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Carbon Market Opportunities in Virginia: Eelgrass, Marshes, Soils, and Forests

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About the Author

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About the Virginia Coastal Policy Center

The Virginia Coastal Policy Center (VCPC) at the College of William & Mary Law School provides science-based legal and policy analysis of ecological issues affecting the state's coastal resources, by offering education and advice to a host of Virginia's decision-makers, from government officials and legal scholars to non-profit and business leaders.

With two nationally prominent science partners – the Virginia Institute of Marine Science and Virginia Sea Grant – VCPC works with scientists, local and state political figures, community leaders, the military, and others to integrate the latest science with legal and policy analysis to solve coastal resource management issues. VCPC activities are inherently interdisciplinary, drawing on scientific, economic, public policy, sociological, and other expertise from within the University and across the country. With access to internationally recognized scientists at VIMS, to Sea Grant's national network of legal and science scholars, and to elected and appointed officials across the nation, VCPC engages in a host of information exchanges and collaborative partnerships.

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VCPC grounds its pedagogical goals in the law school's philosophy of the citizen lawyer. VCPC students' highly diverse interactions beyond the borders of the legal community provide the framework for their efforts in solving the complex coastal resource management issues that currently face Virginia and the nation.

I. INTRODUCTION

Carbon sequestration is the storage and capture of carbon dioxide from the atmosphere. Preserving carbon sequestering sources helps mitigate climate change. Eelgrass, marshes, soils, and forests all sequester carbon. Unfortunately, they are vulnerable to climate change and human development. This paper examines how these sources of carbon sequestration can be incorporated into Virginia's climate change policies, including the creation of a carbon market. Among other aims, a carbon market would incentivize the preservation and restoration of these species, providing important environmental and economic benefits. The first section of this paper identifies several sources of carbon sequestration, as well as their susceptibility to climate change and human behavior. The second section of this paper contains a summary of properly functioning carbon markets such as those in California and the European Union. This section also details how carbon markets can be corrupted and defrauded by bad actors. The paper then explores recent Virginia legislation regarding carbon market participation.[1] This analysis aims to provide a foundation for how carbon markets can thrive in Virginia.

II. CARBON SEQUESTRATION SOURCES

A. Eelgrass

While eelgrass has traditionally been a prominent species of the Chesapeake Bay, its abundance there and on the seaside of the Eastern Shore has varied dramatically over the last century.[2] In the 1930s, a Chesapeake-Potomac Hurricane and noxious slime mold devastated the species.[3] Decades later, the species appeared to begin to rebound when a patch of eelgrass was discovered in a seaside bay off of the Eastern Shore.[4] This discovery indicated that conditions were conducive for the region to once again support eelgrass.[5] In 2008, the Virginia Institute of Marine Science (VIMS) began spreading seeds on state bottomland to restore the species.[6] The Virginia Coastal Zone Management Program aided the restoration of eelgrass beds on the seaside of Virginia's Eastern Shore through the Virginia Seaside Heritage Program.[7]

Eelgrass is the only true seagrass species in the Chesapeake Bay, and it provides multiple benefits.[8] Eelgrass beds serve as nursery habitats, filter pollutants, trap sediment, reduce shoreline

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[1] S. 783, 161st Gen. Assemb., Reg. Sess. (Va. 2020); *see also SB 783 Carbon Market Participation; Submerged Aquatic Vegetation, Va. Legislative Info. Serv.*, https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+SB783 (last visited May 30, 2020).

[2] *See* Kenneth A. Moore et al., *Eelgrass Survival in Two Contrasting Systems: Role of Turbidity and Summer Water Temperature*, 448 MARINE ECOLOGY PROGRESS SERIES 247, 248 (2012).

[3] *Restoring Eelgrass*, THE NATURE CONSERVANCY (June 1, 2019), https://www.nature.org/en-us/about-us/where-we-work/united-states/virginia/stories-in-virginia/vcr-marine-eelgrass-collection/.

[4] *Id*.

[5] *Id*.

[6] *Id*.

[7] *Virginia CZM Program Eelgrass Restoration Efforts*, VA. DEP'T OF ENVTL. QUALITY, https://www.deq.virginia.gov/Programs/CoastalZoneManagement/CZMIssuesInitiatives/SeaGrass.aspx (last visited May 30, 2020).

[8] *SAV Monitoring & Restoration*, VA. INST. OF MARINE SCI., https://www.vims.edu/research/units/programs/sav1/species/eelgrass.php (last visited May 30, 2020).

erosion, and add oxygen to the water.[9] The health of the Chesapeake Bay and coastal waters can severely decline because of the absence of subaquatic vegetation.[10] The Nature Conservancy and VIMS have helped accelerate the natural spread of eelgrass by planting more than 72 million seeds onto 600 acres of bottomland.[11]

Eelgrass restoration efforts in the Chesapeake Bay are threatened by climate change, which poses at least three stressors to eelgrass: increased water temperature, lack of salinity, and turbidity.[12] Eelgrass grows in temperate climate zones, and the Chesapeake Bay is already near the southern boundary of its habitat range.[13] During the summer, in high water temperatures, eelgrass decreases in large amounts.[14] Further, while eelgrass has a salinity tolerance of ten to thirty-five parts per thousand (ppt), it prefers salinity above twenty ppt.[15] Seagrasses have a high light requirement to support large biomass roots in an environment that contains little to no oxygen.[16] This high light requirement makes eelgrass more sensitive to stressors that decrease water clarity.[17] Sea level rise adds water depth, magnifying the effects of low water quality.[18] Low water quality lessens the amount of light reaching the grass, thus negatively affecting eelgrass.[19] Since eelgrass populations are sensitive to these stresses, sea level rise magnifying the effects of all three at once could prove disastrous for eelgrass populations.[20]

1. Threats posed by climate change to Eelgrass in the Chesapeake Bay

By the end of the century, the Chesapeake Bay is expected to experience an increase of its mean temperature of between two and six degrees Celsius, and an increase of fifty to one hundred and sixty percent increase in carbon dioxide concentration.[21] Climate warming threatens eelgrass because, as noted above, the species is currently growing at the southern end of its thermal range in the Chesapeake Bay.[22] Eelgrass's optimal water temperature is ten to twenty degrees Celsius.[23] At these temperatures, the photosynthesis-to-respiration ratios are ideal.[24] Unfortunately, high temperatures of twenty-five to thirty degrees Celsius drastically increase mortality by reducing

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[9] *Id.*
[10] Jonathan S. Lefcheck et al., *Multiple Stressors Threaten the Imperiled Coastal Foundations Species Eelgrass* (Zostera marina) *in the Chesapeake Bay*, *USA*, 23 GLOBAL CHANGE BIOLOGY 3474, 3475 (2017).
[11] *Restoring Eelgrass*, *supra* note 3.
[12] *Cf.* Kenneth A. Moore, *Submerged Aquatic Vegetation of the York River*, 57 J. COASTAL RES. 50, 52-53 (2009) (stating that eelgrass can be stressed by increased water temperatures and turbidity, as well as decreased salinities).
[13] *SAV Monitoring & Restoration*, *supra* note 8.
[14] Moore, *supra* note 12, at 52.
[15] *SAV Monitoring & Restoration*, *supra* note 8.
[16] Lefcheck et al., *supra* note 10, at 3480-81.
[17] *Id.*
[18] *See id.*
[19] *Id.*
[20] Kenneth A. Moore et al., *Impacts of Varying Estuarine Temperature and Light Conditions on Zostera marina (Eelgrass) and its Interactions with Ruppia maritima (Widgeongrass)*, 37 ESTUARIES & COASTS S20, S21 (2014).
[21] Thomas M. Arnold et al., *Twenty-first Century Climate Change and Submerged Aquatic Vegetation in a Temperate Estuary: The Case of Chesapeake Bay*, 3 ECOSYSTEM HEALTH & SUSTAINABILITY 1, 4 (2017).
[22] *SAV Monitoring & Restoration*, *supra* note 8.
[23] Arnold et al., *supra* note 21, at 4.
[24] *Id.*

rates of photosynthesis and growth.[25] Based on the predicted temperature increases noted above, eelgrass may lack the capacity to survive the future climate of the Chesapeake Bay.

The biggest effect of warming will occur in shallow waters, where eelgrass grows.[26] High temperatures in the Chesapeake Bay often lead to increased turbidity, creating a compounded negative effect on eelgrass populations.[27] Increasing temperatures also increase the light requirements for photosynthesis, exacerbating the negative effects of decreasing clarity.[28] High temperatures cause eelgrass to suffer two stressors at once from one source,[29] indicating that rising temperature and its interaction with clarity is the prevalent threat to eelgrass in the Chesapeake Bay.[30]

Eelgrass cannot retreat to cooler water. This movement would require the eelgrass to enter deeper water,[31] where it would not receive adequate sunlight to survive.[32] If water temperature advances beyond the tolerable range of eelgrass, the species will perish. In 2005, the York River suffered eelgrass dieback because of a greater frequency and duration of increased water temperature.[33] Extreme increases of temperature, occurring either for a short-term period or indefinitely, will have negative effects on eelgrass.[34] Both scenarios have the potential to either kill the eelgrass in certain areas or cause the eelgrass to migrate to cooler water temperatures.[35] Eelgrass die-off will deprive the Chesapeake Bay of the benefits of its high-value ecosystem services.[36]

2. Threats of climate change to Eelgrass on the seaside

In 2005, the Chesapeake Bay experienced a decline in its eelgrass population, while Virginia's coastal lagoons experienced an increase[37] because coastal bays are not threatened by increasing water temperature due to their proximity to cooler ocean waters.[38] Elevated temperatures in the summertime are combatted on the coastal bay side by incoming tides and southern winds bringing in cooler ocean water.[39] As a result, the coastal bay does not experience the same elevated water temperatures as the Chesapeake Bay and eelgrass there is buffered from heat.[40] However, eelgrass in the coastal bays faces the danger of sea level rise moving and eroding

[25] *Id.*
[26] *Id.*
[27] Moore et al., *supra* note 20, at S21.
[28] Lefcheck et al., *supra* note 10, at 3480.
[29] Moore et al., *supra* note 20, at S21.
[30] Lefcheck et al., *supra* note 10, at 3480.
[31] Arnold et al., *supra* note 21, at 4.
[32] *Id.*
[33] *Id*.
[34] *Id.*
[35] *Id.*
[36] *See id.* at 2 (estimating the value of ecosystem services provided by Chesapeake Bay SAV beds to be in excess of $2.9 billion per year).
[37] Moore et al., *supra* note 2, at 248.
[38] *Id.* at 253.
[39] *Id.* at 255-56.
[40] *Id.*

the barrier islands.[41] Additionally, if the barrier islands disappear over time, eelgrass in the coastal lagoons will not be protected from hurricanes, sea level rise, or wave action.

Over the past several decades, approximately sixty-eight percent of the barrier islands along the New England and Mid-Atlantic coasts have been eroding.[42] This erosion is primarily caused by relative sea-level rise.[43] Barrier islands and their barrier systems support diverse faunal communities, which include eelgrass beds.[44] They also provide a unique ecosystem for shellfish and hundreds of species of birds.[45] Barrier islands respond to sea level rise in two ways–migrate landward or drown.[46] For example, over the last thirty years, Cedar Island has been migrating toward the Eastern Shore mainland at an average rate of approximately twenty feet per year.[47] Evidence of this movement can be detected by examining adjacent marshes between the mainland and the barrier islands.[48] Barrier islands' landward migration transitions marshes from the position of being behind a barrier island to being in front of it.[49] Rising water levels accelerate this new orientation, pushing the barrier island sand over the marsh.[50] Once this movement occurs, marshes are no longer protected from waves.

Barrier islands moving landward will cause a loss of habitat for marshes and seagrass.[51] The loss of marshes and eelgrass along the Eastern Shore will cause sequestered carbon to be rereleased into the water and atmosphere.[52] Furthermore, as noted above, eelgrass grows in shallow water and is very dependent on high exposure to light;[53] sea level rise accelerates the migration of barrier islands landward increasing water depth, creating an unsuitable habitat for eelgrass in areas where barrier islands used to be.[54]

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[41] *See* Madeleine Jepsen, *Moving Islands: VASG Researcher Studies Historical- and Future- Changes Along Virginia's Barrier Islands*, VA. SEA GRANT, https://vaseagrant.org/movingislandshein/ (last visited June 3, 2020) (explaining that barrier islands migrate landward, eventually ending up behind the previously protected barrier system leaving it exposed to the open sea).
[42] Charles D. Deaton et al., *Barrier Island Migration Dominates Ecogeomorphic Feedbacks and Drives Salt Marsh Loss Along the Virginia Atlantic Coast, USA*, 45 GEOLOGICAL SOC'Y AM. 123, 123 (2017).
[43] *Id.*
[44] *Id.*
[45] Rebecca Sheir, *Scientists Work to Protect Region's Last Coastal Wilderness*, AM. U. RADIO (Feb. 28, 2014), https://wamu.org/story/14/02/28/metro_2/ (last visited June 3, 2020).
[46] Moore et al., *supra* note 2.
[47] Jepsen, *supra* note 41.
[48] *Id.*
[49] *Id.*
[50] *Id.*
[51] *Id.*
[52] *Id.*
[53] Lefcheck et al., *supra* note 10, at 3480-81.
[54] Jepsen, *supra* note 41.

B. Marshes

Tidal marshes sequester significant amounts of "blue carbon,"[55] the carbon stored in coastal wetland ecosystems.[56] The carbon is stored below ground in soil organic carbon (SOC).[57] SOC is a measurable component of soil organic matter (SOM).[58] SOC refers only to the carbon component of organic compounds.[59] In addition to sequestering carbon, marshes improve water quality, protect coasts from storms, and export organic matter that supports both estuarine and marine food webs.[60] Salt marshes have the ability to sequester more carbon than terrestrial ecosystems.[61]

Salt marshes have the capacity to bury carbon approximately fifty-five times faster than tropical rainforests, while inhabiting a small fraction of the total land area of tropical rainforests.[62] Salt marshes not only have the ability to sequester more carbon than rainforests, but they also have the capacity to store carbon for a longer time.[63] While rainforests typically store carbon for decades, salt marshes can store carbon for a millennium.[64] The difference in the temporal span of carbon sequestration among species is mainly driven by rates of decay in ecosystems.[65]

Aerobic ecosystems, such as forests, have higher rates of decay than anaerobic ecosystems such as marshes.[66] High rates of decay in very productive aerobic ecosystems cause once-sequestered carbon to be re-emitted in the atmosphere within several decades to hundreds of years.[67] By contrast, anaerobic ecosystems exhibit higher SOC levels due to suppressed decomposition.[68] Coastal wetlands' high carbon preservation occurs because of regular tidal flooding coupled with the maintenance of saturated soils,[69] which result in low oxygen availability that ensures low decay rates.[70] Therefore, smaller amounts of carbon are re-emitted into water and the atmosphere than are re-emitted by forests.[71]

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[55] Hilary Ford et al., *Large-scale Predictions of Salt-marsh Carbon Stock Based on Simple Observations of Plant Community and Soil Type*, 16 BIOGEOSCIENCES 425, 425 (2019).
[56] *Id.*
[57] *Id.*
[58] *What is Soil Organic Carbon*, GOV'T OF W. AUSTL. DEP'T OF PRIMARY INDUSTRIES & REGIONAL DEV., https://www.agric.wa.gov.au/measuring-and-assessing-soils/what-soil-organic-carbon (last visited July 2, 2020).
[59] *Id.*
[60] Matthew L. Kirwan et al., *Sea Level Driven Marsh Expansion in a Coupled Model of Marsh Erosion and Migration*, 10.1002 GEOPHYSICAL RESEARCH LETTERS 4366, 4366 (2016).
[61] Reid Whittlesey et al., *Salt marsh carbon sequestration: a baseline study. City of Arcata, California*, ENVIRONMENTAL SCIENCE CAPSTONE/PRACTICUM 4 (2013).
[62] Peter I. Macreadie et al., *Loss of 'Blue Carbon' from Coastal Salt Marshes Following Habitat Disturbance*, 8 PLOS ONE 1 (2013).
[63] *Id.*
[64] *Id.*
[65] Whittlesey et al., *supra* note 61.
[66] *Id.*
[67] *Id.*
[68] *Id.*
[69] *Id.*
[70] *Id.*
[71] *Id*.

1. Climate Change and Manmade Threats to Marshes

Salt marshes provide many ecological benefits, but they too are vulnerable to threats from climate change. Sea level rise is a primary climate change threat to salt marshes.[72] In response to rising waters, salt marshes migrate upslope.[73] Upslope migration describes a marsh traveling inland.[74] However, marshes' upslope land migration can be hindered by severe high slopes and human development.[75] When salt marsh retreat cannot keep pace with sea level rise, the marshes drown.[76] Salt marsh retreat occurs through transgression,[77] which is when low marsh species move to locations previously occupied by high marsh species.[78] Erosion occurs on the front end of marshes.[79] If transgression outpaces erosion then the marshes will not drown because of sea level rise.[80] However, when terrain becomes too steep for marshes to migrate further, transgression will not out pace sea level rise and thus marshes will drown.[81]

Natural terrain is only the first issue that can inhibit the landward migration of salt marshes. Human development also severely disrupts transgression. Approximately "[twenty percent] of the Chesapeake Bay shoreline is hardened by riprap, seawalls, and other structures."[82] Such human development disrupts salt marshes' natural response to sea level rise. Steep geographic slopes coupled with human intervention have the potential to severely destroy marshes in Virginia. Salt marshes should be preserved for their high carbon sequestration capacity along with their other ecological benefits such as providing habitat and nutrient filtration.[83]

C. Soil

Soils store the carbon that is sequestered by eelgrass, marshes, and forests. Soils contain approximately seventy-five percent of the carbon pool stored on land.[84] Carbon is primarily stored

[72] Rusty A. Feagin et al., *Salt Marsh Zonal Migration and Ecosystem Service Change in Response to Global Sea Level Rise: A Case Study from an Urban Region*, 15(4) ECOLOGY & SOC'Y 1 (2010).
[73] *Id*.
[74] *Id*.
[75] *Id*.
[76] *See generally* G. Mariotti & J. Carr, *Dual Role of Salt Marsh Retreat: Long-term Loss and Short-term Resilience*, 50 WATER RESOURCES RES. 2964 (2014), *available at* https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2013WR014676 (analyzing salt marsh response to various projected changes in sea level rise and other environmental conditions).
[77] Meagan Eagle Gonneea et al., *Salt Marsh Ecosystem Restructuring Enhances Elevation Resilience and Carbon Storage During Accelerating Relative Sea-level Rise*, 217 ESTUARINE, COASTAL & SHELF SCI. 56, 57 (2019).
[78] *Id*.
[79] *Id.*
[80] *Id.*
[81] David Malmquist, *Barrier-Island Migration Drives Large-Scale Marsh Loss*, WM. & MARY (Jan. 23, 2017), *available at* https://www.wm.edu/news/stories/2017/barrier-island-migration-drives-large-scale-marsh-loss.php.
[82] David Malmquist, *Study Predicts Salt Marshes Will Persist Despite Rising Seas*, VA. INST. OF MARINE SCI. (Feb. 24, 2016), *available at* https://www.vims.edu/newsandevents/topstories/2016/salt_marsh_resilience.php.
[83] *See id.* ("Healthy marshes buffer coasts from storms, improve water quality, provide habitat for commercial fisheries, and help fight global warming by trapping carbon.").
[84] *Carbon Sequestration in Soils*, ECOLOGICAL SOC'Y OF AM., https://www.esa.org/esa/wp-content/uploads/2012/12/carbonsequestrationinsoils.pdf (last visited June 4, 2020).

in soil as SOM.[85] SOM is composed mainly of carbon, hydrogen, and oxygen.[86] The storage of carbon through soil has been threatened by land conversion.[87] The habitual conversion of grassland and forests to crop and grazing land has caused significant loss of carbon storage in soil.[88] This issue occurs at the local, state, national, and global level. Thus, agricultural practices can either exacerbate or mitigate the effects of carbon on climate change.[89]

1. Conservation Techniques to Combat Land Conversion

Adopting soil conservation practices can help conserve and increase SOC.[90] Specifically, SOC can be increased through the practice of no-till farming.[91] No-till farming involves leaving soil undisturbed (not tilled) between plantings and offers several environmental benefits, including increased carbon sequestration.[92] Use of cover crops and crop rotation are also management techniques that can increase carbon sequestration in soil.[93] Cover crops help increase carbon storage by improving soil structure and by also adding SOM.[94] Cover cropping is when crops such as small grains are used to protect soil from erosion between periods of regular crop production.[95] Crop rotation is the practice of growing different crops consistently in recurring succession on the same plot of land.[96] This process mimics the diverse land uses in natural ecosystems.[97] The level of SOM can be increased by varying the types of crops grown.[98] Crop rotation effectiveness is dependent on the types of crops grown and when crop rotation occurs.[99]

No-till farming has been identified as a superior type of conservation tillage to achieve carbon sequestration benefits.[100] Tillage aerates the soil which increases microbial oxidation of organic matter.[101] Soil managed by no till-farming has improved soil structure, increased infiltration capacity, and reduction of runoff and erosion.[102] Improvements in soil quality are typically associated with increasing SOM.[103] While no-till can be very effective to increase soil sequestration, its effectiveness can be limited due to climate and crop system specifications.[104]

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[85] *Id.*
[86] *What is Soil Organic Carbon*, *supra* note 58.
[87] *See What is Soil Carbon Sequestration*, UNFAO, http://www.fao.org/soils-portal/soil-management/soil-carbon-sequestration/en/ (last visited June 4, 2020).
[88] *Id.*
[89] *See id.*
[90] Mark Sperow, *Marginal Cost to Increase Soil Organic Carbon Using No-till on U.S. Cropland*, 24 MITIGATION & ADAPTATION STRATEGIES FOR GLOB. CHANGE 93, 94 (2019).
[91] *Id.*
[92] K. GELLATLY & D.T. DENNIS, COMPREHENSIVE BIOTECHNOLOGY 16 (Murray Moo-Young ed., 2d ed. 2011).
[93] *Carbon Sequestration in Soils*, *supra* note 84.
[94] *Id.*
[95] *Id.*
[96] *Id.*
[97] *Id.*
[98] *Id.*
[99] *Id.*
[100] John T. Spargo et al., *Soil Carbon Sequestration with Continuous No-till Management of Grain Cropping Systems in the Virginia Coastal Plain*, 100 SOIL & TILLAGE RES. 133, 134 (2008).
[101] *Id.*
[102] *Id.*
[103] *Id.*
[104] *Id.*

Studies have found that the absence of tillage in cool, moist climates has a limited effect on soil carbon sequestration.[105] Although there are some limitations on the effectiveness of no-till farming, crop rotation, and cover crops in sequestering carbon, the practices have become more prevalent due to their other environmental and economic benefits.[106]

As of the 2017 Census of Agriculture in the United States, no-till was practiced on 104 million acres of land.[107] This number increased eight percent from the 2012 Census' ninety-nine million acres.[108] Specifically, the number of farms in the United States that practiced no-till in 2017 totaled 279,370.[109] In 2017, 15.3 million acres of cover crops were seeded.[110] This is a forty-nine percent increase from the number of acres in 2012.[111] The United States had a total of 396,433,817 cropland acres in 2017.[112] Also at this time, Virginia had 409,862 acres of cover crops planted,[113] a 35.7% increase from 301,959 acres in 2012.[114] Further, by 2017, Virginia had 1,021,330 no-till acres, ranking third behind only Tennessee and Maryland, for the highest ratio of no-till acres to conventional acres.[115]

D. Forests

Forests also sequester carbon, thus reducing carbon released into the atmosphere, although to a lesser extent than marshes. Forests store carbon in woody tissue and SOM.[116] Young forests have the highest net rate of carbon uptake, which slows down as they age.[117] Carbon stored in forests comprises approximately sixty-eight percent of the United States' terrestrial carbon stocks.[118] Forests ecosystems account for more than ninety percent of land sector sequestration capacity.[119] Forest ecosystems also offset roughly fifteen percent of the United States' total fossil fuel emissions.[120] Forests provide strong mitigation potential for carbon emissions but they are susceptible to climate change.

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[105] *Id*.
[106] *Id.* (explaining that no-till has been adopted on a significant amount of U.S. cropland due to conservation efforts and the reduced fuel costs gained from practicing no-till).
[107] John Dobberstein, *No-Till, Cover Crop Acres Continue Upward Trend*, NO-TILL FARMER (July 10, 2019), https://www.no-tillfarmer.com/articles/8929-no-till-cover-crop-acres-continue-upward-trend?v=preview (last visited June 5, 2020).
[108] *Id*.
[109] *Id*.
[110] *Id*.
[111] *Id*.
[112] Joseph LaRose & Rob Myers, *Progress Report: Adoption of Soil Health Systems Based on Data from the 2017 U.S. Census of Agriculture*, SOIL HEALTH INST. 1, 16, https://soilhealthinstitute.org/wp-content/uploads/2019/07/Soil-Health-Census-Report.pdf (last visited Mar. 19, 2020).
[113] *Id*. at 5.
[114] *Id*.
[115] *Id*. at 8.
[116] *Carbon Sequestration in Soils, supra* note 87.
[117] *Id*.
[118] Todd A. Ontl et al., *Forest Management for Carbon Sequestration and Climate Adaptation*, 118 J. FORESTRY 86, 86 (2020).
[119] *Id*.
[120] *Id*.

1. Climate Change and Man-made Threats to Forests

As the climate changes, forests face rising temperatures, changing seasonality of precipitation, and a greater frequency and severity of natural disasters such as pathogens, forest pests, drought, and wildfire.[121] Deforestation caused by human activity also harms forests' capacity to sequester carbon. Deforestation is the loss of forest through wildfire, timber harvest, urban sprawl, and land clearing for agricultural purposes.[122] From 1990 to 2010, the United States lost approximately 949,750 acres of forests each year.[123] Deforestation is obviously problematic existentially, but also because it reduces these species' ability to sequester carbon in the long term. Deforestation causes sequestered carbon to be re-emitted into the atmosphere, and also causes a loss of the capacity to sequester more carbon. Reforestation can offset environmental harm from climate change and land conversion practices.

The U.S. Forest Service and the Arbor Day Foundation are engaged in country-wide reforestation efforts,[124] and in general there has been an increase in forest area country-wide due to reforestation.[125] In 2007, the United States had 752 million acres of forest,[126] a figure which had increased to 766 million acres by 2012.[127] The Healthy Watersheds Forest Retention Project (HWFRP) also advocates for reforestation efforts in Virginia.[128] The HWFRP developers considered the potential increase in pollutants, phosphorus, nitrogen, and sediments entering the Chesapeake Bay as a result of projected urban growth within the watershed, and how to balance this increase with established total maximum daily load (TMDL) limits.[129] They propose creating a forestland conservation credit, based on the current economic value of reducing pollutants entering the Bay, to offset the effects of future growth and incentivize the retention of high-conservation value forestland.[130] Forests are among the best sources for carbon sequestration, and HWFRP's economic approach to retaining and creating more forestland could represent an important initial step toward the implementation of a carbon market incorporating forestlands in Virginia.

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121 *Id*. at 86–87.
122 Andrea Becker, *Rates of Deforestation & Reforestation in the U.S.*, SEATTLE PI, https://education.seattlepi.com/rates-deforestation-reforestation-us-3804.html (last visited June 5, 2020).
123 *Id*.
124 *Id*.
125 *U.S. Forest Resource Facts and Historical Trends*, USDA, https://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf (last visited June 5, 2020).
126 *Id*. at 8.
127 *Id*.
128 *Healthy Watersheds Forest Retention Project*, VIRGINIA DEPT. OF FORESTRY, http://www.dof.virginia.gov/infopubs/Healthy-Waters-Forest-Retention-Report-Phase-1-2_2017-06.pdf (last visited Mar. 28, 2020).
129 *Id.* at 10.
130 *Id.* at 12.

III. INCORPORATING CARBON SEQUESTRATION INTO VIRGINIA POLICY

The protection of carbon sequestering species and other sources of carbon storage, including eelgrass, marshes, soils, and forests, can be incentivized by featuring them in a carbon market. Because of their ecological benefits, and their distribution throughout the state of Virginia, the United States, and the world, steps should be taken to restore and preserve these resources. Creating carbon markets could help encourage the conservation of these resources by providing a monetary benefit, in addition to an environmental benefit. Evaluating the frameworks of established carbon markets could help Virginia determine the best method to create and implement carbon markets for eelgrass, marshes, soils, and forests.

A. California's Cap on Greenhouse Gas Emission and Market-Based Compliance Mechanisms

In 2012, California established an emissions trading program.[131] California's Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms (California Cap-and-Trade Program) is designed to reduce greenhouse gas (GHG) emissions affiliated with specified entities by applying an aggregate greenhouse gas allowance budget to the covered entities and providing a trading mechanism for compliance instruments.[132] The entities that fall within California's Cap-and-Trade Program initially included large GHG emitters involved in electricity generation and other stationary sources emitting more than 25,000 metric tons of carbon dioxide equivalent (CO_2e) per year, such as refineries, cement production facilities, and food processing plants.[133] The program was expanded in 2015 to include fuel distributors in order to cover transportation emissions and emissions from the combustion of fossil fuels not from large point-sources.[134]

The covered entities under California's Cap-and-Trade program are all entities that cause or are otherwise associated with GHG emissions,[135] including operators of facilities that are associated with one or more of the following processes or operations: cement production, cogeneration, glass production, hydrogen production, iron and steel production, lead production, lime manufacturing, nitric acid production, petroleum and natural gas systems, petroleum refining, pulp and paper manufacturing, self-generation of electricity, or stationary combustion.[136] Covered entities also include first deliverers of electricity, suppliers of natural gas, suppliers of Reformulated Gasoline Blendstock for Oxygenate Blending (RBOB) and distillate fuel oil,

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131 *See generally Cap-and-Trade Program*, CAL. AIR RESOURCES BOARD, https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program (last visited June 8, 2020) for additional background information on California's Cap-and-Trade Program.
132 CAL. CODE REGS. tit. 17, § 95801 (2020).
133 *Cap-and-Trade Regulation Instructional Guidance*, CAL. AIR RESOURCES BOARD 1, 13 (2012), *available at* https://ww2.arb.ca.gov/sites/default/files/classic/cc/capandtrade/guidance/chapter1.pdf.
134 *Id.* For additional information on what entities are covered by California's Cap-and-trade *see Is My Company Subject to the Cap-and-Trade Regulation?*, CAL. AIR RESOURCES BOARD (2012), *available at* https://ww2.arb.ca.gov/sites/default/files/classic/cc/capandtrade/guidance/chapter2.pdf.
135 CAL. CODE REGS tit. 17, § 95811 (2020).
136 *Id*.

suppliers of liquified petroleum gas, suppliers of liquified natural gas and compressed natural gas, and carbon dioxide suppliers.[137]

A covered entity is required to participate in the market if they pass the threshold for inclusion in the program, which is based on the subset of greenhouse gas emissions that create a compliance obligation.[138] For example, the threshold for operators of facilities is 25,000 metric tons or more of CO_2 emitted per data year.[139] A covered entity that meets the inclusion threshold must report and verify annual emissions.[140] Covered entities that do not meet the threshold for required participation can voluntarily participate in the California Cap-and-Trade Program.[141]

Covered entities have reporting requirements described in the Mandatory Reporting Regulation (MRR).[142] The MRR is the California Air Resources Board's (ARB) regulation for the Mandatory Reporting of Greenhouse Gas Emissions.[143] Entities subject to the reporting requirement must retain records of certain documents for at least ten consecutive years and provide the records within twenty calendar days of receiving a written request from ARB.[144]

California's Cap-and-Trade Program has provisions regarding price ceiling sales and trading. A price ceiling is the maximum fixed price at which allowances and price ceiling units would be available for sale to covered entities in the program.[145] The Executive Officer may either serve as sale administrator to handle price ceiling sales or designate an entity to serve as the sale administrator.[146] Only California covered entities and opt-in entities are eligible to participate in price ceiling sales.[147] California's trading provision contains a holding limit,[148] which is the maximum number of California GHG allowances that can be held by an entity at one time.[149] The holding limit is calculated by the following formula: 0.1 x Base + 0.025 x (Annual Allowance Budget – Base).[150] Base equals 25 million metric tons of carbon dioxide equivalent (CO_2e).[151] An entity that exceeds its holding limit has a five-day grace period to bring its account balance under the limit.[152] If it fails to do so, penalties may be applied.[153]

The regulation also provides guidance for registration and ownership of ARB offset credits. The entity who owns the credit has the ability to sell, trade, or transfer its credits.[154] However, this

137 *Id.*
138 *Id.* § 95812.
139 *Id.*
140 *Id.*
141 CAL. CODE REGS. tit. 17, § 95813 (2020).
142 *Id.* § 95850.
143 *Id.*
144 CAL. CODE REGS tit. 17, § 95850 (2020).
145 *Id*. § 95915.
146 *Id*.
147 CAL. CODE REGS. tit. 17, § 95915 (2020).
148 *Id*. § 95920.
149 *Id*.
150 *Id*.
151 *Id.*
152 *Id*.
153 CAL. CODE REGS. tit. 17, § 95815(b)(6) (2020).
154 *Id*. § 95984.

right has limitations; an ARB offset credit may not be sold, traded, or transferred if it has been retired, surrendered for compliance, used to meet any GHG mitigation requirements in any voluntary or regulatory program, or it has been invalidated.[155] Furthermore, an ARB offset credit may only be used in two circumstances:[156] to either meet a compliance obligation under the article or for the purpose of voluntary retirement of credits.[157]

California's Cap-and-Trade Program provides a good example of how a successful carbon market can be implemented within the United States. Virginia can use California's market as a template to determine which elements would best work for a Virginia market. While California's Cap-and-Trade Program does not yet include offset credits utilizing eelgrass, marshes, or soil, it includes a forest offset project,[158] and the state's scoping plan focuses on the substantial carbon stored by wetlands, forests and farmlands.[159] California's forest offset project will be discussed in further detail below, when analyzing how Virginia could create its own forest carbon market.

B. European Union Emissions Trading System

Since 2005, the European Union (EU) Emissions Trading System (ETS, or EU-ETS, collectively) has been the cornerstone of the EU's plan to reduce GHG emissions from industry, electricity, and heat production.[160] The system contributes to the EU target of cutting GHG emissions by twenty percent from 1990 GHG levels by 2020.[161] The EU is on track to exceed their target, cutting GHG emissions by approximately forty percent by 2030.[162] The GHG reduction is part of the EU's 2030 climate and energy policy framework.[163]

The EU-ETS caps emissions from almost 11,000 power plants, manufacturing installations, and over 500 aircraft operators flying between countries that are part of the European Economic Area (EEA).[164] The EU-ETS operates in all of the thirty-one countries of the EEA. Carbon dioxide emissions as well as nitrous oxide emissions are covered under the EU-ETS.[165] Participation in the market is generally mandatory; however, in some sectors, only installations above a certain size are included.[166] Furthermore, countries that participate in the carbon market

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[155] CAL. CODE REGS. tit. 17, § 95984 (2020).
[156] *Id.*
[157] *Id.*
[158] *Id.* § 95983.
[159] *California's 2017 Climate Change Scoping Plan*, CAL. AIR RESOURCES BOARD ES1, 13-14 (2017), *available at* https://ww3.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.
[160] *Report From the Commission to the European Parliament and the Council: Report on the functioning of the European Carbon Market* at 5 (Jan. 16, 2020), *available at* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0557R(01) (last visited June 9, 2020) [hereinafter *European Carbon Market Report*].
[161] *Id.*
[162] *Id.*
[163] *Id.*
[164] *Id.* at 7.
[165] *Id.*
[166] *Id.*

can exclude small installations from the system if alternative and equivalent measures are put in place.[167] A small installation is defined as emitting less than 25,000 tons of CO_2e per year.[168]

Ownership of general and aviation allowances is tracked by recording the amounts owned in the accounts and transactions between accounts in the Union Registry and the European Union Transaction Log (EUTL).[169] The Union Registry holds accounts for stationary installations and for aircraft operators.[170] The EUTL is responsible for checking records and authorizes all transactions between accounts.[171] This ensures that all transfers comply with EU-ETS rules.[172]

The EU-ETS' monitoring system allows several monitoring methods.[173] This approach allows a high degree of flexibility so operators can ensure cost-efficiency and also achieve high reliability of the monitored emissions data.[174] The EU-ETS has a high compliance rate, with about 99% of emissions covered by the allotted allowances on time every year.[175] Less than 0.5% of the installations reporting emissions in 2018 had not purchased allowances covering their emissions by the deadline.[176] In the aviation sector, aircraft operators responsible for 99.1% of EU-ETS emissions from aviation complied with the program.[177] The operators who did not comply were either small or stopped operating in 2018.[178]

The EU-ETS is an example of a functioning carbon market that Virginia can use as a blueprint to craft its own. For instance, the lessons of the EU-ETS offer insights, such as the importance of properly defining who is required to participate in the market,[179] the type of accounting system that should be used, and who should track credit ownership.[180] Abiding by these lessons can alleviate incidences of fraud like those described below.

C. Carbon Market Drawbacks

Carbon markets in California and the EU are potentially good models for creating a carbon market in Virginia. While there are many upsides to implementing carbon markets, they are sometimes vulnerable to fraud and other crimes.[181] These illegal activities include:

1. Fraudulent manipulation of measurements to claim more carbon credits from a project than were actually obtained;

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[167] *Id*.
[168] *Id*.
[169] *Id*. at 9.
[170] *Id*.
[171] *Id.*
[172] *Id*.
[173] *Id*. at 36.
[174] *Id*.
[175] *Id*. at 39.
[176] *Id*.
[177] *Id.*
[178] *Id*.
[179] *Id*. at 7
[180] *Id*. at 9.
[181] *Guide to Carbon Trading Crime*, INTERPOL ENVTL. CRIME PROGRAMME 1, 11 (2013), *available at* https://globalinitiative.net/wp-content/uploads/2017/12/EUROPOL-Guide-to-Carbon-Trading-Crime-2013.pdf.

2. Sales of carbon credits that either do not exist or belong to someone else;
3. False or misleading claims with respect to the environmental or financial benefits of carbon market investments;
4. Exploitation of weak regulations in the carbon market to commit financial crimes, such as money laundering, securities fraud or tax fraud; and
5. Computer hacking/phishing to steal carbon credits and theft of personal information.[182]

Measurements can be falsified to obtain additional credits in at least two ways. The first is by overinflating the estimate of the emissions that would have occurred.[183] The second way is by fraudulently claiming the project reduces emissions to a greater degree than it actually does.[184] Measurements can be manipulated by intentionally misreporting data, or by distorting the analysis of data by only measuring certain variables.[185] One way the possibility of this sort of fraud is by requiring third-party validation and verification before a project can receive carbon credits.[186] However, there is still a concern that the bad actors may bribe third-party participants to manipulate the results.[187]

Another fraudulent misuse of carbon markets can occur when a fraudster sells carbon credits it does not own or that do not exist. This type of fraud is possible where there is no physical indication of the identity of the person who holds the carbon credit rights.[188] This fraud can also occur because of government corruption, which allows persons to register false documents concerning ownership of carbon credits.[189] Furthermore, fraud such as "double counting" can proliferate in carbon markets. Double counting is when the owner of carbon credits sells the same carbon credits to multiple parties.[190] Fraudsters are more likely to get away with double counting when carbon credits are sold through several foreign exchanges with different regulations and loose standards of monitoring.[191] Furthermore, it is challenging for local law enforcement to detect the fraudulent sale of fake or already owned credits, if they are not already monitoring the government carbon registry.[192]

The environmental and financial benefits of carbon market investments are also sometimes overhyped. This issue is primarily linked with a lack of information about these products. Specifically, because these markets are new, traders and buyers have little understanding of them.[193] Due to minimal customer knowledge, companies have produced advertisements and investment advice involving false claims.[194] Because of this deceptive practice by companies, the

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[182] *Id*.
[183] *Id*.
[184] *Id*.
[185] *Id*. at 11-12.
[186] *Id*. at 12.
[187] *Id*.
[188] *Id*. at 14.
[189] *Id*.
[190] *Id*.
[191] *Id*.
[192] *Id*.
[193] *Id.* at 16
[194] *Id.*

United States Federal Trade Commission promulgated guidelines prohibiting unfair and deceptive marketing for carbon markets.[195] The regulations are specifically aimed at helping carbon offset companies comply with the Federal Trade Commission Act, which forbids unfair and deceptive trade practices in the United States.[196]

Other white collar crimes can also thrive within these trading schemes. Sometimes, the more countries that participate in a carbon market, the harder it becomes to trace the carbon credit from its original owner to the final purchaser.[197] Thus, it becomes easier for criminals to take advantage of legal loopholes or inconsistent regulations.[198] For instance, tax fraud has already occurred in an existing carbon market; the EU experienced tax fraud involving the theft of Value Added Tax (VAT).[199] In multi-jurisdictional trading in Europe, this tax fraud occurred because goods imported from a VAT-free jurisdiction were subsequently sold while charging the sales price and the VAT.[200] The goods and the VAT can then be sold through a number of companies. Goods and the VAT can pass across a number of borders, "with each additional layer of transactions making it more difficult to trace the link between the final VAT that is owed to the relevant government authority and the original importer, who by this time has disappeared without paying the tax."[201]

Carbon credits are also targeted by hackers and subject to internet crimes and cyber-attacks. The EU-ETS suffered cyber-attacks because the security systems at some national registries were very loose.[202] The EU-ETS also lacked a hub for the market, a central clearing house, and a single set of laws to define the legal status of carbon credits.[203] In 2011, the EU Climate Change Committee approved regulations to improve security of the registries to prevent fraud.[204] Security implementation, oversight, and enforcement will determine the effectiveness of the new regulations.[205]

Virginia can learn from the issues and criminal behaviors associated with established markets. Analyzing existing programs and issues can aid Virginia in establishing markets for the various carbon sequestering species with more security for traders and buyers. Lessons learned from past fraudulent behavior can guide Virginia to ensure that these schemes are not repeated in the Commonwealth.

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195 *Id*.
196 *Id*.; 16 C.F.R. § 260.5 (2012).
197 *Id*. at 18.
198 *Id*.
199 *Id.* at 18.
200 *Id.*
201 *Id*.
202 *Id*. at 23.
203 *Id*.
204 *Id*.
205 *Id*.

D. Virginia Legislation

Senate Bill 783, Carbon market participation; submerged aquatic vegetation (SAV Bill), was signed into law by the Governor[206] on April 7, 2020.[207] The legislation is effective on July 1, 2020.[208] It amends the Code of Virginia, adding section 10.1-1186.6, relating to the Department of Environmental Quality's (DEQ) participation in carbon markets.[209] The language in the SAV Bill states that DEQ

> may participate in any carbon market for which submerged aquatic vegetation restoration qualifies as an activity that generates carbon offset credits. Any revenue resulting from the sale of such credits shall be used to implement additional submerged aquatic vegetation monitoring and research or to cover any administrative costs of participation in the credit market. DEQ may enter into agreements necessary to affect such participation, including with private entities for assistance with registration and sale of offset credits. DEQ shall hold exclusive title to such credits until sold.[210]

The SAV Bill paves the way for a Virginia carbon market and could provide a framework for incentivizing the recognition and preservation of other carbon sequestering species and carbon sinks in Virginia, such as marshes, soils, and forests. The SAV Bill is relatively short and will require additional agency guidance. For example, it states that the revenue from the sale of credits "shall be used to implement additional submerged aquatic vegetation monitoring and research."[211] However, the bill does not state who may use the funds to handle the additional monitoring or research. Currently, VIMS monitors SAV in the Chesapeake Bay and the coastal bays and can help identify areas where these species exist for interested parties.[212] VIMS uses multispectral aerial imagery as its principal source of information to assess distribution and abundance of SAV.[213] The

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[206] Senate Bill 1027 Clean Energy and Community Flood Preparedness Act; S. 1027, 161st Gen. Assemb., Reg. Sess. (Va. 2020) has passed and is currently awaiting Governor action. S. 1027 seeks to add in Chapter 13 of Title 10.1 an article numbered 4 relating to Clean Energy and Community Flood Preparedness. Under § 10.1-1330 of Article 4, the director of DEQ "is hereby authorized to establish, implement, and manage an auction program to sell allowances into market-based trading consistent with the Regional Greenhouse Gas Initiative ("RGGI") program and this article." Three percent of the revenue will be utilized to "cover reasonable administrative expenses of the Department in the administration of the revenue allocation, carbon-dioxide emissions cap and trade program, and auction and carry out statewide climate change planning and mitigating activities." Senate Bill Electric utility regulation; environmental goals; S. 851, 161st Gen. Assemb., Reg. Sess. (Va. 2020) is a senate enrolled bill that also mentions a market-based trading program for carbon dioxide emissions. S. 851 has an accompanying bill, and both were passed and await Governor action. Under this bill, the Board may "establish rules for trading, the use of banked allowances, and other auction or market mechanisms as it may find appropriate to control allowance costs and otherwise carry out the purpose of this subsection".

[207] S. 783, 161st Gen. Assemb., Reg. Sess. (Va. 2020); *see also SB 783 Carbon Market Participation; Submerged Aquatic Vegetation*, VA. LEGISLATIVE INFO. SERV., https://lis.virginia.gov/cgi-bin/legp604.exe?201+sum+SB783 (last visited July 2, 2020).

[208] *Id.*

[209] *Id.*

[210] *Id.*

[211] *Id.*

[212] *SAV Monitoring & Restoration: Monitoring Methods for SAV*, VA. INST. MARINE SCI., https://www.vims.edu/research/units/programs/sav1/methods/index.php (last visited June 11, 2020).

[213] *Id.*

aerial images are examined to identify all visible SAV beds.[214] Information from ground surveys are also utilized to map beds.[215] The data from ground surveys is then tabulated and entered into the SAV geographic information system (GIS), which is found on the VIMS website.[216] Because VIMS monitors SAV species, they could potentially benefit from revenue from a GHG credit system that would help fund continued monitoring and research of these species.

While implementation of the SAV Bill is yet to come, and there are many unknowns regarding the Virginia legislature's willingness to include other carbon storage sources, it is an important first step for Virginia's entry into carbon markets. Additionally, as SAV carbon market participation progresses, the information gathered can be utilized to identify lessons learned and determine the ideal framework for such markets, potentially informing the creation of similar carbon market legislation for marshes, soils, and forests.

E. Incorporating Marshes, Soils and Forests into a Carbon Market

1. Marshes

While few markets currently include marshes, there are numerous entities working to incorporate them. The National Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserves and their partners have been working to make wetland conservation and restoration profitable, while reducing GHG through blue carbon markets.[217] Through their research efforts, the first United States tool and guide on marketing the blue carbon stored in wetlands was created.[218] Additionally, the Waquoit Bay Research Reserve in Massachusetts, one of NOAA's research partners, developed a protocol to make salt marsh restoration eligible for international carbon markets.[219] The protocol is called the Coastal Wetland Greenhouse Gas Model 2.0 (CWGM).[220] It allows northeastern and mid-Atlantic restoration practitioners, policymakers, and land managers to understand greenhouse gas fluxes in tidal wetlands.[221] As a result, these decision makers can help leverage advances in blue carbon science to support wetland management and restoration.[222] One of the major roles the tool can assist with is to support wetland management and the incorporation of coastal wetlands into carbon markets.[223] The ability to uniformly determine a wetland's capacity to capture and store GHG, such as carbon dioxide and methane, will help support wetland conservation and restoration.[224] If wetlands are damaged, they

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[214] *Id.*
[215] *Id.*
[216] *SAV in the Chesapeake Bay and Coastal Bays: Monitoring -GIS Data*, VA. INST. MARINE. SCI., http://web.vims.edu/bio/sav/sav06/GisData.html (last visited April 23, 2020).
[217] *Reserves Advance "Blue Carbon" Approach to Conserving Wetlands*, OFF. FOR COASTAL MGMT. NAT'L OCEANIC & ATMOSPHERIC ADMIN., https://coast.noaa.gov/states/stories/first-carbon-market-guidance-for-wetlands.html (last visited June 15, 2020).
[218] *Id.*
[219] *Id.*
[220] *New Tool to Predict Greenhouse Gas Fluxes & Potential Carbon Storage in Coastal Wetlands*, WBNERR, http://waquoitbayreserve.org/wp-content/uploads/BWM-2-Model-Fact-Sheet-HR.pdf (last visited June 15, 2020).
[221] *Id.*
[222] *Id.*
[223] *Id.*
[224] *Id.*

can turn into carbon sources by releasing once-sequestered carbon. Protecting wetlands will help maintain a carbon sink.[225]

The CWGM was developed with data from twenty-six tidal wetlands along the mid-Atlantic and northeast coasts.[226] The tool is presented in an Excel spreadsheet.[227] It estimates a wetland's potential carbon storage by accounting for instantaneous predicted fluxes of carbon dioxide and methane.[228] The CWGM is a free and readily accessible tool that could be utilized by Virginia restoration practitioners, policymakers, and land managers to better understand GHG fluctuation in the state's wetlands and help create a wetland carbon market. Since the model was created using data from various mid-Atlantic tidal wetlands, the model should work well for Virginia's wetlands.[229]

2. Soil

Several countries feature soil carbon projects. Because both agricultural practices and soil types vary widely in different regions, soil carbon projects typically require an individualized approach and defy a one size fits all template.[230] For example, some countries have smallholder farming and lower technology settings, while other countries have large and highly concentrated farms with industrialized technology and management systems.[231] Unlike other carbon markets, a carbon-capture agriculture practice will not provide a universal blueprint to be used in different countries or states.[232]

The Leonard Springs Carbon Project is an agricultural credit-producing project located in Victoria, Australia.[233] Individual landholders participate in the project, which is expected to run from March 2017 to March 2052,[234] for a crediting period of twenty-five years.[235] The purpose of the project is to increase carbon in soil on lands within the grazing system, by rejuvenating pastures using a novel Australian invention, "Soilkee," a farming system which facilitates pasture cropping.[236] A pasture cropping system integrates cropping with pasture and livestock farming systems by planting various crops in established pastures.[237] The benefits of this system include increased nutrient supply and improved soil health.[238]

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[225] *Bringing Wetlands to Market: The Power of Coastal Blue Carbon in a Changing Climate*, NOAA, https://oceanservice.noaa.gov/podcast/aug16/mw137-wetlands-bluecarbon.html (last visited Mar. 30, 2020).
[226] *New Tool to Predict Greenhouse Gas Fluxes & Potential Carbon Storage in Coastal Wetlands, supra* note 220.
[227] *Id*.
[228] *Id*.
[229] *Id*.
[230] Moritz von Unger & Igino Emmer, *Carbon Market Incentives to Conserve, Restore and Enhance Soil Carbon,* THE NATURE CONSERVANCY 1, 38 (2018), *available at* https://www.nature.org/en-us/what-we-do/our-insights/perspectives/carbon-market-incentives-to-conserve-restore-enhance-soil-carbon/ (last visited June 16, 2020).
[231] *Id*.
[232] *Id*.
[233] *Id*.
[234] *Id*.
[235] *Id*.
[236] *Id*.
[237] *Id*.
[238] *Id*.

The Leonard Springs Carbon Project was developed with the company Corporate Carbon. Corporate Carbon acts as a large-scale aggregator, preparing project documentation and working with farmers to adopt specific soil carbon management actions.[239] Corporate Carbon also ensures proper monitoring, and represents farmers for the Carbon Farming Initiative (CFI)—the standard-setter—and the Emissions Reduction Fund (ERF), the carbon purchaser.[240] Corporate Carbon covers its own development costs and, in return, is compensated through a share in carbon proceeds.[241] The price per credit currently is AUS $12 (approximately US $9.30).[242] Credits are distributed based on measured increases in SOC, with measurements which are taken every two to three years.[243] While the agricultural technique itself may not transfer to a Virginia market, Australia's legal framework and outreach efforts may.

The Leonard Springs Carbon Project involves contracts between farmers and a project proponent, as well as between the project proponent and the ERF.[244] Outreach has helped increase farmer engagement in the project. Australia built its outreach around the Soilkee system, which includes regular demonstrations of the practice.[245] The project encountered certain challenges, including farmer recruitment and retention.[246] Furthermore, some farmers were concerned that participation in the project would hold them to standards they cannot maintain, that exceeded current agronomic requirements.[247] However, an improved approach to agriculture and access to increased revenue from better soil management are both motivating factors for farmer participation.[248]

This example can guide Virginia's foray into soil preservation for carbon sequestration purposes and development of a soil marketplace. Specifically, Australia's soil market showcased demonstrations of soil conservation to encourage farmers to join the program. Virginia has already seen an upward trend of agricultural landowners participating in soil conservation techniques.[249] Pilot projects demonstrating the advantages of soil conservation practices such as no-till, crop rotation, and cover cropping, can also highlight how these practices store and sequester carbon. Adding monetary incentives and combining these efforts to store carbon with those to reduce phosphorus and nitrogen runoff from farms into the Chesapeake Bay to achieve Bay TMDL limits can also drive uptake of these methods by farmers in Virginia.

3. Forests

California's Cap-and-Trade Program includes forests. Forest sequestration projects under the Cap-and-Trade market will have a portion of their issued ARB offset credits placed into a

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[239] *Id.*
[240] *Id.*
[241] *Id.*
[242] *Id.*
[243] *Id.*
[244] *Id.*
[245] *Id.*
[246] *Id.*
[247] *Id.*
[248] *Id.*
[249] LaRose & Myers, *supra* note 112, at 10.

Forest Buffer Account—an account that can be used in the case of unintentional reversals due to fires, disease or other losses.[250] ARB offset credits placed into the Forest Buffer Account must match the reporting period for which the ARB offset credits are issued.[251] If the ARB determines that an unintentional reversal is a reversal, including a wildfire or disease, that is not the result of the forest owner's negligence, gross negligence, or willful intent,[252] a quantity of ARB offset credits from the Forest Buffer Account are retired.[253]

The Cap-and-Trade Program also provides guidance for intentional reversals of forestland. An intentional reversal is any reversal that is caused by a forest owner's negligence, gross negligence, or willful intent, including harvesting, development, and harm to the area within the offset project boundary.[254] In the event an intentional reversal occurs, the Offset Project Operator or Authorized Project Designee shall provide a written description and explanation of it to the ARB within thirty calendar days.[255] Within one year of an intentional reversal, the Offset Project Operator or Authorized Project Designee shall submit a completed, verified estimate of current carbon stocks within the offset project boundary.[256]

Virginia could follow California's lead and incorporate its standing stock of forests into a carbon market. The Healthy Watersheds Forest Retention Project has made significant progress in that regard. Unlike SAV species, forest stocks can be estimated using existing land cover mapping and do not require underwater mapping capabilities to calculate. Further, because the science behind forests existing as known carbon sinks is widespread and easily understood, incorporating these resources into a carbon market can be a beneficial initial step. For these reasons, forests are an attractive complement to the other carbon sequestering sources in a carbon market.

F. CONCLUSION

Established carbon markets in the United States and other countries provide good examples of successes and possible pitfalls of these tools. Virginia can heed these lessons and select the successful elements of the markets that will fit its specific needs. For instance, a market should list the carbon sequestering species it includes. Eligible participants should also be identified at the start to reduce confusion regarding who can participate in the program. Proper monitoring and record keeping of carbon credits is also needed to prohibit fraudulent activity such as double counting or theft. A carbon market should also provide sufficient information regarding the value of its program, so that buyers and traders understand the system and are protected from false and misleading information. To avoid fostering white collar fraud crimes, markets need to have strong regulations and protections in place and should ensure other markets they associate with do as well. A well-structured, robust market can lead to higher compliance and participation rates. Virginia can create reliable carbon markets for each of the mentioned carbon sequestering

[250] CAL. CODE REGS. tit. 17, § 95983 (2020).
[251] *Id.*
[252] *Id*. § 95802.
[253] *Id*. § 95983.
[254] *Id*. § 95802
[255] *Id*. § 95983.
[256] *Id*.

opportunities by following successful market examples and learning from previous markets' mistakes.

Virginia's SAV Bill and Healthy Watersheds Forest Retention Project are commendable first steps and while there is no corollary for marshes yet, a tool has been developed to calculate how much carbon is sequestered in marshes. Virginia has the ability to analyze the established markets and the newly created marsh tool to build carbon markets specifically for the state. Analyzing previous markets can also help Virginia avoid the growing pains and missteps other carbon markets suffered. The creation of strong, credible carbon markets will also help restore and protect the carbon sequestering species and other carbon sinks featured in these markets.