The National Estuary Program Is Playing a Major Role in Tackling Nutrient Pollution

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Disclaimer

The findings reported herein are made available for informational purposes only.

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1. Overview

Nutrient Challenges and NEPs

Nutrient pollution is one of the nation's most widespread, costly and challenging environmental problems. Excess nitrogen and phosphorus (nutrient pollution) enters the environment from both point sources such as wastewater treatment plants (WWTPs) and municipal separate storm sewer systems (MS4), and nonpoint (diffuse) sources such as agricultural and stormwater runoff and faulty septic systems. Nutrient pollution in the U.S. impacts 65% of the nation's major estuaries and has been shown to cost the U.S. at least $2.2 billion annually.[1] Nutrient pollution in the U.S. coastal waters can cause or contribute to overgrowths of algae that result in harmful algal blooms (HABs). HABs can negatively impact human and pet health, aquatic ecosystems, and local economies, costing the U.S. economy an estimated $82 million annually.[2] Nutrient pollution may also contribute to coastal acidification and hypoxia, which can negatively affect coastal ecosystems and marine organisms, such as corals and commercially-important shellfish.

Established by the Clean Water Act Section 320, the National Estuary Program (NEP) improves the waters and habitats in the 28 designated estuaries of national significance. NEPs function under a unique governance structure called a Management Conference that gives local partners a voice in the decision-making process. NEPs collaborate with, and coordinate among stakeholders at all levels – federal, state, county, city, and citizen – to ensure that local issues are managed. The process brings all stakeholders to the table to work out solutions that are consensus-driven and based on sound science.[3]

The NEPs work with hundreds of partners nationwide, using non-regulatory programmatic solutions to improve and protect water quality and address nutrient pollution. The NEPs are supporting activities targeting both point and nonpoint sources of pollution to their estuaries. These activities include, but are not limited to the following:

- Monitor and assess water quality and habitat conditions;
- Conduct research, collect data, quality control and evaluate data, and develop/apply models to ascertain environmental concerns including eutrophication, HABs, coastal acidification, hypoxia and others;
- Design tailored solutions to reduce pollution entering waterways;
- Develop and implement best management practices;
- Provide funding support for activities ranging from septic upgrades to water quality monitoring,
- Provide technical assistance, outreach and education, and publications (success stories, reports);
- Support collaborations (e.g., councils, programs, consortia) that address nutrient issues;
- Support the implementation of watershed-side nutrient reduction plans;
- Promote the use of innovative green infrastructure and low-impact development at the local and landscape scale; and
- Engage the private sector as partners.

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[1] Source: EPA Nutrient Indicators Dataset

[2] Source: Ocean Health Index: Nutrient Pollution

[3] This description of the NEP's governance structure was taken from the Indian River Lagoon NEP's webpage. All 28 NEPs have a Management Conference with representatives from multiple stakeholder groups.

The NEPs' efforts to address the high priority nutrient pollution problem also support core Clean Water Act programs. These activities are well-aligned with the aims of the Clean Water Act Section 402, National Pollutant Discharge Elimination System (NPDES), which regulates stormwater discharges from municipal storm sewer systems (MS4s) and establishes discharge limits and conditions for discharges from wastewater treatment and industrial facilities, among other activities. Efforts to address nutrient pathways such as septic systems, sewer overflows, stormwater and surface runoff are complementary to the Nonpoint Source (NPS) Section 319 Program, which provides modest funding to reduce, eliminate or prevent water pollution resulting from polluted runoff and enhance water quality in impaired waters. Additional relevant Clean Water Act programs in the context of nutrient management include the Water Quality Monitoring Section 106(b) grant program – which targets funds to support enhanced monitoring efforts by states, interstate agencies, and tribes to monitor and report on water quality – and Total Maximum Daily Loads (TMDLs), which identifies the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards. Lastly, the work of NEPs supports state efforts in the development of water quality criteria (Clean Water Act Section 304(a)) and water quality standards (CWA Section 303(c)). In addition, through addressing habitat degradation, the NEPs support wetlands protection and restoration.

The NEPs are implementing highly successful community-based approaches to watershed management, including significant efforts to tackle nutrient pollution. This report quantifies the results of these efforts in several ways and uses specific examples to illustrate the effectiveness of the NEP approach to address nutrient pollution and improve water quality.

Roadmap

This report presents quantified reductions in nutrient loadings and dollars leveraged for nutrient management; it also describes qualitatively the benefits of the NEP's unique governance structure and management approach. The source for the quantitative estimates (nutrient loadings and leveraged dollars) is EPA's National Estuary Program Online Reporting Tool (NEPORT). NEPORT is a database that NEP staff use for reporting on habitat and leveraging. The methodologies employed for using the NEPORT data are described in the relevant sections of this report. The qualitative information in this report comes from NEPORT and other available information about NEP activities.

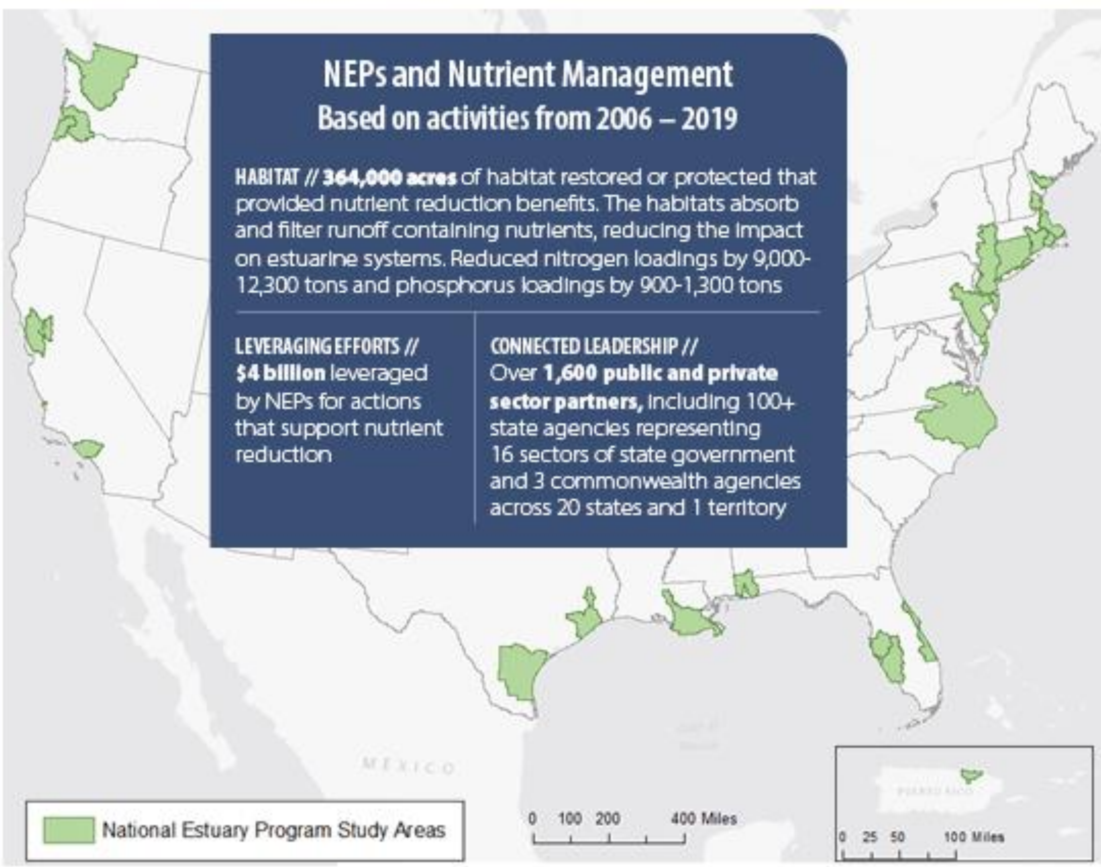
The following pages illustrate the NEP's overall impact in addressing nutrient pollution across the U.S. These include nutrient reduction benefits from habitat restoration and protection, leveraging of funds by individual NEPs to support nutrient management efforts, and the extensive partnering with public and private stakeholders through a network governance model that delivers connected leadership.

Each of these aspects of the NEP's contributions toward addressing nutrient pollution is fully described in the subsequent sections of this report. Section 2 quantifies nutrient reductions achieved through NEP-supported habitat protection and restoration projects. Section 3 quantifies funds leveraged for nutrient management that would not have happened without the NEP. Section 4 describes the benefits of the NEP's "connected leadership approach." Appendix A provides additional details about the nutrient reduction methodology.

HOW THE NATIONAL ESTUARY PROGRAM IS TACKLING NUTRIENT POLLUTION

Nutrient pollution in the United States impacts 65% of the nation's major estuaries and has been shown to cost the U.S. at least $2.2 billion annually. Harmful algal blooms caused by nutrient pollution in U.S. coastal waters cost the U.S. economy an estimated $82 million annually. Nutrient pollution may also contribute to hypoxia and coastal acidification that impacts coastal ecosystems and marine organisms, including corals and commercially-important shellfish.

Through non-regulatory, consensus-based programs, NEP leaders have contributed to 894 nutrient management actions since 2006.

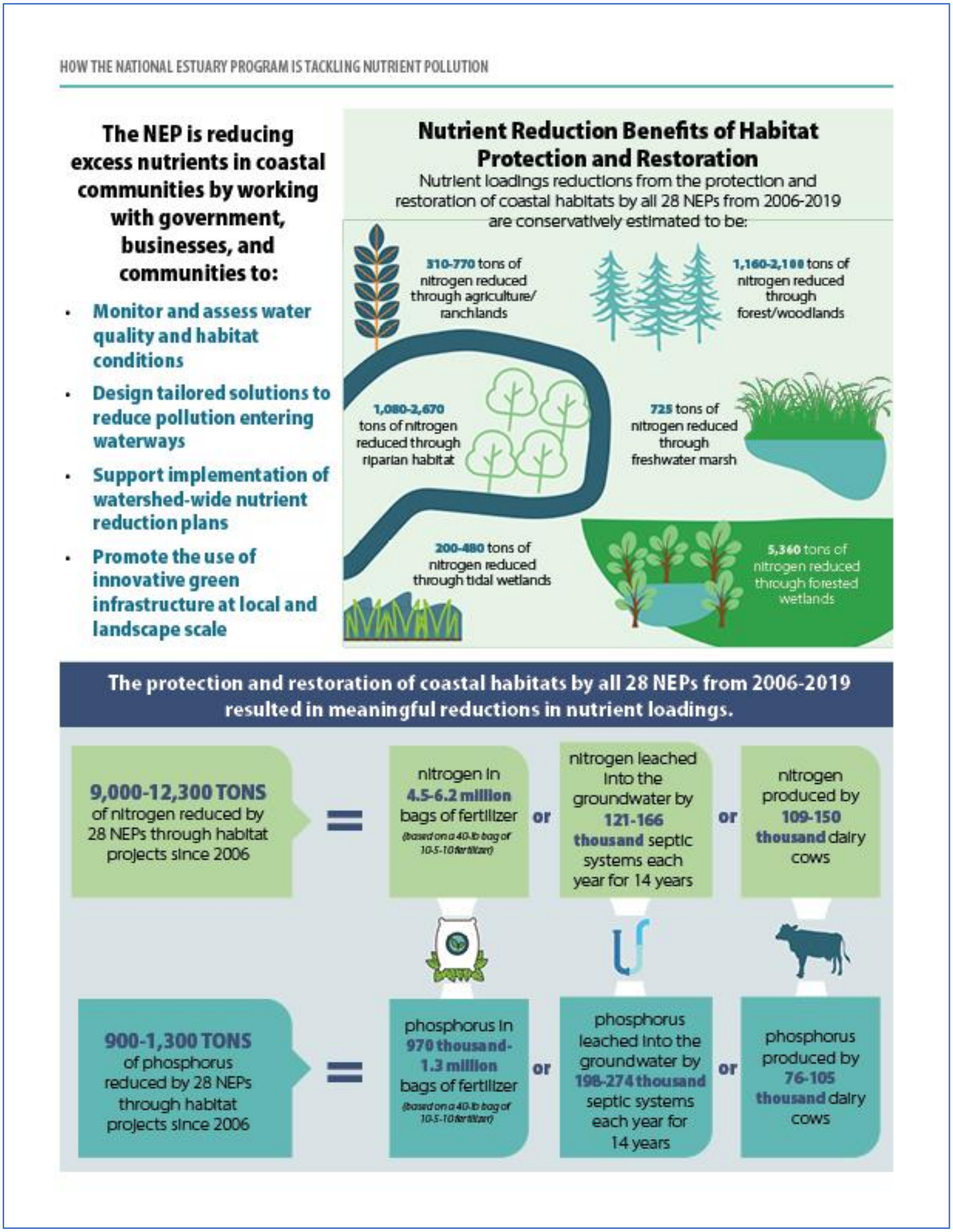


NEPs and Nutrient Management
Based on activities from 2006 – 2019

HABITAT // 364,000 acres of habitat restored or protected that provided nutrient reduction benefits. The habitats absorb and filter runoff containing nutrients, reducing the impact on estuarine systems. Reduced nitrogen loadings by 9,000-12,300 tons and phosphorus loadings by 900-1,300 tons

LEVERAGING EFFORTS // $4 billion leveraged by NEPs for actions that support nutrient reduction

CONNECTED LEADERSHIP // Over **1,600 public and private sector partners,** including 100+ state agencies representing 16 sectors of state government and 3 commonwealth agencies across 20 states and 1 territory


HOW THE NATIONAL ESTUARY PROGRAM IS TACKLING NUTRIENT POLLUTION
The NEP is reducing excess nutrients in coastal communities by working with government, businesses, and communities to:
Monitor and assess water quality and habitat conditions
Design tailored solutions to reduce pollution entering waterways
Support implementation of watershed-wide nutrient reduction plans
Promote the use of innovative green infrastructure at local and landscape scale
Nutrient Reduction Benefits of Habitat Protection and Restoration
Nutrient loadings reductions from the protection and restoration of coastal habitats by all 28 NEPs from 2006-2019 are conservatively estimated to be:
310-770 tons of nitrogen reduced through agriculture/ ranchlands
1,160-2,100 tons of nitrogen reduced through forest/woodlands
1,080-2,670 tons of nitrogen reduced through riparian habitat
725 tons of nitrogen reduced through freshwater marsh
200-480 tons of nitrogen reduced through tidal wetlands
5,360 tons of nitrogen reduced through forested wetlands
The protection and restoration of coastal habitats by all 28 NEPs from 2006-2019 resulted in meaningful reductions in nutrient loadings.
9,000-12,300 TONS of nitrogen reduced by 28 NEPs through habitat projects since 2006
=
nitrogen in 4.5-6.2 million bags of fertilizer (based on a 40-lb bag of 10-5-10 fertilizer)
or
nitrogen leached into the groundwater by 121-166 thousand septic systems each year for 14 years
or
nitrogen produced by 109-150 thousand dairy cows
900-1,300 TONS of phosphorus reduced by 28 NEPs through habitat projects since 2006
=
phosphorus in 970 thousand-1.3 million bags of fertilizer (based on a 40-lb bag of 10-5-10 fertilizer)
or
phosphorus leached into the groundwater by 198-274 thousand septic systems each year for 14 years
or
phosphorus produced by 76-105 thousand dairy cows

HOW THE NATIONAL ESTUARY PROGRAM IS TACKLING NUTRIENT POLLUTION

Leveraging Efforts for Effective Nutrient Management

Nutrient pollution enters the environment from both point sources such as wastewater treatment plants, and nonpoint (diffuse) sources such as agricultural runoff and urban stormwater. Working with their partners, NEPs have supported projects targeting both point and nonpoint sources of pollution to their estuaries.

Partnerships make the NEP stronger, and through collaboration from 2006 to 2019 the NEPs have leveraged:

Connected Leadership

Each NEP has a Management Conference that consists of diverse stakeholders and uses a collaborative, consensus-building approach. The Management Conference functions as a network governance model that delivers connected leadership. It is the connected leadership framework that enables each NEP to implement the NEP directives in Section 320 of the Clean Water Act, leverage partner resources, and restore clean water and healthy estuaries through non-regulatory action.

CONDUCT RESEARCH AND DEVELOPMENT

The NEPs study pathways and effects of excess nutrients on ecosystems and find innovative and optimal solutions to reduce nutrients. All 28 NEPs conduct water quality monitoring tied to nutrient pollution, harmful algal bloom source monitoring, and pollution tracking.

CASE STUDY // San Juan Bay Estuary Program: Initiated a $1.4M 3-year study in 2015 through Clean Water State Revolving Fund (SRF) to identify illicit discharges contributors of nutrients and pathogens in the watershed and their impact to public health. To date, San Juan Bay Estuary Program has leveraged greater than $3 million from SRF to continue the work.

FINANCE NUTRIENT REDUCTION ACTIVITIES

Partnerships make the NEP stronger, and through collaboration with a national network of over 1,600 public and private sector partners the 28 NEPs have leveraged funds that support nutrient reduction activities.

CASE STUDY // Indian River Lagoon NEP: Citizens of Brevard County, FL, an investment partner in the NEP, passed a half-cent sales tax referendum in 2016 that dedicated 100% of revenues to IRL projects that improve water quality and restore habitats. It will collect over $400 million over 10 years.

IMPLEMENT MARKET-BASED APPROACHES ON A WATERSHED SCALE

The NEPs work with state, federal and national organizations to reduce impacts of nutrient pollution and support shared understanding on how to successfully implement the Clean Water Act. The NEPs partner with various organizations to reduce nitrogen loads on a watershed scale through creative market-based approaches (i.e., Water Quality Trading and Nitrogen Trading).

CASE STUDY // Long Island Sound Study: Worked with New York and Connecticut to adopt bi-state TMDLs and develop a nitrogen-trading program among 79 sewage treatment plants, resulting in a 42 million pound nitrogen reduction.

CONDUCT OUTREACH

The NEPs work with partners to promote education and outreach that communicates latest science and creates public awareness of causes, effects, and solutions to nutrient pollution. They perform outreach to encourage homeowners and communities to care for and maintain septic systems.

CASE STUDY // Sarasota Bay NEP: Communicate science-based information on nutrient pollution to coastal communities - including through products like the NEP's Red Tide fact sheet on how to reduce personal nitrogen pollution.

DEVELOP PARTNERSHIPS

The NEPs work with state, federal, and national organizations to reduce impacts of nutrient pollution and support shared understanding on how to successfully implement the Clean Water Act. They partner with agencies, environmental groups, and scientists to analyze data.

CASE STUDY // Santa Monica Bay NEP: Works with state and local partners to leverage $16.5 million to design and implement a complex stormwater infiltration and retention project for the city of Culver. Construction began in 2019 on a system capable of capturing/treating storm runoff from a drainage area of 800 acres. The NEPs work with partners to promote education and outreach that communicates latest science and creates public awareness of causes, effects, and solutions to nutrient pollution. They perform outreach to encourage homeowners and communities to maintain septic systems.

PROVIDE SUPPORT TO STATES

The NEPs support states in developing and refining water quality standards, reporting on water quality conditions, listing impaired waters, and developing TMDLs. They partner directly with 100+ state agencies and 3 commonwealth agencies representing 16 sectors of state government across 20 states and 1 territory - including the agencies overseeing state and interstate water programs.

CASE STUDY // Maryland Coastal Bays Program: The program's Science Techcnical Advisory Committee worked with the state and University of Virginia to revise the Maryland Coastal Bays nutrient TMDLs (approved in 2014). MCBP is working with Worcester County to develop CWA section 319 watershed management plans to address nutrients in all subwatersheds.

2. Nutrient Reduction through Habitat Protection and Restoration

The NEPs work with their local, state, and private sector partners to improve and protect water quality by restoring coastal and estuarine habitat. Many of these projects provide additional services for coastal communities and ecosystems – including creating habitat for commercially important species, protecting shorelines from erosion/storm surge and restoring natural hydrology. Between 2006 and 2019, the NEPs restored or protected over 414,000 acres (equivalent to the combined area of Zion and Rocky Mountain National Parks) that provide water quality benefits.

Much of these habitat areas are created by investments in conservation actions, including through the creation of conservation easements and acquisition of coastal and estuarine lands that provide downstream water quality benefits. Since 2006, the NEPs have protected 392,800 acres of coastal and estuarine habitat through conservation land practices. Other efforts created 2,300 acres of shellfish habitat; planted 4,100 acres of estuarine shoreline, riparian area, wetlands and marsh habitat; and restored 14,900 acres of shoreline through erosion control.

Methodology

This section of the report examines and quantifies how NEPs' habitat protection and restoration activities help reduce nutrient loadings. Below is a brief description of how total nitrogen and phosphorus reductions were calculated, followed by a detailed step-by-step methodology. See Appendix A for a detailed description of the approach for estimating the nutrient reductions along with a breakdown of each ecoregion's calculations.

Classification of NEPs into Ecoregions

The nutrient reduction analysis focuses on quantifying the extent of nutrient reduction achieved through NEP efforts to restore or protect different types of habitat. The first step in the analysis involved defining different ecoregions by grouping NEPs by ecoregions that are in similar climates/geographic locations where habitats will have similar nitrogen removal rates (stated in the literature as denitrification or nitrogen retention). The NEPs are divided into ecoregions as follows:

1. **Northeast (Regions 1 and 2):** Casco Bay Estuary Partnership, Piscataqua Region Estuaries Partnership, Narragansett Bay Estuary Program, Buzzards Bay NEP, Massachusetts Bays NEP, Long Island Sound Study, Peconic Estuary Partnership, New York-New Jersey Harbor & Estuary Program, Barnegat Bay Partnership. (Note: San Juan was excluded from these calculations because it is not in the same climate/region as the Northeast.)
2. **Mid-Atlantic (Region 3)**: Partnership for the Delaware Estuary, Delaware Center for the Inland Bays, Maryland Coastal Bays
3. **Southeast/Gulf of Mexico/Caribbean (Regions 2, 4 and 6)**: Indian River Lagoon NEP, Tampa Bay Estuary Program, Sarasota Bay Estuary Program, Coastal & Heartland National Estuary Partnership, Mobile Bay NEP, Albemarle-Pamlico National Estuary Partnership, Coastal Bend Bays and Estuaries Program, Galveston Bay Estuary Program, Barataria-Terrebonne NEP, and

San Juan Bay Estuary Program. (Note: San Juan Bay Estuary Program was added to this category from Region 2 because the southeast is the ecoregion most closely resembling Puerto Rico's climate.)

4. **California Coast (Region 9)**: San Francisco Estuary Partnership, Morro Bay NEP, Santa Monica Bay NEP
5. **Pacific Northwest (Region 10)**: Puget Sound Partnership, Lower Columbia Estuary Partnership, Tillamook Estuaries Partnership

Identification and Conversion of NEP Habitat Projects to Nutrient Reductions

Determination of Habitat Acres Contributing to Nutrient Reduction

For each ecoregion, EPA identified relevant NEP habitat projects that contributed to nutrient reduction. All NEPs track the annual number of acres of habitat protected or restored and report on this measure via NEPORT. NEPORT contains data for all NEP habitat projects, which have a variety of benefits. Because there is no category specifically designated for "nutrients projects," a filter was applied to screen for habitat restoration and protection projects with characteristics typically associated with nitrogen and phosphorus reduction. Though we cannot state that acres of habitat associated with these projects were protected, planted or restored for the sole, or even primary, purpose of managing nutrients, our filtering criteria suggest these acres substantially contributed to nutrient reduction.

The criteria for identifying projects associated with nutrient reduction included those with one of the following restoration techniques that are associated with nutrient reduction: easements, erosion control, land acquisition, planting, rain garden creation, rehabilitation/creation, stormwater/runoff controls, or vegetation buffer. Additionally, in order to qualify as contributing to nutrient reduction, projects must also cite to improve or protect water quality as one of the project benefits listed.

Habitat Selection and Nutrient Reduction Rate Determination

After this filtering technique was applied, the projects contributing to nutrient reduction were filtered by habitat within each pre-determined ecoregion. If habitats within an ecoregion met an acreage threshold (outlined below in the Methodology), they were determined to represent a relative level of significance based on distribution.

This process focused the literature review, which was conducted to compile data regarding the nutrient removal rates of nitrogen (TN) and phosphorous (TP) in habitats restored, protected or acquired for each of the different geographic regions. The results of this review, listing the habitats for which data on nutrient removal rates were and were not available from peer-reviewed literature, can be found in the appendix (Exhibit A-2). The appendix also contains tables that summarize the nitrogen (Exhibit A-3) and phosphorus (Exhibit A-4) removal rates found in the literature for each of these ecoregion-specific habitats.

Converting NEPORT Habitat Acres to Nutrient Reduction Estimates

The total acres restored or protected contributing to nutrient reduction from 2006-2019 were multiplied by each ecoregion's habitat removal rates found in the literature to determine pounds of nutrients reduced. These pound values were then converted to U.S. tons to better reflect the level of certainty associated with the assumptions used in the analysis.

Detailed Step-By-Step Methodology

Determination of Habitat Acres Contributing to Nutrient Reduction

1. Filter for NEPORT projects in which easements, erosion control, land acquisition, planting, rain garden creation, rehabilitation/creation, stormwater/runoff controls, or vegetation buffer are listed as the restoration technique. Select these first so that they do not go unchecked as filtering continues in future steps. (Note: After regional review of this report, one project was added by Region 6 for Barataria-Terrebonne National Estuary Program. Though it did not have any acres contributing to nutrient reduction after an initial filtering following our methodology, this forested wetland project was added after an argument was made for why this project with the Restoration Technique "Other" should be included as contributing to nutrient reduction.)
2. Select for NEPORT projects in which to "improve or protect water quality" is listed as a project benefit. Because multiple project benefits can be listed for any project, first unselect all project benefits. Next, type "improving or protecting water quality" into the column's search box and select all projects where these key words are mentioned.
3. Separate NEPs into ecoregions based on geographic location and climate as outlined in Sec. 2-1 "Classification of NEPs into Ecoregions." Select the EPA regions that are encompassed by the ecoregion you are filtering for. (Note: If searching for the Northeast, select EPA Regions 1 and 2. Because San Juan Bay Estuary Program is excluded from the Northeast ecoregion, deselect San Juan Bay Estuary Program from the NEP column. Likewise, if searching for the Southeast/Gulf/Caribbean, select EPA Regions 2, 4, and 6. Because San Juan Bay Estuary Program is the only Region 2 NEP included in this ecoregion, deselect Barnegat Bay Partnership, New York-New Jersey Harbor and Estuary Program, and Peconic Estuary Partnership from the NEP column.)

Habitat Selection and Nutrient Reduction Rate Determination

4. Filter for each habitat in each ecoregion and sum the acres for qualifying projects by habitat. Habitats with greater than 700 acres restored or protected from 2006-2019 were selected for that ecoregion. The 700-acre threshold was selected by examining the acres of habitat across all regions and selecting a value that represented a relative level of significance based on the distributions. Using this threshold value served to focus the literature review for nutrient removal rates on those habitats that were likely to have a larger presence and more significant impact within each region.
5. Perform a literature review to compile data regarding the nutrient removal rates of total nitrogen (TN) and total phosphorus (TP) in habitats restored, protected, or acquired in different geographic regions. We used net N and P retention rates (inputs – outputs) for each habitat

within each ecoregion. (Note: sometimes, nutrient reduction rates were not available in the literature for every qualifying habitat within an ecoregion).

Converting NEPORT Habitat Acres to Nutrient Reduction Estimates

6. Multiply the total acres restored or protected contributing to nutrient reduction for each qualifying habitat in an ecoregion by each ecoregion's mean habitat removal rates found in the literature to determine amount of nutrients reduced. Where there are multiple literature rates, find the mean and standard error to provide a range of values following the equation: (qualifying habitat acres*mean nutrient removal rate) ± (qualifying habitat acres *standard error).

Results

The results of this analysis of nutrient reduction from NEP activities reflect habitat protection and restoration projects conducted between 2006 and 2019 and nutrient reduction values represent the sum of estimated annual, not cumulative, reductions.

Exhibit 2-1 presents the total acres restored or protected by NEPs that met the filtering criteria for project benefits and restoration techniques. Although it is not possible to know whether the acres associated with these projects were restored or protected for the purpose of reducing nutrients, the filtering criteria suggest that these acres do contribute to nutrient reduction. Acres protected were included in this analysis because protecting habitats that would otherwise become developed or destroyed prevents the nutrient load that would occur without their presence. Of the nearly 364,000 acres restored or protected, roughly three-fourths are in the Southeast/Gulf/Caribbean region and 15 percent are contributed by the Northeast. The California Coast contains six percent of the restored or protected acres while the Mid-Atlantic and Pacific Northwest each contain about three percent of the restored or protected acres. This may be because each of these two ecoregions contain relatively few NEPs. Habitat protection and restoration is just one contributor to nutrient reduction, and all of the ecoregions, particularly the Mid-Atlantic and Pacific Northwest, reduce loadings through other mechanisms not quantified in this section.

Exhibit 2-1. Total acres restored or protected by NEPs that met the nutrient filtering criteria, by ecoregion.

Ecoregion	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
Northeast	53,443
Mid-Atlantic	11,332
Southeast/Gulf/Caribbean	266,856
California Coast	21,977
Pacific Northwest	10,140
Total	**363,748**

The total acres restored or protected contributing to nutrient reduction were multiplied by each ecoregion's mean habitat removal rates found in the literature to determine amount of nutrients reduced. Where there is a range of values, this represents the average of multiple mean literature rates plus or minus one standard error. The total estimated reductions from NEP habitat project are approximately 9,000 to 12,300 U.S. tons of TN and 900 to 1,300 U.S. tons of TP. These values are presented by habitat type and ecoregion in Exhibits 2-2 and 2-3. The largest reductions resulted from projects related to forested wetland, riparian, forest/woodland and freshwater marsh habitats. By ecoregion, the largest reduction occurred in the Southeast/Gulf/Caribbean, followed by the Northeast and California Coast.

Exhibit 2-2. Estimated annual reductions in Total Nitrogen and Total Phosphorus produced by NEP restoration/protection of various habitats in all ecoregions from 2006 to 2019.

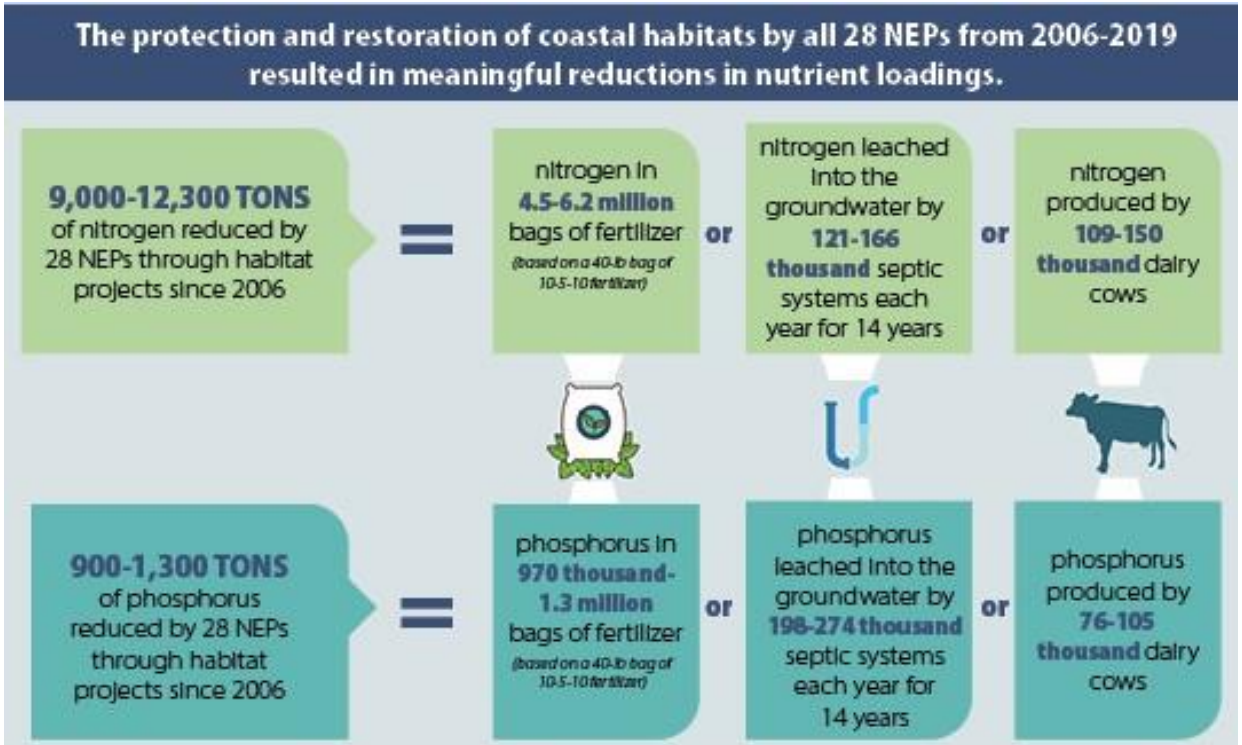
Habitat	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Agriculture	542 ± 234	122 ± 62
Forest/Woodland	1,628 ± 468	190 ± 30
Forested Wetland	5,361	637
Freshwater Marsh	724	44
Grassland	207 ± 34	120 ± 92
Mangrove	3	-
Riparian	1,874 ± 793	43 ± 2
Tidal Wetland	338 ± 141	-
SAV (Submerged Aquatic Vegetation)	N/A	N/A
Total	**10,677± 1,670**	**1,156 ± 186**

Exhibit 2-3. Estimated annual reductions in Total Nitrogen and Total Phosphorus produced by NEP habitat restoration/protection projects implemented in each ecoregion from 2006 to 2019.

Ecoregion	Estimated TN Reduction (U.S. tons) from 2006-2019	Estimated TP Reduction (U.S. tons) from 2006-2019
Northeast	1,650 ± 460	346 ± 30
Mid-Atlantic	259 ± 27	12 ± 2
Southeast/Gulf/Caribbean	7,318 ± 375	678 ± 62
California Coast	744 ± 181	120 ± 92
Pacific Northwest	706 ± 627	N/A
Total	**10,677 ± 1,670**	**1,156 ± 186**

To demonstrate the significance of the estimated nutrient reductions from NEP habitat restoration and protection, Exhibit 2-4 converts them into common sources of nutrient pollution – content of millions of bags of fertilizer, leaching from thousands of septic systems, and production by thousands of dairy cows.

Exhibit 2-4. Equivalents to estimated annual reductions in total nitrogen and total phosphorus produced by habitat restoration/protection projects implemented in all ecoregions from 2006 to 2019.



Case Studies

The case studies highlighted in this section provide selected examples of NEP habitat restoration and protection efforts that support nutrient reduction. These activities include supporting community-based projects to engage volunteers in restoration projects, undertaking scientific investigations to inform future restoration efforts, engaging in public/private partnerships to reduce nutrient loadings from point and nonpoint sources, and assisting in acquiring key habitat to provide water quality benefits.

- **Galveston Bay Estuary Program (GBEP) – Marsh/Wetland.** Marsh Mania is a community-based project supported by GBEP and led by their partner organization the Galveston Bay Foundation. The first Marsh Mania event in 1999 was a huge success that set a national record when 1,500 volunteers planted nearly 70,000 stems of smooth cordgrass and earned two awards: the Governor's Award for Environmental Excellence in the civic/nonprofit category and the First Place Gulf Guardian Award in the civic/nonprofit category from the Gulf of Mexico Program. The program is still growing, having been held for more than 20 consecutive years. During this time, 8,200 community volunteers have helped restore approximately 212 acres of vital salt marsh habitat at 97 sites around Galveston Bay.[4]

[4] Source: https://www.tceq.texas.gov/assets/public/legal/sep/galveston_bay_foundation.pdf

- **GALVESTON BAY ESTUARY PROGRAM (GBEP) – SALT MARSH AND MANGROVE.** With its partners, GBEP has investigated the relationship between freshwater inflows and harmful algal blooms in Galveston Bay; surveyed the health of restored salt marshes and mangrove strands to inform future restoration efforts; and assessed the variability in sediment and nutrient transport in freshwater inflows from rivers to the Bay.[5]

- **TAMPA BAY ESTUARY PROGRAM (TBEP) – SEAGRASS.** TBEP's nitrogen reduction work has led to increases in seagrass beds beyond the CCMP recovery goal. As of 2018, Tampa Bay now has 40,652 acres of seagrass. This is accomplished through TBEP's facilitation of the public/private Tampa Bay Nutrient Management Consortium (NMC). The NMC established recommended caps on all nitrogen sources (more than 180 individual point and nonpoint sources) within the Tampa Bay watershed. In turn, these nitrogen load allocations have been adopted by the State of Florida Department of Environmental Protection (FDEP) through Water Quality Based Effluent Limits and have been incorporated into National Pollution Demonstration Elimination System discharge and Municipal Systems permits. Annual water quality results indicate that Tampa Bay is meeting numeric nutrient criteria in all bay segments most every year. As a result, the FDEP has reclassified all Tampa Bay segments from "nitrogen impaired but managed" (category 4b) to "waterbody has attained water quality standards and targets for designated uses and no longer impaired" (category 2) for total nitrogen. The Tampa Bay estuary was a degraded ecosystem from the 1960s through the 1980s, but its water quality has been largely restored and is currently meeting State Water Quality standards for nutrients for its designated uses.[6]

- **PUGET SOUND PARTNERSHIP (PSP) – TIDAL WETLANDS.** In 2010, PSP participated in the acquisition of 3,160 acres of tidelands in Livingston Bay, on the southeast side of Camano Island, which is a critical stop for waterfowl and other migratory birds on the Pacific Flyway. The Bay also provides vital estuarine rearing habitat for salmon, steelhead, cutthroat trout, and other commercially important fish species. The Livingston Bay conservation project provides water quality benefits for these important species. Today, the site also serves as a feasibility study to determine preferred alternatives to address publicly maintained culverts by engaging private homeowners and other stakeholders to determine the best way forward to restore habitat and protect water quality and private property.[7]

[5] Source: GBEP Program Evaluation Letter
[6] Source: TBEP, Program Evaluation Letter
[7] Source: Information provided by EPA Office of Wetlands, Oceans and Watersheds staff

3. Leveraging Efforts

Partnerships make the NEP stronger, and through collaboration the NEPs have leveraged over $4 billion for nutrient management from 2006-2019. Section 3 provides the methodology, results, and case study highlights for the NEPs' leveraging efforts for effective nutrient management.

Methodology

The leveraging analysis uses leveraged funding data from NEPORT.[8] The leveraging portion of NEPORT is used to report financial or in-kind resources above and beyond the CWA Section 320 grant and line items that the NEP director and staff had some role in directing toward CCMP implementation. Leveraged resources include resources administered by the NEP or NEP partners. Examples include Section 320 match, grants obtained by the NEP, and bonds that the NEP played a role in directing toward CCMP implementation. The leveraged resources do not correspond to habitat project costs because these are two separate reporting mechanisms.

The NEPORT leveraging data was used to estimate dollars leveraged toward nutrient management. The leveraging methodology was as follows:

1. Filter for projects in which NEPs played primary roles (role name of primary).[9]
2. Filter the resulting projects by contribution to nutrient management. In order to calculate these contributions, we only considered projects leveraged primarily by NEPs that included investments (>0%) in managing Nonpoint, Combined Sewer Overflow (CSO), Stormwater, and Wastewater.
3. Multiply the proportion of investment in each type of management by the project's grand total amount (total cash which include in kind contributions) to calculate the estimated dollar value leveraged for each type of management.
4. Sum each category's total leveraged dollars to obtain a nutrient management subtotal for that category.
5. Sum across category subtotals to get the total dollars leveraged toward nutrient management.

Results

First, we look at projects with primary leveraging contribution toward nutrient management in the context of all primary leveraged projects. Funds leveraged toward nutrient management represent a significant share of total funds leveraged by the NEPs. Between 2006 and 2019, NEPs leveraged a total of $6.3 billion for projects where the NEP played a primary role. Of that amount, $4 billion (64 percent) was invested toward nutrient management.

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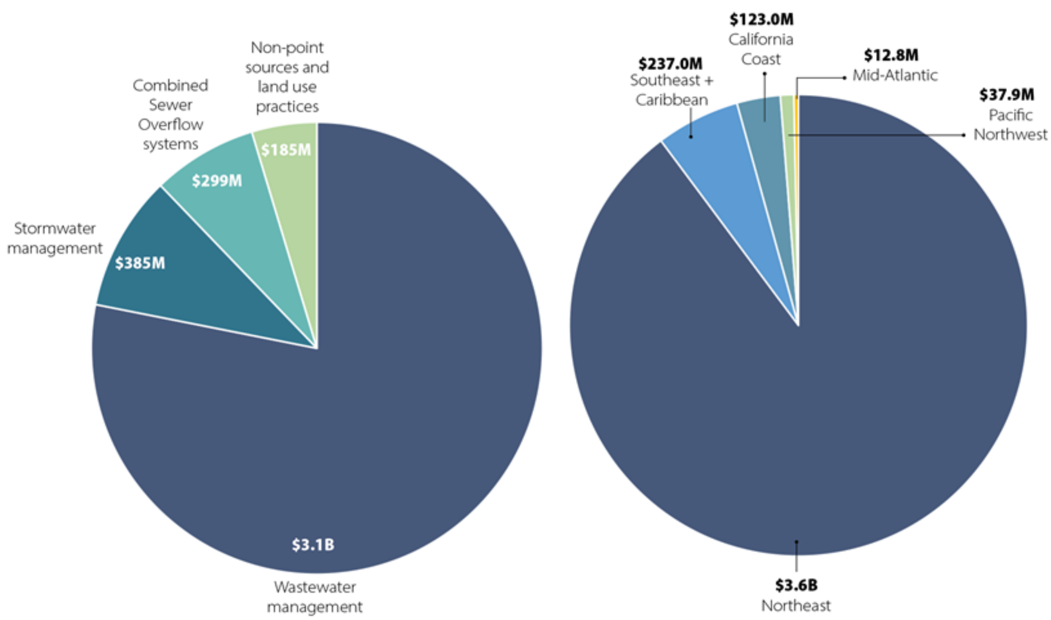
[8] Habitat and leveraging are two different sections in NEPORT. Leveraging data is reported separately from the habitat data. Therefore, leveraged resources do not correspond to habitat project costs.

[9] The NEPs report leveraging in terms of the role they played in obtaining the resources: primary, significant or support. Primary indicates the NEP director, staff, and/or committees played the central role in obtaining leveraged resources. Filtering by primary is a conservative approach for estimating leverage because it omits funds that NEPs may have played a significant or support role in obtaining.

The $4 billion that the NEPs have leveraged toward nutrient management includes $3.1 billion for actions benefiting wastewater management, $385 million for stormwater management actions, $299 million to improve CSO systems, and $185 million for actions supporting nonpoint sources and land use practices. Every ecoregion with NEP presence has leveraged between tens of millions and several billions of dollars toward nutrient management. The Northeast and Southeast/Gulf/Caribbean regions account for the largest investments by NEPs, and the majority of the United States' dead zones and the largest dead zones are located along these coasts.[10] They leverage more funds toward active management of nutrient loads while other ecoregions leverage a greater amount of funds toward public education, land acquisition, monitoring activities, and restoration. Exhibit 3-1 shows the breakout of the $4 billion in leveraged funds by category and ecoregion. (See Section 2 for a description of the ecoregions.)

Exhibit 3-1. Funds leveraged toward nutrient management, by category and ecoregion



The NEPs leveraged the $4 billion across 894 projects. Leveraged dollars in a project range from less than $1,000 to more than $333 million; the average was $4.5 million. Projects that address wastewater management had both the highest total leveraged funding ($3.1 billion) and highest average leveraged dollars per project ($18.6 million). Projects addressing nonpoint sources and land use practices had the lowest total leveraged funds ($185 million) and average leveraged dollars per project ($389,000), but the largest number of projects (475 projects) with leveraged investment in nutrient management. Exhibit 3-2 shows the distribution of the number of projects and leveraged dollars by category.

[10] Source: National Geographic, Dead Zone

Exhibit 3-2. Distribution of leveraging among categories of managing nutrients

	Nonpoint	CSO	Stormwater	Wastewater
Number of Projects with leveraged investment in Nutrient Management *(projects may address more than one category)*	475	36	437	170
Minimum leveraged dollars in a project	$51	$275	$51	$210
Maximum leveraged dollars in a project	$15,766,644	$175,083,680	$140,846,364	$333,455,808
Average leveraged dollars in a project	$388,910	$6,649,701	$881,855	$18,633,581

Case studies

NEPs have played a central role in leveraging funds for projects that manage nutrients coming from nonpoint, CSO, stormwater, and wastewater. The case studies highlighted in this section are examples of the effects of the NEPs' leveraging efforts in each category as they were reported in NEPORT.

Nonpoint

- **LONG ISLAND SOUND STUDY (LISS) – STORMWATER REMEDIATION.** LISS leveraged over $1 million for the reconstruction and augmentation of the drainage system on County Road 48 at Hashamomuck Beach. The preexisting system consisted of approximately 1.8 acres of impervious pavement discharging directly into LIS. The project involved roadside gutters and curbing to send the runoff into leaching basins. The leaching basins will help remove sediment, pathogens, and floatables as well as recharge the groundwater table. This project was designed in order to address the observations of the Priority Waterbodies List which identified the need for stormwater remediation at this location.[11]

- **CASCO BAY ESTUARY PARTNERSHIP (CBEP) – CLEANER STREAMS PROGRAM.** Capisic Brook is one of the last remaining intact urban streams in the City of Portland, Maine. Cleaning up the brook is critical to the overall health of Capisic Pond, the Fore River, Portland Harbor, and Casco Bay. CBEP leverages municipal funds provided through the Cumberland County Soil and Water Conservation District for the Capisic Brook Greener Neighborhoods - Cleaner Streams program. This multigenerational education initiative began in 2011 and continues to grow – educating through hands-on learning in communities and schools. The NEP also supports the District's watershed-based CONNECT program that targets middle school students in eleven communities.[12]

[11] Source: information provided by OWOW
[12] Source: NEPORT

- **Buzzards Bay NEP (BBNEP) – Replacing Failing Septic Systems.** After West Falmouth Harbor, Massachusetts failed to meet water quality standards due to nitrogen pollution, BBNEP worked with the state and localities to establish a TMDL strategy and leveraged greater than $400,000 in regional funds to replace failing septic systems with innovative alternative nitrogen removing septic systems or eco-toilets.[13]

CSO

- **Albemarle Pamlico National Estuary Partnership (APNEP) – Stormwater Improvement Projects.** Created in 1996, the Clean Water Management Trust Fund (CWMTF) makes grants to local governments, state agencies and conservation nonprofits to help finance projects that specifically address water pollution problems. The establishment of the CWMTF was requested in 1994 as an action in the Albemarle Pamlico's Comprehensive Conservation and Management Plan (CCMP). In 2015 alone, the APNEP leveraged over $2.7 million in CWMTF funds for stormwater improvement projects.[14]

- **San Juan Bay Estuary Program (SJBEP) – Sanitary Sewer Discharges.** Sanitary sewer discharges are a severe problem in the water bodies within the watershed of the San Juan Bay Estuary – injecting nutrients and pathogens into the watershed and contributing to public health problems. To address this situation, in 2015, SJBEP began a $1.2 million three-year study financed through the Clean Water State Revolving Fund (SRF) to identify raw sewage discharges and other pollutants in the watershed. The SJBEP contracted the University of Puerto Rico to execute the project. To date, the NEP has received more than $3 million from SRF to continue the work.[15]

- **New York-New Jersey Harbor & Estuary Program (HEP) – Water pollution monitoring projects.** The HEP leverages outside funding, such as CWA Section 106 grants, to establish and implement ongoing water pollution control programs with the help of long-time partner Interstate Environmental Commission (IEC). The IEC is deeply involved in HEP work groups and has conducted pathogens monitoring, municipal and industrial compliance monitoring, combined sewer overflow and MS4 monitoring, shellfish sanitation monitoring, hypoxia monitoring, and public outreach to meet HEP needs to achieve CCMP goals.

Stormwater

- **San Francisco Estuary Partnership (SFEP) – Trash Capture Devices.** SFEP leveraged $5 million in federal Recovery Act funds and California state bond funds for a trash capture demonstration project in the Bay Area. The project was designed to give Bay Area municipalities experience with different sizes of trash capture devices, which was needed to meet trash capture requirements set forth in the San Francisco Bay Regional Water Quality Control Board's Municipal Regional Stormwater Permit. The SFEP project installed over 4,000 trash capture devices in more than 60 Bay Area municipalities. The devices trap and remove trash that would

[13] Source: NEPORT
[14] Source: NEPORT
[15] Source: SJBEP PE Letter

wash downstream, significantly impacting receiving waters, and sediments that carry nutrients into waterbodies.[16]

- **Indian River Lagoon NEP (IRLNEP) – Stormwater Best Management Practices.** IRLNEP leveraged $24 million through the sale of the Indian River Lagoon license plates, federal 319 grants, St. Johns River Water Management District resources and state funds. These funds support implementation of stormwater best management practices throughout the 156-mile-long system. For example, the Egret Marsh Regional Stormwater Park was designed to treat polluted canal water and reduce total nitrogen by 20 percent from a 9,000-acre basin. In roughly three years' time, the Egret Marsh Flow-way – which includes a pond and wetland system – removed greater than 32,500 pounds of nitrogen equivalent to 8,146 bags of fertilizer. By reducing nutrient loading in runoff, the NEP addresses declining water quality, recurring harmful algal blooms and negative impacts to local economies.[17]

- **Santa Monica Bay NEP (SMBNEP) – Stormwater Infiltration Project.** SMBNEP worked with state and local partners to leverage $16.5 million to design and implement a complex stormwater infiltration and retention project for the City of Culver. Construction began in 2019 on an innovative system that will include a below ground infiltration/retention basin, capable of capturing and treating storm runoff from a drainage area of 800 acres. Runoff from 647 acres is infiltrated while runoff from the remaining 153 acres will be retained, treated, and re-used as irrigation. The system will benefit the region by capturing up to 42.79 acre-feet of runoff during a storm event, and 100% of the dry weather flow.[18]

- **Puget Sound Partnership (PSP) – Stormwater Strategic Initiative.** The Washington state departments of Ecology and Commerce, with the Washington Stormwater Center serve as the Stormwater Strategic Initiative Implementation Lead (SI Lead). The SI Lead works closely with the Management Conference, other Puget Sound partners and PSP to align and integrate NEP funding processes with the Puget Sound Action Agenda that applies adaptive management and oversight to the development of stormwater implementation strategies. In 2017, the Partnership leveraged $4.2 million for these efforts.[19]

Wastewater

- **San Juan Bay Estuary Program (SJBEP) – Illicit Discharge Detection & Elimination Task Force.** SJBEP organizes and convenes the Task Force, which comprises representatives from the state, federal, municipal governments and communities working collaboratively to identify, discuss and eliminate raw sewage discharges into the watershed. To support this effort, the University of Puerto Rico identifies and characterizes specific outflows of illicit discharges in the basin and measures water quality and bacterial counts – work that is channeled through the

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[16] Source: SFEP website
[17] Source: NEPORT; IRLNEP director
[18] Source: NEPORT
[19] Source: NEPORT

Task Force for immediate action. NEP-led efforts have successfully addressed and corrected 90 percent of the cases that have been referred to them.[20]

- **Morro Bay NEP (MBNEP) – Water Reuse and Effluent Reduction.** MBNEP leveraged funds for Achievement House, a local nonprofit that provides job training and assistance to adults with disabilities, to construct a 2,600 square foot hydroponic greenhouse to grow vegetables for selling to the general public. The greenhouse uses 4,900 gallons of nutrient enriched water every 15 days. The Estuary Program supported the Achievement House's effort to install a water reclamation storage facility so that the water could be re-used on-site and Achievement House could reduce water demand from local sources. Additionally, the reuse reduces effluent sent to the California Men's Colony, which releases into Chorro Creek.[21]

- **Buzzards Bay NEP (BBNEP) – Wastewater Pollution Control Facility (WPCF).** In 2019, BBNEP leveraged $584,000 for an ongoing effort to relocate the Wareham WPCF's discharge from the Agawam River to the Cape Cod Canal. Phase 1 of the project concluded that the relocation is feasible. Phase 2 will conduct habitat/water quality baseline assessments, evaluate alternatives for expanding capacity of the WPCF, select the relocation route, and evaluate the need for a regional-based governing structure to manage and finance the implementation. At the conclusion of the project, the partners hope to be in the position to move forward with permitting and implementation.[22]

[20] Source: NEPORT
[21] Source: NEPORT
[22] Source: NEPORT

4. Connected Leadership

The National Estuary Program was authorized by Section 320 of the Clean Water Act in 1987 with a Congressional vision to create a non-regulatory program that would bring citizens, scientists and diverse stakeholders together in a Management Conference to solve complex problems impacting the nation's great estuaries. Today, the 28 designated estuaries of national significance within the NEP network convene their individual Management Conferences with a goal to develop and implement a forward-looking Comprehensive Conservation and Management Plan (CCMP) that recommends actions for estuary restoration and stewardship.

The NEPs provide essential leadership to address nutrient pollution through the power of collaboration and consensus building. NEPs are the lynchpins in a nationwide network of over 1,600 public and private sector partners – including over 100 state agencies representing 16 sectors of state government and three commonwealth agencies across 20 states and one territory. Through connecting and mobilizing their networks, NEPs lead the way in non-regulatory, consensus-based approaches to achieving nutrient reduction targets in their watersheds and in meeting Clean Water Act standards. Finally, high quality monitoring data collected, shared and analyzed by NEPs help to elucidate environmental problems affecting estuaries and coastal areas (e.g., eutrophication, hypoxia, and coastal acidification), and provide the foundation for management decisions.

The NEP Management Conference governance model is the foundation for connected leadership and program success. The U.S. Congress recognized that regulatory actions alone could not restore or sustain estuary health. Non-regulatory approaches and innovation were needed to deliver effective and efficient solutions to address complex estuary restoration and management challenges that involve the behavior of millions of people. Solutions were needed that worked across jurisdictional and sectoral boundaries and targeted the behavior of individuals. The Management Conference represents a network system of governance that enables each NEP to implement the NEP directives in Section 320 of the Clean Water Act, leverage partner resources, and restore clean water and healthy estuaries through non-regulatory action.

Specific benefits from the NEP Management Conference include:

- Connected leadership that advances a common vision for the future of our nation's estuaries;
- Explicit recognition that no single agency or entity can do it alone;
- Collaboration among representatives from the public, private and independent sectors that includes exchanging ideas, building relationships, promoting inclusive and equitable partnerships, identifying common interests and needs, evaluating and implementing solutions, considering options, and sharing (leveraging) investments;
- Cooperation amongst different organizations and agencies where there are sometimes antagonistic relationships (e.g. between a state department or wastewater treatment plant and an advocacy organization); and
- Successful non-regulatory actions and investments that restore systems and decrease current and future risks associated with regulatory compliance for private-sector industry.

Section 4 explores the power and effectiveness of the NEP's connected leadership model, as delivered through the NEP Management Conference to address the nutrient crisis.

Methodology

Connected leadership is more difficult to quantify than habitat restoration/reduced nutrient loadings and leveraged dollars; however, it is an essential foundation for NEP's leadership as the programs identify and prioritize nutrient challenges and solutions. Our methodology aims to measure and communicate how the NEPs demonstrate connected leadership through the Management Conference. The method is to quantify a standard set of metrics for an NEP to demonstrate the impact of connected leadership. As an example, we quantify these metrics for Indian River Lagoon NEP, which has taken a leadership role in developing the methodology. We supplement the metrics for Indian River Lagoon with case study examples from other NEPs that collectively demonstrate connected leadership in action.

The metrics, which are based on the significance of the NEPs and their Management Conferences, address two broad topics: 1) Who and what do the NEPs represent? and 2) How do the NEPs represent broad constituencies?

Who and what do the NEPs represent? These metrics link a watershed to human community attributes, characterizing an estuary through the perspective of people and communities. NEPs are more than clean water programs; the NEP watersheds are composed of natural areas, human-built infrastructure, and communities. They also provide significant economic value. The following metrics address who and what the NEPs represent:

- Acres of watershed
- Miles of coastline
- Federal assets in watershed
- States
- Counties
- Cities
- Population
- Annual economic value

How do the NEPs represent broad constituencies (inclusive structure of the Management Conference)? The second set of metrics addresses the vision and power of the NEP Management Conference to deliver connected leadership. The NEP Management Conference is a model for effective and efficient cooperative federalism because it allows EPA to work collaboratively to implement laws that protect human health and the environment, rather than dictating one-size-fits all mandates. These metrics show the size, diversity, and power of connecting representatives from the public, private and independent sectors. These metrics include:

- Individual Management Conference volunteers
- Public sector agencies (federal, state, regional, tribal, local, public universities, and colleges)
- Private sector (industries, small businesses)
- Universities, colleges, and scientific research organizations
- Nonprofit organizations

Results

Exhibits 4-1 and 4-2 provide the metrics for the Indian River Lagoon. Although not listed as part of Indian River Lagoon NEP's Management Conference, federally recognized tribes are included as members of other NEP Management Conferences. In viewing the exhibits, consider the impact if these metrics were reported together for all 28 NEPs; this perspective will provide a sense of the environmental, human, and economic importance of the NEPs – and how they play a vital leadership role in tackling nutrient challenges.

Exhibit 4-1. Who and What the NEP Represents – Indian River Lagoon NEP

Size of Watershed (acres)	Miles of Coastline	Number of States in Watershed	Number Counties in watershed	Number Cities in watershed	Total Population in Watershed	Federal Assets in Watershed (Ports, Military Bases, National Wildlife Refuges, International Airports, National Seashores, etc.)	Annual Economic Value
1,461,760	181	1	7	38	1,600,000	14	$7.6 billion

Exhibit 4-2. Management Conference - Convening Broad Public, Private and Independent Sector Representation – Indian River Lagoon NEP

Individuals	Public Sector				Private Sector		Independent Sector	
Total number of individual volunteers in Management Conference	# Federal Agencies	# State and Regional Agencies	# Local Agencies	Public Universities and Colleges	Small Business or Industry Partners	Industry Associations	Nonprofit Organizations	Private Universities and Research Centers
107	4	9	59	6	11	1	12	8

Case Studies

The power of the connected leadership model can also be demonstrated by successes in tackling challenges associated with nutrients. The NEPs play a leadership role in the following activities that ultimately support reductions in nutrient loadings and improve water quality. These activities and their results stem from the connected leadership model.

- **Develop partnerships:** The NEPs work with state, tribal, federal and national organizations to reduce impacts of nutrient pollution and support shared understanding of how to successfully implement the Clean Water Act. For example, they partner with agencies, environmental groups, and scientists to analyze data in order to identify and prioritize challenges and actions.

- **Conduct outreach:** The NEPs work with partners to promote education and outreach that communicates the latest science and creates public awareness and understanding of causes, effects, and solutions to nutrient pollution. For example, they perform outreach to encourage homeowners and communities to care for and maintain septic systems.

- **Implement market-based approaches on a watershed scale:** The NEPs partner with various organizations to reduce nitrogen loads on a watershed scale through creative market-based approaches (e.g., Water Quality Trading and Nitrogen Trading).

- **Provide support to states:** The NEPs support states in developing and refining water quality standards, reporting on water quality conditions, listing impaired waters, and developing TMDLs. They partner directly with 100+ state agencies and 3 commonwealth agencies. representing 16 sectors of state government across 20 states and 1 territory - including the agencies overseeing state and interstate water programs.

- **Finance nutrient reduction activities:** Partnerships make the NEP stronger, and through collaboration with a national network of over 1,600 public and private sector partners, the 28 NEPs have leveraged funds that support reductions in loads of nutrients.

- **Conduct research and development:** The NEPs study pathways of introduction and effects of excess nutrients in watersheds and find innovative and optimal solutions to reduce nutrients. All 28 NEPs monitor water quality tied to nutrient pollution, harmful algal blooms, and pollution.

The case studies in the rest of this section are organized by the topics listed above. Collectively, the examples further demonstrate the leadership role played by NEPs in efforts to address the nutrient challenge.

Develop partnerships

- **Partnership for the Delaware Estuary (PDE).** PDE and its partners have been implementing best management practices (BMPs) to reduce nutrient pollution in the watershed. For example, they have worked together on projects on farms, projects to address abandoned mine drainage, and projects to reduce pollution from stormwater runoff in the Schuylkill River Watershed, the largest tributary to the Delaware Estuary. This work is largely facilitated through the PDE's involvement as a partner on the Planning Committee in the Schuylkill Action Network (SAN), a coalition of over 500 members working to protect and restore the Schuylkill River Watershed. The SAN worked with water suppliers in the Saucony Creek Watershed to assess groundwater quality improvements over ten years, 2007 - 2017. Ground water nitrate levels have been decreasing steadily (average nitrate concentrations of 7.4mg/l dropped to 6.7 mg/I over ten years) because of the implementation of agricultural BMPs. These BMPs help to improve water quality on farms and contribute to a more sustainable watershed. Decreased volume of nutrients and sediments entering the waterways equates to less treatment costs for public water suppliers and safer drinking water. Reducing excess nutrient loading in the Saucony Creek Watershed also decreases the nutrient/sediment loads flowing downstream into Lake Ontelaunee, the drinking water source for the City of Reading. The success of this NEP initiative serves as a model for other agriculture intensive watersheds.[23]

[23] Source: PDE PE Letter

- **Albemarle-Pamlico National Estuary Partnership (APNEP).** To date, APNEP has worked with local partners in Hyde County, NC, to restore hydrology to over 42,000 acres of drained farmland. Over half of these lands are held in conservation and managed for improved water quality in local waters of the Long Shoal River, the Intracoastal Waterway, Alligator River and Pamlico Sound by allowing runoff to be filtered through soil. These lands also provide vital habitat for migrating shorebirds and waterfowl on a key portion of the Atlantic Flyway and needed habitat for wildlife on the Albemarle Pamlico Peninsula.[24]

- **Sarasota Bay Estuary Program (SBEP).** SBEP tracks expansion of the sewer system and consolidation of wastewater treatment plants by direct participation on the Sarasota County Sewer and Water Advisory Committee. Significant progress was made in FY17 with continued implementation of the septic-to-sewer program and wastewater treatment plant consolidation. As of June 2018, all surface water discharges of wastewater were eliminated in Sarasota Bay. Approximately 65 percent of the wastewater in the Sarasota Bay watershed is treated and reclaimed for irrigating agriculture fields, golf courses, and newer residential communities, thereby reducing water demand on the Floridan aquifer. The remaining 35 percent of the region's wastewater output that is not reused is treated and sent into confined deep injection wells underneath the Floridan aquifer that disperses the impact of the discharge by allowing the water to filter through thousands of feet of karst limestone before reaching other bodies of water. This is a significant accomplishment for the program, with lessons learned for the local and national level.[25]

Conduct outreach

- **Mobile Bay NEP (MBNEP).** A top priority for the Alabama Department of Environmental Management is finalizing the Coastal Nonpoint Source Pollution Control Program by the statutorily mandated deadline of May 2022. MBNEP provides support for addressing coastal nonpoint pollution through education and outreach that stimulates voluntary actions and research that informs guidance. This work demonstrates efforts between the state and NEP to align programs – including expansion of the NEP study area to align with the coastal nonpoint management area and leveraging of Clean Water Act 319 funds. [26]

- **San Francisco Estuary Partnership (SFEP).** For more than two decades, SFEP has worked in the San Francisco Bay and Sacramento River Delta to promote the benefits of clean boating and environmental stewardship to boaters and marinas, in partnership with the California State Parks Division of Boating and Waterways, The Bay Foundation, the Coast Guard Auxiliary, and a vast array of other partners. The multifaceted educational campaign is focused on in-person boater education, building regional capacity, and enhancing the network of pump-out stations. The combination of education and capacity building for boaters and marinas serves to address the complex nature of sewage discharge – including nutrient loading – by providing boaters easy

[24] Source: APNEP PE Letter
[25] Source: SBEP PE Letter
[26] Source: NEP-CZMP Report

access to pump-out information and providing marinas with the tools they need to work with boaters to proactively prevent sewage discharge.[27]

Implement market-based approaches on a watershed scale

- **LONG ISLAND SOUND STUDY (LISS).** In 2001, LISS worked with the states of Connecticut and New York, in concert with the EPA, to complete plans for nitrogen control that identifies the maximum amount, or the Total Maximum Daily Load (TMDL), of nitrogen that can be discharged to Long Island Sound without significantly impairing the health of the Sound. One of Connecticut's management strategies to reduce nitrogen loading was to develop an innovative nitrogen-trading program among 79 sewage treatment plants located throughout the state. LISS was instrumental in developing this program and was awarded EPA's first "Blue Ribbon for Water Quality Trading." This innovative, market-based approach has resulted in nitrogen reductions of 65 percent since 2014. In addition, in New York, Suffolk County's Septic Improvement Program enables homeowners to replace outdated septic systems. This program provides grants up to $30,000 and low interest loans to help homeowners offset the costs of the upgrade to advanced systems that remove nitrogen. To date, 381 active grant certificates have been issued and 80 advanced onsite wastewater treatment systems have been installed. These bi-state efforts, coordinated by the NEP, have led to significant reductions in nitrogen loading and a 57% decline in the summertime extent of hypoxia in the Sound.[28]

Provide support to states

- **PECONIC ESTUARY PARTNERSHIP (PEP).** PEP helped create an inter-municipal agreement and established the Peconic Estuary Protection Committee (PEPC) with initial focus on MS4 compliance and collaboration among villages, towns, Suffolk County, and New York State Department of Transportation. PEP has also developed 12 plans that catalog, prioritize, and partially design infrastructure upgrades that lessen stormwater pollution by employing green infrastructure techniques. These plans aim to reduce stormwater runoff/pollution, maintain total nitrogen levels suitable for eelgrass habitat, support acquisition of open space for habitat protection, and decrease inputs of toxins to the estuary. By creating the PEPC, PEP helped develop efficiencies in stormwater management under the New York state MS4 general permit and achieve compliance with the nitrogen and pathogen TMDL.[29]

- **MARYLAND COASTAL BAYS PROGRAM (MCBP).** MCBP's Science Technical Advisory Committee worked with the DOE and the University of Virginia to revise the MCB nutrient TMDLs. Activities included: 1) developing model scenarios, 2) providing additional nutrient data, 3) advising on changes in watershed composition, 4) evaluating data adequacy, and 5) reviewing comments from agencies and the public. The revised MCB TMDL was approved in August 2014, establishing new targets for nutrient reduction strategies and activities. Since then, MCBP has been working

[27] Source: SFEP PE Letter
[28] Source: LISS
[29] Source: PEP PE Letter

with Worcester County to develop CWA section 319 watershed management plans to address the nutrients issue for all the estuary's subwatersheds.[30]

- **FLORIDA NEPS.** In January 2019, newly elected Governor Ron DeSantis issued an Executive Order implementing major reforms to ensure protection of Florida's water quality – especially to reduce occurrences of harmful algal blooms due in part to nutrient loading. The four Florida NEPs (Coastal & Heartland Estuary Partnership, Indian River Lagoon NEP, Sarasota Bay Estuary Program and Tampa Bay Estuary Program) are engaging directly with the state on these activities. To enhance communication, coordination, cooperation, and ability to speak with one voice, the four Florida NEPs entered a formal Memorandum of Understanding in 2016 to create the Florida Estuaries Alliance. This decision was influenced strongly by a need to respond to HABs plaguing Florida's estuaries and coastal waters. In 2019, the Indian River Lagoon Executive Director was invited by the Governor to serve with 11 other experts on the state's Harmful Algal Bloom/Red Tide Task Force. The Task Force determines research, monitoring, control, and mitigation strategies for red tide and other harmful algal blooms.[31]

Finance nutrient reduction activities

- **MASSACHUSETTS BAYS NEP (MASSBAYS).** Nitrogen pollution from failing septic tanks is harming the water quality of Cape Cod and other Massachusetts Bays. With an estimated $4 billion price tag to replace these systems and a small year-round population the Commonwealth was challenged with how to pay for the necessary upgrades. MassBays identified an innovative and sustainable source of project funding through a new regional clean water fund. The NEP is working with localities and the state to leverage occupancy taxes on short-term rentals – expected to generate $20 million per year. Revenue generated through these taxes will focus on septic-to-sewer conversion and result in reduced nutrient loading to the Bays.[32]

- **BARATARIA-TERREBONNE NEP (BTNEP).** BTNEP staff members have worked with the Minnesota Department of Agriculture (MDA) to implement the BTNEP CCMP Action Plan related to reduction of nutrients from agriculture. A key element of this plan is MDA's assistance to landowners and farmers through low interest loans under the Minnesota Agricultural Best Management Practices Loan Program that can be used to finance practices that prevent pollution to the state's lakes, rivers, and groundwater.[33]

- **INDIAN RIVER LAGOON NATIONAL ESTUARY PROGRAM (IRLNEP).** The IRLNEP worked with the Treasure Coast and East Central Florida Regional Planning Councils (TCRPC and ECFRPC) and the Florida Department of Economic Opportunity to develop a comprehensive economic valuation for the Indian River Lagoon. Estimates showed that the annual value of the IRL was $7.6 billion. TCRPC and ECFRPC (2015) estimated it would cost $4.6 billion to accomplish the required

[30] MCB PE Letter
[31] Sources: NEP-CZMP Report; https://www.flgov.com/wp-content/uploads/2019/01/EO-19-12-.pdf; https://myfwc.com/research/redtide/taskforce/members/
[32] Source: presented at NEP 2019 Workshop and cited in NEP-CZMP Report
[33] Source: BTNEP 2017 Newsletter

nutrient load reductions in all four of the BMAPs associated with the IRL. By this measure, and with efforts extended over a 20-year period, it would require an annual investment of $230 million to sustain an IRL-based economy. When comparing the average annual cost to the IRL's total average annual economic output of $7.6 billion, the Return on Investment (ROI) from a sustainable IRL was 33 to 1.[34]

Conduct research and development

- **Buzzards Bay NEP (BBNEP).** The NEP invests in researching innovative solutions for reducing nutrient pollution in wastewater. Testing of wood chip reactors in the Wareham Wastewater Pollution Control Facility shows new chips can reduce ammonia levels in effluent by 83% and completely remove nitrate in 24 hours. This low-cost technique can provide additional societal benefits – including potential on-site reuse of treated water.[35]

- **Indian River Lagoon NEP (IRLNEP).** Funds from IRLNEP were used to support research by Harbor Branch Oceanographic Institute to measure concentrations of nitrogen and phosphorus in multiple pathways to the Indian River Lagoon. This effort contributed to the development of the 2013 Basin Management Action Plans (BMAPs) for the Banana River Lagoon, North Indian River Lagoon, and Central Indian River Lagoon to implement already-established TMDLs.[36] The IRLNEP assisted Volusia County stakeholders in the development of the Mosquito Lagoon Reasonable Assurance Plan (RAP). In September 2019, the Mosquito Lagoon Rap was adopted by secretarial order of the Florida Department of Environmental Protection.[37]

[34] Source: http://www.tcrpc.org/special_projects_.htm
[35] Source: https://jbioleng.biomedcentral.com/articles/10.1186/s13036-017-0057-4
[36] Source: IRL PE Letter
[37] Source: https://floridadep.gov/dear/alternative-restoration-plans/content/mosquito-lagoon-reasonable-assurance-plan-rap

Appendix A: Approach for Estimating Nutrient Reduction through Habitat Protection and Restoration

Overall Approach

Classification of NEPs into Ecoregions

The nutrient reduction analysis focuses on quantifying the extent of nutrient reduction achieved through NEP efforts to restore or protect different types of habitat. The first step in the analysis involved defining different ecoregions by grouping NEPs by ecoregions that are in similar climates/geographic locations where habitats will have similar nitrogen removal rates (stated in the literature as denitrification or nitrogen retention). The NEPs are divided into ecoregions as follows:

1. **Northeast (Regions 1 and 2):** Casco Bay Estuary Partnership, Piscataqua Region Estuaries Partnership, Narragansett Bay Estuary Program, Buzzards Bay NEP, Massachusetts Bays NEP, Long Island Sound Study, Peconic Estuary Partnership, New York-New Jersey Harbor & Estuary Program, Barnegat Bay Partnership. [Note: San Juan was excluded from these calculations because it is not in the same climate/region as the Northeast]
2. **Mid-Atlantic (Region 3)**: Partnership for the Delaware Estuary, Delaware Center for the Inland Bays, Maryland Coastal Bays
3. **Southeast/Gulf/Caribbean (Regions 2, 4 and 6)**: Indian River Lagoon NEP, Tampa Bay Estuary Program, Sarasota Bay Estuary Program, Coastal & Heartland National Estuary Partnership, Mobile Bay NEP, Albemarle-Pamlico National Estuary Partnership, Coastal Bend Bays and Estuaries Program, Galveston Bay Estuary Program, Barataria-Terrebonne NEP, and San Juan Bay Estuary Program. [Note: San Juan Bay Estuary Program has been added to this category from Region 2 because the southeast is the ecoregion most closely resembling Puerto Rico's climate)
4. **Pacific Northwest (Region 10)**: Puget Sound Partnership, Lower Columbia Estuary Partnership, Tillamook Estuaries Partnership
5. **California coast (Region 9)**: San Francisco Estuary Partnership, Morro Bay NEP, Santa Monica Bay NEP

Identification of NEP Habitat Project Contributing to Nutrient Reduction

For each ecoregion, we then identified relevant NEP habitat projects that contributed to nutrient reduction. All NEPs track the annual number of acres of habitat protected or restored and report on this measure via the NEP Online Reporting Tool (NEPORT). NEPORT contains data for all NEP habitat projects, which have a variety of different benefits. Because there is no category specifically designated for "nutrients projects," we applied a filter to screen for habitat restoration and protection projects with characteristics typically associated with nitrogen and phosphorus reduction. Though EPA cannot state that acres of habitat associated with these projects were protected, planted, or restored for the sole, or even primary, purpose of managing nutrients, the filtering criteria suggests these acres substantially contributed to nutrient reduction.

The criteria for identifying projects associated with nutrient reduction included those that apply to one of the following restoration techniques: easements, erosion control, land acquisition, planting, rain garden creation, rehabilitation/creation, stormwater/runoff controls, or vegetation buffer. In addition, to qualify as contributing to nutrient reduction, they must also cite to "improve or protect water quality" as a project benefit. Our selection of these restoration techniques is based on the results of a literature review, shown in Exhibit A-1 that highlights how these specific techniques contribute to nutrient reduction. All habitat activities were selected, including enhancement, establishment, maintenance, protection, reestablishment, and rehabilitation. Throughout the report, the names of these activities are simplified as acres "protected or restored."

Exhibit A-1. Literature Supporting Selection of Restoration Techniques that Reduce Nutrients

Restoration Technique	Literature Reference
Easements	Hansen L, Delgado JA, Ribaudo M, Crumpton W. 2012. Minimizing costs of reducing agricultural nitrogen loadings: choosing between on- and off-field conservation practices. Environmental Economics 3(4).
Erosion Control	Ritter, William F. 1988. Reducing impacts of nonpoint source pollution from agriculture: a review. Journal of Environmental Science and Health 23(7): 645-667.
Land Acquisition	Berg CE, Mineau MM, and Rogers SH. 2016. Examining the ecosystem service of nutrient removal in coastal watersheds. Ecosystem Services 20: 104-112. Fitch, R, Theodose T, and Dionne M. 2009. Relationships among upland development, nitrogen, and plant community composition in a Maine salt marsh. Wetlands 29(4): 1179-1188.

Restoration Technique	Literature Reference
Planting	Pierobon E, Castaldelli G, Mantovani S, Vincenzi F, Fano EA. 2012. Nitrogen Removal in Vegetated and Unvegetated Drainage Ditches Impacted by Diffuse and Point Sources of Pollution. CLEAN – Soil, Air, Water 41(1).
Rain Garden Creation	Strong P and Hudak PF. 2016. Nitrogen and Phosphorus Removal in a Rain Garden Flooded with Wastewater and Simulated Stormwater. Environmental Quality Management 25(2).
Rehabilitation/Creation	Lewis III RR, Clark PA, Fehring WK, Greening HS, Johansson RO, and Paul RT. 1998. The Rehabilitation of the Tampa Bay Estuary, Florida, USA, as an Example of Successful Integrated Coastal Management. Marine Pollution Bulletin 37(8-12): 468-473.
Stormwater/Runoff Controls	Koch BJ, Febria CM, Gevrey M, Wainger LA, Palmer MA. 2014. Journal of the American Water Resources Association 50(6).
Vegetation Buffer	Mayer PM, Reynolds SK, McCutchen MD, Canfield TJ. 2007. Meta-Analysis of Nitrogen Removal in Riparian Buffers. Journal of Environmental Quality 36(4).

Habitat Selection

Within each region, we identified the total acres of different types of habitat for which the total acres protected or restored in ways that contribute to nutrient reduction exceeded a minimum threshold, which was selected as 700 acres between 2006 and 2019. The 700-acre threshold was selected by examining the acres of habitat across all regions and selecting a value that represented a relative level of significance based on the distributions. Using this threshold value served to focus the literature review for nutrient removal rates on those habitats that were likely to have a larger presence and more significant impact within each region.

Removal Rates for Habitat Types

A literature review was conducted to compile data regarding the nutrient removal rates of TN and TP in habitats restored, protected, or acquired in different geographic regions. Exhibits A-2 shows the results of this review in terms of for which habitats data from peer reviewed literature for nutrient removal rates were and were not available.

Exhibit A-2. Habitats Associated with Projects Meeting Nutrient Management Criteria for Restoration Techniques and Project Benefits – with and without nutrient removal rates

Ecoregion	Habitats used in calculations having both met criteria and available peer-reviewed nutrient removal rates	Habitats meeting criteria but not included in calculation due to lack of nutrient removal rates in peer-reviewed literature
Northeast	Forest/Woodland, Forested Wetland, Tidal Wetland*	Agriculture/ranchlands, Soft bottom/mud, Riparian
Mid-Atlantic	Agriculture/ranchland, Forest/Woodland*, Forested Wetland, Riparian, Tidal Wetland*	Lake/Pond
Southeast/Gulf/ Caribbean	Agriculture/ranchland, Forested Wetland, Freshwater Marsh, Mangrove*, Riparian, SAV (Submerged Aquatic Vegetation)+, Tidal Wetland*	Forest/Woodland (4), Estuarine Shoreline (4), Field/Meadow (4), Grassland, and Soft Bottom/Sand (4)
California Coast	Forest/Woodland*, Grassland, and Riparian*	Agriculture/ranchland, Tidal Wetland
Pacific Northwest	Forest/Woodland, Riparian*, Tidal Wetland*	Estuarine Shoreline
*No TP removal rate was available for this habitat +No TN removal rate was available for this habitat		

Exhibits A-3 and A-4 present summary tables of nitrogen and phosphorus reduction rates for habitat types, along with the literature references by ecoregion. When multiple studies are available for the same habitat in an ecoregion, the average nutrient removal rate and standard error were calculated, providing an estimated range in nutrient reduction.

Most rates were listed in kg/ha/yr or g/m^2/yr. The rates calculated using hectares needed to first be converted to square meters. Next, kilograms and grams needed to be converted to pounds. This yielded a rate measured in lbs/ m^2/yr.

Exhibit A-3. Nitrogen removal rates for habitat types occurring in different ecoregions (mean ± standard error)

Ecoregion	Habitat	Average Nitrogen Removal Rate (g/m^2/year)	Average Nitrogen Removal Rate (lbs/m^2/year)	Nitrogen Removal References
Northeast	Forest/Woodland*	7.9 ± 2.3	0.0174 ± 0.0051	Adegbidi et al., 2001 (Ericsson, 1994; Hytonen, 1995; Hansen and Baker, 1979; Wood et al., 1977; Heilman and Norby, 1998; Lodhiyal and Singh, 1994; Mann et al., 1988); Campbell et al., 2004; University of Maine, 2010; Goodale et al., 2002
	Forested Wetland	22.3	0.0049	Bowden, 1987 (Bartlett, 1979)
	Tidal Wetland	6.2	0.0014	Drake et al., 2015
Mid-Atlantic	Forested Wetland	7.5	0.0165	Correll, 1989
	Forest/Woodland*	0.47 ± 0.1	0.0010 ± 0.0002	Correll, 1977
	Riparian*	4.29 ± 3.12	0.0095 ± 0.0069	Lowrance et al., 1977; Peterjohn and Correll, 1984; Delaware Department of Natural Resources and Environmental Control, 2012
	Tidal Wetland**	9.53	0.0210	Forand et al., 2015 (Hopfensperger et al., 2009; Merrill and Cornwell, 2002; Greene, 2005; Boynton et al., 2008; Merrill, 1999; Davis et al., 2004; Koop-Jakobsen and Gibllin, 2010; Kana et al., 1998; Tobias et al., 2001)
	Agriculture	8.5	0.0187	Willamette Partnership, 2012
Southeast/ Gulf/ Caribbean	Agriculture*	1.61 ± 0.79	0.0035 ± 0.0017	Florida Department of Environmental Protection, 2015; Florida Department of Environmental Protection, 2016
	Forested Wetland	9.58	0.0211	Martin et al., 2001
	Freshwater Marsh*	13.78	0.0304	Moustafa et al., 1996; Moustafa and Havens, 2001
	Riparian	2.82	0.0062	Lowrance et al., 1984
	Tidal Wetland*	4 ± 2	0.0088 ± 0.0044	Russell and Greening, 2015 (Morris, 1991; Wigand et al., 2003; Seitzinger et al., 2006; Craft et al., 2009)
	SAV (submerged aquatic vegetation)	9 ± 2.2	0.0198 ± 0.0049	Russell and Greening, 2015 (Welsh et al., 2001; Eyre and Ferguson, 2002)
	Mangrove*	1 ± 0.1	0.0022 ± 0.0002	Russell and Greening, 2015 (Nedwell et al., 1994; Rivera-Monroy and Twilley, 1996; Kristensen et al., 1998; Corredor et al., 1999)
California Coast	Forest/Woodland	0.9	0.0020	Hark and Firestone, 1990
	Grassland	9.13 ± 1.5	0.0201 ± 0.0033	Woodmansee and Duncan, 1980
	Riparian*	7.98 ± 2.22	0.0176 ± 0.0049	Domagalski et al., 2008
Pacific Northwest	Forest/Woodland*	6.75 ± 1.4	0.0031	Johnson et al., 1982 (Tarrant and Miller, 1963; Newton et al., 1968; Cole et al., 1978; Youngberg and Wollum, 1976)
	Riparian	30.04 ± 27.7	0.0662	Sobota et al., 2012
	Tidal Wetland	0.08	0.0002	Tjepkema and Evans, 1976

*Values of these habitats are an average of multiple data sources and include Standard Error measurements.
**Values of these habitats are an average of multiple data sources, but a Standard Error was not able to be calculated due to unit conversion.

Exhibit A-4. Phosphorus removal rates for habitat types occurring in different ecoregions (mean ± standard error)

Ecoregion	Habitat	Average Phosphorus Removal Rate ($g/m^2/year$)	Average Phosphorus Removal Rate ($lbs/m^2/year$)	Phosphorus Removal References
Northeast	Forest/Woodland*	0.95 ± 0.15	0.0021 ± 0.0003	Yanai et al., 1992; University of Maine, 2010
	Forested Wetland	55	0.0121	Peverly, 1982
Mid-Atlantic	Forested Wetland	0.3	0.0007	Correll, 1989
	Riparian*	0.5 ± 0.21	0.0011 ± 0.0005	Lowrance et al., 1977; Peterjohn and Correll, 1984; Delaware Department of Natural Resources and Environmental Control, 2012
	Agriculture	0.55	0.0012	Willamette Partnership, 2012
Southeast/ Gulf/ Caribbean	Agriculture*	0.40 ± 0.21	0.0009 ± 0.0004	Florida Department of Environmental Protection, 2015; Florida Department of Environmental Protection, 2016
	Forested Wetland	0.88	0.0019	Martin et al., 2001
	Freshwater Marsh*	0.84	0.0019	Moustafa et al., 1996; Moustafa and Havens, 2001
	Riparian	0.17	0.0004	Lowrance et al., 1984
	SAV (Submerged Aquatic Vegetation)	1.2	0.0026	Knight et al., 2003
California Coast	Grassland	5.3 ± 4.05	0.0117 ± 0.0089	Woodmansee and Duncan, 1980
Pacific Northwest	Forest/Woodland*	0.02	0.00004	Sollins et al., 1980
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.				

Results

This section of the appendix presents the results of the analysis of estimated nutrient reductions through NEP habitat protection and restoration projects. The results reflect projects conducted between 2006 and 2019 and nutrient reduction values represent the sum of estimated annual, not cumulative, reductions.

Exhibit A-5 presents the number of habitat projects that qualify as contributing to nutrient reduction after different stages of the filtering methodology. This is indicative of how conservative the estimates are for overall nutrient reductions. This table will also be a valuable reference if replicating this methodology for future years.

Exhibit A-5. Number of Habitat Projects Qualifying as Contributing to Nutrient Reduction After Different Stages of the Filtering Methodology

Stage of Filtering Methodology	Number of Habitat Projects
All Habitat Projects in NEPORT	7,765
After Filtering for Restoration Technique	4,445
After Filtering for Project Benefit	2,634
After Selecting for Habitats by Ecoregion (where literature rates are available)	2,028

Exhibit A-6 presents the total acres restored or protected by NEPs that met the filtering criteria for project benefits and restoration techniques. Although it is not possible to know that the acres associated with these projects were restored or protects for the purpose of reducing nutrients, the filtering criteria suggest that these acres do contribute to nutrient reduction. Of the nearly 364,000 acres restored or protected, roughly three-fourths are in the Southeast/Gulf/Caribbean region and 15 percent are contributed by the Northeast. The California Coast makes up about six percent of the restored or protected acres, and the Mid-Atlantic and Pacific Northwest each have roughly three percent of the restored or protected acres.

Exhibit A-6. Total acres restored or protected by NEPs that met the nutrient filtering criteria, by ecoregion.

Ecoregion	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Number of projects that provided nutrient reduction benefits from 2006-2019
Northeast	53,443	620
Mid-Atlantic	11,332	232
Southeast/Gulf/Caribbean	266,856	749
California Coast	21,977	47
Pacific Northwest	10,140	380
Total	**363,748**	**2,028**

The total acres restored or protected contributing to nutrient reduction 2006-2019 were multiplied by each ecoregion's habitat removal rates found in the literature to determine pounds of nutrients reduced. These pound values were then converted to U.S. tons to better reflect the level of certainty associated with the assumptions used in the analysis. The estimated TN and TP reductions are presented by habitat type and ecoregion in Exhibits A-7 and A-8. The largest reductions resulted from projects related to forested wetland, riparian, forest/woodland, and grassland habitats. By ecoregion, the largest reduction occurred in the Southeast/Gulf/Caribbean, followed by the California Coast and Northeast.

Exhibit A-7. Estimated Total Nitrogen and Total Phosphorus reduced annually through NEP habitat restoration/protection projects from 2006-2019, by habitat.

Habitat	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Agriculture	542 ± 234	122 ± 62
Forest/Woodland	1,628 ± 468	190 ± 30
Forested Wetland	5,361	637
Freshwater Marsh	724	44
Grassland	207 ± 34	120 ± 92
Mangrove	3	-
Riparian	1,874 ± 793	43 ± 2
Tidal Wetland	338 ± 141	-
SAV (Submerged Aquatic Vegetation)	N/A	N/A
Total	**10,677± 1,670**	**1,156 ± 186**
N/A refers to reductions that are negligible when converted to U.S. tons. These numbers represent the annual sum of nutrients reduced by each ecoregion, not the cumulative amount for the total years that each project has been in place.		

Exhibit A-8. Estimated Total Nitrogen and Total Phosphorus reduced annually through NEP habitat restoration/protection projects from 2006-2019, by ecoregion.

Ecoregion	Estimated TN Reduction (U.S. tons) from 2006-2019	Estimated TP Reduction (U.S. tons) from 2006-2019
Northeast	1,650 ± 460	346 ± 30
Mid-Atlantic	259 ± 27	12 ± 2
Southeast/Gulf/Caribbean	7,318 ± 375	678 ± 62
California Coast	744 ± 181	120 ± 92
Pacific Northwest	706 ± 627	N/A
Total	**10,677 ± 1,670**	**1,156 ± 186**
N/A refers to reductions that are negligible when converted to U.S. tons. These numbers represent the annual sum of nutrients reduced by each ecoregion, not the cumulative amount for the total years that each project has been in place.		

The estimated total nitrogen and total phosphorus reduced annually through NEP habitat for each individual NEP is presented in Exhibit A-9.

Exhibit A-9. Estimated Total Nitrogen and Total Phosphorus reduced annually through NEP habitat restoration/protection projects from 2006-2019, divided by individual NEP.

Region	NEP	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
1	Buzzards Bay National Estuary Program	116 ± 32	24 ± 2
1	Casco Bay Estuary Partnership	168 ± 48	24 ± 3
1	Long Island Sound Study	152 ± 44	20 ± 3
1	Massachusetts Bays National Estuary Program	5 ± 1	1
1	Narragansett Bay Estuary Program	28 ± 8	7 ± 1
1	Piscataqua Region Estuaries Partnership	495 ± 142	77 ± 9
2	Barnegat Bay Partnership	610 ± 164	175 ± 11
2	New York-New Jersey Harbor & Estuary Program	35 ± 10	7
2	Peconic Estuary Partnership	41 ± 11	11 ± 1
2	San Juan Bay Estuary Program	9	0
3	Delaware Center for the Inland Bays	10	N/A
3	Maryland Coastal Bays Program	16	1
3	Partnership for the Delaware Estuary	233 ± 27	11 ± 2
4	Albemarle-Pamlico National Estuary Partnership	1,964 ± 173	211 ± 43
4	Coastal & Heartland National Estuary Partnership	4,441 ± 53	408 ± 13
4	Indian River Lagoon National Estuary Program	213 ± 12	18 ± 1
4	Mobile Bay National Estuary Program	62 ± 6	5
4	Sarasota Bay Estuary Program	0	0
4	Tampa Bay Estuary Program	6 ± 1	1
6	Barataria-Terrebonne National Estuary Program	102	9
6	Coastal Bend Bays and Estuaries Program	185 ± 7	14 ± 2
6	Galveston Bay Estuary Program	336 ± 123	12 ± 3
9	Morro Bay National Estuary Program	2	N/A
9	San Francisco Estuary Partnership	698 ± 173	99 ± 76
9	Santa Monica Bay National Estuary Program	44 ± 8	21 ± 16
10	Lower Columbia Estuary Partnership	55 ± 51	0
10	Puget Sound Partnership	520 ± 461	N/A
10	Tillamook Estuaries Partnership	131 ± 115	N/A
	Total	**10,677 ± 1,670**	**1,156 ± 186**

N/A refers to reductions that are negligible when converted to U.S. tons.

These numbers represent the annual sum of nutrients reduced by each ecoregion, not the cumulative amount for the total years that each project has been in place.

Detailed Approach and Results by Ecoregion

Northeast (Regions 1 and 2)

NEPs: Casco Bay Estuary Partnership, Piscataqua Region Estuaries Partnership, Narragansett Bay Estuary Program, Buzzards Bay National Estuary Program, Massachusetts Bays National Estuary Program, Long Island Sound Study, Peconic Estuary Partnership, New York/New Jersey Harbor Estuary Program, Barnegat Bay Partnership. [Note: San Juan was excluded from these calculations because it is not in the same climate/region as the Northeast]

1. Six habitats met the criteria above to qualify as relevant/significant to Regions 1 and 2. A thorough review of the literature revealed nutrient removal rates for only forest/woodland, forested wetland, and tidal wetland habitats in the Northeast. No related studies for nutrient removal rates of agriculture/ranchlands, soft bottom/mud, or riparian habitats in the Northeast were identified despite these habitats fitting our criteria and having known nutrient reduction capabilities.
2. The available removal rates for specific habitats are presented in Exhibit A-10. The total acres of habitat and calculated U.S. tons of nitrogen and phosphorous removed by habitat are shown in Exhibit A-11.

Exhibit A-10. Summary of Nutrient Removal Rates from Literature Review

Habitat	TN Removal Rate ($g/m^2/yr$)	TN Removal Rate ($lbs/m^2/yr$)	TP Removal Rate ($g/m^2/yr$)	TP Removal Rate ($lbs/m^2/yr$)
Forest/Woodland*	7.9 ± 2.3	0.0174 ± 0.0051	0.95 ± 0.15	0.0021 ± 0.0003
Forested Wetland	22.3	0.0049	55	0.0121
Tidal Wetland	6.2	0.0014	-	-
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.				

Exhibit A-11. Summary of Nutrients Reduced through Habitat Restoration/Protection in 2006-2019 through Northeastern NEP Projects

Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Forest/Woodland	44,852	1,581 ± 460	190 ± 30
Forested Wetland	6,366	63	156
Tidal Wetland	2,225	6	-
Total	**53,443**	**1,650 ± 460**	**346 ± 30**

The total acres of habitat restored or protected in the Northeast that provided nutrient reduction benefits from 2006 to 2019 for each NEP are shown in Exhibit A-12. Though we can't state that acres from these projects were necessarily planted or restored for the purpose of managing nutrients, our filtering criteria suggests these acres contributed to nutrient reduction.

Exhibit A-12. Acres of Northeastern NEP Habitat Restoration and Protection Projects that provided nutrient reduction benefits.

Region	NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
1	Buzzards Bay National Estuary Program	Forest/Woodland	3,133.43
1	Buzzards Bay National Estuary Program	Forested Wetland	451.47
1	Buzzards Bay National Estuary Program	Tidal Wetland	424.9
		Total	**4,009.80**
1	Casco Bay Estuary Partnership	Forest/Woodland	4,717.5
1	Casco Bay Estuary Partnership	Forested Wetland	161.5
1	Casco Bay Estuary Partnership	Tidal Wetland	68
		Total	**4,947**
1	Long Island Sound Study	Forest/Woodland	4,269.54
1	Long Island Sound Study	Forested Wetland	71.66
1	Long Island Sound Study	Tidal Wetland	146.7
		Total	**4,487.9**
1	Massachusetts Bays National Estuary Program	Forest/Woodland	91.44

Region	NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
1	Massachusetts Bays National Estuary Program	Forested Wetland	8.5
1	Massachusetts Bays National Estuary Program	Tidal Wetland	570.35
		Total	**670.29**
1	Narragansett Bay Estuary Program	Forest/Woodland	762
1	Narragansett Bay Estuary Program	Forested Wetland	161
1	Narragansett Bay Estuary Program	Tidal Wetland	0
		Total	**923**
1	Piscataqua Region Estuaries Partnership	Forest/Woodland	13,819.54
1	Piscataqua Region Estuaries Partnership	Forested Wetland	762.85
1	Piscataqua Region Estuaries Partnership	Tidal Wetland	72
		Total	**14,654.39**
2	Barnegat Bay Partnership	Forest/Woodland	16,006.5
2	Barnegat Bay Partnership	Forested Wetland	4,379.36
2	Barnegat Bay Partnership	Tidal Wetland	759.01
		Total	**21,144.87**
2	New York-New Jersey Harbor & Estuary Program	Forest/Woodland	982.9
2	New York-New Jersey Harbor & Estuary Program	Forested Wetland	100
2	New York-New Jersey Harbor & Estuary Program	Tidal Wetland	7.5
		Total	**1090.4**
2	Peconic Estuary Partnership	Forest/Woodland	1,069.01
2	Peconic Estuary Partnership	Forested Wetland	269.33
2	Peconic Estuary Partnership	Tidal Wetland	177.34
		Total	**1,515.68**
1	**Regional**	**Total**	**29,692.38**
2	**Regional**	**Total**	**23,750.95**
1+2	**Northeast**	**Total**	**53,443.33**

The calculated U.S. tons of nitrogen and phosphorous removed by habitat protection and restoration are shown for each individual NEP in the Northeast in Exhibit A-13.

Exhibit A-13 Summary of Nutrients Reduced by Northeastern NEPs through Habitat Restoration/Protection in 2006-2019 Projects

Region	NEP	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
1	Buzzards Bay National Estuary Program	4,010	116 ± 32	24 ± 2
1	Casco Bay Estuary Partnership	4,947	168 ± 48	24 ± 3
1	Long Island Sound Study	4,488	152 ± 44	20 ± 3
1	Massachusetts Bays National Estuary Program	670	5 ± 1	1
1	Narragansett Bay Estuary Program	923	28 ± 8	7 ± 1
1	Piscataqua Region Estuaries Partnership	14,654	495 ± 142	77 ± 9
2	Barnegat Bay Partnership	21,144.87	610 ± 164	175 ± 11
2	New York-New Jersey Harbor & Estuary Program	1,090	35 ± 10	7
2	Peconic Estuary Partnership	1,516	41 ± 11	11 ± 1
1	**Regional Total**	**29,692.31**	**964 ± 275**	**153 ± 18**
2	**Regional Total**	**23,750.95**	**686 ± 185**	**193 ± 12**
1+2	**Northeast Total**	**53,443.26**	**1,650 ± 460**	**346 ± 30**

Note: These totals only include acreage for forest/woodland, forested wetland, and tidal wetland habitats. Tidal wetland did not have known TP removal rates. If seeking Region 2 totals, see Exhibit A-20 for San Juan Bay Estuary Program's acreage, TN, and TP data in the Southeast/Gulf/Caribbean section.

Literature Supporting Habitat Nutrient Removal Rates

1. Forest/Woodland –The numbers below were used to calculate average Nitrogen and Phosphorus removal rates for this habitat. The average N removal rate across the six studies identified was 79±23 kg N/ha/yr (7.9±2.3 g N/m^2/yr) and the average P removal rate was 9.5±1.5 kg P/ha/yr (0.95±0.15 g P/m^2/yr).
    a. **Adegbidi HG, Volk TA, White EH, Abrahamson LP, Briggs RD, Bickelhaupt DH. 2001. Biomass and nutrient removal by willow clones in experimental bioenergy plantations in New York State. Biomass and Bioenergy 20(6): 399-411.** This article investigated nutrient removal and nutrient use efficiency in willow and poplar plantings in New York. Authors found that annual biomass production removed 75-86 kg N/ha/year and 10-11 kg P/ha/year. The goal of the study was to determine which clone willow would be most appropriate for biomass crops that are to be used as buffer strips to manage nutrient runoff from agricultural fields. Aboveground woody biomass was harvested at the end of the growing cycle. Nitrogen concentration was determined by the macro-Kjeldhal method (Wilde et al., 1964) and Phosphorus concentration was determined by the ammonium molybdate vanadate method (Wilde et al., 1964).

    Adegbidi et al. also include the following N removal rates for various production systems:

Species	N removal (kg/ha/yr)	P removal (kg/ha/yr)	Source
Willow	75-86	10-11	Adegbidi et al., 2001
Willow	46	7	Ericsson, 1994
Willow	27	4.5	Hytonen, 1995
Sycamore	23-40	3-14	Hansen and Baker, 1979
Sycamore	30	7	Wood et al., 1977
Eastern Cottonwood	25-32	4.5-5.5	Heilman and Norby, 1998
Hybrid Poplar	78	8	Hansen and Baker, 1979
Poplar	76	8	Lodhiyal and Singh, 1994
Black Cottonwood	24-58	4-9	Heilman and Norby, 1998
Hardwoods and conifers	2.7-13.2	0.2-1.8	Mann et al., 1988

i. Wilde SA, Voigt GK, and Iyer JG. 1964. Soil and plant analysis for tree culture. Oxford Publishing House, New Delhi.
ii. Ericsson T. Nutrient cycling in energy forest plantations. Biomass and Bioenergy 1994; 6:115–21.
iii. Hytonen J. Effect of fertilizer treatment on the biomass production and nutrient uptake of short-rotation willow on cut-away peatlands. Silva Fennica 1995;29:21–40.
iv. Hansen EA, Baker JB. Biomass and nutrient removal in short-rotation intensively cultured plantations. In: Proceedings of the Symposium on Impact of Intensive Harvesting on Forest Nutrient Cycling. SUNY-ESF, Syracuse, NY, August 13–16, 1979. p. 130–51.
v. Wood BW, Wittwer RF, Carpenter SB. Nutrient element accumulation and distribution in an intensively cultured American sycamore plantation. Plant and Soil 1977;48: 417–33.
vi. Heilman P, Norby RJ. Nutrient cycling and fertility management in temperate short-rotation forest systems. Biomass and Bioenergy 1998;14:361–70.
vii. Lodhiyal LS, Singh SP. Productivity and nutrient cycling in poplar stands in central Himalaya, India. Canadian Journal of Forest Research 1994;24:1199–209.
viii. Mann LK, Johnson DW, West DC, Cole DW, Hornbeck JW, Martin CW, Riekerk H, Smith CT, Swank WT, Tritton LM, Van Lear DH. E9ects of whole-tree and stem clearcutting on postharvest hydrologic losses, nutrient capital, and regrowth. Forest Science 1988;34:412–28.

b. **Campbell JL, Hornbeck JW, Mitchell MJ, Adams MB, Castro MS, Driscoll CT, Kahl JS, Kochenderfer JN, Likens GE, Lynch JA, Murdock PS, Nelson SJ, Shanley JB. 2004. Input-Output Budgets of Inorganic Nitrogen for 24 Forest Watersheds in the Northeastern United States: A Review**. **Water, Air, and Soil Pollution 151: 373-396.** This study summarizes input-output budgets of dissolved inorganic nitrogen (DIN) for 24 forest watersheds at 15 locations in the northeastern United States. Authors found that DIN retention ranged from 1.2-7.3 kg N/ha/year (mean = 4.4 kg N/ha/year; n=14). Data from the National Atmospheric Deposition Program (NADP) was used for input and output calculations.
c. **University of Maine. January 2010. Woody Biomass Retention Guidelines**. The University of Maine published Woody Biomass Retention Guidelines. In this analysis, nutrient removal was calculated for three whole-tree harvests on a northern hardwood stand in New Hampshire. Biomass and nutrient removal were calculated for the winter with no leaves (230±10 kg N/ha/yr; 18±1 kg P/ha/yr), summer with no leaves (219±23 kg N/ha/yr; 17±2 kg P/ha/yr), and summer with leaves (278±12 kg N/ha/yr; 22±2 kg P/ha/yr).
d. **Goodale CL, Lajtha K, Nadelhoffer KJ, Boyer EW, and Jaworski NA. 2002. Forest nitrogen sinks in large eastern U.S. watershed estimates from forest inventory and an ecosystem model. Biogeochemistry 57/58: 239-266.** This study "quantified forest N sinks in biomass accumulation and harvest export for 16 large river basins in the eastern U.S. with two separate approaches: (1) using growth data from the USDA Forest Service's Forest Inventory and Analysis (FIA) program and (2) using a model of forest nitrogen cycling (pnET-CN) linked to FIA information on forest age-class structure." The mean N retention rate was found to be 6.7 kg N/ha/yr (n=16).
e. **Yanai, Ruth D. 1992. Phosphorus budget of a 70-year-old northern hardwood forest. Biogeochemistry 17: 1-22.** This study used the Hubbard Brook Experimental Forest to monitor P uptake by vegetation, finding an average rate of 9.6 kg P/ha/yr.

2. Forested Wetland Review of the literature revealed only one rate for Nitrogen and for Phosphorus removal of forested wetlands in the northeastern U.S. The Nitrogen removal rate was 22.3 g N/m^2/yr, which is equivalent to 223 kg N/ha/yr. The Phosphorus removal rate was 55 g P/m^2/yr, which is equivalent to 550 kg P/ha/yr.
    a. **Bowden, W.B. 1987. The biogeochemistry of nitrogen in freshwater wetlands. Biogeochemistry 4: 313-348.** This study summarizes N uptake and transfer rates in wetland systems using literature that focuses on different geographic locations. It makes mention of N plant uptake rates found by Bartlett et al. in 1979 to be in be 22.3 g N/m^2/yr in a Massachusetts palustrine wetland.
        i. Bartlett MS, Brown LL, Haines WB & Nickerson NH (1979) Denitrification in freshwater wetland soil. Journal of Environmental Quality 8: 460-464
    b. **Peverly, J.H. Stream transport of nutrients through a wetland. *J. Environ. Qual.* 1982 11 38– 43**. A hydrographic and nutrient analysis of the potential for managed wetlands to remove nutrients from agricultural drainage revealed New York riparian wetlands to have a Phosphorus removal rate of 55 g P/m^2/yr.

3. Tidal Wetland – The literature review identified only one rate for Nitrogen removal of tidal wetlands in the northeastern U.S., and the mean was 6.2 g N/m^2/yr which is equivalent to 62 kg N/ha/yr. There was no available information regarding Phosphorus removal in Northeastern tidal wetlands.
    a. **Drake K, Halifax H, Adamowicz SC, and Craft C. 2015. Carbon Sequestration in Tidal Salt Marshes of the Northeast United States. Environmental Management 56: 998-1008.** The authors examined soil properties, C and N pools, C sequestration, and N accumulation at four marshes managed with open marsh water management and four marshes that were not at U.S. Fish and Wildlife National Wildlife Refuges on the East Coast of the U.S. They found that Northeastern tidal marshes Nitrogen removal rates ranged from 3.5-7.6 g N/m^2/yr (mean=6.2 g N/m^2/yr).

Mid-Atlantic (Region 3)

NEPs: Partnership for the Delaware Estuary, Delaware Center for the Inland Bays, Maryland Coastal Bays Program

1. Six habitats met the criteria above to qualify as relevant/significant to Region 3: Agriculture, Forest/Woodland, Forested Wetland, Lake/Pond, Riparian, and Tidal Wetland. A thorough review of the literature revealed nutrient removal rates for each of these habitats except Lake/Pond.
2. The available removal rates for specific habitats are presented in Exhibit A-14. The total acres of habitat and calculated U.S. tons of nitrogen and phosphorous removed by habitat are shown in Exhibit A-15.

Exhibit A-14. Summary of Nutrient Removal Rates from Literature Review

Habitat	TN Removal Rate ($g/m^2/yr$)	TN Removal Rate ($lbs/ m^2/yr$)	TP Removal Rate ($g/m^2/yr$)	TP Removal Rate ($lbs/ m^2/yr$)
Forested Wetland	7.5	0.0165	0.3	0.0007
Forest/Woodland*	0.47 ± 0.1	0.0010 ± 0.0002	-	-
Riparian*	4.29 ± 3.12	0.0095 ± 0.0069	0.5 ± 0.21	0.0011 ± 0.0005
Tidal Wetland**	9.53	0.0210	-	-
Agriculture	8.5	0.0187	0.55	0.0012

*Values of these habitats are an average of multiple data sources and include Standard Error measurements.

**Values of these habitats are an average of multiple data sources, but a Standard Error was not able to be calculated due to unit conversion.

Exhibit A-15. Summary of Nutrients Reduced through Habitat Restoration/Protection in 2006-2019 through Mid-Atlantic NEP Projects

Habitat	Acres restored or protected which provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Forested Wetland	3,099	104	4
Forest/Woodland*	3,537	7 ± 1	-
Riparian*	1,843	35 ± 26	4 ± 2
Tidal Wetland**	1,140	48	-
Agriculture	1,713	65	4
Total	**11,332**	**259 ± 27**	**12 ± 2**

*Values of these habitats are an average of multiple data sources and include Standard Error measurements.

**Values of these habitats are an average of multiple data sources, but a Standard Error was not able to be calculated due to unit conversion.

The total acres of habitat restored or protected in the Mid-Atlantic that provided nutrient reduction benefits from 2006 to 2019 for each NEP are shown in Exhibit A-16. Though we can't state that acres from these projects were necessarily planted or restored for the purpose of managing nutrients, our filtering criteria suggests these acres contributed to nutrient reduction.

Exhibit A-16. Acres of Mid-Atlantic NEP Habitat Restoration and Protection that provided nutrient reduction benefits.

NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
Delaware Center for the Inland Bays	Forested Wetland	25
Delaware Center for the Inland Bays	Forest/Woodland	412.82
Delaware Center for the Inland Bays	Riparian	0.69
Delaware Center for the Inland Bays	Tidal Wetland	58.8
Delaware Center for the Inland Bays	Agriculture	145.4
	Total	**642.71**
Maryland Coastal Bays Program	Forested Wetland	103
Maryland Coastal Bays Program	Forest/Woodland	356
Maryland Coastal Bays Program	Riparian	14.87
Maryland Coastal Bays Program	Tidal Wetland	0
Maryland Coastal Bays Program	Agriculture	317.3
	Total	**791.17**

Partnership for the Delaware Estuary	Forested Wetland	2,971.21
Partnership for the Delaware Estuary	Forest/Woodland	2,767.99
Partnership for the Delaware Estuary	Riparian	1,827.68
Partnership for the Delaware Estuary	Tidal Wetland	1,081.33
Partnership for the Delaware Estuary	Agriculture	1,249.85
	Total	**9,898.06**
Region 3/Mid Atlantic	**Total**	**11,331.94**

The calculated U.S. tons of nitrogen and phosphorous removed by habitat protection and restoration are shown for each individual NEP in the Mid-Atlantic in Exhibit A-17.

Exhibit A-17. Summary of Nutrients Reduced by Mid-Atlantic NEPs through Habitat Restoration/Protection in 2006-2019 Projects

Region	NEP	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
3	Delaware Center for the Inland Bays	643	10	N/A
3	Maryland Coastal Bays Program	791	16	1
3	Partnership for the Delaware Estuary	9,898	233 ± 27	11 ± 2
	Total	**11,332**	**259± 27**	**12 ± 2**
Note: These totals include acreage and nutrients removed by forested wetland, forest/woodland, riparian, tidal wetland*, and agriculture habitats. N/A refers to reductions that are negligible when converted to U.S. tons. Forest/Woodland and tidal wetland did not have known TP removal rates.				

Literature Supporting Habitat Nutrient Removal Rates

1. Agriculture – The literature review identified only one article citing nutrient reduction rates brought about through conservation easements or water quality trading. The TN removal rate was found to be 84.87 kg N/ha/yr (8.5 g/m^2/yr) and the TP removal rate was found to be 5.47 kg P/ha/yr (0.55 g P/m^2/yr).
    a. **Willamette Partnership. 2012. In it Together: A How-To Reference for Building Point-Nonpoint Water Quality Trading Programs.** This document is a how-to guidance for building a point-nonpoint water quality trading program. It includes a North Carolina water quality trading case study. Through targeted best management practices, land use changes, additional reductions in nonpoint source runoff, and nutrient removal from periodic overbank floods, TN reduction was found to be 84.87 kg N/ha/yr and TP reduction was found to be 5.47 kg P/ha/yr. These numbers were calculated by DENR using previous nutrient loadings and considering nutrient retention rates of implemented best management practices.
2. Forest/Woodland – The average TN removal rate with SE is 4.7±1 kg N/ha/yr (0.47±0.1 g N/m^2/yr). No literature regarding TP removal was found.
    a. **Correll, David. 1977. Watershed Research in Eastern North America: A workshop to compare results. Chesapeake Bay Center for Environmental Studies. Smithsonian Institution. Edgewater, Maryland.** This study from a Clemson hydrologic laboratory examines the effects of management practices on elemental cycles in forested watersheds. Simulation models of nitrogen cycling were used to assess potential effects of various management alternatives (merchantable stem and complete-tree harvests). The table below demonstrates the results of the simulation and the corresponding nitrogen removal rates.

Ecosystem Model	Type of Cut	Rotation Length	Nitrogen Removal Rate (kg/ha/yr)
Oak-Hickory (15 compartment)	Merchantable	90	1.94
Oak-Hickory (15 compartment)	Complete-tree	90	5.08
Oak-Hickory (15 compartment)	Merchantable	50	3.33
Oak-Hickory (7 compartment)	Merchantable	90	2.11
Oak-Hickory (7 compartment)	Complete-tree	90	5.47
Oak-Hickory (7 compartment)	Merchantable	50	3.59
Loblolly pine (7 compartment)	Merchantable	30	3.83

Ecosystem Model	Type of Cut	Rotation Length	Nitrogen Removal Rate (kg/ha/yr)
Loblolly pine (7 compartment)	Complete-tree (with residue removal)	30	11.61
Loblolly pine (7 compartment)	Merchantable (with thinning at age 16)	30	5.46

3. Forested Wetland – The literature review identified one article about Mid-Atlantic forested wetland nutrient removal rates, so we used the TN removal rate of 75 kg N/ha/yr (7.5 g N/m^2/yr) and TP removal rate of 3 kg P/ha/yr (0.3 g P/m^2/yr).
    a. **Correll DL and Weller DE. 1989. Factors Limiting Processes in Freshwater Wetlands: An Agricultural Primary Stream Riparian Forest. Freshwater Wetlands and Wildlife.** This study looks at hydrology and belowground processing of nitrate and sulfate in a riparian forest wetland in the Rhode River Watershed, MD. "Water from surface runoff collector samples and groundwater samples were analyzed for total Kjeldahl nitrogen (TKN), total phosphorus, nitrate, chloride, sulfate, and organic matter content." Nutrient mass balances indicated a net retention by the wetland of 75 kg N/ha/yr and 3 kg P/ha/yr."
4. Riparian – The two literature sources for riparian habitat nutrient removal rates gave different rates. Searching for other articles did not locate any that calculated nutrient retention rates. The mean TN removal rate ± SE is 42.85±31.16 kg N/ha/yr (4.29±3.12 g N/m^2/yr) and the mean TP removal rate ± SE is 4.95±2.06 kg P/ha/yr (0.5±0.21 g P/m^2/yr).
    a. **Lowrance R, Altier LS, Newbold JD, Schnabel RR, Groffman PM, Denver JM, Correll DL, Gilliam JW, Robinson JL, Brinsfield RB, Staver KW, Lucas W, Todd AH. 1997. Water Quality Functions of Riparian Forest Buffers in Chesapeake Bay Watersheds. Environmental Management 21(5): 687-712.** This study examines the Nitrogen and Phosphorus reductions associated with riparian forest buffer systems (RFBS) in Maryland, Virginia, and Pennsylvania. Estimates for total N and P retention in riparian ecosystems in Rhode River, MD, were determined using both surface runoff and groundwater inputs and outputs. Total N retention was found by Peterjohn and Correll (1984) to be 74 kg N/ha/yr, and Total P retention was found to be 2.9 kg P/ha/yr.
        i **Peterjohn, W.T.**, and **Correl, D.L. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest.** *Ecology* **65 1466**– 1475.
    b. **Delaware Department of Natural Resources and Environmental Control. 2012. St. Jones River Watershed Pollution Control Strategy: A Watershed-Based Strategy to Implement Total Maximum Daily Loads in Delaware**. The Delaware Department of Natural Resources and Environmental Control wrote a watershed pollution control strategy for the St. Jones River Watershed. Using habitats in this watershed to track nutrient reduction, they found riparian buffers to reduce .2 lb N/7acres/day and .12lb P/7 acres/day. In annual reductions, this equates to 11.69 kg N/ha/yr and 7.01 kg P/ha/yr.
5. Tidal Wetland – The average Nitrogen removal rate for tidal wetlands is 95.29 kg/ha/yr (9.52 g/m^2/yr). It was possible to calculate the SE for this median rate because there was no value for h^{-1}; therefore, individual denitrification rates could not be converted to kg/ha/yr.
    a. **Forand N, DuBois K, Halka J, Hardaway S, Janek G, Karrh L, Koch E, Linker L, Mason P, Morgereth E, Proctor D, Smith K, Stack B, Stewart S, and Wolinksi B. 2015. Removal rates for shoreline management projects**. WTWG and WQGIT. This study reviews various shoreline management techniques in Chesapeake Bay, including projects, methods, and protocols. The appendix includes a summary table of denitrification rates in coastal mid-Atlantic tidal wetlands found in various literature sources. The µmol N m^{-2} h^{-1} values were converted to kg N m^{-2} h^{-1} values to allow for comparison of these to other rates. There were no depth values available for h^{-1}, so it was not possible to convert the individual denitrification rates to kg/ha/yr. We were, however, able to use the given median lbs/acre/year statistic to find the median rate in kg/ha/yr.

Denitrification rate ($\mu mol\ N\ m^{-2}\ h^{-1}$)	Denitrification rate ($kg\ N\ m^{-2}\ h^{-1}$)	Source
147	2.06	Hopfensperger et al., 2009
44	0.62	Merrill and Cornwell, 2002
120	1.7	Greene, 2005
65	0.9	Boynton et al., 2008
60	0.84	Merrill, 1999
420	5.9	Davis et al., 2004
19.1	0.001	Koop-Jakobsen and Gibllin, 2010
78	1.09	Kana et al., 1998
3165	44.34	Tobias et al., 2001
77.67	1.09	Median
85.02 lbs N/acre/year	95.29 kg/ha/yr	Median

i. Hopfensperger, K.N., S.S. Kaushal, S.E.G. Findlay, and J.C. Cornwell. 2009. Influence of plant communities on denitrification in a tidal freshwater marsh of the Potomac River, United States. Journal of Environmental Quality 36: 618-626.

ii. Merrill, J.Z. and J.C. Cornwell. 2002. The role of oligohaline marshes in estuarine nutrient cycling. Concepts and Controversies in Tidal Marsh Ecology. pp. 425-441.

iii. Greene, S.E. 2005. Nutrient removal by tidal fresh and oligohaline marshes in the Chesapeake Bay tributary. M.S. University of Maryland Center for Environmental Science Chesapeake Biological Laboratory. College Park, MD.

iv. Boynton, W.R., J.D. Hagy, J.C. Cornwell, W.M. Kemp, S.M. Greene, M.S. Owens, J.E. Baker, and R.K. Larsen. 2008. Nutrient budgets and management actions in the Patuxent River estuary, Maryland. Estuaries and Coasts 31: 623-651.

v. Merrill, J.Z. 1999. Tidal freshwater marshes as nutrient sinks: Particulate nutrient burial and denitrification. PhD. University of Maryland, College Park. College Park, MD.

vi. Koop-Jakobsen K, Giblin AE. 2010. The effect of increased nitrate loading on nitrate reduction via denitrification and DNRA in salt marsh sediments. Limnology and Oceanography 55: 789802.

vii. Kana, T.M., M.B. Sullivan, J.C. Cornwell, and K.M. Groxzkowksi. 1998. Denitrification in estuarine sediments determined by membrane mass spectrometry. Limnology and Oceanography 43: 334-339.

viii. Tobias, Craig R., Iris C. Anderson, Elizabeth A. Canuel, and Stephen A. Macko. 2001. Nitrogen cycling through a fringing marsh-aquifer ecotone. Marine Ecology Progress Series 210: 25-39.

Southeast/Gulf/Caribbean (Regions 2, 4 and 6)

NEPs: Indian River Lagoon National Estuary Program, Tampa Bay Estuary Program, Sarasota Bay Estuary Program, Coastal & Heartland National Estuary Partnership, Mobile Bay National Estuary Program, Coastal Bend Bays and Estuaries Program, Galveston Bay Estuary Program, Barataria-Terrebonne National Estuary Program, San Juan Bay Estuary Program, and Albemarle-Pamlico National Estuary Partnership [Note: San Juan Bay Estuary Program was added to this category from Region 2 because the southeast is the ecoregion most closely resembling Puerto Rico's climate; Albemarle-Pamlico National Estuary Program has been added to this ecoregion (from Mid-Atlantic) because NCCA* classifies its location as "Southeast.")

*The National Coastal Condition Assessment (NCCA) uses sediment chemistry to designate regional borders.

1. Eleven habitats met the criteria above to qualify as relevant/significant to Region 4 and/or 6: Agriculture, Forest/Woodland (4), Forested Wetland, Estuarine Shoreline (4), Field/Meadow (4), Freshwater Marsh, Grassland, Riparian, SAV (Submerged Aquatic Vegetation (4), Soft Bottom/Sand (4), and Tidal Wetland. Although Mangroves did not meet the NEPORT filtration criteria for acreage, it was included because it is a known relevant habitat to the area. A thorough review of the literature revealed nutrient removal rates for: Agriculture, Forested Wetland, Freshwater Marsh, Riparian, SAV (Submerged Aquatic Vegetation), Tidal Wetland, and Mangrove.
2. The available removal rates for specific habitats are presented in Exhibit A-18. The total acres of habitat and calculated U.S. tons of nitrogen and phosphorous removed by habitat are shown in Exhibit A-19.

Exhibit A-18. Summary of Nutrient Removal Rates from Literature Review

Habitat	TN Removal Rate ($g/m^2/yr$)	TN Removal Rate ($lbs/ m^2/yr$)	TP Removal Rate ($g/m^2/yr$)	TP Removal Rate ($lbs/ m^2/yr$)
Agriculture*	1.61 ± 0.79	0.0035 ± 0.0017	0.40 ± 0.21	0.0009 ± 0.0004
Forested Wetland	9.58	0.0211	0.88	0.0019
Freshwater Marsh*	13.78	0.0304	0.84	0.0019
Riparian	2.82	0.0062	0.17	0.0004
SAV (Submerged Aquatic Vegetation)	9 ± 2.2	0.0198 ± 0.0049	1.2	0.0026
Tidal Wetland*	4 ± 2	0.0088 ± 0.0044	-	-
Mangrove*	1 ± 0.1	0.0022 ± 0.0002	-	-
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.				

Exhibit A-19. Summary of Nutrients Reduced through Habitat Restoration/Protection in 2006-2019 through Southeast/Gulf/Caribbean NEP Projects

Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Agriculture	66,339	477 ± 234	118 ± 62
*Forested Wetland	121,549	5,194	477
Freshwater Marsh	11,784	724	44
Riparian	50,676	638	39
SAV (Submerged Aquatic Vegetation)	4	N/A	N/A
Tidal Wetland	15,796	282 ± 141	-
Mangrove	708.39	3	-
Total	**266,856**	**7,318± 375**	**678 ± 62**
Values of these habitats are an average of multiple data sources and include Standard Error measurements. N/A refers to reductions that are negligible when converted to U.S. tons.			

*Barataria-Terrebonne National Estuary Program did not have any acres contributing to nutrient reduction after an initial filtering following our methodology. This forested wetland project was added after the report was reviewed by Region 6 and an argument was made for why this project with the Restoration Technique "Other" should be included as contributing to nutrient reduction.

The total acres of habitat restored or protected in the Southeast/Gulf/Caribbean that provided nutrient reduction benefits from 2006 to 2019 for each NEP are shown in Exhibit A-20. Though we can't state that acres from these projects were necessarily planted or restored for the purpose of managing nutrients, our filtering criteria suggests these acres contributed to nutrient reduction.

Exhibit A-20. Acres of Southeast/Gulf/Caribbean NEP Habitat Restoration and Protection Projects which provided nutrient reduction benefits.

Region	NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
4	Albemarle-Pamlico National Estuary Partnership	Agriculture/Ranchland	45,477.55
4	Albemarle-Pamlico National Estuary Partnership	Forested Wetland	24,022.04
4	Albemarle-Pamlico National Estuary Partnership	Freshwater Marsh	15.71
4	Albemarle-Pamlico National Estuary Partnership	Riparian	46,355.31
4	Albemarle-Pamlico National Estuary Partnership	SAV (Submerged Aquatic Vegetation)	0
4	Albemarle-Pamlico National Estuary Partnership	Tidal Wetland	1,480.13
4	Albemarle-Pamlico National Estuary Partnership	Mangrove	0
		Total	**117,350.74**
4	Coastal & Heartland National Estuary Partnership	Agriculture/Ranchland	14,454.8
4	Coastal & Heartland National Estuary Partnership	Forested Wetland	89,581.74
4	Coastal & Heartland National Estuary Partnership	Freshwater Marsh	7,541.24
4	Coastal & Heartland National Estuary Partnership	Riparian	3,213.97
4	Coastal & Heartland National Estuary Partnership	SAV (Submerged Aquatic Vegetation)	3.02
4	Coastal & Heartland National Estuary Partnership	Tidal Wetland	189
4	Coastal & Heartland National Estuary Partnership	Mangrove	288.84
		Total	**115,272.61**
4	Indian River Lagoon National Estuary Program	Agriculture/Ranchland	599.59
4	Indian River Lagoon National Estuary Program	Forested Wetland	4,247.84
4	Indian River Lagoon National Estuary Program	Freshwater Marsh	86
4	Indian River Lagoon National Estuary Program	Riparian	12.9
4	Indian River Lagoon National Estuary Program	SAV (Submerged Aquatic Vegetation)	0
4	Indian River Lagoon National Estuary Program	Tidal Wetland	1,130.19
4	Indian River Lagoon National Estuary Program	Mangrove	397.34
		Total	**6,473.86**
4	Mobile Bay National Estuary Program	Agriculture/Ranchland	0
4	Mobile Bay National Estuary Program	Forested Wetland	1,177
4	Mobile Bay National Estuary Program	Freshwater Marsh	1
4	Mobile Bay National Estuary Program	Riparian	34.8
4	Mobile Bay National Estuary Program	SAV (Submerged Aquatic Vegetation)	0.86

Region	NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
4	Mobile Bay National Estuary Program	Tidal Wetland	648.3
4	Mobile Bay National Estuary Program	Mangrove	0
		Total	**1,861.96**
4	Sarasota Bay Estuary Program	Agriculture/Ranchland	0
4	Sarasota Bay Estuary Program	Forested Wetland	0
4	Sarasota Bay Estuary Program	Freshwater Marsh	0
4	Sarasota Bay Estuary Program	Riparian	0
4	Sarasota Bay Estuary Program	SAV (Submerged Aquatic Vegetation)	0
4	Sarasota Bay Estuary Program	Tidal Wetland	0
4	Sarasota Bay Estuary Program	Mangrove	0
		Total	**0**
4	Tampa Bay Estuary Program	Agriculture/Ranchland	148
4	Tampa Bay Estuary Program	Forested Wetland	50.64
4	Tampa Bay Estuary Program	Freshwater Marsh	37.36
4	Tampa Bay Estuary Program	Riparian	12
4	Tampa Bay Estuary Program	SAV (Submerged Aquatic Vegetation)	0
4	Tampa Bay Estuary Program	Tidal Wetland	2.03
4	Tampa Bay Estuary Program	Mangrove	15
		Total	**265.03**
6	Barataria-Terrebonne National Estuary Program	Agriculture/Ranchland	0
6	Barataria-Terrebonne National Estuary Program	Forested Wetland	*2,395
6	Barataria-Terrebonne National Estuary Program	Freshwater Marsh	0
6	Barataria-Terrebonne National Estuary Program	Riparian	0
6	Barataria-Terrebonne National Estuary Program	SAV (Submerged Aquatic Vegetation)	0
6	Barataria-Terrebonne National Estuary Program	Tidal Wetland	0
6	Barataria-Terrebonne National Estuary Program	Mangrove	0
		Total	**2,395**
6	Coastal Bend Bays and Estuaries Program	Agriculture/Ranchland	1,970.1
6	Coastal Bend Bays and Estuaries Program	Forested Wetland	75
6	Coastal Bend Bays and Estuaries Program	Freshwater Marsh	2,510.45
6	Coastal Bend Bays and Estuaries Program	Riparian	981.19
6	Coastal Bend Bays and Estuaries Program	SAV (Submerged Aquatic Vegetation)	0
6	Coastal Bend Bays and Estuaries Program	Tidal Wetland	54
6	Coastal Bend Bays and Estuaries Program	Mangrove	0
		Total	**5,590.74**
6	Galveston Bay Estuary Program	Agriculture/Ranchland	3,689
6	Galveston Bay Estuary Program	Forested Wetland	0
6	Galveston Bay Estuary Program	Freshwater Marsh	1,457
6	Galveston Bay Estuary Program	Riparian	57.46
6	Galveston Bay Estuary Program	SAV (Submerged Aquatic Vegetation)	0
6	Galveston Bay Estuary Program	Tidal Wetland	12,291.44
6	Galveston Bay Estuary Program	Mangrove	0
		Total	**17,494.9**
2	San Juan Bay Estuary Program	Agriculture/Ranchland	0
2	San Juan Bay Estuary Program	Forested Wetland	0
2	San Juan Bay Estuary Program	Freshwater Marsh	135
2	San Juan Bay Estuary Program	Riparian	8.75

Region	NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
2	San Juan Bay Estuary Program	SAV (Submerged Aquatic Vegetation)	0
2	San Juan Bay Estuary Program	Tidal Wetland	1
2	San Juan Bay Estuary Program	Mangrove	7.21
		Total	**151.96**
4	**Regional**	**Total**	**241,224.20**
6	**Regional**	**Total**	**25,480.64**
2	**Regional**	**Total**	**151.96**
4+6+2	**Southeast/Gulf/Caribbean**	**Total**	**266,856.8**

*Barataria-Terrebonne National Estuary Program did not have any acres contributing to nutrient reduction after an initial filtering following our methodology. This forested wetland project was added after the report was reviewed by Region 6 and an argument was made for why this project with the Restoration Technique "Other" should be included as contributing to nutrient reduction.

The calculated U.S. tons of nitrogen and phosphorous removed by habitat protection and restoration are shown for each individual NEP in the Southeast/Gulf/Caribbean in Exhibit A-21.

Exhibit A-21. Summary of Nutrients Reduced by Southeast/Gulf/Caribbean NEPs through Habitat Restoration/Protection in 2006-2019 Projects

Region	NEP	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
4	Albemarle-Pamlico National Estuary Partnership	117,350.74	1,964 ± 173	211 ± 43
4	Coastal & Heartland National Estuary Partnership	115,272.61	4,441 ± 53	408 ± 13
4	Indian River Lagoon National Estuary Program	6,473.86	213 ± 12	18 ± 1
4	Mobile Bay National Estuary Program	1,861.96	62 ± 6	5
4	Sarasota Bay Estuary Program	0	0	0
4	Tampa Bay Estuary Program	265.03	6 ± 1	1
6	Barataria-Terrebonne National Estuary Program	2,395	102	9
6	Coastal Bend Bays and Estuaries Program	5,590.74	185 ± 7	14 ± 2
6	Galveston Bay Estuary Program	17,494.90	336 ± 123	12 ± 3
2	San Juan Bay Estuary Program	151.96	9	0
4	**Regional Total**	**241,224.2**	**6,686 ± 245**	**643 ± 58**
6	**Regional Total**	**25,480.64**	**623 ± 130**	**35 ± 5**
2	**Regional Total**	**151.96**	**9**	**0**
4+6+2	**Southeast/Gulf/Caribbean Total**	**266,856.8**	**7,318 ± 375**	**678 ± 62**

Note: These totals include acreage and nutrients removed by Forested Wetland, Freshwater Marsh, Riparian, SAV (Submerged Aquatic Vegetation)*, Tidal Wetland*, and Mangrove*.

SAV did not have known TN removal rates. Tidal Wetland and Mangrove did not have known TP removal rates

N/A refers to reductions that are negligible when converted to U.S. tons.

If seeking Region 2 totals, see Exhibit A-12 for the remaining acreage, TN, and TP data in the Northeast section.

Literature Supporting Habitat Nutrient Removal Rates

1. Agriculture – Agricultural restoration or protection in NEPORT typically includes land conservation or protection through acquisition and easements. Many projects involve the implementation of agricultural BMPs, which could involve the establishment of wetlands or riparian buffers or a number of other practices. Because agricultural projects could span many different restoration activities, the analysis relied on BMAPs for nutrient removal rates resulting from agricultural BMPs. The average TN and TP removal rates ± one standard error are 1.61±0.79 g N/m^2/yr and 0.40±0.21 g P/m^2/yr.
    a. **Florida Department of Environmental Protection. 2015. 2015 Progress Report for the St. Lucie River and Estuary Basin Management Action Plan.** As part of the St. Lucie River and Estuary BMAP, there is a plan for targeted nutrient loading reductions. One part of this is through agriculture BMP implementations. Below is a table of Nitrogen and Phosphorus reductions resulting from agricultural BMPs. The TN and TP reductions were listed in lbs/yr, which was converted to g/m^2/yr to be consistent.
    b. **Florida Department of Environmental Protection. 2016. 2016 Progress Report for the North Indian River Lagoon Basin Management Action Plan.** As part of the North Indian River Lagoon BMAP, there is a plan for targeted nutrient loading reductions. Below is a table of Nitrogen and Phosphorus reductions resulting from agricultural BMPs. The TN and TP reductions were listed in lbs/yr, which was converted to g/m^2/yr to be consistent.

Basin	Acres Enrolled in Agricultural BMPs	Total Nitrogen Reduced (lbs/yr)	Total Phosphorus Reduced (lbs/yr)	Total Nitrogen Reduced (g/m^2/yr)	Total Phosphorus Reduced (g/m^2/yr)
St. Lucie River and Estuary	9,083	2,993	795	0.037	0.0098
North IRL Project Zone A	223.8	5,047	1,420	2.53	0.71
North IRL Project Zone B	235.1	4,739	1,029	2.26	0.49

2. Forested Wetland – There was only one article found for the forested wetland habitat. The TN removal rate was 9.58 g N/m^2/yr and the TP removal rate was 0.88 g P/m^2/yr.
    a. **Martin JR, Keller CH, Clark Jr., R.A., Knight, R.L. 2001. Long-term performance summary for the Boot Wetland Treatment System. Water Sci. & Tech.44(11-2): 413-420.** This study examines the nutrient retention success of the Boot Water Treatment System, a cypress-gum wetland in Polk County, Florida. By measuring the inflow and outflow of wastewater nutrients, the authors determine retention rates of the WTS. They found the TN removal rate to be 9.58 g N/m^2/yr and the TP removal rate to be 0.88 g P/m^2/yr.
3. Freshwater Marsh – There were 2 articles for freshwater marsh removal rates. The average TN removal rate was 13.78 g N/m^2/yr, and the average TP removal rate was 0.84 g P/m^2/yr
    a. **Moustafa MZ, Chimney MJ, Fontaine TD, Shih G, Davis S. 1996. The response of a freshwater wetland to long term low level nutrient loads—marsh efficiency. Ecol. Eng. 7: 15–33.** The authors calculated TP and TN mass balances for Boney Marsh, a constructed freshwater wetland along the floodplain of the Kissimmee River, Florida. Nutrient retention rates and loading rates were monitored while the river was diverted through the marsh for a 9-year period (1978-1986). The average TN removal rate was 1.48 g N/m^2/month and the average TP removal rate was 0.06 g P/m^2/month. Converting these to annual rates gives us a TN rate of 17.76 g N/m^2/year and a TP rate of 0.72 g P/m^2/year.
    b. **Moustafa, MZ, and Havens KE. 2001. Identification of an optimal sampling strategy for a constructed wetland. JAWRA 37(4): 1015-1028.** This study by the Everglades Nutrient Removal Project examines the effect of sampling frequency and type on monthly phosphorus and nitrogen loads and concentrations entering and leaving a subtropical constructed wetland. The mean N retention rate was 9.8 g/m^2/year and the mean P retention rate was 0.96 g/m^2/year.
4. Riparian – Only one article was found that listed riparian nutrient removal rates. The TN removal rate was 2.82 g N/m^2/yr, and the TP removal rate was 0.17 g P/m^2/yr
    a. **Lowrance R, Todd R, Fail J, Hendrickson O, Leonard R, and Asmussen L. 1984. Riparian forests as nutrient filters for agricultural watersheds. Bioscience 34(6): 374-377.** This

study of a Georgia coastal plain watershed examines nutrient uptake and removal by riparian forest ecosystems in preventing sediment and chemical transport from agricultural uplands to the stream channel. Inputs, outputs, and vegetation storages of N, P, K, Ca, Mg, and Cl were measure from 1979 to 1981 using filtered samples flowing through a weir. Nitrogen had a retention rate of 28.2 kg N/ha/yr (2.82 g/m^2/yr) and Phosphorus had a retention rate of 1.7 kg P/ha/yr (0.17 g/m^2/yr).

5. SAV (Submerged Aquatic Vegetation) (4) – Two separate articles were found- one for nitrogen and one for phosphorus. The TN removal rate was 9 ±2.2 g N/m^2/year, and the TP removal rate was 1.2 g P/m^2/yr.
    a. **Knight RL, Gu B, Clarke RA, and Newman JM. 2003. Long-term phosphorus removal in Florida aquatic systems dominated by submerged aquatic vegetation. Ecological Engineering 20(1): 45-63.** This study describes an analysis of existing data collected from SAV-dominated lakes and rivers in Florida. The average of P removal rate of 13 SAV-dominated lake and river systems in Florida was 1.2 g P/m^2/yr.
    b. **Russel M and Greening H. 2015. Estimating Benefits in a Recovering Estuary: Tampa Bay, Florida. Estuaries and Coasts 38: S9–S18.** This study looks at ecosystem benefits and cost savings associated with expansion, restoration, and preservation of seagrass, coastal marsh, and mangrove habitats. The nitrogen removal rates through denitrification and carbon sequestration were quantified from previous studies of similar coastal and bay habitats. The TN removal rate was 9±2.2 g N/m^2/year.
6. Tidal Wetland – This study listed an average denitrification rate with standard error found through comparing multiple studies of tidal wetland habitat. The average TN removal rate was 4±2 g N/m^2/yr.
    a. **Russel M and Greening H. 2015. Estimating Benefits in a Recovering Estuary: Tampa Bay, Florida. Estuaries and Coasts 38: S9–S18.** This study looks at ecosystem benefits and cost savings associated with expansion, restoration, and preservation of seagrass, coastal marsh, and mangrove habitats. The nitrogen removal rates through denitrification and carbon sequestration were quantified from previous studies of similar coastal and bay habitats.

Ecosystem Type	Denitrification (g N/m^2/yr)	Reference
Saltwater marsh	4±2	(Morris 1991; Wigland et al. 2003; Seitzinger et al. 2006; Craft et al. 2009)

        i. Morris, J.T. 1991. Effects of nitrogen loading on wetland ecosystems with reference to atmospheric deposition. Annual Review of Ecology and Systematics 22: 257–270.
        ii. Wigand, C., R.A. McKinney, M.A. Charpentier, M.M. Chintala, and G.B. Thursby. 2003. Relationships of nitrogen loadings, residential development, and physical characteristics with plant structure in New England salt marshes. Estuaries 26: 1494–1504.
        iii. Seitzinger, S.P., J.A. Harrison, J.K. Bohlke, A.F. Bouwman, R. Lowrance, B. Peterson, C. Tobias, and G. Van Drecht. 2006. Denitrification across landscapes and waterscapes: a synthesis. Ecological Applications 16: 2064–2090.
        iv. Craft, C., J. Clough, J. Ehman, S. Joye, R. Park, S. Pennings, H. Guo, and M. Machmuller. 2009. Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. Frontiers in Ecology and the Environment 7: 73–78.
7. Mangrove – This study listed an average denitrification rate with standard error found through comparing multiple studies of mangrove habitat. The average TN removal rate was 1±0.1 g N/m^2/yr
    a. **Russel M and Greening H. 2015. Estimating Benefits in a Recovering Estuary: Tampa Bay, Florida. Estuaries and Coasts 38: S9–S18.** This study looks at ecosystem benefits and cost savings associated with expansion, restoration, and preservation of seagrass, coastal marsh, and mangrove habitats. The nitrogen removal rates through denitrification and carbon sequestration were quantified from previous studies of similar coastal and bay habitats.

Ecosystem Type	Denitrification (g N/m^2/yr)	Reference

Mangroves	1±0.1	(Nedwell et al. 1994; Rivera-Monroy and Twilley 1996; Kristensen et al. 1998; Corredor et al. 1999)

i. Nedwell, D.B., T.H. Blackburn, and W.J. Wiebe. 1994. Dynamic nature of the turnover of organic carbon, nitrogen and sulphur in the sediments of a Jamaican mangrove forest. Marine Ecology Progress Series 110: 223–231.

ii. Rivera-Monroy, V.H., and R.R. Twilley. 1996. The relative role of denitrification and immobilization in the fate of inorganic nitrogen in mangrove sediments (Terminos Lagoon, Mexico). Limnology and Oceanography 41: 284–296.

iii. Kristensen, E., M.H. Jensen, G.T. Banta, K. Hansen, M. Holmer, and G.M. King. 1998. Transformation and transport of inorganic nitrogen in sediments of a southeast Asian mangrove forest. Aquatic Microbial Ecology 15: 165–175.

iv. Corredor, J.E., J.M. Morell, and J. Bauza. 1999. Atmospheric nitrous oxide fluxes from mangrove sediments. Marine Pollution Bulletin 38: 473–478.

California Coast (Region 9)

NEPs: San Francisco Estuary Partnership, Morro Bay National Estuary Program, Santa Monica Bay National Estuary Program

1. Five habitats met the criteria above to qualify as relevant/significant to Region 9: Agriculture, Forest/Woodland, Grassland, Riparian, and Tidal Wetland. A thorough review of the literature revealed nutrient removal rates for only Forest/Woodland, Grassland, and Riparian habitats.
2. The available removal rates for specific habitats are presented in Exhibit A-22. The total acres of habitat and calculated U.S. tons of nitrogen and phosphorous removed by habitat are shown in Exhibit A-23.

Exhibit A-22. Summary of Nutrient Removal Rates from Literature Review

Habitat	TN Removal Rate ($g/m^2/yr$)	TN Removal Rate ($lbs/ m^2/yr$)	TP Removal Rate ($g/m^2/yr$)	TP Removal Rate ($lbs/ m^2/yr$)
Forest/Woodland	0.9	0.0020	-	-
Grassland	9.13 ± 1.5	0.0201 ± 0.0033	5.3 ± 4.05	0.0117 ± 0.0089
Riparian*	7.98 ± 2.22	0.0176 ± 0.0049	-	-
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.				

Exhibit A-23. Summary of Nutrients Reduced through Habitat Restoration/Protection in 2006-2019 California Coast NEP Projects

Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Forest/Woodland	2,028	8	-
Grassland	5,081	207± 34	120 ± 92
Riparian*	14,867	529 ± 147	-
Total	**21,977**	**744± 181**	**120± 92**
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.			

The total acres of habitat restored or protected in the California Coast NEPs that provided nutrient reduction benefits from 2006 to 2019 for each NEP are shown in Exhibit A-24. Though we can't state that acres from these projects were necessarily planted or restored for the purpose of managing nutrients, our filtering criteria suggests these acres contributed to nutrient reduction.

Exhibit A-24. Acres of California Coast NEP Habitat Restoration and Protection Projects that provided nutrient reduction benefits.

NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
Morro Bay National Estuary Program	Forest/Woodland	475
Morro Bay National Estuary Program	Grassland	12.71
Morro Bay National Estuary Program	Riparian	0
	Total	**487.71**
San Francisco Estuary Partnership	Forest/Woodland	1,553
San Francisco Estuary Partnership	Grassland	4,176
San Francisco Estuary Partnership	Riparian	14,664.2
	Total	**20,393.2**
Santa Monica Bay National Estuary Program	Forest/Woodland	0
Santa Monica Bay National Estuary Program	Grassland	893
Santa Monica Bay National Estuary Program	Riparian	203.1
	Total	**1,096.1**
Region 9/California Coast	**Total**	**21,977.01**

The calculated U.S. tons of nitrogen and phosphorous removed by habitat protection and restoration are shown for each individual California Coast NEPs in Exhibit A-25.

Exhibit A-25. Summary of Nutrients Reduced by California Coast NEP Projects through Habitat Restoration/Protection in 2006-2019

NEP	Acres restored or protected that ded nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Morro Bay National Estuary Program	488	2	N/A
San Francisco Estuary Partnership	20,393.2	698±173	99±76
Santa Monica Bay National Estuary Program	1,096	44±8	21±16
Total	**21,977.01**	**744 ± 181**	**120 ± 92**
Note: These totals include acreage and nutrients removed by forest/woodland, grassland, and riparian habitats. Forest/Woodland and Riparian did not have known TP removal rates N/A refers to reductions that are negligible when converted to U.S. tons.			

Literature Supporting Habitat Nutrient Removal Rates

1. Forest/Woodland – One study was found for nitrogen removal and none for phosphorus removal. The TN removal rate is 0.9 g N/m^2/yr.
   a. **Hart SC and Firestone MK. 1990. Forest floor-mineral soil interactions in the internal nitrogen cycle of an old-growth forest. Biogeochemistry 12: 103-127.** This study determined seasonal patterns and annual rates of N inputs, outputs, and internal cycling for an old-growth mixed-conifer forest floor in the Sierra Nevada Mountains of California. Estimates of net N mineralization and nitrification were made using an in-field buried-bag technique. The Plant N-uptake rate was found to be 9 kg N/ha/yr (0.9 g N/m^2/yr).
2. Grassland – The average TN removal rate from this study is 9.13 ± 1.5 g N/m^2/yr. The average TP removal rate from this study is 5.3 ± 4.05 g P/m^2/yr.
   a. Woodmansee RG and Duncan DA. 1980. Nitrogen and Phosphorus Dynamics and Budgets in Annual Grasslands. Ecology 61(4). This study examined N and P dynamics in a central California grassland ecosystem over a 3-year period. Biomass and N and P concentrations were observed for the dominant grasses, forbs, and legumes and plant residues. The N and P uptake rates can be found in the tables below.

Year	Total N Uptake (kg/ha/yr)	Total N Uptake (g/m^2/yr)
1972-1973	119	11.9
1973-1974	87	8.7
1974-1975	68	6.8

Year	Total P Uptake (kg/ha/yr)	Total P Uptake (g/m^2/yr)
1972-1973	134.1	13.4
1973-1974	14.5	1.45
1974-1975	10.4	1.04

3. Riparian – The average TN removal rate of these two studies is 7.98 ± 2.22 g N/m^2/yr.
   a. **Domagalski JL, Phillips SP, Bayless ER, Zamora C, Kendall C, Wildman RA, and Hering JG. 2008. Influences of the unsaturated, saturated, and riparian zones on the transport of nitrate near the Merced River, California, USA.** Hydrogeology Journal 16: 675-690. This study examined the transport and transformation of nitrate along a groundwater transect from an almond orchard to the Merced River, California, USA, within an irrigated agricultural setting lined with riparian buffer. The root zone water quality model was used to simulate the movement of water, bromide, and nutrients through the unsaturated zone underlying the almond orchard. During the 2004 simulation, riparian plant uptake was responsible for 139 kg N/ha (13.9 g/m^2) of the nitrate distribution.
   b. **Gumiero B, Boz B, Cornelio P, and Casella S. 2011. Shallow groundwater nitrogen and denitrification in a newly afforested, subirrigated riparian buffer. Journal of Applied**

Ecology 48: 1135-1144. This study examines the use of riparian buffer zones to reduce and prevent water pollution caused or induced by nitrates from agricultural sources. Denitrification rates were tracked for three consecutive years and can be found in the table below.

Year	Total N Retention (kg/ha/yr)	Total N Retention (g/m^2/yr)
1	31.2	3.12
2	74.5	7.45
3	74.5	7.45

Pacific Northwest (Region 10)

NEPs: Puget Sound Partnership, Lower Columbia Estuary Partnership, Tillamook Estuaries Partnership

1. Four habitats met the criteria above to qualify as relevant/significant to Region 10: Forest/Woodland, Estuarine Shoreline, Riparian, and Tidal Wetland. A thorough review of the literature revealed nutrient removal rates for each of these habitats except Estuarine Shoreline.
2. The available removal rates for specific habitats are presented in Exhibit A-25. The total acres of habitat and calculated U.S. tons of nitrogen and phosphorous removed by habitat are shown in Exhibit A-26.

Exhibit A-25. Summary of Nutrient Removal Rates from Literature Review

Habitat	TN Removal Rate ($g/m^2/yr$)	TN Removal Rate ($lbs/\ m^2/yr$)	TP Removal Rate ($g/m^2/yr$)	TP Removal Rate ($lbs/\ m^2/yr$)
Forest/Woodland*	6.75 ± 1.4	0.0149± 0.0031	0.02	0.00004
Riparian	30.04 ± 27.7	0.0662 ± 0.0611	-	-
Tidal Wetland	0.08	0.0002	-	-
*Values of these habitats are an average of multiple data sources and include Standard Error measurements.				

Exhibit A-26. Summary of Nutrients Reduced through Habitat Restoration/Protection in 2006-2019 Pacific Northwestern NEP Projects

Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Forest/Woodland*	1,058	32 ± 7	N/A
Riparian	5,016	672 ± 620	-
Tidal Wetland	4,066	2	-
Total	**10,140**	**706 ± 627**	**N/A**
*Values of these habitats are an average of multiple data sources and include Standard Error measurements. N/A refers to reductions that are negligible when converted to U.S. tons.			

The total acres of habitat restored or protected in the Pacific Northwest NEPs that provided nutrient reduction benefits from 2006 to 2019 for each NEP are shown in Exhibit A-27. Though we can't state that acres from these projects were necessarily planted or restored for the purpose of managing nutrients, our filtering criteria suggests these acres contributed to nutrient reduction.

Exhibit A-27. Acres of Pacific Northwestern NEP Habitat Restoration and Protection Projects that provided nutrient reduction benefits.

NEP	Habitat	Acres restored or protected that provided nutrient reduction benefits from 2006-2019
Lower Columbia Estuary Partnership	Forest/Woodland	0
Lower Columbia Estuary Partnership	Riparian	409
Lower Columbia Estuary Partnership	Tidal Wetland	412
	Total	**821**
Puget Sound Partnership	Forest/Woodland	788.53
Puget Sound Partnership	Riparian	3,693.61
Puget Sound Partnership	Tidal Wetland	3,446
	Total	**7,928.14**
Tillamook Estuaries Partnership	Forest/Woodland	269.2
Tillamook Estuaries Partnership	Riparian	913.73
Tillamook Estuaries Partnership	Tidal Wetland	208.2
	Total	**1,391.13**
Region 10/Pacific Northwest	**Total**	**10,140.27**

The calculated U.S. tons of nitrogen and phosphorous removed by habitat protection and restoration are shown for each individual Pacific Northwest NEPs in Exhibit A-28.

Exhibit A-28. Summary of Nutrients Reduced by Pacific Northwestern NEPs through Habitat Restoration/Protection in 2006-2019 Projects

NEP	Acres restored or protected that provided nutrient reduction benefits from 2006-2019	Estimated TN Reduced (U.S. tons) from 2006-2019	Estimated TP Reduced (U.S. tons) from 2006-2019
Lower Columbia Estuary Partnership	821	55 ± 51	0
Puget Sound Partnership	7,928	520 ± 461	N/A
Tillamook Estuaries Partnership	1,391	131 ± 115	N/A
Total	**10,140**	**706 ± 627**	**N/A**
Note: These totals include acreage and nutrients removed by forest/woodland, riparian, and tidal wetland habitats. Riparian and tidal wetland did not have known TP removal rates N/A refers to reductions that are negligible when converted to U.S. tons.			

Literature Supporting Habitat Nutrient Removal Rates

1. Forest/Woodland – The average TN removal rate from the studies is 6.75 ± 1.4 g N/m^2/year. Only one study was found for phosphorus removal, and the TP removal rate used is 0.02 g P/m^2/year.
   a. **Johnson DW, Cole DW, Bledsoe CS, Cromack K, Edmonds RL, Gessel SP, Grier CC, Richards BN, and Vogt KA. 1982. Nutrient Cycling in Forests of the Pacific Northwest. 186-232.** This is a chapter of a larger book that summarizes nutrient cycling in Pacific Northwestern forests. The section on denitrification highlights several studies on Nitrogen accretion rates of stands of forest in the Pacific Northwest.

Forest Stand	Rate (kg/ha/yr)	Rate (g/m^2/yr)	Reference
Red alder	41	4.1	Tarrant and Miller, 1963
Red alder	321	3.21	Newton et al., 1968
Red alder and Douglas Fir	85	8.5	Cole et al., 1978
Snowbush	108	10.8	Youngberg and Wollum, 1976
Ponderosa Pine	71.5	7.15	Youngberg and Wollum, 1976

      i. Tarrant, R. F., and R. F Miller, 1963, Accumulation of organic matter and soil nitrogen beneath a plantation of red alder and Douglas-fir, Soil Sci. Soc. Am. Proc. 27:231-234.
      ii. Newton, M., B. A. El Hassen, and J. Zavitovski, 1968, Role of alder in western Oregon forest succession, in Biology of Alder, J. M. Trappe, J. F Franklin, R. F Tarrant, and G. M. Hansen, eds., U.S. Department of Agriculture Forest Service, Portland, Oreg., pp. 73-84.
      iii. Cole, D. W., S. P. Gessel, and J. Turner, 1978, Comparative mineral cycling in red alder and Douglas-fir, in Utilization anti Management of Alder, D. G. Briggs, D. S. DeBell, and W. A. Atkinson, compilers, U.S. Department of Agriculture Forest Service General Technical Report PNW-70, U.S.
      iv. Youngberg, C. T., and A. G. Wollum, 1976, Nitrogen accretion in developing Ceanothus velutinus stands, Soil Sci. Soc. Am. J. 40:109-ill.

   b. **Sollins P, Grier CC, McCorison FM, Cromack K, Fogel R, and Fredrikson RL. 1980. The internal element cycles of an old-growth douglas-fir ecosystem in western Oregon. Ecological Monographs 50(3): 261-285.** This study examines primary production, decomposition, hydrology, and element cycling of a mature Douglas-fir forest ecosystem in western Oregon. Through analyzing inputs and outputs, they observe a small net Phosphorus accumulation of 0.2 kg/ha/yr (0.02 g/m^2/yr).
2. Riparian – One study was found for nitrogen removal, and none for phosphorus removal. The TN removal rate is a range: 2.37-57.7 g N/m^2/yr
   a. **Sobota, DJ, Johnson SL, Gregory SV, and Ashkenas LR. 2012. A stable isotope tracer study of the influences of adjacent land use and riparian condition on fates of nitrate in streams. Ecosystems 15: 1-17.** This study investigates the influence of land use (forest, agricultural, and urban) on fates of nitrate in nine stream ecosystems using 24-hour releases of stable isotope tracers. The range of NO_3^- uptake rates in riparian habitats was 6.5-158.1 mg/m^2/day (2.37-57.7 g/m^2/yr).

3. Tidal Wetland – One study was found for nitrogen removal, and none for phosphorus removal. The TN removal rate is 0.08 g N/m^2/day.
   a. **Tjepkema JD and Evans HJ. 1976. Nitrogen fixation associated with *Juncus Balticus* and other plants of Oregon wetlands. Soil Biol. Biochem. 8: 505-509.** This study examines rates of N_2 fixation for *Juncus balticus* and five other plants growing in Oregon wetlands. They assayed intact plants in soil cores and used the C_2H_4 reduction method and observed a N_2 fixation rate of 0.8 kg N/ha/day (0.08 g N/m^2/day).

Detailed Calculations of Nutrient Loading Equivalents in Infographic

Literature Supporting Nutrient Loadings

1. Bags of Fertilizer – The nitrogen reduced by NEPs through habitat restoration and protection is equivalent to 4.5-6.2 million bags of fertilizer. The phosphorus reduced by NEPs through habitat restoration and protection is equivalent to 970 thousand-1.3 million bags of fertilizer.

    a. **Greenview. How to Calculate the Amount of Nitrogen in a Fertilizer Bag. Retrieved June 15, 2020. Retrieved from** https://www.greenviewfertilizer.com/articles/how-much-nitrogen-in-fertilizer/. A 40-pound bag of 10-5-10 fertilizer contains 4 pounds of nitrogen and 2 pounds of phosphorus. 9,000-12,300 tons N x (2,000 pounds/4 pounds N) = 4.5-6.2 million bags of fertilizer. 900-1,300 tons P x (2,000 pounds/2 pounds P) = 970 thousand-1.3 million bags of fertilizer.

2. Septic Systems – The nitrogen reduced by NEPs through habitat restoration and protection is equivalent to 121-166 thousand septic systems leaching into the groundwater each year for 14 years (2006-2019). The phosphorus reduced by NEPs through habitat restoration and protection is equivalent to 198-274 thousand septic systems leaching into the groundwater each year for 14 years (2006-2019).

    a. **Walch, M., Seldomridge, E., McGowan, A., Boswell, S., and Bason, C. 2016. 2016 State of the Delaware Inland Bays. Retrieved from** https://www.inlandbays.org/wp-content/uploads/Final-CIB-State-of-the-Bays-2016-low-res.pdf. A properly maintained septic system leaches 10.6 pounds of nitrogen and 0.7 pounds of phosphorus to groundwater each year. 9,000-12,300 tons N x (2,000 pounds/10.6 pounds N) = 1.7-2.3 million septic systems leaching into the groundwater in 14 years (2006-2019). 1.7-2.3 million septic systems / 14 years = 121-166 thousand septic systems leaching into the groundwater each year for 14 years (2006-2019). 900-1,300 tons P x (2,000 pounds/0.7 pounds P) = 2.7-3.8 million septic systems leaching into the groundwater in 14 years (2006-2019). 2.7-3.8 million septic systems / 14 years = 198-274 thousand septic systems leaching into the groundwater each year for 14 years (2006-2019).

3. Dairy Cows – The nitrogen reduced by NEPs through habitat restoration and protection is equivalent to the nitrogen produced by 109-150 thousand dairy cows' manure. The phosphorus reduced by NEPs through habitat restoration and protection is equivalent to the phosphorus produced by 76-105 thousand dairy cows' manure.

    a. **USDA Natural Resources Conservation Service. December 7, 1995. Animal Manure Management. Retrieved from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/null/?cid=nrcs143_014211#table1** The manure produced by a 1,000-pound dairy cow produces 164.25 pounds of nitrogen and 25.55 pounds of phosphorus a year. 9,000-12,300 tons N x (2,000 pounds/164.25 pounds N) = 109-150 thousand dairy cows. 900-1,300 tons P x (2,000 pounds/25.55 pounds P) = 76-105 thousand dairy cows.