequestration before the meeting adjourned.

Jeremy Daubert commented that in the dairy industry, there was a goal for net zero emissions nationwide and he had worked on one such project. There were lots of ways to accomplish that including heat efficiency and others. Mr. Daubert expressed a desire to find practical methods. The diversity of Virginia agriculture adds a challenge. Mr. Daubert thought the task force needed to organize its thoughts in terms of (1) where the research needed to go, (2) what was possible in the short- and long-term, and (3) what would engage the most stakeholders. Lawns were used as an example: everyone had one; if the maximum height allowed was modified or something similar, how much carbon would be offset? Mr. Daubert wished to clarify that this example was meant to promote thinking about engaging the most stakeholders and not necessarily a proposed approach.

Emily Francis commented on the need to decide which of the five buckets was most important. Virginia agencies were good at silo-ing data, and the report should look at crossover. There was robust work in 3 of 5 categories (blue carbon, forest, agriculture), but additional effort needed to be made into looking at all 5.

Josh Saks stated that the task force did not set out at this meeting to identify the best approach, but to identify ideas. Mr. Saks asked that the attendees think about (1) what projects touched the most people, (2) what projects lasted the longest, and (3) what was the best use of resources?

Chris Bast reiterated the desire to talk about all sectors.

Josh Saks asked if there were any final thoughts.

Karen McGlathery asked if the task force was looking at developing a common metric, like carbon sequestered per acre, in order to compare the different types of approaches.

Josh Saks stated that the task force would start with what was the proper policy approach in each category and then go from there.

Chandler Van Voorhis also commented in the virtual chat: "For approaches, I would consider a tradeable and transferrable tax credit for carbon sequestration practices. There is a move to do something similar at the federal level by altering IRS 45Q: Carbon Sequestration Tax Credit. The effort is to incorporate biological carbon and make it tradable like VA does with conservation easement program."

Secretary Bettina Ring stated that the Virginia Department of Agriculture definitely wanted to identify gaps and would share notes with the group for further digestion at the next meeting. Secretary Ring also wanted to reach out to others for additional expertise that might help in order to ensure the task force captured the best science and ideas.

Josh Saks stated that at the next meeting the task force would put together concrete examples to share.

Meeting adjourned at 11:01 A.M.

MINUTES
CARBON SEQUESTRATION TASK FORCE MEETING
Wednesday, November 3, 2021 9:22 A.M.
600 E. Main St., Richmond, Virginia

MEMBERS PRESENT

• Joshua Saks	Deputy Secretary of Natural and Historic Resources
• Bettina Ring	Secretary of Agriculture
• Chris Bast	Deputy Director, Dept. of Environmental Quality (DEQ)
• James Martin	Chesapeake Bay Coordinator, DEQ
• Becky Gwynn	Dept. of Wildlife Resources (DWR)
• Charles Green	Dept. of Agriculture and Consumer Services
• Terry Lasher	Assistant State Forester, Dept. of Forestry (DOF)
• Dr. Karen McGlathery	Virginia Coast Reserve, Eastern Shore, Univ. of Virginia
• Dr. Mark Luckenbach	Associate Dean, Virginia Institute of Marine Science
• Dr. Rory Maguire	Professor, Virginia Tech
• Dr. Mark Reiter	E. Shore Ag. Research and Extension Ctr., Virginia Tech
• Ben Rowe	Virginia Farm Bureau
• Kyle Shreve	Virginia Agribusiness Council
• Corey Connors	Virginia Forestry Association
• Jeremy Daubert	Virginia Cooperative Extension Service
• Jay Ford	Chesapeake Bay Foundation
• Nikki Rovner	The Nature Conservancy
• Emily Francis	Southern Environmental Law Center, AquaFund
• Mary Sketch	Virginia Soil Health Coalition
• Chandler Van Voorhis	GreenTrees, LLC
• Erin Lasher	Dept. of Environmental Quality (DEQ)
• Tom Ballou	Dept. of Environmental Quality (DEQ)
• Beck Stanley	Virginia Agribusiness Council

ATTENDEES

• Rachel Peabody	Virginia Marine Resources Commission (VMRC)
• Elizabeth Andrews	Virginia Coastal Policy Center (VCPC)
• Katie Hellebush	Hellebush Consulting
• Pam Kiely	Environmental Defense Fund
• Greg Fowler	William & Mary Law
• Taylor Walker	Virginia Institute of Marine Science
• Luke Miller	William & Mary Law
• Eleanor Kolb	William & Mary Law
• Haarika Reddy	William & Mary Law
• Graham Montrose	Virginia Coastal Policy Center

CALL TO ORDER AND INTRODUCTIONS

Secretary Bettina Ring called the meeting to order at 9:22 A.M. and invited attendees to introduce themselves.

Deputy Secretary Joshua Saks discussed the recent gubernatorial election. Mr. Saks explained that the task force's original goal of providing the General Assembly with recommendations for carbon sequestration would continue as planned. Mr. Saks then asked if there were any comments on the last meeting's minutes. None were raised. Mr. Saks reiterated that the goal of today's agenda was to identify ways to quantify carbon sequestration.

PRESENTATION ON VIRGINIA'S INVENTORY OF GREENHOUSE EMISSIONS AND SINKS - DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ)

Chris Bast described how the Department of Environmental Quality (DEQ) had been increasing its capacity to account for greenhouse gas emissions in the state over the past four to six years. Mr. Bast went on to explain that much work was being done to identify previously unknown variables that had the potential to significantly affect the quality of the data collected. Mr. Bast the stated that Tom Ballou leads the planning for this team and Erin Lasher joined the team to assist with accounting and reporting.

Tom Ballou and Erin Lasher led DEQ's presentation, attached as Appendix A.

Tom Ballou explained that DEQ had been doing statewide inventories of greenhouse gas emissions for ten years. DEQ was mandated by the General Assembly to develop a greenhouse gas reporting rule, including updated information on carbon sequestration. In addition, DEQ would develop an updated baseline value to be included in the Clean Energy Virginia Initiative, which will have a component plan consisting of ten years of greenhouse gas mitigation strategies. The objective is decarbonization by 2045.

Erin Lasher began the presentation by explaining the methodology DEQ used for its emissions calculations. DEQ used the Environmental Protection Agency's (EPA) State Inventory Tool (SIT) for the entire inventory, including sequestration. SIT is a Microsoft Excel-based series of workbooks with default data provided by the EPA. States could edit this data if they wished. There are eleven modules within SIT that cover different sectors, like transportation or agriculture. Emissions used to calculate sequestration are in the land use, land use change, and forestry modules. SIT provides emissions data for several particularly relevant areas including land converted to and from forests, remaining forest, biomass above and below the ground, urban tree coverage, yard filling, tree scraps, and soils. For this sector DEQ relied on the EPA's default data with no changes. DEQ had inventories for the years 2005 and 2010, which were suggested as possible baselines, and the year 2018 as well. SIT identified that emissions were declining in Virginia and there was a slight increase in sequestration. The main culprits for emissions were transportation, industry, and energy. Total emissions in 2018 were about 140.6 million tons of Carbon Dioxide Equivalent (CO_2e).

Sequestration in 2018 offset about 51.8 million tons of CO_2e which means the net CO_2e emissions for 2018 were 88.8 million tons of CO_2e. DEQ relied entirely on default data. Erin Lasher stated that supplying SIT with better data was identified as the best opportunity for improvement. For example, data for forests was mostly reported in carbon flux, but it was not species-specific. It was also difficult to edit data within the tool. SIT only looked at terrestrial sequestration which meant that blue carbon, including wetlands and seagrass. Other areas for improvement included better urban tree coverage data, synthetic fertilizer data, yard trimming data, and more input from experts. Ms. Lasher then announced that Mr. Tom Ballou would introduce the next part of the presentation.

Tom Ballou stated that there was a difference between emissions removal and emissions reduction. There were many factors affecting emissions reduction in Virginia including: the state joining the Regional Greenhouse Gas Initiative (RGGI), implementing the Volkswagen Mitigation Trust, and prohibiting the use of Hydrofluorocarbons (HFCs). Mr. Ballou wanted to highlight that there was a good deal of mitigation effort being undertaken.

Chris Bast asked if there was a way to add blue carbon information to the module.

Erin Lasher responded that the US Climate Alliance working group was having conversations about accounting for blue carbon. Ms. Lasher said she would reach out to them for advice on the best way to incorporate blue carbon into the inventory.

Karen McGlathery added that the institutions of the University of Virginia (UVA) and the Virginia Institute of Marine Science (VIMS) had been working on models accounting for blue carbon contributions to carbon sequestration and that Ms. Lasher could reach out to her or Dr. Mark Luckenbach for more information.

Erin Lasher responded that the information would be helpful.

Tom Ballou stated that there had not been a driver for DEQ to go to that extent yet, but it may be an opportunity to gather more Virginia-specific data.

Chandler Van Voorhis recommended using the Forest Inventory and Analysis (FIA) Program's dataset in conjunction with forest vegetation simulations. He also recommended an approach the state of California employed using FIA datasets. Mr. Van Voorhis recommended COMET-VR, a tool which utilizes a generalized ecosystem model to simulate the impact of management practices on soil carbon as well as the effects of land use changes between cropland, grassland, and forest. Mr. Van Voorhis cautioned that looking at total emissions with carbon sequestration could unnecessarily complicate things because it was not a typical baseline.

Secretary Bettina Ring stated that there were some attendees from the Department of Forestry present that may be able to speak further on that point.

Terry Lasher asked for clarification of what information was used in combination with the FIA data.

Chandler Van Voorhis replied that the model was developed by the US Forest Service and used widely by economists to measure credible net carbon by calculating emissions and sequestration per acre.

Karen McGlathery asked if the goal of the task force was to look at both current sequestration as a baseline and the potential for sequestration in 2045.

Chris Bast replied yes to both objectives. Of the five specific tasks the General Assembly assigned the task force, one was to identify a standard methodology to establish a baseline for carbon sequestration and to account for increases over time. The task force should recommend short- and long-term benchmarks.

Corey Connors asked if that data accounted for urban forests.

Chandler Van Voorhis replied that he was not sure, but that Terry Lasher might know.

Terry Lasher did not know for certain but said he would investigate it.

Chandler Van Voorhis said that the FIA data showed plots of forests on private lands in various ecoregions of the country and was a comprehensive and established source of information. On the reforestation side, the Reforestation Hub (reforestationhub.org) was similar. It looked nationwide at the potential for reforestation efforts and broke that data down county by county. It could provide a good baseline for reforestation opportunities.

Secretary Bettina Ring mentioned that the state of Texas looked at incorporating urban forestry into FIA datasets and that information could be useful.

Corey Connors suggested using i-Tree Eco (www.itreetools.org/tools/i-tree-eco), a tool which can quantify forest structure and environmental effects, for urban forest calculations.

Deputy Secretary Joshua Saks asked if Mr. Ballou and Ms. Lasher had any final comments.

Erin Lasher added that the current forestry data DEQ used came from the Environmental Protection Agency (EPA) Annual Inventory of US Greenhouse Gas Emissions and Sinks. It covered the years from 1990-2019.

Chris Bast referred to Mr. Van Voorhis' earlier example of an approach that California developed and asked if anyone knew of any other states attempting to do what this task force was doing.

Erin Lasher did not have a specific example but said the state of Washington and several states in New England had done some work in the area.

Tom Ballou suggested that The Climate Alliance may have more information as well.

PRESENTATION ON DEVELOPING CARBON SEQUESTRATION METHODOLOGIES FOR THE WATERSHED IMPLEMENTATION PLAN (WIP)

James Martin from the Department of Environmental Quality began the presentation by discussing carbon sequestration co-benefits that were present in Phase III of the Watershed Implementation Plan (WIP III). WIP III was developed over two years and completed in August 2019. The plan is essentially a plan to

implement a collection of best management practices (BMPs) to reduce nitrogen and phosphorus by 2025. The planning process engaged 95 local governments, 15 planning districts, and 32 soil and water conservation districts. Because climate change will have many impacts on water quality, such as increased runoff, carbon sequestration co-benefits were a focus of WIP III. The cost effectiveness of BMPs was another important focus. DEQ utilized the CarbOn Management & Emissions Tool (COMET) developed by the United States Department of Agriculture (USDA) in partnership with Dr. Adam Chambers of Colorado State University. The tool estimates the environmental benefits associated with conservation practices and utilizes spatially-explicit data on climate and soils at the field scale. The tool's focus is on farm practices. Because the tool was so agriculture-focused, certain factors used in the Chesapeake Bay program were not perfectly aligned with COMET's BMPs and some assumptions regarding how to best equate them had to be made. For instance, an urban forest buffer was expected to behave similarly to an agricultural forest buffer in terms of carbon sequestration. According to DEQ's calculations, the 1.1 million acres covered by BMPs resulted in 482,000 tons of CO_2e sequestration. With the implementation of WIP III, there would be 2.9 million acres of BMPs and approximately two million tons of CO_2e sequestration. Ten percent of that two million would be soil carbon.

Chris Bast asked if the sequestration figures were cumulative or annual.

James Martin replied that they were annual figures and they had not yet determined a way to account for the cumulative effect of sequestered carbon with COMET. Mr. Martin then directed attention to the next slide which sought to explain the meaning of some of the figures in more practical terms. Two million tons of CO_2e was equivalent to 1.5% of greenhouse gas emissions in Virginia or 4% of transportation generated CO_2 emissions in Virginia, which would have the same sequestration effect as taking 400,000 cars off the road for a year. Two million tons of sequestered CO_2e also was equivalent to growing 33 million seedlings over the period of ten years. The next slide explained that 228,000 tons of soil carbon improved the soil's overall health and productivity. It also increased water retention which meant less runoff (leading to better water quality in the Chesapeake Bay) and greater resilience to drought. The next slide highlighted how tree and forest practices accounted for over half of the sequestered carbon under WIP III but only 5% the acreage of planned BMPs. The next slide dealt specifically with soil carbon and highlighted the importance of tilling and grazing, cover crop, and herbaceous practices. Those practices were most important for soil carbon specifically while tree and forest practices had the greatest total carbon sequestration effect. (This presentation is attached as Appendix B.)

Deputy Secretary Joshua Saks requested that Mr. Martin go back one slide and clarify why tree and forest practices were to be focused upon for overall carbon sequestration but not for soil carbon.

James Martin highlighted that relatively few acres of tree and forest practices would be required to achieve the benefit of 50% of the soil sequestration efforts.

Chandler Van Voorhis added that forest carbon has biomass components above and below ground, so there are more total pools of possible carbon sequestration per acre than would exist from a purely agricultural standpoint. Depending on whether this sequestered carbon would be calculated as reduction or removal could mean a significantly different price valuation in a typical carbon market.

Karen McGlathery wanted to know if these tree and forest sequestration figures accounted for leafy material or just woody biomass. Dr. McGlathery also wanted to point out that when thinking about annual sequestration, carbon in soil did not stay sequestered for a long time while soil sequestered in trees does.

James Martin asked Mr. Jay Ford about the term he mentioned in the last meeting that captured this idea.

Jay Ford said that "permanence of practice" was the best term to use. Mr. Ford also wanted to know how the two million tons of tree and forest sequestration matched with practical implementation considering the fact that the amount of tree canopy in the Commonwealth was decreasing year over year. Mr. Ford was not sure if this accurately represented the net change of actual sequestration in the Commonwealth or was just the difference that would result from implementation of the BMPs.

James Martin said that this did not account for net change, simply the difference that would be seen from implementation of the practices. "Leakage" (the industry term) was not accounted for in these calculations. If 50,000 acres of forest were planted, and 50,000 acres were lost, this model would only account for the 50,000-acre gain.

Chris Bast asked if the same model could be used to look at a project that is destroying wetlands or trees and assign a value to that. Could measures of permanent analysis with this tool be built in?

James Martin said that this tool requires making some assumptions, i.e., that benefits gained by planting are the same benefits lost by cutting. Erin Lasher's model might do a better job at calculating the impact of loss, because it can account for land use changes.

Erin Lasher asked Mr. Martin to clarify if he meant short tons or metric tons?

James Martin said it was metric tons.

Erin Lasher said that her tool may not be the best option.

Chris Bast asked if permanence would be accounted for in DEQ's modeling.

Erin Lasher said that her model looks at remaining forest and forests that have become other land. To some degree it accounts for permanence, but not overall. It accounts for forestry land lost but not wetlands.

James Martin said that DEQ has good land use and land cover data as of 2013 and for the Bay watershed area as of 2017. DEQ can get an indication of the rate of loss from remote sensing, particularly of forest cover which is the easiest land cover to detect. They have data with one meter resolution for the Bay watershed. New data was just released yesterday (November 2, 2021) and as soon as there is a number for acres of tree cover lost that can be incorporated.

Chandler Van Voorhis said that on the carbon market side, leakage is handled by a default factor. In California, they take 24% off the top line carbon calculations.

Secretary Bettina Ring asked when agricultural and forest lands are converted, what does permanent conversion look like. Will farmland be permanently lost to production?

Corey Connors said that the U.S. Forest Service Forest Inventory and Analysis (FIA) provides data that measures growth and drain rates. The drain rate of 1.1 means that forest is growing at a faster rate than it is being removed. Data suggests that canopy or biomass is not being lost.

Terry Lasher added that FIA is tracking urban forest data as well.

James Martin said that a land cover model is probably nowhere near as good at tracking forest biomass as the other methods being discussed. It would recognize the canopy, but the basal area may change significantly.

Terry Lasher said that it would be helpful to define conversion. Aerial data needs to be supplemented with on the ground data to verify growing or removal of forests. Harvest data would help solidify numbers.

Secretary Bettina Ring said new forests will continue to sequester carbon.

Jay Ford said the important distinction between canopy and biomass was a critical thing for the task force to return to and that using either as a sole indicator could skew data. Canopy represents potential for biomass accumulation over time. Mr. Ford opined the right answer is somewhere between the two metrics and the group should continue to think about what the best way to measure sequestration is in forestry.

Secretary Bettina Ring said that Virginia needs to get more trees in the ground, do more reforestation and develop more urban tree canopy across the state.

James Martin agreed that there are lots of good reasons to do so, not just to improve carbon sequestration, but also to improve water quality.

Secretary Bettina Ring added wildlife habitat as an example of a co-benefit and said the list of co-benefits continues far beyond that.

Chris Bast agreed that there are lots of co-benefits, including addressing urban heat. He believed being able to account for the sequestration co-benefit accurately is important.

Secretary Bettina Ring suggested having Dr. Jeremy Hoffman from the Virginia Science Museum present on his climate science research.

Deputy Secretary Joshua Saks announced that Pam Kiely had joined the group virtually.

Chris Bast gave a brief introduction of Pam Kiely, the Associate Vice President of Climate at the Environmental Defense Fund who was asked to discuss carbon markets and offsets.

Pam Kiely delivered a presentation on carbon markets and offsets, attached at Appendix C.

Chris Bast thanked Pam and asked that that that presentation be added to the minutes.

Corey Connors asked to revisit the California slide of the presentation.

Pam Kiely said that the slide focused on revenue distribution and outlined where dollars have gone in carbon markets through fiscal year 2018-19.

Chandler Van Voorhis said a key term to keep in mind is "global warming potential." He expressed his belief that California based their entire regulatory scheme on an outdated Intergovernmental Panel on Climate Change (IPCC) report when it was thought climate change was a 100-year problem instead of a near-term issue. Mr. Van Voorhis stated that he believed the fundamental difference between voluntary and compliance market schemes is that compliance is driven by fear, and voluntary markets tend to be publicly traded companies reporting emissions. In his opinion, compliance markets have a little more regulated integrity, and that capital is invested in such markets as part of a strategy for screening emissions liabilities. Mr. Van Voorhis also mentioned that because California does not allow aggregation, 35-40% of carbon market projects in that state have been on Indian reservations. In his understanding, the California carbon markets have not been accessible to small- and medium-size landowners and access should be more equitable.

Mark Luckenbach asked Erin Lasher if the model looking at net emissions included transition from one type of environment to another. He provided an example, describing that based on his research the Chesapeake region has about 300,000 acres of tidal wetlands and had about that amount 150 years ago. His research also showed that during that time 100,000 acres have eroded, and 100,000 acres of wetlands have transgressed onto forest and agricultural lands. Dr. Luckenbach states that while the overall measure might indicate stability in terms of marshlands, the reality was much more volatile and, in his opinion based on research, directly related to sea level rise.

Erin Lasher said the model does a high-level analysis of the type of land in the forestry sector on an annual basis going back to 1990. She said that it does not have a larger time scale and only includes forestry data, not blue carbon. The model also does not distinguish between coastal forests and other types, and further does not capture transformation between these two typologies.

Mark Luckenbach said that, in his opinion, 300,000 acres is not very much considering the entirety of tidal wetlands and bottomlands in Virginia and Maryland. In his recollection, the total restoration goal for subaquatic vegetation was 180,000 acres for Maryland and Virginia, which, in his opinion, would not be achievable unless water quality significantly improved beyond current projections. He related that he believed Virginia has successfully restored approximately half of its 90,000-acre goal. Dr. Luckenbach also reminded the group that there had been a no-net loss-program associated with public lands in the past, that would be beneficial to re-examine and consider carbon sequestration as a co-benefit. Dr. Luckenbach reiterated that it would be difficult to add blue carbon sequestration above the baseline because submerged vegetation in Virginia was already well-accounted for and largely concentrated on state-owned bottomlands.

Karen McGlathery added that she could provide data on what reaching Virginia's seagrass restoration goal would mean for carbon sequestration. In Dr. McGlathery's opinion, the benefits would be on the scale of tens of thousands of tons of carbon per year, not millions, so an order of magnitude lower for blue carbon than terrestrial carbon. Dr. McGlathery believed it was important to think about the co-benefits and value of the co-benefits for blue carbon. She offered to share her data with the group.

Deputy Secretary Joshua Saks asked Mark Luckenbach for recommendations based on his research.

Mark Luckenbach said that seagrasses and marshes offered some opportunities to increase carbon sequestration, but there exist few opportunities to add more marshland. In Dr. Luckenbach's opinion, there might be opportunities to create perhaps another 10,000 acres, but not much more. Dr. Luckenbach also stated that his data came from eelgrass research, but notably eelgrass is not the majority of subaquatic vegetation in the Chesapeake Bay.

Deputy Secretary Joshua Saks asked Dr. Luckenbach to take that a step further and make a baseline recommendation.

Mark Luckenbach stated that durability had been previously used as an important consideration in prioritizing carbon sequestration efforts. In his opinion, it would be valuable to understand how to consider dynamic and transforming landscapes in estimating durability.

James Martin responded that agriculture would be one such transforming landscape. He stated that while forest loss was at 45,000 acres over 2013-2018, agriculture at roughly the same levels. In his opinion, the situation was similar to Dr. Luckenbach's wetlands example, namely that while the net amount of agricultural land lost was relatively small, thousands of acres had been lost to development while thousands more acres of forestlands were converted to agricultural land to meet food production goals.

Karen McGlathery added that researching the amount of agricultural or forest land lost and the relationship to carbon sequestered per hectare per year was straightforward. In Dr. McGlathery's opinion, agriculture and marshland are roughly the same, between 1.7 and 2.2 carbon tons/hectare/year and that replacing forest would have greater impacts on increasing carbon sequestration. Additionally, Dr. McGlathery believes that marsh replacing agriculture will not be a big change, but marsh replacing forest will be significant.

Mark Luckenbach added that when acres of marsh are lost to erosion, many years' worth of sequestered carbon is also released.

Chris Bast asked if there are any other questions on markets while Pam Kiely was still present.

Karen McGlathery said that writing the methodology that is being used by Verra, the Verified Carbon Standard (VCS) was unbelievably complicated and hard. In Dr. McGlathery's opinion, this complexity was a barrier. Dr. McGlathery asked if Pam Kiely had thoughts on how researchers could develop models conservative enough to ensure appropriate verification standards without creating problematic barriers to entry for otherwise good projects.

Pam Kiely agreed with Dr. McGlathery that the biggest challenge was inspiring investor confidence in the credit valuation without creating insurmountable barriers. Ms. Kiely stated that an international carbon credit standard would be an important step toward reducing barriers.

Karen McGlathery reiterated her belief that there were no quick and easy solutions for getting around these barriers and that the group should keep these kinds of issues in mind when making recommendations.

Pam Kiely added that once protocols get adopted and people gain familiarity, the process can move much more quickly. She described that California took a long time to develop a methane program, but the

program's core components were thereafter readily adaptable to other programs. In her opinion, this speeds up implementation of new programs, which then drives investment.

Chandler Van Voorhis suggested that in addition to challenges with the start-up process, expertise, required statistical precision, lack of uniformity in calculation and modeling tools, and bottlenecks in verification are significant problems. In his opinion, there was little value in blue carbon markets because these types of challenges were even greater in that field than in other markets. Additionally, Mr. Van Voorhis believed the value of maintaining wetlands far exceeds the value of the carbon being sequestered there and the group should look at the green infrastructure value of marshes from an adaptation standpoint.

Karen McGlathery said that globally, blue carbon offsets could offset about three percent of total carbon emissions, a modest amount.

Chris Bast asked for any final questions regarding carbon markets and then thanked Pam Kiely.

Mark Luckenbach said that the transitions between habitats, particularly losing a mature habitat, can lead to a large pulse release of carbon that could take many years to offset even if there were a higher rate of uptake in the replacement habitat. In his opinion, this is an unfortunate situation because sea level rise will cause marsh erosion and marsh drowning. He stated that scientists know how to restore marshes but there is nothing to be done about the initial pulse release of carbon, nutrients, and sediment when marshes erode.

Deputy Secretary Joshua Saks asked for any other ideas, thoughts, or recommendations people had with regard to the topics discussed.

Jay Ford asked Chandler Van Voorhis for more information about the 24% loss figure discussed as a leakage assumption parameter earlier. Mr. Ford asked what would be a reasonable model given the static figures for sequestration and does the 24% figure apply in most market scenarios?

Chandler Van Voorhis responded that, in his opinion, leakage is an academic exercise and hard to prove considering the elasticity of supply and demand. He related that California has used a default factor of 24% leakage in accounting carbon credits, while other voluntary markets offset by 40%. In Mr. Van Voorhis' opinion, the reason accreditation bodies use default factors is because there is little if any peer-reviewed research showing leakage exists. Mr. Van Voorhis believed that if Virginia wanted to account for leakage, the Commonwealth should adopt one of the existing default standards.

James Martin added that, in his opinion, it was really a question of cause and effect, whether the positive action taken on one parcel cause a negative effect on another parcel, not whether there was a net change. He related that on a statewide scale, researchers can measure changes in land use and know that even though more trees were planted, there were still losses in terms of acreage coverage and biomass.

Chandler Van Voorhis said that, in his opinion the questions are what is being measured at what point in time. He related that since 1750, one-third of all carbon emissions have come from land use change, predominantly deforestation.

Chris Bast said that for the task force the baseline is important because the goal is to be forward-looking. He believed that the policy goal is to get net emissions to zero as well as bring down the amount of carbon in the atmosphere.

Chandler Van Voorhis asked what year an appropriate baseline would be.

Chris Bast said that there is a baseline in the law used by the federal government and internationally for carbon emissions.

Tom Ballou said that 2005 is the starting baseline for carbon emissions reduction strategies.

Chris Bast suggested that unless there is a compelling reason to do something different, the group should align the carbon sequestration baseline with the carbon emissions baseline.

Chandler Van Voorhis said that when establishing a leakage rate for forest carbon, the challenge is determining the demand source for timber. In his experience, there is not one timber market, there are many and the timber market depends on location while carbon is a global market. In his opinion, leakage is a slippery slope, so his recommendation would be to use a default factor for leakage rather than spend a lot of time trying to develop something new.

Tom Ballou agreed that it is standard practice to use a default factor if no other better data exists.

Chandler Van Voorhis asked what the loss of forest was annually and how much of that leakage was from conversions intended to decrease emissions or increase sequestration.

Tom Ballou responded that the data does not show a decrease in forests, it shows a slight increase. The data also does not capture blue carbon to create a baseline. In Mr. Ballou's opinion, the bigger question is how detailed an inventory would be appropriate and would it be productive to change methodologies.

James Martin asked if leakage was less of an issue in net-zero emissions questions than carbon markets.

Chandler Van Voorhis answered that when a buyer is buying a credit, leakage is factored into that net-zero calculation, but the buyer does not see the leakage part of the process.

Nikki Rovner said that James Martin's comment moved beyond the market discussion and was addressing net-zero emissions statewide.

Chris Bast said that carbon offsets in markets could be a tool to achieve net-zero emissions in Virginia. He related that net emissions in Virginia in 2021 are 88 million tons a year. In his opinion, Virginia should either decrease emissions or sequester more than total emissions – assuming the authorizing legislation does not place a cap on the amount of carbon sinks that can be entered into the equation. He recalled that some states have limited the number of carbon sinks allowed where the objective is to decrease pollution and stated that leakage matters for setting up the market.

James Martin said the issue goes back to land use. In his opinion, if Virginia does not find ways to incentivize less impactful development, the goal of net zero emissions is going to be hard to achieve.

Deputy Secretary Joshua Saks informed the group that the task force had lost quorum. He then offered to continue, noting the task force's objective is to gather recommendations for its report and that there were

relatively few recommendations recorded at present. In his opinion, it would be beneficial to pursue reducing and offsetting emissions as a goal.

Chandler Van Voorhis recommended that loss of carbon stock be accounted for when ecosystems are destroyed for development. The entire carbon stock should be looked at in the same ways used to account for tropical deforestation.

Karen McGlathery recommended the idea of permanence should be built into the recommendations. She noted that while there are no forest fires underwater, blue carbon stocks are subject to other environmental events like hurricanes and warming temperatures that threaten carbon stock permanence.

Kyle Shreve recommended that fully funding agricultural best management practices (BMP) would meet already-set water quality goals, while also improving carbon sequestration.

Jay Ford agreed with Kyle Shreve's suggestion to fully fund agriculture best management practices and said that, in his opinion, practices maximizing woody biomass are most effective in sequestering carbon and reducing nutrient runoff. Finding a way to further incentivize those practices should be a priority.

James Martin agreed that since the Commonwealth can better quantify those benefits now, using agricultural BMPs should be further incentivized.

Deputy Secretary Joshua Saks agreed that co-benefits are good, but also said the climate issue is so big that Virginia should address it as a direct charge, not just via co-benefits.

James Martin clarified that while many people may think of the term co-benefits to mean one benefit outweighs another, they are all equally important.

Chandler Van Voorhis said that in his opinion, Virginia has excelled in two areas: the transferable land preservation tax credit and nutrient mitigation banks. He believed that if Virginia drew from that experience to create a tradable tax credit around existing best management practices driven by the carbon sequestration benefits, it would lower barriers to participating in carbon markets such as expertise and the need for large, contiguous acreages. He described that, in this scenario, landowners could take the tax credit to any accounting or brokerage firm and trade it directly for cash. Mr. Van Voorhis noted that most farmers and other landowners are land rich and cash poor and pointed out that the land preservation tax credit has incentivized landowners all over Virginia to engage with conservation programs. He asked the question, "How do we go from the passive act of conservation to active restoration and enhancement?" In Mr. Van Voorhis' opinion, that would be a gamechanger and very popular from the landowner side, but he expressed that he was not familiar with whether such an option would be politically feasible.

Mark Luckenbach recommended identifying opportunities for large, extensive marshes to migrate. He noted that this may cause some losses of agricultural land and coastal forest, but the alternative might be to lose those marshes altogether. He asked whether once such lands, which are often privately-owned, were identified, how could they be protected? In Dr. Luckenbach's opinion, it would be more important to identify priority areas for migration than restoration.

Secretary Bettina Ring asked how to incentivize landowners who own the kind of marsh buffer land described by Dr. Luckenbach.

James Martin said that this would involve envisioning land conservation from parcel scale to critical area scale, focusing on critical areas for marsh migration.

Chandler Van Voorhis added that the task force should frame the discussion in terms of climate mitigation or adaptation and use that to guide drafting.

Jay Ford (in virtual chat): "Following up on Marks comment. We need to update the Tidal wetlands bank guidance to account for SLR."

Karen McGlathery asked when task force members would have an opportunity to comment on the draft report.

Deputy Secretary Joshua Saks answered that hope was to circulate a draft outline prior to next meeting for discussion.

Secretary Bettina Ring noted that if additional research is needed, the support team of William & Mary students are prepared but they would need as much lead time as possible.

Deputy Secretary Joshua Saks and Secretary Bettina Ring thanked everyone, and the meeting concluded at 11:44 a.m.

Note: The second meeting appendices are attached to this document as Appendix F.

Appendix C: As-Written Recommendations from Carbon Sequestration Task Force Members

Karen McGlathery

Professor and PI, Virginia Coast Reserve—Eastern Shore, Director of the Environmental Resilience Institute, University of Virginia

- Determine baseline: current area of habitat, sequestration rate
- For future projections of carbon sequestration, we need to know 1) how the area will change over time (e.g., by 2050); and 2) what the potential is for restoration of SAV and marshes
- For SAV, we need to know how sea-level rise and water quality will affect survival of current SAV and potential for restoration. With respect to sea-level rise, we need to include sediment accretion rates in SAV meadows as well as sea-level rise rates. Water quality is not an issue in the coastal bays of the Eastern Shore, but is a consideration in Chesapeake Bay, as it affects the depth limit of SAV and the areal coverage of meadows.
- For marshes, estimates of carbon sequestration must include marsh migration with sea-level rise, marsh accretion rates, and marsh erosion (loss of carbon stocks). For marsh migration, we need to know what habitat is being replaced by marshes (e.g, agricultural fields, forests) and the difference in carbon sequestration rates.

Nikki Rovner

Associate State Director, The Nature Conservancy

- The Commonwealth should have a no-net-loss goal for natural carbon sequestration. While SB 1374 calls on us to explore ways to increase sequestration, development and other pressures could take us in the opposite direction if we don't measure any gains against what we might be losing.
- Accounting for natural carbon sequestration. When presenting its GHG inventory, DEQ acknowledged that they have been using default data on sequestration and that there are a number of opportunities to incorporate more Virginia-specific information. DEQ should work with the following entities to do this
- Department of Forestry to incorporate federal FIA (Forest Inventory Analysis) into the inventory.
- UVA (Karen McGlathery) and U.S. Climate alliance to identify best practices for including urban tree canopy and blue carbon in the inventory.

- Commonwealth participation in carbon markets. The Department of Forestry should explore whether it is possible to generate carbon credits by altering harvest regimes on some of their state forests.

Ben Rowe

National Affairs Coordinator, Virginia Farm Bureau

I want to reiterate a couple points and suggestions to be included in the report. At the first meeting, and again towards the end of this week's meeting it was suggested that the existing Virginia Agricultural BMP program is a recommended starting point for carbon sequestration. We already have data from James Martin and others showing the carbon sequestration benefits of many of the existing nutrient reduction practices. The framework for staffing, implementation, and verification is already in place through DCR and local SWCDs. Efforts to identify the practices with the greatest carbon sequestration benefit, and then increase funding and implementation of those voluntary practices is recommended. At the meeting this week there was broad consensus among the stakeholders in the room and on the phone that this is a path forward.

Appendix D: Background Research on Carbon Sequestration Strategies

Healthy Forests

Forest carbon sequestration refers to the natural process by which forests capture carbon from the atmosphere and use photosynthesis to capture carbon in biomass. Sequestered carbon is stored in five different repositories known as carbon pools. These repositories include above-ground biomass, below-ground biomass, litter, dead wood, and organic carbon in the soil. Existing forests store close to forty-five percent of the organic carbon on land in their biomass and soils.[41]

Advantages

Healthy forests provide an inexpensive means of storing carbon with a high degree of permanence, meaning that the carbon is not easily translated into atmospheric carbon absent a significant event such as a fire. To determine how much carbon trees can store, the net balance between carbon taken in versus carbon respired must be analyzed. When the net balance of carbon emissions is negative, a "carbon sink" is created because forests store carbon in repositories and continue to sequester additional carbon. Forest carbon sequestration can be improved by forest management practices such as tree plantation management, lengthening harvest schedules, fire management, and thinning and understory management.[42] State agencies calculated that forests in Virginia offset nearly twenty percent of the state's annual CO_2 emissions and the standing trees work as a carbon sink, sequestering thirty-seven years of emissions.[43]

VIRGINIA OPPORTUNITIES

Urban Riparian Forest Buffer Restoration: Forest buffers prevent pollution from entering waterways and can establish new forest cover for additional carbon sequestration.

Cropland Conversion: Played-out or fallow fields previously used for crop production can be converted to forest for long-term erosion control and water quality improvement.

Challenges

Forests exemplify the challenges associated with attempting to quantify and track carbon sequestration in natural ecosystems with established carbon cycles. When trees die, the carbon storage process is reversed, and carbon is released back into the atmosphere through the biological decomposition processes. When the net balance of emissions is positive, forests can become an emission source potentially contributing to climate change and enhancing the greenhouse effect. It is important to note that a large amount of decomposition would be necessary to offset the carbon captured

[41] Gordon B. Bonan, *Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests*, 320 SCIENCE 1444, 1444 (2008).
[42] Bill Anderegg et al., *Improved forest management, afforestation, and reforestation*, *in* CARBON DIOXIDE REMOVAL PRIMER, (Jennifer Wilcox et al. eds., 2021).
[43] *Carbon Sequestration in VA*, VA. PLACES, http://www.virginiaplaces.org/climate/carbonsequestration.html#one (lasted visited Dec. 14, 2021).

by a forest ecosystem. In addition, normal forest decomposition can often take decades, greatly slowing the rate of carbon emissions.

Forests are most likely to become an emission source when they are cleared or degraded by deforestation, or by major environmental disturbances such as wildfires. Positive net emissions can be avoided by growing healthy forests and by preventing forest loss to development, deforestation, or unsustainable timbering practices. The conversion of forest land to agriculture or development contributes about three percent to Virginia's carbon emissions each year.[44] It is critical to reduce deforestation as a climate mitigation strategy because it is more costly and time-consuming to restore healthy, carbon-capturing forests, including the abundance of carbon captured in a healthy forest ecosystem, than it is to preserve existing ones with established ecological communities.[45]

Green Communities and Natural Infrastructure

"Green communities and natural infrastructure" describes a process of creating a developed human-centered environment that still provides beneficial ecosystem services such as flood mitigation, stormwater retention, promotion of environmental justice, recreation, improved mental health, and carbon sequestration. Green or natural infrastructure can present in many different forms but some of the most popular are permeable pavements, sky or rooftop gardens, green roofs, and urban forests. Urban forests represent a major opportunity to increase carbon sequestration in the Commonwealth.

Advantages

There are several advantages of incorporating green practices and natural infrastructure into human-centered development. Green design is an important perceived social and environmental good and when done to industry standards, can promote civic engagement and collaboration between several different sectors.

Studies have found that green infrastructure projects encouraged collaborations between local volunteers, non-governmental organizations, and business associations.[46] Together these groups worked to develop diverse projects with significant local impacts such as restoring natural vegetation, monitoring stream water quality, and promoting environmental education. A co-benefit of green community projects is job creation and demand for specialized labor (*e.g.,* landscape architect, hydrologist, and botanists). In one example, implementation of a permeable pavement initiative created a need for skilled labor and expertise for both installation and maintenance.

Green infrastructure has many other co-benefits, including improved stormwater retention, flood mitigation, heat abatement, and flood mitigation. Traditional hardened infrastructure moves water

[44] *Id.*
[45] Anderegg, *supra* note 6.
[46] Vivek Shandas & W. Barry Messer, *Fostering Green Communities through Civic Engagement: Community-Based Environmental Stewardships in the Portland Area*, 74 J. AM. PLAN. ASS'N 408, 412-413 (2008).

quickly, often contributing to flash flooding and overwhelming water management systems that are exacerbated by climate change-related increased storm events. Green infrastructure installations such as urban forests, daylighted streams[47], bioswales, or wetlands can slow and absorb stormwater, improving public safety and preventing property damage. Green infrastructure features such as parks, sky gardens, green roofs, and urban forests can also greatly increase carbon sequestration and improve air quality in densely-developed environments. Urban forests and street trees can help regulate temperature and lower energy costs, keeping hardened areas cool in the summer by providing shade and reducing wind chill in the winter. Studies also indicate that green features have a beneficial effect on community mental and physical health, even reducing lost workdays and hospital admissions.[48]

VIRGINIA OPPORTUNITIES

Green Transportation Corridors are an opportunity to improve air and water quality, an important environmental justice issue. Planting green buffers along highways can drastically improve health indicators for neighboring communities.

Challenges

The many benefits of green infrastructure can be overshadowed by the significant costs of installation and maintenance, as well as design costs associated with developing new technologies. Tree management involves sourcing appropriate species, planting, pruning and leaf management, pest control, and watering, which can offset gains in water conservation and environmental quality improvements. In addition, the space required for urban forest installations can increase urban sprawl and contribute to equity disparities in areas that can accommodate and afford such projects

Bioeconomy

A bioeconomy is an economic model based on biological resources, processes, and products.[49] A bio-based economy focuses on the primary production of biological resources and their uses in various fields, such as infrastructure, technology, public heath, defense, energy, and agriculture, for the development of new products, goods, and services. Through scientific study and technological advancement, different types of biomass can be converted into new forms or degraded into various

[47] The term "daylighted stream" refers to a stream that is brought to the surface after being run through culverts underground.

[48] Stratus Consulting Inc., *A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds*, Boulder, Colorado (2009). Cited by THE ENVIRONMENTAL PROTECTION AGENCY, *Healthy Benefits of Green Infrastructure in Communities* Fact Sheet, EPA OFFICE OF RESEARCH AND DEVELOPMENT, https://www.epa.gov/sites/default/files/2017-11/documents/greeninfrastructure_healthy_communities_factsheet.pdf

[49] MARCY E. GALLO, *The Bioeconomy: A Primer,* CONG. RSCH. SERV., 1-3 R46881 (2021), https://crsreports.congress.gov/product/pdf/R/R46881

reusable components to replace or mix with fossil fuel or fossil fuel-based products.[50] Biological resources and associated waste byproducts can create a more sustainable economic cycle with less need for landfills or other long-term storage options.[51]

Advantages

Because the concept of a bioeconomy encompasses multiple fields, benefits of developing a comprehensive bioeconomy include developing new technology to create new bio-based products. The development of new products has the potential to create jobs in growing the feedstock, in the production cycle, and in the distribution of products. Such job creation can boost development in rural communities. Further, in replacing fossil fuels and fossil fuel byproducts in the production of energy, chemicals, and other materials, bio-based products and materials are renewable and more sustainable. Bio-based products and materials capture and recycle carbon from the atmosphere by supporting various plant and vegetation growth. Scientific research into replacing less sustainable products with bio-based products can increase innovation in all fields. Examples include developing biofuel, which reduces carbon emissions, biofertilizer, which reduces runoff of nutrients like nitrogen and phosphorous into waterways, and biomedicine.[52]

VIRGINIA OPPORTUNITIES:

Marine Biomass such as kelp, seagrasses, or algae can be converted into an oil for biofuel and can be more productive than its terrestrial counterparts without the need for irrigation or fertilizer. Marine biomass captures carbon more efficiently and the use of biofuel reduces emissions. Virginia currently operates two land-based biodiesel refineries and could invest in similar facilities for marine biomass.

Biofertilizer made with algae reduces the nitrogen-phosphorous-potassium ratio seen in chemical fertilizers and fixes more nitrogen and carbon in the soil after application. Biofertilizer presents an opportunity for Virginia to reduce pollutants from run-off into the Chesapeake Bay and increase soil fertility.

Challenges

The lack of a consensus definition of what constitutes a bioeconomy prevents the development of a comprehensive strategy.[53] As a result, some areas of the bioeconomy, such as advancements in bio-based products in agriculture, are developing faster than others; for example, biotechnology and bioecology sectors. Difficulties also include estimating the amount of adequate feedstock, developing

[50] BIOMASS RSCH. & DEV. BD., *Federal Activities Report on the Bioeconomy* (2016), https://www.energy.gov/sites/prod/files/2016/02/f30/farb_2_18_16.pdf .
[51] James Philp, *Why the bioeconomy could be the future of sustainable manufacturing*, WORLD ECON. F. (Aug. 2, 2018), https://www.weforum.org/agenda/2018/08/bioeconomy-101-making-rubber-tyres-from-dandelions .
[52] NAT'L ACADS. OF SCIS., ENG'G, AND MED., SAFEGUARDING THE BIOECONOMY 41-72 (2020), https://pubmed.ncbi.nlm.nih.gov/32352690/ .
[53] Marcy E. Gallo, *supra* at 12; THE WHITE HOUSE OFF. OF SCI. & TECH. POL'Y, *Summary of the 2019 White House Summit on America's Bioeconomy* (2019); NATIONAL BIOECONOMY BLUEPRINT, EXEC. OFF. OF THE PRESIDENT 58 (2012), https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/10/Summary-of-White-House-Summit-on-Americas-Bioeconomy-October-2019.pdf.

innovative conversion technologies, and creating a supply chain infrastructure for biomass and its derived products. A central challenge in developing a bioeconomy is the struggle to manage supply and demand for bio-based products, particularly considering the effects of climate change on agricultural and natural environments.

Blue Carbon

Blue carbon refers to the ability of coastal environments such as mangrove forests, salt marshes, seagrass meadows, and kelp forests to sequester carbon in sediment. Due to climate and habitat constraints, two viable options for Virginia blue carbon efforts are seagrass meadows and salt marshes.

Seagrass meadows and salt marshes both excel at the long-term sequestration of carbon and can accumulate carbon rapidly. Carbon remains buried under seagrass for hundreds of years and salt marshes for a thousand years or more, because the conditions in these environments prevent decomposition.[54] Unlike forests, nearly all the carbon sequestered in seagrass meadows and salt marshes is kept in the soil or sediment rather than biomass. In the event of a major disaster, a marsh or seagrass meadow would not release most of its stored carbon, as opposed to forests or other sinks in oxygen-rich environments. Seagrass and marshes both also provide excellent habitat for wildlife, increasing the carbon benefits of the entire ecosystem.[55]

Seagrasses, which grow in underwater environments, have the additional benefit of helping de-acidify the surrounding water and grow rapidly. There is evidence that restored seagrass meadows are as efficient as natural meadows at sequestering carbon within a decade. Virginia is already a leader in eelgrass restoration and research into the benefits of eelgrass meadows continues at Virginia-based institutions such as the Virginia Institute of Marine Science ("VIMS").[56]

Marshes, which occur in partially-submerged environments, promote flood mitigation in addition to carbon sequestration benefits. Marshes provide valuable buffers against wave action and storm surge for inland areas.

Challenges

Like forests, the carbon from water-based carbon sinks can be released back into the environment in the event the habitat is destroyed. The speed of this release would depend on how quickly, if at all, the soil or sediment is disturbed enough for the carbon to release. Dredged material from construction projects has been used to help speed up the reclamation of marshland but dredging projects can also disturb existing submerged aquatic ecosystems and cause severe losses. Sediment disturbed as part of

[54] Marianne Holmer, *Underwater Meadows of Seagrass Could be the Ideal Carbon Sinks*, SMITHSONIAN MAG. (Nov. 1, 2018), https://www.smithsonianmag.com/science-nature/underwater-meadows-seagrass-could-be-ideal-carbon-sinks-180970686/ .
[55] *Seagrass—Secret Weapon in the Fight Against Global Heating*, UN ENV'T PROGRAMME (Nov. 1, 2019), https://www.unep.org/news-and-stories/story/seagrass-secret-weapon-fight-against-global-heating.
[56] *Seagrass Restoration*, VA. INST. MARINE SCI., https://www.vims.edu/research/units/programs/sav1/restoration/index.php (last visited Dec. 18, 2021).

dredging releases stored carbon directly and indirectly as buried accumulations re-enter the carbon cycle.[57]

Seagrass meadows' greatest vulnerability is their relative fragility. In addition to dredging and other human activities such as boat traffic, seagrass is vulnerable to temperature changes and extreme weather events like hurricanes. The most common seagrass off the Virginia coast, eelgrass, is primarily a cold-water seagrass. Virginia is at the southern extent of eelgrass's native range which would make eelgrass particularly vulnerable to increases in temperature.[58] Seagrass also requires sunlight to thrive, which can conflict with aquaculture in shallow near-shore waters.

Salt marshes are particularly vulnerable to rising sea levels and marsh transgression (migration) can lead to carbon releases as inundation kills trees on the upland side and allows erosion and decomposition of drowned marsh material on the seaward side. If the terrain is unsuitable for retreat due to development, or natural factors like slope, the marsh will be subsumed by the ocean and can no longer function as an active carbon sink.[59] Development pressures have already destroyed or confined many of Virginia's coastal marshes and it can take years for restored or new marshes to become effective carbon sinks.[60]

VIRGINIA OPPORTUNITIES:

Peat Bogs and Pocosins are natural features in Virginia, such as the Great Dismal Swamp, that sequester massive amounts of carbon in underwater deposits. Many of these nutrient-rich boggy areas have been drained for farmland and development. Identifying these areas and "re-wetting" them can re-capture stored carbon and preserve rare ecosystems.

Prioritizing preservation of existing marshes and seagrass areas will be essential to maximizing blue carbon storage potential.

[57] Sebastiaan van de Velde, *Anthropogenic Disturbance Keeps the Coastal Seafloor Biogeochemistry in a Transient State*, 8 SCI. REPORTS 1, 1 (Apr. 3, 2018), https://www.nature.com/articles/s41598-018-23925-y.
[58] *Eelgrass*, VA. INST. MARINE SCI., https://www.vims.edu/research/units/programs/sav/species/eelgrass.php).
[59] James Beever III, et al., *Climate Change Vulnerability Assessment and Adaptation Opportunities for Salt Marsh Types in Southwest Florida,* 18 (June 30, 2012), https://www.epa.gov/sites/default/files/2019-05/documents/climate_change_vulnerability_assessment.pdf.
[60] EPA, *Coastal Wetlands Initiative: Mid-Atlantic Review* 1,5 (2015), https://www.epa.gov/sites/default/files/2015-04/documents/mid-atlantic-review.pdf.

Soil Carbon

Soil stores more carbon than any other terrestrial ecosystem and has a vast capacity to absorb additional amounts, particularly in once-thriving soils that have been depleted, sterilized, or otherwise stripped of natural micro-flora and fauna.[61] Plants take in carbon dioxide from the atmosphere and deliver carbon to the soil through their roots. Mycorrhizal fungi increase the ability of plants to transport carbon to the soil by producing glomalin, a protein which stores carbon and binds soil together into clumps, preventing carbon loss through erosion or oxidization back into the atmosphere.[62] Soil carbon also includes both particulate organic matter—decaying organic material—and mineral-associated organic matter that remains in the soil for hundreds of thousands of years.[63]

VIRGINIA OPPORTUNITIES:

Pasture Cropping is a farming technique in which annual commercial crops are sown into perennial grass pastures. The pastures are grazed, adding nutrients in the form of manure, then planted. Once harvested, the fields are returned to grazing. Research shows increases in pasture diversity, lower livestock parasite loads, less erosion, and uptakes in soil carbon, as well as dramatically improved productivity.

Agricultural practices can increase the amount of carbon taken up by soil and decrease the amount lost. "No-till" farming minimizes soil disruption and prevents tillage from exposing stored soil carbon. Limiting use of pesticides and herbicides can protect soil ecosystems, particularly mycorrhizal fungi. Cover crops prevent erosion and increase the amount of carbon sequestered, as previous seasons' crops are used as manure for commercial crops, along with potential amendments such as compost, biochar, and rock dust.[64] Rotational grazing fertilizes fields without grazing plants too low and can reduce the expense of managing a herd.[65] Pasture cropping combines no-till, cover

[61] Judith D. Schwartz, *Soil as Carbon Storehouse: New Weapon in Climate Fight?*, YALE ENV'T 360 (Mar. 4, 2014), https://e360.yale.edu/features/soil_as_carbon_storehouse_new_weapon_in_climate_fight.
[62] Don Comis, *Glomalin: Hiding Place for a Third of the World's Stored Carbon*, USDA (Sept. 2002), https://agresearchmag.ars.usda.gov/2002/sep/soil.
[63] Renee Cho, *Can Soil Help Combat Climate Change?*, COLUM. CLIMATE SCH. (Feb. 21, 2018), https://news.climate.columbia.edu/2018/02/21/can-soil-help-combat-climate-change/; Emanuele Lugato et al., *Different Climate Sensitivity of Particulate and Mineral-Associated Soil Organic Matter*, 14 NATURE GEOSCIENCE 295 (2021), https://www.nature.com/articles/s41561-021-00744-x.
[64] Cho, *supra* note 32; Kenneth Olson et al., *Long-term effects of Cover Crops on Crop Yields, Soil Organic Carbon Stocks, and Sequestration*, 4 OPEN J. SOIL SCI. 284 (2014), https://www.scirp.org/pdf/OJSS_2014082211341366.pdf; Susan Cosier, *How Adding Rock Dust to Soil Could Help Get Carbon into the Ground*, YALE ENV'T 360 (Sept. 2, 2021), https://e360.yale.edu/features/how-adding-rock-dust-to-soil-can-help-get-carbon-into-the-ground; Mark Hertsgaard, *As Uses of Biochar Expand, Climate Benefits Still Uncertain*, YALE ENV'T 360 (Jan. 21, 2014), https://e360.yale.edu/features/as_uses_of_biochar_expand_climate_benefits_still_uncertain.
[65] Harlan E. White & Dale D. Wolf, *Controlled Grazing of Virginia's Pastures*, VA. COOP. EXTENSION (2009), https://ext.vt.edu/content/dam/shenandoah_ext_vt_edu/files/ag/graze300/418-012.pdf.

crops, and sustainable grazing practices to maximize the benefits of each.[66]

Advantages

Virginia can accomplish much through agricultural best management practices that sequester carbon and create co-benefits for farmers and Virginia.[67] For example, the agricultural practices called for by the 2014 Chesapeake Bay Watershed Agreement to restore the bay also sequestered carbon, though the primary objectives were nutrient management and improved water quality.[68] Cover crops, no-till agriculture, and forested buffers contribute to carbon sequestration and further the Commonwealth's goals of restoring the bay and improving water quality.[69] Carbon-rich soil is healthier soil and sequestration practices can also increase soil productivity.[70]

Challenges

In addition to ongoing gaps in research to understand the absorption capacity of soil carbon sequestration processes, the array of co-benefits associated with soil carbon also presents challenges to quantifying, tracking, and incentivizing carbon sequestration as a primary goal, in addition to ongoing gaps in research to understand the absorption capacity of soil carbon sequestration processes. Typical incentive programs for farmers have carbon sequestration co-benefits that are important and worthwhile, but it will be critical to clearly delineate thresholds for incentives that encourage new, additional carbon sequestration in soils.[71]

Incentive Structures

Policy solutions to reduce carbon emissions and sequester carbon can also benefit from a market-based approach that leverages financial incentives to drive participation in environmentally beneficial schemes. These incentive structures are based on scientific data underpinning an agreed baseline, which then utilizes developed methodologies to account for risk, leakage, durability, and other factors in calculating values for carbon reduction offsets.

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[66] Andre Leu, *Pasture Cropping-The Innovative No-kill, No-till System Developed by Australian Farmers*, REGENERATION INT'L (Mar. 15 2021), https://regenerationinternational.org/2021/03/15/pasture-cropping-the-innovative-no-kill-no-till-system-developed-by-australian-farmers/.

[67] *Fact Sheet: Soil Carbon Sequestration*, AM. U., https://www.american.edu/sis/centers/carbon-removal/fact-sheet-soil-carbon-sequestration.cfm , (last updated June 24, 2020).

[68] Katherine Hafner, *Carbon Hidden in Soil: Could Chesapeake Bay Restoration Methods be a Model for Blunting Climate Change?*, VA. PILOT (Aug. 12, 2021), https://www.pilotonline.com/news/environment/vp-nw-chesapeake-bay-climate-benefits-20210812-kgnmvbc7qrdv3ayqpty2ecqv74-story.html.

[69] Emily Wiggins, et al., *Climate Benefits of Chesapeake Bay Restoration in Virginia,* CHESAPEAKE CONSERVANCY, (July 2021), https://www.chesapeakeconservancy.org/wp-content/uploads/2021/08/Climate-Benefits-of-Chesapeake-Bay.pdf.

[70] Cho, *supra* note 32.

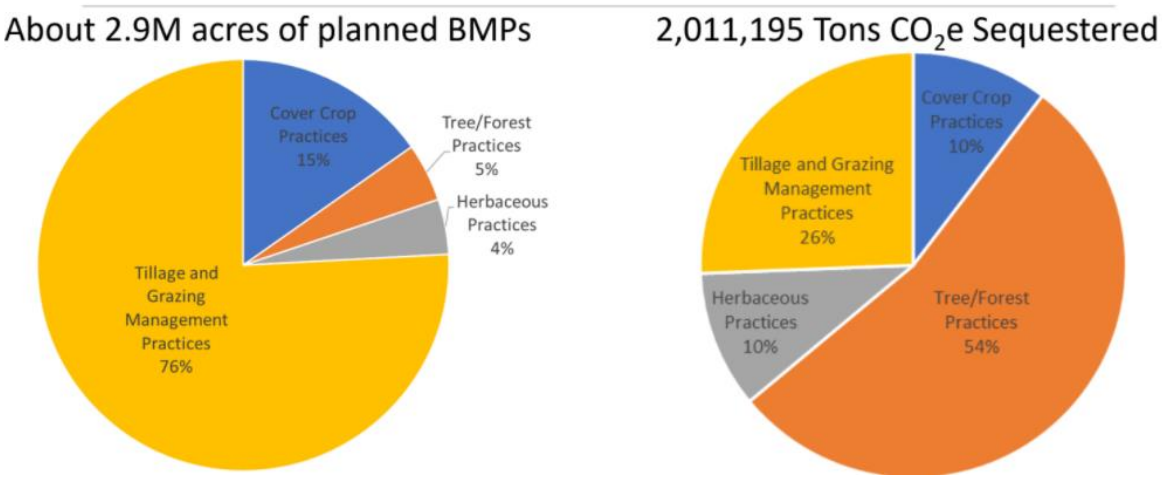
[71] David Pannell, *Soil Carbon Policy Faces Big Challenges*, 20 EUROCHOICES 46 (2021), https://onlinelibrary-wiley-com.proxy.wm.edu/doi/pdfdirect/10.1111/1746-692X.12323.

Quantification and Valuation of Carbon Sequestration in Tidal Wetlands

As part of the work to prepare the Chesapeake Bay Phase III Watershed Implementation Plan (WIP III), DEQ developed a methodology to quantify the carbon sequestration co-benefits of water quality improvement best management practices (BMPs) recommended in WIP III. To support this effort, DEQ utilized the CarbOn Management & Emissions Tool (COMET) developed by the United States Department of Agriculture (USDA) in partnership with Dr. Adam Chambers of Colorado State University. The tool estimates the environmental benefits associated with conservation practices and utilizes spatially-explicit data on climate and soils at the field scale. The tool's focus is on farm practices. Because the tool was so agriculture-focused, certain factors used in the Chesapeake Bay program were not perfectly aligned with COMET's BMPs and some assumptions regarding how to best equate them had to be made. For instance, an urban forest buffer was expected to behave similarly to an agricultural forest buffer in terms of carbon sequestration.

According to DEQ's calculations, the 1.1 million acres covered by verified BMPs in 2020 resulted in 482,000 tons of CO_2e sequestration. With the full implementation of WIP III, there would be 2.9 million acres of BMPs and approximately two million tons of annual CO_2e sequestration. Ten percent of that two million would be soil carbon. Two million tons of CO_2e is equivalent to 1.5% of greenhouse gas emissions in Virginia or 4% of transportation generated CO_2 emissions in Virginia, which would have the same sequestration effect as taking 400,000 cars off the road for a year.

By 2025, full implementation of the planned 2.9M acres of planned BMPs will result in 2,011,195 tons of sequestered CO_2e. However, the quantitative analysis from DEQ shows that BMPs are not created equal when it comes to carbon sequestration potential. The graphs below show that tree/forest practices account for just 5 percent of total planned BMP acreage but over 50 percent of total sequestered carbon.



Market-Based Solutions

Carbon Stock Accounting

Existing methodologies for carbon accounting involve two main approaches.[72] First, the process-based or gain-loss approach measures the annual change in carbon stocks in a biomass pool but does not actually measure the biomass stocks. The second approach is the stock-based approach, or the stock-difference method, which measures the amount of carbon in a biomass pool at two points in time but is difficult to apply to certain types of biomass pools. Baselines for calculating particular carbon stocks are project- and site-specific. A key challenge to accurate carbon accounting is the inability to quantify uncertainty. Some models, while perhaps accurate at calculating carbon emissions, can underestimate emissions of other greenhouse gases (GHGs) from carbon reduction projects, which negate in part benefits derived from reducing the calculated carbon emissions. Another challenge is that carbon emission reductions can result in leakage, which is an increase in carbon emissions elsewhere because of new carbon reduction efforts on a particular site.[73] However, carbon sequestration methods can also result in co-benefits that also sequester carbon but are hard to calculate. Because each sector has different technologies for calculating carbon stocks, sequestration, and emission reductions, these differences lead to measurements that can be inconsistent.

Virginia's Department of Environmental Quality uses a carbon-capture tool, the CarbOn Management & Emissions Tool (COMET), to consider the environmental benefits associated with conservation practices.[74] COMET analyzes best management practice data accounting for county-specific factors that would affect best management practices to calculate carbon sequestration and carbon co-benefit estimates, particularly soil carbon co-benefits. The Environmental Resilience Institute at the University of Virginia also participated in developing a model called the Global Change Assessment Analysis Model (GCAM-USA) to analyze carbon emissions and available nature-based opportunities for sequestration.[75] Calculations made using GCAM-USA show that expanding nature-based sequestration,

[72] DAVID NEIL BIRD ET AL., *Review of existing methods for carbon accounting 1-10* (2010), HTTP://WEBDOC.SUB.GWDG.DE/EBOOK/SERIEN/YO/CIFOR_OP/54.PDF

[73] *E.g.* efforts to mandate carbon reductions in the United States cause manufacturers to move production overseas, where lax regulatory schemes, older equipment, and transportation emissions can offset any reductions from the original effort.

[74] James Davis Martin, Chesapeake Bay Coordinator, Dep't of Env't Quality, Developing Carbon Sequestration Methodologies for the WIP (Nov. 3, 2021).

[75] *See* GLOBAL CHANGE ASSESSMENT MODEL (GCAM), Env't Protection Ag. (EPA), https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OAP&dirEntryId=212503 . *See also,* Needelman, Brian & Emmer, Igino & Emmett-Mattox, Stephen & Crooks, Stephen & Megonigal, Patrick & Myers, Doug & Oreska, Matthew & McGlathery, Karen. *The Science and Policy of the Verified Carbon Standard Methodology for Tidal Wetland and Seagrass Restoration*. 41 ESTUARIES AND COASTS. 2159 (2018).

such as reforestation, improved soil health, or blue carbon, accompanied by biomass energy with carbon capture and storage (BECCS) technology[76] can help Virginia achieve net negative carbon emissions.[77]

Carbon Credits & Offsets

Carbon stocks are traded on a carbon market as an environmental commodity in the form of credits and offsets. One carbon credit represents the reduction, avoidance, or removal of one metric ton of carbon dioxide and is calculated from an emissions baseline. Critically, researchers must make assumptions in the calculation of the baseline, and these can vary significantly between models. Carbon credits may be purchased to offset carbon emissions in response to a regulatory climate obligation or voluntary climate pledge. Because carbon markets are global, the use of offsets reduce total carbon emissions. However, offsetting may not reduce local air pollution.[78]

One challenge is managing and ensuring the quality of the carbon credit. Certain factors apply in characterizing the quality of carbon reductions. One of the most important factors is the consideration of additionality. The carbon reduction that is used to generate the credit must be additional to carbon reduction activities conducted in the absence of an incentive. Higher quality carbon credits consist of the removal of carbon dioxide over a longer period of time. The permanence of carbon sequestration eliminates the possibility of reintroduction of the captured carbon into the atmosphere. The accounting of the carbon credit must be accurate, transparent, and from a credible standard-setting body to ensure the high quality of the carbon credit.[79] Overall, the carbon credit should do no net harm in the process of benefitting the climate through negative environmental or social impacts.[80]

Carbon Markets

A carbon market exists to provide for trading allowances or carbon credits in response to a cap or constraint on carbon emissions.[81]

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[76] *See* Mariliis Lehtveer and Anna Emanuelsson. *BECCS and DACCS as Negative Emission Providers in an Intermittent Electricity System: Why Levelized Cost of Carbon May Be a Misleading Measure for Policy Decisions*. 3 FRONT. CLIM. 15 (2021), https://www.frontiersin.org/articles/10.3389/fclim.2021.647276/full

[77] *See, e.g.* J. M. Edmonds, *et al*. *An Integrated Assessment of Climate Change and the Accelerated Introduction of Advanced Energy Technologies.* 1 MIT. ADAPT. STRATEGIES 311 (1997), https://link.springer.com/article/10.1023/B:MITI.0000027386.34214.60

[78] *See* Lejano Raul P., Kan Wing Shan, Chau Ching Chit. *The Hidden Disequities of Carbon Trading: Carbon Emissions, Air Toxics, and Environmental Justice*. 8 FRONTIERS ENV. SCI. 215 (2020), HTTPS://WWW.FRONTIERSIN.ORG/ARTICLE/10.3389/FENVS.2020.593014

[79] Lejano, *supra* note 78*.*

[80] J. Wilcox, B. Kolosz, & J. Freeman, CARBON DIOXIDE REMOVAL PRIMER (2021), https://cdrprimer.org/.

[81] *See infra* Appendix F, Meeting Presentations. Pam Kiely, ASSOC. VICE PRESIDENT, U.S. CLIMATE, ENV'T DEF. FUND, Carbon Markets: High-Level Overview (November 3, 2021).

Regulatory or Compliance Markets

The regulatory or compliance carbon market applies when international, federal, state, or local law imposes a climate obligation on companies or countries.[82] The mandated cap on carbon emissions ensures that, together, all emitters stay within a carbon budget. Allowances, which only apply to the regulatory market, are the legal right to emit one metric ton of carbon dioxide or an equivalent greenhouse gas and are issued by the regulator, with the number of issued allowances declining over time. This cap-and-trade program, or emissions trading system (ETS), creates supply and demand for emissions allowances and a market price for greenhouse gases.[83] Entities participating in the compliance market have a legal requirement to obtain and surrender allowances.[84]

A carbon credit or offset is generally understood as the equivalent of an allowance that a regulated entity can purchase in a regulated market if they are going to exceed their carbon budget, or can potentially sell if they have generated them by emitting less than their assigned allowance.[85] In a compliance market, a government entity certifies carbon credits for quality, permanence, and equivalence to carbon allowances. A voluntary standard-setting body also can certify credits with relevant approvals. Credits may be generated by emitters in the sense of unused allowances, or by third parties in a variety of ways. A common type of carbon credit is forest carbon, often involving the conservation or planting of forest lands, based on calculations of the amount of carbon that forests take in from the atmosphere in the form of CO^2 via respiration and convert to biomass.[86] The certification process for a carbon credit involves verifying the amount of carbon sequestered, with additional parameters based on factors such as risk of conversion (e.g., a wildfire burning a forest), climate change and weather events, and the length of time the carbon will remain "locked up" and unable to return to the atmosphere.[87]

Regulatory markets tend to be stable, which creates long-term certainty in the levels of carbon emission reductions. Stability creates demand for carbon credits and offsets over time and can lead to more accurate carbon pricing. Compliance markets create pressure to ensure the integrity of credits and offsets that can be used to augment capped emission allowance budgets, which in turn encourages the voluntary market to do the same. Regulatory markets also can raise revenue to invest in other mitigation activities besides direct offsets. For example, California's statewide cap-and-trade program enabled significant investments in preserving, restoring, and planting forests and reducing emissions from rice cultivation.[88]

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[82] INTERNATIONAL SWAPS AND DERIVATIVES ASSOCIATION (ISDA), *Legal Implications of Voluntary Carbon Credits.* December 2021, page 7. https://www.isda.org/a/38ngE/Legal-Implications-of-Voluntary-Carbon-Credits.pdf

[83] *See generally* ENVIRONMENTAL PROTECTION AGENCY, *What is Emissions Trading?* (updated July 8, 2021). https://www.epa.gov/emissions-trading-resources/what-emissions-trading.

[84] ISDA*, supra* note 82.

[85] *Id.* at 10.

[86] Mendelsohn, Robert O. *et al. A framework to ensure that voluntary carbon markets will truly help combat climate change*. THE BROOKINGS INSTITUTION. September 16, 2021, https://www.brookings.edu/research/a-framework-to-ensure-that-voluntary-carbon-markets-will-truly-help-combat-climate-change/

[87] Mendelsohn, *et al. supra* note 85.

[88] ISDA*, supra* note 82 *: e.g. "*New [Voluntary Credit Market]s emerged [after 2010] to facilitate trading of two types of credits: those for reducing emissions and those for capturing carbon already in the atmosphere and either storing

Voluntary Markets

Voluntary carbon markets can be a solution for entities that voluntarily elect to meet climate goals through the use of certified carbon credits to offset emissions. Unlike the compliance market, voluntary markets are not regulated, and credits are certified by nongovernmental registries.[89] The quality of the credits in a voluntary market can be perceived as of lower value than in a regulatory market because the certification processes vary and are less-scrutinized.[90] However, voluntary markets can also provide opportunities to test new types of carbon sequestration projects and fund novel projects.[91] Increasingly, more entities are entering the voluntary market and there is widespread public impetus to reduce carbon impacts.[92]

Voluntary markets are important in mitigating the effects of atmospheric carbon dioxide in areas where no regulations exist.[93] These markets can enable innovation and encourage public and private sector investments. Through participation in a voluntary market, companies can take immediate steps to reach their climate pledges so long as the credits are accurately and consistently accounting for carbon offsets.[94]

Advantages and Challenges of Voluntary Carbon Markets

Advantages	Challenges
Virginia already has awards credits for BioFuel and Green Job Creation→ Framework can be adapted for Carbon Tax Credits	Administration will have to fund upfront cost of verifying cases of carbon sequestration to avoid unjust awarding of tax credits
Revenue generated from taxed carbon emissions → put towards future research & development of other carbon sequestration project	Large businesses may be better equipped to sequester carbon →they may be disproportionately awarded carbon tax credits if there is a cap on credits to be awarded annually
Encourages further carbon sequestration and alternative energy and fuel usage, while disincentivizing emissions	Companies may pollute out of state or elsewhere to avoid being taxed extra for emissions
Provides private land-owners and public businesses the opportunity to engage in carbon sequestration and benefit monetarily	

it underground or embedding it in other products (such as concrete). Forestry and land use projects, which capture carbon, so far have been one of the larger categories of voluntary carbon projects."

[89] ISDA, *supra* note 82 at 9.

[90] Mendelsohn, *et al. supra* note 85: "Critics of [Voluntary Credit Market]s, however, claim that they are in effect a form of greenwashing, enabling companies or other entities to sell credits for carbon reduction efforts they would have undertaken anyway. If so, the sellers and the buyers are taking credit (pun partially intended) for being environmentally responsible when in fact they are doing nothing to mitigate the climate change problem."

[91] ISDA, *supra* note 82 at 8.

[92] *Id.* at 7.

[93] Mendelsohn, *et al. supra* note 85.

[94] *Id. See also* United Nations Environment Programme and International Union for Conservation of Nature, *Nature-based solutions for climate change mitigation*. Nairobi and Gland 31 (2021), https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/37318/NBSCCM.pdf.

Other methods of financing carbon capture can be utilized to further encourage net carbon storage. Carbon tax credits generate tax reductions which can be traded or sold based on measurable amounts of carbon that have been captured and sequestered, or alternatively a program can impose fees for carbon emitted. These types of tax credits may or may not be tied to the standard carbon allowance/offset of one metric ton of carbon, but are generally based on practices that limit, lower, or offset carbon emissions. As an example, in 1991 Sweden issued a carbon tax that charged approximately USD $38 per metric ton of carbon emitted. This tax was increased to approximately USD $136 in later years. As result, between 1991-2015 Sweden recorded a 20% decrease in carbon emissions.[95]

Carbon tax credits can also offer a unique opportunity to incentivize both small and large landowners to become involved in carbon sequestration, in addition to governments and industry. Virginia already supports programs that award tax credits for the creation of green jobs and biofuel.[96] Challenges that should be addressed include transparency and verification of sequestration strategies used (specifically addressing concerns such as additionality) within a carbon tax credit program, which would require additional funding, capacity, and authority for the oversight agency.

[95] *See* Jonsson, et al., *Looking Back on 30 Years of Carbon Taxes in Sweden*, 727 FISCAL FACT 1 (Sept. 2020), https://taxfoundation.org/sweden-carbon-tax-revenue-greenhouse-gas-emissions/.
[96] Va. Code Ann. §§ 58.1-439.12:05, 58.1-439.12:02.

Appendix E: Reference Materials

Healthy Forests

Bill Anderegg et al., *Improved forest management, afforestation, and reforestation*, *in* CARBON DIOXIDE REMOVAL PRIMER, (Jennifer Wilcox et al. eds., 2021).

Bonnie Waring et al., *Forests and Decarbonization – Roles of Natural and Planted Forests*, FRONTIERS FOR GLOB. CHANGE (May 8, 2020), https://www.frontiersin.org/articles/10.3389/ffgc.2020.00058/full.

Carbon Sequestration in VA, VA. PLACES, http://www.virginiaplaces.org/climate/carbonsequestration.html#one .

Chesapeake Conservancy, *Chesapeake Bay Restoration Efforts in Virginia Provide Climate Change Benefits*, (Aug. 4, 2021), https://www.chesapeakeconservancy.org/2021/08/04/chesapeake-bay-restoration-efforts-in-virginia-provide-climate-change-benefits/.

Gordon B. Bonan, *Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests*, 320 SCIENCE 1444, 1444 (2008).

Julia Le Noë et al., *Modeling and empirical validation of long-term carbon sequestration in forests (France, 1850-2015)*, GLOB. CHANGE BIOLOGY 2421, 2422-31(2020).

Kenneth R. Richards & Robert N. Stavins, *The Cost of U.S. Forest-based Carbon Sequestration*, CTR. FOR CLIMATE & ENERGY SOLS., (Jan. 2005), https://www.c2es.org/document/the-cost-of-u-s-forest-based-carbon-sequestration/.

PennState Extension, *How Forests Store Carbon*, (Sept. 24, 2020), https://extension.psu.edu/how-forests-store-carbon.

Green Communities and Natural Infrastructure

Alexis Schaffler & Mark Swilling, *Valuing Green infrastructure in an urban environment under pressure – The Johannesburg case*, 86 ECOLOGICAL ECONS. 246, 254-55 (2013).

Ana Luisa Soares et al., *Benefits and costs of street trees in Lisbon, Portugal*, 10 URB. FOREST & URB. GREENING 69, 72-73 (2011).

Bonnie L. Keeler, *Social-ecological and technological factors moderate the value of urban nature*, 2 NATURE SUSTAINABILITY 29-38 (2019).

DAN M. KURN ET AL., THE POTENTIAL FOR REDUCING URBAN AIR TEMPERATURES AND ENERGY CONSUMPTION THROUGH VEGETATIVE COOLING 5-6 (1994).

ERIK ANDERSSON ET AL., DOUBLE INSURANCE IN DEALING WITH EXTREMES: ECOLOGICAL AND SOCIAL FACTORS OF MAKING NATURE BASED SOLUTIONS LAST 54,60-61 (Nadja Kabish et al. 2017).

Hashem Akbari et al., *Peak power and cooling energy savings of shade trees*, 25 ENERGY & BLDGS. 139, 139-148 (1998).

James Corner, *Landscape City: Infrastructure, Natural Systems and City-Making*, 90 ARCHITECTURAL DESIGN 88, 90-93 (2020).

Krystal Noiseux & Mark E. Hostetler, *Do Homebuyers Want Green Features in Their Communities?*, 42 Env't & Behav. 551, 567-68 (2010).

MICHAEL BOYER & ERICA PENN, TIDAL TURMOIL: ENVIRONMENTAL JUSTICE AND SEA LEVEL RISE IN HAMPTON ROADS: NORFOLK CASE STUDY 2 (Va. Coastal Pol'y Clinic 2013).

Mark Benedict & Edward T. MacMahon, *Green Infrastructure: Smart Conservation for the 21st Century*, 20 Renewable Res. J. 12, 12-13 (2002).

Martina Artmann et al., *How smart growth and green infrastructure can mutually support each other – A conceptual framework for compact and green cities*, 96 ECOLOGICAL INDICATORS 10, 11 (2019).

R. Lal, *Soil carbon sequestration impacts on global climate change and food security*, 304 SCIENCE 1623, 1623-26 (2014).

Ryan Winston et al., *Maintenance measures for preservation and recovery of permeable pavement surface infiltration rate – The effects of street sweeping, vacuum cleaning, high pressure washing, and milling*, 169 J. Evn't Mgmt. 132, 134 (2016).

Shuang Zhao et al., *Environmental Justice and Green Schools – Assessing Students Communities' Access to Green Schools*, 100 SOC. SCI. Q. 2223, 2236-37 (2019).

STRATUS CONSULTING INC., A TRIPLE BOTTOM LINE ASSESSMENT OF TRADITIONAL AND GREEN INFRASTRUCTURE OPTIONS FOR CONTROLLING CSO EVENTS IN PHILADELPHIA'S WATERSHEDS (2009), https://www.epa.gov/sites/default/files/2015-10/documents/gi_philadelphia_bottomline.pdf.

U.S. Dep't of Agric., *Forest management for carbon sequestration, mitigation, and climate adaptation*, https://www.climatehubs.usda.gov/hubs/northern-forests/topic/forest-management-carbon-sequestration-mitigation-and-climate .

U.S. DEP'T OF AGRIC., MEASUREMENT GUIDELINES FOR THE SEQUESTRATION OF FOREST CARBON (2007).

U.S. Env't Prot. Agency, *Basic Information about Nonpoint Source (NPS) Pollution*, https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution .

Vivek Shandas & W. Barry Messer, *Fostering Green Communities through Civic Engagement: Community-Based Environmental Stewardships in the Portland Area*, 74 J. AM. PLAN. ASS'N 408, 412-413 (2008).

YU JOE HUANG ET AL., THE WIND-SHIELDING AND SHADING EFFECTS OF TREES ON RESIDENTIAL HEATING AND COOLING REQUIREMENTS, 1403-05 (1990).

Bioeconomy

A. CHATTERJEE ET AL., *Role of Algae as a Biofertilizer*, *in* ALGAL GREEN CHEMISTRY 189 (2017).

Beth Daley, *Move over, corn and soybeans: The next biofuel source could be giant sea kelp*, THE CONVERSATION (Apr. 1, 2021), https://theconversation.com/move-over-corn-and-soybeans-the-next-biofuel-source-could-be-giant-sea-kelp-156728 .

BIOMASS RSCH. & DEV. BD., FEDERAL ACTIVITIES REPORT ON THE BIOECONOMY (2016).

Bozena Debska et al., *The impact of a bio-fertilizer on the soil organic matter status and carbon sequestration – results from a field-scale study*, 16 J. SOILS & SEDIMENTS 2335 (2016).

Caitlin McDermott-Murphy, *How a biofriendly fertilizer could offer a greener way to grow plants*, HARV. GAZETTE (Sept. 24, 2019), https://news.harvard.edu/gazette/story/2019/09/how-a-biofriendly-fertilizer-could-offer-a-greener-way-to-grow-plants/ .

Eduardo K. Mitter et al., *Rethinking Crop Nutrition in Times of Modern Microbiology: Innovative Biofertilizer Technologies*, FRONTIERSIN (Feb. 19, 2021), https://www.frontiersin.org/articles/10.3389/fsufs.2021.606815/full .

EUR. COMM'N, INNOVATING FOR SUSTAINABLE GROWTH: A BIOECONOMY FOR EUROPE (2012).

Gary Polakovic, *Unlocking kelp's potential as a major biofuel source*, SCI. DAILY (Mar. 2, 2021), https://www.sciencedaily.com/releases/2021/03/210302094053.htm .

James Philp, *Why the bioeconomy could be the future of sustainable manufacturing*, WORLD ECON. F. (Aug. 2, 2018), https://www.weforum.org/agenda/2018/08/bioeconomy-101-making-rubber-tyres-from-dandelions .

MARCY E. GALLO, CONG. RSCH. SERV., R46881, THE BIOECONOMY: A PRIMER (2021).

NAT'L ACADS.SCIS., ENG'G, AND MED., SAFEGUARDING THE BIOECONOMY (2020).

NATIONAL BIOECONOMY BLUEPRINT, EXEC. OFF. OF THE PRESIDENT (2012).

OECD, THE BIOECONOMY TO 2030: DESIGNING A POLICY AGENDA (2009).

OECD, MEETING POLICY CHALLENGES FOR A SUSTAINABLE BIOECONOMY (2018).

Sage Basri, *Kelp to Biofuel and Beyond for Mitigating Climate Change*, KLEINMAN CTR. FOR ENERGY POL'Y (Jan. 25, 2021), https://kleinmanenergy.upenn.edu/news-insights/kelp-to-biofuel-and-beyond-for-mitigating-climate-change/ .

THE WHITE HOUSE OFF. SCI. & TECH. POL'Y, SUMMARY OF THE 2019 WHITE HOUSE SUMMIT ON AMERICA'S BIOECONOMY (2019).

U.S. Biodiesel Plants, Biodiesel Magazine (last modified Dec. 14, 2021), http://www.biodieselmagazine.com/plants/listplants/USA/page:1/sort:state/direction:asc.

Blue Carbon

JAMES BEEVER III, ET AL., CLIMATE CHANGE VULNERABILITY ASSESSMENT AND ADAPTATION OPPORTUNITIES FOR SALT MARSH TYPES IN SOUTHWEST FLORIDA (June 30, 2012), https://www.epa.gov/sites/default/files/2019-05/documents/climate_change_vulnerability_assessment.pdf .

Blue Carbon, IUCN, https://www.iucn.org/resources/issues-briefs/blue-carbon.

Eelgrass, VA. INST. MARINE SCI., https://www.vims.edu/research/units/programs/sav/species/eelgrass.php .

EPA, COASTAL WETLANDS INITIATIVE: MID-ATLANTIC REV. (2015), https://www.epa.gov/sites/default/files/2015-04/documents/mid-atlantic-review.pdf .

Marianne Holmer, *Underwater Meadows of Seagrass Could be the Ideal Carbon Sinks*, SMITHSONIAN MAG. (Nov. 1, 2018), https://www.smithsonianmag.com/science-nature/underwater-meadows-seagrass-could-be-ideal-carbon-sinks-180970686/ .

Hanover Matz, *Current Threats to Coastal Seagrass Ecosystems*, UNIV. MIAMI SHARK RESEARCH (Mar. 18, 2015), https://sharkresearch.rsmas.miami.edu/current-threats-to-coastal-seagrass-ecosystems/ .

Protecting Coastal Blue Carbon Through Habitat Conservation, NOAA, https://www.fisheries.noaa.gov/national/habitat-conservation/protecting-coastal-blue-carbon-through-habitat-conservation .

Seagrass Restoration, VA. INST. MARINE SCI., https://www.vims.edu/research/units/programs/sav1/restoration/index.php .

Seagrass—Secret Weapon in the Fight Against Global Heating, UN ENV'T PROGRAMME (Nov. 1, 2019), https://www.unep.org/news-and-stories/story/seagrass-secret-weapon-fight-against-global-heating .

Shifts in Seagrass Species Composition: A Sentinel Indicator for Sea Level Rise and Climate Change, NCCOS, https://coastalscience.noaa.gov/project/seagrass-species-composition-indicator-sea-level-rise-climate-change/ .

Sebastiaan van de Velde et al., *Anthropogenic Disturbance Keeps the Coastal Seafloor Biogeochemistry in a Transient State*, 8 SCI. REPS. 1 (Apr. 3, 2018), https://www.nature.com/articles/s41598-018-23925-y .

Soil Carbon

Renee Cho, *Can Soil Help Combat Climate Change?*, COLUM. CLIMATE SCH. (Feb. 21, 2018), https://news.climate.columbia.edu/2018/02/21/can-soil-help-combat-climate-change .

Don Comis, *Glomalin: Hiding Place for a Third of the World's Stored Carbon*, USDA (Sept. 2002), https://agresearchmag.ars.usda.gov/2002/sep/soil .

Susan Cosier, *How Adding Rock Dust to Soil Could Help Get Carbon into the Ground*, YALE ENV'T 360 (Sept. 2, 2021), https://e360.yale.edu/features/how-adding-rock-dust-to-soil-can-help-get-carbon-into-the-ground .

Fact Sheet: Soil Carbon Sequestration, AM. U., https://www.american.edu/sis/centers/carbon-removal/fact-sheet-soil-carbon-sequestration.cfm (last updated June 24, 2020).

Katherine Hafner, *Carbon Hidden in Soil: Could Chesapeake Bay Restoration Methods be a Model for Blunting Climate Change?*, VA. PILOT (Aug. 12, 2021), https://www.pilotonline.com/news/environment/vp-nw-chesapeake-bay-climate-benefits-20210812-kgnmvbc7qrdv3ayqpty2ecqv74-story.html .

Mark Hertsgaard, *As Uses of Biochar Expand, Climate Benefits Still Uncertain*, YALE ENV'T 360 (Jan. 21, 2014), https://e360.yale.edu/features/as_uses_of_biochar_expand_climate_benefits_still_uncertain .

Andre Leu, *Pasture Cropping-The Innovative No-kill, No-till System Developed by Australian Farmers*, REGENERATION INT'L (Mar. 15 2021), https://regenerationinternational.org/2021/03/15/pasture-cropping-the-innovative-no-kill-no-till-system-developed-by-australian-farmers/ .

Emanuele Lugato et al., *Different Climate Sensitivity of Particulate and Mineral-Associated Soil Organic Matter*, 14 Nature Geoscience 295 (2021), https://www.nature.com/articles/s41561-021-00744-x .

Kenneth Olson et al., *Long-term effects of Cover Crops on Crop Yields, Soil Organic Carbon Stocks, and Sequestration*, 4 Open J. Soil Sci. 284 (2014), https://www.scirp.org/pdf/OJSS_2014082211341366.pdf .

David Pannell, *Soil Carbon Policy Faces Big Challenges*, 20 EUROCHOICES 46 (2021), https://onlinelibrary-wiley-com.proxy.wm.edu/doi/pdfdirect/10.1111/1746-692X.12323 .

Judith D. Schwartz, *Soil as Carbon Storehouse: New Weapon in Climate Fight?*, YALE ENV'T 360 (Mar. 4, 2014, https://e360.yale.edu/features/soil_as_carbon_storehouse_new_weapon_in_climate_fight .

Jack B. Smith, *California Compliance Offsets: Problematic Protocols and Buyer Behavior*, HARV. KENNEDY SCH. (Mar. 2019), https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/120_final.pdf .

HARLAN E. WHITE AND DALE D. WOLF, CONTROLLED GRAZING OF VIRGINIA'S PASTURES, VA. COOP. EXTENSION (2009), https://ext.vt.edu/content/dam/shenandoah_ext_vt_edu/files/ag/graze300/418-012.pdf .

EMILY WIGGINS, ET AL., CHESAPEAKE CONSERVANCY, CLIMATE BENEFITS OF CHESAPEAKE BAY RESTORATION IN VIRGINIA (July 2021), https://www.chesapeakeconservancy.org/wp-content/uploads/2021/08/Climate-Benefits-of-Chesapeake-Bay.pdf .

Carbon Markets

David Neil Bird et al., REVIEW OF EXISTING METHODS FOR CARBON ACCOUNTING (2010).

GLOBAL CHANGE ASSESSMENT MODEL (GCAM), Env't Protection Ag. (EPA), https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OAP&dirEntryId=212503

J. Wilcox, B. Kolosz, & J. Freeman, CDR PRIMER (2021).

Jack B. Smith, *California Compliance Offsets: Problematic Protocols and Buyer Behavior*, Harvard Kennedy School (M-RCBG Associate Working Paper Series No. 120, 2019).

James Davis Martin, Chesapeake Bay Coordinator, Dep't of Env't Quality, *Developing Carbon Sequestration Methodologies for the WIP* (Nov. 3, 2021).

Karen McGlathery, Dir., UVA Env't Resilience Inst., *Nature-Based Solutions for Carbon Removal Potential for Virginia.*

Pam Kiely, Assoc. Vice President, U.S. Climate, Env't Def. Fund, Carbon Markets: High-Level Overview (November 3, 2021).

Jonsson, et al. *Looking Back on 30 Years of Carbon Taxes in Sweden*. 727 FISCAL FACT 1 (Sept. 2020) https://taxfoundation.org/sweden-carbon-tax-revenue-greenhouse-gas-emissions/ .

Lejano, *et al*. The Hidden Disequities of Carbon Trading: Carbon Emissions, Air Toxics, and Environmental Justice. 8 FRONTIERS ENV. SCI. 215 (2020), https://www.frontiersin.org/article/10.3389/fenvs.2020.593014 .

Mariliis Lehtveer and Anna Emanuelsson. *BECCS and DACCS as Negative Emission Providers in an Intermittent Electricity System: Why Levelized Cost of Carbon May Be a Misleading Measure for Policy Decisions*. 3 FRONT. CLIM. 15 (2021).

United Nations Environment Programme and International Union for Conservation of Nature. *Nature-based solutions for climate change mitigation*. Nairobi and Gland (2021), https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/37318/NBSCCM.pdf .

Appendix F: Carbon Sequestration Task Force Meeting Presentations

Carbon Co-Benefits from Implementing the Commonwealth's Phase III WIP

JAMES MARTIN

DEQ-WATER PLANNING-OFFICE OF ECOLOGY

SIGNIFICANT CONTRIBUTIONS BY ARIANNA JOHNS

WIP III Background

On August 23, 2019 Virginia released its Chesapeake Bay TMDL Phase III Watershed Implementation Plan

- Culmination of 2 year planning effort
- Plan for BMPs to reduce Nitrogen and Phosphorus by 2025
- Local Engagement
  - 95 Local Governments,
  - 15 Planning District/Regional Commissions
  - 32 Soil and Water Conservation Districts
- Account for the load impacts of Growth and Climate Change through 2025
- Practice selection focused on Cost-Effectiveness and Co-Benefits

COMET

- CarbOn Management & Emissions Tool (COMET)
  - Online carbon-capture calculator
  - Estimates the environmental benefits associated with conservation practices
  - Farm - uses spatially-explicit data on climate and soils at field scale
  - Planner – Simplified Regional scale estimator
  - Uses NRCS best management practices

- Developed by USDA in partnership with Colorado State University
  - Dr. Adam Chambers

Additional Assumptions

- Utilized COMET model BMP data
- Averaging to County scale
- Bay BMP designations to NRCS Practices
- Calculations
  - CO_2e Sequestration (Climate Mitigation Co-benefits)
  - Soil Carbon (Soil Health & Climate Resiliency Co-benefits)

Best Management Practices Included

Cover Crops

Tillage Management

Prescribed Grazing

Soil Conservation Plans

Tree Planting

Land Retirement to Ag Open Space

Riparian Forest Buffers

Riparian Grass Buffers

Urban Tree Planting-Canopy

Urban Forest Planting

Wetland Restoration

Living Shorelines

Carbon Co-Benefit Estimates

Estimates of CO_2e and Soil Carbon are available
- by Year 2009-2020 and WIP III 2025 by Practice
- by Bay Watershed County

Practices verified to be on the ground in 2020
- About 1.1M acres of implemented BMPs
- 482,622 Tons CO_2e Sequestered
  - 84,909 Tons Soil Carbon Added

In 2025 with full implementation of the WIP III
- About 2.9M acres of planned BMPs
- 2,011,195 Tons CO_2e Sequestered
  - 228,094 Tons Soil Carbon Added

Carbon Sequestration Co-Benefits in Context

What is 2 Million Tons of CO_2e?

- 1.5% of greenhouse gas emissions in Virginia (2014 estimate)
- 4% of transportation generated CO_2 emissions in Virginia (2018 estimate)
  - Equivalent of about 400,000 cars off of the road for a year
- Growing 33 million tree seedlings for 10 years
  - About 4 trees per person in the Commonwealth

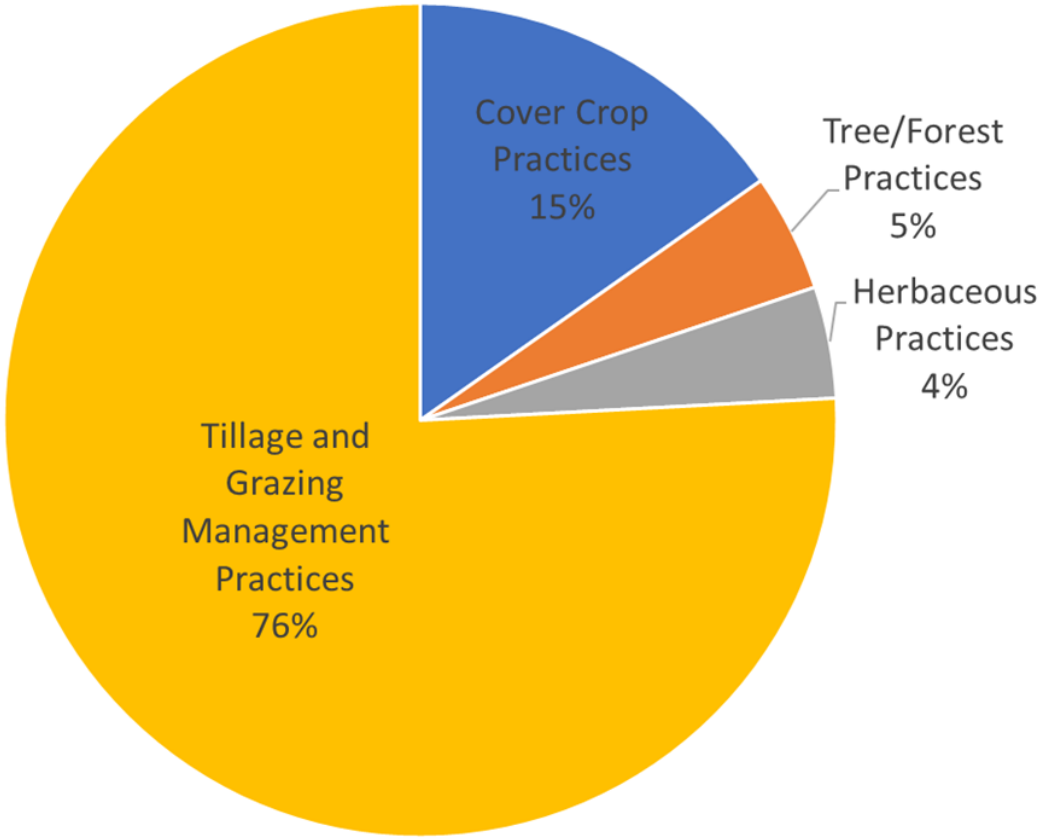
Soil Carbon Co-Benefits

What is 228,000 Tons of Soil Carbon?

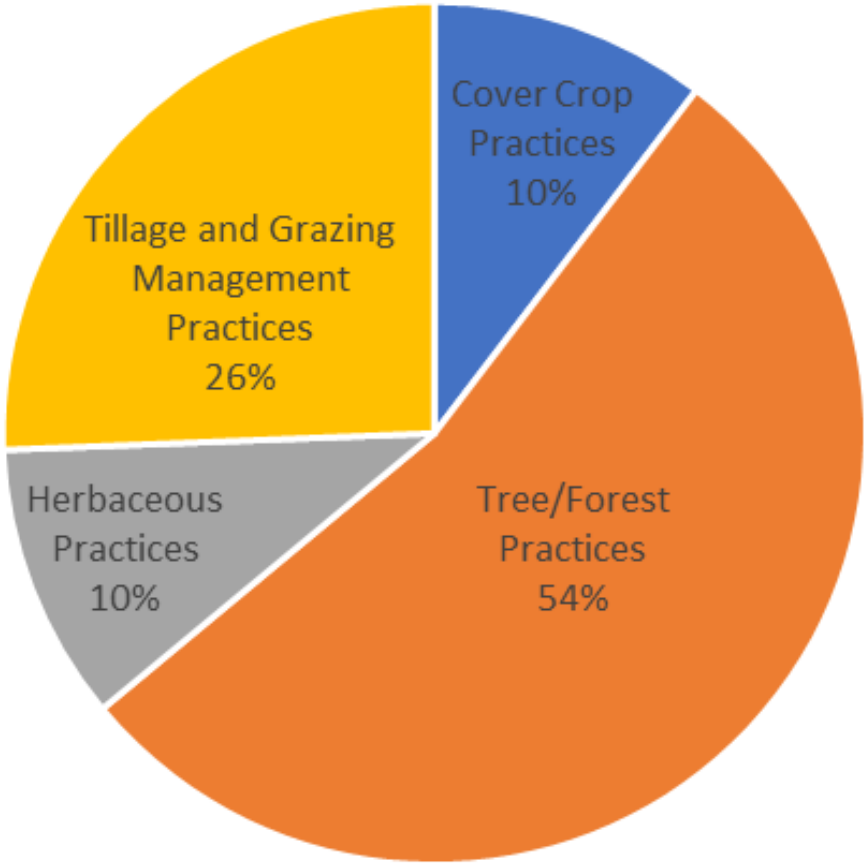
- Mineral, Residue, Humus, and Living
- Soil Microbiome
- Increased Water Retention – Less Runoff
- Increased Water Retention – Resilience to Drought
- Improved Soil Health
- Improved Productivity

In 2025 with full implementation of the WIP III
CO_2e Sequestered

About 2.9M acres of planned BMPs

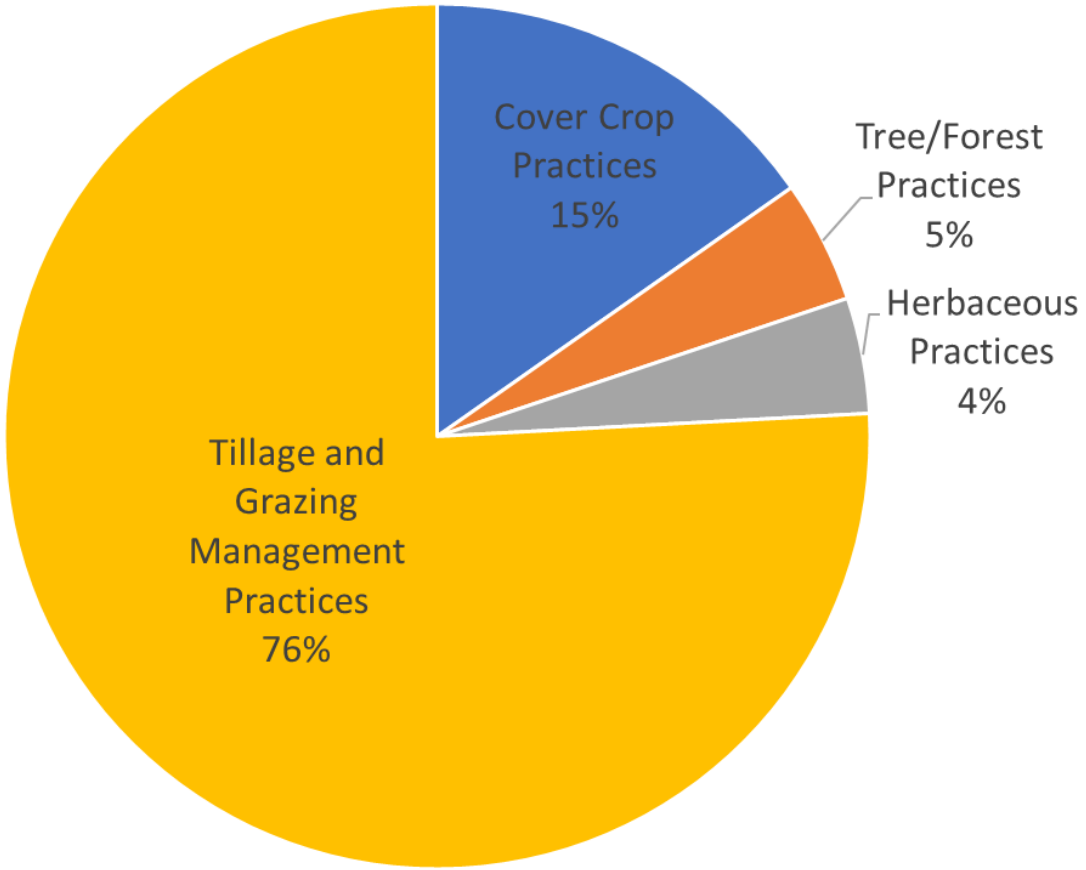


2,011,195 Tons CO_2e Sequestered

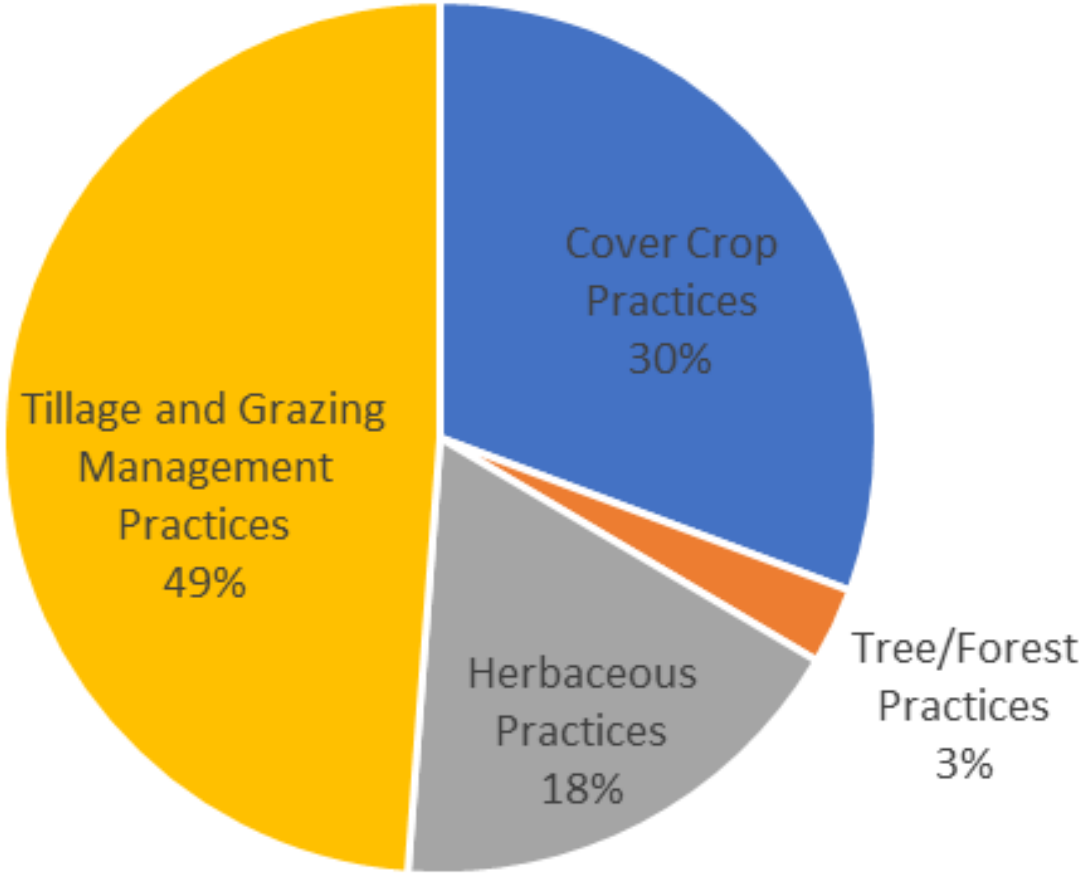


In 2025 with full implementation of the WIP III **Soil Carbon**

About 2.9M acres of planned BMPs



228,094 Tons Soil Carbon



Carbon Co-Benefits from Implementing the Commonwealth's Phase III WIP

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Virginia GHG Emissions Inventory and Sequestration

GHG Inventory Methods and Results

Erin Lasher
GHG Inventory Specialist
Virginia Department of Environmental Quality
November 3, 2021

Methodology

- EPA's State Inventory Tool (SIT) is used for the entire inventory, including carbon removal (sequestration)
  - It is an Excel-based series of workbooks
  - Default data is provided, with options for states to add/edit data as they see fit
- Sequestration emissions are calculated in the Land Use, Land-Use Change, and Forestry workbook
  - Module looks at both emissions and sinks for various land uses
  - Aligns with national inventory methodology

DEQ

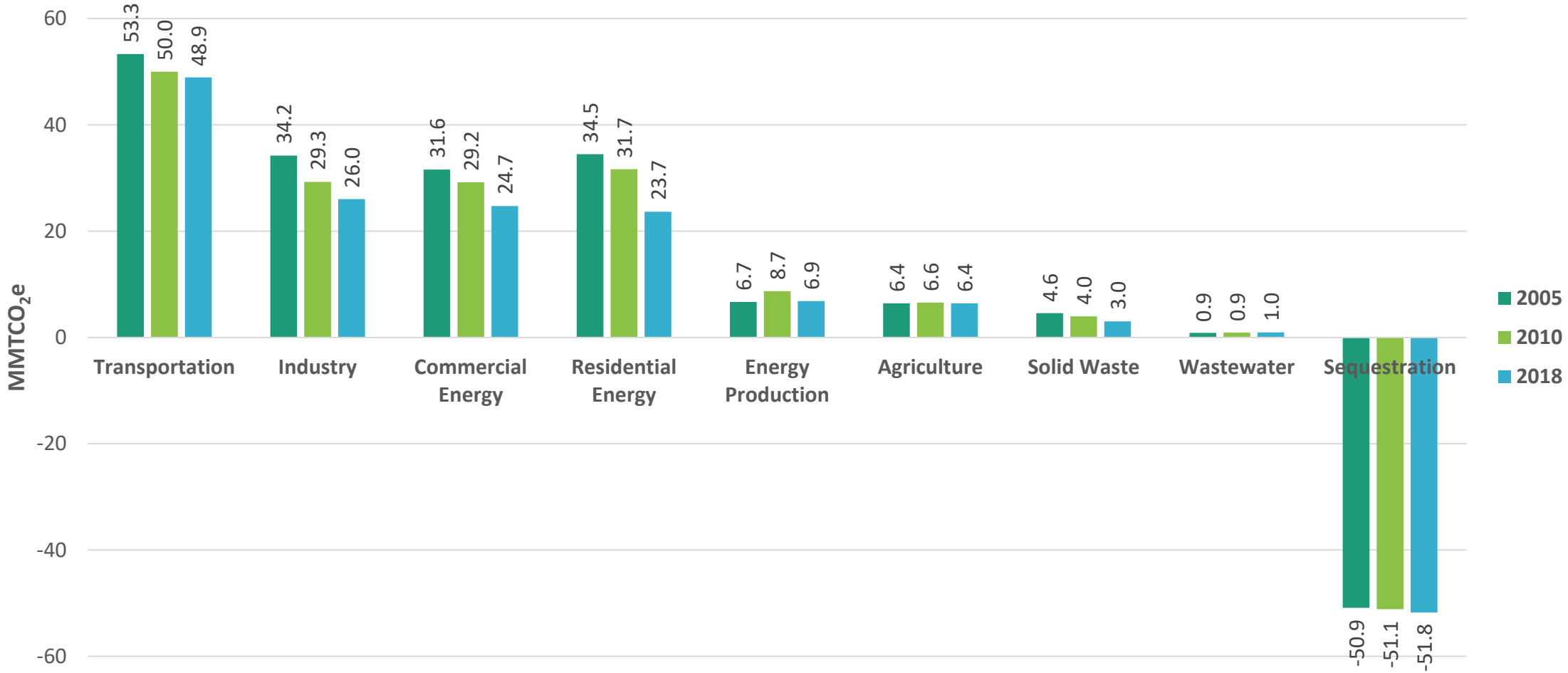
Methodology

- Module provides emissions data for:
  - Forest land (including land converted to and from forest)
    - Aboveground and belowground biomass
    - Deadwood and litter
    - Soil
  - Urban trees
  - Landfilled yard trimmings and food scraps
  - Settlement and agricultural soils

Data Input	Default Data Source
Settlement soils data	Association of American Plant Food Control Officials and The Fertilizer Institute
Landfilled yard trimmings and food scraps	EPA
Forest carbon flux	US Forest Service (USFS) annual report https://www.nrs.fs.fed.us/pubs/62418
Urban tree coverage	USFS
Agricultural soil carbon flux	EPA

DEQ

2005, 2010 and 2018 Emissions by Sector



DEQ

Total and Net Emissions

- **Total emissions – Sequestration = Net Emissions**

2005: 172.1 $MMTCO_2e$ - 50.9 $MMTCO_2e$ = 121.2 $MMTCO_2e$

2010: 160.3 $MMTCO_2e$ - 51.1 $MMTCO_2e$ = 109.2 $MMTCO_2e$

2018: 140.6 $MMTCO_2e$ - 51.8 $MMTCO_2e$ = 88.8 $MMTCO_2e$

DEQ

Gaps and Opportunities for Improvement

- 2005, 2010, and 2018 inventories used default data for this sector
  - We do not have data to supplement this sector at this time
- Gaps within SIT
  - Most data is entered in terms of carbon flux
  - Module is limited on the type of data that can be entered
    - For example, there is no option to enter data such as hectares of forest and species composition
  - Land-based only—blue carbon is not accounted for
- Areas of improvement
  - Urban tree coverage data
  - Synthetic fertilizer use data
  - Yard trimmings and food scrap data
  - Explore possible use of a different tool for forestry and/or soils portion

DEQ

CURRENT CLIMATE MITIGATION INITIATIVES

- DEQ actively working to reduce GHG emissions:
  - Participation in Regional Greenhouse Gas Initiative (RGGI)
  - Further power sector reductions from VA Clean Economy Act
  - Volkswagen Mitigation Trust ($93 million)
  - Diesel Emission Reduction Act (DERA)
  - Clean cars – regulation pending
  - GHG emissions reporting – regulation pending
  - Methane from natural gas infrastructure – regulation pending
  - Hydrofluorocarbons (HFCs) – regulation complete

Carbon Markets: High-Level Overview

Pam Kiely
Associate Vice President, U.S. Climate
November 3, 2021

EDF
ENVIRONMENTAL DEFENSE FUND®
Finding the ways that work

Goals of discussion:

- To provide an overview of compliance and voluntary carbon markets
- To understand what constitutes a high-quality carbon credit or offset
- To take a closer look at both compliance markets and voluntary markets
- To explore some of the opportunities and limitations of voluntary markets and compliance markets

Carbon Markets 101

Terminology

- **Carbon pricing:** An approach that imposes a price on carbon emissions to incentivize emission reductions or removals. E.g., emission trading systems (ETS), carbon credits, carbon taxes, and internal carbon pricing.

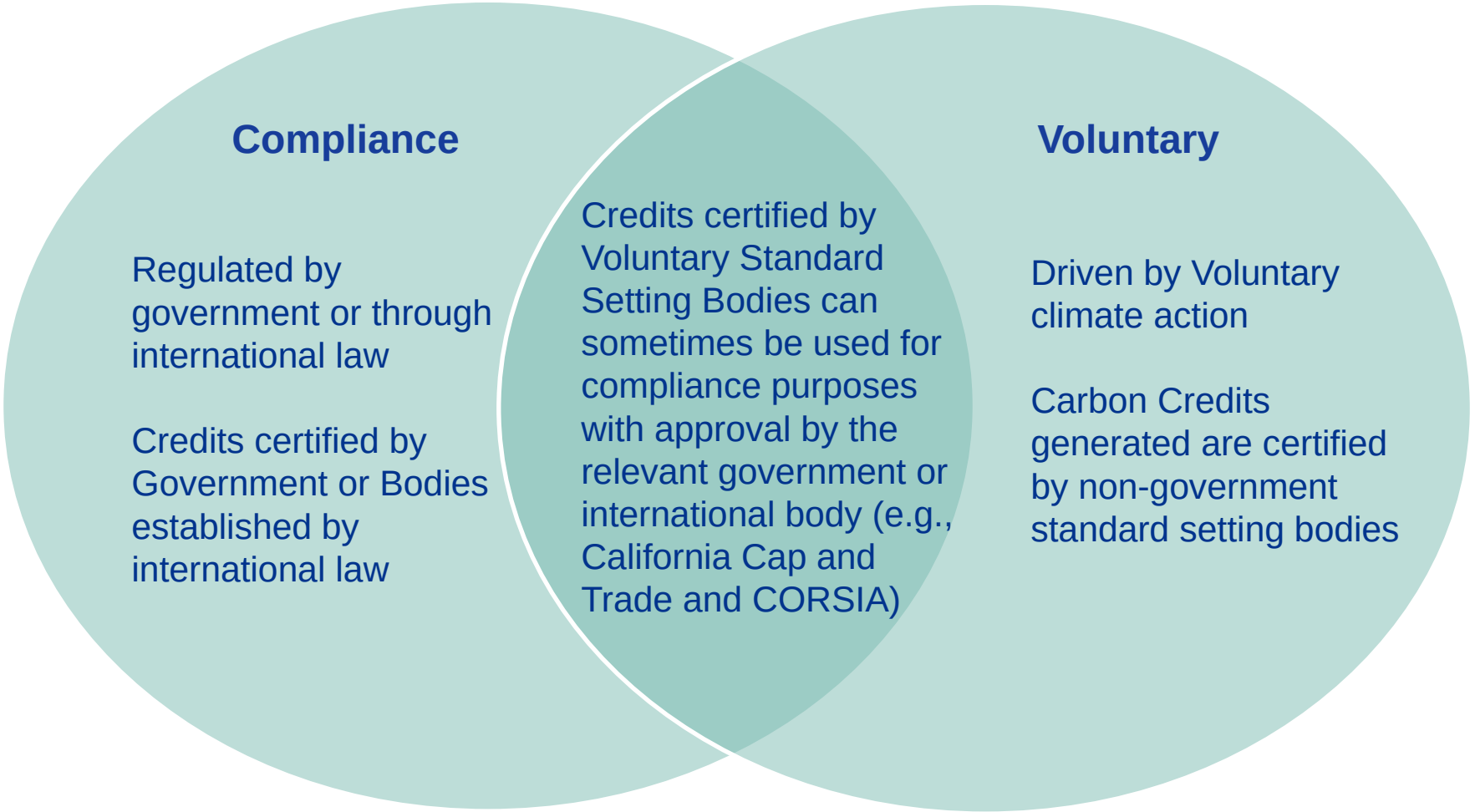
- **Carbon market:** A market for trading allowances and/or carbon credits in response to a cap or constraint on emissions.
  - A **mandatory or compliance carbon market** exists when companies or countries trade units to satisfy a climate obligation established by international, federal, state or local law.
  - **Voluntary carbon markets** operate outside of a compliance framework. Companies use carbon credits certified in the voluntary carbon market to satisfy voluntary climate goals such as carbon neutrality goals or net zero goals.

- **Allowance:** Term used for a certificate or permit that represents the legal right to emit one tonne (metric ton) of carbon dioxide or equivalent greenhouse gas. (applicable in mandatory markets)

- **Carbon credit or offset:** An environmental commodity that represents the reduction, avoidance or removal of 1 ton of CO2e, compared to a projected baseline (this is offset as a noun).
  - **Offsetting**: The use of carbon credits sourced outside of a country/state/region's borders or from outside of a company's supply chain to meet a regulatory climate obligation or voluntary climate pledge (*offset* as a verb).

Source: Carbon Pricing Leadership Coalition, 2021, Report of the Task Force on Net Zero Goals & Carbon Pricing.

Compliance vs. Voluntary Markets



Source: Carbon Pricing Leadership Coalition, 2021, Report of the Task Force on Net Zero Goals & Carbon Pricing.; EDF, 2021, Mobilizing Voluntary Carbon Markets to Drive Climate Action.

Carbon Credits/Offsets

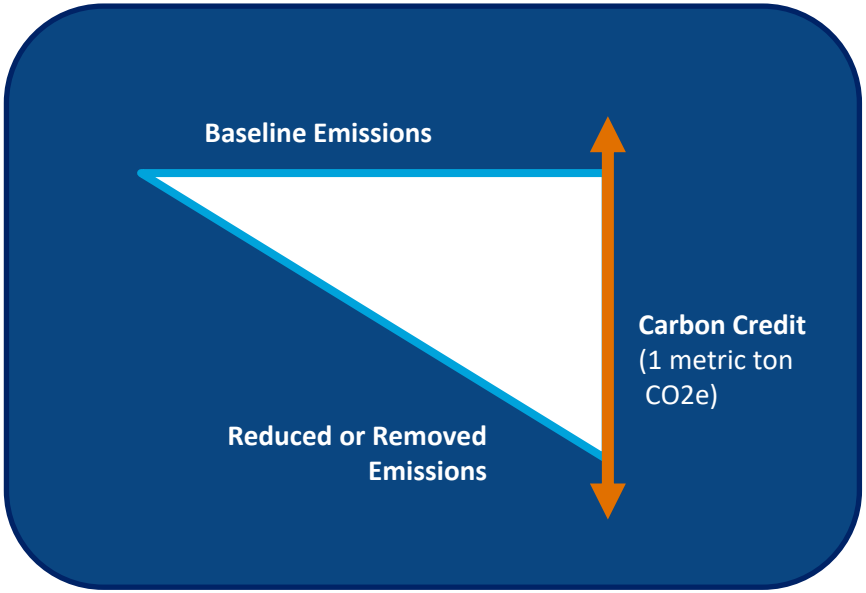
A deeper dive into carbon credits/offsets

An emission unit issued by a carbon crediting program, representing an emission reduction or removal of greenhouse gases.

Carbon credits are calculated from a baseline scenario in which the incentive provided by the credit price would not be present.

Credits can be used to compensate for emissions that have not yet been reduced or eliminated in a company's operations or value chain.

Credits/offsets are used in both regulatory and voluntary carbon markets.



What defines quality in a carbon credit?

Key Dimensions of Credit Quality

1. Additional

- Credits must be **“additional beyond GHG emission reductions or removals that would otherwise occur without revenue from credits”**
  - In other words, the incentive from carbon credits must have led to the activity that generates reductions or removals
  - If not, the carbon credit does not represent any **additional** benefits for the atmosphere beyond what would have otherwise happened
- Assessing additionality can be challenging – however, it is essential for ensuring credits represent actual emissions reductions

EXAMPLE:

A landowner can choose to cut down forest on their property or keep it standing. If revenue from carbon credits results in the landowner preserving the forest, the credits are additional.

If the landowner was required by law to keep the forest standing, the credits did not provide an incentive and did not result in an **additional** climate benefit.

* Definition via TSVCM

2. Permanent

- Credits should represent carbon reductions or removals that are **durable and protected over time**
- Emissions reduced or removed can sometimes be emitted back into the atmosphere, resulting in climate benefits that are only temporary
- Permanence is addressed in different ways by different project types
    - Some projects inherently store or reduce emissions permanently, while others must take steps to ensure reversal risks are managed

EXAMPLE:

Events like a wildfire could damage a forest protected through the sale of carbon credits, emitting the carbon previously stored in that forest.

Carbon credit programs can plan for and address these risks. For example, setting aside an extra "buffer pool" of credits that is big enough to compensate for potential reversals can help mitigate risks of impermanence.

3. Monitored, Reported and Verified

- **Accurate, transparent, and credible accounting** is also critical for carbon credit quality
- Credits should be associated with a recognized and credible standard-setting body that has robust and transparent governance
- Credits should also be validated or verified by an accredited, third-party entity

4. Accounts for Leakage

- In some cases, activities that reduce or remove emissions can have other impacts, potentially increasing emissions elsewhere. This is known as **leakage**
    - For example, a forest protection project could inadvertently push illegal logging into other areas, resulting in emissions from deforestation in new locations
- Credit programs should rigorously monitor and mitigate potential leakage

5. Does No Net Harm

- Climate benefits provided by credits cannot come at the expense of negative environmental or social impacts
- Safeguards must exist to ensure credits enable conditions for a just and sustainable low carbon transition
- At minimum, credits should do **no net harm**, and include impact assessments, stakeholder consultations, and grievance mechanisms

EXAMPLE:

A new forest protection program might be interested in selling carbon credits.

In order to do so, it would need to justify to crediting programs and future buyers that it undertook rigorous community impact assessments, obtained free, prior and informed consent, and has robust ongoing mechanisms for community feedback (among other required safeguards).

Compliance Markets

Compliance Markets: a closer look

Compliance markets are driven by mandated caps on greenhouse gas emissions. The concept is also known as an emissions trading system (ETS) or cap-and-trade program.

An overall cap on emissions limits the supply of allowances available. The cap is an essential feature of the program.

- **By creating supply and demand for emissions allowances, the ETS establishes a market price for GHGs**
- The overall cap helps ensure that the required emission reductions will take place to keep emitters (in aggregate) within their pre-allocated carbon budget.

Allowances and offsets within compliance markets

Regulated entities face a legal requirement to obtain and surrender **allowances**, which are permits to emit one ton of greenhouse gas emissions.

Entities may also purchase **offsets** – credits for emissions reductions or removals in uncovered sources and sectors – to meet a portion of their compliance obligation.

Examples of existing compliance markets

California's cap-and-trade program

- A **statewide** cap-and-trade program.
- First compliance period in 2013.
- One of the largest multi-sectoral emissions trading systems in the world, and the first multi-sectoral ETS in the U.S.
- **Covers over 80% of the state's emissions.**
- Linked to the broader Western Climate Initiative.

Examples of existing compliance markets

The Regional Greenhouse Gas Initiative (RGGI)

- A cooperative, mandatory emissions trading program with participation by eleven Northeastern and Mid-Atlantic states.
- First compliance period began in 2009.
- The first **regional** cap-and-invest initiative to be implemented in the United States.
- **Covers emissions from the electricity sector.**

In a compliance market, high-quality offsets can function as a tool for:

Containing compliance costs

Expanding mitigation incentives beyond the covered sectors

Generating co-benefits

The Voluntary Market

The Voluntary Market: a closer look

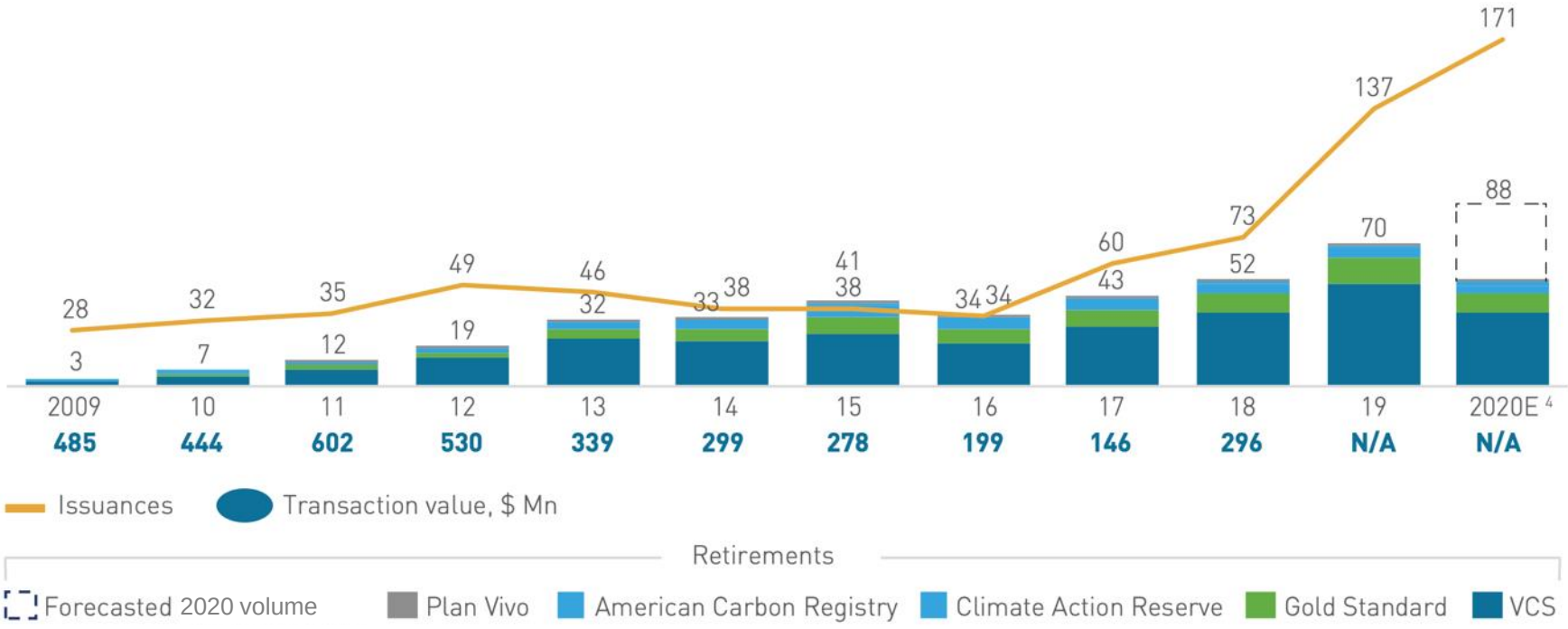
- The voluntary carbon market enables businesses, governments, NGOs, and individuals to *voluntarily* offset their emissions by purchasing carbon credits.
- Over 1,000 companies have made net-zero commitments, including over 60 fortune 500 companies.
- Credits certified by NGO third parties "*The Registries*"
- Quality of the credits only as good as the methodology used in the certification process.
- Direct reductions also critical

How big is the voluntary carbon market?

Market Size by Traded Volumes of Voluntary Carbon Offsets, pre-2005 to 31 August 2021

Via Forest Trends' Ecosystem Marketplace. 2021. 'Market in Motion', State of Voluntary Carbon Markets 2021, Installment 1. Washington DC: Forest Trends Association: https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2021/

How big is the voluntary carbon market?



(1) One carbon credit represents one ton of carbon dioxide equivalent (CO_2e) avoided or sequestered. (2) Issuances and retirements based on registry data and McKinsey analysis; transaction value based on Ecosystem Marketplace 2019 report. (3) $MtCO_2e$ = metric tons of carbon dioxide equivalent. (4) Based on YTD volumes until end of September 2020 (ie, 114 million for issuances and 63 million for retirements); we project 2020 FY volumes based on extrapolation in line with historical seasonality (last 5 years); this does not reflect any potential impact related to Covid-19. Source: Ecosystem Marketplace; press search; data from VCS, GS, CAR, ACR and Plan Vivo market registries; McKinsey analysis

Where are credits sourced?

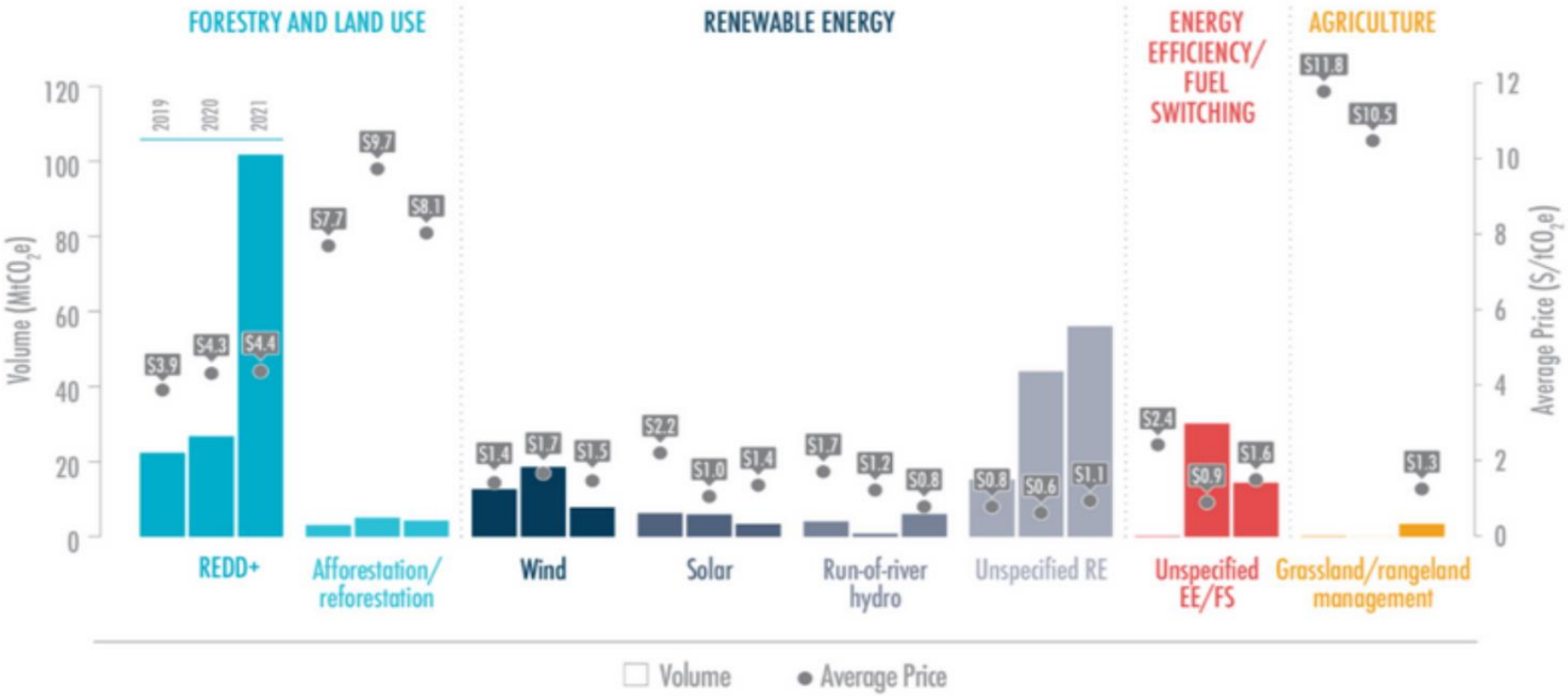
Transacted Voluntary Carbon Offset Volume and Average Price by Project Region, 2019-August 2021

	2019		2020		2021 (through August)	
	Volume (MtCO2e)	Price (USD)	Volume (MtCO2e)	Price (USD)	Volume (MtCO2e)	Price (USD)
Africa	16.1	$3.94	14.9	$4.24	23.9	$5.52
Asia	45.6	$1.80	63.0	$1.60	91.8	$3.34
Europe	1.1	$2.92	1.7	$9.47	0.8	$2.96
Latin America & Caribbean	15.3	$3.45	18.9	$4.17	36.6	$3.74
North America	15.5	$3.51	11.6	$6.31	10.0	$5.13
Oceania	0.5	$12.53	0.1	$20.57	0.1	$32.93

Via Forest Trends' Ecosystem Marketplace. 2021. 'Market in Motion', State of Voluntary Carbon Markets 2021, Installment 1. Washington DC: Forest Trends Association: https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2021/

What projects are companies investing in? And at what prices?

Transacted Voluntary Carbon Market Sizes by Largest Project Types 2019 – 2021



Via Forest Trends' Ecosystem Marketplace. 2021. 'Market in Motion', State of Voluntary Carbon Markets 2021, Installment 1. Washington DC: Forest Trends Association

Voluntary & Compliance Markets

Opportunities & Limitations

Opportunities- Compliance Markets

- Compliance markets offer high certainty about the level of emissions reductions that will be achieved over time.
  - Importantly, this also creates a **stable, long-term price signal and source of demand** for carbon reductions and sequestration.
- High ambition enabled by unlocking lowest-cost abatement strategies
  - Good for planet, good for regulated entities, good for ensuring offset strategies are getting paid what they are worth for avoided emissions

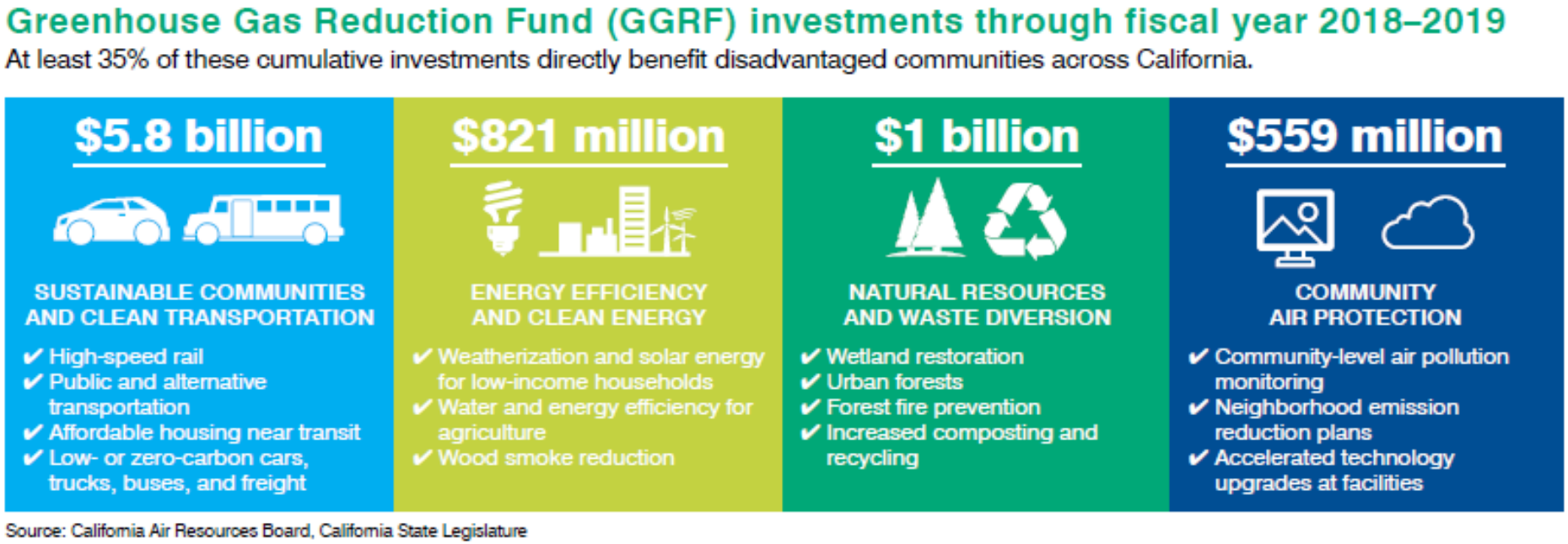
Opportunities- Compliance Markets (cont.)

Premium on integrity of “offsets” in compliance markets– good for climate (but limit on eligible activities.)

BUT, in addition to funding emissions reductions through offsets, compliance markets raise additional revenue that can be invested. This allows compliance markets to fund a **wider range of projects** that reduce pollution and build resilience.

California's program as an example

Revenue from California's cap-and-trade program funds projects that reduce pollution and build resilience.



Opportunities- Voluntary Markets

- Enables transfer of $$ to important mitigation activities absent regulatory framework
  - Enables innovation
  - Mobilize public and private sector investment in the most critical areas of climate action
- Give companies the tools to make immediate and meaningful progress on their net-zero commitments.
- Provides some accountability and third-party transparency for corporate commitments

Limitations- Compliance Markets

Limits on offset use in compliance markets

- For example, when Washington State's cap-and-trade program begins in 2023, offset usage will be limited to 8% of a regulated entity's compliance obligation.

Value constrained if ambition isn't properly calibrated

- In a compliance market while the value of one ton co2e avoided/removed will be clear, transparent… it may also be undervalued if allowance supply in compliance market isn't calibrated to appropriate ambition

Limitations- Voluntary Market

Demand For Credits/Value of Credits Uncertain

- Much higher level of uncertainty about what demand for voluntary carbon credits will look like over time. This is especially true at a regional scale.
- Smaller subset of companies with voluntary climate goals will choose to participate (instead of compliance market– entire sectors regulated, and regional demand)
- Price discovery hard; value hard to predict/plan around/drive project finance

Integrity of Credits

- Not all credits represent genuine greenhouse gas reductions or deliver the same climate benefit.
- This lack of clarity and consistent quality creates a barrier to investment that costs us time we don’t have.

Limitation- distributional impacts of offsets

Geographic distribution of emissions reductions.

- If a facility uses a high-quality offset, the aggregate amount of climate pollution is reduced.
- However, emissions at the source will be higher than in a situation where the offset was not used – **which has important impacts on local air pollution.**

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