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Wetland Resource Considerations for A New Jersey Natural and Working Lands Strategy

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While individual participants of the Alliance do not necessarily agree with each and every insight outlined in this product, the Steering Committee concurs that the content of this report/product presents critically important issues facing New Jersey. The views expressed do not necessarily represent the official positions of participants of the New Jersey Climate Change Alliance or the funders who supported this work. Rutgers University serves as the facilitator of the Alliance and recommendations in the report do not represent the position of the University.

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Introduction

The New Jersey Climate Change Alliance (The Alliance) is a network of diverse public, private, non-governmental and academic organizations from across New Jersey facilitated by Rutgers University. The Alliance's goal is to provide science-informed climate change strategies for New Jersey. The Alliance's Natural and Working Lands Workgroup (NWLWG) charge is to identify areas to advance natural and working land strategies for climate mitigation.

In Fall 2021, the NWLWG convened a Wetland Workgroup to identify strategies to reduce/avoid emissions and enhance carbon storage and sequestration in New Jersey's wetland resources. The organizations represented in the Wetland Workgroup are listed in Appendix A.

This report summarizes the process and strategies from the Workgroup's efforts. These options can inform the New Jersey Department of Environmental Protection's (NJDEP's) Wetlands section of a Natural and Working Lands Strategy.

Wetlands and Carbon

New Jersey contains both tidal and nontidal wetlands. Freshwater wetlands are defined by state regulation (the *Freshwater Wetlands Protection Act* rules) as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation" (N.J.A.C. 7:7A-1.3). Tidal wetlands are defined by statute in New Jersey and refer to "any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the State of New Jersey" along a series of specified bodies of water or "at any inlet, estuary or tributary waterway or any thereof, including those areas now or formerly connected to tidal waters whose surface is at or below an elevation of 1 foot above local extreme high water, and upon which may grow or is capable of growing" specific plants identified by the state (see the *Wetlands Act of 1970* - N.J.S.A. 13:9A-2 for a complete definition of water bodies and plant species). Furthermore, under the *Freshwater Wetlands Protection Act* rules (N.J.A.C. 7:7A-1.3), NJDEP regulates any tidal wetlands that are not mapped under the *Wetlands Act of 1970* (N.J.S.A. 13:9A) as Freshwater Wetlands. As of 2015, New Jersey's total wetland acreage (tidal and nontidal) cover over 990,000 acres; New Jersey has lost approximately 60,000 acres or just over 5% of wetlands since 1986 (Lathrop & Hasse, 2020). Soil carbon estimates for New Jersey's wetlands are currently undetermined as limited data is available for certain wetland types (NJDEP, 2020). Recent work at Duke University estimated New Jersey's coastal marshes and seagrasses store around 25.3 million metric tons of carbon dioxide equivalent (Warnell, 2020), and a 2021 Coastal Carbon Research Coordination Network study estimates New Jersey's tidal wetland total carbon stock at 25.9 million metric tons of carbon (Holmquist et al., 2021), however, no data or estimates exist of nontidal / freshwater wetlands of New Jersey at this time.

Tidal and non-tidal wetlands provide ecosystem services and serve as some of the most important and efficient options for carbon sequestration and storage (Taillardat et al., 2020; Were et al., 2019; Nahlik & Fennessy, 2016). Tidal wetlands along the coast experience a range of salinities from fresh to saline and are important for carbon sequestration and storage. Methane, another important greenhouse gas, is produced in wetlands, but its production and subsequent emission is lower in saline waters. Non-tidal wetlands encompass freshwater emergent wetlands, seasonal wetlands such as floodplains and forested lands (swamps), and peatlands. Coastal and floodplains wetlands serve as flood protection and filter nutrients that cause algae blooms (i.e., events that caused oxygen depletion in aquatic systems, resulting in fish kills). Wetlands act as carbon sinks, removing more carbon from the atmosphere than they emit and storing it in the soil and vegetation (Moomaw et al., 2018; Villa & Bernal, 2018). Wetlands are estimated to hold more than 20% of the global soil carbon (Nahlik & Fennessy, 2016) and can store carbon for several hundreds of years to millennia (Were et al., 2019). Terrestrial wetlands in North America account for about 36% of global wetland carbon stock, and these carbon pools are relatively stable over short time intervals in undisturbed wetlands (Nahlik & Fennessy, 2016; Kolka et al., 2018).

Carbon sequestration is influenced by decomposition and mineralization of carbon-containing materials (Villa & Bernal, 2018). The water present in wetlands inhibits oxygen in the soil, slowing down the aerobic decomposition of plant material while allowing carbon to accumulate over time (Nahlik & Fennessy, 2016; Moomaw et al., 2018). However, the lack of oxygen creates conditions for methanogenesis (i.e., the creation of methane) which uses oxidized carbon found in anoxic conditions as a terminal electron acceptor. Methane is considered a more potent greenhouse gas than carbon dioxide (Lyu et al., 2018). Methane emissions are mitigated in tidal wetlands because of the presence of sulfates and aeration due to the cyclic rise and fall of tidal water levels in these wetlands (Nahlik & Fennessy, 2016). The high concentrations of sulfates in saline water results in tidal wetlands emitting non-methane decomposition gases such as hydrogen sulfide as sulfate-reducing bacteria outcompete methane-producing archaeans (methanogens) for energy sources (Megonigal & Neubauer, 2009; Poffenbarger et al., 2011; Villa & Bernal, 2018). Other drivers of methane emissions in tidal wetlands are poorly understood, but species composition, temperature, and tidal inundation all play a role (Knox et al., 2019; Al-Haj & Fulweiler, 2020; Trifunovic et al., 2020). Conversely, freshwater wetlands experience high rates of methanogenesis and are one of the largest natural sources of methane emissions globally (Knox et al., 2021), yet these wetlands appear to also experience anaerobic oxidation of methane, lowering their potential methane emissions by up to 50% (Segarra et al., 2015). The carbon sequestration potential of wetlands can diminish because of disturbances such as wetland drainage or filling and changes in abiotic factors (Villa & Bernal, 2018; Kolka et al., 2018). For example, reductions in salinity in tidal wetlands from disruptions to tidal flows from impoundments, dikes, and drainage lead to higher methane emissions (Kroeger et al., 2017). Likewise, sea-level rise will increase salinity further upstream of estuaries, inlets and tidal streams and will change the biogeochemistry in these freshwater wetlands, likely decreasing methane emissions (Luo et al., 2019; Megonigal & Neubauer, 2009). Higher temperatures will likely increase methane production, oxidation, and subsequent release; conversely, if more droughts occur and inland wetlands dry out periodically, this will decrease methane production and subsequent emissions (Altor & Mitsch, 2008; Knox et al., 2021). Methane production and release in any wetlands are tightly coupled processes, hence any increase or decrease in production will result in increase or decrease in release (Megonigal & Neubauer, 2009). Climate change and human management will thus have impact on the methane burden and carbon sequestration and storage potential of wetlands.

This report includes stakeholder-identified options from the Wetlands Workgroup to build on the work the state is already doing to maintain New Jersey's wetlands as carbon sinks.

Methodology for Strategy Identification

During the Fall of 2021, a survey was distributed to Workgroup members asking respondents to highlight current New Jersey wetland carbon sequestration strategies and identify themes, areas of importance, and strategy gaps with respect to New Jersey's wetland resources. The Workgroup also received copies of the New Jersey Global Warming Response Act 80 x 50 report and the New Jersey Wetland Program Plan 2019 - 2022 (herein referred to as the Wetland Program Plan) to identify existing New Jersey strategies to protect wetland carbon storage capacity.

Following the survey, reports from eight other states[1] and non-governmental organizations (NGOs) were also reviewed for carbon strategies for wetland resources. The reviewed reports included wetland program plans, climate plans, and natural and working land strategies. These strategies were compared to the existing New Jersey strategies to identify wetland actions for New Jersey to consider in a Natural and Working Lands Strategy. Appendix B shows this comparison.

The Workgroup then held a stakeholder meeting in November 2021 with 30 participants for an opportunity to discuss the strategy crosswalk, survey results, and additional wetland strategies. Professor Schäfer presented information on wetlands and their carbon sequestration ability, and NJDEP scientists provided an overview of the current Wetland Program Plan. An overview of the initial survey results was presented to the group as well. Attendees were encouraged to send additional input following the stakeholder meeting.

After the group's meeting, the 2021 Natural and Working Lands Strategy Scoping Document was released by NJDEP in December of 2021. The Scoping document has also been considered in the identified stakeholder options.

Stakeholder Identified Options for a New Jersey Natural and Working Lands Strategy for Wetlands

The options shown below are a synthesis of the wetland strategies identified by the Workgroup through the strategy crosswalk, survey, and stakeholder discussion. These strategies are grouped into four key areas: characterizing climate change and wetlands in New Jersey; actions to enhance carbon storage and sequestration; measuring progress; and data needs.

Key Area 1: Characterizing Climate Change and Wetlands

1. *Understand the extent of New Jersey wetlands*. Understanding what wetland resources New Jersey has requires a clear definition of what land types are considered wetlands, recognizing there can be a distinction between a regulatory delineation of a wetland and classification schemes for purposes of broader assessments. The strategy can define wetlands and call for updated maps of New Jersey's wetlands. For example, the USFWS National Wetlands Inventory in New Jersey was last updated in the late 2000s (U.S. Fish and Wildlife Service, 2007-2009). Updated maps can also establish an inventory of New Jersey's wetland resources and allow tracking of changes in wetland cover over time. As another example, the maps promulgated under the Wetlands Act of 1970 which are still used for regulatory purposes, become more inaccurate over time due to the effects of climate change and development.
2. *Understanding climate impacts on New Jersey wetlands*. The strategy can include details on the climate impacts to wetlands. Climate change impacts wetland salinity, temperature, water inundation, and oxygen, and these abiotic factors play a role in the carbon sequestration and storage ability of wetlands. Properly managing wetlands will require understanding how these abiotic factors will change under various climate projections and how this will influence the carbon sequestration potential of wetlands. Furthermore, overall assessment of structure, function and ecological health of wetlands are necessary to assess degradation and intervention as needed.
3. *Understand the potential for emissions reduction/avoidance and carbon storage and sequestration in New Jersey wetlands.* Pursuing strategies to maintain and enhance carbon

[1] California, Colorado, Connecticut, Delaware, Massachusetts, Nevada, North Carolina, and Oregon

sequestration and storage in New Jersey's wetlands would benefit from knowledge of the existing and future carbon sequestration and storage capacity of the state's wetlands. Different wetlands have different carbon storage potential requiring detailed information. For example, tidal wetlands and nontidal wetlands generally possess different carbon storage capacity as well as climate change threats (e.g., release of methane). Understanding and quantifying these differences can help identify vulnerable and priority areas for the state's strategies to protect and enhance ecological function and carbon sequestration capabilities.

Key Area 2: Actions to Enhance Carbon Storage and Sequestration in New Jersey's Wetlands

1. *Pursue protection of tidal and nontidal wetlands*. Protecting existing wetlands will help protect existing and potential future carbon stores and avoid emissions related to degradation. In pursuing wetland protection, a strategy can include efforts such as acquisition of land in fee or through conservation easements, incentivizing protection by private landowners, creating and updating wetland protection plans, supporting state regulatory programs, and identifying gaps in existing regulatory protections to analyze where and under what circumstances threats to wetland loss exist. Protection efforts could also be incorporated into land use planning/permitting, such as prioritizing avoiding impacts to highly functioning wetlands that provide ecosystem services such as flood mitigation, water quality improvement, coastal protection as well as carbon sequestration (Mitsch et al., 2012; Liu et al., 2021). Such highly functioning wetlands can be identified using data and assessment tools the state finds appropriate. For example, the NJDEP evaluated such tools alongside Rutgers University in a 2004 report Development of Wetland Quality and Function Assessment Tools and Demonstration. Protection measures can also consider updates to management practices, such as addressing the impacts of deer populations and invasive species on wetland carbon storage, as well as facilitating sea-level rise or climate change induced transitions among wetland types where beneficial or appropriate (e.g., protecting nontidal freshwater wetlands and facilitating their conversion to tidal wetlands by removing hydrological barriers). Deer forage in forested wetlands prevent regeneration, while invasive plant species can outcompete native trees (Hazelton et al., 2014). Management to protect the carbon sequestration value of trees could also consider restrictions on logging in wetlands and wetland transition areas.
2. *Pursue restoration and creation of tidal and nontidal wetlands*. Restoring, protecting and creating wetlands, including adjacent areas that can serve as inland migration zones for coastal wetlands, can help expand the carbon sequestration and storage potential of New Jersey's wetlands. The state can pursue a variety of approaches to accomplish wetland restoration and creation.
    a. Pursue active planting and maintenance to restore nontidal and tidal wetlands. For example, Duke University created a 10,000-acre carbon farm on formerly drained pocosin peatlands in 2018 to help meet the University's goal of carbon neutrality by returning these non-tidal wetlands to their natural state (Duke University, 2018). New Jersey could pursue similar restoration efforts (for example, on state or other preserved lands) to increase long-term carbon storage such as, for example, replanting tidal mudflats that help carbon accretion and provide more protection from sea-level rise.
    b. Define what dredge materials are appropriate for use and use such material in tidal wetland restoration and creation, where conditions disallow production of excess methane and acid sulfate soils. Across the country, several hundred million cubic feet of sediment is dredged each year, and this material can be used for the development of wetland habitats (Environmental Protection Agency, n.d.). New Jersey can use dredge

material to reduce tidal wetland losses and protect inland habitat and infrastructure from sea-level rise (Liu et al., 2021).

   c. Prioritize land purchased through the NJDEP Blue Acres Program for wetland creation, restoration and/or enhancement. Blue Acres purchases flood prone properties, demolishes the existing buildings, and then leaves the land as open space. The land provides an opportunity to reestablish wetlands with wetlands specific flora and create new carbon storage capacity for the state. For tidal wetlands, Blue Acres might also be a way to preserve or re-establish marsh migration space (i.e., upslope locations that marshes might occupy in the future given rising sea levels) in urban or suburban areas.
   d. Restore tidal flow by removing or right-sizing dams and culverts that would help restore former tidal wetlands. This would potentially help municipalities prepare for sea-level rise and address related flooding and erosion issues. In some cases, this will speed conversion of currently non-tidal freshwater wetlands to tidal systems, which in turn might help mitigate methane emissions but also change ecosystem functions and values. Assessing possible opportunities and advancing pilot projects could help identify best opportunities and create partnerships with other state and local agencies.
   e. Evaluate opportunities to re-establish previously altered wetlands during development or redevelopment activities as a condition of regulatory approvals. Such opportunities for restoration could also be explored as part of natural resource damage assessments resulting in multiple benefits of carbon sequestration, flood mitigation, and hazard reduction in overburdened communities.
   f. Continue efforts to restore Atlantic White Cedar swamps on public and private lands in upland areas that are not vulnerable to sea-level rise.
3. *Explore wetland carbon markets*. Carbon markets may offer a financial incentive for opportunities to increase carbon sequestration in New Jersey wetlands. For example, the Sacramento-San Joaquin Delta Conservancy developed an avoided emissions protocol for the delta aimed at incentivizing rewetting of delta soils; the Conservancy is conducting pilot projects to demonstrate the protocol’s feasibility (Sacramento-San Joaquin Delta Conservancy, n.d.; I. Campbell, personal communication, December 2, 2021). As another example, American Carbon Registry has a carbon offset methodology for wetland restoration in the Mississippi Delta (American Carbon Registry, n.d.). These methodologies could serve as potential models or resources for New Jersey.
4. *Pursue regulatory updates for tidal wetlands*. Update state regulations to reflect climate change and sea-level rise in permit decisions, including buffer area protection, and consider supplementing platform sediment and replanting wetlands to maintain elevation relative to sea-level rise. Wetland elevation enhancement would continue to protect adjacent areas from storms, particularly where wetland migration is not possible.

Key Area 3: Measuring Progress

1. *Conduct baseline study* to measure current carbon stocks and sequestration rates and monitor consecutive increases in carbon.
2. *Conduct pilot projects to demonstrate the carbon sequestration and ecosystem benefits of different wetland restoration techniques.* Pilot projects provide an opportunity to evaluate viability and clarify unknowns surrounding each technique.
3. *Create a Statewide wetlands inventory.* On a regular basis, conduct and update an inventory of wetlands that would also include land ownership (private and public) to help inform management strategies.

4. *Continue to support and expand existing New Jersey coastal wetlands monitoring programs* like the Mid-Atlantic Coastal Wetlands Assessment.

Key Area 4: Data and Related Needs

1. *Additional information on the state's existing wetlands*. This includes wetland condition, type, location, extent, ownership, elevation, soil/sediment depth, carbon storage potential, sediment accretion rates, expected climate change impacts, land use history, and soil composition including carbon density. Further data on carbon storage potential can help understand potential differences in functionality between recently created wetlands, historic created wetlands, and natural wetlands. Existing information can be synthesized, through a combination of measured data, literature values and modeling into a clearinghouse of information for decision makers and planners.
2. *The role of wetland soil profiles in carbon storage*. Describing and mapping the distribution of various wetland soil types in New Jersey provides exceptional context to soil carbon storage potentials. Additionally, different soil types reflect various components of physical and chemical soil properties that can be considered when designing restoration projects. For example, when dredged materials containing sulfide-bearing minerals are placed on wetlands, they can create acid-sulfate soil conditions with reduced pH if left dry and exposed to oxygen (USDA Natural Resources Conservation Service, 2019). The extremely acidic conditions which result can inhibit vegetation growth, decreasing carbon storage. and creating additional environmental issues. Understanding these different chemical and physical soil properties can inform management decisions. Gaining this understanding for New Jersey's wetlands will likely require more accurate Coastal Zone Soil Mapping (i.e., tidal marshes, subaqueous soils, and nearshore soils).
3. *Wetlands vulnerable to sea-level rise and candidate locations for inland migration*. Determining which wetlands are vulnerable to sea-level rise and where vulnerable wetlands have space to migrate inland can inform management decisions and highlight priority areas. This analysis can build upon work conducted by scientists in the region. An evaluation of concomitant implementation policies such as management techniques to facilitate this migration could be conducted. These analyses and information could be developed in concert with state, local and nonprofit planning and preservation efforts.
4. *Wetlands impacts on water thermal regulation and microclimates.* More data are needed on the role of wetlands in regulating water and air temperature in urban areas. As the impacts of climate change continue, understanding how wetlands can combat rising temperature may influence the strategies pursued for wetlands. This type of data can be collected as part of future wetland restoration projects.
5. *Maintain an inventory of wetlands projects with carbon sequestration implications.* A variety of projects for wetlands carbon sequestration are in process across New Jersey by groups such as Duke Farms, the American Littoral Society, and Partnership for the Delaware Estuary that could provide lessons across the state. The state can maintain a list of these efforts and the organizations completing them to allow for collaboration, knowledge sharing and enhanced communication between organizations. An existing resource for these efforts is the NJDEP's Coastal Ecological Restoration and Adaptation Plan tool.
6. *Most cost-effective methods for wetland preservation and restoration*. For example, evaluating restoration of hydrology to modified agricultural wetlands, deer management, or the utility of phragmites revegetation as an alternative to native species where native species recovery is not feasible. With this information New Jersey can prioritize the most cost-effective methods in a Natural and Working Lands strategy.

7. *Additional data on submerged aquatic vegetation, including seagrass*. More information is needed on the distribution of seagrass and its carbon storage potential in New Jersey. Seagrass meadows, a type of subtidal coastal wetland chiefly in the Barnegat Bay, have the potential to store carbon. In the freshwater tidal corridor of the Delaware River, expanses of subtidal submerged aquatic vegetation also pose a similar carbon storage benefit. Current efforts to monitor, study, and restore these systems need further support.

Prioritizing Efforts

Feedback from the Workgroup included criteria for prioritizing wetlands for maintaining and increasing carbon storage and sequestration. The criteria are listed below.

- Prioritize wetlands with the greatest carbon sequestration potential. One approach is evaluating wetlands for those that sequester the most carbon per unit of area (i.e., identifying wetlands that are accreting at the highest rate). Precise data for this approach are not yet available for New Jersey but could be obtained.
- Wetlands at greatest risk of:
    - Sea-level rise
    - Development
    - Drought.
- Wetlands providing high degree of co-benefits such as:
    - Flood mitigation
    - Nutrient mitigation / filtration
    - Biodiversity conservation
    - Endangered species habitat.

Implementation Considerations

The workgroup identified considerations for implementing a Natural and Working Lands Strategy that address barriers to achieving carbon sequestration through wetlands initiatives.

- *Evaluate the funding pathways for implementing and monitoring progress of the strategies*. Funding pathways include the resources and the personnel necessary to implement strategies. Implementing these options requires available resources and existing expertise.
- *Determine the feasibility of potential strategies*. Conduct cost-benefit analyses comparing the feasibility of each strategy to the benefits achieved. Feasibility could include the economic, ecological, and political viability of each strategy.
- *Consider the net gain or loss of wetlands*. Incorporate considerations for net carbon gain or prevention of net carbon loss in permitting decisions.
- *Consider regulatory changes to enable enhancement of carbon sequestration in wetlands*. The Clean Water Act federally mandated species composition of restored wetlands does not allow for example *Phragmites* to exceed a 5% cover; however, this species has been shown to stabilize wetland substrates and enhance sediment elevation (Weis et al., 2021). Where project goals dictate or where native species recovery is deemed infeasible, allowing *Phragmites* to revegetate naturally to a higher cover limit might be a suitable alternative. This could be especially true when carbon sequestration and flood abatement are primary goals and attempts at *Phragmites* eradication do more harm than good.

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Appendix A: Organizations Represented in the Natural and Working Lands Workgroup

***Denotes those Whose Representatives Participated in the Wetland Working Group**

AKRF Inc.*
American Littoral Society*
Amy Greene Environmental*
Barnegat Bay Partnership*
C-Change Conversations*
Drexel University
Ducks Unlimited*
Duke Farms*
Fairleigh Dickinson University*
Great Swamp Watershed Association*
Honey Brook Organic Farm
Hunterdon Land Trust*
Isles, Inc.
Jim Lyons, Consultant*
Mercer County Park Commission
Natural Resources NJ Sports and Exposition Authority*
The Nature Conservancy of NJ*
NJ Audubon
NJ Conservation Foundation*
NJ Department of Agriculture*
NJ Farm Bureau*
NJ Food Democracy Collaborative*
NJ Forest Service
NJ Future
NJ Highlands Coalition*
NJ Shade Tree Federation
NJ Sports and Exposition Authority*
NJ Tree Foundation
NJDEP Bureau of Climate Resilience*
NJDEP Bureau of Climate Change & Clean Energy*
NJDEP Division of Science and Research*
NJDEP Office of Natural Lands Management*
NJDEP Office of Natural Resource Restoration*
Northeast Organic Farming Association of NJ
North Jersey Resource Conservation & Development*
NY-NJ Harbor& Estuary Program*
Partnership for the Delaware Estuary*
Pew Charitable Trusts *
Pinelands Preservation Alliance*
Princeton Hydro*
PSEG*
Raritan Valley Community College*
Rutgers University*
Terhune Orchards*
The Nature Conservancy - NJ
USDA Natural Resource Conservation Service*

USDA Natural Resource Conservation Service Cape May Plant Materials Center*
US Environmental Protection Agency*
US Fish and Wildlife Service*
The Watershed Institute*

Appendix B: Comparison of New Jersey Strategies with Strategies of Other States and NGOs

NJ	Other States and NGO
The type of wetland (tidal or nontidal) each strategy applies to follows each strategy in brackets.	*The type of wetland (tidal or nontidal) each strategy applies to follows each strategy in brackets.*
State Policy	State Policy
NJ Wetland Program Plan: Continue to improve upon existing wetland protection efforts under our assumed freshwater wetland program; develop more clearly definable coastal wetland protection standards; improve regulatory permit and data management processes to maximize efficiency and transparency; increase attention on mitigation processes, protocols and monitoring; strengthen coordination between permitting and enforcement programs and develop and implement public outreach services. **NOTE**: **This strategy does not include carbon sequestration, but it is included for comparison to the adjacent CT strategy.** [Tidal and Nontidal Wetlands]	CT: To encourage protection of wetlands, update and develop wetland protection policies, including regulatory programs, to ensure they include protection for climate change mitigation, adaptation, and resiliency benefits of wetlands near coastal waters. Updating policy/laws examples include strengthening the Inland Wetlands and Watercourses Act and Tidal Wetlands Act to specifically mentioned the importance of wetlands in carbon sequestration. Identify legislative policy modifications that would facilitate the implementation of adaptation strategies at sufficient scale to effect change. [Tidal and Nontidal Wetlands] (Wetlands Subgroup, 2020)
NJ 80 X 50 Report: Develop a Blue Carbon Action Plan that includes goals, a comprehensive list of blue carbon projects within the state, project prioritization criteria and monitoring policies [Tidal Wetlands]	
NJ 80 X 50 Report: Create a voluntary wetland stewardship program, similar to federal programs that incentivize restoration and stewardship on private lands such as the Natural Resources Conservation Service's Wetlands Reserve Program. - The NRCS's Wetlands Reserve Program provides technical and financial support to landowners for wetland restoration. Eligible lands include farmed wetlands; prior converted cropland; farmed wetland pasture; certain lands with potential to become a wetland; rangeland, pasture or forest production lands where hydrology has been severely degraded and could be restored; riparian areas that link protected wetlands; lands adjacent to protected wetlands; and wetlands that have previously been restored that need long-term protection. [Wetland Type Not Specified]	

NJ 80 X 50 Report: Extend Marine Conservation Zone to seagrass beds. [Tidal Wetlands]	
NJ 80 X 50 Report: Set reforestation, wetland revegetation and urban reforestation goals for the state. Explore the potential to reforest less agriculturally productive lands (agricultural modified wetlands) on preserved farms. [Wetland Type Not Specified]	
Blue Carbon Markets and Accounting	Blue Carbon Markets and Accounting
NJ 80 X 50 Report: Evaluate adopting a blue carbon market to provide funding for wetland conservation and restoration in the state. [Tidal Wetlands]	NGO: CARB can facilitate the development of new carbon markets for wetland restoration by reviewing and adopting a wetland restoration protocol as part of the state's cap-and-trade program. CA could approve accounting protocols developed by voluntary climate registries and use them in the State's cap-and-trade program [Wetland type not specified] (Chamberlin et al., 2020)
NJ Wetland Program Plan: Develop tools to inform the Blue Carbon program (Regional Greenhouse Gas Initiative) How: - Support and participate in NRCS's efforts to better map tidal wetland soils in New Jersey and evaluate blue carbon potential - Develop new tools to identify, design, construct and monitor blue carbon projects [Tidal Wetlands]	
Wetland Protection	Wetland Protection
NJ Wetland Program Plan: Establish long term wetland protection through acquisition by continuing to acquire conservation easements or acquire land in fee that includes wetlands as well as associated uplands for wetland-dependent wildlife and continuing to pursue grant opportunities for wetland acquisition [Wetland Type Not Specified]	CT: Prioritize acquisition of land and conservation easements for ecosystem services most at risk from climate change, leveraging Connecticut's Green Plan and open space grant programs to encourage protection of wetlands (GCE Governor's Council on Climate Change, 2021) and acquire land to provide upslope advancement zones next to tidal marshes (Wetlands Subgroup, 2020) [Tidal and Nontidal Wetlands]
	CO, NGO: Pursue avoided conversion CO: Implement or improve wetland protection plans to avoid conversion of wetlands to protect stored carbon. The focus is on protection of wetlands over restoration because the report cites an article stating 80-90% of carbon lost in

	conversion cannot be regained through restoration efforts making preservation a better option for preserving carbon stocks. (Brandt et al., 2017) NGO: Tidal and Nontidal Wetlands] (Ahlering, et al., 2021)
	NC: Protect wetlands by incentivizing the protection of coastal wetlands and migration corridors to allow for landward migration and using conservation easements and innovative acquisition strategy to secure priority coastal wetland habitat [Tidal Wetlands] (North Carolina Department of Environmental Quality, 2020a)
	MA: Protect inland and coastal wetlands [Tidal and Nontidal Wetlands] (Executive Office of Energy and Environmental Affairs, 2020)
	ME: Conserve coastal and marine areas (including wetlands and marshes) to preserve their carbon-storage value [Tidal Wetlands] (Maine Climate Council, 2020)
	OR: Oregon Department of Land Conservation and Development established a no net loss of intertidal and tidal marshes [Tidal Wetlands] (Oregon Global Warming Commission, 2021)
Wetland Restoration	Wetland Restoration
NJ 80 X 50 Report: Reforestation of wetlands and "other" lands that were historically forested via active planting and maintenance [Wetland Type Not Specified]	CA: Create saline tidal wetlands in coastal regions and freshwater wetlands in the Sacramento-San Joaquin Delta. No specifics on how the state will accomplish this. [Tidal and Nontidal Wetlands] (California Environmental Protection Agency et al., 2019)
NJ Wetland Program Plan: Increase wetland acreage through wetland restoration and creation and improve wetland conditions and functions through enhancement - Develop site specific plans for wetland restoration, creation and enhancement projects and monitor completed projects - Evaluate tracking of 1) acres of wetlands restored, created and enhanced and 2) the level of or improvements in function/condition based on wetland	CA: Support wetlands restoration and protection projects that sequester carbon, allowing California's natural resources to benefit from California's carbon market and/or projects that reduce anticipated impacts of climate change [Wetland Type Not Specified] (California Wetland Interagency Team, 2017).

indicators [Wetland Type Not Specified]	
NJ 80 X 50 Report: Salt marsh and seagrass restoration and enhancement to maintain and increase carbon sequestration [Tidal Wetlands]	NGO: Pursue wetland restoration by restoring inland and coastal wetlands to avoid emissions from drained soils and increase carbon stocks by ensuring funds are appropriated for wetland restoration [Nontidal and Tidal Wetlands] (Chamberlin et al., 2020)
NJ 80 X 50 Report: Pilot projects to demonstrate the carbon sequestration and other ecological benefits of living shorelines, beneficial use of dredged material, seagrass restoration, and other tidal wetland restoration techniques [Tidal Wetlands]	MA, NC, NGO: Pursue wetland restoration for - inland and coastal wetlands (Executive Office of Energy and Environmental Affairs, 2020) - wetlands, particularly those that support forest cover to ensure wetlands will be a carbon sink, not a carbon source (North Carolina Department of Environmental Quality, 2020a) NGO: (Ahlering, et al., 2021) [Tidal and Nontidal Wetlands]
	ME: Restore coastal and marine areas (including wetlands and marshes) to preserve their carbon-storage value [Tidal Wetlands] (Maine Climate Council, 2020)
	OR: Increase restoration and protection of carbon-rich tidally influenced coastal ecosystems through investments in updating estuary management plans and conservation and restoration of tidal wetlands [Tidal Wetlands] (Oregon Global Warming Commission, 2021)
	NV: Expand specific programs to restore and enhance habitats, including wetlands, with measurable carbon sequestration co-benefits [Wetland Type Not Specified] (State of Nevada Climate Initiative, 2020)
Data Gaps, Research and Monitoring	Data Gaps, Research and Monitoring
NJ 80 X 50 Report: Identify areas where salt marshes are expected to move/form inland as sea level rises and evaluate policies to protect these areas from development and impediments to tidal flow. [Tidal Wetlands]	DE: Conduct research to better understand the potential loss of carbon storage if expansive tidal emergent wetlands are converted to open water and improve methods to estimate the natural range of carbon storage [Tidal Wetlands] (Delaware Department of Natural Resources and Environmental Control, 2020)
NJ 80 X 50 Report: Develop blue carbon best management practices based on pilot projects and lessons learned from projects in other states. [Tidal Wetlands]	CT: Develop a habitat suitability model for restoring inland and coastal wetlands, identifying areas which provide the greatest increase in ecosystem benefits when protected or restored. Ecosystem benefits

	include carbon sequestration, habitat, reduced shoreline erosion, reduced flooding, infrastructure protection, nutrient reduction, improved water quality, and enhanced recreational opportunities. [Tidal and Nontidal Wetlands] (Wetlands Subgroup, 2020; GCE Governor's Council on Climate Change, 2021)
NJ Wetland Program Plan: Identify the components of tidal marsh and forest systems that enhance carbon sequestration. How: - Summarize research on different wetland types on capacity for carbon sequestration, and create a provisional map of aerial extent of potential carbon sequestration based on wetland types utilizing LULC and other GIS data including coastal wetlands mapping and FIA forest type data [Tidal and Nontidal Wetlands]	CT: Develop quantitative metrics of the ecosystem services provided. For example, how much carbon storage/sequestration, denitrification does a wetland habitat support. [Tidal and Nontidal Wetlands] (Wetlands Subgroup, 2020)
NJ Wetland Program Plan: Identify by mapping tidal marsh and forest system features where restoration, enhancement and protection of these features maximizes carbon sequestration. How: - Using provisional map of existing carbon stock by coastal and forested wetlands, identify areas where future impacts may compromise the carbon sequestration potential and restoration, or enhancement are feasible - Identify areas best suited to wetland protection based on carbon sequestration value and climate model predictions of habitat change over time - Using the SLOSH and New Jersey FloodMapper tools, create a map of future wetlands by type based on climate scenarios for coastal zones predicted to be impacted by sea level rise and storm surge [Tidal and Nontidal Wetlands]	CT: Encourage research to understand the effects of potential adaptation approaches and develop new, innovative approaches to support adaptive management by: - Developing strategies for quantifying all major ecosystem services likely to be affected by climate change and monitoring guidelines for each service. - Quantifying current services and project effects of climate change under different adaptation strategies. Services include carbon storage and sequestration, denitrification, flood control, pollutant removal, biodiversity protection, and recreational opportunities. [Tidal and Nontidal Wetlands] (Wetlands Subgroup, 2020)
	DE: Improve understanding of, and promote possible use of blue carbon value system for coastal wetlands as it relates to climate change [Tidal Wetlands] (Delaware Department of Natural Resources and Environmental Control, 2020)
	MA: Continue to help develop the latest blue carbon mapping and inventory techniques while monitoring potential increases in methane emissions from degraded wetlands [Tidal Wetlands] (Executive Office of Energy and Environmental Affairs, 2020)

	ME: Conduct a coastwide survey of coastal environments (like salt marshes, seaweeds, and seagrass beds) to determine where and how much blue carbon can be stored [Tidal Wetlands] (Maine Climate Council, 2020)
	ME: Explore the opportunity for formal blue-carbon storage incentives or carbon-permit program to encourage blue-carbon habitat conservation and restoration [Tidal Wetlands] (Maine Climate Council, 2020)
	NC: Develop ways to facilitate private, state, and federally owned land pathways to provide migration corridors for coastal wetlands and other coastal habitats to preserve the coastal protection and carbon benefits including identifying potential areas for buyouts and determining state and private programs that could hold and manage acquired lands [Tidal Wetlands] (North Carolina Department of Environmental Quality, 2020a)
	OR: Invest in improvements in inventory data and research. Specific to blue carbon: - Development of a comprehensive map of restored, restorable and least disturbed tidal wetlands - Completion of more consistent mapping of submerged aquatic vegetation in all Oregon estuaries and of kelp in Oregon’s territorial waters - Research to better understand the sequestration benefits of protecting and restoring eelgrass and kelp forests [Tidal Wetlands] (Oregon Global Warming Commission, 2021)