Maryland Department of Natural Resources
Climate Mitigation, Adaptation, Education and Outreach
2024 Report

Environmental Article § 2-1305(c), (SB 528, Chapter 38 and HB 570, Chapter 570 in 2022)

Introduction

Climate change is an important consideration under the mission and operations of the Maryland Department of Natural Resources (DNR). The department uses science, data, monitoring and modeling to inform investment decisions, determine impacts to habitat, and understand the potential effects climate change has on our waterways and our communities, with a particular focus on our most vulnerable communities, typically those that have been historically underserved. The department also leads the Maryland Commission on Climate Change Adaptation and Resiliency Working Group (ARWG), which recommends actions on preparedness from sea level rise and more intense storms, among other anticipated impacts from climate change.

The Climate Solutions Now Act (CSNA) has set a goal of a 60% reduction of gross greenhouse gas emissions by 2031 and the state meeting net-zero emissions by 2045. The department contributes to mitigating greenhouse gasses through managing public and private forests, planting trees, and restoring streams and wetlands. This report reflects changes in how we are calculating the carbon benefits of the programs for the 2031/2045 plan. This document details what the department has done in the past year to contribute to greenhouse gas mitigation and our progress towards the goals laid out in Maryland's Climate Mitigation plan, dated December 28th, 2023. It also details our work to integrate environmental justice throughout our climate mitigation and adaptation work and providing guidance for climate adaptation and what we have done to provide education and resources on how climate change will impact Marylanders.

Highlighted Facts and Figures

- Both Planting and Managing Forests Have Exceeded the 2020 goal and are progressing towards the 2031 goals
- 41,066 Forest Acres Managed in 2023 - 100% of 15 year average.
- 886 Forest Acres Planted in 2023 - 60% of 15 year average.
- The Chesapeake and Atlantic Coastal Bays Trust Fund restored 52.3 acres of wetlands and 42.7 acres of riparian buffers in FY24, and has funded the restoration of 3,430 acres of wetlands and 1,740 acres of riparian buffers since 2009.

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Planning for 2031 and 2045

The department will continue to track all the programs included in the Greenhouse Gas Reduction Act tracking for meeting Maryland's Climate Solutions Now 2031 and 2045 GHG reduction goals. While the 2031 plan is based on a reduction to gross emissions, which does not factor in Maryland's natural carbon sinks from forests and wetlands, the 2045 plan is for the state to reach net zero emissions, so removals from the atmosphere through natural sinks or carbon removal and storage will need to balance remaining emissions. Taking action now to preserve and enhance our natural carbon sinks is necessary to ensure Maryland is able to meet its ambitious 2045 goal.

There are changes in the 2031/2045 plan relative to what was included in the original 2020 plan to reflect new carbon accounting, scientific data, understanding, and tools. For example, emission of methane from wetlands makes the net GHG impact of restoring wetlands uncertain, so we now only include tidal wetland restoration where methane emissions are typically negligible. The 2031/2045 plan deemphasizes associating carbon outcomes with specific programs, with the exception of tree planting. The 2020 plan measured progress relative to a baseline of no action, whereas for the 2031/2045 plan progress is measured as absolute change in the natural lands carbon sink in Maryland, which is the determining factor for measuring the removal aspect of net GHG emissions (in addition to any future GHG removal technology to be utilized in the state). Taking an inventory approach for measuring progress means that the actions of the state cannot be easily disaggregated from other factors influencing the forest or wetland carbon sink, like sea level rise or increasing disturbance rates in forests due to climate change. We can have confidence that actions like climate smart forest management or wetland restoration will contribute towards increasing the resiliency of these systems, but the degree to which they will increase our natural carbon sink by 2031 or 2045 is difficult to quantify. Conversely, for tree planting we have partnered with Maryland Department of the Environment (MDE) and University of Maryland (UMD) to utilize an advanced model of tree growth and monitoring approach so we can have confidence about the carbon outcomes, and that the program will be additive to the existing forest carbon sink.

DNR's ongoing efforts associated with Biomass for Energy Production, Geological Opportunities to Store Carbon, or Creating Ecosystems Markets may produce positive results in the upcoming 2024-2030 period, where the department lacked measurable benefits between 2006-2023. For example, Maryland is one of eight partner states in the Midwest Region Carbon Sequestration Partnership whose role is to identify, locate, and characterize potential geologic storage opportunities.

Maryland is actively working to promote biomass to energy and anticipates new installations prior to 2030 which will promote the development of markets that support stewardship of forests. Facilities utilizing wood for energy provide financially feasible outlets for otherwise nonmarketable wood, keeps energy dollars within local communities, and adds or preserves local jobs, often in our least prosperous areas. The Maryland Forest Service was awarded Wood Innovations Grant funding in 2021 that was renewed in 2023 from the U.S. Department of Agriculture (USDA) to develop priority projects with the assistance of the Maryland Wood Energy Team. This partnership with the Maryland Clean Energy Center (MCEC), Maryland Department of Commerce, University of Maryland Extension, the USDA Forest Service, and others aim to develop modern, low-emissions wood energy facilities creating new jobs and opening renewable energy markets for underutilized forest products, which will in turn benefit the health of Maryland's sustainable forests. The funding is supporting the staffing of the MCEC Wood Energy Coordinator in collaboration with the Maryland Wood Energy Team to identify wood energy opportunities

throughout the state. The Maryland Forest Service and experts at the USDA Forest Service provide supply mapping and system design assistance to five to 10 facilities annually showing high probability for successful conversion to wood fuel.

Maryland is also actively working to advance markets for the forest industry, including advocating for policy changes related to Thermal Renewable Energy Credits (TRECs) that would provide greenhouse gas benefits. MDE commissioned a report released in October of 2023 studying a potential Clean Heat Standard for Maryland which would include qualifying biomass as a source of TRECs. Diverse markets that include outlets for low-value wood from urban tree management, thinning, timber stand improvement help land managers carry out sustainable forestry and generate a mix of forest products.

The US Climate Alliance (USCA) funded a project led by the University of Maryland which worked with partners including DNR, Delaware Department of Natural Resources and Environmental Control, and the World Resource Institute to combine high resolution LiDAR based estimates of forest carbon with annual estimates of forest cover change from satellite imagery. This has been applied to Maryland's greenhouse gas inventory allowing for a better understanding both of how much forest is being lost or gained and how that translates into our carbon budget. This allows the state to more frequently and accurately track progress towards our forestry goals. The estimates of forest change and trees outside of forests. The resulting inventory estimates have been integrated into Maryland's 2020 GHG inventory[1] and have been backcasted to 2006 in order to assess progress relative to Maryland's inventory baseline.

Environmental Justice Impacts and Initiatives

DNR recently prioritized a more inclusive and equitable principle to uplift the most vulnerable communities, which reads "Maryland DNR commits to fostering a culture and workforce that is inclusive, equitable, and representative of the State's diversity. We are committed to increasing accessibility to our public lands, waterways, and natural resources for all communities to enjoy. By engaging and understanding communities that have historically been left behind, we strive to address and remove systematic barriers that perpetuate environmental injustices. Through this work, we celebrate these values within nature, our partnerships, and the communities we serve."

We will take the following actions to ensure that environmental justice is embedded throughout our climate plans and activities. These actions include, but are not limited to:

- Use the state's Climate Vulnerability tool and the Environmental Justice Screening Tool alongside other relevant state and federal tools indicative of climate vulnerability to ensure resources are allocated equitably;
- Prioritize grant funding and programs in underserved and overburdened communities;
- Establish a community liaison program to ensure underserved and overburdened communities have a voice in our work and decision making;
- Provide technical assistance to underserved and overburdened communities; through our programming; and

[1] Maryland Department of the Environment. Greenhouse Gas Emission Inventory Methodology. 2023. https://mde.maryland.gov/programs/air/climatechange/pages/greenhousegasinventory.aspx

- Provide equitable and accessible public access opportunities through these climate projects.

This work is currently being implemented via several initiatives and programs at DNR that include Greenspace Equity Program, Community Forestry Catalyst Fund, Whole Watershed Act and Fund, Grants Gateways Program, and partnerships like Envision the Choptank. Maryland is committed to the Justice40 initiative and tracking progress towards the goal of spending at least 40% of federal funds in underserved communities. The Climate Pollution Reduction Grant (CPRG) received by Maryland and partner states, described later in this document, will contribute towards this goal.

In 2024, the Maryland General Assembly directed the Critical Area Commission to update the Critical Area Program with respect to environmental justice, which includes considering the equitable distribution of the benefits and burdens of development, restoration, mitigation, conservation and adaptation to climate change; as well as ensuring equitable representation and participation in these processes. The Commission will promulgate regulations that specify how State agencies and local jurisdictions shall incorporate environmental justice considerations in their projects and local Critical Area programs. Once promulgated, all 64 local jurisdictions with Critical Area Programs will update their Critical Area ordinances to (1) identify underserved and overburdened communities within the Critical Area, (2) include measures to ensure the equitable distribution of the benefits and burdens of development, restoration, and mitigation within the Critical Area, (3) include measures to ensure equity in the public participation process, and 4) include measures to ensure public access to the water, shoreline, and other natural areas for underserved or overburdened communities. These regulations will address existing development and new development in the Critical Area.

Greenhouse Gas Mitigation Programs

1. Managing More Forests to Capture Carbon

Program Description

Managing more forests to capture carbon promotes sustainable forestry management practices in existing Maryland forests on both public and private lands. Enrolling unmanaged forests into forest management plans and implementing sustainable forest best management practices can enhance forest productivity, which increases rates of carbon sequestration in forest biomass and the amount of carbon stored in harvested durable wood products, and decreases the risk of forest pest or disease outbreaks. This can translate to economic benefits for the landowner and the forest products industry in Maryland, which had an annual economic impact of over $3.3 billion in 2019. Over 90% of State Forests are dual certified for sustainable forest management and sustainable practices are regularly implemented on other state owned lands like Wildlife Management Areas and State Parks. Only~ 40% of privately owned forests in Maryland are enrolled in forest management plans, with the remaining lands representing opportunities to engage these landowners in sustainable forest management.

The 2020 GGRA goals of this program were to improve sustainable forest management on 30,000 acres of private land annually, and ensure 50% of state-owned forest lands will be third-

party certified as sustainably managed. These goals have been achieved; the 2020 15 year target goal for cumulative acres managed was exceeded in 2018. The CSNA 2031 goals of this program are to improve sustainable forest management on 38,000 acres of private land annually, and ensure greater than 50% of state-owned forest lands will continue to be third-party certified as sustainably managed. This annual acreage target was exceeded in 2020, 2021, 2022 and 2023.

Carbon Accounting

Sustainable forest management (sometimes referred to as "climate smart forest management") refers to a broad suite of practices that are meant to increase the health of the forest and meet the management objectives of the landowner. In some cases these practices have clear and measurable benefits in terms of increasing carbon sequestration in the forest (e.g. extended rotations, plantings to increase density), some practices are likely to increase carbon capture but are difficult to quantify (e.g. invasive species removal, deer browse control) and some do not increase carbon sequestration, but are likely to increase the resilience of the forest to climate impacts, increase the economic return of the forest, or improve the quality of wildlife habitat (e.g. timber stand improvement, thinnings).

The department partnered with American Forests, US Forest Service, Northern Institute of Applied Climate Science, Canadian Forest Service, and Michigan State University to identify a broad suite of forest management scenarios for Maryland and simulated forest growth and removals over 150 years. The modeling showed that increasing sustainable forest management practices like extended rotations, deer browse control, restocking, reducing high grading, silvopasture, and afforestation would significantly increase the carbon sink in the state by approximately 47% (0.37 million metric tons carbon dioxide equivalent, MMTCO2e, per year) by 2050 relative to a business as usual scenario. A no-harvest scenario was simulated as well, and while this scenario does result in the greatest carbon accumulation within forests over time, it was shown to create conditions where the forest sector became a net emitter of GHGs by 2060. This is due to the leakage of some forest harvest to areas outside of Maryland in response to decreased in-state harvests, forgone carbon storage in long lasting wood products that will no longer be produced, and the likely use of more emission intensive building materials if locally sourced wood was not available.

While this study was useful in identifying relative benefits of different forest management practices, it was not meant to be predictive of the Maryland Greenhouse Gas Reduction Plan. As such, there is not a specific carbon outcome associated with this pathway, but forest management is clearly essential in maintaining and increasing our forest carbon sink. Progress will continue to be tracked and ultimately be reflected in the forest and harvested wood product sinks in Maryland's GHG Inventory.

Implementation Milestones

Public Lands:

- Since 2006, 211,000 acres of State Forests have been certified with dual third party certification for Forest Sustainability to the Sustainable Forestry Initiative and Forest Sustainability Certification standards.

- DNR is developing similar sustainable forest management practices on wildlife land. Forest Stewardship Plans are being developed for State Park lands to control invasive species and improve the health of the forest.
- DNR's Wildlife and Heritage Service is developing Forest Stewardship Plans on several Wildlife Management Areas.
- The DNR has accelerated pace of silvicultural activity:
    - Savage River State Forest will increase the number of timber sales from 14 to 20.
    - State Forest Annual Work Plans included State Forest Annual Work Plans include 3,296 acres of timber harvests planned for FY24 that will be naturally regenerated.

Private Lands:

- Since 2006 we have implemented-
    - 400,475 acres of stewardship plans
    - 242,736 acres of sediment control
    - 127,842 acres of forest stand improvements (eg., State Forest regeneration, timber stand improvements, wildlife habitat)
    - Total of 771,053 acres of forest management planning activities on private lands
- DNR has met the 2020 goal and is on track for 2031.

Technical Assistance Provided:

- Forest Stewardship Plan preparation
- Forest Stewardship Plan implementation – expanded Special Rivers project
- Financial assistance – state and federal cost sharing
    - Woodland Incentive Program
    - Healthy Forests/Healthy Waters
        - Working on the next round of projects
    - Backyard Buffer Program
    - Environmental Quality Incentive Program (EQIP)
    - Conservation Reserve Enhancement Program (CREP)
    - Income Tax Modification (TAXMOD)
        - Expanded eligibility of forestry practices in 2014
    - Forest Conservation and Management Program
    - Woodland Assessment Program
- Completed the development and application of the University of Maryland remote sensing capability for forest carbon assessment. This work is the basis for the forest carbon sink that has been included in the 2020 GHG Inventory, released by MDE in October 2022.
- Launch of National Aeronautics and Space Administration, U.S. Department of Agriculture and U.S. Department of Energy climate science project for remote sensing, modeling and field-based measurements to quantify the carbon consequences of alternate development and management plans across rapidly changing forests in Maryland.
- Forest Management Study

    DNR identified a forest management site that utilizes three forest management plans: Low Management (100% hardwoods), Moderate Management (50-70 percent pines: 30-50 percent oaks) and High Management (100% pine). DNR's Resource Assessment Service continues to evaluate the below ground carbon sequestration on these management plots to complement the determination of carbon sequestration in the above-ground forest. Baseline data was collected

annually from 2011 to 2014. After analysis of the 2014 data, this project was changed to a 5-year sampling interval. Expected project completion is 2030.

- DNR worked with federal partners at the US Department of Commerce and an array of Maryland conservation and economic development agencies to conduct an Economic Adjustment Strategy for the forestry industry in Maryland.

Table 1 Acres of Forest Management

Calendar Year	Stewardship Plan(1)	Sediment Control(1)	State Forest Regeneration(2)	Timber Stand Improvement(1)	Wildlife Habitat(1)	Total Acres
2006	13,834.10	9,113.10	2,417.00	3,092.90	2,172.60	30,629.70
2007	14,135.00	11,204.80	1,731.00	5,925.60	3,331.40	36,327.80
2008	26,787.30	11,692.20	1,823.50	5,611.20	4,146.40	50,060.70
2009	17,936.90	11,044.40	2,234.10	3,789.20	3,212.80	38,217.40
2010	14,921.20	9,539.80	2,158.20	3,178.00	2,070.60	31,867.80
2011	22,012.10	11,585.80	1,891.80	4,496.00	3,302.10	43,287.80
2012	19,486.40	12,177.60	1,723.60	3,910.00	2,705.80	40,003.40
2013	18,945.00	12,235.90	1,524.90	5,054.90	1,062.50	38,823.10
2014	16,580.00	13,100.60	1,249.20	3,072.90	434	34,436.60
2015	23,111.60	13,973.80	1,803.70	5,373.80	279	44,541.90
2016	35,224.30	18,022.10	1,866.60	3,802.10	696.2	59,611.30
2017	24,795.10	18,048.60	2,504.70	3,506.30	1,223.40	50,078.00
2018	26,369.10	16,571.80	2,469.60	3,233.80	525.6	49,170.00
2019	25,145.40	11,547.70	2,324	3,940.40	608.4	43,566.00
2020	26,128	11,466	1,500.00	3,486	716	43,296
2021	31,100.5	16,516.8	1,374.0	1,007.7	328.5	50,327.4
2022	23,048.7	17,720.1	2,026.5	881.8	265.7	43,942.8
2023	20,914.7	17,174.6	2,144.5	623.1	209.4	41,066.2
Total	400,475.4	242,735.7	36,565.9	63,985.5	27,290.3	771,052.8

Average Annual	22,248.6	13,485.3	2,031.4	3,554.7	1,516.1	42,836.3
From the Maryland Forest Service PMAS report where a calendar year is defined as Quarters 3 & 4 of the preceding year, and Quarters 1 & 2 of the current Fiscal Year. For example, the number for 2006 represents the reported values from PMAS for Q3 & Q4 of 2006 and Q1 & Q2 of 2007.						
State Forest harvest acres are only tracked by FY. Number reported from the annual State Forest Harvest Report and harvest data from WMAs and demonstration forests for the same fiscal year.						

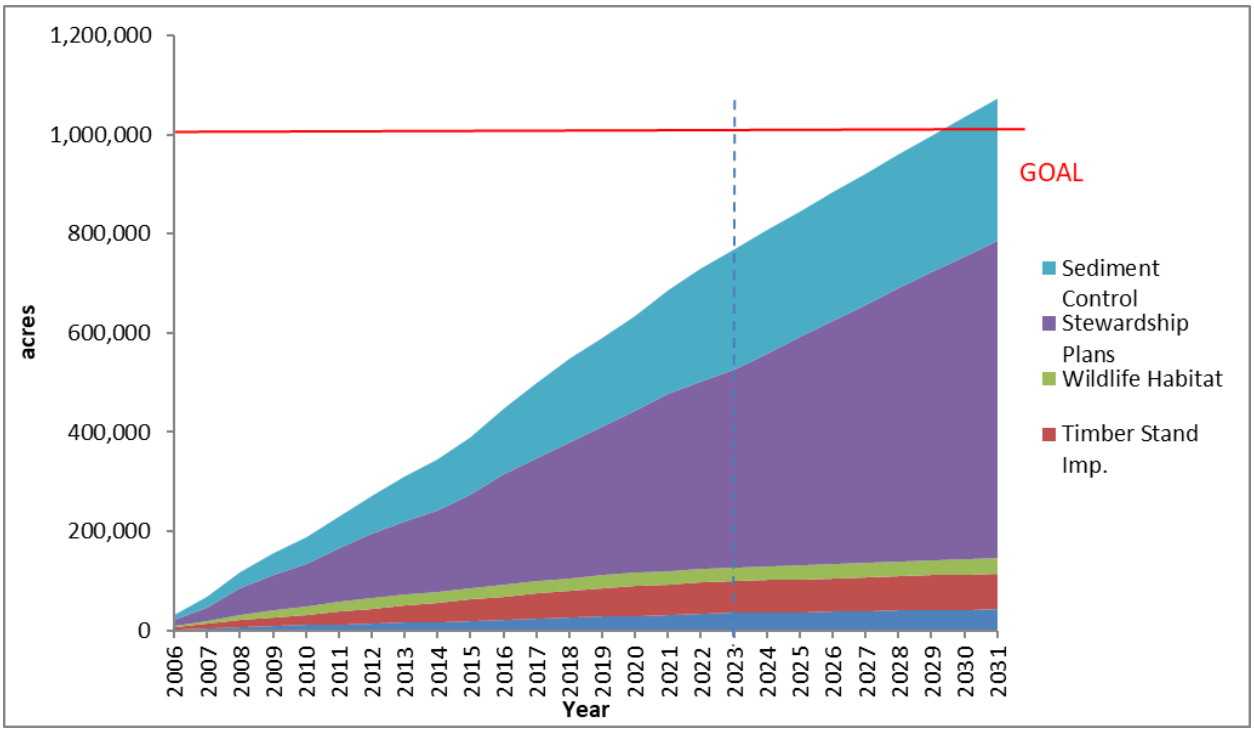

Figure 1: Managing Forests to Capture Carbon. The Maryland Department of Natural Resources is promoting sustainable forestry management practices in existing forests on public and private land through a suite of efforts, policies and programs. The dotted line indicates current progress through 2023.

Enhancement Opportunities

There are many potential actions by federal and non-profit partners other than Maryland state government that could result in increasing natural and working lands' carbon sinks in the state, contributing toward our 60 by 30 goal and the 2045 net-zero goal. Market-based solutions that incentivize public-private partnerships, enhanced outreach to landowners, and additional incentives are examples.

The Nature Conservancy and the American Forest Foundation have partnered to create the Family Forest Carbon Program targeted towards smaller forest landowners. They are working with the carbon verifier

Verra to conduct carbon friendly forest management practices on smaller forest parcels and create a practice-based protocol with a much lower cost (~75% less) for verification than traditional approaches. This program has recently expanded to Maryland, and landowners in Garrett, Allegany, Washington, Frederick, and Carroll counties with between 30 and 2,400 acres of forest are eligible to enroll. Landowners sign a contract and agree to conduct specific forest management practices shown to reduce carbon in exchange for regular annual payments over the contract period. Maryland Forest Service foresters began assisting forest landowners with enrollment in November, 2021 and as of October 2023 a total of 31 landowners have enrolled a combined 3,164 acres in the program.

Funding

The USDA Urban and Community Forestry Program provides funding for boosting the nation's tree cover in urban, suburban and rural communities nationwide, with significant additional funding made available through the Inflation Reduction Act. In 2022 DNR was awarded $5 million through this program to support urban tree planting, and in 2023 partner groups throughout the state received over $34 million through this program.

DNR provides cost-share for sustainable forest management through the Woodland Incentive Fund, with approximately $200,000 per year for 2,000 acres of forest practices, and technical assistance covering 400+ landowners and more than 20,000 acres annually in Forest Stewardship Plans designed to maintain healthy forest cover. This fund receives revenues from a number of sources including fees for service and assistance in implementation of an approved practice, funding from the Chesapeake and Atlantic Coastal Bays Trust Fund (under § 8-2A-04 of § 5-307), and subject to approval by the secretary and the Board of Public Works, a portion of the revenues derived from the forestry practices on designated lands owned and managed by DNR. Another important revenue source is property tax from the transfer of forest lands (up to $200,000 per year).

Maryland was recently awarded $10 million for a four-year NRCS Regional Conservation Partnership Program project to conduct tree plantings and climate smart forest management. These additional funds will support technical assistance to landowners and the implementation of projects on agricultural land in Maryland. The award includes over $700,000 of funding over five years for climate-smart forest management. These are practices that increase carbon sequestration over time or lower the risk of disturbances, such as wildfire or insect outbreaks.

The Maryland/DC Chapter of the Nature Conservancy was awarded $50 million by the EPA through the MD/NC/SC/VA Climate Pollution Reduction Grant (CPRG) award. Each state's chapter was awarded $50 million. In Maryland these funds will be dedicated to climate smart forest management and strategic land conservation, targeted in Western Maryland.

Challenges

The lack of a reliable market for low quality wood is a challenge because without the ability to sell wood after thinning, the landowner will bear a cost, even with cost share from the state and often chooses to forgo forest management without the ability for it to pay for itself. Educating the public on the benefits of climate-smart and forest health driven forest management will likely increase the willingness of landowners to implement management actions.

2. Planting Forests in Maryland

Program Description

Planting trees expands forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through practices such as soil preparation, erosion control, supplemental planting and full site planting. These actions help to ensure optimum conditions to support forest growth and expand forest area. By 2020, the implementation goal of this program was to achieve the afforestation and reforestation of 43,030 acres in Maryland. This goal was exceeded in 2019 with 44,931 cumulative acres planted through 2020 (inclusive of natural regeneration, no longer tracked in this report). In 2021 the Tree Solutions Now Act was passed, establishing the goal of planting 5 million trees by 2031, in addition to the tree planting goals established in Maryland's 2019 GHG reduction plan.

While Maryland has successfully implemented an aggressive tree planting program over time, the overall trend of tree canopy cover in the state has been essentially stable since 1999, according to the 2022 Maryland Forest Technical Study.[2] This was despite the population in the state increasing by 17% over that period, a credit to tree planting initiatives as well as the Forest Conservation Act forest loss mitigation requirements and local tree conservation ordinances. The study did find a loss in forest cover compared to overall tree canopy, a decrease of 0.7% between 2013 and 2018, indicating an increase in forest fragmentation over that period.

Program Objectives and Carbon Accounting

By 2031, the implementation goal of this program is to achieve the afforestation (planting trees in areas that are not currently forested) of 21,812 acres in Maryland cumulatively since 2006. This goal includes the acres tracked under the riparian buffer category. To meet this goal, as well as the 5 million tree goal, ~11,800 acres will need to be planted over the next nine years (2023-2031). Achieving the target should increase the state's forest carbon sink by approximately 87,000 metric tons of CO2 equivalent (0.087 MMTCO2e) annually, on average over the first 30 years of growth.

Reforestation, i.e. planting trees in areas that are or were recently forest, such as after a harvest, is also an important function of the state to maintain forest land as forest. Reforestation does not increase the forest carbon sink relative to current conditions, but it is essential in maintaining the sink into the future. Maryland DNR has reforested nearly 14,000 acres since 2006 and plans to reforest an additional 5000 acres by 2031. These plantings increase the forest carbon sink by 0.075 MMTCO2e, relative to a scenario of forest loss on those acres.

Implementation Milestones

The department is implementing this program through a suite of efforts, policies and programs, including:

Public Lands:

- State Forest annual work plan implementation

[2] Chesapeake Conservancy, 2022. Maryland Forest Technical Study. https://www.chesapeakeconservancy.org/projects/maryland-forest-technical-study

- The Maryland Park Service, in partnership with the Maryland Forest Service, Chesapeake and Coastal Service, and various non-profit environmental stewardship groups reforested approximately 284 acres of parkland in 2023. An additional 92 acres were put into early successional meadow habitat as well. The majority of these reforestation and meadow creation projects occurred on land that was previously part of conventional, row-crop agriculture, further contributing to the carbon reduction of the restoration projects.

Private Lands:

- Technical Assistance
  - Forest Stewardship Plan implementation
  - Forest Conservation Act (FCA) implementation

Financial Assistance – Rural Lands: State and Federal Cost Sharing:

- Woodland Incentive Program (WIP –MD Forest Service)
- Income Tax Modification (TAXMOD)- expanded eligibility of forestry practices in 2014
- Environmental Quality Incentive Program (EQIP – federal/NRCS)
- Conservation Reserve Enhancement Program (CREP – federal/NRCS)

Estimated Emission Reductions for CY 2023

Cumulative plantings since 2006 increase Maryland's forest carbon sink by approximately 0.10 MMTCO2e in 2023.

Table 2 Forest Planted in Maryland

	Year	Afforestation(1)(2)	Reforestation(1)(3)	Riparian Buffers(4)	Total Acres
	2006	845.7	3,318.00	388.2	4,551.9
	2007	343.4	1,990.20	242.8	2,576.4
	2008	404.9	1,598.20	191.2	2,194.3
	2009	531.1	1,497.40	162.6	2,191.1
	2010	596	417.4	545.6	1,559.0
	2011	1,223.60	633.9	503.1	2,360.6
	2012	433.7	615.3	320.1	1,369.1
	2013	198.1	593.6	237	1,028.6
	2014	409.8	559.2	287.3	1,256.2
	2015	294.1	633.1	213.7	1,140.9

	2016	180	638.9	263	1,081.9
	2017	97.6	434	127.4	659.0
	2018	134.2	423.4	212.9	724.6
	2019	107.3	254.2	115.6	526.5
	2020	239	312	163.6	714.6
	2021	168.8	234.6	169.0	572.4
	2022	393.8	189.0	215.2	798.0
	2023	309.2	417.9	116.0	843.1
	Total	6,910.0	14,760.2	4,477.8	26,147.9
	Average Annual	383.9	820.0	248.8	1,452.7
(1).	From the Maryland Forest Service PMAS report where a calendar year is defined as Quarters 3 & 4 of the preceding year, and Quarters 1 & 2 of the current Fiscal Year. For example, the number for 2006 represents the reported values from PMAS for Q3 & Q4 o				
(2)	PMAS field CREP/HEL Afforestation plus the Other Afforestation Acres.				
(3)	PMAS field Reforestation Acres.				
(4)	Acres reported by the Maryland Forest Service Riparian Forest Buffer Restoration Program. http://dnr.maryland.gov/forests/Pages/programapps/rfbrestoration.aspx				
(5)	Estimated area of privately owned forest regenerated annually following timber harvest. Assumes 20% of Sediment and Erosion Control permitted acres reported by counties are actually harvested and regenerated. Historically, the average is 1,400 acre/year.				

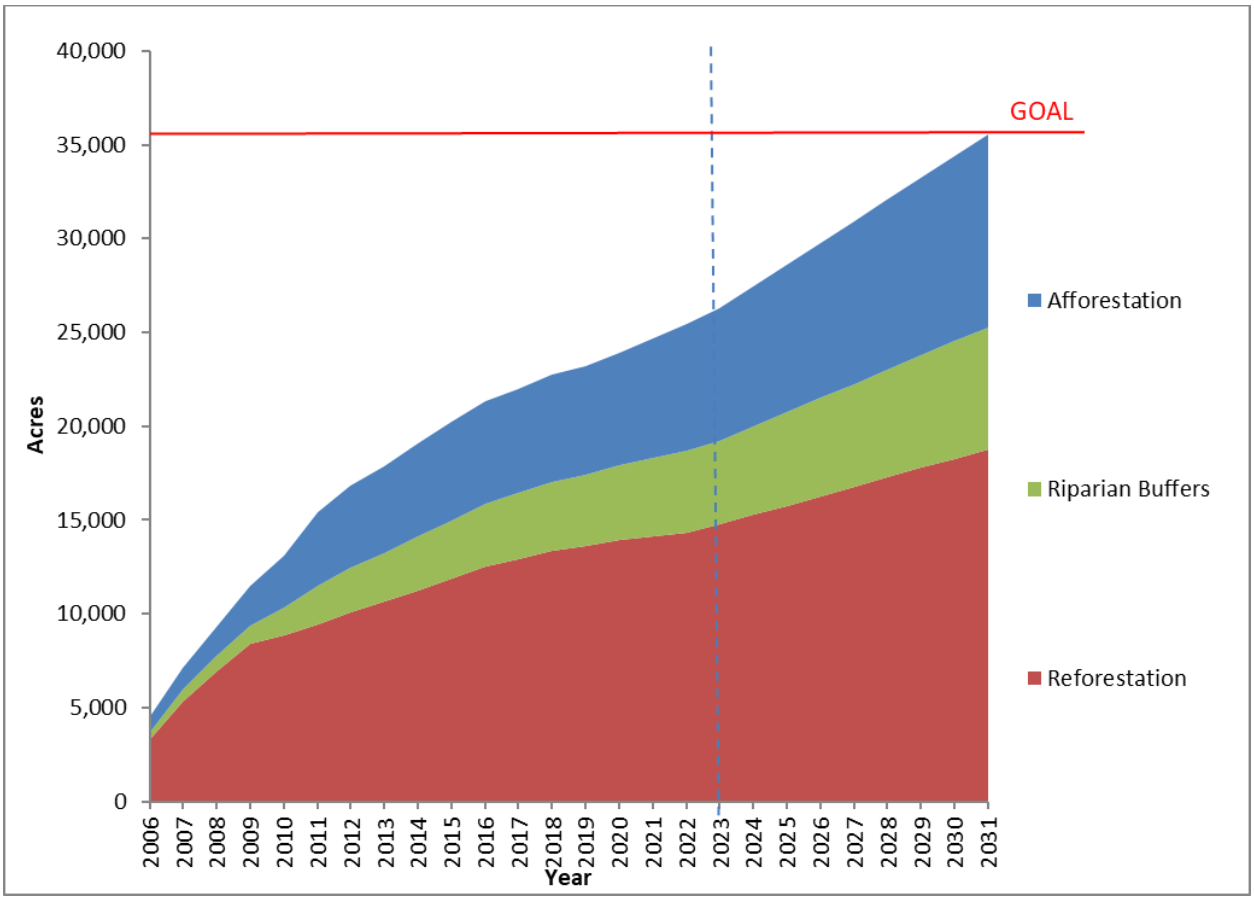

Figure 2 Planting Forests in Maryland. Riparian buffers are tracked separately from afforestation, but together they represent progress towards the 5 Million Tree goal, whereas reforestation acres are not. The dotted line represents progress through 2023.

Enhancement Opportunities

The Tree Solutions Now Act, House Bill 991, was passed by the Maryland legislature in 2021 and requires that five million trees be planted in the state by 2031. These trees must be in addition to trees already projected to be planted in Maryland's 2030 Greenhouse Gas Reduction Plan and 10% must be planted in urban underserved areas, as defined in the bill. The bill dedicates $10 million per year for urban tree plantings to be administered by the Chesapeake Bay Trust and that $2.5 million of the Chesapeake and Atlantic Coastal Bays Trust Fund will go towards tree planting per year, and to support 13 additional staff. The bill also stipulates that the Maryland Department of Agriculture can pay an additional $1,000 per acre for tree plantings through MDA and the Conservation Reserve Enhancement Program (CREP). The recently selected NRCS RCPP project will provide funding for tree planting as well.

The additional 13 positions to DNR from HB991 will provide technical assistance, planning, and coordination related to tree plantings, tree buffer management, and forest management, including invasive vine removal, on public, private, and agricultural lands and in "underserved areas". These positions can expand awareness of existing and new planting programs to accelerate progress towards climate mitigation goals.

In 2023 the Maryland Legislature passed an update of the Forest Conservation Act that increases replanting requirements when forest is lost due to development and allows for forest conservation to be credited towards mitigation. The goal of the act is to increase the area of forest in Maryland, which will help the state grow the forest carbon sink.

Funding

Important challenges faced by this program include engaging landowners willing to plant more trees, funding site preparation for successful tree planting in challenging urban locations, and maintenance needs after grants for establishment have ended.

Funds from both the EPA Climate Pollution Reduction Grant and NRCS Regional Conservation Partnership will support tree planting in Maryland over the next five years. The CPRG will support 500 acres of tree planting on the lower Eastern Shore of Maryland, targeting priority Atlantic White Cedar habitat, with $5 million in funding. The RCPP anticipates planting up to 2000 acres of forest, targeting riparian buffers and marginal productivity soil classes on agricultural land with $7 million in funding.

Challenges

The Maryland Department of Planning projects the state's population to grow by 800 thousand people by 2045. Population growth and associated demand for land will need to continue to be balanced with land conservation and forest cover. Tools to facilitate that balance include priority funding areas, transfer of development rights, land conservation programs, and the Forest Conservation Act.

3. Maryland's Blue Carbon

Program Description

In addition to forests, wetlands are known to be efficient at sequestering carbon. DNR is planting forested stream buffers (captured under Planting Forests) and pursuing the creation, protection and restoration of wetlands to promote carbon sequestration through several means including the Natural Filters Program provided through the Chesapeake and Atlantic Coastal Bays Trust Fund, which restores wetlands and buffers on state and public lands to meet water quality goals. The objectives of the Coastal Wetlands Initiative include restoring natural tidal marsh hydrology to coastal wetlands through ditch plugging practices and the development of a terrestrial carbon sequestration protocol. DNR's Shoreline Conservation Service funds or finances living shoreline projects that can function to protect and enhance carbon stocks.

In 2022 Maryland became one of the first states to integrate blue carbon into its GHG inventory. Blue carbon in Maryland refers to the carbon captured by the ocean and coastal ecosystems, including coastal salt marshes and seagrasses. For the Maryland GHG inventory, blue carbon stocks and fluxes comprise the state's estuarine wetlands and seagrasses, otherwise referred to as submerged aquatic vegetation (SAV). Many of the wetland projects tracked here do not have benefits to Maryland's carbon sink for reasons explained below, but all are important in providing climate resilience benefits, wildlife habitat, and improving water quality.

The department is including another best practice for carbon sequestration through its Shoreline Conservation Service projects to install Living Shorelines. These are additional coastal wetland restoration practices that may function to sequester carbon, or protect existing wetland carbon stocks.

Carbon Accounting

Methane emissions are an important consideration when assessing the climate impact of wetlands. Freshwater and brackish wetlands tend to support a bacterial community within their soils that produces methane, with higher salinity (18+ ppt, parts salt per thousand parts water) wetland soils typically not being sources of methane. For that reason, we only considered wetlands in the southern, saltier region of the Chesapeake Bay and the Coastal Bays for the MD GHG Inventory and for the projections here. This includes the mesohaline region, where salinities range between 5 and 18 ppt and significant methane emissions do exist, but carbon sequestration in soils has a larger climate benefit, on average. It should also be noted that the choice of global warming potential (GWP) for methane greatly impacts the net GHG impact of wetlands. Under a 20 year GWP where methane warming is 86 times that of carbon dioxide Maryland coastal wetlands are a net source of GHGs. Results here are presented using the 100 year GWP of methane; 28 times that of CO2. Under that assumption tidal wetlands and SAV in the Chesapeake Bay and Atlantic Coastal Bays removed 0.3349 MMTCO2e in 2020. It is estimated that wetlands in the mesohaline portion of the Chesapeake Bay removed 1.57 MTCO2e per acre per year and wetlands in the polyhaline region (essentially just the Atlantic Coastal Bays) remove 2.99 MTCO2e per acre per year. SAV removes a smaller amount of carbon per acre, varying between 0.15 and 0.45 MTCO2e per acre per year.

Tidal Wetlands Restored from 2006-2023 and Estimated Carbon Benefit

For this initial estimate we only consider tidal wetlands restored from 2006 to 2023+ and use the rate of 1.57 MT of CO2e per acre per year for restored wetlands for mesohaline wetlands in the Maryland Blue Carbon Inventory methodology.[3] The coastal wetland initiative predominantly restored tidal fresh wetlands. These wetlands typically emit levels of methane that exceed the rates of carbon sequestration in soils, so no GHG benefit was estimated for these acres. Existing US Army Corps of Engineers (USACE) documents show over 2,000 acres of tidal wetland creation and restoration have occurred at Poplar Island, Barren Island, and James Island, see Table 3. Some tidal wetland projects, like thin layer placement, do not create new wetland habitat, and while they will likely extend the lifespan of the marsh they do not change the near term carbon removal of the wetland.

[3]Maryland Department of Natural Resources and Department of the Environment. Blue Carbon Inventory Methodology. 2023. https://mde.maryland.gov/programs/air/ClimateChange/Documents/VIMAL/MD_BlueCarbon_Flux_Methodology_01.06.23.pdf

Table 3 Carbon Sequestration Estimate from Coastal Wetlands

Funding Source	Acres Restored	Carbon Sequestration MT CO2e per year
Coastal Wetland Initiative	505.6	0
DNR Trust Fund	3.8	6.0
DNR Resiliency through Restoration	9.82	15.4
Federal Partners	2096.9	3292.1
Total	2608.66	3,313.5

Implementation Milestones

On the ground wetland and waterway restoration projects:

The Natural Filters Program restored 5 acres of wetlands on state and public land and planted 8 acres of streamside forest buffers on state and public lands in state fiscal year 2024. Typically these acres contribute towards the state's Watershed Implementation Plan (WIP) goals for state and public lands. Funded through The Chesapeake and Atlantic Coastal Bays Trust Fund, these projects are designed to accelerate bay restoration by focusing limited financial resources on the most efficient, cost-effective non-point source pollution control projects, which include wetland and buffer restoration projects. Additional wetland restoration projects are anticipated in SFY25.

The Chesapeake and Atlantic Coastal Bays Trust Fund has, as of the end of state fiscal year 2024, funded the restoration of 52.3 acres of wetlands and 42.7 acres of riparian buffers, totalling 3,430 acres of wetlands and 1,740 acres of riparian buffers funded since 2009. These totals include restoration gains from the Natural Filters Program, as documented above, and projects that have occurred on private lands. Implementation tracking includes both public and private land restoration projects that are funded through the Trust Fund.

Through a partnership between DNR, The Nature Conservancy (TNC), U.S. Fish and Wildlife Service, Natural Resources Conservation Service and National Oceanic and Atmospheric Administration, we were able to restore 2,174 acres. The Pocomoke project's primary focus was to reconnect the mainstem, and to channelize the Pocomoke River with its historic floodplain. The wetlands restored were mostly forested riparian wetlands, with some emergent wetlands restored in agricultural fields in the watershed.

Coastal Wetlands Initiative Program: As of 2023, 505.6 acres of coastal wetlands have been restored by plugging existing drainage ditches to restore these drained wetlands.

Living Shorelines through the Shoreline Conservation Service: Between 2006 and 2020, a total of 13.24 acres of Living Shoreline have been created or restored.

The Resiliency through Restoration program has constructed 9.82 acres of wetlands to date.

Wetland restoration and enhancement by federal agencies: The US Fish and Wildlife Service has restored or enhanced 211 acres of tidal wetlands in the Blackwater National Wildlife Refuge over the past 10 years. The US Army Corps of Engineers has created, restored, or enhanced 1,875 acres of tidal wetlands in the Maryland portion of the Chesapeake Bay since 2006, with the most significant projects being a wetland enhancement project on Deal Island and wetland creation on Poplar Island. Recent research has shown that the Poplar Island created wetlands are sequestering carbon at similar rates to natural wetlands.

Wetland Area and Carbon Change in 2030 and 2045

In 2021 Maryland DNR partnered with The Nature Conservancy, George Mason University and Warren Pinnacle, Inc. to simulate change in coastal wetlands and other lands over a 100 year period in 10 year increments under six different sea level rise (SLR) scenarios. The scenarios ranged from 1.2 to 1.5 feet of SLR by 2050, with results for the scenario simulating 1.4 feet by 2050 used here. Results for 2045 were obtained by averaging the 2040 and 2050 model results. In all of the scenarios wetland area increased over time, due to migration into areas that are now upland forests, agriculture, or open areas and existing marshes largely being able to keep up with SLR through building of new soils. Low elevation counties on the southern Eastern Shore in particular are expected to experience extensive wetland migration into uplands. This region is already experiencing the impacts of saltwater intrusion as sea level rises, with ghost forests and less productive or barren agricultural fields becoming more common. Carbon loss due to land-use conversion driven by SLR is likely to be significant, but is not quantified here. The changes projected are just due to expected SLR and do not account for any ecological restoration efforts the state may engage in, such as thin layer placement or tidal wetland creation. Rates of coastal wetland restoration implementation have been low; only 510 acres have been restored by the state and 2,096 acres restored by federal agencies since 2006.

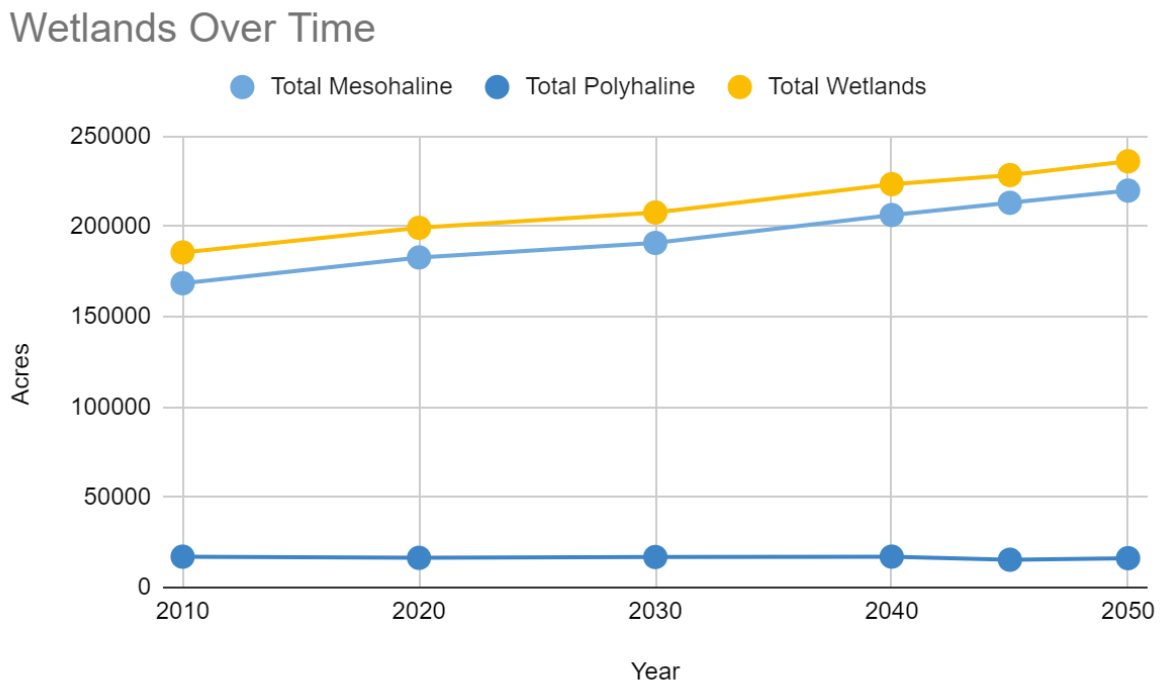

Fig 3. Change in Maryland's mesohaline and polyhaline wetlands over time under a 1.4 feet of SLR by 2050 scenario

According to the SLAMM results for wetland area change under the chosen SLR scenario and our current best understanding of wetland carbon accumulation and methane emission rates Maryland's blue carbon sink is projected to increase by 14%, from -336,000 metric tons of CO2e per year in 2020 to -383,000 metric tons of CO2e per year in 2045. While this is one plausible scenario, different models of SLR and wetland change may result in different results, although the differences between models and scenarios becomes greater as they extend into the future. In the scenarios modeled under this SLAMM run 2070-2080 is an important inflection point, with higher rates of SLR outpacing many wetlands' ability to keep up through soil building and rapid, extensive wetland loss projected to occur. However, under lower SLR projections, such as those expected to be experienced under a stable emissions scenario, many wetlands are able to keep up with those lower rates and wetland area is projected to be relatively stable.[4]

[4] Warren Pinnacle. 2021. Application of the Sea-Level Affecting Marshes Model to Coastal Maryland https://warrenpinnacle.com/prof/SLAMM/EESLR_MD/EESLR_MD_SLAMM_Report_12-28-2021.pdf

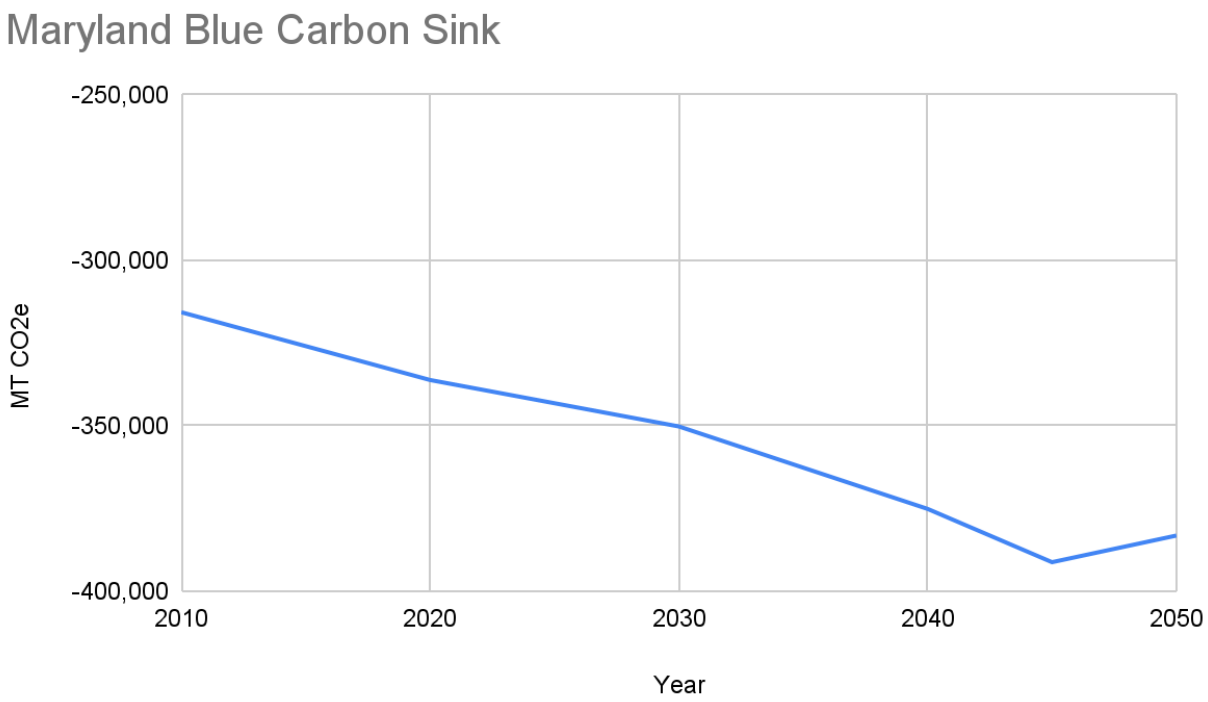

Fig. 4. Change in Maryland's Blue Carbon Sink over time. Negative values indicate a net removal of carbon from the atmosphere. The figure uses the 100-year GWP of methane.

Enhancement Opportunities

The Sea Level Affecting Marsh Model (SLAMM) has been completed for Maryland coastlines and is being actively used for a variety of wetland management practices including:

- Factoring climate change and resiliency into DNR's land acquisition scoring process.
- Developing new easement opportunities for landowners that own land within these wetland adaptation area transition zones.
- Factoring climate change into restoration design.
- Identifying the value of current and future wetlands for protecting communities and infrastructure from coastal flooding and shoreline erosion through DNR's Coastal Resiliency Initiative.

As mentioned previously, restoration of coastal wetlands has not been widely implemented in Maryland, apart from the large island creation projects where dredge material is used to build up islands that are partially composed of wetlands. While coastal wetlands are vital ecosystems that provide important ecosystem services like erosion prevention and wildlife habitat restoration of these systems is quite expensive, frequently exceeding $50,000 per acre restored. Maryland DNR has partnered with The Nature Conservancy and ESA, Inc. to conduct a blue carbon feasibility study of several existing or potential wetland restoration projects in Maryland. The study is ongoing, but preliminary results indicate that the sale of blue carbon credits would not be able to support the costs associated with project implementation, even if the price of carbon were to rise

dramatically. Under certain price points it is possible for the sale of credits to fund a portion of the cost of maintaining the project. Given project costs, it is likely that going forward projects will be done for reasons other than blue carbon, like enhancing coastal resiliency or ensuring habitat for endangered species, but blue carbon will remain an important co-benefit of this work. A possible exception may be projects that reconnect freshwater systems to tidal waters and increase the salinity of a large area of wetlands, thus inhibiting methane emissions. Prior work by scientists from Duke University[5] found limited opportunities for this type of restoration project on the Eastern Shore, but the impact to existing living resources in the freshwater system would need to be considered.

Protecting the migration corridor for coastal wetlands will help ensure that the modeled wetland expansion by 2045 will actually occur. Maryland DNR is piloting a Coastal Resilience Easement program as part of Program Open Space, that identifies land parcels where we expect wetlands to either persist into the future or migrate to. DNR develops a resilience plan with participating landowners to facilitate the transition to wetlands over time.

Funding

The EPA CPRG will support marsh restoration, tidal connectivity, living shorelines to protect marshes, and marsh migration through Coastal Resilience Management Plans. Over five years the award includes $17 million for living shorelines, $9 million for marsh restoration, $2.5 for resilience easement plans, $4 million for tidal reconnection, and $140k for community support to help make sure the projects best serve residents of these areas. DNR anticipates GHG reductions of approximately 367,700 mt CO_2e by 2050 from these efforts.

The Chesapeake and Atlantic Coastal Bays Trust Fund: In 2007, the Maryland General Assembly created the Chesapeake and Atlantic Coastal Bays Trust Fund (Trust Fund) to provide financial assistance to projects that advance Chesapeake Bay restoration. A large portion of this funding is targeted at local grants for counties and municipalities to reduce nutrient pollution to waterways which includes forested buffers, reforestation, wetland restoration, stream and floodplain restoration, stormwater retrofits and other bioremediation projects. In FY24, $32.57 million was allocated for these projects and to support adaptive management.

Resiliency through Restoration Initiative: Since 2011, Maryland has experienced seven hurricane, tropical storm and flood events warranting presidential disaster declarations, resulting in more than $145 million in federal public assistance. Recognizing that coastal habitats help buffer communities from these climate-related impacts, the Maryland Department of Natural Resources' Chesapeake and Coastal Service (CCS) launched a new Resiliency through Restoration Initiative. This Initiative provides technical and financial assistance to restore, enhance and create coastal habitat with the goal of protecting Maryland communities and public resources from extreme weather and climate-related events. To date, the Initiative has led to the design and/or construction of 37 living shoreline, coastal, and inland restoration projects around Maryland, with 14 of those projects implemented with RtR funds.

[5] Warnell et al. 2022. **Sea level rise drives carbon and habitat loss in the U.S. mid-Atlantic coastal zone.** https://doi.org/10.1371/journal.pclm.0000044

Coastal Wetlands Initiative (CWI): There are no dedicated funds currently allotted to CWI. Funding is typically acquired through a competitive grant process using state transportation and other federal funding sources.

Shoreline Conservation Services: This program is funded through the Shore Erosion Control Construction Loan Fund through DNR.

Department of Natural Resources/Department of Transportation Memorandum of Understanding: The Maryland Department of Natural Resources has partnered with the State Highway Administration (SHA) in an effort to lead by example in restoring the Chesapeake Bay and local waters. State parks will provide opportunities for the State Highway Administration to implement restoration projects required by their Federal Stormwater Permit (MS4) and their nutrient and sediment reduction goals required under the Bay Total Maximum Daily Load (TMDL). A Memorandum of Understanding was signed in 2013 to initiate this program, which will increase the rate of restoration projects on state and public lands. In addition, there is a new agreement between DNR and MDOT that builds upon the SHA-DNR MOU but has a wider purview and an expanded scope of partnership. This new MOU applies to all MDOT transportation business units and supports common objectives including (but not limited to) Chesapeake Bay watershed restoration; climate resiliency, adaptation and mitigation efforts; and environmental compliance, stewardship and sustainability activities.

Challenges

While wetland restoration, in both inland, freshwater and tidal environments, are practices that significantly contribute to terrestrial carbon sequestration rates throughout the state, the highly variable rate of methane emissions has a marked effect on net greenhouse gas benefits. Research by state, regional, national and global entities continues to evolve and narrow in on more precise methods to evaluate the greenhouse gas benefits of wetland restoration.

There is a need to improve the design of Coastal Wetland Initiative projects to ensure success in future efforts. Ongoing monitoring is underway to measure the success of various methodologies.

Removing barriers to accessing federal funds could also incentivize landowners to participate in restoration projects. DNR is actively working with the Maryland Department of Agriculture and the United States Department of Agriculture on removing those barriers.

4. Biomass for Energy Production

Program Description

Maryland is working to promote the use of locally-produced woody biomass for the generation of thermal energy and electricity. Energy from forest byproducts can be used to offset fossil fuel-based energy production and associated GHG emissions. There are many end users in the United States that are successfully employing wood heating and cooling, and Maryland could benefit from such a program. For example, schools, hospitals, and municipalities could utilize local woody biomass for their energy needs. Creating a woody biomass fuel market would provide an incentive for harvesting low grade wood, a key component of healthy forest management.

Maryland DNR recommends that sources of woody biomass for renewable energy production be consistent with the recommendations for qualifying biomass made by Woody Biomass sub-group of the Mitigation Working Group in 2022. This definition is as follows- a non hazardous, organic material that is available on a renewable or recurring basis including waste material derived from wood residues from manufacturing, climate smart forest management, natural wood waste, wood waste diverted from landfilling, and excluding any woody material sourced from old growth forests.

The goals of this program are to develop policies that recognize wood as a renewable energy source, the largest source of bioenergy production in Maryland, and offer incentives to utilize locally produced wood to meet thermal energy needs.

Program Objectives

While there have not been any biomass to energy facilities built in the state yet, Maryland continues to explore opportunities for new facilities.

Implementation Milestones

- Woody biomass is now used as part of the heating at Cypress Branch State Park, delivering low-cost renewable fuel grown and processed on the Eastern Shore. A tour to Vermont illustrated the variety of options, community benefits, and forest health improvements that come with adoption of clean modern wood heat systems.

- In October 2023 the Regulatory Assistance Project (RAP) completed a study on a Clean Heat Standard for Maryland. The study recommends including certain sources of woody biomass as qualifying sources of Thermal Renewable Energy Credits.

- In 2022 the Maryland Commission on Climate Change Mitigation Working Group convened a Woody Biomass sub-group that produced a report on woody biomass authored by Tassew Mekuria, a postdoctoral fellow at UMCES, and recommended that the state modify the definition of woody biomass qualifying for renewable energy credits and adopt a Clean Heat Standard for thermal energy that would include qualifying woody biomass.

- DNR is actively working with partners including the Maryland Energy Administration, and the Maryland Department of Commerce to facilitate installation of wood energy systems and has committed to a pilot program on the Eastern Shore and in Western Maryland.

- The Maryland Energy Administration has an existing grant program for wood to energy systems that could be reinstated if adequate demand is demonstrated.

- A webinar series on the potential of woody biomass to energy in Maryland was presented in 2020. This series was sponsored by the Maryland Forestry Foundation and Maryland Clean Energy Center in partnership with DNR and the Sustainable Forestry Council. More information and recordings can be found at the Maryland Clean Energy website.

- The U.S. Department of Commerce Economic Development Administration awarded a grant to the Western Maryland Resource Conservation and Development Council, who partnered with DNR and the Maryland Department of Commerce to develop an Economic Adjustment Strategy for Maryland's forestry industry. The plan, which has been finalized, serves as a roadmap for capitalizing on new opportunities in the forest industry including biomass for energy production and creating jobs, particularly in Opportunity Zones.
- Recognizing the need for an analysis of "wood sheds" where available wood resources are quantified will help raise confidence in the feasibility of an area to support industrial scale biomass to energy. The Eastern Shore Regional GIS Center (ESRGC) at Salisbury University recently partnered with DNR, the Western Maryland Resource Conservation and Development Council, and the Maryland Department of Commerce to assist in determining feasibility of industrial scale biomass to energy. A Maryland Forest Inventory Resource Viewer (MFIRV) was also developed so potential investors and forestry-related businesses could have information on potential markets and market viability.

Estimated Emission Reductions for CY 2023
None.

Enhancement Opportunities
Allowing thermal renewable energy credits (TRECs) to be generated from combined heat and power systems using woody biomass would provide an additional incentive to use this type of system. Creation of a Clean Heat Standard accomplishing this would require statutory change.

Funding
See 'Challenges' section.

Challenges
Awareness of wood energy technology is the primary barrier to this program, in particular adequately informing the managers of commercial and institutional spaces of the opportunities to save money while improving environmental outcomes that are offered by the simple switch to wood fuels. Establishing some demonstration projects in Maryland would greatly assist with DNR's ability to showcase available technology.

The Maryland Energy Administration has temporarily discontinued its Commercial Wood Boiler grant incentive program; however, they have stated that the program could be reinstated if sufficient industry demand is demonstrated.

5. Increasing Urban Trees to Capture Carbon

Program Description
Trees in urban areas are important to Maryland's carbon budget because they help offset some of the greenhouse gas emissions from urban pollution sources such as power production and vehicle emissions, reduce heating and cooling costs and energy demand by moderating temperatures around buildings and slow the formation of ground level ozone as well as the evaporation of fuel from motor vehicles. Implementation is supported by several Maryland laws and programs that

include outreach and technical assistance for municipalities to assess and evaluate their urban tree canopy goals and plant trees to meet those goals.

This program has tracked 6.3 million tree plantings in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland, and 5-103 State Highway Reforestation Act planting programs from 2006 through 2023. Trees planted through the Forest Conservation Act, required mitigation for forest loss, have comprised 85% of tree plantings through this program up to 2023.

Going forward, the long-term goal of this program is to plant an additional 2.65 million trees in urban areas through the Forest Conservation Act, Marylanders Plant Trees, Tree-Mendous Maryland and 5-103 State Highway Reforestation Act planting programs by 2031 from our 2020 tree planting progress. The 2021 Tree Solutions Now Act requires that 500,000 of the 5 million trees to be planted by 2031 be planted in urban underserved areas, as defined in the law.

Program Objectives and Carbon Accounting

From 2023-2031 we estimate that planting 56,000 trees per year on average in urban underserved areas will be necessary to meet the urban tree component of the 5 Million Trees goal. Additionally, we anticipate an average of 209,000 trees will be planted through Forest Conservation Act and State Highway mitigation plantings. This will equate to 2.385 million total trees planted from 2023-2031. The low estimate of GHG benefit associated with these plantings is 0.0023 $MMTCO_2e$ per year, and the high estimate is 0.0046 $MMTCO_2e$ per year, with the expectation of 0.0035 $MMTCO_2e$ per year of additional carbon sink in 2031.

Implementation Milestones

DNR's Maryland Forest Service (MFS) has developed tree planting assistance programs that reach landowners within the urban/suburban areas of Maryland. The programs target 1.1 million acres of turf statewide. Each program targets different lot sizes and available planting space.

- The"5 Million Trees for Maryland" program initiated by the General Assembly's passage of the Tree Solutions Now Act of 2021 has recorded 892,491 trees planted above baseline afforestation rates across the state since July 2021, as of November 2024. Of the total, 57,799 (6.5%) have been planted in urban underserved areas and 673,282 (75%) are attributable to programs administered by Maryland DNR-Forest Service.
- The "Lawn to Woodland" program, a partnership with the Arbor Day Foundation, targets small lots with 1-5 acres of plantable space or turf. The Foundation does outreach while MFS handles the tree planting at no cost to the lot owner. In the spring of 2014, a pilot was done with 14 acres planted on 12 lots. In the spring of 2015, 100 acres were planted on 84 sites and in the spring of 2016, 60 acres were planted on 55 sites, totalling 174 acres planted on 151 sites.
- The "Marylanders Plant Trees" program is a $25 coupon reimbursement program targeting individuals wishing to plant a tree through advertisements on the MD Forest Service portion of DNR's website and at participating nurseries. Landowners with small lots can purchase a tree valued at $50 or more and reduce their cost by $25. 85 nurseries across the state participate in the coupon reimbursement program. From the program's inception in FY09 to FY19, over 49,000 coupons have been reimbursed and 49,000 trees planted.

- Financial Assistance – Urban Lands: Public/Private Partnerships.
    - Tree-Mendous Maryland.
    - 1,865 trees planted in 2021.
- Marylanders Plant Trees/Private Nurseries.
    - Reimbursed coupons for 4,035 trees in 2020.
- Lawn to Woodland
    - Kicked off in spring 2014 with 4.3 acres planted.
    - 100.73 acres on 84 sites planted in spring 2015.
    - 60.33 acres on 55 sites planted in spring 2016.
- Maryland Urban and Community Forestry Committee Grants.
    - In 2023 this grant program was expanded through a partnership with the Maryland Department of Transportation and in FY 23 awarded $47,126.50 to 29 projects.
- Small Community Urban Tree Canopy (UTC) Grants lead to the planting of 0 trees in 2020. Gatherings for tree planting were prevented due to COVID-19.

Estimated Emission Reductions for CY 2023

Urban tree plantings that were planted in excess of mitigation requirements are estimated to increase the carbon sink in Maryland by 0.008 MMTCO2e in 2023. Plantings required for mitigating forest loss are not credited here because, while essential for maintaining Maryland's tree cover, the loss of mature forest will show up as a carbon loss in the state's GHG inventory and new plantings will not fully compensate for that loss for many years.

Table 4. Urban Tree Planting (number of trees)

Year	Forest Conservation Act (FCA)[1]	Reforestation 5-103[1]	Tree-Mendous & Marylanders Plant Trees Programs	Total Trees
2006	623,700	33,750	8,178	665,628
2007	473,400	27,000	6,057	506,457
2008	499,500	9,900	2,160	511,560
2009	450,900	13,950	39,020	503,870
2010	337,950	308,250	23,000	669,200
2011	481,050	15,750	17,200	514,000
2012	42,300	68,850	21,700	132,850
2013	119,250	23,850	23,800	166,900
2014	140,580	24,615	21,500	186,695
2015	142,875	6,251	8,435	157,561

2016	341,640	37,557	8,798	387,995
2017	412,300	8,388	12,545	433,233
2018	256,050	5,913	7,718	269,681
2019	158,535	10,697	10,166	179,398
2020	262,971	2,560	5,900	271,431
2021	200,579	27,183	7,364	235,127
2022	210,150	66,560	12,226	288,936
2023	232,916	*	5,186	238,102
Total	5,386,645.5	691,024.5	240,953.0	6,318,623.0
Average Annual	299,258.1	40,648.5	13,386.3	351,034.6
(1).	Assumes 450 trees planted/acre. Plantings are for mitigation and do not contribute towards 5 million Tree goal			

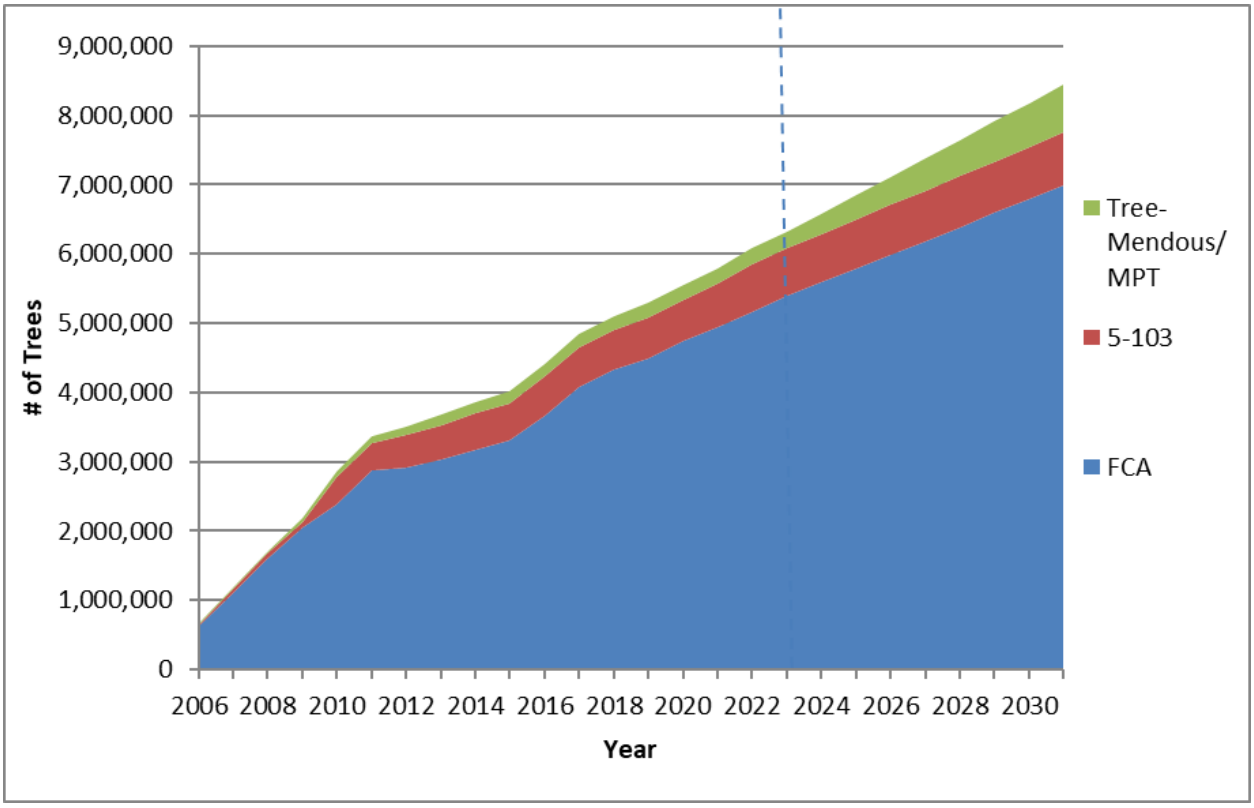

Figure 3. Increasing Urban Trees to Capture Carbon. Current progress and projections to 2031.

Enhancement Opportunities

The Tree Solutions Now Act includes a goal of planting 500,000 trees in urban areas by 2030. Efforts to expand and diversify buffer and urban tree canopy plantings related to Chesapeake Bay restoration will also benefit greenhouse gas reduction efforts. Additional funding mechanisms are being explored, from revolving loan funds repaid through purchase of MS4 credits or local government climate resilience bonds. The quantification of carbon sequestration for tree planting, soil carbon sequestration, and forest management estimates could form the basis for aggregating private forest management and tree planting for the voluntary carbon credit market.

Funding

Year to year variability in program availability and funding levels creates a challenge in building program awareness in the public and perception of programs as reliable funding sources

The "Lawn to Woodland" and the "Marylanders Plant Trees" programs are both funded through forest mitigation funds received as a result of highway construction projects complying with Reforestation Law (NRA 5-103). This makes the funding variable from year to year, and for the past several years the "Lawn to Woodland" program was on hold due to limited available funds. Identifying an alternative funding source when mitigation funds are limited or not available would allow for these programs and others to be consistently offered to the public. Options are being pursued through 5 Million Trees programs and other fund sources, such as federal funds from the Infrastructure Investment and Jobs Act.

Challenges
See Funding section above.

6. Geological Opportunities to Store Carbon

Program Description
Geological carbon sequestration differs from other discussed sequestration methods because it captures carbon at the source and transports it to a sequestration site. Maryland, through DNR's Maryland Geological Survey, is one of eight partner states in the Midwest Region Carbon Sequestration Partnership whose role is to identify, locate, and characterize potential geologic storage opportunities. This has evolved into the MidWest Region Carbon Initiative which is a coordination of over 12 states, the nonprofit Battelle Memorial Institute, and the U.S. Department of Energy. More than 10 gigatons of storage capacity has been identified within the terrestrial portion of Maryland (103 years of storage capacity at current CO2 estimated production rate of 97 million metric tons per year). In the offshore region ranging from Maryland to New York, an estimated 450 gigatons of geologic capacity has been calculated.

The goal of this program is to identify and assess geologic storage opportunities. The program is performing as designed, however, no quantification target has been assigned.

Program Objectives
The potential emission reductions from the Geological Opportunities to Store Carbon program have been aggregated with the estimated emission reductions from the Terrestrial Sequestration bundle (Forestry and Wetlands).

Implementation Milestones
Previous Geological Carbon Sequestration funding has come from the US Department of Energy through the nonprofit Battelle Memorial Institute. Research funds for geologic carbon sequestration ceased in 2020 with a refocusing of DOE funds into implementation of geologic carbon sequestration. Maryland is funded at $28,000 per year to assist in educating policymakers and other interested parties about geologic carbon sequestration opportunities. An additional twenty thousand dollars per year is provided through the state's Environmental Trust Fund.

The Department of Natural Resources' Resource Assessment Service (RAS) has completed or is currently working on the following implementation milestones.

- Total organic carbon content in Maryland black shales (e.g., Marcellus) has been evaluated as a precursor for determining the viability of these as storage units for carbon dioxide. This data is incorporated into regional and national databases for various integration projects. This project is completed.
- The potential for offshore carbon sequestration has been evaluated in partnership with Harvard University, Battelle, U.S. Department of Energy, Rutgers University, University of Texas and the surrounding Mid-Atlantic States. Focus areas of this study included geologic characterization, capacity evaluations, injectability and risk analyses. This project has provided foundation knowledge and an assessment of potential for carbon sequestration offshore in the Baltimore Canyon Trough. Projections from this study state

over 450 gigatons of carbon sequestration are possible within our region using offshore sequestration targets. This project is completed.

- In the offshore environment, the state has identified the need for the U.S. Bureau of Ocean Energy Management to balance renewable energy development with future geologic carbon sequestration opportunities
- The potential of saline aquifers located under the Coastal Plain in Maryland as a target for carbon sequestration is being evaluated in cooperation with multiple state Geological Surveys. There is currently no funding for this research and saline aquifers remain a potential, but unvalidated, sink for the greenhouse gas carbon dioxide (CO2).
- Baseline data has been collected to provide the foundation for conducting risk analyses for the potential development of stray gas migration into potable aquifers. This project is complete.
- Research is ongoing to assess the CO2 chemical adsorption capacity of power plant combustion by-products and the organic shales and clays in the closest geologic formations.
- Research has been completed to assess the possibility of CO2 sequestration as both structural and chemical storage within triassic rift basins. The exposed Gettysburg-Culpepper basin has been characterized and documented as a proxy of the buried rift basins located throughout Maryland. Further research is planned to study the collected cores through the Taylorsville Basin, however those cores are currently difficult to access and located out of state. Phase I of this project is complete. Phase II is still pending the availability of collected cores.
- Research is being performed in the Western Maryland retired gas fields to understand the current abandoned well bores. Documentation of this is necessary as a precursor to evaluation of this area as a CO2 sequestration site. Discussions are occurring between Lehigh Cement, Warrior Run Power Plant, Battelle, and the Maryland Energy Administration to determine if this site could be a pilot site for Maryland to evaluate geologic carbon sequestration.

Other Resources Assessment Service program notes include:

- Site testing (carbon capture, transport and storage) continues in Michigan and Ohio (regional partners to Maryland in CO2 sequestration projects) and has been completed in Kentucky. A large-scale project is currently being performed in Illinois capturing 6.5 million tons of CO2 annually. These programs are being evaluated at a national level and the results continue to be favorable at this time.
- Depleted gas fields present the most immediate option for permanent storage of carbon dioxide in Western Maryland. Maryland Geological Survey is currently working on identifying the site characteristics of individual wells to assist MEA in determining a pilot project injection site.
- A methane emissions study of the Deer Park Anticline by the Western Maryland Regional GIS Center has ruled out using this Anticline for structural storage of CO2 due to observed methane leaks primarily from the old Mountain Lake Park Gas Field. It could still have potential for chemical adsorption of CO2.

- In collaboration with Maryland Energy Administration, a CO2 Sequestration conference was held in November 2019. MEA recorded the talks and are using these talks as educational material for legislators and their staff.
- The Maryland Geological Survey is working with NASA to identify technologies that would assist in identifying methane emitters such as transmissive geologic faults, poorly abandoned wells, fissures, etc. There is presently no funding for this activity;this project is in its infancy.
- The Maryland Geological Survey is working with DOE, Battelle, and Heidelberg Materials for the capture and sequestration of CO2 from the cement manufacturing process. This project has been proposed to DOE and is awaiting a decision for award

Estimated Emission Reductions for CY 2023

None.

Enhancement Opportunities

A federal, regional, or state action to put a cap on carbon emissions would potentially create a demand for geologic sequestration, if it is cost-competitive with other options to offset emissions. If the price of carbon offsets reaches parity with the cost to do geologic sequestration this would also spur action.

A pilot project currently being discussed at the Maryland Energy Agency will allow Maryland to understand the execution of a geologic carbon sequestration program.

The Maryland Geological Survey, through the MRCI partnership and relationships with the Illinois Geological Survey, are working together in evaluation of the Illinois Carbon Sequestration pilot project that has currently sequestered over 4 million metric tons of CO2. This relationship and the lessons learned throughout its development and operations provide vital knowledge for Maryland should the state proceed with geologic carbon sequestration.

Funding

Previous Geological Carbon Sequestration funding has come from the US Department of Energy through Battelle. Research funds for geologic carbon sequestration ceased in 2019 with a refocusing of DOE funds into implementation of geologic carbon sequestration. Twenty thousand dollars per year is provided through the state's Environmental Trust Fund.

Challenges

The cost of capturing CO2 using current technologies involves a parasitic loss of approximately 8-20 percent at the generation site depending upon the source. This cost has decreased over the last 10 years by 30-40 percent due to developing methods to capture the CO2 and the concentration of the CO2 in the smokestack. However, the IRS has created a section 45Q tax credit incentive that allows businesses that geologically sequester carbon to receive a significant offset which is $85 per metric ton for geologically sequestered carbon beginning in 2022. This tax incentive significantly offsets the cost of carbon capture and geological sequestration, allowing for profit making business plans using current technology.

A significant, but often overlooked cost for sequestration, is transportation of the CO2 from its source to the sequestration site. Ideally, the sources would be located on top of the sequestration site making this cost minimal. However, it is likely that pipelines will need to be created to efficiently pipe the CO2 from the production location to the sequestration location. Significant legislative support has occurred in the last year supporting CO2 pipelines and a nationwide plan is being developed.

Retrofitting equipment onto existing power plants and industrial processing plants is often cost and space prohibitive. CO2 capture will need to be part of the design of new power generation plants and industrial processing plants (cement, fertilizer, steel).

7. Creating Ecosystems Markets to Encourage Greenhouse Gas Emission Reductions

Program Description

Establishment of ecosystem service markets, particularly for carbon, has the potential to increase carbon sequestration or avoid additional emissions. Maryland's Forest Conservation Act and Critical Area Act require mitigation for natural resource impacts generated through land development, and mitigation banking are examples of ecosystem markets that help avoid additional GHG emissions through land-use conversion. The Conservation Finance Act (CFA) of 2022 signifies a large step forward for the state in fostering conditions conducive for ecosystem market development.

The goal of this program is to foster the establishment of ecosystem markets, create a tracking mechanism and develop protocols to assess/quantify GHG benefits of ecosystem credit trading in Maryland. No quantification target has been assigned in terms of carbon because it is anticipated that GHG benefits gained through participation in ecosystem markets will be captured through existing programs, and ultimately through the GHG inventory.

Program Objectives

The objective of this program is to increase ecosystem credit trading in Maryland. The Conservation Finance Act charges Maryland DNR with establishing two carbon projects on state lands, one blue carbon project and one upland project, by June of 2024.

Implementation Milestones

- Maryland DNR partnered with The Nature Conservancy and ESA, Inc. to produce a Blue Carbon Offset feasibility study[6], as part of meeting the requirements of the Conservation Finance Act. This study showed that it is not likely for the sale of blue carbon offsets to pay for restoration projects.
- Maryland DNR produced a tree planting carbon offset feasibility study, to be released in CY2024. This study also indicates that carbon offsets are not likely to pay for tree planting projects in Maryland. DNR will be monitoring the carbon sequestration on 118 acres of tree planting on Tuckahoe State Park as part of this project.

[6]MD Department of Natural Resources, The Nature Conservancy, ESA. 2022. Maryland Blue Carbon and Resilience Credit Feasibility Study. https://dnr.maryland.gov/ccs/Documents/Maryland-Blue-Carbon-Resilience-Credit-Feasibility-Study-2023-12-22.pdf

- The Nature Conservancy and the American Forest Foundation have expanded their Family Forest Carbon program into western Maryland. This program allows small forest landowners to generate revenue from selling carbon credits based on implementing sustainable forest practices. As of October 2023 31 landowners have enrolled a total of 3,164 acres in the program
- Ecosystem co-benefits from existing and areas of potentially restorable forests and wetlands,have been spatially quantified across Maryland. Spatial models for co-benefits have been completed and are available on Maryland GreenPrint.[7]
- The Nontidal Wetlands Mitigation Banking bill removes barriers to mitigation banking in Maryland, with the goal of reducing the cost for meeting mitigation requirements in an ecologically beneficial way.
- Under FCA banking, several counties in Maryland allow offsite mitigation for forest loss through purchasing credits in a forest bank. Over 2,000 acres of forest loss have been mitigated in this way over the past 15 years.

Enhancement Opportunities

Enhancement opportunities include the expansion of voluntary, market-based approaches for carbon offset and streamlining the verification and certification process for existing carbon markets available to Maryland landowners. The CFA allows for the state to function as an aggregator of ecosystem credit projects, and this may present an opportunity to lower the barrier of entry for small landowners. In the mitigation sector, banks for forests and wetlands could prioritize habitat types that have high potential for carbon sequestration, like higher salinity coastal wetlands, forested wetlands, or deciduous forests on productive soils. Increasing investment in the conservation and restoration of natural lands, and projects that promote co-benefits will create a positive trend in the ecosystem services provided, including the sequestration of carbon.

Funding

See "Challenges.

Challenges

Working within the boundaries of currently functioning ecosystem marketplaces for wetlands, forests and habitat presents limited opportunities for generating net carbon reductions. RGGI does allow for carbon emissions offsets to be generated through forest planting or management activities, but at this time there have not been any offsets generated in this way because they are not currently cost-competitive with emission allowances on the RGGI market. The Conservation Finance Act specifically allows for landowners that receive state dollars for restoration projects to participate in ecosystem markets, but in most cases projects that have already been paid for through existing funding sources would not qualify for credit generation because they would not be considered additional to existing action. The CFA also allows for the state to produce credits from projects on state lands, but there is a conflict between selling the credits to a third party and the state claiming credit for the project towards its own GHG reduction goals, as outlined in this report and Maryland mitigation plan.

[7] Maryland GreenPrint Map. https://geodata.md.gov/greenprint/

8. Regenerative Agriculture and Agroforestry

Program Description

In partnership with the Maryland Department of Agriculture (MDA), DNR provides funding for best management practices on agricultural lands that both improve water quality and sequester carbon through the Healthy Soils and Cover Crop Programs.

DNR leases approximately 10,000 acres of land for agriculture to Maryland farmers, and the vast majority of these areas are in traditional, high-intensity corn/soybean row crop rotations. DNR is currently engaged in a pilot project with Beauty Blooms Farm for implementing regenerative agriculture practices at Patuxent River State Park, and anticipates expanding this initiative once a site suitability analysis and replicable legal framework for implementation are established. Regenerative agriculture is a term that was introduced by Dr. George Washington Carver, a professor at Tuskegee Institute and one of the most prominent Black scientists of the early 20th century. It is a form of land management and stewardship approaches that draws on traditions and innovations from African, Indigenous, and original land stewards; promotes culturally important food, climate justice programs and initiatives to provide the greatest community benefits. Regenerative agriculture improves soil health and water quality, enhances ecosystem biodiversity, sequesters carbon in the soil, and reduces fossil fuel consumption in the production process. These practices include multi-species cover crops, crop rotation, low to no-till, mulching, roller-crimping, silvopasture and composting. Many agroforestry practices can also be considered regenerative agriculture, such as multi-story food forests.

Program Objectives

Expand implementation of regenerative agriculture practices on land owned by Maryland DNR but leased for agricultural activities. Expand implementation of agroforestry practices on DNR lands, where deemed appropriate.

Implementation Milestones

The MFS has helped create a demonstration food forest at White Marsh Park in Queen Anne's Co. and federal funding awarded to the MDA will be available in coming year to support agroforestry practices on private lands. These practices both mitigate carbon emissions and help to increase the resilience of agricultural land to climate impacts like increased frequency of droughts and high intensity rain events.[8] Regenerative agriculture has a longer return-on-investment than traditional agriculture, and soil health restoration takes several years to show results. Therefore, to pursue regenerative agriculture, DNR is examining the potential for longer-term lease agreements for these properties.

Enhancement Opportunities

Increase the availability of training available to farmers on regenerative agriculture practices. Farmers leasing land from DNR could be required to implement certain regenerative agricultural practices as a condition of their lease.

[8] Study in Preparation for a Maryland Agriculture Climate Vulnerability Assessment, Harry R. Hughes Center for Agro-Ecology

Funding

The Healthy Soils and Cover Crop programs with the Maryland Department of Agriculture provide funds for many practices that could be part of regenerative agriculture. The CPRG award will provide $5 million over the next five years for agroforestry practices, with the funds administered by MDA.

Challenges

The vast majority of Maryland farmers grow corn and soybeans, and while some regenerative agricultural practices can be used with these crops, a continuous corn/soybean rotation would not likely qualify as being truly regenerative agriculture.

Adaptation, Resiliency, Education, and Outreach

Overview

The Department of Natural Resources participates actively and continually in a variety of state and regional efforts to collectively address climate change. Many of the specific projects and programs highlighted in this report directly support goals, outcomes and milestones of those commissions, working groups, partnerships, and collaboratives.

1. Maryland Coast Smart Council

The Coast Smart Council (CSC) was created in 2014 with the passage of HB615 for the purposes of adopting specific Coast Smart siting and design criteria to address impacts associated with sea level rise and coastal flooding on future capital projects. The council is chaired by the DNR Secretary and staffed by DNR employees. The original Coast Smart Construction Program (CSCP) Siting and Design Guidelines (Guidelines) were published in 2015. The CSCP Guidelines were updated following the passage of HB 1350 in 2018, HB 1427 in 2019, and SB 299 in 2024. The 2024 update codified exemptions and gave the Council the ability to recommend regulations.

2. Adaptation and Resiliency Working Group of the Maryland Commission on Climate Change

DNR is a member of the Maryland Commission on Climate Change (Commission) and the chair of the Adaptation and Resiliency Working Group (ARWG). The ARWG is chaired by the DNR secretary and staffed and coordinated by DNR employees. The ARWG supports the Commission by hosting quarterly meetings and coordinating the development of a comprehensive strategy aimed at reducing the vulnerability of Maryland to climate change impacts and providing tools to state and local governments. ARWG's membership is composed of a working group of representatives from state agencies, including three DNR employees, General Assembly members, and public sector representatives.

3. Chesapeake Bay Program, Management Board and Work Groups

DNR employees from across the agency participate actively in the Chesapeake Bay Program, the regional partnership aimed at achieving set goals for Chesapeake Bay Health. DNR staff serve on the Management Board, as chairs for multiple Goal Implementation Teams (GIT), and participate actively in a number of the working groups including Sustainable Fisheries, Habitat Goal, Watershed Technical, Urban Stormwater, Water Quality Goal, Agriculture, and Climate Change Resiliency. These workgroups allow for DNR staff to communicate and coordinate efforts with other Chesapeake Bay Watershed states as a continuation towards achieving goals set by the 2014 Chesapeake Bay Watershed Agreement. DNR also maintains a role in the Chesapeake Executive Council providing background and support for Maryland's representative, and current Chesapeake Executive Council chair, Governor Wes Moore.

In 2019, Maryland's Phase III WIP to reduce nutrients and sediment entering the Chesapeake Bay devoted a chapter to climate change. The plan identifies nutrient and sediment control strategies that can assist in mitigating the increase in GHGs and adapting to anticipated climate impacts. The Plan acknowledges Maryland's role in helping to understand how nutrient control practices might be impacted by climate change. It also affirms Maryland's partnership with the Chesapeake Bay Program to estimate the effects of climate change on future nutrient and sediment loads to the Bay. In addition to the Phase III WIP, Maryland includes climate change mitigation and adaptation strategies within its two-year milestone strategy.

4. Whole Watershed

In 2024, Maryland passed the Whole Watershed Act (SB 969/HB 1165) establishing a highly collaborative, science-based approach to watershed restoration across the state promoting innovative, science-based solutions to waterway restoration efforts. The legislation coordinates existing state funds through a new Whole Watershed Fund supporting a five-year pilot program that targets five Maryland watersheds that best represent the state's diverse land uses, geographies, and impairments. A direct response to the Chesapeake Bay Program's Scientific and Technical Advisory Committee's Comprehensive Evaluation of System Response (CESR) report, the pilot projects will address multiple restoration and conservation benefits, including water quality, increased public access, wildlife habitat, fisheries improvement, environmental justice and climate resiliency. Projects will appropriately integrate climate resilience, adaptation and sustainability considerations into their implementation efforts.

5. Environmental Justice

Environmental Justice is at the forefront of DNR's goals and objectives agency-wide. In 2024, the Department hired its first Environmental Justice Officer (EJO) in the Office of the Secretary. This position was designed to provide oversight and advice on incorporating environmental justice principles in programs and policies for all units. Since starting, the EJO has hosted agency-wide diversity, equity, and inclusion as well as environmental justice visioning meetings and have worked to consult staff, develop environmental justice metrics and assist with annual reports deliverables and metrics required by the Maryland legislature. Additionally, DNR recently adopted a new Diversity, Equity, Inclusion, Justice, and Accessibility (DEIJA) statement, which reads "Maryland DNR commits to fostering a culture and workforce that is inclusive, equitable, and representative of the State's diversity. We are committed to increasing accessibility to our public lands, waterways, and natural resources for all communities to enjoy. By engaging and understanding communities that have historically been left behind, we strive to address and remove systematic barriers that perpetuate environmental injustices. Through this work, we celebrate these values within nature, our partnerships, and the communities we serve."

Upcoming work for the EJO includes but is not limited to:

- Adopting and implementing an Environmental Justice Policy
- Implementing an Internal DEIJA Action Plan
- Assessing equity and barriers in grantmaking
- Identifying policy gaps and opportunities for long term funding/investments
- Establishing a Community Liaison Program

- Increasing resources and technical support to EJ communities working in agriculture

2024 Project and Program Updates

1. Practice and Place

Maryland Climate Change Adaptation & Resiliency Framework (Framework) and Next Generation Adaptation Plan: In 2021, the Adaptation and Resiliency Working Group of the Maryland Commission on Climate Change, completed the initial phase of evaluating and updating the state's adaptation strategy. Through sector and focus group working sessions, co-led by sector appropriate leaders on adaptation, The Maryland Adaptation Framework was put together identifying key goals, strategies and activities needed to move adaptation and resiliency efforts forward. Beginning in 2022, the Adaptation and Resiliency Working Group used the resilience strategies identified in the framework to develop the Next Generation Adaptation Plan which spans a 10-year roadmap to resilience and helps meet the state's GHG reduction goals. This work was completed in August and is a climate milestone in Maryland's Phase III WIP.

Targeted Resiliency Areas: The Chesapeake and Coastal Service Unit continued efforts to develop "Targeted Resiliency Areas" (previously referred to as *Resiliency Opportunity Zones*) to demonstrate how restoration and conservation projects can work together synergistically to generate area wide resiliency benefits to protect natural resource based economies, high value ecosystems, public lands and at-risk communities. In 2021, the team worked to refine the scope, approach and criteria used to determine the TRA's and map out next steps to incorporate these areas into the development of "Comprehensive Water Quality and Climate Resiliency Project Portfolios" that reduce climate risks in vulnerable areas and also generate water quality, carbon sequestration, and habitat co-benefits. These area-specific plans for resiliency will provide the basis for robust funding partnerships and long-term financing strategies. In 2022, the City of Hagerstown and the lower Pocomoke River region, including Pocomoke City, were selected as pilot geographies. This effort is included as a climate milestone in Maryland's Phase III WIP. In 2024, the Chesapeake and Coastal Service worked with a contractor to finalize the project portfolios for the Hagerstown and Lower Pocomoke River TRAs. These two portfolios included the ranked prioritization of numerous potential projects within each TRA based on project cobenefits, ability to improve resilience to Climate Change induced flooding, and likelihood of implementation.

Innovative Technology Fund: Maryland's Innovative Technology Fund (ITF) expanded its scope of eligible techniques and technologies to include consideration of climate impacts. In addition to the traditional technologies focused on nutrient and sediment reductions, the state will also invest in the research, development, and commercialization of solutions addressing mitigation of GHG emissions. In 2024, the program invested funds in N5 Sensors to further refine their wildfire monitoring and adaptation platform, and NextGlass to build prototype full scale vacuum insulated glazed windows that can reduce energy loss by up to 75% compared to traditional windows

Chesapeake and Atlantic Coastal Bays Trust Fund (Trust Fund): Since its inception in 2009, the Trust Fund has provided more than $780 million in support of over 3,400 projects, including

wetland restoration (non-tidal and tidal), stream buffer planting, stream restoration, and bioretention facilities. Wetland restoration and forest buffer planting practices are very efficient at sequestering carbon. Establishing broad riparian buffers along stream corridors also allows for channel migration resulting from increased precipitation. The Trust Fund invests in stream restoration practices that enhance and restore wetlands by reconnecting the stream to its floodplain, which also helps to spread and slow flood waters. Bioretention projects have been identified in federal and state vulnerability studies as a recommended best management practice for water quality improvement, increasing stormwater retention capacity, and tidal flooding resiliency. With the passing of the Conservation Finance Act of 2022, the Trust Fund can now strategically invest in co-benefits, including carbon sequestration, resilience, habitat and DEIJ. In effect, the Trust Fund managers can broaden the myopic focus on cost per pound of nitrogen, phosphorus and sediment reduced, and include other desirable environmental outcomes in investment decisions.

EPA Funding CBIG: DNR's, Chesapeake and Coastal Service (CCS) receives annual funding from the U.S. Environmental Protection Agency (EPA) to advance the outcomes and goals in the *2014 Chesapeake Bay Watershed Agreement* through the Chesapeake Bay Implementation Grant (CBIG). This grant supports a variety of outcomes including Climate Resiliency and Climate Adaptation, ensuring that climate change is incorporated at every stage - planning, design, implementation, and post-construction monitoring. For example, CBIG supports climate change readiness through funding local stormwater and flood management plans, tree planting projects, water quality Best Management Practice (BMP) design projects, living shoreline research and implementation, and performs monitoring of project sites. Funding for 2024 will support water quality monitoring including stream temperatures, tree plantings, agricultural BMPs, and water quality BMP design and implementation.

Following the passing of the Bipartisan Infrastructure Law (BIL), CCS began receiving five years of funding to support green infrastructure projects from federal fiscal year 2022 - 2026. CCS is starting projects from the third year of funding, which include stream restoration, urban tree plantings, and living shorelines. All project proposals that are considered for funding under BIL are reviewed for water quality benefits, incorporation of climate change into design or implementation, and their ability to address or serve disadvantaged communities. This year's funding will support planting urban trees, stream restoration, water quality BMPs design and implementation, and a living shoreline.

Coast Smart Council and Construction Program Outreach: Since the publishing of the Coast Smart Construction Program Document in 2020, efforts of the Coast Smart Council have centered on raising awareness and compliance with the law along with deciding ways in which it might be updated to further protect state investments. In 2024, MDE and MDOT delivered individual presentations to the Council to help understand how agencies have integrated the law into their workflow. Additionally, six educational overview presentations were delivered outside of meetings to various state agencies that may interact with the Coast Smart law. A Coast Smart question and answer session was organized as a breakout session during three of the Planning for Coastal Flood Risk webinars hosted by the Coastal Training Program. Attendees at these webinars primarily represented local governments.

Community Resilience Grants/Resiliency through Restoration: DNR solicited and funded community-based resilience projects in 2024 through DNR's Grants Gateway. These projects leverage federal dollars with state "Resiliency through Restoration" capital funding to promote and support comprehensive, holistic planning and implementation projects that address both water quality and quantity issues. Through these projects, DNR is helping Maryland communities become more resilient to flood risks, and enhance the protection and management of the state's resources including the bay and the ocean. Examples of some projects funded in 2024 include; creating Watershed Master Plans in Baltimore City to holistically address flooding; conducting a feasibility study for tide gate implementation in the Town of St. Michael's; designing green infrastructure practices to help reduce stormwater flooding at churches in Baltimore and Dorchester counties; designing living shorelines to address flooding, erosion, and equitable access in Charles and Kent counties; and designing stormwater practices to help address community-wide flooding in the towns of North Beach and Cambridge. This work continues a decade-long effort to provide support to local communities to assess risk, plan risk-reduction efforts and implement projects. This effort is included as a climate milestone in Maryland's Phase III WIP.

Maryland Habitat Connectivity Network and Co-Benefits of Ecological Restoration: DNR partnered with the Chesapeake Conservancy to update Maryland's GreenPrint network, renamed the Habitat Connectivity Network. This map shows the connections across the landscape of intact habitat hubs in Maryland. The project also mapped opportunities for tree plantings, coastal and inland wetland restoration, and stream restoration across Maryland and the projected associated ecosystem service benefits that would be gained should those areas be restored. These data products will be used to prioritize conservation and restoration opportunities and are now available on the Greenprint web map[9] and the new Restoration and Resilience Map[10].

Beneficial Use of Dredged Material: In 2024, DNR is revisiting and updating its Beneficial Use (BU) policy to further streamline environmentally and economically sound practices that enhance coastal resiliency. Once approved by senior leadership, the revised policy and processes will proactively guide the identification of beneficial use opportunities. Tools like the Beneficial Use: Identifying Locations for Dredge (BUILD) mapping tool will continue to support project managers in quickly identifying beneficial use sites, while assisting counties and communities in planning efforts. This year, DNR is funding or partnering on several coastal resiliency projects utilizing dredged material. Additionally, 2024 marks the launch of the Shallow-Draft Channel Dredging and Restoration Assessment, aimed at evaluating current shallow navigation channel conditions, future dredging needs, and identifying new beneficial use opportunities. Dredging projects funded by the Waterway Improvement Fund will continue to prioritize beneficial use when possible, with regular collaboration during the planning phase to align scheduled maintenance dredging with beneficial use goals.

Clean and Resilient Marinas and Waterway Improvement Projects: The Maryland Clean Marina Initiative provides climate change and severe weather resiliency information to marinas via workshops, on line, and via newsletters. Updated resources related to adaptation and resiliency

[9] Maryland GreenPrint Map. https://geodata.md.gov/greenprint/
[10] Maryland Resotration and Resilience Map. https://dnr.maryland.gov/ccs/Pages/Restoration-and-Resilience-Mapping.aspx

have also been added to the Maryland Clean Marina website. In addition, beginning in 2021, the state Waterway Improvement Fund Program has been incorporating climate vulnerability information into the application, Waterway project manual, review process, and grant issuance processes. Early coordination with grant recipients is taking place to assure that site owners are aware of specific projections related to climate vulnerability. CCS staff are actively providing guidance as to what can be incorporated into planning and design of public boating facility projects to ensure longevity of public investments in infrastructure.

Maryland Park Service (MPS) Strategic Management Planning: MPS is actively engaged in a methodic park-by-park strategic management planning effort. These plans identify specific threats to park resources (such as storm-related flooding) and identify tasks to address those threats.

Building resilient landscapes: MPS is working with Land Acquisition and Planning and Chesapeake and Coastal Service staff to identify marginal agricultural lands on park properties that can be converted to more resilient, natural landscapes such as wetlands, meadows and forests. This has resulted in the protection of sensitive resources (e.g., hydric or highly erodible soils) while also improving park aesthetics and addressing identified erosion concerns. Maps were created for Kings Landing, Merkle NRMA, Tuckahoe SP, and Wye Island to highlight agricultural areas impacted by sea level rise. Ecological and stormwater restoration implementations were installed at Tuckahoe and Elk Neck State Parks in 2024.

Electric Vehicle (EV) Charging: DNR has an internal EV Charging Task Force with representatives from several units who work together on EV charging-related projects. Over the past year, Task Force members representing MPS have developed a regional assessment of potential locations for charging infrastructure installation. MPS has completed the fleet charger buildout in the southern, central and eastern regions and has five active projects in the western region of the state. Expected completion of fleet chargers in all facilities is expected in spring 2025. Acquisition of new EV fleet vehicles will begin once EV's are made available under contract. Key Task Force initiatives have also included working with utility companies on the evaluation of DNR owned lands for charging infrastructure through the Public Service Commission's EV Pilot Program and developing right of entry agreements for pilot program projects. DGS completed the installation of two charging projects at the Tawes complex in 2024. MFS is in the process of constructing three DC fast charger projects at Pleasant Valley Office (WR), Madonna Ranger Station (CR), and Powellville Work Center (ER). Forestry is also installing a Level-2 charger at the Pasadena Office location when it was determined a DC fast charger was prohibitively expensive. Resource Assessment Service is in the process of installing two Level II chargers in Baltimore at the Weaver building. Completion is expected in February 2025. DNR has recently applied for a Maryland Clean Energy Council grant to install additional public EV chargers at two Gunpowder Falls State Park sites, Assateague State Park, Rosaryville State Park and Pocomoke River State Park.

Energy upgrades at existing park buildings: Two parallel efforts are being made to improve energy efficiency at existing park facilities. First, all park sites are being analyzed for the potential installation of solar panels on existing park buildings. MPS is now under contract with MES to coordinate 15 solar projects at five state parks, including Assateague Island State Park,

Merkle NRMA, Sandy Point State Park, Fair Hill NRMA and Deep Creek Lake State Park. Remaining work is needed to complete the Fair Hill NRMA and Deep Creek Lake State Park projects with all projects expected to be complete by December 2024.

Energy Upgrades at other DNR facilities: The 30,000 sq. ft. Kenneth Weaver building in Baltimore is having a traditional 125 Ton chiller/boiler system replaced by Heat Pump technology, automated building system installed, all lights retrofitted to LED, and an insulation package to tighten up the building envelope on this historic building. Design is expected to be complete by the summer of 2025 with a construction commencement date of summer of 2026.

PALS project on Renewable Energy: Partnership for Action Learning in Sustainability (PALS) is an ongoing partnership between Chesapeake and Coastal Service and the University of Maryland. This year, CCS funded a PALS project to evaluate alternative, renewable, power sources for Maryland DNR properties. Students evaluated renewable energy sources such as wind, power, and wood and created a series of score cards that can support early stage scoping for Maryland DNR properties.

Land Conservation and Climate Resilience: Program Open Space Stateside fee and easement acquisitions are evaluated and scored for coastal resilience benefits. Properties are assessed for the presence of future wetland habitat and resilience benefits important for protecting coastal communities together with other ecological and land management criteria. In addition, LAP and CCS are working together to identify potential conservation easement candidates ideal for coastal resilience elements. POS Stateside easements with coastal resilience elements offer an opportunity to expand land conservation, support adaptation of vulnerable communities, and engage new communities in conservation efforts.

Targeted climate change acquisitions: In recognition of the increasing frequency of flooding and storm events and the resulting impacts on facilities and visitors, land management units work with Land Acquisition and Planning to identify potential sites for relocating facilities and recreational areas where "retreating" from flooded or flood prone areas may become the only viable option. While some level of further investment in existing facilities is likely, catastrophic storm events are not out of the realm of possibility. Planning ahead and ensuring sites meet the needs of our visitors will ensure visitor enjoyment despite flooding events.

Nuisance Flood Plan Guidance: An interagency workgroup collaborated and updated the Nuisance Flood plan Guidance document to provide direction to counties and municipalities for the required 2025 update. The guidance is available on the Chesapeake and Coastal Service website. Additionally, six communities received financial assistance to complete the 2025 update. Four webinars were held in October 2024 on Planning for Coastal Flood Risk that provided a more in depth and comprehensive look at planning for nuisance or high tide flooding.

Climate and Fisheries Coastal Management Fellow: A 2022-2024 Coastal Management Fellow completed a project with DNR to support advancing climate adaptation priorities related to natural resources management with a focus on fisheries. Project outcomes were compiled into a Climate-Ready Fisheries Planning Menu that provides adaptation and resilience recommendations for managing the ecological, socioeconomic, and governance components of

Maryland's fisheries. Priority areas of focus include fishery management plans and scientific monitoring of fish species. The fellow also served on the plan development team for the ARWG's Next Generation (NextGen) Adaptation Plan to co-lead content development and assist with the final approval process.

Nature-Based Solutions and Adaptive Management Fellow: A 2024-2026 NOAA Coastal Management Fellow recently began a project with DNR to support Maryland's Climate Adaptation Workforce and building capacity for nature-based solutions and adaptive management. This project will focus on developing data-led adaptive management approaches based on site-level project success to guide state investments in resilient, nature-based restoration projects and advancing support for adaptation industries by helping to build Maryland's coastal natural resource–based workforce. The fellow is currently analyzing monitoring data to identify trends and site-level adaptive management needs. Based on these findings, the fellow will develop a department-wide adaptive management structured decision-making framework.

Saltmarsh Sparrow Habitat Prioritization: CCS staff continue to work with state, local and federal partners towards prioritization of saltmarsh restoration and protection areas with the goal of protecting and restoring habitat for the Saltmarsh sparrow, a tidal marsh obligate songbird of Conservation Concern. The habitat is threatened by sea level rise and marsh degradation. Maryland Saltmarsh Restoration Priorities for the Saltmarsh Sparrow document was updated in April of 2022. Partners also worked together to create the Coastal Marsh Restoration - an Ecosystem Approach for the Mid Atlantic. An online spatial tool[11] was created based on this information in October 2022. CCS is working with various partners on the Maryland Coastal Restoration Alliance (previously known as the Chesapeake and Coastal Bays SMARTeam) to support saltmarsh restoration projects identified through this work with technical assistance and funding support. This collaboration has led to a Trust Fund Grant to design (four) and implement (three) saltmarsh restoration projects (FY 25 funding). Additional projects may be funded through Federal grants (see the EPA Climate Pollution Reduction grant work referred to in the mitigation sections).

Climate Change Adaptation and Resilience Planning on State Lands: CCS continued to collaborate with the Maryland Park Service, Maryland Forest Service, and the Wildlife and Heritage Service to update climate change adaptation and resilience plans on state lands and identify areas in need of future plans. An adaptation plan was developed for Newtowne Neck State Park in collaboration with MD Park Service and the Northeast Institute of Applied Science. On-the-ground projects were discussed with various land unit managers, including Pocomoke State Park, Martinak State Park, Wye Island Natural Resources Management Area, Tuckahoe State Park, Newtowne Neck State Park, and Point Lookout State Park. A drone survey was conducted to monitor sand movement at Assateague State Park, and planning for a living shoreline was initiated at Point Lookout State Park. Additionally, CCS partnered with the Maryland Partnership for Action Learning in Sustainability (PALS) program to initiate a project on virtual reality visualization of climate adaptation options at Point Lookout State Park.

Centering Equity and Community-Led Climate Adaptation Planning: The Nature Conservancy (TNC) and Maryland Department of Natural Resources (MDNR) are leading initiatives to protect

[11] Atlantic Coast Venture. Saltmarsh Sparrow.. https://acjv.org/saltmarsh-sparrow/

and restore coastal landscapes to ensure the long-term resilience of critical habitats and coastal communities. Working with both organizations, Sabine Bailey, NOAA Digital Coast Fellow 2022-2024, played an integral role in facilitating cross-agency conversations to reform land protection activities with equity-oriented implementation and to promote community-supported marsh migration and community resilience. Specifically the fellow (1) lead landowner engagement on the Lower Eastern Shore to ensure local perspectives were driving the design of a the Resilient Protection Framework initiative with TNC, (2) developed an engagement plan with local indigenous communities to understand how TNC can support their goals, and developed a background document for use in onboarding and education for staff (3) drafted a recommendations document for DNR to advance engagement and build trust with local indigenous communities and the Maryland Commission on Indian Affairs, (4) drafted policy recommendations for long-term adaptation strategies that align with a climate justice community on the Eastern Shore, (5) provided expertise to MDNR's Targeted Resilience Area Implementation Team on equitable community engagement and land protection, (6) supported IRA proposal development for the Pocomoke Sound. In August of 2024, DNR hired Bailey to continue her work with indigenous community engagement and policy.

2. Community Engagement and Communication

2024 Mid-Atlantic Climate Change Education Conference: The 2024 Mid-Atlantic Climate Change Education Conference (MACCE-C) was another successful convening of formal and non-formal educators to share and learn about the latest trends in climate change education. In its fifth year, the conference was hosted virtually June 25-27. There were 208 registered participants. The conference was made possible through partnerships and collaboration with the following agencies: Chesapeake Bay National Estuarine Research Reserve Maryland (CBNERR-MD), National Oceanic and Atmospheric Administration (NOAA) Chesapeake Bay Office, DE Sea Grant, DE NERR, Jacques Cousteau NERR (NJ), Earth Force, Communitopia, teachers from Thomas Stone High School in Waldorf, Maryland, the University of Wisconsin-Stevens Point and Reach Cyber Charter School.
The conference fee remained affordable to participants ($25). Highlights focused on climate education policy examples from Washington, NY, NJ, and MA, Climate Anxiety and mental health, and youth-led climate action.

Mid-Atlantic Climate Change Education Forum: In 2021, the planning team of the MACCE Conference considered how to expand beyond an annual conference, and began seeking ideas to transform the multiple avenues of education into the ambitious action needed to build a healthy, livable, just future. The team invited bold ideas from around the Mid-Atlantic to lead this conversation, share lessons and leverage lessons learned, scale and celebrate successes, network across sectors, and engage together. Seeking a strategy centered in equity and justice, they co-created a regional forum to advance education for climate action. The inaugural forum was held in 2022. The task groups and core planning team continue to meet monthly as part of the ongoing MACCE Collaborative and CCS members have been tasked with representing MACCE in the planning of the Regional Outdoor Learning Network annual Environmental Literacy Forum. The forum will take place at NCTC in West Virginia January 7-9, 2025 and will focus on training for change makers around sustainable funding for e-literature and climate education at the local level.

Teachers on the Estuary: The 2024 Teachers on the Estuary (TOTE) program, offered through a partnership with CBNERR-MD, the Chesapeake Bay Foundation, and NOAA Chesapeake Bay Office, featured a hands-on learning experience for both students and environmental science professionals. Participants collected real data throughout the watershed to address questions about climate change. Participants learned to integrate data into the classroom through cross-disciplinary, hands-on field activities, and online resources. This dynamic course enhances the learning experience by conducting investigations of participants' local environments. This course is designed to model a Meaningful Watershed Educational Experience (MWEE) through participant-driven field experiences and hands-on research. The past three TOTE courses focused on merging pillars of Social Emotional Learning with the actionable steps of the MWEE. Participants for both courses met with community members from coastal island communities (Hoopers Island, 2022, and Deal Island 2023 & 2024) to discuss impacts of changes to cultural heritage resources, natural resources and community values. Visits included on site presentations about the science of restoration efforts and subsequent monitoring of projects within these communities.

Shoring Up Resiliency Through Education (SURE): This ongoing project aims to support Somerset County Public Schools in addressing regional vulnerability to climate impacts and building community resilience through understanding how environment, science and cultural heritage work together to strengthen a community. Students in fifth, seventh and ninth grades experience, study and analyze trends in local conditions such as weather and water quality that affect the natural resources upon which much of their local economy depends. Participating teachers receive professional development annually, through which they are supported in writing lessons to support this project. Partners include the Maryland Department of Health, Chesapeake Bay Trust, and Somerset County Public Schools.

Communicating About Climate Change with Confidence: Trainings continue throughout the region for the informal education community (MD Master Naturalists, State Parks Interpretation, CBT CCCC Orientation and the Maryland Climate Corps) on tools for building confidence in communicating about climate change. In 2024, approximately 150 individuals received this in-person training. Of special interest, CCS partnered with NOAA to train teachers, superintendents, administrators and facilities staff at Prince George's County Public Schools in support of the district's new Climate Action Plan in Education. This event reached 55 staff members.

Communicating Risk to the Public: Public trainings were offered throughout the Coastal Zone to communities and local organizations to encourage the use of the MyCoast MD flood documentation app and website. MyCoast MD can be used to track tides, submit photos of flooding, and identify areas for adaptation strategies. MyCoast MD saw an increase of 880 users in 2024. Staff also helped lead Flood Awareness Month campaign which included a webinar and virtual Open House. In the fall of 2024, staff hosted four trainings on Planning for Coastal Flood Impacts reaching 175 registrants from a wide array of backgrounds including local government, university, non-profit and state agencies. These trainings included a core module on flooding in Maryland, sea level rise, and understanding Maryland's sea level rise projections. Then each training offered focused breakout sessions on related topics including Critical Area and resilience, designing nature based solutions for SLR and flood impacts, visualizing flood

impacts, Coastsmart Construction program, and using MyCoast for nuisance flood planning efforts.

Sea Level Rise Bench: DNR built a large interactive display bench to help visualize potential sea level rise and increased flooding in the state of Maryland. The bench is accompanied by a sign explaining the purpose of the bench design and includes a QR code with a link for more information. The bench has visited a few locations in the past year including the Westfield Annapolis Mall for Earth Day, Maryland's State Fair, the DNR All-Staff Meeting, and Sandy Point State Park. In 2025 the plan is to continue to move the bench to different locations around the state of Maryland. Sandy Point State Park staff have observed multiple park visitors interacting with the bench and sign. The hope is that this bench will increase awareness and education of potential sea level rise and direct visitors to the DNR website with more information.

Equitable Community Engagement in Climate Action and Resiliency Planning: DNR provided funding to support Defensores de la Cuenca (DDLC) to initiate a Spanish-taught watershed steward academy in the Patapsco watershed and on the Eastern Shore. This cohort included both La Academia and a project implementation phase. The purpose of this academy is to engage people in the Latino/a community in environmental stewardship and awareness of flooding issues in Maryland's Coastal Zone. The class focuses on best management practices for stormwater management, ways to address runoff by incorporating native plantings and encouraging tree growth, and environmental communication. DDLC continues to expand the reach of La Academia as well as fostering new partnerships with key community partners such as Shore Rivers, CCA Maryland and AGSF.

Building Capacity in Under-Engaged Communities for Resilient Infrastructure Projects: Through Coastal Management and Environmental Protection Agency Bipartisan Infrastructure Law funding opportunities, DNR is partnering with the Chesapeake Bay Trust for a third year on the Community-Based Organization Capacity Building Initiative (CBO-CBI). By leveraging five years of targeted capacity funding, the Department will be working to address project identification and development needs with under-engaged communities that have not previously participated in core community resilience grant programs. This CBO-CBI partnership will build meaningful connections with historically under-engaged community-based organizations (referred to as "connector" groups) that focus on reaching out to and engaging groups to identify resilient infrastructure projects. The second type of partner organization - "technical assistance providers" - provide support with green infrastructure design, engineering, and grant proposal writing. The organizations will work closely together to build the capacity of community-based organizations interested in applying to and advancing resilient natural- and nature-based projects.

Climate Impacts in Maryland: Understanding the training and education opportunities across the coastal zone: Using the results of the Market Analysis/ Needs Assessment completed in 2024, CCS has been developing a training strategy which includes a combination of in person and virtual training opportunities to meet the needs of a variety of audiences. Training topics included, planning nature based solutions projects, communicating science to decision makers, using Maryland DNR's Coastal Atlas and Targeted Adaptation Areas layers, and Planning for Coastal Flood Impacts. In 2024, 500 people attended CCS trainings.

In 2024, CCS partnered with Chesapeake Bay Landscaping Professionals to pilot a Living Shoreline Certification for Maryland. This intensive certification course included two virtual training days and two in-person training days with a practicum. The lengthy waitlist for this pilot course demonstrates the great need to continue pursuing these types of offerings.

Outdoor Recreation: DNR's Office of Outdoor Recreation is committed to demonstrating the connections between climate and recreation and increasing educational programming and access to nature initiatives in order to better prepare communities for climate change. This approach helps foster a connection to nature, encouraging communities to see themselves as part of natural solutions rather than separate from them. Examples of this work in the past year include:

- Forming a partnership with AllTrails and the UMD PALS program to study the impacts of climate change on state trail systems, and support climate education engagement on our public lands.
- Including a session about the impacts of climate change on recreation opportunities across the state, and how public lands and outdoor businesses such as ski resorts and outfitters are affected, during the inaugural Outdoor Recreation Summit in October 2024.
- Partnering with Together Outdoors, (Outdoor Recreation Roundtable's initiative to make the outdoors more inclusive and diverse), to increase community engagement and expand outdoor recreation opportunities for underserved populations through the Maryland Outdoor Equity Program. Through this program, OOR provided funding and support to award grants of up to $7,500 to four organizations and initiatives that actively promote inclusion and diversity in outdoor recreation in Maryland. These grants supported a wide array of partners and projects: the Live Water Foundation created a paddling program for military veterans, Defensores de la Cuenca established a new outdoor gear library serving the Latin American community, M.O.R.E. of Baltimore Homeschool will create a program to provide camping equipment for children in Baltimore, and Young Successful Leaders will build a community garden and outdoor space in Baltimore's Edmondson Village.
- Leading and coordinating workforce development programs through the Greater Baltimore Wilderness Coalition's Climate Crew Network. This network provides funding, training, and industry exposure opportunities coupled with planting and maintenance projects so that participants can earn a wage while improving their community and gaining the skills and experience necessary to participate in the growing green workforce. Since fall 2023, Climate Crew Network participants have planted more than 1,200 trees (many in overburdened communities) and 1,600 live stakes, and received training and certifications on topics such as understanding and communicating climate change, stormwater management best practices, and invasive species removal.
- Co-leading and providing translation services for Spanish programs centered around the effects of climate change, such as flooding and invasive species, at the Es Mi Parque programs. Es Mi Parque is a cross-unit initiative hosting bilingual programs and events at Maryland state parks to provide education and recreation opportunities to the Spanish-speaking community. Since May of 2024, OOR has co-lead and provided translation support for three Es Mi Parque events, engaging over 200 individuals.

3. Advancing the Science

Margaret A. Davidson Fellowship: The Margaret A. Davidson Graduate Fellowship is a fellowship program that places a graduate student in each of the 30 NERRs to address key coastal management questions through cross-discipline research projects.
The 2022-2024 fellow, Sylvia Jacobson, completed her fellowship in August 2024, and is preparing her results for the completion of her doctoral dissertation. The outcome of this project aims to determine if there are underlying drivers of these changes that could be assessed in other tidal wetlands in Maryland as they respond to climate change. Jacobson will continue engaging with Reserve staff during the remainder of her PhD program.

The 2024-2026 fellow, Allyson Kido, began in fall 2024, and will focus her research on the impact of land cover changes on the distribution of Submerged Aquatic Vegetation (SAV) in all three Reserve components; Otter Point Creek, Jug Bay and Monie Bay.

Using both historical Reserve-collected and newly-collected data, Kido's project will measure how changes in land cover impact the distribution and diversity of SAV habitat in the Reserve. The results of this project will help determine best practices for the restoration and preservation of SAV in the Chesapeake Bay region.

Ecological Effects of Sea Level Rise: DNR previously partnered with George Mason University and The Nature Conservancy to complete Maryland's Ecological Effects of Sea Level Rise Project to monitor and model the wave attenuation and flood reduction benefits of marshes, submerged aquatic vegetation and other nature-based features. This four-year project quantified the protective characteristics of Maryland's natural features and predicted how those characteristics may change as sea levels rise. Work is underway to integrate results into existing spatial tools for conservation and restoration decision-making. In 2024, the Department updated the state's Wetland Adaptation Areas and held three trainings and one webinar with internal staff to support data application. Planning is underway to provide additional modeling support and technical assistance to one coastal community in support of future applications to federal grant programs.

Resource Assessment Service Monitoring: Based on climate change projections, many of Maryland's streams are likely to become warmer and the flows are likely to become more extreme. Some coastal streams could also become inundated as a result of sea level rise. These changes may alter the ecology, water quality and physical habitat of streams. The Maryland Biological Stream Survey (MBSS) tracks trends in factors such as aquatic species distributions, water temperature, and erosion that are indicators of potential climate change influences on Maryland's streams. Based on temperature and species distribution information, the MBSS has specifically identified stream animals that prefer cold water and, as a result, may be particularly sensitive to stream temperature increases. Detailed stream temperature information from the MBSS may also help identify streams with cold and more stable water temperatures (often due to substantial groundwater influence), and thus are likely to be resilient to temperature increases.

In addition to a representative sampling of Maryland's streams, the MBSS has been monitoring a network of "sentinel" streams since 2000 to specifically examine for potential influences of

factors such as climate and weather on Maryland's stream ecology, temperature, water quality and physical habitat. Two reports that include temperature monitoring results were recently completed and are available as DNR document DNR12-042823-354.

The Chesapeake Bay Sentinel Site Cooperative (CBSSC): The Chesapeake Bay Sentinel Site Cooperative (CBSSC) is a regional collaboration between government agencies, research institutions, nonprofits, and land managers based in coastal Maryland (MD) Virginia (VA) and Delaware (DE) (i.e. the Chesapeake Bay and coastal bays, "CB region") that integrates science findings from local observations and ecological knowledge across the CB region to improve planning and management decisions regarding sea level rise (SLR) and other effects of changing climate conditions. The CBSSC is coordinated by Maryland Sea Grant.

Assessing winter temperatures and spring river flows as limiting factors for Striped Bass recruitment: The Chesapeake Bay is the primary production area for the Atlantic Striped Bass population. While striped bass spawn in the spring, previous studies have shown that both winter temperatures and spring river discharge play a role in determining the strength of each year's spawning success, as measured by the Maryland Department of Natural Resources' juvenile index survey. Colder winters and wetter springs generally boost reproductive success, while warmer and drier conditions lead to the opposite. However, predicting the average year-class strength based solely on climate data is unreliable because many other unknown or unmeasured factors also contribute to these outcomes. To address this, researchers are developing a predictive framework based on Liebig's Law of the Minimum, which focuses on limiting factors. Using quantile regression techniques, models are being developed to estimate the maximum potential year-class strength by considering winter temperatures and spring river flows as key constraints. This framework will enable fishery managers to use climate data to estimate the potential productivity of the striped bass stock under current and future climate conditions. Ultimately, this approach aims to enhance the management of striped bass by offering more accurate predictions of reproductive success, allowing better planning and conservation efforts in the face of changing environmental conditions.

Climate effects on the timing of Maryland striped bass spawning runs: Water temperatures have increased through time and are expected to continue increasing in the Chesapeake Bay due to climate change. Striped bass spawning is primarily triggered by water temperature. In this study, Fishing and Boating Services examined how the timing of spawning has shifted with changing water temperatures and considers strategies for managing the spawning stock under changing environmental conditions. Results suggest that the start of the spawning season has not changed significantly, but the length of the spawning season has shortened. Since older and younger females spawn at different times throughout the season, fishery managers can consider the age range of spawning females to support the production of eggs and larvae over a wider time period. If environmental conditions vary across the season, some of the larvae may be produced at times when the conditions are favorable for growth and survival[12].

Tracking conditions on the Choptank River during striped bass spawning season: In 2013, the Fishing and Boating Services Ecosystem Assessment Division started monitoring striped bass

12 Angela Giuliano, Climate effects on the timing of Maryland Striped Bass spawning runs, *Marine and Coastal Fisheries*, Volume 15, Issue 6, December 2023, e210274, https://doi.org/10.1002/mcf2.10274

spawning conditions in the Choptank River originally to investigate the impacts of urbanization and is now investigating factors contributing to the recent series of poor year classes. Major influences on year-class success include temperature and river discharge during late winter into spring. These conditions influence egg survival and the availability of plankton food source for larvae. The results from 2023 data suggest that despite successful egg production, food availability, and postlarval survival, the year class was relatively poor. Unsuitable temperatures may have contributed to mortality of eggs and prolarvae that still rely on the yolk sac for nutrition. Under projected warming scenarios, a more rapid increase in spring temperatures may reduce the period when larval survival is favorable.

Brook Trout Annual Monitoring Network: Fishing and Boating Services developed a brook trout annual monitoring network in 2023 to improve coldwater resource data collection and track long-term population and temperature trends. The network includes 51 monitoring stations throughout the state that will be annually surveyed for brook trout population data, temperature data, and habitat data. Stations were selected to broadly represent both brook trout populations and the range of stressors that influence population success. The impacts of climate induced elevated stream temperatures on brook trout populations will be included in the analysis. This will be an ongoing monitoring effort that was recently initiated, so results are not currently available.

Maryland Blue Carbon Resilience Credit Feasibility Study: Maryland DNR has partnered with The Nature Conservancy (TNC) and Environmental Science Associates (ESA) to support the assessment of blue carbon and resiliency crediting feasibility at five project sites throughout Maryland. The feasibility study has gathered existing data and information to inform whether market project development is viable and to provide recommendations for next steps. The final report from ESA was released in March of 2024 and includes a detailed assessment of technical, organizational, landscape, legal and social feasibility factors (see footnote 6 for reference).

Resiliency through Restoration Monitoring: The Chesapeake Bay National Estuarine Research Reserve developed and implemented monitoring protocols at select restoration sites to track restoration success and inform adaptive management needs. Staff partnered with the University of Maryland Center for Environmental Science (UMCES) to expand monitoring efforts across a portfolio of shoreline projects. In 2024, DNR and UMCES partners monitored two pre-restoration sites and five post-restoration sites.

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