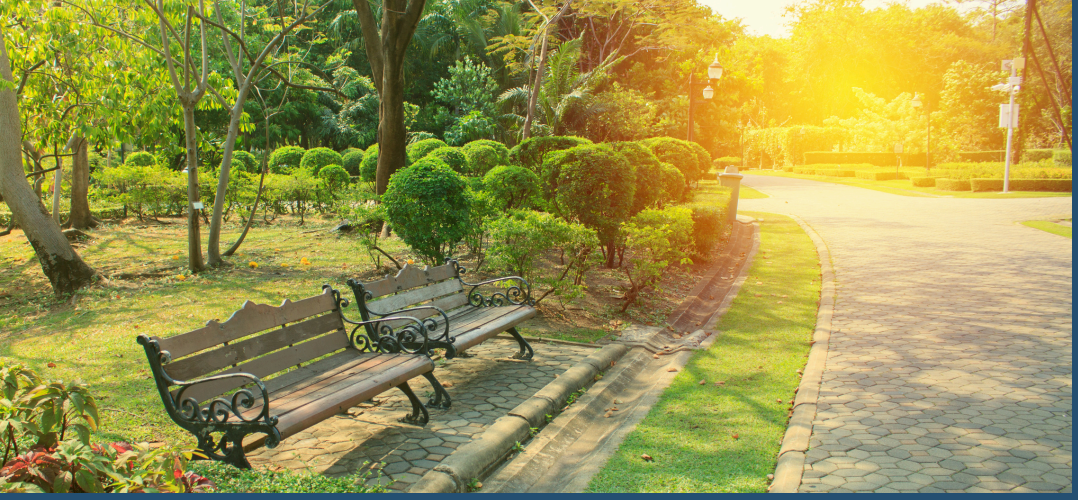

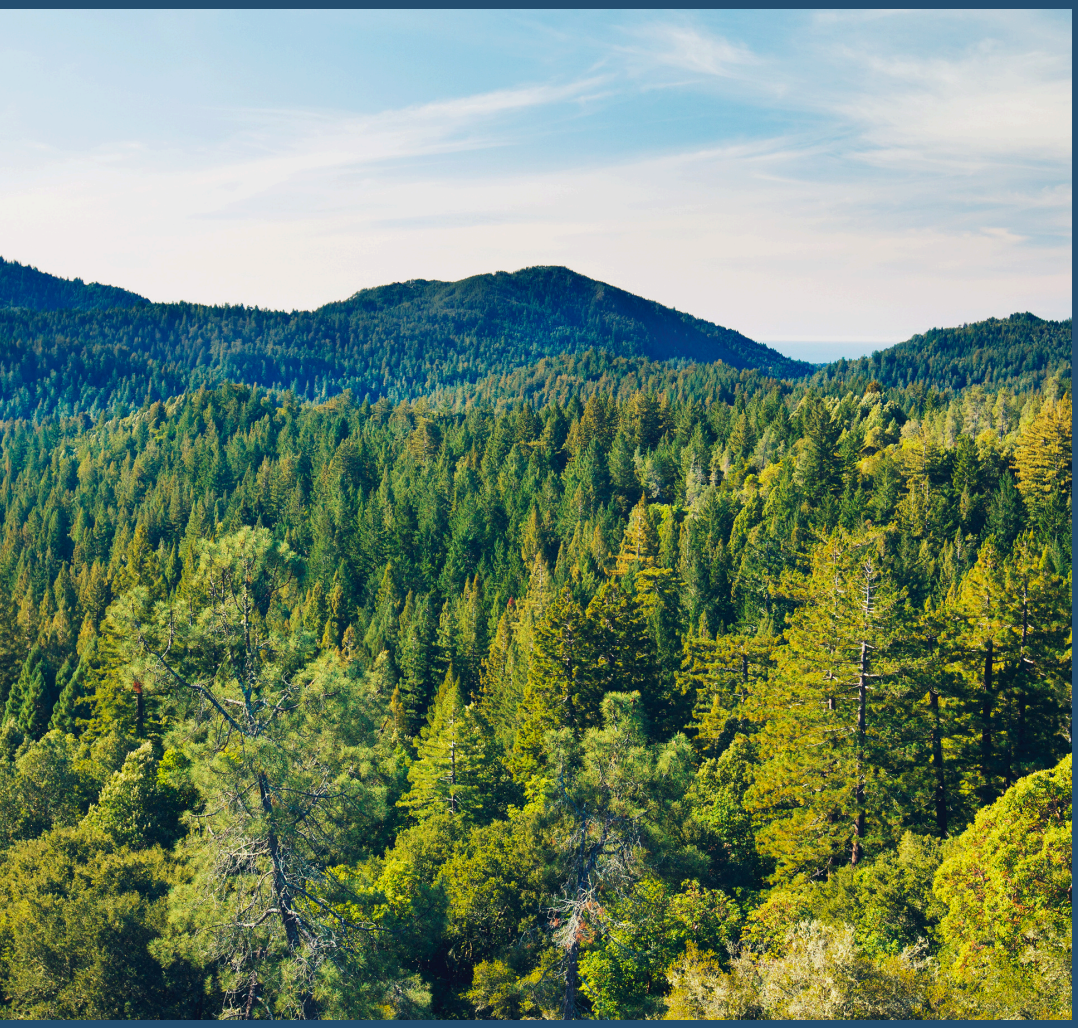

A STRATEGY TO ADVANCE CARBON SEQUESTRATION ON NEW JERSEY'S NATURAL AND WORKING LANDS

New Jersey Department of Environmental Protection
New Jersey Department of Agriculture

September 19, 2024

Fellow New Jerseyans,

Ours is called the Garden State for a reason. New Jersey is the proud steward of a diverse landscape of natural and working lands, including vast forests, agricultural lands, wetlands, shorelines, and developed lands, as well as many aquatic resources and habitats. These natural and working lands are central to our State's identity and culture, and critical to our economy. Natural and working lands also play an essential role in sequestering carbon and reducing the net emissions of greenhouse gases (GHGs) that continue to fuel our changing climate. As we continue to enjoy and make productive use of our lands, this *Strategy to Advance Carbon Sequestration on New Jersey's Natural and Working Lands* will support New Jerseyans in harnessing the full potential of these natural assets in the gravely necessary work of reducing planet-warming emissions in order to secure a stable climate for our residents today and all those who follow.

As New Jerseyans know too well, climate change is here, it is worsening, and it represents the greatest long-term threat to our communities, economy, and way of life. Global atmospheric warming, caused largely by human activities, is leading to significant changes in climate patterns here in New Jersey, across the United States, and around the world. The adverse effects of climate change are already impacting New Jerseyans and, unfortunately, are only projected to intensify in the years ahead. With an increase of 3.5°F in the average annual temperature over the last century, New Jersey is the most rapidly warming state in the northeast. Sadly, heat–related illnesses have led to more than 10,000 emergency department visits by our residents in the last ten years. Extreme weather events have increased in frequency and intensity, leading to devastating and disruptive flooding. New Jersey is also experiencing the adverse effects of rising sea levels, which are projected to rise locally at a rate more than twice the global average, posing serious risks to coastal and inland communities, as well as our natural and working lands.

While the current impacts and future risks of climate change pose great challenges, New Jersey state government, under the leadership of Governor Phil Murphy, is hard at work positioning our residents, communities, businesses, and institutions to meet these challenges head-on. Through partnerships across the many sectors of our economy and every region of our State, New Jersey continues to modernize public policy and deploy innovative programs that will help us eliminate the climate pollutants necessary to thwart the worst impacts of climate change, while simultaneously building our communities' resilience to unavoidable climate impacts.

The *Strategy to Advance Carbon Sequestration on New Jersey's Natural and Working Lands*, like the Global Warming Response Act of 2006 (GWRA) that directs this important work, recognizes that carbon sequestration helps to offset the State's overall GHG emissions. Importantly, increasing our carbon sequestration will enable us to counterbalance continuing emissions from the sectors of our economy that pose the greatest challenges to achieving the drastic GHG reductions necessary. All current indications reflect that multiplying our carbon sequestration capacity is central for New Jersey to achieve its legislatively prescribed target of reducing GHG emissions by 80% by 2050.

The benefits of amplifying carbon sequestration extend far beyond securing a more livable climate for current and future generations. The strategies identified here will also improve and protect the ecology of our natural and working lands, which help provide healthy food, clean air and water, habitats for our wildlife, and recreation for our fellow residents. The work ahead is considerable and the stakes are high. And while no one person or institution can meet this moment on their own, together, we can keep New Jersey the safe, healthy, and beautiful place we love.

Onward,

Shawn M. LaTourette, Commissioner
New Jersey Department of Environmental Protection

ACKNOWLEDGMENTS

This report is issued with special thanks to Governor Phil Murphy and Department of Environmental Protection Commissioner Shawn M. LaTourette for their leadership in recognizing and responding to the threat of climate change, and with thanks to New Jersey Department of Agriculture Secretary of Agriculture, Edward D. Wengryn, for his contributions. Thank you for your dedication of staff in the pursuit of this important work. This report—and its role in mitigating climate change for the benefit of our state, country, and world—would not have been possible without the hard work and commitment of many people across the Executive Branch of New Jersey State Government including our expert workgroups and steering committee. We cannot achieve our 80x50 goals without investing in the natural ability of our lands to sequester carbon. This strategy coupled with other complementary strategies, such as those identified in the 80x50 report, will ensure that New Jersey can significantly reduce its emissions profile.

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EXECUTIVE SUMMARY

Climate change is an existential global crisis informed by clear scientific consensus. It is altering precipitation patterns, temperature, and rates of sea-level rise and will impact nearly all our natural resources and developed areas. A coordinated effort to decrease greenhouse gas emissions locally and globally is needed to slow the rate of global warming.

New Jersey has made great strides in reducing greenhouse gas emissions from burning fossil fuels for energy generation. From 2006 to 2020, greenhouse gas emissions dropped from 121.6 to 91.0 million metric tons of carbon dioxide equivalent (CO_2e) is a measurement of the total greenhouse gases emitted, expressed in terms of the equivalent measurement of carbon dioxide; CO_2e allows comparison of greenhouse gases with different warming potentials). Further reductions are anticipated through a commitment to increased efficiency and electrification of the transportation and building sectors.

According to recent estimates, emissions must decrease by 50% below 2006 levels by 2030, to roughly 60.6 million metric tons CO_2e per year.[1] The Global Warming Response Act states that emissions must fall further to 80% below 2006 levels by 2050, or to about 24.2 million metric tons of CO_2e. New Jersey will need to cut about 75% of current GHG emissions between today and 2050. An economy-wide transformation is necessary to meet this goal. All sectors must accept and adopt fundamental changes in energy consumption, waste production, and management of natural and working lands. Despite these significant efforts, an excess of emissions will remain. This gap must be bridged to meet these goals. That is where carbon sequestration comes in.

Natural and working lands (e.g., forests, farms, underutilized developed lands) sequester carbon, pulling carbon from the air and storing it in plants and soils long-term. What follows is a scientifically supported and fact-based strategy that sets forth concrete methods of conserving and managing these lands to increase the amount of carbon removed from the atmosphere and stored to offset greenhouse gas emissions. The land management practices in this strategy aim to maintain existing carbon stores through conservation and/or increase carbon sequestration by increasing plant cover and growth without compromising ecological function.

The natural lands that are the focus of this strategy include aquatic habitats, wetlands, and forests. Some recommendations for maximizing carbon sequestration in these lands include protecting submerged aquatic vegetation, restoring Atlantic white cedar swamps, and installing living shorelines in tidal wetlands. In forests, some specific targets are for planting acres of trees through afforestation and reforestation, along with recommendations for improving forest management. This strategy also presents goals for working lands that include agricultural land and developed land. Some of the targets in agricultural land are related to composting and planting cover crops. In developed land, the focus is mainly on creating new public open space on brownfield sites, revitalization of older parks and urban schoolyards, adding green infrastructure elements, and street tree planting.

While this strategy focuses largely on actions that can be achieved on State lands, the Department's sincere hope is that other entities, such as local governments, universities, nonprofits, private individuals, and businesses and industry partners, will heed this call to action and begin to implement thoughtful and progressive land management practices through the implementation of this strategy on their assets. The targets set in the strategy cannot be reached without adoption by other entities. If implemented collectively and collaboratively, this strategy will help New Jersey in its efforts to combat climate change by boosting carbon sequestration and offsetting greenhouse gas emissions.

New Jersey Natural and Working Lands Strategy Targets for Carbon Sequestration Actions

These targets are a combination of goals for state government and other entities. The majority of targets are totals to be achieved by 2030 and 2050; however, some targets are expressed as a yearly rate (e.g., 2,000 acres/yr). For targets

that can't be quantified or for which values are not yet available, the 2030 and 2050 values are designated as an "X." The Strategy text contains detailed descriptions of each target.

FORESTED LAND				
Recommendation Type	ID	Target	2030	2050
Afforestation	F1	Identify & plant non-forested land to a forested condition with appropriate species	1,600 acres (200 ac/yr)	4,000 acres (200 ac/yr)
Reforestation	F2	Prioritize sites for reforestation actions	10 sites	40 sites
	F3	Identify & restore degraded forests across all forest ownerships	800 acres	2,000 acres
Afforestation/Reforestation	F4	Increase nursery production to annually service more municipalities & private landowners	20% increase	20% increase
Avoided Conversion	F5	Minimize conversion of forested lands to non-forest uses	Maintain at 4,000 acres/yr	Reduce to 2,000 acres/yr
	F6	Enroll forest land into a carbon market	75,000 acres/yr	100,000 acres
Improved Forest Management	F7	Plan ecological forest management	100,000 acres	200,000 acres
	F8	Provide cost share to properties for improved forest management	100 properties/year	500 properties/year
	F9	Private landowner enrollment in forest stewardship program and Farmland Assessment programs	115 properties/ year	All properties enrolled

WETLANDS				
Recommendation Type	ID	Target	2030	2050
Restoration	WL1	Complete tidal reconnection projects	1 site/yr	2 sites/yr
	WL2	Increase cover of salt marsh vegetation	70 acres/yr	200 acres/yr
	WL3	Restore Atlantic White Cedar Swamps	10,000 acres	20,000 acres
	WL4	Install X linear feet of living shorelines	7,800 ft/yr	10,000 ft/yr
Wetland Protection	WL5	Minimize disturbance of wetland soils	Reduce by 10%	Reduce by 30%
	WL6	Protect tidal wetland migration zones	X	20% of migration zones

AQUATIC HABITATS				
Recommendation Type	ID	Target	2030	2050
Monitoring	AQ1	Assess SAV density and health with ongoing monitoring	X	X
Conservation	AQ2	Protect existing SAV from further loss	Limit to 10% loss	No net loss
Restoration	AQ3	Restore X acres per year (to be quantified after baseline is updated via monitoring)	Within 5 years	Expand program

AGRICULTURAL LAND				
Recommendation Type	ID	Target	2030	2050
Compost	AG1	Apply compost to cropland harvested	4,150 acres/yr	12,700 acres/yr
	AG2	Apply compost to cropland pastured	750 acres/yr	1,950 acres/yr
	AG3	Apply compost to permanent pasture	2,400 acres/yr	6,500 acres/yr
Cover Crops	AG4	Plant cropland harvested and cropland pastured with cover crops	9,850 acres	40,300 acres

DEVELOPED LAND				
Recommendation Type	ID	Target	2030	2050
Afforestation	DL1	Plant street trees/shade trees	250,000 trees	1,000,000 trees
Promote Urban Forest & Street Tree Stewardship	DL2	Enroll all municipalities that are eligible in Urban Stewardship programs	X	X
Brownfield Redevelopment to Create Parks	DL3	Redevelop brownfield sites to create new green space	20 sites (100 acres)	200 sites (1000 acres)
Revitalize Older Parks & Urban Schoolyards	DL4	Enhance public parks in urban areas and improve urban schoolyards	20 sites (50 acres)	(100 sites) 250 acres
Enhancement	DL5	Improve soils through remediation and capping	500 acres	5000 acres

Photo credit NJDEP Metthea Yepsen

GLOSSARY OF TERMS

For consistency, many of these definitions are borrowed verbatim from the cited sources. Please refer to the reference section at the end of this document for complete citations.

Afforestation: The process of establishing trees on land that has lacked forest cover for a very long time or land that has never been forested.[2]

Avoided conversion: a defense strategy that aims to prevent forest conversion to non-forest land use. Avoided conversion strategies are appropriate for forested lands at risk of being developed or converted from a forested to a non-forested condition.[2]

- Silvicultural management such as regeneration cuts (clearcuts, shelterwoods, seed trees, patch cuts) are not considered forest conversion as these cuts aim to regenerate forested land.

Avoided emission: methods or procedures that reduce the risk of emission from forest carbon pools.[2]

Blue Carbon: carbon captured by the world's ocean and coastal ecosystems.[3]

Brownfield: any former or current commercial or industrial site that is currently vacant or underutilized and on which there has been, or there is suspect to have been, a discharge of a contaminant.[4]

Carbon markets: are trading systems in which carbon credits are sold and bought. One tradable carbon credit is equal to one ton of carbon dioxide or the equivalent amount of a different greenhouse gas reduced, sequestered, or avoided.

- There are two different types of carbon offset projects:
    - Captured-based projects are the traditional carbon offset, where the volume of carbon stored over a set time frame is measured and sold.
    - A practice-based project pays landowners of all sizes to conduct forest management practices known to sequester carbon. This can involve invasive species management to support the regeneration of native tree species or managing forests to grow to a larger size. These programs also allow for some timber harvesting within certain guidelines (e.g., they are sustainable, or forests are not high-graded).[5]

Carbon sequestration: is the uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide from the air and water as part of photosynthesis. The carbon is sequestered in biomass, soils, and geological formations.

Contaminated Sites: are those sites and properties where soil or groundwater contamination has been confirmed at levels equal to or greater than applicable standards.

Damage Causing Agent: With respect to forested areas, Damage Causing Agents (DCAs) are those that cause the decline and mortality of vegetation. The NJ Forest Service recognizes DCAs as either native or exotic and biotic (insects, disease, deer, invasive plants) or abiotic (climate change, wildfire, sea level rise, storms).[2]

Ecological forestry: is an approach to forest management that emphasizes and considers ecological processes and functions.[2]

Ecosystem function: The major ecosystem processes that regulate or influence the structure, composition, and pattern of the ecosystem. These include nutrient cycles, energy flows, trophic levels (food chains), diversity patterns in time/space development and evolution, cybernetics (control), hydrologic cycles, and weathering processes. (NJ State Forest Action Plan)

Enhancement: a change in the physical, chemical, and/or biological characteristics of a natural resource to heighten, intensify, or improve a specific function(s). Enhancement results in the gain of selected natural resource function(s) but also may lead to a decline in other function(s).[6]

Environmental Justice: the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.[7]

Farmland Assessment Program: The Farmland Assessment Act of 1964 was amended in 1986, requiring some woodland owners to develop and implement a state-approved forest management plan to qualify for reduced property taxation. Under the amended act, woodland owners must fulfill special requirements concerning property used exclusively for the production and sale of forest products, excluding Christmas trees. Some woodland owners are eligible for reduced property taxes if they follow a state-approved forestry plan.[8]

Fire-dependent systems: Forests, grasslands, and other ecosystems historically composed of species of plants that evolved with and are maintained by fire regimes.[2]

Forest conversion: Conversion of forested land to a permanent non-forest condition.[9]

Forest health: Defined by the production of forest conditions that directly satisfy human needs and by resilience, recurrence, persistence, and biophysical processes that lead to sustainable ecological conditions.[10]

Forest Inventory and Analysis (FIA): A program of the US Forest Service, FIA reports on the status and trends in forest area and location; in the species, size, and health of trees; in total tree growth, mortality, and removals by harvest; in wood production and utilization rates by various products; and in forest land ownership.

- New Jersey has FIA data dating back to the 1980s. Currently, it receives data at 2x intensification (meaning that the entire state is re-inventoried on a 5-year cycle, with one plot per every 3,000 acres).[11]

Forest land: Land that has at least 10 percent crown cover by live tally trees of any size or has had at least 10 percent canopy cover of live tally species in the past, based on the presence of stumps, snags, or other evidence. To qualify, the area must be at least 1.0 acre in size and 120.0 feet wide. Forest land includes transition zones, such as areas between forest and nonforest lands that meet the minimal tree stocking/cover and forest areas adjacent to urban and built-up lands. Roadside, streamside, and shelterbelt strips of trees must have a width of at least 120 feet and a continuous length of at least 363 feet to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classified as forest if they are less than 120 feet wide or less than an acre in size. Tree-covered areas in agricultural production settings, such as fruit orchards, or tree-covered areas in urban settings, such as city parks, are not considered forest land.[2]

Forest restoration: A broad strategy that involves repairing forest ecosystem function, which allows forests to grow and sequester carbon in places where a forest's ability to sequester efficiently or to transfer carbon between pools has been compromised.[2]

Fragmentation (habitat): The break-up of a large continuous land area by reducing and dividing into smaller patches isolated by areas converted to a different land type. Habitat can be fragmented by natural events or development activities.[2]

Fragmentation (forest): The breakup of a large land forest area into smaller patches isolated by areas converted to a different land type; it is the opposite of connectivity.[2]

Greenhouse gas (GHG): is any gaseous compound (such as carbon dioxide or methane) that absorbs infrared radiation, traps heat in the atmosphere, and contributes to the greenhouse effect.[12]

Improved forest management: For the purpose of this strategy, improved forest management refers to forest management practices that result in increased carbon stocks within forests and methods that reduce greenhouse gas emissions from forestry activities.[13] It also refers to actions that help increase data accuracy and abundance, ensure contracts and plans are well-written and efficient in scope, and carry out planned management. [13]

Inventory (forest): A survey of a forest area to determine data such as area, condition, timber, volume, and species for a specific purpose, such as planning, purchasing, evaluating, managing, or harvesting.[2]

Leakage: refers to the leakage of methane or other gases during drilling and storage and during transfers through pipelines. Leakage also can refer to the situation in which a carbon sequestration activity (e.g., tree planting or avoided deforestation) on one piece of land inadvertently, directly or indirectly, triggers an activity, which in whole or in part counteracts the carbon effects of the initial activity.[2]

Logging: In the forestry profession, the basic principle behind the term "logging" is that it can generally be used synonymously with "harvesting." The implication in this context is that trees are removed for harvest, rather than simply being cut.[14,15]

Mesophication: the process that occurs when fire is removed from a fire-dependent forest such as an Oak Savanna. Removing fire causes these forests to shift from open, sun-loving, fire-tolerant forests to closed, shade-tolerant, fire-sensitive forests.

Mitigation: compensating for impacts resulting from regulated actions or injury to resources such as fish, wildlife, plants, and their habitats.[6]

Overburdened Community (OBC): is a census block group with: (1) at least 35 percent low-income households, (2) at least 40 percent of the residents identify as minority or as members of a State recognized tribal community, or (3) at least 40 percent of the households have limited English proficiency.[16]

Prescribed burn: the skillful application of fire under exacting conditions of weather and fuel in a predetermined area, for a specific purpose, such as limiting the spread and intensity of wildfire to protect stored forest carbon, to achieve specific results. While the principal reason for prescribed burning in New Jersey is wildfire hazard reduction, it also has numerous secondary benefits, including wildlife habitat management, site management for forestry activities, ecological plant and animal management, forest disease and pest control, nutrient recycling, grassland management, improved accessibility, and enhanced appearance.[17]

Reforestation: the reestablishment of forest cover either naturally or artificially.[2]

Regeneration: Seedlings or saplings existing in a stand or the act of renewing tree cover by establishing young trees naturally or artificially.[2]

Restoration: the process of re-establishing a self-sustaining habitat that closely resembles its natural structure and function.[18]

Shellfish Habitat: an estuarine bay or river bottom which currently supports or has a history of production for hard clams (*Mercenaria mercenaria*), soft clams (*Mya arenaria*), eastern oysters (*Crassostrea virginica*), bay scallops (*Argopecten irradians*), or blue mussels (*Mytilus edulis*).[19]

Silviculture: the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society, such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis.[20]

Soil Amendments: any material added to a soil to improve its physical properties, such as water retention, permeability, water infiltration, drainage, aeration, and structure.[21]

Storm Water Green infrastructure: the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters (2019 Water Infrastructure Improvement Act P.L. 115-436-Jan. 14, 2019).

Submerged Aquatic Vegetation (SAV): rooted, aquatic plants that grow entirely underwater. These plants occur in both freshwater and saltwater, as well as estuaries, where fresh and saltwater mix together.[22]

Thinning: The cutting and/or harvesting of living trees to scientifically determined lower targeted densities, where a majority of the forest growth during this planning cycle in treated areas will come from existing living trees retained within the forest rather than from the establishment of new trees (regeneration).[2]

Urban & Community Forestry: The New Jersey Urban & Community Forestry Program (NJUCF) is where biotic and abiotic resources connect to increase the function of our urban, human-occupied ecosystems. Authorized by the New Jersey Shade Tree and Community Forestry Assistance Act,[23] this unique program works to encourage, promote, and support the local stewardship and effective management of trees and forest ecosystems in New Jersey's communities through technical assistance and financial assistance.[24]

Woodland Stewardship Program: The New Jersey Woodland Stewards Program (NJ WSP) is an educational program of Rutgers Cooperative Extension, the New Jersey Forest Stewardship Program, State Forestry Services, and the New Jersey Forestry Association. The program is intended to encourage the management of private forestland for non-commodity benefits, such as wildlife, recreation, aesthetics, and water quality, as well as traditional commodities like timber and wood products. Forest Stewardship promotes long-term active management while emphasizing consideration of all the forest resources and benefits.[25]

INTRODUCTION

Climate change is a global phenomenon that requires global action to limit the impacts of a warming earth. Business as usual is no longer an option. New Jersey is pursuing aggressive goals to limit its greenhouse gas emissions but increases in electrification and rapid expansion of clean energy capacity alone won't be enough to meet our goals. Contributions from natural and working lands to remove and store carbon will be needed to meet New Jersey's climate goals.

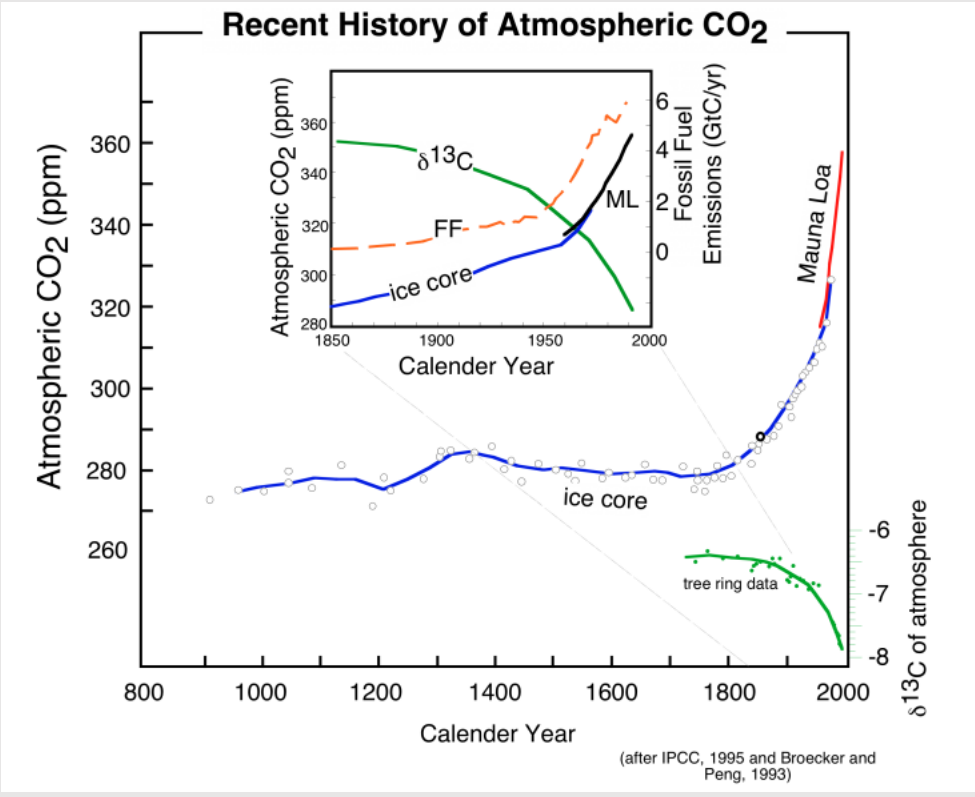
The natural and working lands discussed in this Strategy include agricultural land, aquatic habitats, developed land, forests, and wetlands. These lands can sequester or remove carbon dioxide from the atmosphere through long-term accumulation in plants and soils. In New Jersey and elsewhere, ongoing development continues to result in the loss of agricultural lands, wetlands, and forests, leading to higher annual emissions. Despite these losses, New Jersey's land sector sequestered an estimated 8 percent of the State's net carbon emissions in 2018.[26]

By designing and implementing an effective Natural and Working Lands Strategy, New Jersey can maximize carbon sequestration in its natural and working lands.

Climate Change and the Carbon Cycle

Climate change is largely attributed to global atmospheric warming, which is primarily caused by human activities that increase concentrations of carbon dioxide and other greenhouse gases in the atmosphere. Carbon that was previously bound up in fossil fuels for millennia is being released into the atmosphere at an accelerating rate, as evidenced by atmospheric carbon dioxide data collected at NOAA's Mauna Loa Observatory (Figure 1).

Figure 1. The recent history of atmospheric carbon dioxide from Mauna Loa observations back to 1958 and ice core data beginning in 900. *A substantial increase in atmospheric carbon dioxide is apparent around the time the Industrial Revolution began in the late 1800s. Atmospheric carbon isotope composition measured as δ13C declines at the same time, consistent with the composition of fossil fuel emissions.*[27]

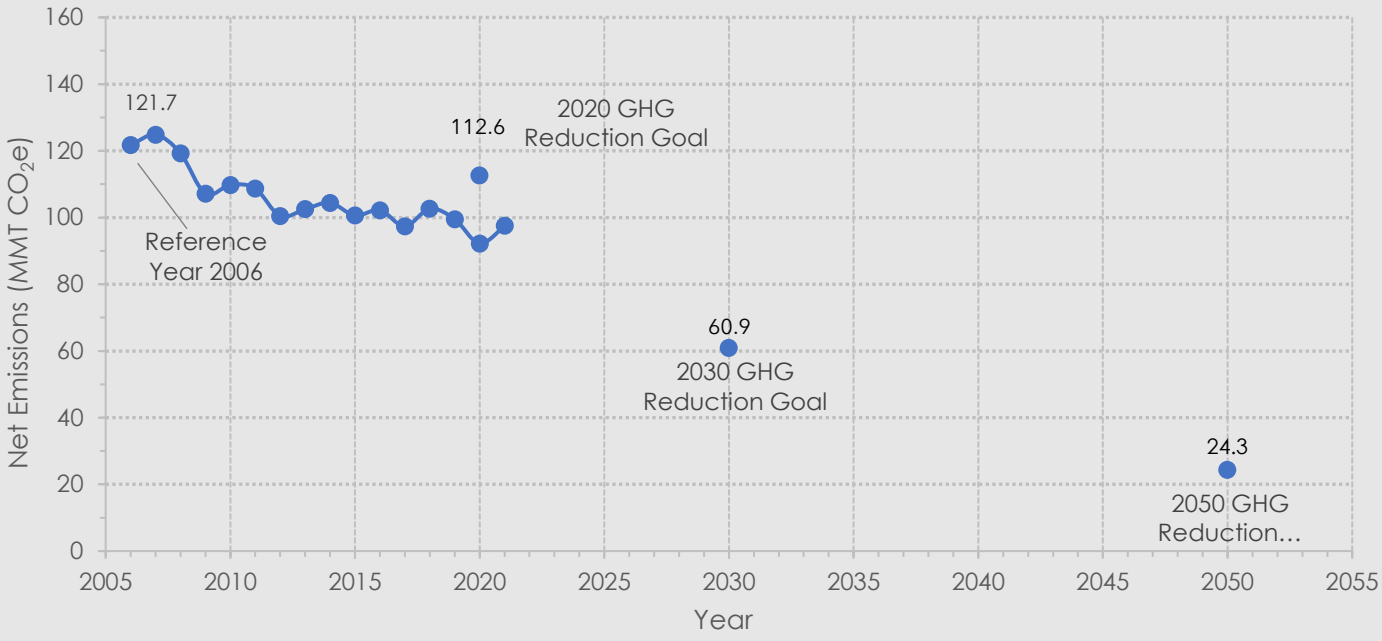


Combating climate change is no small task; it requires a many-pronged approach with coordinated efforts from all sectors. New Jersey is working on several paths to reduce its emissions of greenhouse gases to fight climate change. In 2007, New Jersey passed the Global Warming Response Act, which set targets for reducing carbon emissions. New Jersey has since exceeded its 2020 reduction goal but will need to make more significant reductions to meet its 2050 goal.

The trajectory of GHG emissions in New Jersey has decreased since 2005 (Figure 2). The 2020 goal to reduce emissions to 1990 levels or below was successfully met, but more significant changes are needed to reduce emissions to a total of 60.6 million metric tons by 2030, a 50% reduction of 2006 levels based on recent estimates, as called for in E.O. 274.[28] Ultimately, emissions must fall further to a total of 24.2 million metric tons CO2e by 2050, an 80% percent reduction from 2006 levels, to be in accordance with the Global Warming Response Act. Meeting the 2050 goal will require a 73% reduction in net emissions based on present-day (2020) measured emissions. An economy-wide transformation is needed to meet this goal. All sectors must accept and adopt fundamental changes in how energy is consumed, waste is produced and disposed of, and how natural and working lands are managed.

Even with a complete shift to clean energy, this level of emission reduction will not be attainable without an additional decrease of 6.0 to 10.8 million metric tons of CO_2e per year due to carbon sequestration (Figure 3).

Figure 2. New Jersey GHG Emission Reduction Targets. *The blue dots represent actual measured emissions and the black dots represent goals set forth in the 80x50 report.*[2]

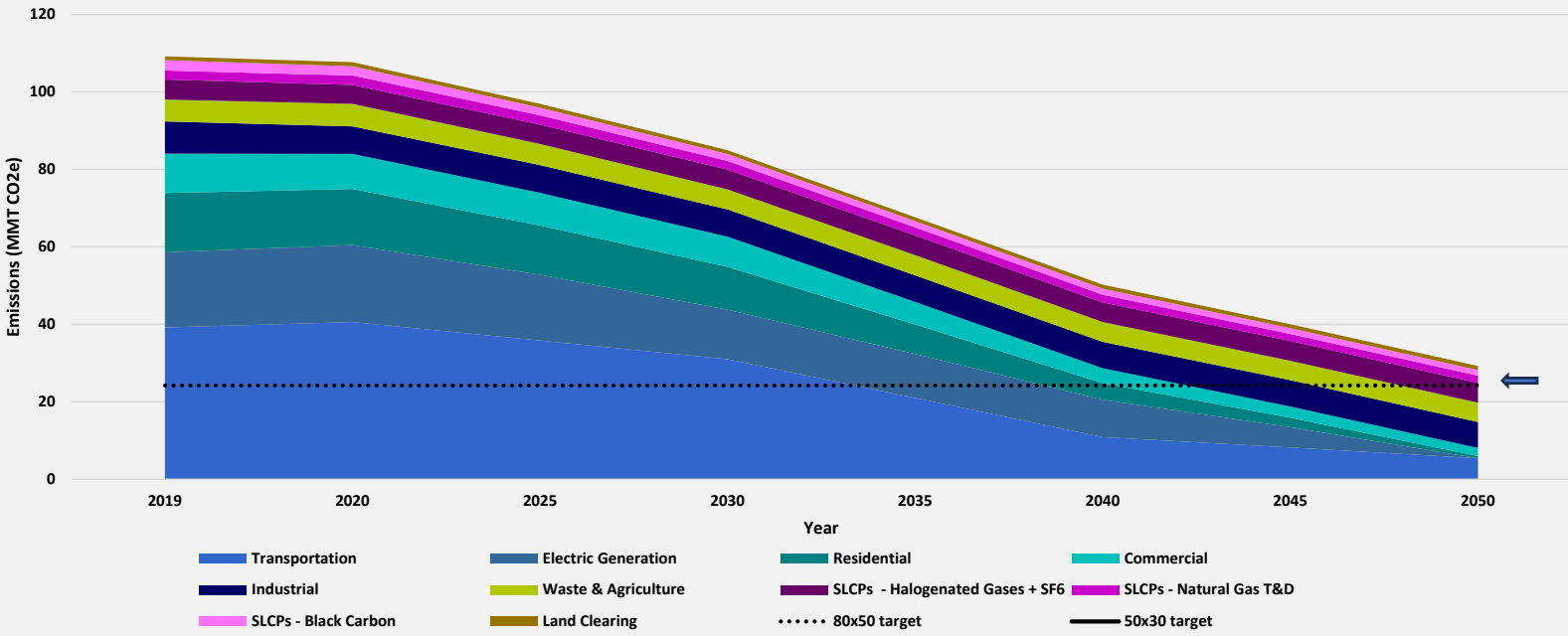


In 2020, the New Jersey Department of Environmental Protection (NJDEP) released the 80x50 report, which serves as the State's climate action plan[26]. The report identified pathways to achieving the 80x50 reduction goal. These pathways include electrifying all vehicles in New Jersey, as well as home and water heating and replacing fossil fuel electricity generation with green energy. These measures will help the state approach its GHG reduction goals, but additional carbon sequestration will be needed to offset the gross emissions. The Natural and Working Lands Strategy presents opportunities for increasing sequestration.

While New Jersey is embarking on its first Natural and Working Lands Strategy, it is not alone in this effort. In recent years, several states have begun similar efforts to leverage carbon sequestration through natural processes. As of May 2023, natural and working lands were included in the greenhouse gas inventories for 15 states. Currently, 11 states have conservation or sequestration goals for natural and working lands. There are also 11 states with healthy soils legislation that encourage regenerative agricultural practices.[29]

Beyond our nation's borders, the US Climate Alliance is working with Canada and Mexico to reduce GHG emissions and work toward a common goal of 50% of power generation from zero-carbon sources by 2025 collectively across North America. Through a Joint Statement on North American Climate Leadership, Canada and Mexico joined the U.S. in committing to managing natural and working lands to be a net sink of carbon and to protect and increase carbon storage capacity.[30] Overseas, the European Union revised its land use regulations in 2023 to specify how natural and working lands can contribute to EU climate and carbon removal goals.[31] The EU also included natural resources in its Net Zero Strategy.[32]

Figure 3. New Jersey GHG Emissions Pathway to 2050 (MMT CO2e). *The arrow denotes the amount of emissions reductions that will need to be offset by carbon sequestration to meet New Jersey's 2050 goal.*[26]



Currently, New Jersey sequesters about 8 MMT CO_2e in natural and working lands. This is likely an underestimate because it does not include wetland sequestration. By 2050, the carbon that is already sequestered in plants and soils needs to be maintained plus an increase the rate of sequestration to around 10 MMT CO2e per year. Preliminary calculations by the US Climate Alliance[33], used in the Global Warming Response Act 80x50 Report[26], estimate that New Jersey could sequester and store an additional 2 to 3 million metric tons of carbon dioxide by actively managing, enhancing, and protecting natural and working lands.[26] With the implementation of this Natural and Working Lands Strategy (NWLS), New Jersey will make incremental progress toward its goal of reducing 10.8 million metric tons of CO_2e through carbon sequestration. The NWLS identifies a list of land management practices that sequester and store carbon and are considered by subject matter experts to be reliable management practices. Through policy changes and adopting these land management practices, it is possible to optimize the amount of carbon stored in natural and working lands.

Ecosystem Services and the Social Cost of Carbon

Resource managers consider the economic value of ecosystem services when making management decisions. The National Wildlife Federation defines ecosystem services as "any positive benefit that wildlife or ecosystems provide to people."[34] Carbon sequestration is just one of many ecosystem services provided by the land types discussed in this strategy. Some ecosystem services include provisioning services, such as food or products. Other ecosystem services are regulating services, such as plants that clean air and filter water or tree roots that anchor soil and prevent erosion. There are also cultural services, like recreation and creativity, that are spurred by interactions with nature. Lastly, supporting services provide the fundamental foundation for ecosystems and include photosynthesis and nutrient cycling.

This Strategy recognizes the importance of terrestrial and aquatic plants in sequestering carbon. New Jersey can increase the rate of this natural process by consciously managing public and private lands to protect existing carbon stores and by adopting policies that facilitate ongoing sequestration. This can be accomplished by promoting practices that enable green growth and minimize carbon loss on public and private lands. The health of natural ecosystems should not be jeopardized for the sake of increasing carbon sequestration. The strategy focuses on management activities that are both good for carbon sequestration and for ecosystem health.

In natural lands, healthy functioning habitats provide many ecosystem services and sequester more carbon than they release. Working lands, on the other hand, provide less carbon sequestration potential than natural lands. However, there are opportunities for improvement. Whether by planting more trees in developed areas or rotating grazing paddocks for livestock, this Strategy presents several ways to increase sequestration on working lands.

All of the recommended land management practices and policy changes in this report are intended to protect New Jersey's existing carbon storage and/or increase sequestration, most often by facilitating vegetation growth, without compromising ecological function. From submerged aquatic vegetation such as eelgrass, to row hedges in agricultural fields, to hardwood trees in centuries-old forests - protecting these resources and increasing their abundance will increase carbon sequestration and fight climate change. The targets that were selected for this Strategy are expected to sequester additional carbon and/or protect sequestered carbon while maintaining or improving ecosystem health.

Achieving the full list of targets in this strategy will result in significant costs. The social cost of carbon (SCC) is a useful measure for assessing whether they are worth pursuing. SCC is an estimate of the economic impact of carbon dioxide on society. It represents the long-term monetary value of the damage caused by each additional ton of carbon dioxide emitted into the atmosphere. When fossil fuels like coal, oil, and gas are burned, carbon dioxide is released into the atmosphere. This contributes to global warming and climate change, leading to a multitude of negative impacts on society. These include extreme weather events like hurricanes and droughts, rising sea levels that threaten coastal communities, disruptions in agriculture and food supply, health issues due to heat stress and air pollution, and economic losses from damage to infrastructure and property. The SCC aims to quantify the monetary value of these damages. When carbon is sequestered through natural climate solutions, these negative impacts on society are reduced and therefore the social cost of carbon is reduced. The concept of SCC helps policymakers and businesses understand the costs associated with climate change and aids in decision-making regarding emissions reduction strategies and climate policies. Using the most recent estimates of Social Cost of Carbon developed by the EPA, sequestering 10 million metric tons of CO2 in 2050 will provide between 2.4 and 5.6 billion dollars of social benefits. The per ton value of SCC increases over time, so the annual benefits of sequestering will also increase beyond 2050.[35]

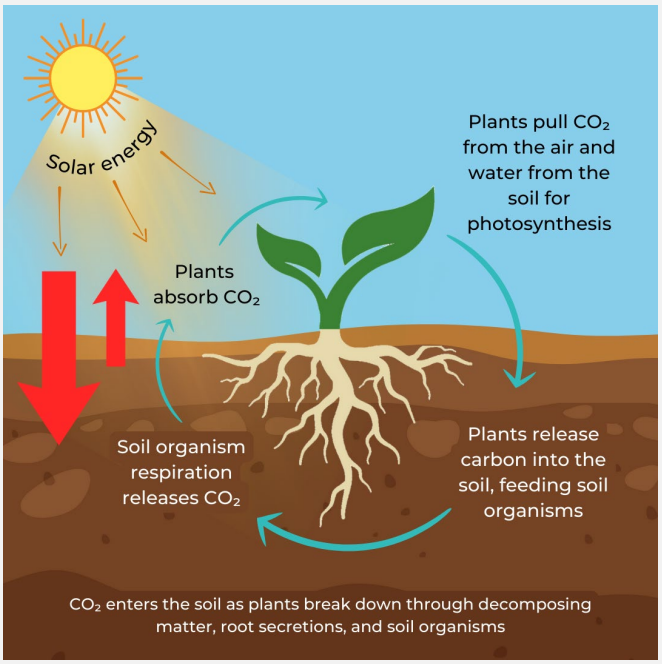
Sequestration Basics

Vegetation provides a solution to rising levels of atmospheric carbon dioxide through natural processes. Plants are primary producers that pull carbon dioxide from the air and use it for photosynthesis, then store the carbon in plant material. The stored carbon will later be incorporated into the soil through root secretions, by organisms that feed on plants, and via the dead plant material (Figure 4).

The process of sequestering carbon from the atmosphere into plant material is universal, whether in wetland plants such as Spartina and Phragmites or in hardwood trees such as white oak (Quercus alba) and red maple (Acer rubrum). While this process is common among plants and trees, there are differences in the rate of sequestration and the quantity of carbon stored in plants and soils. Some of the carbon that is stored in plant materials and soil gets re-released into the atmosphere through microbial respiration as greenhouse warming gases (e.g., carbon dioxide, methane, and nitrous oxide). The types of plants and soil characteristics impact how much plant growth occurs annually and the rate of sequestration.

Disturbances to natural and working lands like fires, ditching, and tilling can result in the release of carbon. To improve carbon sequestration, it is important to minimize anthropogenic disturbance, maintain plant cover, and improve overall ecosystem health.

Figure 4. Plants and the carbon cycle.[36]



Forests

The 5 forest carbon pools recognized in New Jersey include aboveground live, belowground live, litter, dead wood, and soil. These pools currently store about 141 million metric tons of carbon in New Jersey, and they sequester more and more every year.[37] Protecting and adding to these carbon pools are a primary objective of the forest section of this strategy.

In the terrestrial environment, trees have significant carbon sequestration advantages over other plants, including longer lifespans, larger aboveground biomass, and more extensive root systems. To this end, forest conservation and management can increase above ground carbon storage by accelerating the growth rates and survival of trees, while enhancing below ground carbon storage through the conservation of older forest age classes and management that increases woody debris.[38]

Forested land can become net sources of carbon when they are converted to a non-forested land use (e.g., warehouses) and as a result of catastrophic fires or pest outbreaks that kill large percentages of trees.[39,40]

Wetlands

Wetlands are one of the most productive habitats on the planet.[41] Like other ecosystems, wetland vegetation pulls carbon dioxide out of the air, uses it in photosynthesis, and then sequesters it in plant materials and soils.

Wetlands also have a special power to store carbon because of the presence of water levels at or near the soil surface. The water decreases oxygen availability, which slows down the decomposition rates of dead organic matter in the soil.[42,43] As a result of the decreased decomposition, wetlands can develop deep deposits of carbon-rich soils called peat that accrue over thousands of years.[44,45]

As with all other habitat types, the carbon sequestration benefit of wetlands is offset by warming greenhouse gasses that are released into the atmosphere from soils as part of microbial respiration and decomposition. However, unlike other habitats, the low oxygen conditions in wetlands that help sequester carbon can also lead to the release of methane. When oxygen is available, microbes use it during the decomposition of organic matter and produce CO2. In the absence of oxygen, microbes use other compounds for respiration including NO3-, Mn4+, Fe3+, SO42-, and CO2, depending on bioavailability and with decreasing preference from NO3- to CO2. In salt marshes, SO42- tends to be higher in abundance and when used, the byproducts of HS- and CO2 are produced. However, in brackish and

freshwater wetlands, CO2 is more abundant than O2 or SO42-, resulting in methanogenesis or the production of CH4 (methane). Methane is a very powerful greenhouse gas, 25 to 83 times as potent as carbon dioxide.[46] Methane release from salt and brackish marshes is currently thought to be low enough that both protection and restoration provide a net carbon sequestration benefit as well as providing enhanced coastal resilience. In brackish and freshwater wetlands (including freshwater tidal wetlands and inland wetlands such as tidal freshwater marshes, red maple swamps, calciferous fens, etc.), the methane release is highly variable and, in some cases, high enough that restoration of freshwater wetlands may lead to net emissions of warming greenhouse gasses rather than net sequestration.[47–49] As a result, the protection of carbon-rich soils in freshwater wetlands is included in the Strategy, but restoration and enhancement are not (except for Atlantic White Cedar Swamps). Research is needed to determine what types of wetlands would have a net sequestration benefit.

Net carbon sequestration in wetlands is reduced when carbon rich soils are eroded, when marsh plants drown and stop sequestering carbon, and when salinities are artificially lowered by dykes or other tide blocking structures.

Aquatic Habitats

In estuarine waters, oysters and other shellfish have the potential to provide carbon storage. They build their shells by filtering calcium and carbonate (CaCO3) from the water. Carbonate is formed when carbon dioxide dissolves in the ocean and reacts with water. Therefore, much like plants, shellfish are pulling carbon from the environment and storing it in their shells. While shellfish may help to protect carbon that is stored in sediment and sequester it in their shells, the net carbon fluxes from shellfish vary widely based on age and environmental context. Recent research has yielded conflicting results, with one source describing low levels of net oceanic carbon sequestration from shellfish[50], and another source suggesting that shellfish are sources of carbon rather than sinks due to the processes of calcification and respiration.[51] More research is needed for a better understanding of the net GHG effect of shellfish.[52]

Submerged aquatic vegetation (SAV) sequester carbon in plant tissue and ultimately stores it in submerged sediment, which the SAV in turn preserves by preventing erosion from wave action. While the current extent of carbon storage in NJ seagrass species is not well known, seagrasses throughout the world in tropical and temperate regions are being studied for their carbon sequestration potential.[53] In recent decades, seagrass habitat in New Jersey has been declining in size and density due to threats such as waterfront development projects (e.g., dredging); damage from boat propellers; coastal eutrophication leading to harmful algal blooms (HABs), storms, floods, disease, and poor water quality; and sea level rise.

Given the uncertainty surrounding shellfish carbon flux, recommendations for land management practices in the aquatic environment focus on SAV species.

Agricultural Lands

Agricultural lands are like natural habitats in that they have high plant productivity, which means high rates of initial carbon capture by plants. They differ from natural habitats in that plants are generally harvested each year and many conventional soil management practices decrease storage. For example, by breaking up the soil, tilling prepares land for new crops and helps control weeds, but also releases a lot of stored carbon. Minimizing soil disturbance and maintaining healthy soil characteristics are some of the practices that can facilitate sequestration. Two of these methods include diversified cropping rotations and utilization of livestock manure for plant fertility. Reducing tillage and relying on cover cropping with effective crop residue management can aid in sequestration.[54]

Developed Lands

Urban settings are typically characterized by compacted soils and impervious surfaces. Increasing vegetation and soil improvements will increase carbon sequestration in developed areas. Urban forests are located within cities and towns, and some examples include urban parks, street trees, and greenways. In New Jersey, urban forests already have 178.7 million trees, which store about 27 million metric tons of carbon.[55]

Environmental Justice

The state government in New Jersey is operated by the people and for the people, and that includes all the people. Historically, New Jersey's low-income communities and communities of color have borne the brunt of environmental burdens by being exposed to a disproportionately high amount of environmental and public health stressors. These same communities also suffer disproportionate climate-related impacts, including heat waves, poor air quality, flooding, and other impacts.[56] Further, these communities lack resources and capacity and are therefore also the least prepared for and the least able to recover from these deleterious climate change impacts.

In this document, we will use the terms overburdened communities (OBCs) and environmental justice (EJ) communities. NJDEP regulations identify OBCs as block groups with at least 35% low-income households, or at least 40% of the residents identify as minority, or at least 40% of the households have limited English proficiency. EJ communities are OBCs that are subject to adverse cumulative environmental and public health stressors as compared to other areas of the state.

Many EJ communities are already experiencing disproportionate impacts to their environment and public health, with the most serious impacts of climate change, including increased air temperatures, worsening air quality, more frequent stormwater flooding, and rising vulnerability to tidal flooding serving as a threat multiplier to individuals residing in our most vulnerable communities. Using an environmental justice lens, these communities should be prioritized to receive attention and funding for climate improvement projects, which also often have the benefit of sequestering carbon as described above. Because the climate threat to EJ communities is higher, the benefit of any climate threat reduction is also greater in EJ communities. Improvements here will not only address the adverse health stressors that these communities disproportionately bear but they are also likely to increase carbon sequestration. EJ communities are also likely to see the greatest economic development and community revitalization gains per investment in climate-related projects, as current environmental stressors often discourage or limit investment in these areas.

While there may be concerns regarding gentrification and maintenance of trees and other improvements, thoughtful planning and support can lessen these concerns. Ultimately, by implementing this Strategy, the State can increase urban tree canopy cover, better identify, and remediate more brownfield sites, create more open space opportunities, install stormwater green infrastructure elements, and enhance urban green spaces— especially older parks and schoolyards. These actions will begin to address adverse health stressors by alleviating heat island effects, improving air quality, mitigating flooding, and preventing water pollution.

Regional Greenhouse Gas Initiative (RGGI) and Overburdened Communities

The Regional Greenhouse Gas Initiative (RGGI) is a cooperative, market-based effort among several northeastern states to cap and reduce carbon dioxide emissions from the electric generating power sector. It represents the first cap-and-invest regional initiative implemented in the United States. NJDEP allocates 10% of the State's RGGI auction proceeds towards investment in carbon sequestration projects in New Jersey (P.L. 2008, c. 340). NJDEP relies on the Strategic Funding Plan to direct RGGI investments into projects and programs that reduce greenhouse gas emissions and help the state progress towards its climate, clean energy, and equity goals.[57] The RGGI Strategic Funding Plan is updated every three years. It has allocated funding for two initiatives that protect and enhance the state's natural carbon sinks: Promote Blue Carbon in Coastal Habitats and Enhance Forests and Urban Forests. In addition, RGGI funds are prioritized to aid overburdened communities (OBC) as one of the key goals identified towards climate mitigation and decarbonization.

Figure 5. Project locations for Natural Climate Solutions Grants awarded in 2023.

NJDEP has dedicated over $17 million in auction proceeds to five blue carbon sequestration projects that create living shorelines and restore tidal salt marsh vegetation through the Natural Climate Solutions Grant Program (NCS) (Figure 5).[58] 33% of these funds were awarded to projects located in overburdened communities. Through this program the NJDEP has also dedicated over $6 million to two forest restoration and seven urban tree planting and forest canopy enhancement projects through the Natural Climate Solutions Grant Program. 86% of these funds were awarded to projects located in overburdened communities. The map on the right shows the projects selected for funding in the first round of the NCS program.

Additionally, the NJDEP has also launched the Trees for Schools grant program in the Spring of 2023, which commits $2.5 million in auction proceeds to fund tree plantings on school campuses, with priority given to schools in New Jersey's overburdened communities.[59]

CARBON SEQUESTRATION TARGETS

To build this strategy, NJDEP worked to locate any plans or reports that identified carbon sequestration strategies in natural and working lands. This included a broad review of state, federal, and international plans developed by jurisdictions outside of New Jersey. A list of actions that would be applicable in New Jersey was curated from these documents. The targets and recommended policy changes in this document build upon that list with additional suggestions from NJDEP and the New Jersey Department of Agriculture (NJDA).

As part of the target development process, NJDEP held four stakeholder meetings in March 2023 to receive input on a draft list of targets posted on the NJDEP website. The meetings had approximately 775 attendees, with affiliations ranging from private citizens to universities, conservation organizations, government agencies, and industry. All comments received during the meetings, via emails, and online submissions were reviewed and considered while developing this strategy.

The primary focus of this strategy is actions that will sequester carbon or protect existing carbon stocks in our natural and working lands without compromising ecosystem health. Subject experts from NJDEP and NJDA developed

recommendations for land management practices and policy changes based primarily on published scientific literature. All practices recommended in this Strategy are widely implementable in New Jersey and have documented net carbon sequestration benefits in scientific publications or from NJDEP's data collection and analysis.

In Table 1 there are recommended land management practices with targets to achieve set quantities of specific actions by 2030 and by 2050. The years 2030 and 2050 were chosen to align the Strategy with the state's climate goals.[26] For example, one target in the forest section sets a goal to afforest, or plant to a forested condition, 200 acres per year through 2030. Many land management recommendations include adding biomass that will pull carbon from the atmosphere, store it in plant material, and transfer that carbon to the soil for long-term storage. Other recommendations are for practices that keep carbon in the soil more effectively, such as the agricultural targets to plant cropland with cover crops.

New Jersey Natural and Working Lands Strategy Targets for Carbon Sequestration Actions

These targets are a combination of goals for state government and other entities. The majority of targets are totals to be achieved by 2030 and 2050, however some targets are expressed as a yearly rate (e.g., 2,000 acres/yr). For targets that either can't be quantified or for which values are not yet available, the 2030 and 2050 values are designated as an "X". The text of the Strategy contains detailed descriptions of each target.

Recommended land management activities include conservation targets to protect existing carbon stores and monitoring targets to improve New Jersey's carbon storage inventory. Some targets specify enhancement actions, such as amending soils in developed areas, and others describe restoration activities, such as restoring Atlantic White Cedar swamps.

The policy recommendations in this strategy fall into several broad categories, which are intended to either protect stored carbon or help increase the implementation of land management activities that sequester carbon. Guidance recommendations are aimed at developing best management practices and other technical support methods that will help ensure the success of projects. Outreach and education recommendations serve to engage the public by increasing awareness of the benefits of specific practices for carbon sequestration. Planning targets are recommendations for NJDEP to make decisions that will add to the total amount of carbon stored in New Jersey's lands. Funding recommendations propose the development of incentives to encourage a change in behavior by private landowners. Recommendations also identify areas where regulations can be strengthened to protect natural and working lands.

FORESTED LAND				
Recommendation Type	ID	Target	2030	2050
Afforestation	F1	Identify & plant non-forested land to a forested condition with appropriate species	1,600 acres (200 ac/yr)	4,000 acres (200 ac/yr)
Reforestation	F2	Prioritize sites for reforestation actions	10 sites	40 sites
	F3	Identify & restore degraded forests across all forest ownerships	800 acres	2,000 acres
Afforestation/Reforestation	F4	Increase nursery production to annually service more municipalities & private landowners	20% increase	20% increase
Avoided Conversion	F5	Minimize conversion of forested lands to non-forest uses	Maintain at	Reduce to 2,000 acres/yr
	F6	Enroll forest land into a carbon market	4,000 acres/yr	100,000 acres
Improved Forest Management	F7	Plan ecological forest management	75,000 acres	200,000 acres
	F8	Provide cost share to properties for improved forest management	100,000 acres	500 properties/year
	F9	Private landowner enrollment in forest stewardship program and Farmland Assessment programs	100 properties/ year	All properties enrolled

WETLANDS				
Recommendation Type	ID	Target	2030	2050
Restoration	WL1	Complete tidal reconnection projects	1 site/yr	2 sites/yr
	WL2	Increase cover of salt marsh vegetation	70 acres/yr	200 acres/yr
	WL3	Restore Atlantic White Cedar Swamps	10,000 acres	20,000 acres
Wetland Protection	WL4	Install X linear feet of living shorelines	7,800 ft/yr	10,000 ft/yr
	WL5	Minimize disturbance of wetland soils	Reduce by 10%	Reduce by 30%
	WL6	Protect tidal wetland migration zones	X	20% of marsh migration zones
AQUATIC HABITATS				
Recommendation Type	ID	Target	2030	2050
Monitoring	AQ1	Assess SAV density and health with ongoing monitoring	X	X
Conservation	AQ2	Protect existing SAV from further loss	Limit to 10% loss	No net loss
Restoration	AQ3	Restore X acres per year (to be quantified after baseline is updated via monitoring)	Within 5 years	Expand program
AGRICULTURAL LAND				
Recommendation Type	ID	Target	2030	2050
Compost	AG1	Apply compost to cropland harvested	4,150 acres/yr	12,700 acres/yr
	AG2	Apply compost to cropland pastured	750 acres/yr	1,950 acres/yr
	AG3	Apply compost to permanent pasture	2,400 acres/yr	6,500 acres/yr
Cover Crops	AG4	Plant cropland harvested and cropland pastured with cover crops	9,850 acres	40,300 acres
DEVELOPED LAND				
Recommendation Type	ID	Target	2030	2050
Afforestation	DL1	Plant street trees/shade trees	250,000 trees	1,000,000 trees
Promote Urban Forest & Street Tree Stewardship	DL2	Enroll all municipalities that are eligible in Urban Stewardship programs	X	X
Brownfield Redevelopment to Create Parks	DL3	Redevelop brownfield sites to create new green space	20 sites (100 acres)	200 sites (1000 acres)
Revitalize Older Parks & Urban Schoolyards	DL4	Enhance public parks in urban areas and improve urban schoolyards	20 sites (50 acres)	(100 sites) 250 acres
Enhancement	DL5	Improve soils through remediation and capping	500 acres	5000 acres

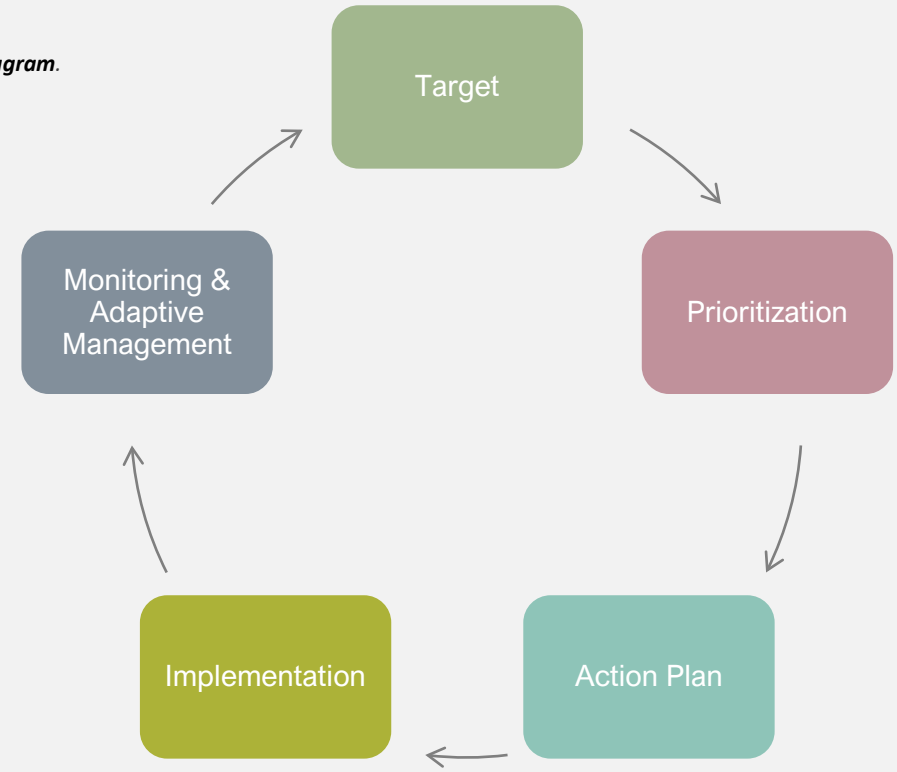
RECOMMENDATIONS FOR IMPLEMENTATION

While this Strategy establishes targets for 2030 and 2050, the next step will be to develop a NWLS Action Plan. The NWLS Action Plan will identify and prioritize actionable, measurable, achievable, and beneficial actions to meet the goals set forth in the NWLS. Both the NWLS and the subsequent Action Plan are a call to action for all who own and

manage land in New Jersey. Entities that have the potential to help mitigate climate change through these recommended practices extend beyond local and state governments to non-governmental organizations, private landowners, and others. A critical aspect of the NWLS Action Plan will be to identify funding. The NWLS Action Plan will list strategic funding opportunities, especially new funding streams from the federal government (e.g., Bipartisan Infrastructure Law, Inflation Reduction Act, Climate Pollution Reduction Grants), to leverage current NJDEP funding mechanisms. To facilitate the implementation of the NWLS, the following workflow diagram visualizes how NJDEP plans to conduct and reach its NWLS target goals.

The Action Plan will prioritize the targets in this Strategy using metrics based on climate, socioeconomics, program capacity, and available funding. This process will define which targets NJDEP and NJDA should focus its resources on first to maximize the state's success in increasing carbon sequestration, improving human quality of life, and restoring New Jersey's natural and working lands. Partnership development will also be crucial to successfully implementing the Natural and Working Lands Strategy. NJDEP will rely on a diversity of partnerships with a common goal to collectively mitigate climate change on New Jersey's natural and working lands. This encompasses all levels of government, public-private groups, academia, and individuals. Such broad, diverse and all-inclusive partnership endeavors represent a healthy working group to drive the Strategy forward through implementation.

Figure 5. NWLS Workflow Diagram.



Monitoring and adaptive management will be crucial to ensuring that the implementation of the NWLS is meeting the set targets. NJDEP plans to regularly report and track ongoing NWLS target programs and projects throughout the state and monitor its progress via:

- NWLS Action Workplan-Progress Report
- Future carbon accounting and tracking tool
- RGGI tracking via New Jersey RGGI Climate Investments online dashboard
- Further policy formulation, if needed
  - Guidance development
  - Rule proposals

Table 2. Potential Partners

POTENTIAL PARTNERS					
Partners	Forested Land	Wetlands	Aquatic Habitats	Agricultural Land	Developed Land
Federal government agencies	X	X	X	X	X
US Fish and Wildlife Service	X	X			
US Department of Agriculture	X			X	
US Department of Agriculture Forest Service	X				
US Department of Agriculture Natural Resource Conservation Service	X				
National Estuary Programs		X	X		
New York-New Jersey Harbor Estuary Program		X	X		
Barnegat Bay Partnership		X	X		
Partnership for the Delaware Estuary		X	X		
State government agencies	X				
NJ Department of Environmental Protection					
NJ Department of Transportation		X			
NJ Department of Agriculture	X			X	
Local governments (counties and municipalities)	X	X	X		X
Wetland mitigation banks		X			
Corporate partners					X
Redevelopment authorities					X
Private and public developers					X
Non-governmental organizations		X			X
Environmental Non-profits	X	X			X
Non-profits that purchase land	X				
Private landowners	X	X	X		
Academic institutions	X				X

Table 3. Potential Funding Sources

POTENTIAL FUNDING SOURCES					
Potential Funding Sources	Forested Land	Wetlands	Aquatic Habitats	Agricultural Land	Developed Land
National Oceanic and Atmospheric Administration grants	X	X	X		
Habitat Restoration & Coastal Resilience Grants					
Effects of Sea Level Rise Grants		X	X		
Coastal Zone Management funding		X	X		
U.S. Department of Defense Advanced Research Projects Agency grants		X	X		
U.S. Army Corps Developing Engineering Practices for Ecosystem Design Solutions		X			
U.S. Environmental Protection Agency grants		X			
Brownfield Grants	X				X
National Fish and Wildlife Foundation Grants					X
America the Beautiful Grants	X	X			
National Coastal Resilience Fund	X	X			X
Delaware Watershed Conservation Fund		X			
Restore America's Estuaries Watershed Grants for National Estuary Programs		X			
Regional Greenhouse Gas Initiative (e.g. Natural Climate Solutions Grants)		X			
NJDEP Grants	X	X	X	X	X
319 Grants					
Green Acres Stewardship Grants		X			X
Hazardous Discharge Site Remediation Fund grants		X			
Green Acres acquisitions					X
Blue Acres acquisitions	X				X
NJ Corporate Wetlands Restoration Partnership		X			X
Non-governmental organizations and other non-profits		X			
The Nature Conservancy	X	X	X	X	X
World Wildlife Fund	X	X	X	X	

National Wildlife Federation	X	X	X	X	
Public-private partnerships	X	X	X	X	
Research foundations	X	X	X	X	X
Universities and research institutions	X	X	X	X	X

FORESTS

FORESTS

New Jersey's forests cover approximately 40 percent of the state's total land area, making up the largest land area of any ecosystem type in New Jersey. Forests provide a variety of ecological, social, and cultural services, including habitat for wildlife, public recreation, water filtration, and carbon sequestration and storage. In 2004, the ecosystem services of New Jersey's forests were valued at $2,025 per acre per year or $2.96 billion per year, after adjusting to 2020 dollars.[60] Including live and dead biomass and soil organic carbon, the forests of New Jersey currently store about 141,320,375 metric tons of carbon, and they sequester more and more every year. While historic trends show significant deforestation beginning in the 1800s, the State's total forested area has largely stabilized in recent years, with only a 6.9% loss between 1986 and 2012.[61] However, the percent forest cover is expected to decrease once again in the coming decades due to additional development pressures, shifting forest age class diversity, and the impacts of invasive species.[62]

Considerations for All Forest Targets

Co-benefits

Forests provide valuable ecological, social, and cultural services. Some of these services include wildlife habitat, public recreation and health, water filtration, and carbon sequestration and storage.[63,64] Afforestation has many co-benefits. Adding forested areas creates wildlife habitat for forest-dependent species, which can help to increase the connectivity of forested habitats, reducing habitat fragmentation.[65] When green spaces such as forests are in close proximity to developed areas, they can benefit communities through improved air and water quality, shade/temperature regulation, recreation, increased property values, flood attenuation, and a variety of mental health benefits.[66,67] Well-placed afforestation projects can also increase biodiversity on a landscape scale, aid in flood mitigation, and create a demand for green jobs.

Reforestation and forest restoration provide many of the same benefits as afforestation, in addition to restoring ecosystem function and habitat connectivity. Reforestation provides habitat benefits for threatened and endangered bird species that depend on young forests and open-canopy mixed-aged forests dispersed within mature forests.[68–71] It also helps to diversify forest structure and age, while promoting healthy tree regeneration in areas that previously struggled with specific site conditions, mesophication, over-abundant deer populations, and invasive plant presence, amongst other things.[72]

Avoided conversion ensures that forested areas remain as forests. This recommendation seeks to reduce the development of forested lands, and contributes to the maintenance of wildlife habitat, better air and water quality, availability of recreation opportunities, and the protection of carbon pools. In addition, forest protection supports movement corridors for wildlife. The conversion of forests is detrimental to carbon storage and sequestration. When forest land is converted to other uses, the result is a generally permanent loss of carbon stored in trees and future sequestration associated with those trees.

Improved forest management co-benefits include creating and maintaining diverse landscapes that foster diversity in tree age, forest structure, habitat type, and species composition. Forest stand improvement can include a variety of on the ground management techniques such as thinning, shelterwood, invasive plant removal, prescribed burning, planting, etc.[40] The combination of Indigenous population decline and displacement, fire suppression, and extensive logging as a result of unregulated forest harvesting drastically changed the fire regime in New Jersey. These changes resulted in consequences such as a reduction or loss of important ecosystem services, altered fuel and fire behavior, an increase in forest stand density, and a largely homogenized landscape.[73] With an average of 1,500 wildfires burning approximately 7,000 acres of forest each year,[74,104] wildfire mitigation is a high priority for the state. Wildfire and Southern Pine Beetle mitigation can be accomplished by a combination of forest thinning and prescribed fire.[75] Prescribed burns do not aim to kill overstory trees, but they can aid in regeneration of fire-dependent tree species that require high heat to release their seeds. Therefore, prescribed burns can provide the benefits of a low-level fire regime

to fire dependent species and regions such as the New Jersey pine barrens while reducing the threat to human life and property.

Potential Negative Impacts/Tradeoffs

Afforestation can be primarily accomplished on abandoned agricultural fields, where re-establishing forests is prioritized over reviving the fields for agricultural purposes. When considering potential areas for afforestation, NJDEP will conduct an evaluation to determine the ecological services that may be lost when afforestation occurs. These could include impacts to species that rely on the land in its current state, including pollinators and grassland-dependent wildlife. Threatened and endangered species of grassland-dependent wildlife are of particular concern.

Active forest management for ecological health and function can also result in an immediate loss of some stored carbon depending on the management type in exchange for added resilience, stability or biodiversity.[76] Tradeoffs in carbon storage and sequestration for forest resilience, ecosystem function, and wildlife habitat must be carefully examined and calculated prior to management implementation.

Smoke from wildfires and prescribed burns can impact air quality and associated human health. Recent studies have demonstrated a relationship between wildfire smoke exposure and adverse health effects, specifically respiratory and possibly cardiovascular effects.[77–80] On the other hand, there has been little research done on the impact that smoke from prescribed burns has on human health. In an Australia-based study by Haikerwal et al.[81] data showed that exposure to smoke from prescribed burning was usually less than a day, but that prescribed burning smoke could result in short-term peak exposures that were up to 15 times higher than advised daily standards. Although smoke exposure from prescribed burns tends to be shorter duration than wildfire smoke and wildfire smoke exposures are typically an order of magnitude greater than prescribed burns, prescribed burns generally occur on rotations that are more frequent than wildfire, and can expose nearby residents to more regular peak concentrations of harmful pollutants.[81,82]

Expected Impacts of Climate Change on Carbon Sequestration

Climate change will apply additional pressure to forests from sea level rise, increasing temperatures, and increased probability of droughts. It will be important to plant tree species that are tolerant of higher temperatures, drought-tolerant, and fall within projected shifts in species ranges. Planting outside the reach of projected sea level rise will make New Jersey forests more resilient in a changing climate.

Climate change is expected to increase damaging pest populations such as Southern Pine Beetle (Dendroctonus frontalis). Southern Pine Beetle (SPB) are native to the Southeastern US, and there is evidence that increases in minimum winter temperatures across geographic ranges have facilitated their movement into New Jersey and other Northeastern states.[83] However, thinning overstocked forest stands and promoting mixed-species forest stands provides a tool to help mitigate these pest infestations.[84–86]

Precipitation patterns are also changing over time, with a minor projected increase in annual precipitation that is expected to fall in less frequent, more intense storms. Trees will continue to play an important role by absorbing rainwater to mitigate flooding. Controlled burns will also help to mitigate large wildfires as New Jersey experiences more frequent dry periods due to climate change.

Improved forest management is the comprehensive strategy for increasing forest health and resilience in the face of a changing climate. Healthier forests will be less impacted by stress due to increased temperatures, drought, resource competition, severe storms, and invasive insects.[87,88]

Environmental Justice Considerations

As described above, forested spaces in overburdened communities, particularly those in highly developed areas, are often lacking. Where present, these green spaces provide positive contributions to the improvement of air and water quality, flood mitigation, provide shade and temperature regulation to reduce heat island effects, create space for recreation, lead to an increase in property values, and support improved physical and mental health. To ensure that members of OBCs can receive these myriad benefits without added economic and financial burdens, steps must be taken to provide sufficient financial, technical, and planning support to maintain planted trees.

Some OBCs can benefit from avoided emissions through fire risk mitigation measures that protect life and property, especially in wildland urban interface areas.

Forest Recommendations for Land Management Practices

Afforestation Target (F1)

- Afforest 200 acres per year, for a total of 1,600 acres through 2030 and 4,000 acres through 2050.

Afforestation is the practice of establishing trees on land that has lacked forest cover for a very long time or on land that has never been forested. The first afforestation target is to identify and plant non-forested land to a forested condition with appropriate species, in appropriate locations. For example, ash trees would not be appropriate trees to plant throughout the state at this time due to ongoing invasive Emerald Ash Borer (Agrilus planipennis) outbreaks causing high mortality across ash species. Similarly, it isn't recommended to plant upland tree species in wetlands or lowlands. It is imperative to match tree species habitat and resource requirements to the sites that need to be planted.Bear

Afforestation expands the overall carbon pools by establishing more forest that can pull carbon dioxide out of the air and store it for hundreds of years. Establishing forest on abandoned agricultural lands and other non-forested lands has the greatest potential for creating net carbon sequestration.[2]

How the target was developed

The afforestation target to convert 200 acres of non-forest land to forest land per year through 2050 and the reforestation target to reforest or restore 40 sites across the state and restore 2,000 acres by 2050 are set lower than our neighboring states targets for these same recommendations.[89–92] This is a result of New Jersey's dense population and the extensive work that has already been done in preserving our forested and agricultural lands. According to Lathrop and Hasse,[61,93] New Jersey is the most densely populated state in the nation with the highest percentage of its land in urban land uses, and by 2015 nearly 33% of the state's roughly 5 million acres were urbanized. New Jersey's most urbanized counties are providing indicators that they are nearing buildout, with other counties already approaching functional buildout. As acres of urbanization and development in our state continue to increase annually, acres of forest, wetlands, and agriculture have continued to decrease over the past 29 years.[61,93] On the flip side, the NJDEP's Green Acres Program has been very successful in purchasing and preserving land within the state since its inception in 1961. As of June 2022, the Green Acres Program has directly protected 681,234 acres of open space and parkland and has funded 1,256 local and nonprofit park development and stewardship projects in communities around the state, overall preserving 1,626,108 acres of open space in New Jersey.[94] The state of New Jersey has created and preserved forested land at a consistently high rate up until this point. With buildout anticipated in some counties in the near future, there is limited land remaining within the state that is appropriate for afforestation or reforestation, and the targets aim to reflect that limitation.

Near-term actions

- Research the most efficient way to transform abandoned agricultural lands/brownfields/other non-forested spaces into ecologically functioning forests.
- Identify plant-able space in urban settings for potential afforestation.
- Target outreach and education towards consulting foresters and private landowners with the capacity to afforest property.
- Increase production of seedlings at the state nursery to supply sufficient trees for planting.
- Create afforestation Best Management Practices to increase the success of public and private afforestation projects. This will include practices that increase equity and access for EJ communities in New Jersey.

Reforestation/Forest Restoration Target (F2)

- Reforest 10 state-owned sites through 2030 and 40 state-owned sites through 2050.

Prioritize sites on state land for reforestation. Reforestation is the practice of reestablishing forest cover where it previously existed, either through natural or artificial methods assisted by human intervention. NJDEP will identify degraded forests where ecosystem function is disrupted and plan to restore or enhance them to a forested condition that will efficiently capture and store carbon long-term.

How the target was developed

Similar to the development of the afforestation target (target F1), this reforestation target was developed based on the limited land capacity for reforestation in the State. This target will focus on highly degraded forests where ecosystem function is heavily disrupted or halted, and intends to reforest 40 sites (of varying sizes, dependent on availability and project feasibility) by 2050.

Near-term actions

- Continue to assess state land in accordance with the current inventory agreement with the USDA Forest Service FIA program to aid in identifying priority sites for reforestation.
- Prioritize state lands that have disrupted ecological function for future forest restoration/reforestation projects.
- Revisit state owned properties that are permitted for forest restoration/reforestation activities to assess next steps.

Reforestation Across Ownerships Targets (F3)

- Reforest 800 total acres through 2030 and 2,000 total acres through 2050.

A large portion of forests in New Jersey are on privately owned land. Reforesting privately owned lands can increase carbon sequestration beyond what is attainable by focusing solely on publicly owned land. This target sets a goal for reforestation or forest restoration on lands that are not state-owned.

How the target was developed

Similar to the development of the afforestation target (target F1), this reforestation target was developed based on the limited land capacity for reforestation in the State. This target will focus on highly degraded forests on privately-owned lands where ecosystem function is heavily disrupted or halted and intends to reforest 2,000 acres by 2050. This target was also developed based on current availability of nursery stock for planting, as well as the willingness of private landowners to restore their forests.

Near-term actions

- Assist homeowners in restoring degraded forests on their properties by providing education and financial incentives.
- Externally, NJDEP can encourage non-profits and other organizations to do the following:
- Survey their land-bases for forests in need of restoration or land that has the potential to be forested.
- Increase outreach and training programs to private landowners to encourage participation in forest management programs on private lands.

Nursery Production Target (F4)

- Increase tree nursery production across the state by 20% by 2030 and then maintain through 2050.

Existing tree nursery stock is limited and will need to increase to provide seedlings for future forestry projects and planting goals. A 20% increase in production will support municipalities, private landowners, and state-led management afforestation and reforestation efforts. Increasing support, funding, and production at tree and native plant nurseries across the state will result in a direct increase in carbon stored and sequestered as new trees are grown to be sold for planting projects in urban, suburban, rural, and traditional forest settings.

How target was developed

With the afforestation, reforestation, and urban and developed lands planting targets all requiring trees, a target to increase nursery productivity across the state (including the NJ Forest Service Nursery and privately-owned nurseries) will be necessary to ensure the availability of enough trees in a variety of sizes and species to contribute to statewide planting goals.

Near-term actions

- Determine needs for additional funding, physical materials, and potential additional staff in order to increase production by 20%.
- Provide nursery stock that is more climate, pest, and disease resistant.
- Provide nursery stock of native tree and other rare species.

Minimize Conversion of Forested Lands Targets (F5)

- Maintain annual forest conversion rate of 4,000 acres converted to non-forest cover until 2030, then reduce forestland converted to non-forest cover to 2,000 acres per year, by 2050.

Avoided conversion helps us to protect our forested lands and has the greatest potential for carbon sequestration benefits, as it keeps trees alive and sequestering carbon. According to data collected by Lathrop et al.,[47,70] between 2007 and 2015, New Jersey forest lands were being converted to non-forest uses at an average of approximately 4,051 acres per year. Forest Inventory and Analysis data shows that the average acre of New Jersey's forest stores approximately 370 metric tons CO2e per acre, meaning that every acre we avoid conversion from forest use, we are protecting those 370 metric tons CO2e per acre of stored carbon plus the approximately 2 metric tons CO2e that are sequestered per acre per year that otherwise would have been lost to conversion.

New Jersey is approximately 40% forested, with state, federal, county, and municipal government owning 53% of that forested land, and private landowners owning the remaining 47% of forested land. Private landowners own a mixture of both traditional and urban forests. These forests are at a higher risk of conversion to non-forest uses like development because they have less protections than government-owned forest land. According to data from the 2018 National Woodland Owners Survey,[95] 93% of private family landowners in New Jersey had moderate to great concerns about the cost of property taxes, 82% had moderate to great concerns about keeping land intact in future generations and 49% of private family landowners responded that they would sell their land if offered a reasonable price. Current state forestry programs such as Woodland Assessment and Forest Stewardship help to mitigate some of this risk by providing property tax breaks to owners that manage their forests.[96,97] These programs help keep forests as forests and healthy forests as healthy forests. However, there are still losses to these programs mainly through fragmentation as properties are split up into smaller units and through development. These are hard to track as more properties enter the program every year than are lost to the program. As of 2015, urban lands comprise the largest acreage of land-use in the state, and several counties are close to reaching buildout.[93] With such limited space left in the state for afforestation or reforestation and so much forested land already protected, forest conservation and management to mitigate risks to forest carbon are a high priority for carbon sequestration in New Jersey's forests.

Existing forests store a wealth of carbon in live and dead vegetation and wood, leaf litter, and soil. When forests are converted to developed lands, they not only lose stored carbon on that specific site but cease to sequester carbon into the foreseeable future. By minimizing the conversion of forested lands to non-forest uses these areas can continue to function as net GHG sinks by keeping carbon stored in forests on the landscape and by keeping forests continuously sequestering carbon as they grow. Protecting forests involves controlling the drivers of development, such as urban expansion, and forest degradation through insect and pathogen outbreaks and wildfires. Keeping forests as forests not only conserves existing forest carbon pools, but provides important co-benefits like preserving biodiversity and ecosystem function and services.[98]

How the target was developed

A 2012 estimate by Lathrop et al. [61] looked at the rate of deforestation in New Jersey from 2007 to 2012 and found that just over 4,000 acres of forestland were converted to non-forest use each year.[61] The target aims to cut this in half and hold deforestation to 2,000 acres per year.

Near-term actions

- Increase the percentage of forested land and overall acreage purchased by the Department and through funding provided by the Green Acres program.
- Explore revising Green Acres regulations to preserve forested uses.

- Enroll approximately 75,000 acres of state forest lands in a carbon market.
- Encourage enrollment of private lands in carbon markets.
- Increase enrollment of private landowners into the forest stewardship and Farmland Assessment program.
- Increase education regarding forest management.

Externally, NJDEP can encourage non-profits and other organizations to do the following:

- Increase their land-base to leverage opportunities to keep forests as forests.
- Increase outreach and training programs to private landowners to encourage participation in forest management programs on private lands.

Forest Carbon Market Target (F6)

- Enroll 75,000 acres of forest lands into a carbon market by 2030 and 100,000 acres by 2050.

Voluntary carbon offset markets allow landowners to sell the carbon sequestered in their forest to another entity to offset emissions made elsewhere. The income from state land carbon credits could be used to fund forest management activities and potentially the conservation of additional lands to forested use.

How the target was developed

The New Jersey Forest Service has recent inventory data across 75,000 acres of state-owned land that can be used to assess those lands for carbon market potential. The NJFS hopes to enroll all 75,000 acres into a forest carbon market by 2030, and at least 25,000 more acres by 2050 (dependent on future market conditions). By 2050, the hope is that more entities within the state will be able to enroll their properties in carbon markets to reach a target of 100,000 acres enrolled.

Near-term actions

- Release a Request for Expression of Interest (RFEI) for a carbon market on state land.
- Conduct exploratory research on the viability of carbon markets on privately held forested lands appropriate to the distribution and size of these lands in New Jersey.
- Educate non-profits and other natural resource-based organizations on carbon markets – how they work, barriers to entry, etc.

Improved Forest Management – Ecological Management Target (F7)

- Plan ecological forest management to sequester carbon while mimicking natural processes and diversity in forest systems on 100,000 acres by 2030 and 200,000 acres by 2050.

Active forest management can improve carbon sequestration, while enhancing forest resilience, health, and ecological benefits. Forest management helps ensure the longevity of native forests while providing age and structural diversity.

As forests grow and regenerate, they sequester carbon from the atmosphere, and store increasing amounts of carbon as they continue to age and grow. Disturbance events such as fire, insect outbreaks, or disease release carbon back into the atmosphere. As the forest recovers and regrows from the disturbance, it removes carbon from the atmosphere once again. Due to the forest carbon cycle's reliance on disturbances to complete the loop, carbon balances in forests fluctuate throughout time, but tend to trend upwards due to overall stands of trees continuing to grow. Trees need to photosynthesize to grow and survive. If photosynthesis is impacted in any way, it influences the amount of carbon that will be sequestered. Photosynthesis can be impacted by tree crowding, competition for forest resources, drought, insect and pathogen outbreaks, high winds, or fires. By implementing management practices that keep our forest resilient and healthy, we are positively influencing photosynthesis, and therefore carbon uptake by forest stands benefiting from that management.

Ecological forest management can have many benefits, including protecting stored carbon when practices help to keep forests as forests by preventing catastrophic loss of forests from stand-killing wildfires or pest infestations. The practice involves creating and maintaining diverse landscapes that foster diversity in tree age, forest structure, habitat type, and

species composition. Forest stand improvement can include a variety of on-the-ground management techniques such as thinning, shelterwood, invasive plant removal, prescribed burning, planting, etc.[40] It can also include inventory and research techniques. Carbon sequestration is one of many goals of ecological forest management. To balance priorities, resource managers must analyze the potential carbon outcome(s) of all forest management projects. Resource managers must also assess the project's risks, tradeoffs, and other ecological benefits.

The New Jersey Forest Service is currently working on a carbon-focused model that uses data collected over the past 5 years from New Jersey forests to better understand the carbon tradeoffs of different types of management techniques. This model, called the Forest Carbon and Risk Modeling Assessment (ForCARMA) model will help to inform ecological forest management decisions as they relate to carbon. This model will take into account risks like wildfire and insect outbreaks and will be able to compare risk scenarios with management scenarios, business-as-usual scenarios, and "lab conditions" to assess what the carbon impacts of some management decisions are relative to other management decisions.

For example, we can identify forested areas at high risk of SPB outbreaks by looking at forest data and metrics such as species composition, basal area, trees per acre, and disturbance history at that site. Mortality due to insect outbreaks in New Jersey in the last decade has far exceeded the area impacted by fire, harvesting, or windstorms.[46] As of 2023, there are many invasive insects negatively affecting New Jersey's forests. Some of the most impactful insects include Southern Pine Beetle (SPB)(Dendroctonus frontalis), Emerald Ash Borer (EAB) (Agrilus planipennis), and LDD Moth (Lymantria dispar dispar). Invasive and non-native invasive insects have few natural predators in New Jersey and destroy native plants, which in turn can emit carbon and impact native wildlife.[99] Insects such as SPB and EAB can quickly grow their populations to outbreak levels in the right conditions and can kill large swaths of trees in just a few months to a few years, resulting in large, immediate losses in carbon. Other insects, like LDD Moth, have cyclical outbreaks that can slowly kill large swaths of trees over several years to decades, resulting in smaller carbon losses over the course of several decades. States in the western USA and parts of Canada have been heavily impacted by Mountain Pine Beetle (Dendroctonus ponderosae) over the past few decades to the point where some of their forests have converted from carbon sinks to carbon sources.[47,48] Actively managing forests that are currently being impacted by or are at high risk of being impacted by invasive and non-native insects can mitigate the risk of large carbon losses over the next few years and decades.

On average, New Jersey has 1,500 wildfires across 7,000 acres of forested land annually.[96] To help mitigate catastrophic wildfire events that release large amounts of carbon into the atmosphere, the New Jersey Forest Fire Service conducts prescribed burns in fire-dependent forest and grassland systems. While the action of prescribed burning does release stored carbon into the atmosphere, careful selection of forests where the risk of forest loss due to tree deaths from wildfire may have a net carbon benefit over time. The purpose of prescribed burns is for fire to consume the fuels on the forest floor and in the understory without killing overstory trees so that if a wildfire were to occur, it would be less aggressive and may spread more slowly due to lack of fuels thus reducing the risk of catastrophic tree deaths and forest loss.

Low and from below thinning is another wildfire and pest mitigation tool that is implemented by the NJ Forest Service in conjunction with the NJ Forest Fire Service. Low and from below, or low thinning only removes the shortest suppressed trees within an even-aged forest stand, mimicking the natural mortality of self-thinning during normal stand development at an accelerated rate. These removed trees are often small in diameter with misshapen or deformed crowns and are the least likely to survive to healthy levels of maturity or to be marketable. This type of thinning does not promote the regeneration of trees. Suppressed and intermediate trees can serve as ladder fuels in our forests, helping to carry potential wildfires from the forest floor up into the main forest canopy. Low and from below thinning removes these fuels, mitigating the risk of a wildfire jumping into the forest canopy. Trees cut in this type of thinning are generally left on the forest floor within the site. Like prescribed burning, the action of thinning releases stored carbon into the atmosphere, however its use to prevent likely future outbreaks can reduce the scale of those outbreaks and careful selection of forests where the risk of forest loss due to tree deaths from wildfire or pest outbreaks may have a net carbon benefit overtime from preventive thinning.

How the target was developed

This ecological forest management target was developed based on planning and management trends by the NJ Forest Service over the past several decades. Based on current inventory data and planning cycles, the NJFS prioritizes specific state parks and forests for the creation and implementation of ecological forest management plans that prioritize select forest stands within that park or forest for management. These management practices will increase carbon sequestration potential and carbon stored in stands where ecological function and/or regeneration have been disrupted. Co-benefits of these management actions can include forest restoration, habitat for wildlife and rare plants, wildfire mitigation, and mitigation of invasive insects, diseases, and plants, amongst other goals. Past forest stewardship plans that have been written and implemented by the New Jersey Forest Service that incorporate ecological forest management include the Double Trouble State Park Natural Resource Stewardship Plan and the Whiting Forest Stewardship Plan. NJDEP intends to stakeholder, create, and implement 2-3 new ecological management plans across state lands by 2050, encompassing approximately 200,000 acres of state forest land.

Near-term actions

- Create a New Jersey-specific Forest Management Model to analyze carbon tradeoffs among a variety of forest management, forest risk, and no-management scenarios.
- Coordinate with NJDEP Fish & Wildlife for opportunities to incorporate Connecting Habitat Across New Jersey (CHANJ) into forest planning.
- Assess forest lands for adequate tree regeneration in response to extensive deer browse or the presence of invasive species.

Improved Forest Management – Cost Share Targets (F8)

- Provide cost share to properties for improved forest management of 100 to 500 acres per year through 2050.

This funding source will enable carbon-centric forest management practices such as afforestation, reforestation, forest restoration, improved forest management, and avoided emissions to take place on private and municipal properties.

How the target was developed

This target was developed based on the availability of funding and cost-share opportunities for private and municipal forest landowners, such as the Regional Greenhouse Gas Initiative (RGGI) Natural Climate Solutions Grant program and a variety of Natural Resource Conservation Service (NRCS) grants, that can help these landowners to plan and implement forest management projects on their properties.

Near-term actions

- Make private and municipal landowners aware of RGGI Natural Climate Solutions Grant program, and qualifications for submitting applications.
- Make consulting foresters working with private landowners aware of RGGI grant opportunities and the qualifications private and municipal landowners must meet to apply.
- Create new or more inclusive grant opportunities for private and municipal landowners to have their forested properties inventoried for future planning and management.

Private Forest Stewardship Targets (F9)

- Enroll private properties that are eligible into NJFS stewardship and Farmland Assessment programs, aiming for 115 additional properties per year through 2030, with all eligible properties enrolled by 2050.

This target helps forests remain forests. According to data from the 2018 National Woodland Owners Survey[95], 93% of private family landowners in New Jersey had moderate to great concerns about the cost of property taxes, 82% had moderate to great concerns about keeping land intact in future generations. and 49% of private family landowners responded that they would sell their land if offered a reasonable price. Current state forestry programs such as

Woodland Assessment and Forest Stewardship help to mitigate some of this risk by providing property tax breaks to owners that manage their forests.[96,97] These programs help keep forests as forests and healthy forests as healthy forests.

New Jersey's forest stewardship program is available to private landowners with a minimum of five acres of forested land or land that is capable of becoming a forest, with at least 10% canopy cover.[100] This program is beneficial to landowners because it allows them to qualify for Farmland Assessment preferential tax benefits. The program involves a 10-year commitment that includes generating and following a plan to actively manage the forest, along with monitoring progress every three years. These programs encourage landowners to keep their forested land intact and well-managed instead of selling it to avoid the high cost of property taxes or to the highest-bidding developer, directly contributing to the forest carbon protection and future sequestration goals outlined in the avoided emissions section, as well as the ecological forest management and improved forest management sections. According to statistics garnered from the NJ Woodland Assessment Program and Stewardship database, properties enrolled in the program are less likely to convert forested land for development than other privately held properties, which directly contributes to our target for avoiding forest conversion to protect stored forest carbon and encourage future sequestration – especially on privately held lands . The goal of this target is to increase participation in this program to encourage conservation of privately owned forests.

How the target was developed

On average, the NJFS Private Lands Stewardship Program adds approximately 115 additional properties to the program each year. This target is based on the current rate and aims to continue enrolling and encouraging more private landowners to participate in forest management activities each year.

Near-term actions

- Increase outreach to private landowners to make them aware of the forest stewardship program and its range of benefits to property owners and the environment.

Forest Recommendations for Policy Changes

Improved Forest Management: Under this strategy there are opportunities to do more to ensure net carbon sequestration and the health of New Jersey's forests through several actions.

- The NJDEP will provide 10 years of predictive forest management implementation opportunities consistent with the New Jersey State Forest Action Plan. These opportunities will heavily focus on forest carbon protection and increased sequestration.
- Monitoring: In order to make informed decisions regarding forest management, well-established forest monitoring planning, protocols & implementation must maintain high standards, and integrate new data collection methodology to provide more accurate forest carbon metrics.
- Expand damage causing agent surveys across the state, for all forest ownerships, which will allow resource managers to respond to forest pest and disease outbreaks in a timely manner, and limit forest carbon emissions to the atmosphere.
- Map, monitor, and remove invasive plant species in conjunction with the New Jersey Invasive Species Strike Team to increase forest regeneration success and ensure that there is forest carbon continuity within impacted stands.
- Annually survey state lands & identify areas where ecosystem function is disrupted, and carbon sequestration is limited.
- Annually assess regeneration status of forest lands that have been affected by wildfires or damage causing agents to ensure continuity of stored and sequestered forest carbon in impacted stands.
- Assess the impacts of climate change to areas where northern hardwoods have succeeded oak forests.
- Upgrade New Jersey's current Forest Inventory and Analysis (FIA) Inventory Agreement contracts to include Phase 3 inventory plots that relate to forest ecosystem function, condition, and health to help prioritize areas for beneficial forest carbon management.

Funding: NJDEP will also work to make funding available for public and private forest management projects through several avenues.

- Encourage Green Acres and the State Agriculture Development Committee to afforest their properties where appropriate.
- Incentivize agricultural landowners to establish forests in areas where field production is no longer financially feasible and where opportunities for carbon markets exist that may provide enough financial benefits to dissuade land-use changes to uses with higher carbon footprints than forests.
- Create grant opportunities for municipal and private landowners to hire and consult with local forestry professionals for forest inventory, planning, and implementation on their forested lands.

Outreach: By enhancing the scope of outreach efforts, NJDEP and other natural resource-based organizations can convey the importance of carbon sequestration and storage in forests as a means of mitigating climate change to the public.

- Improve forest management outreach, programming, and curriculum to emphasize carbon sequestration at State and partner facilities.
- Increase geographical reach of forestry education programs.
- Publish a new NJDEP webpage on forest carbon, climate & forest management.
- Enhance outreach and education by utilizing and improving State and partner facilities
- Install kiosks and displays with forest management information throughout the state to engage a wider audience.
- Establish a forestry cooperative with the state's land grant institution, Rutgers University, and establish forestry-based academic joint-ventures with other universities.

Locally sourced durable forest products: In this modern era, wood products continue to be commonly used in construction and textiles. There is strong evidence at the product level that wood products from sustainably managed forests are associated with less greenhouse emissions in their production, use and disposal over their lifetime compared to products made from emission-intensive and nonrenewable materials.[98] When wood products are transported across states or even across oceans, significant greenhouse gas emissions are generated by the transportation. Sourcing wood products locally can greatly reduce the emissions from transporting those products.

Increases in carbon storage in wood products can be accomplished by 1) increasing the amount of long-lived wood products available through additional tree harvesting or reallocation of harvested wood, 2) increasing the lifetime of wood products through proper care, and 3) by increasing recycling of these products after use.[98] Wood products can also contribute to reaching GHG emissions goals through material substitution, which involves the use of wood products for building and textiles over the use of other materials like concrete or steel to reduce emissions associated with the production, use, and disposal of those products that wood products would be replacing.

Public forest management in New Jersey does not prioritize tree harvesting for wood products as a primary management goal. Any wood products that come from public lands management are ancillary to the management objectives, like forest health and protecting larger carbon pools, and we can work to ensure those products remain local, and incentivize their use over other more emissions-intensive products like concrete or steel. New Jersey's citizens will continue to utilize wood and paper products in their everyday lives, and being able to provide a source of sustainably and locally harvested materials, while ensuring a new tree crop will be planted, can reduce emissions through the supply chain.

Regulation:

- Consider updating building codes to accommodate and incentivize the use of emerging carbon-positive construction materials such as mass timber over the use of concrete and steel which have significantly larger associated carbon footprints.

Funding:

- Incentivize the use/consumption of long-lived wood products over more carbon-intensive products such as steel or concrete, where applicable.

Outreach:

- Improve consumer awareness of the "New Jersey Grown" agricultural designations for wood products to help combat carbon leakage.

Coordination:

- Support and collaborate with businesses that are interested in starting niche forest product markets in New Jersey.
- Maintain and update the list of Forest Industry Professionals working and running their businesses using local New Jersey forest products.

Knowledge Gaps:

- Soil carbon storage capacity of forests – what factors affect the capacity? What management practices can enhance soil carbon storage?
- Soil structure on post-agricultural lands – does it differ from traditional forests of varying ages?
- Carbon flux – what are the rates and factors influencing flux between forest carbon pools? What design or implementation variables can maximize sequestration benefits?
- Economic impact of carbon leakage – what are the effects at local and global scales?
- Social science – what motivates our stakeholders and how can support and collaboration be garnered for forest management?
- Carbon markets – how do these work economically and how can they be implemented on smaller scales, such as on private lands with small forest holdings?
- Assess what wood products are being brought into the state & identify their uses.

WETLANDS

Photo credit Kirk Raper

WETLANDS

A wetland is a unique ecosystem where the land is regularly saturated with water for an extended period each year. There are a variety of types of wetlands, such as bogs, marshes, and swamps, but all wetlands have three essential characteristics in common: 1) water at or above the surface during part of the year; 2) saturated soils for long enough that soils become anaerobic (lack oxygen), and 3) have plants that are specially adapted to survived in wet and anaerobic soils. Wetlands can be found throughout the state, from the salty green grasslands that form a band around the coast, to the forested swamps. New Jersey's wetlands cover approximately 993,249 acres, about 17% of the total land area.[101]

Considerations for all wetlands targets

Co-benefits

Wetlands provide a myriad of ecosystem service benefits. They clean and absorb water, provide habitat for commercially important fish and endangered plants and animals, and attract ecotourists.

Out of all New Jersey's natural and working lands, the ecosystem services of wetlands provide the largest economic value, at $11 billion per year, adjusted to 2021 dollars.[63,64] For example, approximately $625 million in storm damage was prevented by coastal wetlands during Hurricane Sandy.[102]

Atlantic white cedar swamps are an ecologically significant habitat for several state and federally-listed species, such as swamp pink (Helionas bullata). They also provide valuable habitat for Pinelands fauna, such as Timber Rattlesnake (Crotalus horridus), which hibernate in cedar swamps in the winter. In addition, the Hessel's hairstreak (Mitoura hesseli), listed as a species of concern in New Jersey, exclusively depends on Atlantic white cedar swamps.

Potential Negative Impacts/Tradeoffs

Animal use will change if site characteristics transform (e.g., changes in hydrology, salinity, or plant cover). There are often habitat tradeoffs when environmental restoration is performed. For example, rebuilding salt marshes can replace mudflats where wading birds feed and may reduce the area for submerged aquatic vegetation habitat.

Because tidal reconnection projects are reintroducing tidal flow, there is a risk of increasing flooding in nearby communities. Projects can be designed to prevent an increase in flood risk.

There is a risk that when freshwater wetlands are restored, the methane produced will negate the climate change benefits associated with the additional carbon storage. Not enough is known about the amount of methane produced by the majority of freshwater wetland types in the State. For this reason, besides Atlantic white cedar swamps, restoration of freshwater wetlands has not been included in the strategy.

Expected Impacts of Climate Change on Carbon Sequestration

Tidally influenced wetlands are precariously placed between the ocean and upland. They exist in a narrow band of elevation and are susceptible to increasing rates of sea level rise. Without action, tens of thousands of acres of tidal wetlands are expected to be lost due to sea level rise and erosion.

Inland, freshwater wetlands are also susceptible to the effects of climate change. Drought might shift the role of wetlands from carbon sinks to carbon sources. However, higher temperatures and more rain can maintain the role of wetlands as carbon sinks.[103] Changes in precipitation and temperature patterns will affect the variability of groundwater levels in wetlands. This can impact wetland services such as flood protection, carbon storage, water cleansing, and wildlife habitat.[98,104]

When these habitats are lost, they not only lose their ability to sequester carbon, but also gain the possibility that they will become significant sources of greenhouse gases as stored carbon is released back into the atmosphere.

Environmental Justice Considerations

Tidal wetland restoration and living shoreline projects can add environmental benefits in EJ communities by providing improved water quality, additional recreation opportunities, protection from storms and a subsequent reduction in residential flooding, and beautification of the scenery. On the other hand, because tidal reconnection projects are reintroducing tidal flow, there is a risk of increasing flooding in nearby communities. Projects can be designed to prevent an increase in flood risk.

Wetlands Recommendations for Land Management Practices

Tidal Reconnection Target (WL1)

- Complete one tidal reconnection project annually through 2030 and then two tidal reconnection projects annually through 2050.

Tidal flow in wetlands can be restricted or completely blocked by dikes, undersized culverts, roads, or other human made constrictions. This can lead to artificially low salinity in wetlands, which can increase methane release[49], and lower elevations, which can decreased vegetation cover. Reconnection projects can increase net sequestration when, 1) there is a goal to increase the cover of vegetation in salt marshes via increased sedimentation and/or planting, 2) the salinity of the marsh is expected to greatly increase as a result of restoring tidal flow and thus decrease methane emissions. Projects need to increase the salinity behind a tidal restriction from below 5ppt to above 5ppt and preferably to above 18ppt to reduce methane emissions.

How the target was developed

A target of one or two projects per year was selected for the following reasons:

1. To date, there have been few tidal reconnection projects in New Jersey. So, scaling up to 1 per year is a good stretch goal.
2. The carbon sequestration benefits of tidal reconnection projects will be site-specific. There needs to be nearly fresh water behind the tidal restriction and a salinity of over 18 parts per thousand outside the restriction. At this time, it is unknown how many sites fit this description.
3. These projects tend to be expensive because they require complicated engineering and heavy construction equipment.

Near-term actions

- Opportunities to restore tidal flow in tidally restricted salt marshes and impoundments in high salinity parts of estuaries were explored by Warnell and Olander[48], who identified about 10,100 acres in New Jersey where hydrologic connection projects could be targeted to reduce methane emissions.
- Survey impounded marshes that would naturally be saline if the impoundments were removed and create a list of potential project sites. These projects can be added to the Coastal Ecological Restoration and Adaptation Plan and partners can begin to develop projects.[105]

Salt Marsh Vegetation Target (WL2)

- Vegetate 70 acres of salt marsh per year through 2030 and 200 acres per year through 2050.

This target increases carbon sequestration by increasing the cover of native salt marsh vegetation.

How the target was developed

The targets were set based on the past rate of permitting for these types of projects. From 2015 to 2022, around 50 acres of salt marsh were restored per year statewide. The highest acreage restored in any given year was 160 acres in 2020. These scaled-up targets of 70 to 200 acres per year are likely achievable with additional resources.

Near-term actions

Identify marshes with large areas of vegetation loss. Add projects to the Coastal Ecological Restoration and Adaptation Plan and partners can begin to develop projects.[105]

Reforestation Target (WL3)

- Restore 10,000 acres of Atlantic White Cedar Swamps by 2030 and 20,000 acres by 2050.

How the target was developed

The reforestation target for Atlantic white cedar forests was based on DEP's Atlantic White Cedar Wetland Ecosystem Restoration Strategy.[106] Through the stakeholder process for that strategy, DEP identified around 22,000 acres in New Jersey as hardwood forests with a cedar component. Sites were selected using the NJFS 2017 cedar assessment and topography was considered to determine vulnerability to sea-level rise. The presence of rare plants and niche wildlife were also considered in selecting candidate sites.

Near-term actions

- Stakeholder meetings for identified projects
- Establish a contracting mechanism to assist with project implementation
- Develop and receive permits
- Implement projects

Living Shoreline Target (WL4)

- Install 7,800 feet of living shoreline annually through 2030, then 10,000 feet annually through 2050.

By protecting wetlands from wave action by installing living shorelines, carbon that has been accumulating for centuries can be protected from re-emission by storms and other erosive forces.

How the target was developed

The targets to install 7,800 and 10,000 linear feet of living shoreline per year were selected for the following reasons:

1. The annual length of permitted living shoreline from 2015 to 2022 were tabulated, and a 3-year rolling average was reviewed and a significant rate of increase was determined.
2. The rate of increasing permitted living shoreline was used to calculate the 2030 target of 7,800 feet per year. The 2050 value was selected at levels below the historical rate of increase to acknowledge the intermittent nature of funding.

Near-term actions

- Prioritize the development of living shoreline projects in areas with high erosion rates. Add the sites into the Coastal Ecological Restoration and Adaptation Plan so partners can begin to develop projects.[105]

Protect Wetlands (WL5)

- Reduce wetland soil disturbance by 10% by 2030 and 30% by 2050.

When wetland soils are disturbed by ditching or other anthropogenic activities, the soils can dry out and be exposed to oxygen. This can lead to centuries of stored carbon being rapidly emitted into the atmosphere as greenhouse warming gasses.

How the target was developed

The targets were selected for the following reasons:

1. Since authorization to implement the Federal permitting program in 1994, actual freshwater wetland losses have been tracked in the Department's databases (Paradox, NJEMS) and incorporated into an annual report to EPA. Based on these reports, approximately 150 acres of freshwater wetlands are disturbed per year.
2. The reduction of disturbance set to be achieved by 2030 and 2050 seem ambitious and reasonable.

Near-term actions

- Prioritize carbon rich wetlands for protection.
- Explore and implement regulatory and land acquisition options to meet targets.

Protect Tidal Wetland Migration Zones (WL6)

- Protect 20% of marsh migration zones from development by 2050.

As sea level rises, more upland areas are being flooded by daily tides and new tidal wetlands are forming inland. This can only happen in areas that remain undeveloped and where roads and other infrastructure are not blocking tidal flow. Protecting marsh migration areas allows new tidal wetlands to form, offsetting areas that are lost to due to sea level rise and erosion.

How the target was developed

The target of protecting 20% of marsh migration areas by 2050 was selected for the following reasons:

1. No targets for 2030 were selected because a mechanism to protect marsh migration zones has not been established.
2. Because the mechanism for protection is unknown, the success of the mechanism is unknown as is the ecological success of marsh migration. The 20% protection target was selected as a conservative estimate.

Near-term actions

- Select a marsh migration model to use in planning
- Research mechanisms for protecting marsh migration zones
- Implement marsh migration zone protection policies and programs

Wetlands Recommendations for Policy Changes

There are five focus areas to maximize carbon sequestration in tidal wetlands: guidance, outreach, planning, funding, and regulations.

Guidance:

- Develop best management practices for maximizing carbon sequestration in Blue Carbon projects, integrating lessons from earlier implementation projects.

Outreach:

- Develop and implement a public outreach campaign.
- Institute a voluntary wetland stewardship program, like federal programs incentivizing restoration and stewardship on private lands, such as the Natural Resources Conservation Service's Wetlands Reserve Program.[107]
- Educate private landowners and developers on ways to manage their land to minimize impacts to wetlands and reduce risk from climate change.

Planning:

- Reevaluate the Green Acres and Blue Acres programs to consider prioritizing the acquisition of land and conservation easements that will protect areas with high current carbon storage and future sequestration potential.
- Develop a Blue Carbon Action Plan to lay out specific goals for wetland sequestration.
- Review state and local Natural Hazard Mitigation Plans and Climate Adaptation Plans to ensure that wetlands are incorporated as essential green infrastructure.

Funding:

- Evaluate the adoption of a blue carbon market or other incentive program to help fund wetland conservation and restoration in NJ.

Regulation:

- Review and improve wetland protection regulations to reduce drivers of degradation and destruction of high-carbon wetlands.

Knowledge gaps:

- Carbon dynamics of marsh migration
- Carbon sequestration vs. methane emission in brackish and freshwater systems

AQUATIC HABITATS

Photo credit NJDEP Nina Colagiovanni

AQUATIC HABITATS

Aquatic habitats in New Jersey include freshwater resources such as rivers and lakes, coastal resources such as estuaries, and marine ecosystems in areas deeper than 50 meters.[108] In these ecosystems, two habitats essential for carbon sequestration and storage are submerged aquatic vegetation (SAV) beds and shellfish beds/reefs.

Coastal SAV beds in New Jersey are primarily characterized by eelgrass (Zostera marina) and widgeon grass (Ruppia maritima). SAV is one of the most productive marine ecosystems known worldwide. Submerged aquatic vegetation, like saltmarshes and mangroves, helps to mitigate climate change impacts. They are capable of taking up carbon dioxide from the atmosphere and buffering ocean acidification. The full benefits of seagrasses in mitigating climate change impacts continue to be researched to strengthen these services.

Protection and enhancement are needed for SAV habitat, which is declining globally and in New Jersey. Seagrasses are among the world's most threatened ecosystems, with annual global loss rates of seagrass extent averaging 1.5% since the beginning of the twentieth century and accelerating in recent decades. An estimated 29% of the seagrasses known to exist at the beginning of the twentieth century have disappeared, generally replaced with unvegetated, unconsolidated mud and sand soils. This rapid loss of seagrasses resulted in a substantial decrease in C sequestration by seagrass ecosystems of 6 to 24 Tg C yr−1.[109] Significant declines in seagrass beds have occurred in New Jersey estuaries over the last 30 years[110] has resulted in the reduction of essential fish habitat and the potential loss of commercially and recreationally important species.[111]

Considerations for all aquatic habitat targets

Co-benefits

In addition to carbon sequestration, SAV also removes nutrients from the water and provides physical stabilization of sediments. It is also a source of food and shelter to valuable nearshore communities. Healthy SAV beds provide essential habitat as the foundation for healthy stocks of fish and invertebrate species, along with successful commercial and recreational fisheries. SAV beds are important because they serve as the base of the food web, providing food to marine life throughout the ecosystem. Seagrass beds provide refuge for shellfish and finfish, while also stabilizing sediment.[112] They improve water quality by storing nutrients, trapping suspended sediment, and protecting shorelines by dampening wave action and currents.

SAV habitat is important for multiple life stages of different species managed in New Jersey, such as American eel, Atlantic croaker, Atlantic herring, Atlantic sturgeon, black sea bass, scup, spot, striped bass, summer flounder, and tautog. Shellfish such as oysters have the potential to sequester carbon and help to stabilize sediment and protect shorelines by buffering waves and reducing coastal erosion. In addition to dissipating wave action, shellfish improve water quality by filtering excess nutrients and sediments from the water column.

Potential Negative Impacts/Tradeoffs

Minimal tradeoffs are anticipated from strengthening the protection of SAV habitat. For coastal development projects, additional costs could arise if enhanced protections impact these projects or if stronger mitigation requirements are imposed when impacts are unavoidable. For example, regulations could be adopted that would address impacts to SAV habitat of less than one acre, which are currently permitted in some circumstances.

The siting of some wave attenuation projects and shoreline protection projects may be impacted by the nearshore presence of SAV beds. These types of projects should avoid the healthiest SAV meadows and do the utmost to avoid direct impacts to this critical habitat.

Expected Impacts of Climate Change on Carbon Sequestration

Global and local SAV has been declining for some time, largely attributed to the degradation of water quality and clarity.[113–117] SAV distribution is expected to change as a result of sea-level rise, with impacts such as alteration of growth

rates, shifts in distribution, and changes in sexual reproduction, as well as others.[118] The impacts of rising water temperatures and water levels will be even greater without improving water quality. By increasing water quality targets at the local and regional levels, managers can offset SAV losses caused by increasing temperatures and water depth. Only by adopting such an integrative perspective can SAV be protected and restored.[119]

Environmental Justice Considerations

Protection of this valuable habitat would have a positive effect on all of New Jersey's citizens, including those in Environmental Justice communities. The potential for carbon storage in SAV will offset greenhouse gas emissions, and protection will ensure available habitat for many life stages of fish. This is especially important to the families and individuals that rely on subsistence fishing in OBCs.

Aquatic Habitat Recommendations for Land Management Practices

SAV Monitoring Target (AQ1)

- Assess SAV acreage, density, carbon sequestration, and health with ongoing monitoring

Monitoring is fundamental to quantifying and determining trends in the density and spatial extent of existing seagrass beds in New Jersey. Monitoring will generally include acquisition of aerial photography, field validation, and an assessment of SAV health parameters. The availability of satellite imagery has been explored as a more cost-effective tool for mapping and monitoring of the areal extent of seagrass beds with a high degree of accuracy. The health parameter assessment will measure aboveground and belowground biomass, canopy complexity, microalgal cover, macroalgal cover, and sediment organic content. This SAV health data will inform modeling, which will potentially allow resource managers to link SAV health to specific environmental conditions and refine their predictive abilities. This will also allow resource managers to respond to SAV impacts sooner.

How the target was developed

The most recent effort to map SAV within New Jersey was completed in the summer of 2023, and new maps will be created in order to identify the presence of eelgrass, widgeon grass, and macroalgae throughout the Barnegat Bay to Little Egg Harbor. In addition to mapping statewide, monitoring will be a key tool in understanding the health and distribution of SAV beds in the years to come. Monitoring is a critical element in any efforts to study and conserve marine habitats such as submerged aquatic vegetation. In order to respond to losses of SAV, there is a need to understand the current status of SAV in New Jersey waters. Monitoring will also indicate areas of interest for restoration efforts, as well as furthering our understanding of blue carbon storage capabilities.

Near-term actions

- Obtain funding and contractors to conduct an SAV aerial survey with field validation every one to two years.
- Secure funding for monitoring SAV health parameters.
- Measure carbon sequestration in New Jersey seagrass beds.

SAV Conservation Target (AQ2)

- Limit SAV loss to 10% between now and 2030 then maintain no net loss through 2050.

Protecting existing SAV from further loss may maintain carbon storage. After determining a baseline for SAV, the target is to limit losses to 10% through 2030, then maintain no net loss through 2050.

How the target was developed

Data demonstrate a 62% loss of SAV in the southern portion of the Barnegat Bay from 1975 to 2000[120], while a broader assessment of seagrasses in NJ indicated a 2000- to 3000-ha loss during that same time period.[112] The Barnegat Bay accommodates ~75% of all of NJ's seagrass. Further, global losses of SAV since 1980 are estimated at about one-third.[116] Further studies of carbon storage in NJ seagrass beds are necessary to better understand the actual potential for sequestration.

Near-term actions

- Prioritize SAV conservation in areas where it is vulnerable, such as in dredging areas associated with waterfront development projects, areas with heavy boat traffic, and areas with poor water quality.
- Launch an outreach program to educate the public about the value of SAV and how they can help to protect it.

SAV Restoration Target (AQ3)

- Establish an acre-specific goal for SAV restoration with a target to be met before 2030.

Restoration of NJ's seagrass beds is important to enhance and maintain the ecosystem services they provide and to reduce and mitigate threats and damage to existing seagrass beds. Successful restoration will offer a potential to sequester atmospheric CO2. Once a baseline is established through monitoring, NJDEP can set an acre-specific goal for restoration with a target to be met before 2030. However, conservation over restoration should be prioritized, as restoration can be costly and challenging. More research is needed to understand how restoration practices for SAV can be successfully implemented within the state.

How the target was developed

The target to limit SAV loss to 10% was set based on extrapolated losses in the Barnegat Bay. When statewide data is available, this target should be revisited.

Near-term actions

- Establish a baseline for SAV acreage and density through aerial surveys.
- Conduct research on best practices for SAV restoration within New Jersey waters.
- Develop SAV restoration guidance for best practices, adaptive management strategies, and success criteria.
- Create an SAV alliance advisory group to better coordinate SAV conservation and restoration efforts throughout the state and the region.

Aquatic Habitat Recommendations for Policy Changes

Policy recommendations focus on regulations and mitigation.

Regulation: New land use regulations to promote SAV protection can work in tandem with new programs and policies. Adopt and implement more stringent water quality and clarity standards would support improved SAV habitat.

Mitigation: Adopt regulations that require compensatory mitigation for all impacts to SAV habitats to strengthen SAV protection in an effort to incentivize applicants to take all necessary steps to accommodate SAV habitat in their project design and construction.

Research: Investigate the net carbon flux of shellfish in New Jersey, including but not limited to oysters, hard clams, surf clams, and scallops.

Knowledge Gaps:

- Best practices for SAV restoration
- Facilitate research to assess the carbon sequestration of shellfish farming and reefs

AGRICULTURAL LAND

AGRICULTURAL LAND

Agricultural croplands and pasturelands in New Jersey cover about 750,000 acres, or about 12 percent of the land area, according to the 2022 United States Department of Agriculture, National Agricultural Statistics Service.[121]

These important working lands significantly contribute to the state's economy, with agricultural products contributing over $1.2 billion in 2020.[122] In addition to providing agricultural products, agricultural land provides habitat services. There are around 411,000 acres of agricultural land in New Jersey where the practices described below could be implemented.

Considerations for all agricultural targets

Co-benefits

The targets for agricultural land include applying compost, planting cover crops, and a suite of other land management practices such as rotational grazing, agroforestry, and alley cropping. While these practices have been selected for their carbon sequestration potential, there are other benefits associated with each practice. Applying compost to cropland has several co-benefits, such as a reduction in food waste entering landfills. Composting can also aid in animal waste and nutrient management. Using compost provides a supplemental nutrient source, reducing the need to use synthetic fertilizers. Soil health also benefits from composting, as increased soil organic matter fosters healthier plants with improved pest and disease resistance. Compost application at a rate of 20 tons per acre (about ¼" depth) results in higher, more consistent yields, lower nutrient and water demands, and a decrease in pest and disease pressures.[123]

Cover crops not only help to sequester more carbon, but they also help improve soil health by reducing compaction, increasing porosity and water retention, and enhancing microbial diversity, which in turn reduces the need for fertilizers. Utilizing cover crops in a rotation can help to alleviate pest and disease pressure. Cover crops also suppress weed growth, decrease erosion and soil loss, and moderate soil temperatures. They can benefit livestock when used for forage. Economically, cover crops can protect from market volatility instead of relying solely on cash crops and reduce the need for costly fertilizers and pesticides.

Potential negative impacts/tradeoffs

In certain situations, there can be negative impacts associated with some of these practices. Depending on management, cover crops could take some crop land out of production, sacrifice crop yields, require investment in new/alternative production equipment, annual purchase of seed and associated learning curves. Further, return on investment may not be immediately realized, since this practice is aimed towards improving soil health, which can require multiple crop seasons. These factors when collectively considered could have a negative economic impact on farmers.

Compost provides nutrients that would otherwise come from synthetic fertilizers. However, the nutrients from compost are not immediately available for plant uptake. Therefore, compost must be applied further in advance than synthetic fertilizers.

The placement of composting facilities will be important, as improper placement close to wetlands or open water could result in nutrient leaching. Further, compost may be contaminated with heavy metals, organic pollutants, phosphorus, and weed seeds. The compost type, determined by initial ingredients (carbon and nitrogen sources), composting method, and length of curing, should be carefully selected based on the type of crop it will be used for, and timing of application. Further, analytical testing of compost could be used to understand nutrient content of the compost. On-site retention of plant residual would also prevent contamination from products being brought in from off-site.

Expected Impacts of Climate Change on Carbon Sequestration

Increasing temperatures and changes in climate patterns could influence an increase in pest and disease pressures, alter soil nutrient cycling via microbial populations and limit the types of crops that can be grown. These changes can

also affect planting times and hinder the implementation of cover crop rotations due to competing resources and time for planting cash crops. Limiting the quantity and quality of the types of plants that could be grown could decrease plant biomass deposition on soil, ultimately reducing sequestration.

Environmental Justice Considerations

The siting process of composting facilities must consider the cumulative environmental burden in a community, especially if the community is overburdened, and include mitigation measures to avoid or minimize disproportionate impacts to said OBC. In addition, monitoring must confirm that there are no significant levels of contaminants in the compost material before application.

Agricultural Recommendations for Land Management Practices

Soil health can be quantified by assessing three components of soil, physical structure, biological nature and chemical constituents. Two of the leading practices that improve soil health are applying compost and implementation of cover crops within cropping rotations. Further, beneficial application of cover crops must consider effective management of plant residues, diversifying cover crop mixtures, and delaying, as practical for the operation, timing of cover crop termination. These practices are most effective when used in combination with other management measures, many of which are already being implemented.

Applying compost as a soil amendment can help to improve soil structure and drainage, decreasing soil erosion. Compost application can also improve soil health by adding nutrients, improving the prevalence of beneficial microorganisms, and increasing soil organic matter (SOM) content.

Compost is the process of controlled decomposition and is incredibly diverse. Compost types are differentiated by the types and quantities of feedstocks, and or, ingredients, which contain specific carbon to nitrogen (C:N) ratios, cellulose, and hemicellulose content. Feedstock materials can consist of various organic materials that will provide desired C:N ratio specifically intended for the type of cropping application. Carbon-rich feedstocks include woodchips, sawdust, cardboard, cereal grain hulls, and deciduous shade-tree leaves. Animal manures, vegetative wastes (grass clippings, food scraps), and coffee grounds are examples of nitrogen-based materials that can be utilized.

The quality of a compost is distinguished by the quality and ratio of feedstocks utilized, composting method, and time cured. Cured composts have different C:N ratios. Higher carbon concentrations favor a material that is more fungal dominant, preferred for perennial cropping systems.[124] A mixture with lower carbon content creates a more bacterially dominant compost, a mixture that is preferred in annual cropping systems due to its higher content of plant-available nitrogen. Compost application is beneficial for carbon sequestration because it amends soil by facilitating an increase in organic matter (OM) content, as well as fulvic and humic acids (longer-term carbon compounds), which are formed during the decomposition, mineralization, and immobilization of organic materials. Further, soil microorganisms are stimulated and replenished. Quality compost enhances soil conditions and can improve plant growth.[125]

Annual application of compost can increase soil organic matter (SOM) content by 1%, utilizing a rate of 20 tons per acre (about ¼" application depth). However, a soil's capacity to increase and store OM largely depends on soil texture (sand, silt, loam), temporal precipitation and temperature conditions, mineral composition, pH, and land-use history. Soils with higher clay content can accumulate carbon more rapidly. Clay soils have slower rates of OM decomposition, and greater propensity to store SOC. Conversely, sandy soils display vastly lower rates of carbon accumulation, storage, rapid OM decomposition, and mineralization of SOM.[126] Compost can be applied to cropland that is harvested, held in temporary pasture, and held permanently in pasture to improve soil quality and facilitate greater carbon sequestration.

Biochar can be added as a complement to traditional compost. Biochar can be produced utilizing various types of feedstock materials, some of which include, straw, crop residues (corn stalks, grain hulls), wood chips or manure. The selected feedstock will then undergo pyrolosis, a process that heats the biomass under oxygen deprived conditions. This process is distinct from open burning, since over 50% of the initial carbon biomass is retained, and because of the higher temperatures used in pyrolosis (600-1000 degrees Celsius), less smoke and other volatiles are emitted.

Application of biochar in field soils can increase soil organic matter content, alleviate soil compaction, decrease loss of applied nutrients, improve soil water holding capacity and enhance populations of beneficial soil microbes. The material has shown promise, when combined with other BMP's, to be an effective tool towards achieving net-negative emissions in agriculture. Studies have observed a reduction in nitrous oxide, methane and carbon dioxide soil emissions, 78%, 92% and 85% respectively, when biochar was applied in combination with other soil amendments.[127]

Agricultural Land Management Practices

Compost Cropland Harvested Target (AG1)

- Apply compost to 4,150 acres per year of cropland harvested through 2030, then 12,700 acres per year through 2050

"Cropland harvested" refers to agricultural lands on which cash crops are grown and harvested.

How the targets were developed

The compost application target for cropland harvested by 2030 was set at 1% of the total cropland in New Jersey, while the target for 2050 was set at 3% of the total cropland in the state. This equates to the following subtotals by region:

1. Northern NJ – 750 ac/yr through 2030, 2,400 ac/yr through 2050
2. Central NJ – 1,100 ac/yr through 2030, 3,300 ac/yr through 2050
3. Southern NJ – 2,300 ac/yr through 2030, 7,000 ac/yr through 2050

Compost Cropland Pastured Target (AG2)

- Apply compost to 750 acres per year through 2030, then 1,950 acres per year through 2050

"Cropland pastured" refers to agricultural lands where uses rotate between cash crop harvest and livestock pasture.

How the targets were developed

The compost application target for cropland harvested by 2030 was set at 3% of the total cropland in NJ, while the target for 2050 was set at 8%. This equates to the following subtotals by region:

1. Northern NJ – 230 ac/yr through 2030, 600 ac/yr through 2050
2. Central NJ – 320 ac/r through 2030, 850 ac/yr through 2050
3. Southern NJ – 200 ac/yr through 2030, 500 ac/yr through 2050

Compost Permanent Pasture Target (AG3)

- Apply compost to 2,400 acres of permanent pasture per year through 2030, then 6,500 acres per year through 2050

"Permanent pasture" is land that is not cultivated because its maximum economic potential is realized from grazing or as part of erosion control programs. Animals may or may not be part of the farm operation for this land type.

How the targets were developed

Permanent pasture: the compost application target for permanent pasture by 2030 was set at 3% of the total permanent pasture in NJ, while the 2050 target was set at 8%. This equates to the following subtotals by region:

1. Northern NJ – 750 ac/yr through 2030, 2,000 ac/yr through 2050
2. Central NJ – 950 ac/yr through 2030, 2,600 ac/yr through 2050
3. Southern NJ – 700 ac/yr through 2030, 1,900 ac/yr through 2050

Near-term actions

- Create a map of cropland harvested, cropland pastured, and permanent pasture in NJ.
- Use the map to identify areas with carbon sequestration and storage potential.
- Find a funding mechanism to help support permitting of mid-scale composting.
- Explore regulatory changes to allow for outdoor composting.

- Explore regulatory changes to encourage the development of mid and small-scale composting operations.
- Collaboration with NJDEP, NJDA and Rutgers Agricultural Extension towards the development of regulatory plain language guidance for food waste composting and its end use on agricultural lands.

Cover Crop Targets for Cropland Harvested and Cropland Pastured (AG4)

- Plant cropland harvested and cropland pastured with cover crops, for a total of 9,850 acres by 2030 then 40,300 acres by 2050

Cover crops help to stabilize topsoil between cash crop growing seasons and sequester carbon from the atmosphere as part of photosynthesis. Cover crops are typically terminated before planting cash crops. Proper timing of cover crop termination is important to the success of this practice. Mechanical termination is one alternative to traditional herbicide termination.

Cover crops add aboveground and belowground biomass (roots), which enhances soil organic matter content and soil organic carbon under tillage systems and exposes the soil to fewer cultivation passes. The rate and extent of carbon storage are determined by a soil's physical and chemical properties, along with the climactic conditions of that region.[128] Carbon sequestration in sandier soils is limited but can be enhanced by selecting cover crops that accumulates high proportions of above and belowground biomass.[129] Extending the time before termination of cover crops and employing effective plant/cover crop residue management positively impact carbon storage. Crop Residue management (CRM) refers to an agricultural conservation practice that aims to reduce the intensity and frequency of field tillage operations, while also retaining portions of plant material (previous cash crop or cover crop) on the soil's surface.[130] CRM is designed with the intent of protecting soil from damage caused by erosive forces, compaction, and to increase the deposition of organic matter.[131] Incorporating cover crop mixtures by using a combination of grass and forbs species, is another practice that can effectively increase soil carbon content.[132]

Residue management is defined by how the producer, prior to planting the cash crop, utilizes the cover crop biomass (crop residue) grown in the field. Management techniques will depend on the types of cover crop(s) terminated, cropping system, equipment, and field conditions.130 Options for managing residues could include incorporation via cultivation, retention of residue (most frequently associated with a no-till operation), or a combination of the two. Management choices can significantly impact the amount of carbon sequestered by these practices.[133] Crop residues retained on the soil surface have shown minimal contribution to long-term soil carbon stores. However, root biomass (belowground residue) provides a direct input for carbon storage and slower rates of decay.[134]

How the targets were developed

Data from the 2020 USDA Census of Agriculture[135] was used to approximate the following baseline values, which were then increased to set region-specific targets:

1. In northern NJ, the baseline for cover crops is 0.7% of cropland harvested and cropland pastured. This value was scaled up to 1.5% of land (1,250 ac/yr) by 2030, and 10% of land (8,300 ac/yr) by 2050.
2. In central NJ, the baseline for cover crops is 1.4% of cropland harvested and cropland pastured. This value was scaled up to 2% of land (2,200 ac/yr) by 2030, and 10% of land (10,800 ac/yr) by 2050.
3. In southern NJ, the baseline for cover crops is 2.03% of cropland harvested and cropland harvested. This value was scaled up to 3% of land (6,400 ac/yr) by 2030, and 10% of land (21,200 ac/yr) by 2050.

Other agricultural land management practices that benefit carbon sequestration

There are several other ways to improve carbon sequestration in the agricultural sector. For livestock, pasture restoration, and fallowed cropland, such practices include rotational grazing, seeding select areas warm-season grasses, and diversification of cover crop mixes with perennial grains.

Rotational grazing involves a management system that allows livestock to graze only a portion of pasture while the remainder "rests." The pasture is subdivided into a series of smaller grazing areas (paddocks), and livestock are regularly moved from one paddock to another. In contrast, the conventional continuous grazing system, which is the most common, allows livestock access to pastured areas for long durations of the season. In rotational grazing, the number of paddocks, sizing, and configuration for each system can vary and will depend on the size of the pasture, livestock type, water access, and desired management objectives. Further, rotational intensity requires consideration of the types of pasture forage (forbs and grasses), variability of forage growth, herd size, seasonal growing constraints, and cumulative precipitation. There are many benefits to adopting these systems, not only from a plant and soil health perspective but also from a production efficiency and economic standpoint. Allocating rest periods to areas of pasture enhances above and belowground plant growth. As a result of increased root growth, forage will have greater tolerance to stress (drought, compaction, weed competition) and reduce soil erosion caused by overgrazing. Root access to soil mineral nutrients will provide higher nutritional quality to animals and improve the herd. Animal manures in these systems are more evenly distributed. Manure falls on the field and allows the return of nutrients directly into the soil, increasing soil OM content and reducing the need for fertilizer inputs.

Warm-season grasses are recommended for permanent pasture because they will better tolerate increasing temperatures from climate change. Seeding these varieties will enhance plant survival and, once established, produce large amounts of biomass. These native grasses can be applied as a complement to cool season grass pastures.[136]

Agro-forestry is an approach that utilizes numerous management practices, combining the cultivation of trees and shrubs with crops and livestock. These intensive practices are designed to allow additional plant growth on farms to sequester more carbon, creating many ancillary benefits for the crops, livestock, and the environment. Recommendations for agro-forestry include facilitating research of commercial scale projects and researching the net-GHG benefits of agro-forestry. NJDA should collaborate with the NJ Forest Service and the United States Department of Agriculture (USDA)-Natural Resource Conservation Service (NRCS) to develop and encourage producer enrollment in existing programs that provide technical and financial assistance for the implementation of agro-forestry practices on farms. There are many practices that can be implemented within an agro-forestry system. The design and implementation of these systems are often site-specific, have flexibility and the ability to incorporate multiple practices within the same site. Each approach has varying degrees of management intensity and commercial scaling ability. The recognized systems include alley cropping, silvopasture, riparian buffers, forest farming, and windbreaks.

Alley cropping is a practice that combines trees planted in single or multiple rows with agricultural or horticultural crops cultivated between tree rows. Riparian buffers can include forested buffers or areas, strips of grass, forbs, and shrub vegetation. These areas of permanent vegetation consist of trees, shrubs, and grasses and are commonly planted or managed adjacent to water bodies (lakes, wetlands, ponds, streams, or rivers), providing protection from erosion and non-point source pollution. Silvopasture integrates livestock and forestry by combining trees with forage (pasture) production, increasing carbon storage over traditional pasture. Silvopasture systems can be established by adding trees to an existing pasture or by thinning an existing forest stand. Windbreaks and variations of this practice (hedgerows, shelterbelts, timber-belts, and living snow-fences) are planted and managed as part of a crop or livestock operation. Cropping systems utilize this practice to protect plants that are sensitive to wind.[137] Forest farming is a method of production for high-value specialty crops, which are cultivated under the protection of a forest overstory. The forest has been modified to provide sustained timber production or induce a particular micro-climate condition. Crops commonly cultivated utilizing this methodology include shade-tolerant plants such as ginseng, medicinal botanicals, decorative ferns, and shiitake mushrooms.

Agricultural Recommendations for Policy Changes

Targets were developed utilizing existing USDA National Agriculture Statistics Service Census Data.[121] Though the current census information is thoroughly reported and documented, staff recognize the need for a more extensive questionnaire format. This could help determine which of the following practices are already being implemented such that "early adopters" can be adequately compensated. A more extensive questionnaire format could further identify the needs of our producers, establish parameters for further research, and elucidate pathways for funding and incentives.

The U.S. Department of Agriculture encourages climate-smart agriculture practices and provides specific funding opportunities for adopting these practices. Climate-smart practices "aim at conserving soil moisture, retaining crop residues for soil fertility, disturbing the soil as minimally as possible, and diversifying through rotation or intercropping." NJDA can work to encourage the adoption of climate-smart practices by developing cooperatives for producers and working with NRCS to increase the number of available Technical Service Providers who provide access to conservation assistance. Recommendations include securing or providing funding assistance for practices that increase soil health, climate-smart practices, and insuring farmers who change practices to increase carbon sequestration. One additional way to adapt to a changing climate is to initiate a state-specific breeding initiative for cover crops and cash crops. Selecting breeds that are best suited to New Jersey's current and future climate will help to ensure the success of these crops.

Knowledge gaps

- NJDA should gather baseline data on where climate-smart practices are already occurring, provide education and outreach to interested producers, and provide financial incentives for adopting rotational grazing and seeding warm-season grasses.
- NJDEP should also assess and consider updating its organic and food waste and composting regulations to revisit the organic requirements and the criteria that classify food waste and composting facilities.

DEVELOPED LAND

DEVELOPED LAND

34 percent of New Jersey's land area is covered by urban or developed lands. While much of that land area is occupied by buildings, roads, and other infrastructure, the shade trees, vegetated green spaces and green stormwater infrastructure mixed among the built structures have an outsized benefit for their relatively small area providing important services for communities and the environment. Benefits include decreased temperatures, improved aesthetics, and access to recreation. After adjusting to 2020 values, these urban and developed spaces are valued at $388 per acre annually or $575 million per year in 2004[60] by improving air and water quality, mitigating runoff from rainfall and flooding, reducing noise impacts, providing shade and cooler temperatures for communities, mitigating the impacts of urban heat island effect, and enhancing overall human health and well-being. These services can provide help provide essential relief to communities disproportionately impacted by climate change and mitigate other environmental justice concerns such as air and water pollution. The 178.7 million trees located within New Jersey's urban areas store approximately 26.9 million metric tons of carbon, and urban forests alone sequester about 1.03 million metric tons of carbon every year.[2] As a result, the US Climate Alliance rates urban and community forests within the top five natural climate solutions in New Jersey when it comes to carbon sequestration potential.

Considerations for all developed land targets

Creating and enhancing open space and improving urban lands are goals for developed lands. Much of the existing developed lands are covered in impervious surfaces and currently have a low potential for carbon sequestration without intervention and improvements. Green infrastructure elements, such as rain gardens and vegetative swales, can be easily added to developed lands to better manage stormwater runoff and flooding, and adding other co-benefits, such as carbon sequestration and help in mitigating urban heat island impacts. Street trees and other shade trees also provide carbon sequestration and some relief from urban heat island impacts, while tree trenches and tree boxes have the added benefit of managing stormwater runoff in impervious areas.

Green infrastructure practices have been around for years to aid in reducing local urban flooding, manage stormwater flows that enter sewage treatment plants, and treat stormwater before discharge directly to surface water bodies. More recently, green infrastructure has been valued for its other benefits, including addressing urban heat island impacts and its role in sequestering carbon. Provided that carbon sequestration projects on currently developed lands are well-planned and well-maintained, an increase in carbon sequestration should be attained.

Brownfield sites and other polluted sites typically have contaminated soils and/or historic fill that was contaminated before it was added to the site, necessitating remediation as part of site redevelopment. These sites are also commonly dominated by impervious surface cover and provide less carbon sequestration than vegetated sites with pervious surfaces. To remediate these sites, contaminated soils are often removed or capped with clean fill and topsoil to provide a healthy substrate for tree growth and vegetative cover. By cleaning up the soil where needed and transforming these abandoned properties into green spaces, there is potential to add carbon through plant and tree capture, as well as in amended soils, while improving stormwater management. In addition to these co-benefits, cleaning up contaminated sites eliminates sources of pollution.

Co-benefits

The co-benefits of rain gardens are numerous, including improved stormwater management to help mitigate flooding and improve water quality, reduced heat and heat island effects, improved local air quality, creation of wildlife habitat, and beautification of neighborhoods leading to higher economic value of surrounding properties. Overburdened communities can especially benefit from rain gardens as these areas have some of the greatest climate-related impacts and have the least amount of resources to mitigate the impacts of climate change. Vegetated swales bring similar benefits.

Trees provide many of the same benefits as rain gardens. All trees aid in nutrient and rainwater uptake, however tree trenches and tree boxes have an advantage over street trees, because they drain excess rainwater into a retention system. Brownfield sites that are converted into green spaces can provide many of these same benefits.

Brownfield sites are typically abandoned or underutilized industrial or commercial properties with high proportion of impervious surface coverage. Transforming brownfield sites into green open spaces can address many environmental and public health stressors in communities, including mitigate stormwater and/or tidal flooding, improved air quality, ameliorate urban heat temperatures, and improve public health outcomes. Reuse of brownfield sites also removes blighted areas of neighborhoods that improve the social and economic conditions in communities, including raising property values in the surrounding neighborhood and to provide valuable recreational opportunities. Co-benefits include remediation of contaminated sites include new plantings, soil remediation and amendments, improved stormwater management, reduction of heat (and heat island effects), better local air quality, increased the health of local people & wildlife, creating new wildlife habitat in developed areas, improving water quality in local waterways, lowering crime rates (DOI: 10.1093/aje/kwx096), beautification of neighborhood (leading to higher economic value of surrounding properties), and the ability to be implemented into small (crowded) developed spaces.

Potential Negative Impacts/Tradeoffs

Streets and sidewalks will need to be temporarily closed while installing rain gardens, planting street trees, or transforming brownfields. Communities will need to pay for the operation and maintenance of new parks, and for ongoing street tree maintenance to prevent damage to sidewalks, vehicles, and homes. Other property owners will need to maintain rain gardens, vegetative swales and other improvements on newly redeveloped lands. Brownfield redevelopment can be a catalyst for gentrification of distressed communities, so planning for those impacted by rising land values and rents should be considered for areas that undergo large-scale brownfield redevelopment.

Expected Impacts of Climate Change on Carbon Sequestration

Increased occurrence and duration of drought conditions from climate change may necessitate additional watering to keep plants in rain gardens and green spaces alive. Shifting ranges of flora and pests will necessitate careful selection of plants and trees. Native plant species should be planted to support local wildlife and provide root systems suited for the amount of precipitation that this region receives. Provided that the developed land carbon sequestration project is well-planned and well-maintained, increased temperatures and increased precipitation should allow for robust and increased carbon sequestration over time.

Additionally, many of the expected impacts of climate changes, including increased temperatures and increased local flooding from more intense precipitation events, will impact developed lands more than natural and other working lands. Therefore, from a social and environmental equity lens, developed lands should receive strong consideration for carbon sequestration projects, especially ones that have demonstrated co-benefits.

Environmental Justice Considerations

There are environmental justice concerns related to the burden of improvements. EJ communities typically have limited funds to maintain improvements such as new parks, rain gardens, vegetative swales, and street trees. Dedicated funding streams should be considered as part of project selection in these areas to ensure the maintenance of the improvements and investments in carbon sequestration.

For example, with respect to urban tree planting, despite the benefits of street trees, many residents in OBC's have concerns about the risks and costs assumed by residents over the course of a tree's life, the threat of gentrification associated with trees, limited plantable space, limited capacity for community members and leaders to take on planting and maintenance, and concerns about tree disservices (broken sidewalks, dangerous limbs, etc.).[138] It is imperative that tree planting goals within OBC's are discussed with community members and leaders prior to their implementation, and that support is granted to these communities for the long-term needs of tree stewardship.

There may also be concerns about gentrification in areas that undergo large-scale brownfield redevelopment activities. Good local redevelopment planning, and the use of equitable development principles should be part of the brownfield

redevelopment activities so those impacted by rising land values and rents can remain in these communities undergoing broad revitalization and gentrification.

Overall, developed areas, including OBCs will significantly benefit from climate-related investments across the state. These communities will especially benefit from local investments in carbon sequestration and other climate-related projects as these communities are currently experiencing many of the worst climate-related impacts, including increased air temperatures, poor air quality, stormwater flooding, and tidal flooding events. From an environmental and social justice perspective, these EJ communities should be prioritized for carbon sequestration and other beneficial climate-related investments.

Developed Land Management Practices

Afforestation Target (DL1)

- Plant and maintain 250,000 street and shade trees by 2030, and 1,000,000 trees by 2050

Afforestation of urban communities is recommended, with practices including the planting of street trees and other shade trees. Urban tree planting can maximize carbon benefits by planting the right tree species in the right places, and planting them on open soils or enhanced soil treatments. Urban and street tree placement is of the utmost importance as it ensures that tree growth and lifespan will not be impaired by power and phone lines, or by impervious surfaces like roads and sidewalks. This afforestation goal overlaps with the Forestry section, with the New Jersey Forest Service managing the state's Urban and Community Forests.

How the target was developed

The targets to plant 250,000 street and shade trees by 2030, and 1,000,000 trees by 2050, are set at high values based on the tree planting targets of surrounding states, and the variety of tree planting grant programs already in existence in the state.

Near-term actions

- Develop partnerships with communities interested in installing street trees tree trenches, and tree boxes.
- Identify funding sources and facilitate grants for tree planting.

Promote Urban Forests and Street Trees Through Stewardship Target (DL2)

- Enroll all municipalities that are eligible in Urban Stewardship programs by 2050.

Within urban and community forests, strategies can be implemented that maintain the health and safety of existing mature trees, thus protecting the existing urban forest carbon pool. The Urban and Community Forestry Program accomplishes this by encouraging municipalities and residents with trees on their private property to care for their trees through drought, by reducing pressure from insects and disease, and by performing structural and maintenance pruning. Such measures ensure that trees can establish quickly, grow to their full potential, and safely provide the maximum amount of ecosystem service benefits throughout their lifetime. UCF will encourage local governments to manage across and above municipal and county lines to maximize local forest, street tree, and park tree survivorship.2

How the target was developed

Currently, the NJ Forest Service's Urban and Community Forestry program has 254 approved management plans for enrolled municipalities in the state, meaning that approximately 45% of all municipalities in the State are enrolled in the program. NJ Forest Service aims to expand the program to support all municipalities in New Jersey in caring for their trees.

Near-term actions

- Enhance stewardship by annually developing 10 new municipality management plans, 10 new or updated inventory grants, and CORE training for 100 participating individuals.

- Continue to provide annual grants for tree planting & resiliency planning.
- Implement a consistent state-wide urban tree/forest inventory program.
- Expand Urban and Community Forestry grants program for urban tree planting & maintenance

Brownfield Redevelopment Target (DL3)

- Transform 20 brownfield sites or known contaminated sites (100 total acres) into green open space by 2030, and 200 sites (1,000 total acres) by 2050.

In urban areas of NJ there is a large inventory of vacant residential lands, brownfields, and contaminated sites available for improvement. Brownfields are vacant or underutilized former industrial or commercial sites that are presumed to be contaminated. They are typically characterized by impervious surfaces, abandoned buildings, and compacted soils. Under these conditions, there is little carbon sequestration, and the developed land does not serve a productive social or economic purpose.

Known contaminated sites and brownfield sites are found throughout the state, with a higher density occurring in older urbanized areas. There are currently about 14,000 known contaminated sites in the state, and potentially over 10,000 currently vacant or underutilized commercial or industrial brownfield sites. This type of land conversion eliminates sources of pollution while increasing the amount of carbon sequestered per unit area through new vegetation growth and enhanced soils. Contaminated compacted soils and/or impervious surface cover is typically removed at these sites and clean soil and topsoil is often placed on the remediated areas.

How the target was developed

The targets to transform 20 brownfield sites or known contaminated sites at a minimum of 100 acres into green open space by 2030 and 200 sites at a minimum of 1,000 acres by 2050 are constrained due to the current costs of remediation and redevelopment of these projects.

Near-term actions

- Update inventory brownfield sites that can be targeted for open space creation.
- Identify and improve funding opportunities to support the transformation of brownfield sites into open spaces.

Enhance Local Parks and Urban Schoolyards Target (DL4)

- Enhance older parks and urban schoolyards at 20 sites (50 total acres) by 2030 and 100 sites (250 total acres) by 2050.

Enhancement of local parks and urban schoolyards is recommended, as many older parks in developed areas could be improved with new plantings and soil amendments to improve tree growth and enhance recreational opportunities. Some of the existing urban parks are contaminated and will need to be remediated before they are enhanced. Additionally, there are many urban schoolyards that consist primarily of impervious surfaces that could be improved. This land enhancement can increase the amount of carbon sequestered per unit area through new vegetation growth and enhanced soils. These restored parks and schoolyards are essential community assets, and improving these areas will greatly improve the local quality of life.

How the target was developed

The target to enhance older parks and urban schools was developed by collaborative work the NJDEP Office of Brownfield and Community Revitalization is doing with local communities. Based on recent successes in Camden, the target for enhancing older parks and urban schoolyards is 20 sites (50 total acres) by 2030, and 100 sites (250 total acres) by 2050. The opportunities to enhance older parks and urban schoolyards are constrained due to the cost of investigation and possible remediation of these sites, and the cost of new playground equipment and new park features.

Near-term actions

- Work with overburdened communities on an inventory of older parks and urban schoolyards.
- Identify and improve funding opportunities to support open space and schoolyard improvements.

Soil Amendment Target (DL5)

- Amend soil through site remediation on 500 acres of land in developed areas by 2030 and 5,000 acres by 2050

When contaminated sites are cleaned up, soil is often removed or capped with clean fill and topsoil. The clean fill and topsoil are placed in landscaped areas of the redeveloped site to provide a healthy substrate for tree growth and vegetative cover. Soils can be further amended with the addition of organic material to improve vegetative growth. On urban restoration sites, afforestation has been found to increase soil carbon storage compared to degraded urban soils.[139] One advantage of this practice is its ability to be implemented in small, densely developed spaces.

Amendment is the process of incorporating materials into the soil to change properties such as drainage, soil structure, and rooting depth. Compost is a common amendment that can come from biosolids, manures, and yard or wood waste. Biosolids and manures are characterized by higher levels of nutrients such as nitrogen compared to vegetative waste. Compost is typically screened to remove large clumps before soil incorporation. For areas to be sodded, after on-site construction traffic has ended, compost is spread evenly over the surface to a depth of just over an inch. The area should then be tilled to a depth of 6 to 8 inches. For individual plants or trees, the planting holes should be individually amended with compost.[140] The goal is to improve growing conditions for vegetation by increasing available nutrients, while improving soil structure to improve water retention and allow roots to grow deeper, thereby sequestering additional carbon.

How the target was developed

The targets to amend soil through site remediation on 500 acres of land in developed areas by 2030 and 5,000 acres by 2050 were established based in part on the long-term historic rate of remediation. The opportunities to promote soil remediation with clean fill and topsoil improvements during the site remediation process are constrained by staff time to work more closely with responsible entities, private developers, municipal officials, and Licensed Site Remediation Professionals (LSRPs).

Near-term actions

- Work closely with responsible entities, private developers, municipal officials, and LSRPs in the development community to ensure that sites undergoing redevelopment enhance the existing soil conditions with soil amendments as part of the remediation activities.

Developed Land Recommendations for Policy Changes

NJDEP will focus on two priority areas for developed land - funding and research.

- NJDEP will identify external and internal funding sources to aid development of carbon sequestration projects such as brownfield redevelopment, park creation, enhancement of older parks and schoolyards, urban land restoration, green infrastructure, vegetative swales, street trees, and soil amendments.
- Research is needed to better quantify the carbon sequestration potential of developed lands. Research is also recommended to build further understanding of the many co-benefits of these projects in developed land areas.

Knowledge Gaps

- Studying carbon sequestration rates of improvements on developed lands.
- Research is needed to better quantify the carbon sequestration potential of developed lands. Research is also recommended to build further understanding of the many co-benefits of these projects in developed land areas.
- Evaluating the social, economic, and public health co-benefits of carbon sequestration projects in urban and EJ communities.

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