# Delaware's Natural and Working Lands

## A Policy Report for Supporting Carbon Benefits

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Prepared by:
Jennifer Volk, Environmental Quality Extension Specialist
University of Delaware Cooperative Extension

for the:
Delaware Department of Natural Resources and Environmental Control
Division of Climate, Coastal and Energy

# Executive Summary

## Purpose of this Report

In 2020, the state of Delaware began developing its first statewide Climate Action Plan. This planning effort, led by the Department of Natural Resources and Environmental Control (DNREC), includes evaluating strategies for minimizing greenhouse gas emissions and maximizing resiliency. One of the areas of focus in Delaware's Climate Action Plan is Natural and Working Lands. To better understand the opportunities for climate action in this sector, DNREC contracted with the University of Delaware Cooperative Extension (UDCE) to research and prepare this policy report. The purpose of this report is to identify existing goals and programs to support the climate benefits provided by natural and working lands.

This report reviews best management practices that contribute to maintaining and increasing *carbon storage* and *sequestration* on agricultural lands, forest lands, urban greenspaces, and wetlands. DNREC and UDCE, with partner and stakeholder support, developed this policy report to highlight best management practices that are currently used in Delaware to promote environmental benefits and that present opportunities for maintaining and increasing carbon storage and sequestration on natural and working lands.

## Climate Benefits of Natural and Working Lands

Natural and working lands – including forests, grasslands, croplands, wetlands, and urban greenspaces – are landscapes that sequester carbon and provide significant and cost-effective opportunities to reduce greenhouse gas emissions. Many of the conservation and management practices that support carbon sequestration have other important co-benefits such as improving water quality, providing habitat for pollinator species and wildlife, and increasing resilience to climate change impacts. Enhancing carbon sequestration and storage on natural and working lands is an important strategy for achieving Delaware's climate goals.

*Carbon storage* = the carbon locked in biomass or soils (measured in units of metric tons CO2e/acre)

*Carbon sequestration* = the process of removing carbon dioxide from the atmosphere through photosynthesis and converting it into another form (measured in units of metric tons $CO_2e$/acre/yr)

*Carbon mitigation* = actions that reduce carbon dioxide emissions into the atmosphere

This report describes two broad approaches to "natural climate solutions" that maximize carbon storage and sequestration: conservation and enhancement. Conservation strategies focus on protecting carbon that is already stored in natural lands. By preventing degradation or conversion that could lead to the loss of stored carbon, this defensive approach can be measured in terms of avoided emissions. Enhancement strategies include management and restoration actions that increase carbon removal (sequestration), providing an ongoing, measurable benefit of carbon removal from the atmosphere.

While the role of carbon sequestration and storage in some natural and working lands is known to be important, it can also be difficult to measure with certainty, leading to challenges with quantifying the carbon benefit of these lands. A variety of carbon estimation tools are available for quantifying the carbon benefits of land management practices at different scales. These tools are continually being refined and updated with new data and improved methodologies. Further work is needed to develop approaches to carbon metrics using the best available tools, supported by sound science, to quantify carbon sequestration and storage.

## Strategies and Opportunities

Each section of this policy report summarizes the best management practices that support carbon sequestration and storage, existing programs to implement these practices, and opportunities to achieve greater benefits over the next five years. A selection of strategies presented below are aligned with existing state goals and commitments by DNREC, the Delaware Department of Agriculture, and the Delaware Forest Service.

***Agricultural Lands:***

- Increase statewide implementation of winter cover crops with a goal of reaching 223,750 acres annually by 2025 through continued state funding for cost-share programs and partnership with Conservation Districts.
- Increase use of grassed buffers from just over 9,000 acres statewide in 2018 to slightly more than 13,000 acres by 2025 through implementation of Delaware's Watershed Implementation Plan as part of the Chesapeake Bay Program.
- Increase use of forest buffers adjacent to croplands by 171 acres with a goal of reaching a total of 1,000 acres by 2025 in the Inland Bays and Chesapeake watersheds.
- Increase tree planting in agricultural lands with a goal of 671 acres of trees planted by 2025.

***Forest Lands:***

- Permanently protect 2,500 acres of forest areas by 2028 and 1,000 acres of headwater forests by 2025, through conservation easements or fee acquisition.

***Urban Greenspaces:***

- Increase urban tree planting throughout the state by 371 acres by 2025.
- Establish 5 miles of urban riparian buffers along impaired waterways and isolated wetlands by 2025.

In addition, this report includes discussion of wetlands and the significant role they play in carbon sequestration and storage. This section describes some of the ongoing research underway and opportunities to utilize new coastal wetlands carbon mapping in research and management planning efforts.

## Partnerships and Programs

Each section of the report also highlights existing programs that provide technical and financial support to implement the strategies described above. Delaware has a wide range of programs

and policies that support land conservation, habitat restoration, and best management practices that apply to many types of natural and working lands. Two examples of state plans that establish restoration goals for water quality or resource protection are the Chesapeake Bay Watershed Implementation Plan and Statewide Forest Strategy. These and other existing programs and policies can play an important role in supporting carbon sequestration and storage.

Delaware's efforts in the natural and working lands sector build on a long history of coordination between federal, state, local, nonprofit, and academic sectors. A Natural and Working Lands team of staff from the Department of Natural Resources and Environmental Control (DNREC), Department of Agriculture (DDA), Delaware Forest Service (DFS), University of Delaware Cooperative Extension, and The Nature Conservancy have participated in meetings and workshops over the past two years to learn about natural and working land initiatives. The Delaware team has also met with staff from other states engaged in similar efforts, with support from the U.S. Climate Alliance and affiliated partner organizations.

The Natural and Working Lands team represents a wide range of expertise and responsibility for management of existing programs. A selection of these programs includes:

- Federal cost-share programs, such as the Environmental Quality Incentive Program (EQIP), Conservation Reserve Program (CRP), Nonpoint Source Program (NPS), and Chesapeake Bay Program
- State and local assistance programs, such as the Nutrient Management Program, Urban and Community Forestry Program, and Community Water Quality Improvement Program
- Federal and state conservation programs, such as the Forest Legacy Program, Forestland Preservation Program, and Delaware Agricultural Lands Program

To achieve Delaware's environmental goals requires staffing, funding, training and outreach, and coordination between partners. This policy report summarizes the ongoing efforts and opportunities to invest in best management practices that deliver multiple benefits: water quality, habitat protection, soil health, resiliency, and carbon sequestration and storage.

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# Introduction

## Purpose of this Report

In 2020, the state of Delaware began developing its first statewide Climate Action Plan. This planning effort, led by the Department of Natural Resources and Environmental Control (DNREC), includes evaluating strategies for minimizing greenhouse gas emissions and maximizing resiliency. One of the areas of focus in Delaware's Climate Action Plan is Natural and Working Lands. To better understand the opportunities for climate action in this sector, DNREC contracted with the University of Delaware Cooperative Extension (UDCE) to research and prepare this policy report. The purpose of this report is to identify existing goals and programs to support the climate benefits provided by natural and working lands.

This report reviews best management practices that contribute to maintaining and increasing *carbon storage* and *sequestration* on agricultural lands, forest lands, urban greenspaces, and wetlands. DNREC and UDCE, with partner and stakeholder support, developed this policy report to highlight best management practices (BMPs) that are currently used in Delaware to promote environmental benefits and that present opportunities for maintaining and increasing carbon storage and sequestration on natural and working lands.

Natural and working lands – including forests, grasslands, croplands, wetlands, and urban greenspaces – are landscapes that sequester carbon and provide significant and cost-effective opportunities to reduce greenhouse gas (GHG) emissions. Many of the conservation and management practices that support carbon sequestration have other important co-benefits such as improving water quality, providing habitat for pollinator species and wildlife, and increasing resilience to climate change impacts. Enhancing carbon sequestration and storage on natural and working lands is an important strategy for achieving Delaware's climate goals.

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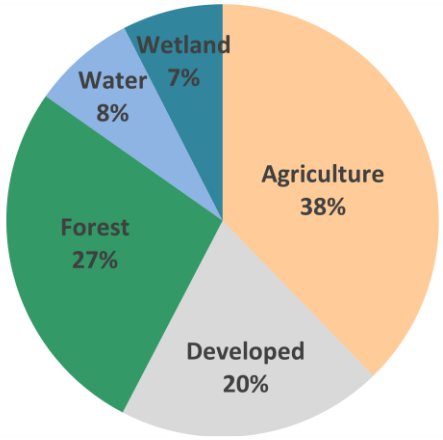
## Natural and Working Lands in Delaware

Delaware is rich in agricultural, forest, and natural landscapes that support economic benefits, environmental resources, and recreational opportunities for state residents and visitors (Figure 1; FirstMap, 2020). These lands also provide important ecosystem services that include the sequestration and storage of carbon. This abundance of natural and working lands represents a significant amount of carbon already stored in plants and soils. Delaware has an enormous opportunity to preserve this stored carbon (avoiding greenhouse gas emissions) and to enhance those systems' ability to increase their potential to sequester additional carbon, further reducing greenhouse gas emissions from the land sector.

**Figure 1. 2012 Delaware Percent Land Use and Land Cover**




Source: FirstMap, 2020

## Partnerships and Existing Initiatives

Delaware's efforts in the natural and working lands sector build on a long history of coordination between federal, state, local, nonprofit, and academic sectors. A core team of staff from the Department of Natural Resources and Environmental Control (DNREC), the Department of Agriculture (DDA), the Delaware Forest Service (DFS), the University of Delaware Cooperative Extension and The Nature Conservancy participated in workshops hosted by the U.S. Climate Alliance in July 2018 and October 2019 to learn about natural and working land initiatives. These Learning Labs included teams from other Alliance states and technical experts in forestry, agriculture, and wetlands. Collaboration with the U.S. Climate Alliance and other Alliance states benefits Delaware by sharing tools and practices that support the implementation of natural and working lands strategies. The Alliance provides valuable technical assistance through non-governmental partner organizations and, with support from private funders, recently awarded grants to two projects in which Delaware is a cooperating partner:

- *High-Resolution Annual Forest Carbon Monitoring Utilizing Remote Sensing* - Led by Maryland Department of Natural Resources and University of Maryland
- *Prioritizing coastal habitats for carbon sequestration and resilience benefits* - Led by North Carolina Department of Environmental Quality and Duke University

The goals of the natural and working lands initiative aligns closely with the goals of other partner organizations. Delaware has a wide range of programs and policies that support land conservation, habitat restoration, and best management practices that apply to many types of natural and working lands. A number of initiatives to plan and establish restoration goals for

water quality or habitat purposes have also already occurred; the Chesapeake Bay Watershed Implementation Plan is just one example. Many of these existing programs and initiatives can support carbon mitigation co-benefits, and thus align with natural and working lands strategies. For example, agricultural cost-share programs offer an incentive for land management practices that promote healthy soils, which increases their capacity for carbon storage. Projects that improve water quality, such as forested buffers along streams, can also achieve the added benefit of increasing carbon sequestration and storage. Existing programs utilize federal and state dollars to:

- Provide cost-share support for conservation practices in cropland and forestland
- Purchase easements or fee title to protect farmland, forest, and wetland habitat
- Support agricultural and forest land uses through tax abatement
- Offer grants and loans for water quality and habitat enhancement projects

The natural and working lands strategies discussed here align with other efforts to reduce greenhouse gas emissions. Delaware is one of ten northeast states that comprise Regional Greenhouse Gas Initiative (RGGI), a market-based program to reduce emissions in the electric power generation sector. This successful cap-and-trade program has enabled the state to achieve significant reductions in greenhouse gases in the electric power sector. In addition, the proceeds from the auction of carbon allowances supports a wide range of programs and projects that support energy efficiency and renewable energy, helping to further drive down greenhouse gas emissions. Activities that achieve "negative emissions" by increasing the carbon sink in the natural and working lands sector are well-aligned with these greenhouse gas reduction goals. As quantification metrics for carbon reduction and avoided emissions can be developed, investment of RGGI funds may be used to support climate mitigation in the natural and working lands sector. Other states that are part of RGGI, including Rhode Island and New Jersey, have used RGGI proceeds to support forestry initiatives.

## Climate Solutions on NWLs

The world's plants and soils serve as natural "carbon sinks" – carbon reservoirs that increase as more carbon accumulates over time. Plants use photosynthesis to remove (sequester) carbon from the atmosphere by taking in carbon dioxide ($CO_2$), releasing oxygen and using the carbon as building material for plant tissue in leaves, stems, and roots. Soils are important carbon sinks, storing more than 80 percent of the total carbon found in terrestrial systems. Soil carbon is formed both directly from growth and decay of plant material, and indirectly, as carbon compounds move between plant roots and soil microbes. Plants, and soils can be carbon sources as well as sinks, by emitting $CO_2$ produced through respiration and decomposition. In addition, terrestrial systems can be sources of other greenhouse gas emissions such as methane ($CH_4$) and nitrous oxide ($N_2O$). Natural and working lands have complex interactions that vary over time and space. For example, carbon sequestration by plants varies seasonally, as deciduous plants lose their leaves in winter, reducing their ability to sequester carbon through photosynthesis. Managed landscapes, such as cropland and managed forests, also vary

in function as sinks and sources depending on land management practices, such as tillage and fertilizer use.

Natural climate solutions are conservation or management practices that capture and store carbon, reduce greenhouse gas emissions, or improve ecosystem resiliency. Solutions focused on capturing and storing carbon look to do so on agricultural land, forest land, urban greenspaces, and wetlands, all of which act as carbon sinks. To meet Delaware's greenhouse gas emissions (GHG) reduction goals, natural and working lands must be conserved and enhanced. Conservation strategies focus on protecting carbon that is already stored in natural lands. By preventing degradation or conversion that could lead to the loss of stored carbon, this defensive approach can be measured in terms of avoided emissions. Enhancement strategies include management and restoration actions that increase carbon removal (sequestration) and carbon storage. The following sections detail a number of conservation and enhancement strategies. For each strategy, there must be a reliable carbon accounting system and successful programs and policies to support them.

## Accounting for Greenhouse Gas Benefits on NWLs

The need to quantify carbon benefits is important for several reasons: 1) to understand the contribution that existing land protection and management actions have toward carbon sequestration and storage, 2) to compare the relative benefits of different climate pathways and prioritize opportunities, and 3) to track progress toward increasing the carbon sink in the natural and working lands sector.

Delaware's Greenhouse Gas (GHG) Inventory, prepared by DNREC's Division of Air Quality, provides an analysis of historical estimates and projected trends in GHG emissions. The objectives of this inventory include identifying and characterizing GHG emissions sources and sinks, quantifying GHG emissions and sequestration, and documenting both inventory data sources and analytical results. Greenhouse gas emissions are generated from a variety of sources, which are tracked by economic sectors including: Electric Power, Transportation, Industrial, Residential, Commercial, Agricultural, Waste Management, and the Land Use sector (referred to as Land-Use, Land-Use Change and Forestry or "LULUCF").

Delaware's current GHG emissions inventory identifies the land-use sector as a sink for GHG emissions in Delaware. Carbon emissions and/or sequestration in the land-use sector is calculated as the annual change in carbon storage among different carbon pools of Delaware's forest and croplands, as well as harvested wood products. Based on the current inventory for base year 2017, total GHG emissions for land-use were -730,000 metric tons of carbon dioxide equivalent ($MTCO_2e$); meaning, 730,000 $MTCO_2e$ in GHG emissions were sequestered from the atmosphere as a result of Delaware's land sector (DNRECa, 2020).

Quantifying "negative" or "avoided" emissions in natural and working lands presents a number of challenges. One is that these systems are varied, dynamic, and subject to change. Certain types of plants and soils may be more or less more efficient at sequestering and storing carbon.

For example, fast-growing trees sequester carbon most in the first few decades of active growth; long-lived trees, however, can keep carbon stored for a century or longer. Carbon storage in soils may be relatively permanent if left undisturbed, but human and natural disturbances do in fact occur. Carbon stored in plants can be lost to the atmosphere, either through human action (e.g. harvest) or natural processes (e.g. decay, fire).

Tools and methodologies for quantifying carbon benefits vary. Performance-based metrics (e.g. soil testing in multiple locations where carbon enhancement practices are being used) can be expensive and labor-intensive and require quality control for data collection and analysis. Alternatively, using estimates derived from average measures or model analyses may not be considered reliable for greenhouse gas accounting. Market-based systems, both voluntary and regulatory, have made significant progress in defining protocols for carbon offsets in a variety of land use types, including forests and grasslands. The use of these protocols, however, requires an investment of time, effort, and cost associated with monitoring, reporting, and verification. It is important to quantify the carbon that is already stored (as a baseline) as well as measuring how carbon stores are changing over time. Different pathways identified for achieving carbon mitigation in agricultural lands, forests, urban greenspaces, and wetlands will have various approaches to how those carbon benefits are measured and tracked.

A variety of carbon estimation tools are available for quantifying the carbon benefits of land management practices at different scales. These tools are continually being refined and updated with new data and improved methodologies. Further work is needed to develop approaches to carbon metrics using the best available tools, supported by sound science, to quantify carbon sequestration and storage.

## Co-Benefits and the Value of Resilience on NWLs

The benefits of the strategies that follow are not limited to carbon sequestration or storage but have a multitude of co-benefits that support healthy soils, biodiversity, and air and water quality. In fact, many of the agricultural strategies discussed have been the focus of water quality improvement programs for decades. The forestry strategies, while increasing wood stores, can also provide bioenergy resources, recreation opportunities, and ecosystem services. And the shade provided by trees in developed areas also helps to lower energy costs, thus providing multiple mitigation benefits, not to mention the aesthetic value that trees offer.

A number of practices not only support climate mitigation but also climate adaptation. For example, increasing carbon content in soil, a mitigation strategy, may improve its capacity to retain moisture during periods of drought, helping to help make the landscape more resilient to the impacts of climate change, an adaptation strategy as well. Many agricultural conservation practices used to promote water quality and soil conservation – adaptation strategies – also enhance carbon sequestration. Forestry management activities that improve forest health, timber productivity, and habitat value, all of which make the forest more resilient, can also increase carbon storage.

And, there is a true value to resiliency. The costs of weather and climate disasters appears to be on the rise. The National Climatic Data Center reports that during the 2010s (2010-2019), there were 119 disasters resulting in at least one billion dollars' worth of damages. This is up from the 62 billion-dollar disasters recorded in the 2000s, 53 in the 1990s, and 29 in the 1980s (NCDC, 2020). The costs of these disasters include property damage, flood damage, and crop damage or losses from droughts, severe storms, and fires. Forests and wetlands especially have the ability to protect against flooding, which improves the resilience of neighboring properties during heavy rain events. Agricultural lands that focus on soil health are more resilient to extreme conditions as those soils help to retain moisture during dry periods and tend to drain better during wet periods. Thus, natural and working lands provide both climate mitigation and adaptation benefits.

# Opportunities on Agricultural Lands

## Profile of Delaware's Agricultural Lands

Agriculture is the predominant land use in Delaware, making up just under 40% of the area (530,000 acres) in 2019 according to Delaware Agriculture Statistics Bulletin (2020). Approximately 99% of Delaware's farms are sole or family owned businesses, with 2,300 farms. Delaware is known for its poultry, grain, and vegetable production. Delaware is the birthplace of the commercial broiler industry and in 2019, ranked 7$^{th}$ nationally for pounds of broiler (meat) chickens produced. The majority of cropland within the state is devoted to producing grains like corn (185,000 acres), soybeans (155,000 acres), wheat (60,000 acres) and barley (21,000 acres), much of which is used for poultry feed (DDA-USDA, 2020). Delaware is also recognized as a leading producer of a number of fruit and vegetable crops. In 2017, Delaware ranked number one in lima bean production, number nine in watermelon production, and number ten in sweet corn production (DDA-USDA, 2018).

## Existing Programs that Support BMP Implementation on Agricultural Lands

Conservation programs that help support the preservation of land and implementation of practices resulting in GHG benefits are offered at the federal, state, and local levels as well as by non-profit partners. These programs provide financial assistance to growers, known as cost-share or incentive payments, to aid in the implementation of the conservation practices. Often, the program priorities are protecting and improving water quality or establishing or improving habitat, but GHG benefits are an ancillary benefit. Some programs are underutilized, while others have more demand than financial resources available.

### Federal Programs

The U.S. Department of Agriculture oversees a number of programs funded through the Farm Bill that results in the implementation and maintenance of BMPs.

*USDA-NRCS*: The Natural Resource Conservation Service (NRCS) has programs that provide technical and financial services to landowners who voluntarily choose to install certain conservation practices. Delaware's NRCS financial assistance programs include: the Agriculture Management Program, the Conservation Stewardship Program, and the most widely used, Environmental Quality Incentive Program (EQIP). For the EQIP program, each state office, in consultation with their State Technical Committee members, identifies natural resource concerns and priority practices. Resource priorities in Delaware include: reducing non-point source pollutants (nutrients, sediment, and pesticides) and groundwater contamination; conserving ground and surface water resources; reducing emissions that contribute to air quality impairments; promoting habitat recovery for at-risk species; and reducing soil erosion and sedimentation from erodible land.

Because of the large poultry presence in Delaware, at least 50% of the practices funded by EQIP address resource concerns related to this livestock industry. As a result, a large portion of the

funding has not traditionally gone toward practices with GHG benefits. However, a number of recent changes may result in increased implementation of those practices. The first change is that Delaware's NRCS started offering higher payment rates through EQIP for "High Priority Practices" when they are implemented anywhere in the state. These practices include but are not limited to tillage management, riparian forest buffers, and filter strips, which are also GHG benefiting practices. This past year, NRCS began providing higher payment rates for BMPs implemented in Source Water Protection areas. These are ground water recharge areas in southern Kent and Sussex Counties identified by DNREC's Source Water Protection Program. Numerous BMPs are eligible for higher payments in these areas including the following GHG benefiting practices: nutrient management, reduced tillage and no-till, cover crops, conservation cover, filter strips, riparian herbaceous buffers, riparian forest buffers, and prescribed grazing.

Similar to, yet separate from the Source Water Protection initiative, is the National Water Quality Initiative (NWQI). This is a partnership between USDA-NRCS and EPA which has a goal of accelerating implementation of practices on farms in small watersheds most in need of water quality improvements. NWQI began in 2012. In Delaware, the Clearbrook Branch in the Nanticoke portion of the Chesapeake Bay watershed was selected as the targeted watershed due to the very high levels of nitrogen in ground and surface waters. Since that time, NRCS has worked to identify opportunities to implement additional practices to address the high nitrogen levels on farms within the small watershed, including nutrient management and cover crops, but limited opportunities remain. Three new watersheds have been identified: Drawyer Creek in the Appoquinimink River Watershed in New Castle County; Duck Creek in the Smyrna River Watershed in Kent County; and Cow Bridge Branch in the Indian River Watershed in Sussex County. Planning and outreach will begin in FY21 with practice implementation likely starting in FY22. A benefit to growers who participate in this program is that they receive up to 90% cost share versus the traditional 75% coverage.

Finally, in 2020, the USDA nationally broadened the purpose of EQIP to include adapting to and mitigating against increasing weather volatility and addressing drought resiliency. Improving soil organic matter has been identified as methods to protect against both and the following new practices are available for funding in Delaware – soil carbon amendment, soil health conservation activity plan, agricultural energy design plan, and soil testing activity (Marks, 2020).

One final NRCS program worth noting is the Agricultural Conservation Easement Program. This program is designed to keep farmland as farmland through conservation easements. The Delaware Agriculture Lands Preservation Program, a state led program with similar goals, is discussed in detail below. Preservation programs that keep working lands in their current condition protect the carbon that can be sequestered and stored on these lands.

*USDA-FSA*: Another section of the USDA that supports conservation practice implementation is the Farm Service Agency (FSA). Landowners may be eligible for conservation contracts, loans, or to participate in the Conservation Reserve Program (CRP) or the Conservation Reserve

Enhancement Program (CREP). CRP/CREP is the country's largest voluntary, private-land conservation program that offers producers contracts for 10-15 years to remove environmentally sensitive land from agricultural production and plant grasses or trees in the sensitive areas with the purposes of improving water quality, controlling erosion or enhancing habitat. Producers receive cost share for practice implementation and annual rental payments.

In 2020, FSA launched the CLEAR30 Pilot, which offers growers the opportunity to enter into 30-year contracts. This program is available to growers with water quality practices already enrolled in CRP and whose contracts are set to expire September 30, 2020. Those that reenroll in the CLEAR30 pilot program will receive annual rental payments, a rental rate enhancement of 27.5%, and either full or partial (7%) coverage of maintenance costs over the 30-year contract period (FSAb, 2020). GHG benefiting practices eligible in this program include grassed waterways, filter strips, and riparian buffers.

CREP, a program within the CRP focuses targeted conservation practices on high-priority conservation goals that are identified by the state. In Delaware, the goal is to address water quality and loss of habitat concerns. Like CRP, CREP contracts are voluntary for 10-15 years and producers receive cost-share and rental payments through a combination of federal and non-federal funds. Federal and state resources are made available to program participants. Eligible CREP practices in Delaware that also have GHG benefits include hardwood tree planting, permanent wildlife habitat (land retirement), filter strips (form of grassed buffers), and riparian buffers (forest buffer). CREP practices have been implemented on 4,000 to 6,000 acres in the state but CREP administrators have a goal of enrolling up to 10,000 agricultural acres in CREP practices (FSAa, 2020); some of the strategies detailed in Section E will support this goal. Those working on the CREP program have focused efforts on re-enrolling acres already in the program as contracts expire and providing technical assistance to existing participants. In order to achieve this increased acreage goal, plans are to increase efforts on recruiting new participants, which would involve increased outreach to inform producers of the program. A persistent challenge however is that these practices take land out of production and producers must balance the financial considerations of losing cropland with their conservation goals.

*EPA NPS*: The Environmental Protection Agency (EPA) Non-Point Source (NPS) Program, which is established under Section 319 of the Clean Water Act, provides states with grant funding to support a number of activities to reduce the impacts of nonpoint source pollution. The Nonpoint Source Program within the Division of Watershed Stewardship at the Delaware Department of Natural Resources and Environmental Control (DNREC) administers these funds in Delaware. A competitive grant program is offered annually to support non-regulatory NPS reduction programs, technical assistance, financial assistance, education, training, technology transfer, or for demonstration projects.

*EPA CBP*: The Chesapeake Bay Program is a partnership between EPA and other federal agencies, jurisdictional agencies within the Chesapeake Bay watershed, and other nonprofit and academic organizations with the goal of protecting and restoring our nation's largest estuary. A Total Maximum Daily Load was established for the entire Chesapeake Bay Watershed in 2010

calling for reductions in nitrogen, phosphorus, and sediment. Jurisdictions developed Watershed Implementation Plans in three phases to identify the practices necessary to achieve these goals by 2025 and set Two-Year Milestone Goals to ensure continued progress. Each year, progress toward implementation and nutrient reduction goals is assessed. Funds are available to the jurisdictions for practice implementation and program capacity building to aid in these efforts. In Delaware, these funds are administered by the Delaware DNREC Division of Watershed Stewardship.

### State and Local Programs

A number of conservation programs within Delaware also have ancillary GHG benefits. The Delaware Department of Agriculture oversees the *Nutrient Management Program*, which was developed in response to the Nutrient Management Law and has the purpose of maintaining and improving water quality while ensuring the continued profitability of Delaware agriculture. Through the program, cost-assistance is provided for nutrient management planning and manure relocation. Nutrient management plans are required for anyone applying nutrients to 10 acres or more or with eight or more animal units and the cost of plan development by a certified consultant can be reimbursed by the program. The manure relocation program reimburses farmers for transporting poultry litter from areas of excess to areas in need. Both of these practices have the potential to provide GHG benefits.

The Delaware Department of Agriculture also oversees the *Delaware Agriculture Lands (Aglands) Preservation Program*, which is aimed at keeping land in agriculture through the formation of preservation districts and use of conservation easements. If a landowner enrolls their farm into a preservation district, they voluntarily agree to only use the land for agricultural purposes for a period of 10 years. Once in a preservation district, the landowner may additionally opt to place the land into a conservation easement, which is when the development rights are purchased from the landowner, permanently protecting the land from development. The Young Farmers Loan Program helps young farmers purchase land to start their operation and as a condition of the no-interest, 30-year loan, for applicants 18-40 years in age, the purchased land is automatically enrolled into permanent preservation easements. Delaware has more than 1,000 agricultural easements on almost 140,000 acres of farmland, more than 25% of Delaware's farmland. According to the *Farms Under Threat* report by the American Farmland Trust, Delaware ranks at or near the top of states for percent of ag land protected, funding per capita, ratio of acres protected to acres converted, among other criteria (Freedgood et al., 2020). Programs that preserve land in agriculture also preserve the carbon stored in those lands.

Each of Delaware's three counties has a Conservation District, which are authorized by Delaware Code to further "the conservation, protection, development and utilization of land and water resources" (7 Del. C. 1953, § 3901). Efforts in each district are guided by the Division of Watershed Stewardship at DNREC as well as a locally elected boards of supervisors. Districts also closely coordinate, and often share space, with staff from NRCS. Each district offers cost

share programs for a number of conservation practices and funding levels depend on local interests and needs. Cost-share programs for cover crops are offered in all three counties.

In addition to governmental agencies, nonprofit partners also actively implement conservation practices. The Partnership for the Delaware Estuary, the Center for the Inland Bays, Delaware Wildlands, Delaware Nature Society, and the Nanticoke Watershed Alliance are nonprofit organizations actively implementing practices for water quality, habitat, and climate change purposes in Delaware. Often using funds from the programs discussed above or special grant opportunities, these organizations help to facilitate implementation through relationship building and educating landowners on available program options.

## Agricultural Best Management Practices with GHG Benefits

The Agriculture sector in Delaware is considered a net source of GHGs in Delaware, making up 4% of the total gross GHG emissions in the state (DNRECa, 2020). At emission rates of roughly 600,000 MT $CO_2e$/year, emissions from this sector have remained relatively constant since the 1990s and are projected to remain at this level for the foreseeable future. The largest sources of emissions in the Agriculture sector are agricultural soils management and manure management. There are a number of management practices though, that have the potential to reduce the impact from this sector, potentially making it a net sink. Many of these practices are already widely used for other purposes like water quality or habitat goals but their climate benefits have not yet been accounted for in current inventories. Practices with climate benefits include those that reduce GHG emissions, but also those that draw $CO_2$ out of the atmosphere and store it temporarily or long term in plant biomass or soils.

In February 2020, USDA's Secretary Perdue released the Agriculture Innovation Agenda. This agenda intends to stimulate innovation with the goal of "increasing U.S. agricultural production by 40 percent while cutting the environmental footprint of U.S. agriculture in half by 2050" (USDA, 2020). Cutting carbon emissions while increasing carbon sequestration are part of the strategies to cut US agriculture's environmental footprint and specific activities include:

- Capture biogas
- Improve livestock production efficiency
- Renewable energy – improve efficiency and carbon capture
- Conserve sensitive and marginal lands
- Reforestation and forest management
- Improve fertilizer and manure management through use of new and innovative technologies and practices
- Soil health practices to improve carbon sequestration/storage in soils

The potential for these strategies to be implemented depends on the nature of agriculture in each state. In Delaware, a number of conservation practices that can be characterized under the last four activities on this list are already implemented to some degree and supported by existing local, state, and federal programs or initiatives (further discussed below).

The COMET-Planner tool, a planning tool developed by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and Colorado State University, estimates the net GHG benefits (reduced emissions and carbon sequestration potentials) that could result from implementing many agricultural practices. Conservation planners who wish to consider greenhouse gas benefits in their analyses may use this tool. These NRCS practices are grouped into five categories within the tool: (1) cropland management; (2) cropland to herbaceous cover; (3) cropland to woody cover; (4) grazing lands; and (5) restoration of disturbed lands. A brief overview of the *Delaware-relevant agriculture conservation practices* are discussed below; their potential impact on GHGs are described from COMET-Planner methodology (Swan et al., 2019).

## Cropland Management

The Cropland Management classification includes practices that reduce soil erosion, maintain or improve soil quality (soil organic carbon content), and reduce the potential for GHG emissions. Practices include, but are not limited to, nutrient management, tillage management, and cover crops, all three of which are annual practices that do not represent a land use change. The practices can be applied to irrigated and non-irrigated lands producing varying GHG benefits.

*Nutrient Management* is a conservation practice that helps budget and conserve nutrients which helps promote healthy soils and minimizes nonpoint source pollution of surface and groundwater resources and improves air quality by reducing nitrogen emissions and the formation of atmospheric particulates. There are several ways to better manage nutrients including reducing application rates, improving the timing of application, and adjusting application methods for optimum plant uptake and minimal loss to the environment. COMET-Planner characterizes the GHG benefits for nutrient management practices that reduce fertilizer application rates by 15% when following a nutrient management plan on irrigated or non-irrigated land. The reduced usage of nitrogen fertilizers reduces the soil nitrous oxide emissions. A consequence of reducing fertilizer inputs in the COMET-Planner, however, is that the model then predicts a decrease in plant production and a decrease in the biomass and carbon introduced to soils.

*Manure relocation programs* promote switching from inorganic to organic sources of nutrients (such as compost or poultry litter). COMET-Planner also characterizes the GHG benefits of switching a portion of a crop's nutrient needs from synthetic fertilizer to broiler chicken (meat bird) manure, again on irrigated or non-irrigated lands. The GHG impacts of this practice include an increase in soil carbon and small changes in soil nitrous oxide emissions. Cultivated areas in Delaware are particularly susceptible to low soil organic matter, which presents an opportunity for increasing storage on land that does not have a history of these soil amendments. COMET-Planner allows users to only select decreased fertilizer applications or use of poultry litter as the fertilizer source and these practices cannot be used at the same time, which is not a representation of reality on Delmarva.

*Tillage Management* is a strategy to lessen the negative effects of conventional tillage, which utilizes heavy machinery to loosen and turn over the soil in advance of planting but can lead to soil compaction and erosion. The machinery used to perform conventional tillage requires fossil fuel inputs. Less machinery is used under reduced or no-till management, which reduces energy use and particulate emissions which aids in improving air quality. A switch to reduced or no-till systems may also result in changes to nitrous oxide emissions due to changes in the soil environment. The mechanical fragmentation of soil carbon can stimulate biogenic emissions and a shift from conventional tillage to reduced or no-till systems limits the disturbance of soil to better manage the crop residue left after harvest. Crop residue increases soil organic matter while anchoring the soil to prevent erosion and increasing the reservoir of soil carbon. COMET-Planner characterizes the GHG benefits of converting conventional, intensive tillage on both irrigated and non-irrigated lands to reduced or no-till systems, as well as the benefit of converting from a reduced-till setting to no-till.

*Cover Crops* are forbs, legumes, and grasses that are seasonally grown for the benefit of vegetative cover when commodity crops are not present. These crops are used for a variety of reasons including to promote healthy soils through minimizing erosion, increasing organic matter, and improving water quality and storage. Cover crops also suppress weeds and provide habitat while sequestering carbon and increasing soil carbon pools and providing small changes in soil nitrous oxide emissions. COMET-Planner differentiates between legume and non-leguminous cover crops planted on irrigated and non-irrigated lands (essentially, four classifications of cover crops).

### Cropland to Herbaceous Cover

This category of COMET-Planner practices involves taking cropland out of production and replacing with herbaceous covers like grasses, rushes, sedges, ferns, legumes, and forbs.

*Conservation Cover* establishes and maintains a permanent vegetative cover on what once was crop land. This practice produces carbon benefits through the cessation of tillage thereby limiting carbon losses and increasing soil organic matter from plant residues. There are also small decreases in nitrous oxide emissions that result from the land use change too as fertilizers are no longer applied to crops.

COMET-Planner includes four sets of practices (*Field Boarders, Filter Strips, Grassed Waterways, and Riparian Herbaceous Cover*) with identical sequestration rates and as such will be collectively classified as *Grassed Buffers*. All of these practices establish a permanent vegetative cover through or around the perimeter of a field or along a body of water. In each case, GHG benefits result from the cessation of cropping, which eliminates fertilizer applications and need for tilling, and the accumulation of plant residues.

## Cropland to Woody Cover

Similar to the category above, these practices within COMET-Planner permanently convert cropland acres to areas planted with woody cover. COMET-Planner includes a number of NRCS practices in this category and those most relevant to Delaware are described below.

*Riparian Forest Buffers* are the addition of trees along a watercourse on what was once cropped or grassed lands. The GHG benefits of each of these practices result from the cessation of fertilizer applications and tillage practices and the increased the potential for carbon sequestration in the woody biomass.

*Tree/Shrub Establishment* is the planting, seeding, or natural regeneration of woody plants in areas that were previously cropped or existed as grassy areas. *Windbreak/Shelterbelt Establishment* is the planting of trees on crop or grassed areas in two or more linear rows to protect an area from strong winds.

## Grazing Lands

There are several NRCS practices within COMET-Planner that apply to grazing lands. While these may apply to the limited livestock operations in Delaware, data on current practices is limited or unknown, thus difficult to estimate the current or potential GHG benefits at this time.

*Prescribed Grazing* is a practice that manages the foraging of pasture or rangeland by livestock with both animal and environmental health in mind. Livestock are moved from field to field over the course of the year, which controls the amount grazed from any particular plot. This practice results in increase carbon stored in soils and variable changes to soil nitrous oxide emissions.

*Nutrient Management* is a practice that can also apply to grazing lands, but on this land use type, COMET-Planner only includes options for replacing a portion of synthetic fertilizer by compost or animal manure rather than just reducing to total amount of fertilizer applied. This substitution results in small decreases in nitrous oxide emissions and increases in soil organic carbon. Data on nutrient management on pasture lands is not readily available so this practice is not considered in this assessment.

*Silvopasture* is an agroforestry practice which intentional integrates trees or shrubs with compatible forages for livestock on the same land. These trees help to reduce erosion, improving soil and local water quality, while also enhancing biodiversity, improving pollinator and wildlife habitat, and providing shade relief to livestock (McFarland, 2020). The added trees may offer added economic benefits to the landowner by adding potential new fruit, nut, or timber revenue streams. The GHG benefit is due to carbon accumulation in the woody biomass. Silvopasture has not been a practice traditionally employed in Delaware and the current extent of silvopasture by those who voluntarily implement this practice in Delaware is currently unknown.

### Restoration of Disturbed Lands

Finally, the last category of practices within COMET-Planner are those that restore lands disturbed by natural disasters or manmade disturbances. In these locations, vegetation is often removed and soils are exposed and vulnerable to erosion. One of the NRCS practices under this category is *Riparian Restoration* and involves the rehabilitation of degraded streambanks and replanting of vegetation. The GHG benefits of this practice include increasing soil organic carbon through bank stabilization and addition of plant residues and carbon storage in woody biomass.

## Strategies to Enhance GHG Benefits on Agricultural Lands

Given the positive benefits existing conservation practices have on GHG, it is prudent to examine if and how these programs can be amplified to further increase the GHG benefits that takes place within this sector. This goal setting process can occur both through numeric implementation goals for the practices discussed above but may also include programmatic initiatives that put in place the policies and procedures necessary to ultimately result in increased implementation of GHG sequestering practices.

### Numeric Goals

As a result of water quality restoration efforts to achieve established Total Maximum Daily Loads, a number of implementation plans or strategies have been developed across the state and call for increased implementation of many of these same conservation practices. These existing initiatives have been consulted to set numeric implementation goals to also benefit GHGs. The Chesapeake Bay Program Watershed Implementation Plan (WIP), which is in its third phase, is one such initiative. As with the baseline scenario above, Delaware's implementation goals in the Chesapeake watershed through 2025 have been downloaded from the Chesapeake Assessment and Scenario Tool (CAST; https://cast.chesapeakebay.net/) (DNREC, 2019). A number of the implementation goals were set at a statewide level and lend themselves nicely to this exercise. Other watershed implementation plans or strategies established across the state, as detailed in the 2019 Nonpoint Source Program Annual Report (NPS, 2020), have also been included, as has the Inland Bay Watershed Reforestation Plan (CIB, 2019) and Comprehensive Conservation and Management Plan (CIB, 2020)[1]. These goals overlap and support a statewide CREP goal of enrolling an additional 5,000 acres of conservation practices into that program (FSAa, 2020).

The numeric implementation goals for the above practices are described in the following section.

- Nutrient Management – Delaware's Chesapeake Bay Phase III WIP, calls for **85% of Delaware's eligible croplands (statewide) to operate under a core nutrient management plan by 2025.**

[1] The Center for the Inland Bays Comprehensive Conservation and Management Plan is out for public review through November 15, 2020 and expected to be finalized in early 2021. Goals may change prior to finalization.

- Tillage Management – The Phase III Chesapeake also sets goals for tillage, with an **overall implementation rate of 90% of acres across the state leaving 15% or more residue on the ground**. Breaking this down, the goals are to have by 2025 15% of Delaware's cropland utilizing low-residue tillage (15-30% residue), 60% of the cropland in conservation tillage (30-59% residue), and 5% in high-residue tillage (>60% residue). These implementation goals are in some cases actually a decrease from 2018-2019 levels but reflect stakeholder expectations for the future implementation of this practice.

- Cover Crops - Delaware's Phase III Chesapeake WIP aims to substantially expand the use of this already popular BMP by increasing implementation in that watershed by 63% above current levels to almost every available acre using a cover crop by 2025. On a statewide basis however, this is an overly aggressive goal for the next five years. Rather, it is believed that aiming to **plant cover crops after every acre of corn and single-crop soybeans (223,750 acres)** is a more realistic statewide goal for 2025. This push is expected to cost at least $4.2 million dollars annually to support existing cost share programs. In FY20, the Delaware Department of Agriculture secured an additional $2.9 million dollars from the State budget for cover crop cost share programs and incorporated these new funds into already existing programs run by the County Conservation Districts. As a result of the insurgence of new dollars, record cover crop acres were planted in 2019; in Sussex County alone, almost twice as many cover crops were planted in 2019 as compared to the previous year. The conservation districts managed the new funds by maintaining the cost share rate ($/acre) but increased the cap on the number of acres each producer could enroll in the program which allowed larger farms to enroll more acres. It was anticipated that this increase would last through at least FY23, however, due to budget constraints resulting from the coronavirus pandemic in 2020, the $2.9 million for cover crops was cut back to $1 million in the FY21 budget. Producers are interested and willing to implement this practice, but more funds are needed to fully support cost-share of this practice.

- Conservation Cover – Practices that take land out of production are less popular among producers because it means losing the earned income from the cash crop on those acres and the demand for poultry feed means every productive acre is planted. Typically, under producing areas (marginal land) or parts of oddly shaped fields are enrolled in these types of practices, which then financially benefits the landowner. As a result, Delaware's Phase III Chesapeake WIP has only a modest **goal of enrolling another 191 acres for a total of 1,742 acres** in permanent conservation cover.

- Grass Buffers – Because there are many ditches running through Delaware farm fields which are opportunities for grass buffer implementation, the Chesapeake Phase III WIP has rather aggressive grass buffer goals. The goal is to **increase implementation from just over 9,000 acres statewide in 2018 to slightly more than 13,000 acres by 2025**, which the majority of this increase to occur in Chesapeake watersheds.

- Forest Buffers – It is difficult to increase forest buffers acreage as forested buffers present a number of challenges to growers, including shading of and deer damage to adjacent row crops. Increasing the payment rates for this practice has not proven successful in the past and implementation goals for this practice tend to be rather conservative. As a result, the numeric goals for this practice will be to **maintain the existing buffer acreage in the Appoquinimink watershed** of New Castle County and to only **increase the buffer acreage by 171 acres (total of 1,000 acres) by 2025 in the Inland Bays and Chesapeake watersheds**. This later goal is more aggressive than what the Phase III Chesapeake WIP calls for but takes into consideration restoration goals established by the Inland Bays Pollution Control Strategy and implementation goals for the CREP program too.

- Tree Planting – This goal represents an increase of 671 acres of trees planted by 2025. The Phase III Chesapeake WIP calls for **73 of these acres to be planted in the Chesapeake Bay watershed**. The remaining **598 acres are anticipated to be planted in the Inland Bays Watershed**; 178 of these acres are called for by the Watershed Reforestation Plans for Delaware's Inland Bays and will occur on lands owned by Sussex County and DNREC's Division of Fish and Wildlife; 420 of these acres are called for by the Inland Bays Comprehensive Conservation and Management Plan and will occur on the Wolfe Neck and Inland Bays wastewater treatment facility lands.

- Prescribed Grazing – Using the Phase III Chesapeake WIP, a **goal of 139 acres has been established**. This is actually a decrease from statewide 2018 progress. When better data on the current use of this practice from those not receiving cost-share, this goal can be revised accordingly.

- Riparian Restoration – The Phase III Chesapeake WIP calls for **17,000 feet of non-urban stream restoration to take place by 2025**. Assuming these restoration projects are an average of 30 feet wide, this equates to an area of 12 acres.

### Programmatic Strategies

In addition to the numeric implementation goals above, there are a number of programmatic or policy strategies that should also be explored and if implemented, have the potential to lead to increased carbon sequestration and storage or produce other GHG benefits.

*Maintain and increase funding for conservation programs* – In order to maintain current BMPs and increase implementation to the levels identified above and beyond, additional financial resources to support cost-share programs should be identified. As an example, it is estimated that at least $4.2 million is needed to fully implement cover crop goals. Additionally, for practices that result in a land use change, like those supported by the CREP program, additional funds are needed for practice management and maintenance. Without actively managing these areas, they can quickly become impacted by noxious and non-native species. Other financial

mechanisms like tax credits or reduced crop insurance premiums may provide incentives to adopt practices.

*Maintain and increase funding for agriculture preservation programs* – In addition to allocating more resources for practice implementation, allocating additional resources should also be identified to retain land in agriculture. These lands, as demonstrated above, sequester and store carbon and if lost, the same functions and benefits may not be realized. These efforts should coincide with strategic and comprehensive land use planning at the local level.

*Increase education, outreach, and technical assistance* – As a result of a number of new initiatives and the underutilization of certain existing programs, increased education, outreach, and technical assistance to growers and producers will help to raise awareness of all available opportunities. To increase outreach, it may first be necessary to increase the number of technical service providers operating within the state. Additional training for existing conservationists may also be beneficial. Moreover, the Sussex Conservation District is the only district in the state with an equipment program to aid in practice installation and private companies may be needed to implement new practices. More knowledgeable and experienced outreach agents may help growers become aware of the increased payment rates for high priority practices and for practice implementation in source water protection areas and the new NWQI watersheds. Additionally, the training of individuals and businesses on practice installation and maintenance needs will further increase the capacity to implement and care for new BMPs.

*Explore the use of technology to aid implementation* – Technology is always evolving and new tools or applications for existing tools become available each year. These opportunities should also be considered with GHG benefits in mind. DNREC for example is planning to use geographic information systems to identify and prioritize ditch segments appropriate for buffering with grasses or trees or for stream restoration. This technique has the ability consider the carbon benefits in addition to nutrient and habitat goals and therefore a number of prioritization scenarios may be developed. Another example of using technology to achieve implementation goals is the use of an air seeder to plant cover crops into a standing corn or soybean crop, rather than waiting to plant after harvest which decreases the window of opportunity for planting. The Sussex Conservation District owns an air seeder however it is currently underutilized. This may be remedied through increasing education, outreach, and technical assistance.

*Improve tracking and reporting of conservation practices* – In order to account for the GHG benefits offered by conservation practices, it is necessary to have a robust program in place so that the total number of acres of each practice currently on the ground can be quantified. Baseline implementation levels for several practices are currently unknown, which makes it difficult to establish implementation goals. Technical difficulties have also resulted in other practices that are on the ground but out of cost share contract to be removed from implementation ledgers. It is critically important to be able to ensure that new practices

implemented with new funding sources produce a true increase in practices on the ground (and carbon sequestered/stored) rather than a reshuffling of financial resources and no net gains.

*Develop and test technologies to measure carbon* – A number of initiatives are underway by major agriculture organizations like Bayer, Land O'Lakes, and Smithfield to develop technologies that have the ability to measure and reduce GHG emissions and soil carbon at the farm scale. These technologies also look at fertilizer use and leaching and have a goal of improving nutrient use efficiency, reducing inputs, and achieve farm sustainability goals (Clayton, 2020). Other initiatives are exploring the ability of using smart phones to measure soil density which can be used to infer nutrient and carbon stock data (AgDaily, 2020). Technologies such as these should be investigated and tested for their applicability and accuracy in the Mid-Atlantic region, especially given the sandy nature of soils in Delaware. If deemed appropriate, these types of tools could be factored into potential future carbon programs.

*Develop remote sensing tools for practice verification* – Verification protocols are required by the Chesapeake Bay Program to ensure nutrient reducing practice implementation and verification should be a component of efforts to track and report carbon reducing practices. However, on-site verification protocols can be resource intensive. One strategy that could streamline efforts is the use of remote sensing data. DNREC is currently working with the US Geological Survey to investigate the use of remote sensing for verification of winter cover crop planting and termination on the Delmarva Peninsula. The use of this or similar technologies should be investigated for other practices as well.

*Increase training for technical service providers* – In order to consider GHG benefits in conservation planning scenarios, technical service providers need to be aware of and trained to use existing tools. Outreach on the availability of the COMET-Planner tool, as well as other resources that may currently be available or those available in the future should be a priority.

*Investigate the inclusion of agriculture in carbon markets* – The GHG benefits offered by the agriculture sector could be incorporated into voluntary carbon markets. If the GHG benefits offered by agricultural practices can be quantified and tracked with confidence, the potential exists open a new funding stream for these conservation practices. There is interest in opening these funding streams for agriculture at the national level. During the summer of 2020, the Growing Climate Solutions Act was introduced as proposed legislation with the goal of helping agricultural landowners generate carbon credits for conservation practice implementation. This bill as proposed would create a certification program at USDA which would create a one-stop-shop where agricultural producers could voluntarily receive technical assistance and third-party verification of offsets produced on their lands (Braun et al., 2020).

# Opportunities on Forest Lands

## Profile of Delaware's Forest Lands

The next largest sector of land use in Delaware is forests, making up about 29% of the landscape at approximately 359,000 acres. Forest acreage in Delaware has fluctuated over time in response to population and development trends as well as in response to forest and agricultural markets, management strategies, and conservation and preservation efforts. Very few forest parcels in Delaware exceed 500 contiguous acres, with a fairly even distribution falling between 1-9 acres, 10-49 acres, 50-99 acres, and 100-499 acres in size. Approximately 78% of the forested acres in Delaware are privately owned (individuals, corporations, or nongovernmental conservation groups). About 86% of the tree volume in Delaware is composed of hardwoods including low-value hardwoods (27%), soft maples (22%), yellow poplar (15%), red oaks (13%), and white oak (9%) species. The remaining 14% is composed of softwoods, primarily loblolly pine. Most of Delaware's forests contain older and larger trees. These forests provide habitat to many plant and animal species as well as environmental benefits to our air and water quality and recreational opportunities. And, these forests offer the potential for valuable wood products (DFS, 2020).

## Existing Programs that Support BMP Implementation on Forest Lands

Federal, state, and local programs exist to protect or preserve existing forest lands, plant new or replant existing forested areas, and support the management or stewardship of forests.

### Federal Programs

The US Fish and Wildlife Service (USFWS) owns lands at both Bombay Hook and Prime Hook National Wildlife Refuges. Both of these refuges are designed to protect coastal marsh habitats but do include some forested lands at each site. USFWS staff in Delaware are partners in conservation and often lend their technical skills and resources to projects around the state.

The federal Forest Legacy Program, administered by the Delaware Forest Service (DFS), operating under the Delaware Department of Agriculture, has the intent of protecting working forestlands that are threatened by development or land conversion. The lands are protected through fee simple purchase or conservation easement using funds from the U.S. Forest Service's State and Private Forestry (S&PF) budget. For lands to be eligible for this program, they must exist within a Forest Legacy Area as identified in the Forest Legacy Assessment of Need, which are areas within the state with the highest concentrations of forests. There are currently four areas within Delaware: the White Clay Creek area in New Castle County; the Blackbird/Blackiston area along the New Castle and Kent County boarder; the Redden/Ellendale area and the Cypress Swamp area, both in Sussex County. The DFS is currently proposing a small expansion of the Redden-Ellendale area in Sussex County and the addition of five new areas: the Milford Neck area in Kent County; and in Sussex County the Marshyhope area, Nanticoke area, Central Sussex area, and Southwest Sussex area. This program has protected more than 3,000 acres of forested land in Delaware; some of this acreage has been added to

existing State Forest areas while other lands protected through easements remain privately owned. Additionally, as described in the agriculture section above, a number of the federal USDA NRCS cost share programs support tree planting on agricultural lands.

## State and Local Programs

DFS manages three state forests of more than 21,000 acres in Delaware: Blackbird State Forest primarily in southern New Castle County (5,973 acres), Taber State Forest in southern Kent County (1,323 acres), and Redden State Forest in Sussex County (13,911 acres). Each State Forest consists of numerous, often disconnected parcels. DFS also oversees a number of programs that support forest conservation, management, and stewardship on privately owned lands (DFSa, 2020).

*Administering Rules and Regulations* - The DFS administers the Delaware Forest Practices Erosion and Sedimentation Law (72 Del. Laws, c. 235, §2) to ensure that silvicultural activities are completed in a manner to minimize the occurrence of pollution, which includes minimizing erosion and the loss of soil carbon during harvest. Another law administered by the DFS is the Delaware Seed Tree Law which requires that landowners reforest harvested sites ten acres or more with 25% or more pine or yellow-poplar to preserve the existence of these species in our forest assemblages (72 Del. Laws, c. 235, § 2).

*Preserving Forest Lands* – A state level counterpart to the Forest Legacy Program is the Forestland Preservation Program. Similar to the AgLands Preservation Program described above, landowners can enroll their forested parcels into a preservation area for a period of ten years. Once enrolled, the lands may be placed into a permanent easement, which passes to new landowners at the time of sale. To be eligible for this program, parcels must be at least 10 acres in size, exist outside a designated growth zone, and have a forest management plan. Additionally, the land must have the potential to produce an income from forestry activities over a 20-year period; therefore, high quality forest land scores higher. More than 36,000 acres have been protected through easements by this program, with almost 8,000 protected by permanent easements (DFSa, 2020). This program is currently underutilized in the state as less than half of the allocated $1 million dollars has been expended in recent years. On average, the cost of the easements is about $5,000/acre with about 100 acres being protected annually.

Additionally, to help working forests stay in forest, the Commercial Forest Plantation Act is a law that allows landowners to receive a 30-year property tax exemption if the forestland is managed for timber production. To qualify, there must be 10 contiguous forested acres operating under a DFS approved forest management plan. More than 27,000 acres of private forests, about 10% of the privately owned forests, are presently enrolled in this program (DFSa, 2020).

*Providing Landowner Assistance for Forest Management and Health*- Staff from the DFS are also available to assist forest landowners with a number of services such as developing a Forest Stewardship Plan to achieve individual objectives ranging from timber production to managing

for wildlife. This free service is offered in exchange for the landowners' good faith commitment to implement the plan. DFS staff can conduct forest inventories, supervise reforestation or timber improvement projects, provide guidance on timber sale contracts, and connect sellers to a list of potential buyers. The DFS also works in coordination with the Maryland Forest Service to offer landowners the opportunity to purchase and plant low cost seedlings for conservation, lumber and/or cut Christmas tree purposes. And, specialists at the DFS monitor the forests within our state for forest health measures and are available to diagnose pest problems and recommend treatments. All of these activities help to foster good forest stewardship practices and managing the carbon stored in biomass and soils.

*Prescribed Fire Program* – Another forest management technique is prescribed fire and the DFS oversees these initiatives. Prescribed fires reduce the potential for uncontrolled wildfires and also enrich soils with nutrients that benefit existing and next generation vegetation.

In addition to the many forest conservation and management programs offered by the DFS, DNREC also owns land through both the *Delaware State Park Program* and the *Delaware Fish and Wildlife Program*. These lands include a mixture of forested, agriculture, and open space areas. DNREC also administers a land conservation program known as the *Open Space Program*. This program, which is a partnership effort, works to expand the footprint of state parks and preserves, fish and wildlife areas, state forests, and cultural resource sites. Landowners can donate land, agree to a conservation easement, or sell their property to one of the partnering agencies.

*Delaware Natural Areas Preservation System*, guided by the Delaware Natural Areas Advisory Council and coordinated by DNREC, recognizes and permanently protects areas within the state that contain important natural, geological, or archaeological features. They are both publicly and privately owned areas. Interested landowners first go through a process to have the property evaluated and placed on the State Registry of Natural Areas. Then, they can dedicate it as a State Nature Preserve through articles of dedication or conservation easements. There are 34 Nature Preserves covering 7,000 acres of land in the state (NAPS, 2020).

In addition to the programs at the state level that protect forested areas, each County within the State owns and maintains land with conservation in mind, often making purchased lands available to the public for recreational purposes. For example, Sussex County recently formed a land conservation workgroup to identify and securing lands that that will both support conservation goals but also provide public access opportunities. A few municipalities have also participated in natural land acquisitions for conservation and recreation purposes.

There are also a number of nonprofit organizations that operate either statewide or locally that support land conservation activities in Delaware. Delaware Wild Lands, Inc. and The Nature Conservancy own over 11,000 and 4,000 acres of forestland in Delaware, respectively (DFSa, 2020).

*Master Naturalist Volunteers* – The Delaware Master Naturalist Program is a science based natural resource training program jointly facilitated by University of Delaware Cooperative Extension and Delaware Nature Society. Participants who complete the program give back to Delaware's natural world through volunteer service that includes managing natural areas, providing education and outreach, and conducting citizen science. Master Naturalists are affiliated with Local Organizing Partners, which may include state or local agencies or nonprofit organizations that own and manage natural lands. The program began in the spring of 2020 and two classes of Naturalists have completed their initial training to date. Master Naturalists may become a critical partner in helping to manage natural lands, such as forests, to improve their carbon storage potential.

## Forest Land BMPs with GHG Benefits

Forests are intricately linked to carbon sequestration and storage. Through photosynthesis, carbon is removed from the atmosphere and is used to build biomass. Approximately 66% of forest carbon pools exist in the aboveground biomass (stem, branches, leaves). Carbon also builds in biomass below ground in the living roots and this accounts for 13% of the forest carbon pool. Forest litter, or the loose, non-living organic material (twigs, leaves, bark, etc.) that has fallen to the forest floor, accounts for 9% of the forest carbon pool. Approximately 7% of the forest carbon pool exists in the downed dead trees while 3% exists in the dead trees still standing.

Carbon also exists in the understory, the vegetation (saplings, shrubs, grasses, etc.) growing between the forest canopy and forest floor; this portion of the forest accounts for 2% of the forest carbon pool (DFSa, 2020). Carbon also builds in the soils of forested areas through processes occurring at the roots and through decomposition of forest organic materials. The rate of carbon sequestration in a forest varies depending on tree species, age, condition, and other factors.

Some of the carbon stored in the biomass and soils is released back to the atmosphere through respiration and decomposition. Carbon stored in woody materials may remain stable until the tree naturally dies or when disturbed by pests, fire, harvesting practices, or land use change. Carbon may be retained for decades or centuries in certain harvested hardwood products (Domke, 2019).

The US Forest Service's annual Forest Inventory and Analysis (FIA) provides data on the extent, condition, volume, growth, and health of forest resources for each state. These data are then used in EPA's State Inventory Tool (SIT), a spreadsheet tool that gives users the option to utilize default state data, which has been gathered by federal agencies, like FIA, or to input their own specific data. The Land-Use, Land-Use Change and Forestry (LULUCF) sector of the SIT includes worksheets on forest carbon flux, urban trees, agricultural soil carbon flux and $N_2O$ from settlement soils, landfilled yard trimmings and food scraps. Sample data requirements for this sector include those on carbon emitted or sequestered from above and belowground biomass,

urban area total, urban tree cover area, and carbon emitted or sequestered on cropland or grassland.

According to the Environmental Protection Agency's most recent *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 –2018*, the Land Use, Land Use Change, and Forestry Sector sequestered 12% of the total U.S. emissions in 2018 (EPA, 2020). While this total sink has decreased since the 1990 period as a result of converting forested acres to development, agriculture and grassland, individual pools have increased over that time. This is presumably due to forest management practices, retaining more carbon in products and disposal sites (as opposed to burning wood waste), and more recent conservation and restoration efforts.

Forestry practices that result in GHG benefits include retaining existing forested areas, increasing the footprint of forested areas through reforestation or afforestation, and managing forests for optimal carbon storage.

*Avoided Forest Conversion* – Avoided forest conversion to other land uses like grassland, cropland, and developed areas is one of the biggest ways to contribute to carbon sequestration. Forests are the largest carbon sink in the United States as they store carbon in aboveground biomass and belowground carbon in soil organic matter. When forests are converted to other uses, that land loses its ability to store carbon and its ability to continue sequestering carbon. Other land use types cannot sequester as much carbon and these areas are likely to shift from carbon sinks to carbon sources. Ensuring that forests have value beyond their aesthetic qualities is critical to keeping these lands in forest. This means that there should be markets for forest and wood products so that forest landowners are not forced to sell or develop these areas.

*Reforestation* – Reforestation is the restocking of trees in areas that have been depleted either through harvesting activities or by unplanned events like fires or damage from storms or pests. Reforestation may occur by allowing natural regeneration to take place (which is the most common and preferred current practice in Delaware after harvesting hardwood stands) or through the intentional planting of trees in depleted areas. It is best to undertake reforestation efforts shortly after disturbance to reestablish cover and forest functions.

*Afforestation* –Afforestation is the establishment of trees on land that was not previously forested, such as cropland or grassland. Afforestation is done to achieve a number of goals including water quality, habitat, and climate objectives. This too can happen by allowing trees to naturally populate an area or by purposefully introducing tree seeds or seedlings.

Reforestation and afforestation activities both offer an opportunity to introduce new species that may be more tolerant of changing climate conditions, such as those with differing tolerances for temperature, drought, or shade.

*Forest carbon management* – Forest management helps maintain and enhance the overall health of the system. Management takes multiple forms including monitoring for disease and

pest outbreaks, controlling invasive plants, minimizing carbon losses from natural disturbances and enhancing and aiding recovery after disturbances, maintaining and enhancing existing stocks, and promoting species that are better adapted to future conditions (Ontl et al., 2020). All of these practices have a variety of benefits but have a common goal of maintaining a stock of healthy forests, which are able to sequester and store carbon long-term.

## Strategies to Enhance GHG Benefits on Forest Lands

In order to identify numeric goals to further enhance GHG benefits on forest lands, the Delaware Forest Strategy (DFSb, 2020), was consulted. This document identifies priority issues, threats, and opportunities currently facing the forests in Delaware. It is a very comprehensive strategy that focuses on forest health and functionality, markets, sustainable forest management, and public awareness and appreciation for forests. The actions described below are high level summaries of both numeric and programmatic strategies that can be undertaken to increase forest GHG benefits; the Forest Strategy should be consulted for additional details and specific actions.

### Numeric Strategies

*Avoided conversion* – The Delaware Forest Strategy has set a **goal to protect 2,500 acres of forests within priority areas by 2028 and 1,000 acres of headwater forests by 2025**.

*Reforestation/Afforestation* –Many of the areas that could be reforested or planted in trees are currently agricultural lands in our state. Goals for tree planting have been discussed in the previous section focused on agricultural opportunities.

*Forest management* – The DFS' Forest Strategy has identified a goal of creating stewardship plans to cover 9,000 new acres by 2025, including 6,500 acres in rural priority areas. Forest stewardship plans identify specific actions that focus on forest health and functionality reducing forest loss, fragmentation, and parcelization; improving the diversity of tree types, controlling native pets and nonnative invasive species, and reducing wildfire risks. These types of activities likely result in increased carbon sequestration and storage however, sequestration values are not currently known.

### Programmatic Strategies

In addition to the numeric implementation goals above, there are a number of programmatic or policy strategies that should also be explored and if implemented, have the potential to lead to increased carbon sequestration and storage or produce other GHG benefits.

*Improve inventories forest/wood inventories for the state* – To improve carbon sequestration and storage estimates for the forestry sector, work should continue to revise and improve inventories of forest types/species as well as biomass.

*Fully utilize funding for forest preservation programs* – As discussed above, less than half of the allocated funding for the Forestland Preservation Program is used each year in Delaware. These

lands sequester and store carbon and if lost, the same functions and benefits will not be realized by other land uses. Once existing allocations are fully utilized, annual budget increases should be sought to further enhance preservation efforts.

*Aid in the development/enhancement of forest product markets* – Finding forest product markets and aiding the recovery of the forest product industry in Delaware is the most important strategy to keep forests as forests. Currently, growth exceeds removal in our forests, so there is plenty of wood, but a lack of markets demanding that wood. The Governor's Council on Forestry is actively working to attract the forest industry back to the region to get it up and running again. This may result in improving traditional markets or creating new non-traditional markets or bioenergy markets. Given the high percentage of low-value hardwoods, it is important to investigate potential uses for these materials, possibly as a renewable resource in the heat or energy sector. Other challenges exist however, such as Delaware's incinerator law which prohibits new boilers, commonly needed with mill operations. Additionally, there are discussions around increasing the size of the Port of Wilmington to enhance importing and exporting of Delaware grown products. Reinvigorating existing markets and creating new forest product markets will have the side benefits of creating of new jobs, increasing landowner attention to forest management, and of course, carbon storage.

*Identify additional opportunities for reforestation/afforestation on State-owned lands* – In order to lead by example, opportunities for reforestation or afforestation on State Forests, State Parks, and State Fish and Wildlife areas should be explored. This strategy can be expanded to other governmental agencies, such as the Delaware Department of Transportation, and county and municipal governments to assess opportunities on their properties.

*Increase education, outreach, and technical assistance* – Increasing outreach will help inform forest landowners of recommended management strategies and the financial support programs and opportunities available. For example, increasing outreach about the Forestland Preservation Program may help enroll more acres in what is currently an underutilized program. Currently, it is believed that participants hear about the program through word of mouth, so strategic marketing may be an option to explore. Additionally, since lands must have a forest stewardship plan prior to enrolling in that program, increased technical assistance will prepare landowners so that plans are in place when they pursue application. In addition to communicating the value of stewardship to landowners, it is also important to provide them with resources on estate management and changes in ownership with conservation in mind. Outreach to local governments with conservation goals should also take place to help ensure actions taken are done in a comprehensive and strategic method to achieve multiple environmental benefits. Finally, outreach around the benefits of forest harvesting should occur to remove the negative stigma associated with cutting down trees.

*Identify/develop metrics to quantify the GHG benefits of prescribed fire* – Prescribed fire is used and promoted in Delaware as a strategy to restore and manage wildlife habitat. The Forest Strategy identifies a goal of 250 acres/year to maintain and restore fire adapted ecosystems. If

this practice can enhance carbon sequestration or storage, appropriate metrics for Delaware are needed.

*Identify/develop metrics to quantify the GHG benefits of forest management practices* – The specific GHG benefits offered by specific forest management practices could not be obtained for this exercise nor was a rate that can be applied to forest management in general, such as through the development and implementation of a forest stewardship plan. Additional research and development should take place to quantify the carbon sequestration and storage impacts of individual or collective actions.

*Improve tracking and reporting of forest management practices* – Baseline implementation levels are currently unknown, which makes it difficult to establish implementation goals. In order to account for the GHG benefits offered by forest management practices, it is necessary to have a robust program in place so that the total number of acres receiving each management treatment can be quantified.

*Consider future climate conditions in forest management decisions* – Given that two thirds of the state are already in the northern extent of the southern forest region, it is not likely necessary to plan for integrating new more climate-ready tree species in Kent or Sussex Counties. Forests in New Castle County, however, may start looking more like those in central and southern Delaware. As reforestation/afforestation projects take place in New Castle County, those overseeing the projects should consider slowly integrating species that are more likely to thrive in hot, wet, environments. Another challenge facing Delaware forests as a result of climate change is the salinization of coastal forests, resulting in “ghost” forests, or dead standing trees that have succumbed to new saltier conditions. Land managers in these parts of the state have two approaches to consider:  salvage the wood for those that are timber minded; or leave or fell the wood for those that are managing for ecosystem services.

*Promote the inclusion of forestry practices in carbon markets* – Carbon market programs have the potential to encourage private landowners to manage their land in such a way that forest health improves while carbon sequestration and storage increases. However, there are challenges to entering these programs, such as upfront costs and legal requirements, that may be daunting. Nonprofit organizations are seeking ways to address these barriers. For example, the American Forest Foundation and The Nature Conservancy have developed the Forest Family Carbon Project which is designed to bring together family forest owners, private sector companies, and public partners to implement forest practices with carbon benefits. This program aims to enable more private forest landowners to participate in voluntary carbon markets.

# Opportunities on Urban Greenspaces

## Profile of Delaware's Urban Greenspaces

For the purposes of this exercise, urban greenspaces are considered to be the natural or maintained (mowed/landscaped) vegetated areas in the developed environment, on both public and privately owned lands. Examples may include urban forests or the open space areas associated with parks, homeowner's associations, rights-of-ways around roads and communities, and other community open spaces. Individual private yards are not included in this definition. Delaware has 57 incorporated cities and towns and 3,514 individual communities or neighborhoods, all of which may contain some degree of urban greenspaces that could support BMPs for GHG benefits. Older communities are less likely to contain community open space as requirements to incorporate these spaces in new developments only came about in the 1990s. Communities with open space areas set aside often devote the area to stormwater management, recreation, or natural resource protection. Statewide, urban tree cover within municipal areas is 25% (22,551 acres), though canopy cover widely varies from 10-85%, and this value increases to about 31% (81,126 acres) when expanded to other urban areas outside of municipal boundaries (DFSa, 2020). The acreage of urban forests is expected to increase in the future as developed areas continue to expand. Urban greenspaces offer additional opportunities for sequestering and storing GHGs.

## Existing Programs that Support BMP Implementation on Urban Greenspaces

Like agriculture and forestry, there are a number of programs that support urban greenspace management in terms of preservation and enhancement programs. These programs are largely administered by state agencies, but some are supported with funding and technical assistance from federal or nonprofit partners.

The DFS administers the *Delaware Urban and Community Forestry (UCF) Progra*m with guidance from the Urban Community Forestry Council. This program provides financial and technical assistance to municipalities, community associations, nonprofit organizations, and individual homeowners. Communities are scored and ranked for their priority needs and support by this program, with the top 15 scoring communities receiving high priority designation. Higher ranking indicates higher priority for UCF program delivery, though low priority communities will receive targeted resources to grow their urban forestry capacity. Technical assistance comes in the form of aid in developing publicly owned community forest management plans, identification and remediation recommendations for pest, disease, and storm damage issues, and planting recommendations.

UCF staff also assist municipalities and communities with setting tree canopy goals. An online tool (www.de.gov/treecanopy) allows one to view existing canopy levels in towns and neighborhoods across the state (currently 25% within municipalities and 31% when urban areas outside of municipalities is considered on a statewide bases; DFSa, 2020). Once a community established tree canopy goals, they are eligible for additional resources from the UCF program.

Financial assistance comes from the federal Urban and Community Forestry Program under the Eastern Region State and Private Forestry fund. The Delaware Program received $200,000 each of the last three years from this program. The UCF Program offers a community grant program each year offering up to $5,000 to recipients for tree planting or tree management on public lands. Municipalities, homeowners' associations, and nonprofit organizations with tree canopy goals are eligible to apply but must provide non-federal match which may come in the form of cash or in-kind services. Trees are often planted in open space areas or within rights-of-ways along streets and surrounding communities. In most cases, the trees planted through this program are not densely planted and there is still mowed turf beneath. The UCF program recently developed a database and online dashboard to track projects; to date, 568 grants have been awarded totaling more than $1.7M and resulting in the planting of more than 13,000 trees (DFSa, 2020).

There are a number of recognition programs for those that engage in urban and community forestry. *Tree City, USA* is program sponsored by the Arbor Day Foundation in cooperation with the US Forest Service and National Association of State Foresters. This program recognizes municipalities that have a tree board, a tree care ordinance, a tree care budget, and observe Arbor Day. Currently, 17 of Delaware's 57 incorporated cities and towns (30%) have achieved Tree City USA status with five of these in New Castle County, four in Kent Count, and eight in Sussex County. To recognize communities or neighborhoods outside of municipal boundaries that are excluded from the Tree City USA designation, the DFS created the Tree-Friendly Community Program. This program honors communities that are committed to protecting and enhancing urban forest resources if they implement three or more of the following actions: 1) hold an annual community forest ceremony, 2) develop a community forestry management plan, 3) complete a tree project that enhances existing urban forests, 4) adopt a community tree ordinance that protects trees, 5) form a tree commission or tree board that serves as the guiding body for tree related decisions, and 6) have a tree budget of $1/residential household (DFSa, 2020).

Additionally, the Arbor Day Foundation also sponsors the *Tree Campus USA* program and *Tree Line USA* program. Tree Campus USA recognizes higher education institutions that effectively manage their trees and engage their students; Delaware State University has this designation in Delaware. And Tree Line USA recognizes utility companies that engage in quality tree care, hold annual worker training programs, and participate in tree planting and public education; Delmarva Power holds this designation in Delaware. The Arbor Day Foundation also offers the Energy-Saving Tree program in which they partner with utility companies, municipalities, and corporate organizations to provide residents free trees to lower their energy bills by planting trees in places to provide shade (ADF, 2020).

DNREC also oversees a number of programs related to urban greenspaces. In previous sections of this document, the Nonpoint Source Program, Open Space Program, and the Natural Areas Preservation System have been described. The Nonpoint Source Program has resources available to support BMP implementation in developed areas, including tree plantings and other initiatives that would benefit water quality. The Open Space Program and Natural Areas

Preservation Systems programs help to protect and conserve open spaces, including those that may exist in more urbanized areas.

An additional program administered by DNREC that supports BMP implementation in the developed sector is the *Community Water Quality Improvement Grant* (CWQIG) program. The CWQIG is an annual grant offered to non-profit organizations, conservation districts, community organizations and/or homeowner's associations. The grant is supported by funds from the Delaware Clean Water State Revolving Fund (CWSRF) Non-Federal Administrative Account. Projects must demonstrate that they achieve water quality goals, however as discussed, many practices, especially those that involve tree planting and soil health, have GHG benefits as well. The CWSRF provides low-interest loans and grants to municipalities, private organizations, nonprofit organizations and private individuals for projects that will improve water quality (CWQIG, 2020).

DNREC also administers the *Sediment and Stormwater Program*, which implements the Sediment and Stormwater Regulations. Community open space areas are often a part of the community's sediment and stormwater management system. DNREC staff and staff from the delegated agencies manage stormwater for quantity and quality which consists of approving construction plans, inspecting controls during and post construction, and providing education and outreach on stormwater management. There are opportunities, if allowed within stormwater permits, to implement practices that would provide GHG benefits in stormwater management areas.

The *First State Resource Conservation & Development (RC&D) Council* is a partnership organization coordinated under the USDA NRCS in Delaware. RC&D Councils have the goal of accelerating conservation, development and utilization of natural resources and improving economic, environmental, and standard of living conditions in RC&D areas. The Natural Resources Conservation Service can provide RC&D Councils grants for land conservation, water management, community development, and environmental needs in authorized RC&D areas. All three County Conservation Districts and the state government, through 21$^{st}$ Century Funds, also support RC&D projects in Delaware. In 2017, the First State RC&D Council entered into an agreement with the Delaware NRCS office to provide conservation services, including the planting of 40 acres of pollinator habitat. While these projects are permitted to occur on agricultural or developed lands, of the pollinator habitats that were planted in the form of meadows, one was at a wastewater treatment facility, one was at a school, and two have been on community open space (FSRCD, 2020).

Finally, trained and highly skilled volunteers are critical partners in urban greenspace management and maintenance efforts. *Delaware Tree Stewards* are citizens empowered through education and training to help plant and care for trees within the state. This program, which was initiated in 2020, trains interested participants in topics that include how trees work, obtaining trees for planting, planting methods, tree care, and community organization, tree advocacy, and fundraising. Participants attend four one-hour training sessions and participate in a tree planting event. The goal of this program is for trained Tree Stewards to take action to

plan, coordinate, and implement tree planting and care projects in their own communities across the state. This program is currently supported by the Delaware Forest Service and organizers hope to ultimately have program administration rest with a partner organization, such as the Delaware Center for Horticulture. The Delaware Urban and Community Forestry Program intends to require future applicants to their grant program to have a Delaware Tree Steward involved with the project to improve the success of tree planting projects.

In addition to the Delaware Tree Stewards, the *Delaware Master Naturalists*, described in the forestry section above, may also prove to be important partners for managing urban greenspace areas for their carbon storage potential. Master Naturalists are trained on beneficial and invasive plant and animal species and could effectively aid in urban greenspace management.

## Urban Greenspace BMPs with GHG Benefits

BMPs in the urban greenspace sector can be classified into four general categories: urban tree planting, urban riparian buffers, urban stream restoration and conservation landscaping, or meadow creation.

*Urban tree planting* – Maintaining urban tree canopy as well as planting trees in urban greenspaces (often along streets and in open space areas) has the potential to greatly increase stored carbon. These plantings increase urban tree canopy yet often do not resemble forested conditions. Trees in urban settings though often do not have to compete for resources (light, water, nutrients) like those planted in existing forests which leads to greater sequestration rates per tree compared to rural trees. The GHG benefit results in the carbon sequestered and stored by the trees. Urban tree plantings often occur in such a way that grass still exists below the tree, so reduced emissions from reduced mowing may not be realized. Proper site selection of plantings though can potentially reduce energy requirements for heating and cooling of adjacent building since trees provide shade and block winds, helping to reduce the urban heat island effect.

*Urban forest buffers* – In addition to naturally occurring rivers, streams, lakes, and ponds, the urban environment also includes water features associated with stormwater management systems. This may include grassed swales, ditches, wet and dry detention basins, and bioretention areas, to name a few. Targeted installation of grassed or forested buffers in urban areas on both the naturally occurring and manmade water features can reduce the velocity and impact of stormwater runoff, provide water quality and habitat benefits, and potentially result in GHG benefits too.

*Urban riparian restoration* – Stream restoration projects are quite common in urban environments due to the fact that these areas have higher percentages of impervious surfaces resulting in greater runoff volumes and instances on stream bank erosion and incision. Restoration rehabilitates degraded streambanks and reestablishes vegetation. The GHG

benefits of this practice include increasing soil organic carbon through bank stabilization and addition of plant residues and carbon storage in woody biomass.

*Conservation landscaping* – Depending on a community's needs and intended uses for their open space areas, mowed turf areas may be converted into meadows. (Conservation landscaping is the term used by the Chesapeake Bay Program.) Maintained turf areas often require watering, fertilization, and regular mowing, which can amount to significant maintenance costs and GHG emissions. By converting away from a mowed maintenance regime to a system that requires less frequent mowing, no or minimal fertilization and watering requirements, carbon emissions from these lands should be reduced. Additionally, native grasses are believed to have deeper root systems than turf grasses and the potential to build more soil organic carbon below ground. If any wood shrubs are incorporated into the mixture, additional carbon will be stored in that biomass. In addition to the potential GHG benefits meadows can provide, they are also beneficial for water quality and wildlife, especially pollinators.

It should also be noted that modeling tools do exist to estimate the GHG benefits of urban tree planting if sufficient data is available. i-Tree is a suite of programs offered by the USDA Forest Service and partners. iTree was first released in 2006 and has since evolved into a suite of core programs and tools. iTree components can estimate a number of ecosystem services, including carbon storage and sequestration. iTree Eco estimates the carbon stored in trees, sequestration on an annual basis, and carbon emissions through decomposition. The model requires a number of inputs by the user including tree species, height and diameter at breast height. The model estimates annual carbon sequestration by comparing the carbon stored from one year to the next after adjusting for the changed tree diameter at breast height based on the annual growth rate of the tree species (Nowak, 2020).

## Strategies to Enhance GHG Benefits on Urban Greenspaces

Given the progress that has taken place to date and goals established by both the Chesapeake Bay Phase III WIP (DNREC, 2019) and 2020 Milestone Goals (DNRECb, 2020) for Delaware and the Delaware Forest Strategy (DFSb, 2020), opportunities exist to increase GHG benefits offered by urban greenspaces in Delaware.

### Numeric Goals

- Urban tree planting – The Forest Strategy has established a goal of **afforesting 5 acres of vacant open space managed by civic associations by 2025**. The Phase III Chesapeake Bay WIP for Delaware has established an aggressive **goal of planting trees on 1%, or 366 acres, of turf grass in Kent (100 acres) and Sussex (266 acres) counties by 2025**. To move towards this goal, the following specific implementation projects were identified in the 2020-2021 Chesapeake Milestones for Delaware: a) the Nanticoke Watershed Alliance, a nonprofit organization, will plant over 1 acre of trees in the Nanticoke Watershed; b) the Delaware Department of Transportation will plant 3 acres of trees in

the Bohemia watershed; and c) the DFS will plant 3.5 acres of trees at Blackbird State Forest. **In total, goals have been made for 371 acres of tree planting**.

- Urban forest buffers – The Delaware Forest Strategy has established a **goal of implementing 5 miles of forested buffers along impaired waterways and isolated wetlands by 2030.** Personal communication with DFS staff indicated that it is very likely for these plantings to take place along urban streams. Assuming an average width of 30 feet, which may be an overestimate as less space may be available for these practices in an urban setting, this equates to approximately 18 acres of urban forest buffers.

- Urban stream restoration – The Phase III Chesapeake Bay WIP for Delaware has set an aggressive **urban stream restoration goal of 35,617 feet by 2025**. Again, assuming an average 30-foot buffer width, which may not always be possible in the urban environment, this amounts to 25 acres of restored urban riparian areas.

- *Conservation landscaping* – **The Phase III Chesapeake Bay WIP for Delaware established implementation goals for converting mowed turf to meadow as 5% of the acres (3,207 acres total)** in New Castle (343 acres), Kent (709 acres), and Sussex (2,155 acres) counties.

### Programmatic Goals

In addition to the numeric implementation goals above, there are a number of programmatic or policy strategies that should also be explored and if implemented, have the potential to lead to increased carbon sequestration and storage or produce other GHG benefits.

*Maintain and increase funding for urban greenspace programs* – With substantial goals for urban tree planting and urban stream restoration, funding is needed to aid communities in implementing these initiatives. Additional financial resources are likely required. Resources are also needed to help communities maintain the spaces they have; to keep carbon stored, trees need to be healthy. This is especially important given pest pressures like Emerald Ash Borer and the Spotted Lantern Fly.

*Increase education, outreach, and technical assistance* – Individuals and community leaders often do not have the education or training needed to effectively manage urban greenspaces, especially urban forests. A number of partner organizations work in this arena – DFS, DNREC"s Open Space Program, Sediment and Stormwater Program, Nonpoint Source Program, UD Cooperative Extension, First State RC&D Council, Delaware Invasive Species Council, the Livable Lawns Program, and many other nonprofit partners. It would be advantageous for these organizations to come together to strategically plan how education, outreach, and technical assistance can be done most effectively given each organizations expertise and resources. Additionally, the Forest Strategy notes a need for more certified arborists who could assist with some of this outreach and technical assistance. Communities, organizations, and individuals require assistance with the following topics:

- Ordinances to protect existing trees/natural resources and to plant new trees as land is developed or re-developed
- Establishing tree canopy goals
- Developing urban forest management plans, including maintenance plans and invasive species management
- Value of urban trees, meadows, and well managed greenspaces. Often, naturally managed landscapes look unmanicured and could give the impression to an uninformed person that the area is unmanaged. It is especially important to educate the community on what these spaces should look like so that they become aesthetically pleasing and valued.
- Criteria to become an established member of Tree City USA, Tree Campus, USA or Tree Line USA

*Improve tracking and reporting of conservation practices* – Communities likely need assistance inventorying their trees. Additionally, as noted above, there is not currently a tracking and reporting system for conservation landscaping and this needs to be developed to track meadow implementation by communities.

*Train partners on the use of iTree* – As more people work on urban greenspace issues, it would be advantageous to train partners on the use of the iTree program to assist with annual tracking and reporting initiatives.

*Identify/develop metrics to quantify the GHG benefits of conservation landscaping* –The GHG benefits of this practice are not currently well documented. Research should be done to identify or develop metrics for meadow planting.

*Develop urban wood utilization markets* – Urban trees produce wood debris through regular trimming, but also when damaged in storms, or when trees die either due to age or prematurely due to pests, disease or other issues. That wood must be dealt with and often is sent to landfills or mulched, where the stored carbon is released back to the atmosphere. Urban wood utilization is an approach to find alternative ways to use, rather than dispose of, urban tree waste. Michigan has developed an Urban Wood Toolkit (https://www.miurbanwoodnetwork.com/toolkit) to find the best and most economically advantageous uses for urban and community tree wood and something like this could be developed for Delaware. A tool kit of this type would identify opportunities for using larger branches and trunks in lumber or other products like furniture where the carbon will continue to be stored for many more years. It will be necessary to invest time and resources to develop urban wood markets and associated urban mills.

# Opportunities on Wetlands

## Profile of Delaware's Wetlands

Positioned almost entirely on the Coastal Plain, Delaware is relatively flat in elevation creating a wet, poorly drained landscape in many locations. These wetlands range in type and location from coastal salt marshes to freshwater forests at the upper reaches of watersheds. Wetlands are an integral part of the natural system and provide valuable benefits to people, including reducing flooding, controlling erosion of lands, decreasing damage from severe storms, serving as a filter to clean water, providing recharge to groundwater aquifers, offering recreation opportunities, hosting habitat for important plants and animals, and sequestering carbon.

Delaware contains 296,351 acres of wetlands, including 129,754 of tidal (saline) wetlands and 166,597 acres of nontidal (freshwater) wetlands. Slightly less that 25 percent of Delaware is considered wetland, which is less than half the extent of wetlands that existed historically. Changes, losses and gains of wetlands over time can occur due to natural and human-induced actions, and those same forces exist today. Typical human impacts to wetlands stem from using the land for a different purpose which tends to remove the ability of a wetland to provide important functions. These human impacts include draining, filling, dredging, construction of ponds, and discharging of pollutants. Natural processes that impact wetlands are rising sea levels, erosion of coastal marsh, strong storm events such as hurricanes or nor'easters, severe flooding and severe droughts.

There was a loss of more than 3,000 acres in the most recent analysis (2007 to 2017), and inherently loss of the beneficial functions that wetlands provide. Recent changes at the federal level results in less federal jurisdiction leaving some nontidal wetlands with no protection. A majority of coastal tidal wetlands in Delaware are protected through regulation and by federal or state ownership, meaning that coastal blue carbon stocks, while threatened by climate change and sea level rise, are an asset to continue to manage and protect.

## Existing Programs that Support BMP Implementation on Wetlands

Although wetlands vary in type, all wetlands have tremendous value for carbon storage. Protecting and restoring wetlands is vital for future climate planning, accounting for carbon stocks, and for increasing sequestration. Tidal wetlands may be regulated at the federal and state levels. State-regulated tidal wetlands are protected by law through Chapter 66 of the Delaware Code. While tidal wetlands are well protected by State of Delaware regulations, many nontidal and isolated forested wetlands are threatened because of gaps in existing regulations. Although there are federal regulations in place through the Clean Water Act, nontidal wetlands continue to diminish which adds to climate change through loss of carbon benefits.

There are many resources at the federal and State level to assist landowners with wetland restoration and protection. A selection of existing programs is listed below; many of these are

previously described in the Agriculture section of this paper. Wider use of these programs will be necessary to secure carbon stocks and increase sequestration.

- Agricultural Conservation Easement Program (ACEP) Wetlands Reserve Easement: Natural Resource Conservation Service (NRCS) program provides technical and financial assistance directly to private landowners to restore, protect and enhance wetland through permanent or 30-year easements
- Environmental Quality Incentives Program (EQIP): NRCS program helps participants develop habitat for upland, wetland, aquatic and riparian species through 1- to 3-year voluntary agreements
- Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP): NRCS program helps participants convert marginal cropland or pastureland to habitat, including wetlands
- Chesapeake Bay Forestry Grant Program: Chesapeake Bay Program supports establishing forested buffers in impaired waterways within the watershed
- Community Water Quality Improvement Grants: Delaware Water Infrastructure Advisory Council (WIAC) program provides financial support for projects to improve water quality in designated impaired watersheds

In addition to existing programs to support wetland conservation and management, the state supports ongoing research programs. Below is a brief list of current 'blue carbon' related research activities which the Delaware Department of Natural Resources and Environmental Control's Delaware Coastal Programs (DNREC-DCP) are supporting, participating with, and/or leading.

- DNREC-DCP has been collecting tidal marsh soil samples over a wide range of salinities, dominant vegetation types, and locations on the marsh platform. These soil samples have been measured for organic matter, total soil carbon, dry bulk density, soil nitrogen, and soil sulfur with the goals of 1) creating an inventory of soil carbon values to help improve carbon modelling efforts and 2) to understand the spatial variability of carbon stocks within a Delaware tidal wetland.
- The NASA Carbon Monitoring System project titled "Data-Model Integration for Monitoring and Forecasting Coastal Wetland Carbon Exchanges: Serving Local to National Greenhouse Gas Inventories" led by James Holmquist from the Smithsonian Environmental Research Center has the goal to improve our ability to upscale tidal wetland methane gas fluxes in the contiguous United States using remote sensing capabilities. For this effort, the DNREC-Delaware National Estuarine Research Reserve (DNERR) is being leveraged as a ground-truthing site. Data collected at the DNERR will help improve the predictive capacity for methane fluxes, which has been a large uncertainty in understanding the net carbon gas exchange in tidal marshes.
- The Delaware Geological Survey is currently leading a modelling effort titled "Assessing spatial distribution and vulnerability of stored soil carbon in St. Jones and Blackbird marshes" lead by Daniel Warner, and funded by the DNERR. The project seeks to map

tidal marsh carbon storage using statistical modelling approaches. The general goals of this project are to 1) improve the estimates of stored carbon in Delaware tidal marshes, 2) identify 'hot spots' of elevated carbon storage within the marshes, and 3) assess areas of high vulnerability to help inform marsh preservation and mitigation strategies.

- DNREC-DCP will continue to support visiting researchers at the DNERR through site coordination, local/subject matter expertise, and providing access/awareness to complementary, pre-existing data. Current, on-going research includes comprehensive studies on greenhouse gas exchange at the St. Jones Reserve led by the University of Delaware.

## Wetlands BMPs with GHG Benefits

Considering Delaware has lost more than half its original wetland area, and that wetland loss continues, protection of remaining wetlands is vitally important in maintaining the natural functions wetlands provide. Acquisition of wetland area for protection is one tool that has been used in Delaware, and fortunately approximately 75% of tidal wetlands are owned by federal/state agencies and non-profit conservation organizations. That goes a long way in protecting blue carbon stocks. However, natural erosion and sea level rise are the primary causes of continued tidal wetland loss. Using preventative management practices such as living shoreline protection to prevent erosion and creative use of dredge material to keep marsh elevations intact provide important mechanisms battling climate change. Protection of nontidal wetlands, especially nontidal forests, must also be a priority for the carbon benefits these wetlands provide. Many nontidal wetlands have been altered by drainage which in turn lessens the ability of these systems to provide carbon storage. Protecting and maintaining the natural hydrology of nontidal wetlands supports wetland health and the ability of these habitats to provide beneficial functions.

Protecting existing wetlands only goes so far, and more needs to be done to maximize natural functions including carbon benefits. Natural resource managers and scientists continue to improve actions to restore wetlands bringing back their important functions. The most widespread action leading to wetland loss or degradation is removing hydrology from wetlands either through drainage or through physical barriers. Some physical barriers are difficult or impossible to rectify but restoring hydrology can be simple such as plugging a drainage ditch or cutting through a soil berm to allow flow to resume to an adjacent wetland. Reconnecting floodplain wetlands can increase carbon storage and provide crucial flood storage. In addition to full wetland restoration, there are opportunities for improvement in partially degraded wetlands through enhancement actions. Partially drained wetlands can be returned to original hydrology, and removal of invasive species allows for natural vegetation and soil processes to provide greater carbon benefits.

Wetlands, like forest lands, are important for actively sequestering carbon from the atmosphere and for storing carbon in plant tissues and in the soil. Thus, both protection and restoration of wetlands are essential strategies to preserving the carbon already stored in these ecosystems, and to promote and enhance their ability to continue absorbing carbon dioxide

from the atmosphere. When wetland habitats are lost or degraded – through conversion to other land uses, changes to hydrology, erosion, or other impacts – these losses result in carbon loss as well. Wetlands are highly productive systems that have the potential to sequester carbon at greater rates than forests. While the potential for carbon sequestration and storage in wetlands is significant, it is also part of a complex and dynamic system of gas fluxes that can vary spatially and temporally. In particular, wetlands can produce emissions of methane and other greenhouse gases through decomposition, and as a result can be both a sink and a source for greenhouse gases.

Blue carbon refers to carbon stored in ocean and coastal ecosystems. In general, coastal wetlands with higher salinity provide higher levels of carbon sequestration than coastal wetlands in lower salinity areas. However, gas fluxes can vary considerably under different site conditions. As described below, field research and soil testing is underway in Delaware's National Estuarine Research Reserve to better understand the variability of carbon stocks in tidal wetlands. While some types of freshwater wetlands and certain land uses in the floodplain may release carbon, forested floodplain areas and woody wetlands are also important for storing and sequestering carbon. Due to the complexity of estimating carbon flux in these systems, the tools and methods for estimating the carbon sequestration potential from tidal and non-tidal wetlands are still in early stages of development.

A recent project by researchers at Duke University is developing modeling and mapping products that can be used identify and prioritize coastal wetlands based on their vulnerability to climate change and their contribution to carbon sequestration. Delaware is one of six states that will be working toward using the project results to inform wetland management plans, identify opportunities for marsh migration, and improve methods for estimating carbon sequestration potential.

## Strategies to Enhance GHG Benefits on Wetlands

While the role of carbon sequestration and storage in wetlands is known to be important, it can also be difficult to measure with certainty, leading to challenges with quantifying the carbon benefit of these lands. Continuing research, as described above, is making an important contribution to understanding carbon fluxes in wetlands. However, the tools and methods for estimating the carbon sequestration potential from some ecosystems, such as tidal and non-tidal wetlands, are still in early stages of development. A key strategy for wetlands is to improve methods for measuring and tracking carbon sequestration. Improvements to tracking annual carbon sequestration enable us to reliably account for the carbon sinks from our natural and working lands. Delaware can continue to make progress in this area by utilizing new coastal wetlands carbon mapping conducted by Duke University in current research and management planning efforts.

# Experts Consulted and Stakeholder Outreach

Throughout the development of this document, subject matter experts from partner agencies and organizations were consulted to gain insight into current practice use and acceptability of proposed goals. The consulted experts are listed below. Those marked with an (*) have participated on Delaware's Natural and Working Lands Team. Those marked with a (+) are contributing authors to this document. Special thanks to Jennifer de Mooy and Katelyn Frye, who provided a proposed outline and supporting text for this report.

Debbie Absher, Sussex Conservation District
Jayme Authors, NRCS
Mark Biddle, DNREC Division of Watershed Stewardship (+)
Nikko Brady, DDA
Kesha Braunskill, DDA Delaware Forest Service (*)
Chris Brosch, DDA Nutrient Management Program (*)
Clint Gill, DDA Nutrient Management Program
Kyle Hoyd, DDA Delaware Forest Service
Michelle Schmidt, Center for the Inland Bays
Kari St. Laurent, DNREC Division of Climate, Coastal, and Energy (*) (+)
Brittany Sturgis, DNREC Nonpoint Source Program
Sam Topper, DDA Delaware Forest Service
Michael Valenti, DDA Delaware Forest Service
Patti Webb, Nonpoint Source Program, DNREC
Christian Wisniewski, DNREC Division of Air Quality (*) (+)

To gain additional feedback and support for this work, a number of presentations have been made to stakeholder audiences. Participants had an opportunity to comment on assumptions made, ask questions, and make recommendations on goal setting strategies. Following the October 2020 outreach period, the document was edited to provide additional clarity based on questions received and calculations were updated to reflect feedback received on assumptions used and proposed goals.

10/6/20 –Delaware NRCS State Technical Advisory Committee

10/27/20 – DNREC Conservation Programs Section

10/27/20 – Sussex Conservation District Board Meeting

1/15/21 – Woodland Workshop at Delaware Ag Week

# References


ADF, 2020. Energy Saving Tree Program, Arbor Day Foundation, https://energysavingtrees.arborday.org/#Home. Last accessed October 23, 2020.

AgDaily, 2020. Smartphones prove to be time-saving soil analytical tools. AgDaily. https://www.agdaily.com/technology/smartphones-saving-soil-analytical-tools/. Last accessed October 23, 2020.

Birdsey, R.A., A.J. Dugan, S.P. Healey, K. Dante-Wood, F. Zhang, G. Mo, J.M. Chen, A.J. Hernandez, C.L. Raymond, and J. McCarter. 2019. Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of U.S. national forests. Gen. Tech. Rep. RMRS-GTR-402. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 116 pages plus appendices.

Braun, M, D. Stabenow, L. Graham, and S. Whitehouse. 2020. The Growing Climate Solutions Act of 2020. https://www.braun.senate.gov/sites/default/files/2020-06/Growing%20Climate%20Solutions%20Act%20One%20Pager_0.pdf. Last accessed October 23, 2020.

CIB, 2019. Watershed Forest Restoration Plan for Delaware's Center for the Inland Bays. Delaware Center for the Inland Bays, Rehoboth, DE.

CIB, 2020. Comprehensive Conservation and Management Plan. Delaware Center for the Inland Bays, Rehoboth, DE. (in review; expected final in early 2021)

Clayton, C. 2020. Big Data to Calculate Carbon, Progressive Farmer. https://www.dtnpf.com/agriculture/web/ag/news/farm-life/article/2020/08/03/new-ag-tech-programs-stress-reducing. Last accessed October 23, 2020.

CWQIG, 2020. Community Water Quality Improvement Grant, Delaware Department of Natural Resources and Environmental Control, https://dnrec.alpha.delaware.gov/environmental-finance/community-water-quality-improvement/. Last accessed October 23, 2020.

DDA-USDA, 2018. 2017-2018. Delaware Agriculture Statistics Bulletin. Delaware Department of Agriculture and US Department of Agriculture, National Agriculture Statistics Service, Dover, DE 19901.

DDA-USDA, 2020. 2019-2020. Delaware Agriculture Statistics Bulletin. Delaware Department of Agriculture and US Department of Agriculture, National Agriculture Statistics Service, Dover, DE 19901.

De Villiers, C., S. Chen, C. jin, Y. Zhu, 2014. Carbon sequestered in the trees on a university campus: a case study, Sustainability Accounting, Management and Policy Journal, Vol. 5 Iss 2 pp. 149 – 171 http://dx.doi.org/10.1108/SAMPJ-11-2013-0048
DFSa, 2020. Delaware Forest Resource Assessment. Delaware Forest Service, Delaware Department of Agriculture, Dover, DE (in review).

DNREC, 2019. Delaware's Phase III Watershed Implementation Plan. Prepared by Delaware's Chesapeake Bay WIP Steering Committee and coordinated by the Delaware Department of Natural Resources and Environmental Control, Dover, DE.

DNRECa, 2020. Delaware's 2017 Greenhouse Gas Emission's Inventory. Delaware Department of Natural Resources and Environmental Control, Division of Air Quality. Dover, DE 19901.

DNRECb, 2020. Delaware 2020/2021 Two-Year Milestones - Programmatic Commitments and BMP Implementation Targets, Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Domke, Grant M.; Walters, Brian F.; Nowak, David J.; Smith, James, E.; Ogle, Stephen M.; Coulston, J.W.; Wirth, T.C. 2020. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018. Resource Update FS-227. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p. https://doi.org/10.2737/FS-RU-227.

EPA, 2020. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2018. U.S. Environmental Protection Agency. EPA 430-R-20-002

FirstMap, 2020. Delaware FirstMap Data. https://opendata.firstmap.delaware.gov/. Last accessed December 17, 2020.
Freedgood, J., M. Hunter, J. Dempsey, and A. Sorensen. 2020. Farms Under Threat: The State of the States. Washington, DC: American Farmland Trust.

FSAa, 2020. Delaware Conservation Reserve Enhancement Program (CREP) Fact Sheet. Farm Service Agency, US Department of Agriculture, January 2020.

FSAb, 2020. CLEAR30 Pilot Fact Sheet. Farm Service Agency, US Department of Agriculture, April 2020.

FSRCD, 2020. First State Resource and Conservation development Council, 2019 Annual Report, https://www.midatlanticrcd.org/new-page/first-state-rcd. Last accessed October 23, 2020.

iTree, 2020. iTree Tool Website. Last accessed October 23, 2020.
Law, N and J. Hanson. 2016. Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion. A report prepared on behalf of the Chesapeake Bay Program Expert Panel.

Marks, E. 2020. New NRCS Practices to address Climate Change Issues, USDA Climate Hubs. https://www.climatehubs.usda.gov/hubs/northeast/news/new-nrcs-practices-address-climate-change-issues

NAPS, 2020. Delaware Natural Area Preservation System, Delaware Department of Natural Resources and Environmental Control, https://dnrec.alpha.delaware.gov/parks/natural-areas/. Last accessed October 23, 2020.

NCDC, 2020. NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2020). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

NPS, 2020. 2019 Annual Report. Nonpoint Source Program, Division of Watershed Stewardship, Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Nowak, D. 2020. Understanding iTree: Summary of Programs and Methods. US Department of Agriculture, Forest Service, Madison, WI.

Ontl, T.A., C.W. Swanston, M.K. Janowiak, J.Daley. 2020. Practitioner's menu of adaptation strategies and approaches for forest carbon management. In: Ontl, T.A, Janowiak, M.K., Swanston, C.W., Daley, J., Handler, S.D., Cornett, M., Hagenbuch, S., Handrick, C., McCarthy,

L., Patch, N. 2020. Forest management for carbon sequestration and climate adaptation. Journal of Forestry 118(1):86-101. doi:10.1093/jofore/fvz062.

Swan, A., M. Easter, A. Chambers, K. Brown, S.A. Williams, J. Creque, J. Wick, and K. Paustian. 2019. COMET-Planner: Carbon and Greenhouse Gas Evaluation for NRCS Conservation Practice Planning.

USDA. 2020. Agriculture Innovation Agenda. US Department of Agriculture. https://www.usda.gov/aia. Last accessed October 23, 2020.

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