Inland Bays Wetland Restoration Strategy

DELAWARE DEPARTMENT OF
NATURAL RESOURCES AND
ENVIRONMENTAL CONTROL

Inland Bays Wetland Restoration Strategy

Delaware Department of Natural Resources and Environmental Control
Division of Watershed Stewardship
285 Beiser Boulevard, Suite 102
Dover, DE 19904

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Table of Contents

Figures

Maps

Tables

List of Acronyms

BMP - Best Management Practices
CCMP – Comprehensive Conservation and Management Plan
CIB - Delaware Center for Inland Bays
CREP- Conservation Reserve Enhancement Program
DAR - Delaware Association of Realtors
DELSC - Delaware Living Shoreline Committee
DFS-Delaware Forest Service
DISC-Delaware Invasive Species Council
DNREC - Delaware Department of Natural Resources and Environmental Control
DRWG - Delaware Restoration Work Group
HOA - Home-Owners Association
LULC - Land Use and Land Cover
NASF - National Association of State Foresters
NRCS – Natural Resources Conservation Service
OMWM- Open Marsh Water Management
PCS - Pollution Control Strategy
PLUS-Preliminary Land Use Service
SAV - Submerged Aquatic Vegetation
SCD – Sussex Conservation District
SET - Surface Elevation Table
SMZ - Streamside Management Zone
SWMP - State Wetland Mapping Project
SWMS - Shoreline and Waterway Management Section
TMDL - Total Maximum Daily Load
WMAP - DNREC's Wetland Monitoring and Assessment Program
WBWG - Wetlands and Buffers Working Group
WRR - Watershed Resource Registry

Executive Summary

Wetlands are a vital part of the economy, culture, and aesthetic of Delaware's Inland Bays. They provide many important ecosystem services, including storm and flood protection, provision of wildlife habitat for sensitive and economically important species, water quality improvement, carbon storage, and provision of environmental education and outdoor recreation opportunities. The Inland Bays contain 58,906 acres of wetlands, which represents 20% of all of Delaware's wetlands. These wetlands exist amid significant amounts of agriculture and development, with development in the area steadily on the rise.

Many wetland losses and stressors have been documented in recent years in the Inland Bays. According to Delaware's 2017 state wetland maps, development, land clearing and deforestation, and agriculture were leading causes of non-tidal wetland loss in the Inland Bays from 2007 to 2017, translating into a net loss of 481 acres of non-tidal wetlands. In that same time frame, tidal wetlands in the watershed experienced a small net acreage gain of 27 acres because of marsh migration inland. However, the small net gain of tidal wetlands was offset by the fact that many tidal wetlands changed from being vegetated to non-vegetated during that time, likely because of erosion and sea-level rise. Such changes signified losses of important wetland functions.

Field monitoring efforts by DNREC's Wetland Monitoring and Assessment Program (WMAP) in the mid-2000s showed that wetlands in the Inland Bays were in fair to poor condition. Non-tidal riverine and tidal estuarine wetlands were in particularly alarming condition, as they scored a D and a D+ letter grade, respectively. Taken together, state wetland mapping data and field data showed that sea-level rise and land subsidence, migration barriers, invasive species, and hydrology alterations (e.g., ditching) were the key issues faced by tidal wetlands in the Inland Bays. Non-tidal wetlands were identified as suffering most from habitat conversion and fragmentation, invasive species, and hydrology alterations (e.g., channelized streams and ditches).

Like wetlands, submerged aquatic vegetation (SAV) provides many important ecosystem services, such as water quality improvement, wave attenuation, carbon storage, and provision of fisheries habitat. SAV was once common in the Inland Bays until a major die-off event in the 1930s occurred. Eelgrass (*Zostera marina*) has never recovered following that event, and widgeon grass (*Ruppia maritima*) has only been found in isolated patches in recent years. Poor water quality and limited natural recruitment have been identified as two major issues preventing the successful reestablishment of SAV in the Inland Bays.

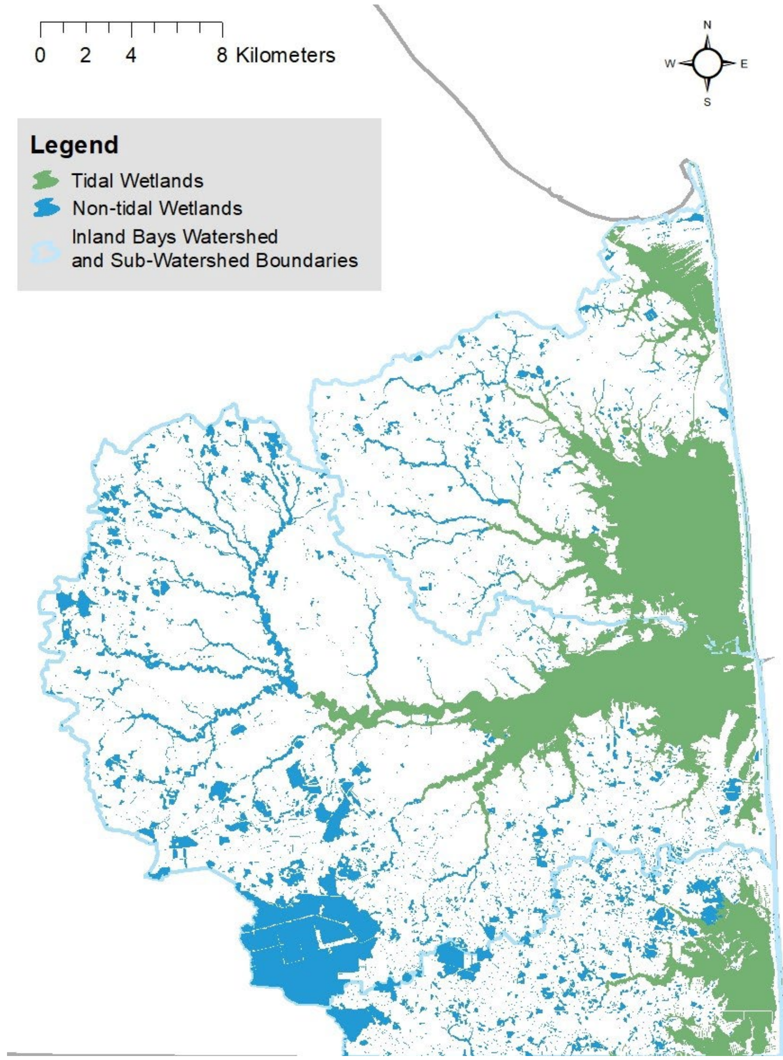
Based on documented trends of acreage losses and declining health of wetlands and SAV in the Inland Bays, the Inland Bays Wetland Restoration Strategy was developed, with the primary purpose of identifying tactics that can address the specific issues most affecting tidal wetlands, non-tidal wetlands, and SAV in the Inland Bays watershed. The strategy was also designed to help justify needs for wetland or SAV restoration projects in the Inland Bays and to serve as the basis for future wetland and SAV restoration goals. In addition, the strategy was created to identify some priority areas for wetland and SAV restoration on public, protected lands where restoration tactics could potentially be implemented.

Strategy development began with WMAP staff compiling and reviewing relevant documents and conducting interviews with many organizations that work in or own land in the Inland Bays. Feedback from those interviews helped shape the content and format of the restoration strategy. The final document is organized by habitat type, then by restoration tactic, and then by tasks to carry out each tactic. A summary table of tactics and tasks by habitat type is included in Appendix B. Spatial analyses conducted for the identification of prime restoration opportunities on public, protected lands were performed using publicly available data layers in ArcMap and in Delaware's Watershed Resources Registry (WRR). Restoration opportunities were reported on a sub-watershed basis (i.e., Rehoboth Bay, Indian River Bay, and Little Assawoman Bay), and maps of such restoration opportunities are included in Appendix A.

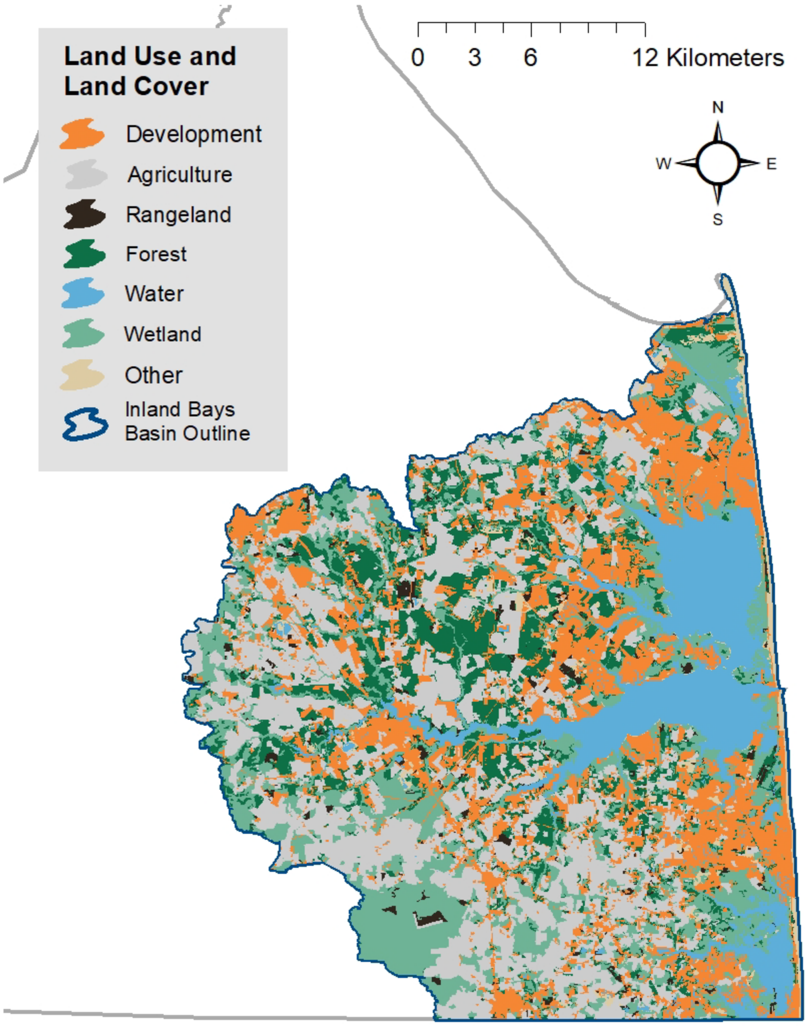
The main restoration tactics described to boost acreage and condition of tidal wetlands in the Inland Bays were installing living shorelines, increasing the beneficial use of dredge material, restoring natural hydrology, preserving tidal wetlands with easements or land acquisition, controlling invasive *Phragmites australis*, and improving land use planning. To help non-tidal wetlands, the most effective restoration tactics were described as practicing reforestation and sustainable forestry, preserving non-tidal wetlands with easements or land acquisition, restoring natural hydrology, controlling invasive species, and improving land use planning. Lastly, tactics to help bolster SAV populations in the Inland Bays included performing direct restoration (e.g., seeding), encouraging indirect restoration (e.g., improving water quality), and securing support (e.g., education and awareness, and financial). Based on mapping analyses, most restoration opportunities on public, protected lands consisted of *P. australis* control, encouraging marsh migration, expanding wetland complexes, connecting wetland habitat fragments, and converting poorly drained agricultural lands back to wetlands.

Introduction

Wetlands are a vital part of the economy, culture, and aesthetic of Delaware's Inland Bays. They provide many important ecosystem services, including storm and flood protection, provision of wildlife habitat for sensitive and economically important species, water quality improvement, carbon storage, and provision of environmental education and outdoor recreation opportunities. The Inland Bays watershed drains 210,064 acres of land in southern Delaware, and according to Delaware's 2017 Statewide Wetland Mapping Project (SWMP), 58, 906 acres of the basin are wetlands. This represents 20% of all of Delaware's wetlands. Over half (61%; 35, 805 acres) of those wetlands are tidal, with 11,493 acres vegetated (32%) and 24, 312 acres non-vegetated (68%, which includes open water bays). The remaining 39% (23,101 acres) of the watershed's wetlands are non-tidal, with 19,527 acres vegetated (85%) and 3,574 acres non-vegetated (15%; Map 1).



Map 1. Tidal and non-tidal wetlands in the Inland Bays watershed based on Delaware's 2017 state wetland maps.



Map 2. 2017 LULC in the Inland Bays watershed.

Based on Delaware's 2017 land use and land cover (LULC) spatial dataset, wetlands in the Inland Bays exist amid significant amounts of agriculture (28%), development (22%), and forest (14%), with remaining land uses including rangeland, open water, and other (i.e., transitional land, extraction, or sandy shoreline; Map 2). The amount of development in the watershed has steadily increased since 1997, while forest, agriculture, and wetland cover have all decreased over time.

Trends in the Inland Bays

Wetlands

Wetlands in the Inland Bays watershed have faced many threats in recent years. Based on the 2017 SWMP, the Inland Bays lost 502 acres of vegetated wetlands between 2007 and 2017. Of those wetlands, 492 acres were non-tidal, and 10 acres were tidal (Figure 1). Most tidal losses were attributed to environmental impacts from erosion and sea-level rise, and losses included those of coastal tidal forest (6 acres; 63% of losses), high marsh (3 acres; 28% of losses), and low marsh (1 acre; 9% of losses). Most non-tidal losses were because of land clearing and deforestation, development, or agriculture, and losses included those of forested wetlands (445 acres; 90% of losses), scrub-shrub wetlands (24 acres; 5%), and emergent wetlands (23 acres; 5% of losses; DNREC 2022).

In that same time, the Inland Bays watershed gained only 48 acres of vegetated wetlands, including 11 acres of non-tidal wetlands and 37 acres of tidal wetlands (Figure 1). Non-tidal vegetated gains were those associated with residential or industrial development (i.e., pond or wetland construction), and some other gains were caused by agricultural or restoration activities. For tidal wetlands, the story was a bit different, as all vegetated gains were because of marsh migration inland (DNREC 2022). Together, these data show that there was a net loss of 481 acres of non-tidal vegetated wetlands and net a gain of 27 acres of vegetated tidal wetlands (Figure 1).

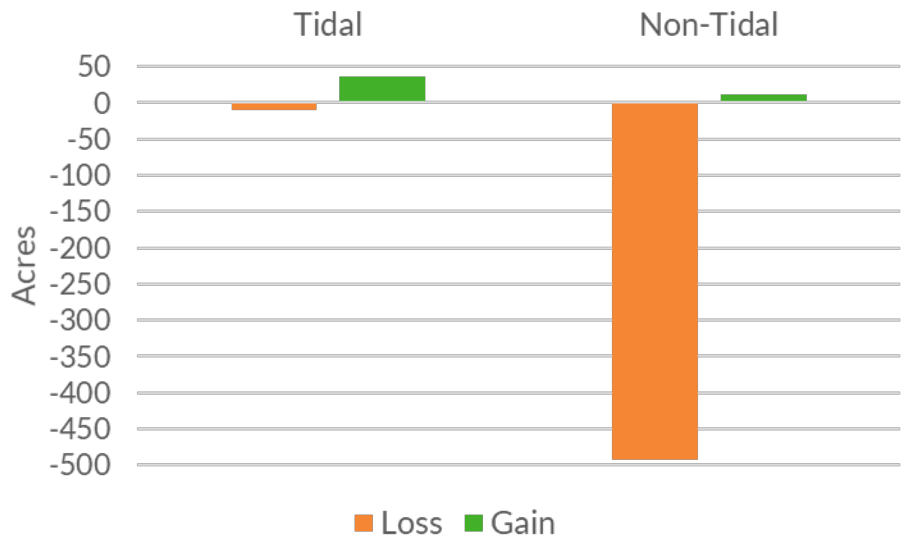


Figure 1. Gains and losses of vegetated wetlands in the Inland Bays watershed from 2007 to 2017.

The small net gain in tidal wetland acreage was offset by the fact that many tidal wetlands in the Inland Bays changed from being vegetated to non-vegetated between 2007 and 2017. Such vegetation losses were because of marshes converting to estuarine unconsolidated bottom (168 acres) or to intertidal unconsolidated or rocky shore (58 acres; Table 1), likely because of erosion and sea-level rise. Loss of vegetation signifies loss of many important wetland functions, such as wave attenuation, water quality improvement, and provision of wildlife habitat for marsh obligate species. Alternatively, some tidal wetlands changed from non-vegetated to vegetated wetland types from 2007 to 2017, where vegetation grew from estuarine unconsolidated bottom (66 acres), intertidal unconsolidated shore (17 acres), or from tidal freshwater lakes or ponds (1 acre; Table 1). Wetlands increase their functional capacity in cases where they change from non-vegetated to vegetated.

Other types of changes to tidal wetlands were from tidal palustrine (freshwater) to estuarine (i.e., saltwater; 181 acres), suggesting that sea-level rise pushed saltwater farther inland. Some wetlands also showed signs of vegetation type changes due to increased flooding (55 acres), further demonstrating the effects of rising sea level in the watershed. Successional changes occurred in 30 acres of tidal wetlands where emergent or scrub-shrub vegetation shifted to forest (Table 1).

Many non-tidal wetlands experienced changes between 2007 and 2017 as well (1,259 acres). Some went from being non-tidal to tidal wetlands (228 acres), suggesting that the head of tide is pushing inland because of sea-level rise.

Vegetative loss to freshwater ponds or lakes occurred in 24 acres of non-tidal wetlands, while vegetative growth from non-tidal ponds or lakes occurred in 71 acres of non-tidal wetlands. Deforestation caused forested wetlands to change to emergent or scrub-shrub habitats (479 acres), while successional changes happened in 457 acres (Table 1). Successional changes included changes such as emergent to scrub-shrub, emergent to forest, or scrub-shrub to forest.

Table 1. Wetland type changes in the Inland Bays watershed from 2007-2017.

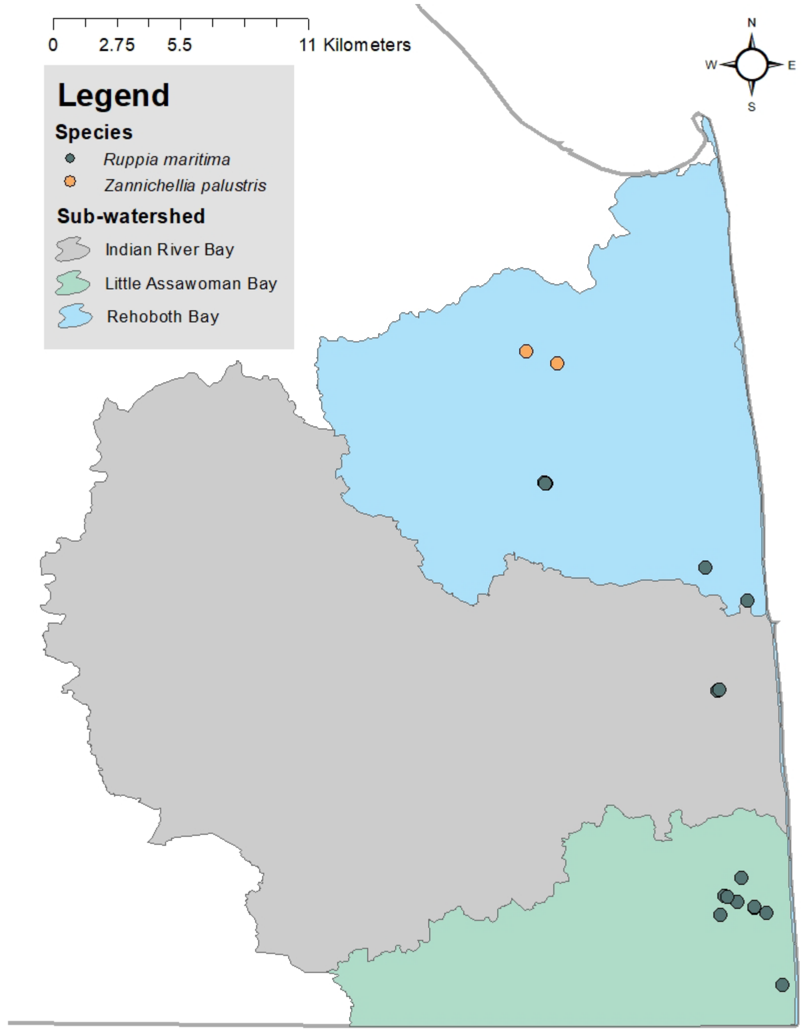
Wetland Type	Change Type (2007-2017)	Change Description	Acres
Tidal	Saltwater intrusion:	Tidal palustrine to estuarine	181
	Vegetation growth from:	Estuarine unconsolidated bottom	66
		Intertidal unconsolidated shore	17
		Tidal freshwater ponds/lakes	1
	Vegetation loss to:	Intertidal unconsolidated or rocky shore	58
		Estuarine unconsolidated bottom	168
	Vegetation changes:	Succession	30
		Increased flooding	55
	Total Tidal Changes		**576**
Non-tidal	Tidal regime:	Non-tidal to tidal	228
	Vegetation growth from:	Non-tidal freshwater ponds/lakes	71
	Vegetation loss to:	Freshwater ponds/lakes	24
	Vegetation changes:	Succession	457
		Deforestation	479
	Total Non-tidal Changes		**1,259**

Submerged Aquatic Vegetation

In addition to wetlands, there has been growing concern about submerged aquatic vegetation (SAV) populations in the Inland Bays. SAV was once common in Delaware's Inland Bays until there was a major die-off event of eelgrass (*Zostera marina*) in the 1930s. Eelgrass never recovered in the bays following that mass mortality event, which was believed to be caused both by a wasting disease and a devastating hurricane. High nutrient levels and far distances from donor SAV beds were then responsible for preventing recovery (Orth et al. 2006). In 1985 and 1986, SAV surveys were conducted in the Inland Bays, and no eelgrass or widgeon grass (*Ruppia maritima*) beds were found, suggesting that for a time, SAV had completely disappeared or only remained in small, undetected pockets (Orth and Moore 1988). Since that time, there have been no organized monitoring efforts for SAV in the Inland Bays until 2018, when Delaware's Department of Natural Resources and Environmental Control (DNREC) put together a SAV Work Group that partnered with the Delaware Center for the Inland Bays (CIB) to monitor and restore SAV in the bays.

There is no current areal estimate of SAV cover in the Inland Bays because organized monitoring efforts only began recently in 2018 and because SAV cover can be highly variable from year to year. However, DNREC's SAV Work Group and CIB have begun to keep a record of general locations where native SAV has been observed.

Based on this recent monitoring work, widgeon grass (*R. maritima*) is currently the most common SAV species in the Inland Bays and has been found in all three sub-watersheds, including Rehoboth Bay, Indian River Bay, and Little Assawoman Bay. Horned pondweed (*Zannichellia palustris*) has also been found in a couple locations, though only in Rehoboth Bay (Map 3). Eelgrass (*Z. marina*) has not recently been recorded in survey locations.



Map 3. SAV observations in the Inland Bays from 2018-2020.

Wetland and SAV Monitoring Efforts in the Inland Bays

In the mid-2000s, DNREC's Wetland Monitoring and Assessment Program (WMAP) led wetland field monitoring efforts that resulted in a two-volume watershed report, which detailed tidal (Rogerson et al. 2009) and non-tidal (Jacobs et al. 2009) wetland condition and major stressors in the Inland Bays. Each wetland type was assigned a letter grade based on overall condition and the prevalence of stressors. The WMAP found that wetlands in the watershed faced many stressors that degraded their health, particularly non-tidal riverine and tidal estuarine wetlands. Non-tidal depressions were not assigned a letter grade because the sample size was too small to reliably extrapolate results to an entire population (Table 2).

Table 2. Results summary from WMAP's watershed condition report published in 2009.

Wetland Type		Letter Grade	Prevalent Stressors
Non-Tidal	Flat	B-	Ditching, forestry, fill, roads
	Riverine	D	Stream channelization, invasive species, fill
Tidal	Estuarine	D+	Ditching, diking, invasive species, migration barriers

Based on assessment results, the WMAP created a set of management recommendations to help increase wetland acreage and overall condition in the Inland Bays. These recommendations included creating a restoration plan for the Inland Bays, controlling invasive species, restoring natural hydrology, protecting large forest blocks, and implementing sustainable forest management (Jacobs et al. 2009, Rogerson et al. 2009).

In addition, DNREC's WMAP has been monitoring annually for sudden wetland dieback in salt marshes since 2006. Monitoring began in response to a sudden wetland dieback event that was detected by DNREC and CIB in the Inland Bays in 2006 that affected many salt marshes for reasons unknown. To monitor recovery from dieback, several permanent vegetation plots were established to measure both vegetation species composition and percent cover. Fortunately, all monitored sites have managed to recover to some extent. For example, one site on the Piney Point Tract of Assawoman Wildlife Area experienced sudden dieback in 2006 and again in 2011, but average live vegetation has steadily increased since then (Figure 2). These data suggest that although there is always some variation in live vegetation percent cover from year to year, and that dieback events have occurred in the past, no recent alarming trends have been observed. Therefore, sudden wetland dieback is not currently a pressing, long-term issue in the Inland Bays but will continue to be monitored in case that changes.

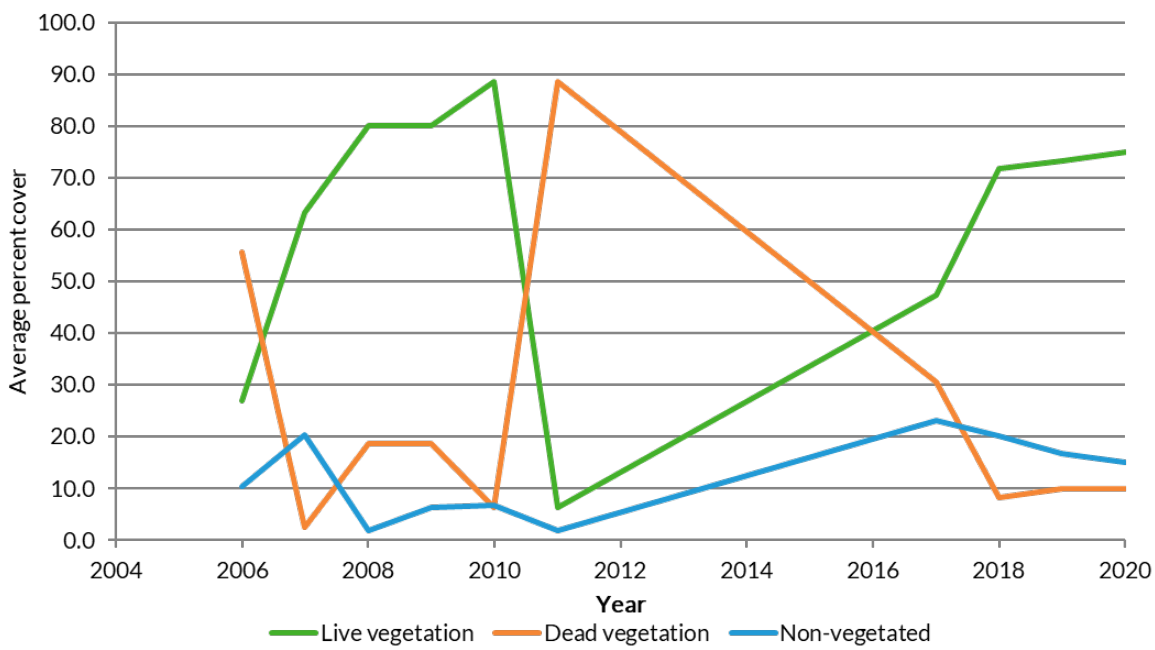


Figure 2. Vegetation monitoring data over time from the Piney Point Tract of Assawoman Wildlife Area, a site affected by a sudden wetland dieback event in 2006. Values shown are percent covers of live vegetation, dead vegetation, and non-vegetated areas averaged across three permanent vegetation plots.

CIB also monitors surface elevation tables (SET) at several salt marshes in the Inland Bays each year to track accretion and elevation changes over time. The data they collect will help scientists determine if tidal wetlands in the Inland Bays are keeping pace with sea-level rise. At those same salt marshes, DNREC's WMAP monitors transects annually, where high-precision elevation data and vegetation data are collected to supplement data collected by CIB.

As previously mentioned, organized monitoring efforts for SAV have only just begun in the Inland Bays. In 2018, DNREC's newly formed SAV Work Group started to informally record locations of SAV sightings. Soon after in 2020, CIB started organized SAV monitoring efforts by performing kayak and drone surveys to look for patches of SAV.

Major Issues Facing Wetlands and SAV

This section details the major challenges that wetlands and SAV face in the Inland Bays watershed as identified by mapping and monitoring efforts described above. Wetlands were split into tidal and non-tidal because each of them faces their own unique set of problems.

Tidal Wetlands

A. Sea-level rise and land subsidence

Tidal wetlands face enormous threats from sea-level rise. The Mid-Atlantic region, including Delaware, is a sea-level rise hotspot (Sallenger et al. 2012), meaning that waters are rising more rapidly relative to many other coastal areas in the U.S. Sea-level rise is a major factor causing marsh edge erosion, which can lead to salt marsh acreage losses (Figure 3). Land subsidence in Delaware can exacerbate the effects of sea-level rise. When waters rise while land sinks, interior marsh pooling can develop, which eventually leads to marsh drowning and loss. In their 2016 State of the Delaware Inland Bays report, CIB stated that sea-level rise and subsidence are largely responsible for tidal wetland loss because they cause erosion and marsh drowning. In fact, since 1938, there has been a net loss of more than 3,500 acres of salt marshes in the Inland Bays, and there has been a

Figure 3. Tidal marsh edge loss in the Inland Bays.

drastic rise in documented acres of interior salt marsh pooling since 1970 (Walch et al. 2016).

B. Migration barriers

Tidal wetlands can migrate inland naturally as sea-level rises. Through such landward migration, tidal wetland acreage can be preserved. However, constraining factors, such as development, limit successful wetland migration. Development that lies adjacent to tidal wetlands presents a physical barrier to migration, leaving the marsh to face sea-level rise and subsequently drown. When tidal wetlands are lost, so are all the beneficial services that they provide, including wave attenuation, floodwater storage, carbon storage, and provision of habitat for commercially important fish and shellfish species and for sensitive marsh specialists.

In the Inland Bays, residential and commercial development are very prevalent migration barriers to tidal wetlands. In 2009, DNREC's WMAP found that 30% of tidal wetlands in the Inland Bays had barriers to landward migration (Rogerson et al. 2009), and this number has likely increased in recent years given the increase in development in the watershed.

C. Invasive species

Many tidal wetlands in the Inland Bays suffer from the presence of invasive species. In particular, numerous wetlands contain the invasive *Phragmites australis australis* (hereafter *P. australis*; Figure 4). An estimated 9% of vegetated tidal wetlands (1,052 acres), and 51% of estuarine high marsh habitat (992 acres), in the Inland Bays watershed is composed entirely or partially of the *P. australis* based on the 2017 SWMP dataset. In 2009, DNREC's WMAP found that moderately stressed tidal wetlands had 9% cover of invasive species on average and severely stressed wetlands had 20% cover of invasive species on average (Rogerson et al. 2009).

Figure 4. A thick stand of invasive *P. australis* in an Inland Bays tidal marsh.

P. australis is a problem because it can outcompete native saltmarsh plant species that are necessary for obligate saltmarsh species such as the saltmarsh sparrow (*Ammodramus caudacutus*). *P. australis* can also drastically change marsh elevation and hydrology because of its rapid growth rate, dense rhizome network, and significant dead litter accumulation (Zedler and Kercher 2004). Such changes could make marshes uninhabitable for native saltmarsh plants and the wildlife that depend on them. Once *P. australis* is established, it is incredibly challenging to eradicate, and habitats are unlikely to return to their native states without extensive human intervention.

Figure 5. An aerial view of extensive grid ditching in the Inland Bays.

D. Hydrology alterations

Historically, many grid ditches were dug out in salt marshes across the Inland Bays (Figure 5). This was done as a form of breeding mosquito control, as the ditches drained water off the tidal wetlands to make conditions less favorable for mosquito reproduction (Wolfe et al. 2021). Although grid ditches are no longer installed in tidal wetlands in the Inland Bays, their effects still linger. The shape of these straight ditches causes water to move rapidly in and out of the marshes and are in stark contrast to meandering natural tidal creeks. In 2009, DNREC's WMAP found that 72% of tidal wetlands in the Inland Bays contained ditches (Rogerson et al. 2009), showing that the problem is substantial.

Non-Tidal Wetlands

A. Habitat conversion and fragmentation

Non-tidal wetlands in the Inland Bays have suffered greatly from habitat loss and fragmentation. The watershed once had an estimated 75,000 acres of non-tidal and tidal wetlands before European settlement, but by 2009, about 60% of those wetlands had been lost, and most of those losses were of non-tidal wetlands (Jacobs et al. 2009). This negative trend has continued in more recent years. As mentioned previously, there was a net loss of 481 vegetated non-tidal wetlands between 2007 and 2017, and most of that was because of land clearing and deforestation, development, and agriculture (DNREC 2022; Map 4). The state of Delaware does not regulate non-tidal wetlands unless they are 400 contiguous acres or more, leaving most non-tidal wetlands in the Inland Bays vulnerable to damage and total loss. As wetlands are lost, so too are the beneficial functions they provide, such as provision of wildlife habitat, floodwater storage, and improvement of water quality.

Map 4. Example of non-tidal wetland loss to development in the Inland Bays from 2007 (top) to 2017 (bottom).

Non-tidal wetland losses also lead to more and more wetland habitat fragmentation. Fragmentation is a major problem for many wetland-dependent species that tend to move among wetland patches, including many reptiles and amphibians.

Wetland restoration in the Inland Bays has not been able to combat loss and fragmentation. Between 2003 and 2015, about 3,000 acres of natural habitat were protected in the watershed, but only 4% of that (120 acres) represented freshwater wetlands. In that same time span, roughly 1,500 acres of natural habitat were restored or enhanced, and only 7% of that (105 acres) was of freshwater wetlands (Walch et al. 2016). These data show that non-tidal wetland loss in recent years is occurring at a far greater rate than non-tidal wetland preservation and restoration.

B. Invasive species

Invasive plant species are one of the most pervasive issues in non-tidal wetlands in the Inland Bays, particularly in riverine wetlands. Back in 2005 and 2006, although only 13% of non-tidal flat wetlands had invasive species, 64% of riverine wetlands had invasive species (Jacobs et al. 2009). There is a strong possibility that invasive plants are even more widespread now, as invasive species can establish and spread rapidly. Some common invasive species that have been found in non-tidal wetlands include Japanese honeysuckle (*Lonicera japonica*), English ivy (*Hedera helix*), multiflora rose (*Rosa multiflora*), reed canary grass (*Phalaris arundinacea*), and the European reed (*P. australis*).

C. Hydrology alterations

Hydrology alterations are very common in non-tidal wetlands in the Inland Bays. According to wetland assessment data from 2005 and 2006, 28% of flat wetlands and 44% of riverine wetlands contained ditches or channelized streams (Figure 6). These types of alterations were often made because of agriculture or forestry activities within or near wetlands (Jacobs et al. 2009). Ditches tend to increase drainage in wetlands, making them artificially dry and rendering them uninhabitable by many native wetland plants and wildlife. Stream channelization can increase water velocity, thereby increasing bank erosion. Many channelized streams also have spoil piles along their banks, which disconnects floodplains from streams.

Figure 6. A channelized waterway in the Inland Bays.

SAV

A. Poor water quality

SAV occurrence and distribution is largely limited by light availability, temperature, and water pollution levels. Delaware's Inland Bays have a history of high levels of nutrient pollution because of surrounding non-point sources like agriculture and development and point sources like wastewater treatment plants. In 2008, a Pollution Control Strategy (PCS) was published for the Inland Bays (Inland Bays Tributary Action Team 2008) that detailed many regulatory and voluntary components to reduce pollution and achieve the Total Maximum Daily Load (TMDL) for nitrogen and phosphorus in the bays. Since that time, all major point sources have been removed through PCS actions, which has significantly reduced pollution entering waterways.

Many non-point source actions outlined in the PCS related to agriculture, urban land use, and stormwater are voluntary (Inland Bays Tributary Action Team 2008). Some progress has been made toward goals around voluntary items on agricultural land. For instance, there was an increase in farms with cover crops, poultry manure sheds, and alternative manure use from 2005 to 2016. There was little to no progress towards goals regarding many other voluntary efforts, including establishing forested or grassy buffers around waterways and restoring wetlands on former agricultural lands (Walch et al. 2016).

Non-point source nutrient load trends from 2006 to 2014 show that inputs of nitrogen have remained above the goal limit throughout the Inland Bays. Phosphorus inputs have remained somewhat steady and below the goal limit in Rehoboth and Little Assawoman Bays but are still high and well above the goal limit in Indian River Bay (Walch et al. 2016). With nutrient pollution above healthy limits and with many voluntary actions lagging far behind goals, more action is clearly needed to improve water quality in the Inland Bays.

B. Limited natural recruitment

As previously mentioned, SAV was once plentiful in the Inland Bays, but has suffered many hardships, including disease, hurricanes, and pollution. Now, small beds of widgeon grass are present in the Inland Bays, and eelgrass is absent. The small areal extent of SAV suggests that there is currently very little natural recruitment occurring in the Inland Bays. Supplemental restoration efforts, such as seeding and planting of mature plants, are needed to enhance current populations and support natural recruitment alongside water quality improvement actions.

Restoration Strategy Development

Restoration Strategy Purpose

The primary purpose of this strategy is to identify some key tactics that can address the specific issues previously mentioned affecting tidal wetlands, non-tidal wetlands, and SAV in the Inland Bays watershed while also identifying some priority areas on public land where these tactics could be implemented. In this document, the term ‘restoration’ refers to any activity that can maintain or increase the condition, function, or acreage of wetlands or SAV, including creation, enhancement, rehabilitation, and preservation.

Secondarily, this plan can be cited by organizations to help justify needs for wetland or SAV restoration projects in the Inland Bays, such as when applying for funding. It also supports wetland management goals of several entities. For example, wetland restoration and protection are main objectives in Delaware’s Wetland Program Plan, and the development of watershed-level restoration plans is considered one of the action items to help achieve those objectives (DNREC 2021). In Delaware’s Wildlife Action Plan, many wetland types that occur in the Inland Bays are listed as habitats of conservation concern, and several conservation actions relate to wetland protection and management planning (DNREC 2015). Similarly, CIB includes many objectives regarding wetland and SAV protection and restoration in their most current comprehensive conservation and management plan (CCMP; CIB 2021). The Delaware Natural Resources Conservation

Service (NRCS) listed several objectives and strategies about curbing non-point source pollution and enhancing wildlife habitat in their 2020-2025 Delaware Strategic Plan (NRCS 2020). Many water quality improvement actions are described within the Inland Bays PCS (Inland Bays Tributary Action Team 2008). Plans published by the Delaware Forest Service (DFS; DFS 2020) and by Sussex County (Sussex County 2019) also contain sections relating to wetlands.

Finally, many organizations that work in the Inland Bays do not have concrete wetland or SAV-related goals or plans, so this document can serve as a starting point for such organizations to understand the current state of wetlands and SAV and potential effective strategies to combat prevalent issues. It could perhaps serve as the basis for future concrete wetland or SAV restoration goals. This strategy is also meant to foster collaboration, as collaboration is more likely to occur if interested parties are all kept informed equally.

Project Development Process

Background Research and Interviews

DNREC's WMAP first began compiling and reviewing relevant documents in the spring of 2021, such as their own Inland Bays wetland condition reports (Jacobs et al. 2009, Rogerson et al. 2009) and CIB's most recent state of the bays report (Walch et al. 2016). They then met internally to organize a draft outline for the restoration strategy, identify useful contacts, and decide on a list of questions to ask those contacts. Once those initial steps were complete, the WMAP reached out to contacts to determine who was interested in providing feedback regarding the restoration strategy.

Beginning in June 2021 and spanning through September 2021, the WMAP conducted interviews with interested organizations. All interviews were virtual because of Covid-19 concerns, and each lasted for approximately one hour. The contacts listed below (Table 3) include those interviewed, and all provided useful information that helped shape this restoration strategy.

Table 3. Contacts interviewed for input while developing the Inland Bays Wetland Strategy.

Organization	Contacts
Delaware Center for the Inland Bays	Chris Bason
Delaware Forest Service	Erich Burkentine
	Kyle Hoyd
Delaware Wild Lands	Kate Hackett
	Andrew Martin
	Al Rizzo
DNREC Division of Fish and Wildlife and Mosquito Control Section	Kenneth Conaway
	Rob Gano
	Bill Meredith
	Paul Zarebicki
DNREC Division of Parks and Recreation	Chris Bennett
DNREC SAV Work Group	Michael Bott
	Lori Brown
	Kayla Clauson
DNREC Division of Watershed Stewardship and Conservation Programs	Patti Webb
Ducks Unlimited	Jake McPherson
Natural Resources Conservation Service	Jayme Arthurs
	Heather Beaven
	John Bushey
Sussex Conservation District	Bryan Jones
Sussex County	Todd Lawson
	Jamie Whitehouse
The Nature Conservancy	Su Fanok
	Keith Fisher
U.S. Fish and Wildlife Service	Brian Jennings

The restoration plan outline was updated by WMAP in early August 2021 based on feedback obtained from contact interviews. The plan draft was started in mid-August while still finishing the last of the contact interviews, making additional small revisions to the outline as necessary. The WMAP shared the outline with all interviewees to provide an opportunity for additional comments, adjusting the outline and written draft as comments were received. The final draft was shared with all interviewees for review and input.

Spatial Analysis Methods

Although the tactics identified in this restoration strategy are applicable to wetlands and SAV on both public and private property, the spatial components presented in this document are focused only on public protected lands. To identify optimal tidal and non-tidal wetland restoration opportunities on public protected lands in the Inland Bays, DNREC's WMAP used 2017 SWMP data, wetland restoration data from the Delaware Watershed Resource Registry (WRR), marsh migration data from DNREC's WMAP and DNREC's Coastal Programs, 2017 LULC data, and soils data. The projection used for all layers in ArcMap for this project was NAD_83_StatePlane_Delaware_FIPS_0700.

The wetland restoration layer from the WRR rated the restoration potential of wetland polygons from one to five stars, with one star being the lowest priority and five stars being the highest priority. For polygons to be included in the wetland restoration layer, they could not already be wetlands, could not be developed, could not be in or directly around a federally funded airport, could not be on a parcel with >20% impervious cover, and had to be on poorly drained or very poorly drained soil. If polygons met these conditions, they were then rated on a relative scale based on the following characteristics, after which they received a star rating between one and five: if they were within a drained 100 or 500-year floodplain; if they were planned for Preliminary Land Use Service (PLUS); if they were within 200 feet of, but not within, a protected area; if they were within 200 feet of, but not within, a stream, wetland, or Category One wetland; if they were within 200 feet of, but not within, an existing mitigation site; or if they were within 200 feet of or within a green infrastructure core or corridor.

The marsh migration layer from DNREC was created in 2017 and is based on 2007 SWMP maps and aerial imagery. The model identified areas that were highly suitable for marsh migration based on several factors, including slope, impervious cover, proximity to current tidal wetlands, elevation, and soil type, excluding areas that were already tidal wetlands, open water, or impervious surfaces. Layers were created from the model output representing highly suitable marsh migration land under several sea-level rise scenarios of two feet, four feet, and seven feet of elevation. For this restoration strategy, WMAP used the intermediate four-foot sea-level rise scenario to identify highly suitable areas for marsh migration on public protected lands.

DNREC's SAV Work Group provided a shapefile with point locations of SAV observations in the Inland Bays from 2018 to 2020. The WMAP used those locations to show areas where seeding may be helpful to supplement existing populations. They also used DNREC's aquaculture layer to consider where SAV might be able to grow near oyster reefs.

The WMAP then used the 2017 Delaware LULC dataset and Delaware soils spatial dataset to identify areas of somewhat poorly drained, poorly drained, or very poorly drained soils occurring on agricultural or rangeland. In the past, wetlands were often converted to agriculture or rangeland, so by finding those lands with poor drainage, the WMAP could highlight some additional areas that may be prime candidates for wetland restoration.

Using the layers described above, maps of potential wetland and SAV restoration opportunities were created and are shown in Appendix A. Again, this document does not cover opportunities on private lands, so only options on public protected lands are presented. Layers described above were crossed with DNREC's public protected lands layer to achieve this. Highlighted in black on tidal and non-tidal restoration maps are areas that are partially or entirely dominated by *P. australis* and could be restored to native salt marsh habitat by multiple cycles of spraying and burning the invasive species. Yellow, orange, and dark green areas on the maps represent areas identified by the WRR as three, four, and five-star wetland restoration opportunities, respectively. Tan-colored areas on the maps show areas somewhat poorly drained, poorly drained, or very poorly drained soils on agricultural or rangeland. Transparent blue and green regions on the maps show current tidal and non-tidal wetlands based on 2017 SWMP data (Appendix A).

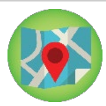
On SAV restoration maps, locations where *R. maritima* has been observed are denoted with mint green points, and where *Z. palustris* has been seen, with orange points. Tan-colored circles mark oyster aquaculture areas (Appendix A).

Restoring and Preserving Wetlands in the Inland Bays

This restoration strategy is presented first by habitat type, then by restoration tactic, and finally by task. The habitat types that are covered include tidal wetlands, non-tidal wetlands, and SAV. Under each habitat type, there are several types of restoration tactics that are described. Then, for each tactic, there are several tasks listed that detail how to implement each tactic. Tactics and tasks were designed to address the major issues that wetlands and SAV face in the Inland Bays that were detailed earlier in this document.

Each task is accompanied by an icon that matches those used in Delaware's 2021-2025 Wetland Program Plan (DNREC 2021; Table 4). The icons represent six major themes: mapping, monitoring, climate adaptation, restoration, collaboration, and education. Icons next to each task serve to categorize the task under a theme for the reader's benefit. For example, if a reader was interested in the living shoreline tactic for tidal wetlands and was specifically looking for education-related tasks, they would look for the education icon to quickly determine if any tasks met those criteria.

Table 4. Theme icons from Delaware's 2021-2025 Wetland Program Plan that are used in this strategy.

Theme	Icon
Mapping	
Monitoring	
Climate Adaptation	
Restoration	
Collaboration	
Education	

A summary table of all tactics and tasks, the issues they address, and their current progress are provided in Appendix B for tidal wetlands, non-tidal wetlands, and SAV (Tables 5, 6, 7, and 8; Appendix B). These tables also summarize the results of a crosswalk between this strategy and management plans and strategies from many organizations, including the Delaware 2021-2025 Wetland Management Plan (DNREC 2021), CIB's revised CCMP (CIB 2021), the 2015-2025 Delaware Wildlife Action Plan (DNREC 2015), NRCS's 2020-2025 strategy for Delaware (NRCS 2020), the Inland Bays Pollution Control Strategy (Inland Bays Tributary Action Team 2008), the 2020 Delaware Statewide Forest Strategy (DFS 2020), and the Sussex County Comprehensive Plan (Sussex County 2019). This crosswalk shows what organizations have goals, plans, or language already in place related to tasks in this restoration strategy (Appendix B).

Tidal Wetlands

Restoration Tactics

A. Install Living Shorelines

Traditionally, structures like bulkheads or seawalls were installed in the Inland Bays along many shoreline properties to protect them from wave energy and erosion. However, these "gray" structures remove the connection between land and water, destroying important wildlife habitat. Such structures may facilitate more erosion along the bottom and sides, because as they deflect wave energy, scouring frequently occurs. In contrast, green techniques, including traditional and hybrid living shorelines, maintain the crucial connection between land and water and absorb wave energy rather than deflect it elsewhere. There is growing evidence that bulkheads tend to be more expensive overall than living shorelines (Smith et al. 2017), and that living shorelines tend to withstand storm and hurricane damage better than bulkheads (Gittman et al. 2014, Smith et al. 2017). Therefore, living shorelines can be effective tactics to address tidal wetland loss to erosion and sea-level rise.

Task 1: Promote use of green techniques for shoreline work

Many landowners have misconceptions about living shorelines. For example, some believe that natural shoreline protection options are less effective than bulkheads at preventing erosion and are more expensive (Scyphers et al. 2015), neither of which are true. Many landowners may not even know what living shorelines are or that green infrastructure is an option. Although this task has been started by the Delaware Living Shorelines Committee (DELSC), more outreach is needed. Moving forward with outreach efforts:

- Target landowners, home-owners associations (HOAs), and other communities in the Inland Bays
- Combat misconceptions

- Continue promotion through DELSC website and online materials, webinars, trainings, and in-person events and presentations

Task 2: Provide trainings for professionals working in the Inland Bays

Restoration Highlight

The DELSC has hosted an Introduction to Living Shorelines Training annually since 2015. The training is designed for professionals and includes classroom and field components.

Living shorelines are still relatively new solutions to erosion issues or shoreline improvement, and the science behind them is ever-changing. Because of this, trainings are needed to teach professionals about living shorelines and to encourage them to offer green infrastructure options to clients. With confidence and knowledge, professionals will hopefully increase implementation of living shorelines in the Inland Bays. This task is already underway, as the DELSC has hosted an annual Introduction to Living Shorelines training since 2015 and a Site Evaluation training since 2019. Moving forward:

- Develop more specific trainings on topics such as project design or monitoring
- Continue existing trainings

Task 3: Facilitate collaboration through the DELSC

The DELSC represents a group of partners who support the implementation of living shorelines and encourage sharing knowledge and collaborating on projects in Delaware. The committee is composed of several sub-committees with different focuses, including outreach, standards of practice, engineering and design, implementation, and regulatory, policy, and programmatic development. The entire committee meets twice a year and sub-committees meet as needed to accomplish different tasks, all of which facilitate collaboration among a diverse group of organizations. Moving forward:

- Continue and expand current collaborations to share knowledge and leverage resources for project implementation
- Bring in new interested members to the DELSC

Task 4: Create a grant program or incentives for living shorelines for landowners

One hurdle that often prevents interested landowners in the Inland Bays from installing living shorelines is cost. A cost-share program currently exists in Sussex County, but the criteria are very strict, and landowners must pay money up front and then get reimbursed. A grant program that is specific to living shorelines could help offset costs for landowners to make shoreline projects more affordable. Grant funds may also incentivize some landowners to install living shoreline projects who may not have otherwise done so. Such a grant program should:

- Have eligibility requirements to ensure that traditional gray infrastructure is not supported
- Be flexible in supported project types, as different site conditions may necessitate different designs to be successful (i.e., traditional or hybrid)

Task 5: Install more living shoreline projects

Several living shoreline projects are already in place in the Inland Bays, including one at Sassafras Landing, the Delaware Botanic Gardens, along Read Avenue in Dewey Beach, the Indian River marina, along Seagrass Plantation, and along the Bethany Loop Canal. Installing more projects can both improve tidal wetland resiliency and increase visibility of living shorelines throughout the Inland Bays. Therefore, more living shoreline projects should be installed wherever possible in areas that demonstrate need. Projects should:

- Benefit sensitive coastal wildlife species, such as diamondback terrapins (*Malaclemys terrapin*), blue crabs (*Callinectes sapidus*), Eastern oysters (*Crassostrea virginica*), and various shorebird species
- Where possible, exist as one part of more wholistic restoration projects that combine multiple green infrastructure components (e.g., buffer and stream restoration along with a living shoreline)

B. Increase Beneficial Use of Dredge Material

Beneficial use of dredge material is one tactic that helps increase the resilience of salt marshes in the face of sea-level rise. This tactic involves using dredge material from routine dredging operations to either boost the elevation of an existing, struggling marsh (thin-layer placement) or to rebuild a wetland that has completely drowned (thick-layer placement). Project designs vary and are site-specific depending on local conditions. Beneficial use is still a fairly new practice in Delaware and best techniques for successful projects are still being learned.

Task 1: Plan projects near routine dredging operations

Restoration Highlight

DNREC's WMAP worked with DNREC's SWMS to supply a waterlogged salt marsh in the Piney Point tract of Assawoman Wildlife Area with a thin layer of dredged sediment in 2013. The project was successful and efficient, boosting marsh elevation and helping new native vegetation grow.

DNREC's Shoreline and Waterway Management Section (SWMS) conducts routine dredging in the Inland Bays. To leverage resources and make restoration projects more time-efficient, those planning and designing beneficial use projects should collaborate with SWMS. For example, it would be easiest to install a project that is close to an area that is being dredged the same year as proposed installation. Such collaboration occurred between DNREC's WMAP and SWMS at Piney Point in 2013. Those planning future projects should:

- Communicate with DNREC's SWMS
- Prioritize areas that are both in need of sediment and near active dredging operations

Task 2: Implement more projects that consider future conditions

With so many salt marshes being lost to open water, restoration through the beneficial use of dredge material is more in demand than ever. More projects should be planned and installed in the Inland Bays to keep existing wetlands healthy at sustainable elevations and to rebuild former marshes when possible. However, such projects should always be done with future conditions in mind, meaning that sea-level rise should always be a consideration. To do so:

- Prioritize projects in areas where marsh migration is not possible (i.e., constrained by development or other barriers) because those marshes would be lost to rising waters without action
- Target the upper elevation range of native plants, expecting that waters will rise beyond current levels
- Take extraordinary care to avoid *P. australis* invasion in new projects

Task 3: Restore high marsh to help at-risk species

As sea-level rises, inundation frequency of high marsh areas will also increase, which will eventually lead to eventually drowning of native high marsh plants. In areas where marsh migration is constrained by barriers, high marsh patches will have nowhere to move inland, meaning that they will disappear. Loss of high marsh habitat is a major problem for obligate species like saltmarsh sparrows (*A. caudacutus*) and black rails (*Laterallus jamaicensis*), which both require high marsh for nesting. These species are experiencing rapid population declines, largely because of nesting habitat loss. Therefore:

- Restore or create patches of native high marsh habitat to benefit at-risk saltmarsh bird species
- Take extraordinary care to avoid *P. australis* invasion in new projects

C. Restore Natural Hydrology

Restoration work should focus on the major hydrology stressors found in tidal wetlands in the Inland Bays, including ditches and dikes. Restoring natural hydrology would help make salt marshes more inhabitable by native plants and wildlife and would also help make them more resilient in the face of sea-level rise.

Task 1: Fill non-functional mosquito ditches

Many grid ditches no longer serve any mosquito control purpose; they simply degrade the condition of marshes. To improve tidal wetland hydrology in the Inland Bays:

- Fill non-functional ditches whenever possible
- Communicate any ditch filling activities with DNREC's Mosquito Control Section to verify that the ditches being filled are no longer serving a public health purpose
- Consider issues such as interior marsh drowning, marsh resiliency, and potential effects on sensitive wildlife for any necessary new mosquito control open marsh water management (OMWM) projects

Task 2: Remove ecologically detrimental dikes

Many dikes that were originally designed to keep water out of crop fields, for example, are doomed to fail as sea-level rises. Rising waters will eventually overrun dikes, or water will be diverted to some other undesirable location. However, dikes can still negatively affect the flow of water in tidal wetlands or their ability to successfully migrate inland. To improve tidal wetland hydrology in the Inland Bays:

- Remove dikes where they are no longer functional or will no longer be functional soon

Task 3: Remove dams to allow for tidal freshwater wetland migration

As sea-level rises, saltwater will continue to be pushed farther inland. This process will, over time, convert current tidal freshwater wetlands to saltwater wetlands. Tidal freshwater wetlands have the potential to migrate inland, but only if tidal flow is unconstrained in streams and rivers. To help preserve tidal freshwater wetlands in the Inland Bays:

- Dams should be removed wherever possible to allow tidal freshwater wetlands to migrate upstream freely

D. Preserve Tidal Wetlands with Easements or Land Acquisition

Land purchases and conservation easements are protection tactics that can prevent many direct and indirect impacts to tidal wetlands. Restoration activities are also more likely to be implemented on areas that are already protected.

Task 1: Target highly suitable land for marsh migration

Some tidal wetland loss is inevitable as sea-level rises. However, some losses may be prevented if tidal wetlands are permitted to migrate naturally inland. As mentioned previously, there are many barriers to marsh migration in the Inland Bays, and there will likely be even more in the future as development in the region continues to rise. It is therefore imperative that land that is highly suitable for marsh migration is targeted and acquired to protect it as future tidal wetland. Several efforts to identify highly suitable marsh migration land are already underway in the Inland Bays. DNREC's WMAP and Coastal Programs teamed up in 2017 to model marsh migration suitability statewide, including the Inland Bays. CIB, Sussex Conservation District (SCD), and NRCS have also recently collaborated on a marsh migration project. To target highly suitable land:

- Utilize existing mapping efforts to plan outreach with landowners and promote conservation easements on highly suitable marsh migration land
- Reference existing mapping efforts when prioritizing land purchases and protection
- Continuously update marsh migration models as new data becomes available

Task 2: Secure more funding to support acquisition

Land acquisition is a necessary but expensive task to preserve and restore tidal wetlands. To increase land acquisition in the Inland Bays:

- Make securing funding for land purchases a priority
- Identify new funding sources that have not previously been used to increase variety of sources

E. Control Invasive *Phragmites*

As *P. australis* is by far the most widespread invasive species in tidal wetlands in the Inland Bays, control efforts are needed to prevent further spread.

Task 1: Focus *Phragmites* control in marsh migration corridors

With *P. australis* being so pervasive in the Inland Bays, it may not be realistic to eradicate all of it. It may be more effective to target control efforts in specific key locations. Mid-Atlantic research has shown that *P. australis* tends to rapidly colonize marsh migration areas where trees along marsh edges are dying due to rising water and salt levels (Smith 2013, Dorset and Rogerson 2017). This species prevents forest edges from converting to native high marsh. If *P. australis* colonizes future high marsh areas before native species can take hold, then the future of native high marsh is grim, as is the future of species that rely on that habitat, such as the saltmarsh sparrow (*A. caudacutus*). To make *P. australis* control most effective:

- Focus control in marsh migration areas to reduce overall invasive species cover while also paving the way for native high marsh to move inland

Task 2: Educate landowners and HOAs about *Phragmites* treatment

Private landowners and communities can contribute significantly to invasive *P. australis* control. However, many people may not realize that *P. australis* is an invasive species, and they may not realize that control options exist. Not only does this aggressive grass keep native species out, but it also degrades waterfront views that are important to many landowners and communities in the Inland Bays. To further improve *P. australis* control in the Inland Bays:

- Educate landowners and HOAs about benefits of treating *P. australis* and planting native species in its place
- Inform landowners and HOAs about cost-share options that exist for eligible landowners through DNREC's *Phragmites* Control Program

F. Improve Land Use Planning

Improved land use planning can address many of the major issues that tidal wetlands face in the Inland Bays, including barriers to marsh migration and sea-level rise impacts.

Task 1: Incorporate marsh migration into development and infrastructure planning

Land planners and developers in the Inland Bays should consider marsh migration. In doing so, communities could retain all of the important ecosystem services that tidal wetlands provide, including protection of infrastructure against coastal storms. It would also help prevent flooding issues in developments in the future. Areas that are highly suitable for marsh migration are very likely to get wetter and wetter as sea-level rises, creating unfavorable conditions for development and infrastructure. To incorporate marsh migration into planning:

- Avoid construction of new commercial buildings, housing developments, and roads in areas that are highly suitable for marsh migration
- Keep highly suitable marsh migration areas natural to facilitate tidal marsh migration as sea-level rises
- Increase outreach to HOAs, large communities, and municipalities to increase awareness and knowledge

Task 2: Incorporate marsh migration and sea-level rise into natural resource planning

Natural resource agencies should consider marsh migration as it relates to natural managed habitats, such as freshwater wetlands, upland forests, and freshwater impoundments. To do so:

- Take extra care to maintain freshwater impoundments that are managed for waterfowl that are close to current tidal wetlands or waterways
- Monitor changes in coastal freshwater forested wetlands with marsh migration, as plant and wildlife distribution will be affected
- Monitor changes in freshwater Category One wetlands, such as interdunal swales, that are likely to be affected by rising seas and migrating marshes

- Consider how marsh migration may affect recreational uses of natural resource areas, such as hunting or hiking

Restoration Highlight

Salt water was threatening to breach a barrier and enter a freshwater impoundment in Assawoman Wildlife Area at Sassafras Landing. DNREC, CIB, and Cardno collaborated in 2019 to design and construct a hybrid living shoreline. This project restored fringing marsh and protected an important freshwater impoundment from saltwater inundation.

Task 3: Prevent development and preserve buffers adjacent to tidal wetlands

As development increases in the Inland Bays, so does the likelihood that construction will occur in tidal wetland buffers. Currently, Sussex County regulations state that tidal wetland buffers should be at least 50 feet wide. In 2020 CIB and other partners led an effort to increase the required buffer width in the county, but that effort was (as of September 2021) unsuccessful. Despite this setback, more needs to be done in the Inland Bays:

- Prevent development in tidal wetland buffers to reduce non-point source pollution entering wetlands, reduce spread of invasive species, maintain important wildlife corridors, and reduce flooding
- Continue efforts to increase required buffer widths around tidal wetlands

Task 4: Educate realtors about tidal wetlands

Landowners rely heavily on realtors for advice and service when it comes to buying and selling houses. It is therefore critical for realtors to know more about tidal wetlands and what they mean for property owners. Realtors should be able to explain to landowners what tidal wetlands are, their general functions, where they are in relation to properties for sale, what state and federal regulations as well as local codes and ordinances surround them, and what sea-level rise and marsh migration could mean for properties close to wetlands. This task is already underway, as DNREC's WMAP presented at a Delaware Association of Realtors (DAR) meeting in 2019 to start educating realtors about wetlands. Moving forward:

- Continue and expand realtor education through meetings and workshops, online platforms, and printed materials

Task 5: Conduct more research to better understand the process of marsh migration

Marsh migration has been documented in the Inland Bays through aerial imagery (DNREC 2022). However, many details about the process of marsh migration are unknown. Marsh migration research has been initiated in the broader Mid-Atlantic region, but none has yet focused on the Inland Bays. Moving forward, marsh migration field research should be conducted and focus on questions like:

- At what rate are marshes moving inland in the Inland Bays, converting freshwater wetlands or uplands to saltwater marshes?
- How accurate are marsh migration spatial models proving to be on the ground in the Inland Bays, and how can we make those models even more accurate?
- How are different wildlife species responding to marsh migration in the Inland Bays?

Where to Restore

There are many wetland restoration opportunities for tidal wetlands in the Inland Bays on public protected lands (see maps in Appendix A). In Little Assawoman Bay, the southern part of the Inland Bays, only two small areas were identified as being dominated by *P. australis* on public protected land, and both of those areas were in Assawoman Wildlife Area. All wetland restoration opportunities identified by the WRR were three or four-star opportunities within Assawoman Wildlife Area, and most were directly adjacent to existing tidal wetlands. Many of these opportunities also fell on land that were somewhat poorly drained, poorly drained, or very poorly drained soils on agricultural lands (Map 5, Appendix A). Poorly drained agricultural lands that are adjacent to existing tidal wetlands represent prime restoration opportunities, as they could easily be converted back to wetlands and become tidal marsh migration corridors. Other prime areas were upland forests adjacent to current tidal wetlands or situated between current tidal and non-tidal wetlands. Restoring those types of areas would connect and expand wetland complexes.

Additionally, there is a significant amount of public protected land that is highly suitable for tidal marsh migration under a moderate sea-level rise scenario of four feet. Many of these areas are in Assawoman Wildlife Area and are currently either non-tidal wetland, upland forest, or agricultural land. Other highly suitable areas are in Fenwick Island State Park, concentrated along Route One (Map 6, Appendix A). Some of those areas overlap with those identified by the WRR as being prime restoration opportunities (Maps 5 and 6, Appendix A).

Many public protected areas in the Indian River Bay have opportunities for high marsh restoration via invasive *P. australis* treatment. These areas are within the Piney Point Tract of Assawoman Wildlife Area, Holts Landing State Park, James Farm Ecological Preserve, Fresh Pond, and Delaware Seashore State Park. Within all of those same areas, there are also many three, four, and five-star opportunities identified by the WRR. Most of the WRR options are within upland forest or poorly drained agricultural land that is adjacent to current tidal wetlands and is often also adjacent to bands of *P. australis* (Map 7, Appendix A). In these cases, it may be best to do multilayer projects, where restoring former wetlands occurs along with nearby treatment of *P. australis*. This could help prevent the invasive reed from colonizing new restoration projects.

There is also some highly suitable land for marsh migration in the Indian River Bay on public protected lands under a four-foot moderate sea-level rise scenario. This land is currently either non-tidal wetland or upland forest and is in Assawoman Wildlife Area, Fresh Pond, Holts Landing State Park, or Delaware Seashore State Park (Map 8, Appendix A). There is significant overlap between highly suitable marsh migration lands and prime restoration opportunities identified by the WRR (Maps 7 and 8, Appendix A), further demonstrating how valuable these lands are for the future of tidal wetlands in this watershed.

Most of the tidal wetland restoration opportunities in Rehoboth Bay are *P. australis* treatment options. Many of them are in Cape Henlopen State Park or Angola Neck Nature Preserve. Small bands exist along the Love Creek Fishing Access and Masseys Landing Access Area. Very few three or four-star opportunities were identified on public protected land by the WRR in Rehoboth Bay. Those that were identified were in Angola Neck Nature Preserve, Masseys Landing Access Area, or Thompson Island Nature Preserve. There are no five-star opportunities on public protected land in this area. Some small bands of somewhat poorly drained, poorly drained, or very poorly drained soil on agricultural lands are highlighted in Cape Henlopen State Park and Angola Neck Nature Preserve. All are adjacent to existing tidal wetlands, meaning that they are ideal candidates to convert to future marsh with marsh migration (Map 9, Appendix A).

Rehoboth Bay also contains some public protected land that is considered highly suitable for marsh migration under a moderate four-foot sea-level rise scenario. Much of that land is currently non-tidal wetland or upland forest and is scattered throughout Cape Henlopen State Park in the northern half of the bay (Map 10a, Appendix A). In the southern half of the bay, highly suitable land exists in upland forests or non-tidal wetlands in Delaware Seashore State Park, Angola Neck Nature Preserve, and the Love Creek Fishing Access area (Map 10b, Appendix A).

Non-tidal Wetlands

Restoration Tactics

A. Minimize Forestry Impacts to Non-tidal Wetlands

Forestry impacts to forested non-tidal wetlands should be minimized, as deforestation was identified as a common cause of non-tidal wetland loss and change from 2007 to 2017 based on wetland maps (DNREC 2022). This was particularly true in forested flat wetlands. Delaware is required to protect water quality during forestry operations by using best management practices (BMPs) as directed in the state's Forestry Erosion and Sedimentation Law. The law, which is enforced by DFS, requires that all commercial forestry operations and landowners that are planning harvests of one acre or more must submit a permit application to DFS. DFS then reviews the permit and accepts it given that proper BMPs are planned, and DFS also inspects forestry operation sites to ensure that BMPs are being implemented (DFS 2010). However, that law does not prevent clear cutting from occurring in non-tidal wetlands, provided that BMPs are followed, and the land remains under forest management. For example, clear cutting in a forested wetland may still occur if soil compaction is minimized, if harvesting takes place during drier periods, and if streamside management zones (SMZs) are maintained (DFS 2017).

Task 1: Continue implementing forestry BMPs

BMPs ensure that forestry activities are sustainable and minimize impacts to natural habitats and water quality. According to a forestry survey performed by the National Association of State Foresters (NASF), Delaware achieved a wetland BMP implementation rate of 99% and a SMZ implementation rate of 97% in 2019 (NASF 2019). These data indicate that in most cases, BMPs are used to reduce impacts to wetlands and streams in timber-harvested areas. Examples of wetland forestry BMPs include not harvesting in saturated soils and using tires that minimize soil rutting and compaction. Delaware's BMPs also specify that a SMZ of 50 feet should be maintained along forested perennial and intermittent streams, within which forestry activities should take extra care to minimize disturbance (DFS 2017). Moving forward:

- Forestry BMP implementation should continue in the Inland Bays at maximum rates to keep forested wetlands, streams, and their buffers intact and functioning
- Consider elimination of forestry practices within SMZs

Task 2: Allow for natural regeneration of previously forested areas

Heavily timbered areas that have been clear-cut should be allowed to regrow naturally or through planting. In doing so, forested non-tidal wetlands may eventually recover at least some of their former condition and function. Natural soil and hydrology conditions should also be restored in heavily timbered areas. Moving forward:

- Allow for regrowth of natural hardwood or softwood forests in heavily timbered areas instead of pine plantations to support native wetland plants and wildlife
- Restore natural vegetation in wet areas where pine plantations were previously created on former wetlands by planting wetland hardwood or softwood species
- Restore natural wetland hydrology in heavily timbered areas by filling old ditches
- Ensure that windrows have breaks that allow for natural hydrology and wildlife movement
- Allow for regrowth of natural hardwood or softwood forests in inactive agricultural lands that were previously forested wetlands
- Prioritize reforestation in areas that can connect existing forest blocks to reduce habitat fragmentation

Task 3: Reduce clear cutting in forested non-tidal wetlands

Clear cutting can have a variety of ecological consequences, such as increased water and soil temperature, increased sediment and nutrient runoff, and reduced leaf litter, all of which can negatively affect wetland plant and wildlife species that are adapted to forested wetland conditions (Jiang 2016). Hydrology impacts are unavoidable, and it can take decades to restore natural hydrology. Clear-cutting of trees also removes forested wetland habitat patches from the landscape that many wildlife species depend on for foraging, breeding, or resting. Even if those patches are allowed to regenerate, it will take decades for the successional process to recreate old growth forest conditions needed for optimal forested wetland function. Moving forward:

- Avoid clear cutting in non-tidal forested wetlands

- Where forestry activities must take place, reduce impacts to old growth non-tidal forested wetlands by selective cutting instead of clear cutting, and by harvesting in drier seasons
- Replant native vegetation and restore natural soil and hydrology conditions as quickly as possible on lands that were previously clear-cut

B. Preserve Non-Tidal Wetlands with Easements or Land Acquisition

As development increases in the Inland Bays and state regulations for non-tidal wetlands remain absent, one of the best tactics for preserving intact non-tidal wetlands is land protection through direct purchase by a conservation group or state entity or through conservation easements. Focusing particularly on large forest blocks and forested corridors between wetlands would best help to address major non-tidal wetland loss and fragmentation issues seen in the watershed.

Task 1: Facilitate regular work by the Delaware Restoration Work Group

Different groups and entities should collaborate to identify the best opportunities to purchase land or enact conservation easements, particularly on large forest blocks or corridors connecting large forest blocks that are not already permanently protected. Collaboration would allow for pooled staff time and resources on projects, which would make restoration efforts more successful and efficient. Progress on this task has only just started with the formation of and first meeting of the Delaware Restoration Work Group (DRWG) in 2021. To improve collaboration:

- Continue to hold several meetings of the DRWG per year and recruit more organizations to become involved
- Encourage project and technique sharing among DRWG members
- Work together through the DRWG to identify priority wetland restoration and protection areas

Task 2: Secure more funding to support acquisition

As with tidal wetlands, land acquisition is a necessary but expensive task to preserve and restore non-tidal wetlands. Moving forward:

- Make securing funding for land purchases a priority
- Identify new funding sources to increase flexibility and leveraging

- Focus acquisition efforts on current non-tidal wetlands such as riparian corridors and headwater forests, on forested corridors between current non-tidal wetlands, and on wet croplands to convert them back to their former wetland state

Task 3: Educate landowners about conservation options

There are several options for landowners to preserve or restore wetlands on their land. However, many landowners may be unaware of those options or may not understand the benefits of those options. This task is already underway, as groups like NRCS, DNREC's Non-Point Source Program, and Ducks Unlimited work to educate the public about a variety of conservation options. Continue to expand landowner education in the Inland Bays about options such as:

- The Conservation Reserve Enhancement Program (CREP), which incentivizes agricultural landowners to remove some croplands from production to restore ecologically important habitats like wetlands
- The Working Lands for Wildlife Program, which allows landowners to continue working on their agricultural or forest lands while also providing ecological benefits for wildlife
- The Forestland Protection Program, which allows landowners to permanently preserve their working forests via conservation easement while still allowing for sustainable timber harvesting

Task 4: Restore non-tidal wetlands previously converted to cropland

Some croplands are still active on public protected lands, such as those leased on DNREC's Division of Fish and Wildlife property. Parts of some of those croplands exist on former wetlands. Agricultural fields that exist on poorly drained soils represent prime candidates for non-tidal wetland restoration, as they are often too wet to sustain successful crop yields. Moving forward:

- Target previously converted wetlands on public lands and return them to their natural states
- Encourage private landowners to put their wet croplands under conservation easement and restore wetlands

C. Restore Natural Hydrology

Several types of actions should be taken to improve degraded hydrology in non-tidal wetlands in the Inland Bays. Streams and their floodplains should be restored to their natural state, and tax ditches should be improved to be more ecologically sound. These types of projects will be new in the region, so designs and lessons learned should be shared among professionals.

Task 1: Reverse stream channelization

Natural meanders and lower banks need to be re-established in streams to slow down water velocity, reduce bank erosion, and promote healthy floodplain connection. This task has not yet begun, as no known stream restoration projects in the Inland Bays exist that have reversed channelization. To ensure successful restoration:

- Mimic conditions found in healthy Coastal Plain streams and associated riverine wetlands
- Monitor all restoration projects after installation to perform any necessary adaptive maintenance and to determine if the practices used are successful

Task 2: Make ecological updates to tax ditches

Most tax ditches were created with straight channels and steep banks, and they do not mimic the low bank, meandering natural streams found in the Inland Bays. To improve ecological condition of tax ditches while retaining their intended drainage functions:

- Create some meanders in existing tax ditches to slow down water and reduce erosion
- Minimize mowing alongside tax ditches to maintain a natural, vegetated buffer on both sides that could help filter and clean water
- Plant trees alongside ditches to help clean water and lower water temperature, promoting increased dissolved oxygen and better conditions for fish and other aquatic organisms
- Inform and involve those responsible for tax ditch maintenance in all ecological updates

Task 3: Make ecological updates to stormwater retention ponds

Many wetland gains that were documented from 1992 to 2007 (Tiner et al. 2011) and from 2007 to 2017 (DNREC 2022) were that of manmade stormwater retention ponds. As they are now, most of these ponds lack vegetation and do not mimic natural wetlands, limiting their functional capacity. Stormwater ponds will continue to be created with new developments, so to improve their ecological condition while still maintaining their intended function:

- Focus on creating new ponds with more natural wetland features, including native vegetation within and around the pond
- Avoid mowing directly around the edges of ponds

Task 4: Encourage project and technique-sharing

The process of restoring natural hydrology in non-tidal wetlands and their associated waterways, and making constructed wetland features more natural, has not yet started in the Inland Bays, as was noted in Tasks One, Two, and Three above. When projects are put into place:

- Share techniques used, successes, and failures with other restoration professionals in the region

Task 5: Provide trainings for restoration professionals

To properly restore natural hydrology to non-tidal wetlands, professionals that are planning, designing, constructing, and monitoring projects need to better understand characteristics of natural wetlands. The same is true for those who aim to create new wetlands for voluntary restoration or mitigation purposes. Wetland restoration or creation in the Inland Bays will not be successful without a complete understanding of natural wetland hydrology in the region, as hydrology is what drives formation of hydric soils and growth of hydrophytic plants. Trainings should:

- Focus on properly siting and designing projects in areas that will be successful

- Emphasize the importance of long-term monitoring to determine if goals are met and if adaptive maintenance is needed
- Address the importance of replacing wetland types and functions that have been lost in the Inland Bays rather than simply creating open-water habitats

D. Control Invasive Species

Invasive species control needs to occur to help combat the widespread prevalence of invasive plant species in non-tidal wetlands in the Inland Bays, particularly in riverine wetlands. Private landowners play an important role in this because of their proximity to non-tidal wetlands.

Task 1: Encourage landowners to control invasive species and promote native plants

Many non-tidal wetlands are on or near private property, making them vulnerable to invasion by non-native species from lawns or gardens. Encouraging landowners to control invasive species in their own backyards and promoting planting of native species would therefore have a large, positive impact on non-tidal wetland health. This task is already underway. For example, DNREC's WMAP has a wetland plant field guide that is publicly available that helps landowners identify native and invasive wetland plants (DNREC 2018). In addition, CIB holds a popular annual native plant sale in the Inland Bays that offers native plants for purchase and educates the public about the benefits of native plants. Moving forward:

- Continue to educate landowners about the harms of invasive species and how to control and eradicate them
- Promote the benefits of native plants

Task 2: Secure funding to support invasive plant control

Invasive species control is a necessary, but often time-consuming and expensive, task. More funding is needed to support control and eradication efforts by private landowners and natural resource organizations alike. Some cost-share programs and grants do already exist, such as a *P. australis* control program offered by DNREC's Division of Fish and Wildlife and NRCS. The Delaware Invasive Species Council (DISC) has also had small grants available in the past for invasive species control projects. To expand available funding and types of species addressed:

- Prioritize acquisition of funding for invasive plant control
- Expand existing state programs to address more than one invasive species

E. Improve Land Use Planning

Improved land use planning is critical to prevent future non-tidal wetland losses and impacts, as are state regulations for non-tidal wetlands. The tasks listed below identify actions that can be completed to help further this wetland preservation tactic.

Task 1: Support state non-tidal wetland regulations and regulation enforcement

Current federal regulations for non-tidal wetlands do not cover many small, geographically isolated wetlands because they are not directly adjacent to regulated navigable waterbodies. Delaware's state regulations leave nearly all non-tidal wetlands vulnerable, as they only cover non-tidal wetlands that are 400 contiguous acres or more. Federal regulations are frequently not enforced. On a local level, land planning and zoning ordinances often exist but are not always followed. State non-tidal wetland regulations are needed to fill gaps left by federal regulations and to prevent further loss and damage to these wetlands in the Inland Bays. Past efforts to pass legislation related to non-tidal wetland regulation have failed, but efforts were renewed in 2020. If passed, the new legislation would create state regulations for non-tidal wetlands. Moving forward:

- Support non-tidal wetland legislation by contacting representatives, making positive public statements, and gathering stakeholder support
- Increase enforcement of regulations
- Follow local land planning and zoning ordinances that are in place to protect wetlands

Task 2: Reference updated wetland maps when approving new developments

In 2020, DNREC released the newest version of the SWMP, which represents the most recent wetland mapping effort in Delaware. The maps are based on 2017 aerial imagery and are available for public download on the Delaware First Map website. Although the maps are not regulatory, they are a useful screening tool to let users see where functioning wetlands likely occur on the ground, what types of wetlands occur, and how wet they are. To improve land use planning with respect to wetlands:

- Encourage use of updated wetland maps by developers and those working with developers to help avoid planning developments on or directly adjacent to non-tidal wetlands
- Field-verify information gathered from screening of maps

Task 3: Work with municipalities and Sussex County to encourage wider buffers around non-tidal wetlands and riparian areas

Currently, there are no buffer regulations in place for non-tidal wetlands in Sussex County, leaving them vulnerable to many indirect impacts. It also means that buffer habitats around non-tidal wetlands can be eliminated, increasing habitat destruction and fragmentation. Such habitats are important for flood reduction and water quality improvement. They are also important for wildlife species that live in and near wetlands, and buffers often serve to connect wetland pockets in the landscape. Progress on this matter was attempted in 2019 when a diverse group of stakeholders called the Sussex County Wetlands and Buffers Working Group (WBWG) formed. Their goal was to create a set of recommendations to improve wetland and stream buffer ordinances in the county. Their recommendations for federally regulated non-tidal wetlands and intermittent streams were that buffers around them should at least increase from zero to 30 feet. This effort was ultimately unsuccessful. Despite this setback, work should be done to:

- Persist in efforts to increase required buffers around non-tidal wetlands and streams through diverse stakeholder groups such as the WBWG
- Collaborate with municipalities to increase local buffer ordinances
- Incentivize leaving vegetated buffers intact

Task 4: Educate realtors about non-tidal wetlands

As mentioned previously, landowners rely heavily on realtors for advice and service when it comes to buying and selling houses. It is therefore critical for realtors to know more about non-tidal wetlands and what they mean for property owners. Realtors should be able to explain to landowners what non-tidal wetlands are, their general functions, where they are in relation to properties for sale, what federal or state regulations or local codes and ordinances surround them, and the benefits of preserving them. Realtors should also be aware of floodplain locations and communicate to landowners the risks of living in or near floodplain areas.

This task is already underway, as DNREC's WMAP presented at a DAR meeting in 2019 to start educating realtors about wetlands. Moving forward:

- Continue and expand realtor education through meetings and workshops, online platforms, and printed materials

Where to Restore

There are fewer wetland restoration opportunities on public protected lands for non-tidal wetlands in the Inland Bays compared with tidal wetlands (see maps in Appendix A). The best non-tidal wetland restoration opportunities on public protected land in Little Assawoman Bay are in Assawoman Wildlife Area. These options are rated as three or four-star opportunities by the WRR. They are mostly adjacent to existing non-tidal wetlands, and they are all on somewhat poorly, poorly, or very poorly drained soil on agricultural lands (Map 11, Appendix A). Restoring these lands would expand the amount of protected, contiguous non-tidal forested wetlands.

Non-tidal restoration opportunities on public protected land are scattered throughout Indian River Bay. In Holts Landing State Park there is patch of invasive *P. australis* within existing non-tidal wetlands that could be treated (Map 12a, Appendix A). In Fresh Pond there are a couple of three and four-star opportunities highlighted by the WRR, which are located on somewhat poorly drained agricultural lands and are adjacent to current non-tidal forested wetlands that are ditched (Map 12b, Appendix A). Most of the options in Indian River Bay are concentrated in the western part of the bay. The majority of these are currently upland forest or poorly drained agricultural lands in Midlands Wildlife Area, and they are all very close or adjacent to existing non-tidal wetlands. Restoring these parcels would help expand corridors of forested non-tidal wetlands. It would also be beneficial for water quality, as they are in a headwater region of the watershed. There is also one patch of *P. australis* in Midlands Wildlife Area that could be treated to restore native species (Map 12c, Appendix A).

There are very few non-tidal wetland restoration opportunities on public protected land in Rehoboth Bay. Where options have been highlighted, they occur in small pieces and slivers. One parcel of somewhat poorly drained agricultural land could be restored to non-tidal forested wetland in Redden State Forest. The WRR also identified several small three-star options to restore along forested ditches in Redden State Forest (Map 13a, Appendix A). There are several small *P. australis* patches along agricultural land in Cape Henlopen State Park that could be treated (Map 13b, Appendix A), and another small patch along Delaware Seashore State Park (Map 13c, Appendix A).

Restoration Tactics

A. Perform Direct Restoration

Direct restoration involves collecting seeds from existing beds and planting those seeds to either enhance other existing beds or to establish new beds where conditions are favorable. Those performing restoration projects should always be cognizant of potential physical disturbances, such as destruction by boat propellers or excessive grazing by Canada geese (*Branta canadensis*).

Task 1: Identify optimal areas for seeding

SAV seeding will be most successful in areas that have clean, clear water, and where SAV is already growing. Therefore, monitoring for existing SAV beds and for ideal water quality could help identify where in the Inland Bays new beds may succeed. This task is already underway, as CIB and DNREC's SAV Work Group began organized SAV monitoring in the Inland Bays in 2020. Some water quality stations are already in place in the bays and are monitored annually by CIB, and DNREC's SAV Work Group is currently exploring the possibility of installing more water quality stations. To continue to help inform where seeding should take place:

- Continue and expand monitoring for existing SAV beds
- Increase water quality monitoring efforts

Task 2: Implement more projects for widgeon grass

If populations can be supplemented and increased through restoration, more natural reproduction will occur, which would help to create natural, sustainable populations. Restoration efforts have just begun, as DNREC's SAV Work Group and CIB have opportunistically supplemented several existing SAV beds throughout the Inland Bays. The fact that wigeon grass (*R. maritima*) is currently much more plentiful than eelgrass (*Z. marina*) suggests that conditions are better for widgeon grass, so initial focus should be on widgeon grass. For new project implementation moving forward:

- Enhance existing beds through permitted seed collection and distribution
- Establish new beds where conditions are deemed favorable

- Monitor all restoration projects to determine project success, perform adaptive management, and identify lessons learned

Task 3: Conduct more research for potential eelgrass restoration

As previously mentioned, eelgrass (*Z. marina*) was once plentiful in the Inland Bays but has since been wiped out almost entirely. Past efforts to restore this species in the Inland Bays have not been successful. In the hopes of restoring eelgrass:

- Conduct more research regarding specific conditions under which eelgrass restoration may be successful, such as more water quality monitoring and learning what has worked in other Mid-Atlantic states

B. Encourage Indirect Restoration

Indirect restoration involves addressing the underlying issues that are largely preventing SAV from making a full recovery in the Inland Bays. The main factor limiting SAV in this watershed is degraded water quality from surrounding agriculture and development, so these tasks focus on addressing water quality issues. Less nutrient pollution (i.e., nitrogen and phosphorus) would mean less nuisance algae, which in turn would lead to greater dissolved oxygen and water clarity. Reducing excess sediment entering the bays would also increase water clarity.

Task 1: Encourage implementation of more agricultural BMPs

Agricultural BMPs described in the Inland Bays PCS (Inland Bays Tributary Action Team 2008) are mostly voluntary in nature. To increase adoption of these voluntary measures:

- Encourage agricultural landowners to adopt more BMPs, such as wetland restoration on former agricultural land, planting riparian forested buffers and grassy buffers around ditches, and using poultry manure storage sheds
- Offer incentives for implementing agricultural BMPs

Task 2: Promote improved stormwater management

Many of the stormwater management BMPs identified in the Inland Bays PCS (Inland Bays Tributary Action Team 2008) are voluntary in nature. To increase adoption of these voluntary measures:

- Encourage landowners, communities, and municipalities to adopt more BMPs, such as installing rain gardens or swales, restoring or creating wetlands with native vegetation, using pervious paving materials, maintaining green space, and reducing lawn fertilizer and pesticide use
- Offer incentives for implementing stormwater BMPs

Task 3: Convert more septic systems to central sewage systems

Converting septic systems to central sewage systems is identified as an important wastewater action to improve water quality in the Inland Bays PCS (Inland Bays Tributary Action Team 2008). Septic systems may overflow or fail, leaching waste into groundwater supplies that eventually make their way into the bays. Converting septic systems would help ensure that wastewater is kept out of streams, rivers, and bays. Significant progress has been made on this task; from the 1970s to 2016, more than 50,000 dwellings the size of single-family homes were converted from septic to central sewage systems (Walch et al. 2016). Moving forward:

- Continue to increase conversion of septic systems to central sewage systems

Task 4: Support oyster restoration and aquaculture

Eastern oysters (*Crassostrea virginica*) help filter and clean the water, making conditions more favorable for SAV. Many SAV species also thrive in similar conditions to oysters in relatively sandy, shallow areas. This means that where oyster aquaculture or restoration is successful, conditions may also be favorable for SAV. To further aid SAV recovery:

- Support sustainable oyster aquaculture and restoration through funding, personnel and volunteer time, or outreach
- Investigate further to see if specific aquaculture or oyster restoration areas are fit for SAV restoration

C. Secure Support

Past SAV restoration efforts in the Inland Bays were largely unsuccessful, and new efforts are in their infancy. To ensure success and increase staff time and resources available, partnerships among different organizations are crucial. More steady funding will then be needed as partnerships and projects expand.

Task 1: Build partnerships with other agencies and states

As SAV monitoring and restoration activities have only just restarted within the last few years, it is critical to build partnerships with other organizations who work in the Inland Bays. This task is underway, as DNREC's SAV Work Group and CIB have started to team up to monitor SAV, identify ideal locations for restoration, and apply for subaqueous restoration permits. Moving forward:

- Continue collaboration between CIB and DNREC's SAV Work Group to ensure that there are no overlapping efforts and maximize funds and staff time
- Extend partnerships to other interested organizations to further increase available staff time, money, and efficiency
- Reach out to other Mid-Atlantic states to see what has and has not worked for them for SAV restoration

Task 2: Provide more education about the value of SAV and clean water

Many people who live along the Inland Bays view SAV as a nuisance that clogs canals and gets stuck in boat propellers. They do not realize that native SAV provides many benefits, including helping water quality and providing habitat for commercially and recreationally important blue crabs (*C. sapidus*) and fish species. To address this issue:

- Organize outreach efforts that target the general public to teach them about the values of SAV

Task 3: Secure funding to support restoration and monitoring

SAV restoration efforts should first focus on small projects to learn important lessons that can inform larger or more challenging projects down the road. With the success of smaller projects, partners can start to move forward with larger ones based on their knowledge and experience. To accomplish this:

- Secure funding to support larger and more widespread SAV restoration projects once smaller restoration projects are found to be successful
- Acquire funding to monitor any restoration projects that are implemented to determine success and lessons learned

Where to Restore

Some of the best places to start restoration activities are where SAV beds already exist because conditions are clearly favorable for growth in those areas. Protection efforts should also be focused on existing beds. SAV restoration may be effective near Eastern oyster (*C. virginica*) aquaculture areas as well, as shellfish help to filter and clean the water, making conditions more favorable for SAV. Many SAV species also thrive in similar conditions to oysters in relatively sandy, shallow areas. This means that where aquaculture is successful, conditions may also be favorable for SAV. However, if restoration occurs near active aquaculture operations, extreme care should be taken to ensure that aquaculture activities do not negatively affect restored beds, such as through physical disturbance.

In Rehoboth Bay, *R. maritima* has been observed in Herring Creek and on Raccoon Point on the other side of Massey's Ditch, and *Z. palustris* has been found in Love Creek. Those beds should be protected and enhanced. Additionally, there are aquaculture areas by Angola Landing and along Delaware Seashore State Park that could potentially support favorable conditions for SAV (Map 14, Appendix A).

R. maritima has been documented near the Burton's Island trailhead and by James Farm Ecological Preserve in the Indian River Bay, so these would be prime locations to enhance existing beds. An aquaculture area exists where Pepper Creek joins the bay (Map 15, Appendix A). In Little Assawoman Bay, *R. maritima* has been found in many places, mostly within Assawoman Wildlife Area but also just offshore of Fenwick Island State Park. Two aquaculture areas are located offshore of Fenwick Island State Park as well (Map 16, Appendix A).

SAV restoration may also be successful where water quality has been documented as being favorable. For example, CIB created a water quality index using nitrogen and phosphorus concentration, algae concentration, and water clarity data to rate different areas as being supportive or unsupportive of SAV restoration. According to this water quality index, several locations within the Inland Bays could support SAV growth, most of which are in Little Assawoman Bay and Indian River Bay (Walch et al. 2016; Map 17, Appendix A). However, it should be noted that water quality is just one parameter that controls SAV growth, so other conditions such as proper substrate and temperature must be present in those areas as well for restoration to be successful.

Looking Forward

Wetlands and SAV in the Inland Bays face many challenges. However, there are many opportunities outlined in this strategy to combat specific issues and restore and protect them. Significant collaboration will be necessary among natural resource organizations to move restoration forward. Those who wish to move forward with any of the tasks outlined in this document should communicate with other organizations who are involved with wetlands or SAV in the Inland Bays to form collaborations or work groups. Early communication would increase efficiency and reduce redundancy. The summary tables in Appendix B show what tasks different organizations plan to work on in some fashion soon based on their various management plans. Those tables can serve as a starting point for other organizations to see who to reach out to for collaborating on certain tasks. Note that not all entities consulted for this restoration strategy (see Table 4) have management plans related to wetlands or SAV, so not all entities are represented in Appendix B.

Organizations should also use this restoration strategy when justifying project need for funding applications. This strategy contains a comprehensive overview of major issues faced by wetlands and SAV in the Inland Bays and the diverse tactics that can be used to address those problems. As such, it will hopefully serve as a valuable resource to brainstorm new restoration and protection ideas and secure the funding to implement them. While the spatial portion of this strategy only focused on public protected lands, the tactics and tasks relate to both public and private lands. Organizations that are able should work with landowners, HOAs, municipalities, and developers to make progress on the tasks described above that are related to private landholdings.

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