DELAWARE INLAND BAYS HABITAT MANAGEMENT PLAN

APRIL 11 2025

30 YEARS
DELAWARE CENTER FOR THE INLAND BAYS
preserve • protect • restore

ACKNOWLEDGEMENTS

The Inland Bays Habitat Management Plan was written and produced by Biohabitats, Inc. with support from Michelle Koenig, Bryanna Lisiewski, and Meghan Noe Fellows with the Delaware Center for the Inland Bays, the Center's CCMP Implementation Committee and Scientific and Technical Advisory Committee, and countless dedicated and talented professionals from DE Department of Agriculture, DE Forest Service, DE Geological Survey, DE Department of Natural Resources and Environmental Control, EPA Region 3, Maryland Coastal Bays Program, Nanticoke Indian Tribe, The Nature Conservancy, and University of Delaware.

This project was funded by President Biden's Bipartisan Infrastructure Law through the United States Environmental Protection Agency under assistance agreements 4T-95308901-0 and 4T-95333501-0 to the Delaware Center for the Inland Bays. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does EPA endorse trade names or recommend the use of commercial products mentioned in this document.

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EXECUTIVE SUMMARY

The Delaware Inland Bays and their watershed contain a diverse and multifaceted gradient of ecosystems, from ocean to salt marsh to upland forest. These ecosystems, while resilient, are today a small fraction of their former size, and many species face imminent decline or extinction due to multiple stressors and threats to their habitats from development, water quality degradation, and climactic variables. As a result, each of the species you see pictured throughout this document (including the glossary and appendix) are those that are prioritized for protection and restoration efforts.

This document provides context, landscape analysis, and habitat management guidance for the Delaware Center for the Inland Bays in its mission to preserve, protect, and restore Delaware's Inland Bays and the critical species in their watersheds. It uses geospatial data analysis based on established ecosystem science to help guide and prioritize the restoration and preservation of ecological communities. The historical, ecological, and social context of this analysis is described in **Section 1**.

Underlying the analysis is the well-established principle that larger contiguous habitat areas support greater species diversity and elevated ecosystem function. The recommendations made in this document for the creation of a robust habitat network, therefore, aim to maximize the size and interconnectedness of current and potential habitat areas within the Inland Bays watershed. This strategy of creating a robust network of natural habitats complements the Comprehensive Conservation and Management Plan (CCMP) and provides for many associated water quality benefits, especially when focused along waterways.

Section 2 outlines important concepts used throughout the analysis, describes the types of wildlife habitat present in the project area, and summarizes the stressors and threats faced by these ecological communities.

Following initial spatial data gathering and assessment, the habitat types in the study area were delineated into three broad categories: upland and nontidal; tidal marsh, beach, and dune; and tidal river and bay. These categories, while interconnected, face distinctive stressors and threats and require distinctive approaches to conservation and restoration.

The spatial analysis, described in **Section 3**, consisted of three principal components. They are:

- **An analysis of the land use and land cover trends in the Inland Bays**, with mapping of land development in the watershed since 1992 and identification of habitat areas vulnerable to future development.
- **An exploration of multiple sea level rise (SLR) scenarios in the Inland Bays watershed**, with mapping of three SLR scenarios to reveal areas vulnerable to future inundation and potential areas of marsh migration.
- **A least-cost path analysis of the current and potential future habitat network,** with mapping of key areas for habitat conservation and restoration in each subwatershed of the Inland Bays.

The analysis revealed that natural vegetated habitat and open water presently account for less than 50% of land cover in the Inland Bays watershed. While many climactic and anthropogenic stressors are influencing habitat quality at a patch level, the primary threats that emerged are high rates of development that continue to fragment existing habitat areas, and wetland loss and degradation from sea level rise that is projected to outpace marsh m igration.

These trends highlight the importance of protecting and establishing a connected and robust habitat network, limiting development in key areas, and protecting marsh migration zones.

These key findings were used to inform the creation of the following plan goals and objectives to be achieved through community partnerships, policy support, and management initiatives over the next 10 years. These goals and objectives and associated actions, defined in **Section 4,** also set a foundation for decision making and complement the existing initiatives of the CCMP.

GOAL 1: Improve the health and resiliency of the high conservation value habitats (HCVH) in the Inland Bays

Objective 1.1 l Strengthen land protection policies for HVCH

Land protection policies have watershed-wide benefits and can profoundly increase habitat area and connectivity. Plan actions seek to demonstrate the benefits of land conservation practices and identify opportunities to integrate these practices into policies and regulation within the next 5 years.

Objective 1.2 l Improve connectivity among identified HVCH

A network of connected habitat cores will make the fish and wildlife populations of the Inland Bays more resilient to stressors and threats from development pressure and climactic variables. Plan actions call for a plan to prioritize, acquire, restore and manage key habitat connectors within the next 5-10 years.

Objective 1.3 l Implement Nontidal Stream and Tax Ditch Buffer Plantings to Benefit Habitat, Connectivity, Water Quality, and Stream Temperature (Forest and Non-Forest, Respectively)

Buffers on drainage features, including tax ditches, are effective in expanding the green infrastructure network and providing watershed-wide co-benefits of improving water quality and regulating water temperatures. Plan actions aim to develop and implement a buffer planting program within the next 2-3 years.

Objective 1.4 l Identify Broad Patch-level Management Strategies for HVCH

Broad patch-level management strategies are intended to provide an overview of management activities that may be needed on a rotating basis to ensure that delineated habitat patches are providing functional habitat or maintaining a trajectory toward providing functional habitat. Plan actions seek to identify strategies and establish a framework for managing HVCH patches, over the next 5 years.

Objective 1.5 l Demonstrate benefits of existing incentives program for landowners/developers/agricultural producers

Incentive programs are intended to offer a benefit to landowners/operators for integrating certain conservation activities on their lands or in their operations. Examples of such programs could be buffer establishment, native plantings, cover cropping, etc. Plan actions target the development of an incentives framework and a pilot project for this program within the next 10 years.

Objective 1.6 l Partner with developers to integrate patch-level conservation strategies into development plans and/or HOA by-laws (e.g., buffer strips, turf reduction, etc.)

Science has demonstrated strong relationships between access to natural spaces and human health. Integration of conservation measures into land development offers opportunities to achieve a triple bottom line – profit, people, and planet. Plan actions call for the creation educational materials to easily communicate the benefits of conservation strategies to developers and provide support to developers, community members, and HOAs to implement these strategies into future development and land management activities within the next 3 years.

Photo credit: Driscoll Drones

Goal 2: Protect and expand the presence of non-forest and early successional habitat on the landscape (e.g., meadow, grassland, young and transitioning forest)

Objective 2.1 | Conservation and management of early successional habitat.

Since natural habitats are limited by other land uses in the Inland Bays, focusing on preserving and enhancing existing early successional habitats is important to maintaining the habitat mosaic. Plan actions outline steps to map, categorize, and assess threats to early successional habitats within 3 years and engage volunteers to sustain an ongoing effort within 5 years.

Objective 2.2 | Convert non-habitat or less valuable habitat types

Some habitats, such as agriculture buffers and residential yards, can be managed to optimize their habitat value while providing their intended function. Shorter term actions include establishing partnerships with agricultural producers to implement pilot projects such as buffer strips and pollinator-friendly agricultural practices and promoting existing habitat creation incentive programs for homeowners. In the longer term, plan actions target larger-scale integration of these strategies into the management of agricultural lands, game lands, and residential yards.

Goal 3: Establish priority conservation areas in the coastal zone to allow for habitat migration and the preservation and establishment of HVCH

Objective 3.1 | Pursue long-term protection of focal areas

The sea level rise analysis discussed in Section 3 delineates areas where marsh migration and wetland development were likely based on topographic conditions. From these areas, marsh migration focal areas (discussed in Section 5) are delineated. Long-term protection of these areas will be critical to sustaining the Inland Bay's populations of marsh dependent species. Plan actions call for a targeted plan to prioritize, acquire, restore and manage key marsh migration corridors within the next 5-10 years.

Objective 3.2 | Develop management strategies for protected lands

In addition to conserving land, it is important to develop management strategies for the land to ensure the investment in these lands meets the established goals. Conserved lands in the Coastal Zone should be evaluated and managed to remove impediments to establishing a trajectory toward tidal marsh or wetland within planned timeframes. Plan actions seek to create management guidelines for protected areas and begin to establish a volunteer base for implementation within the next 6 years.

Section 5 contains the focal areas for conservation maps for each of the 8 Inland Bays subwatersheds, showing where these actionable objectives may be implemented. The focal area maps show the most vulnerable areas to habitat loss and fragmentation and their connection to the overall green infrastructure network. An overall focal areas map is shown here (Figure 1.0).

For upland and nontidal habitats, conservation priority focused on large existing forested tracts, forested wetlands, existing protected lands, and the corridors that connect other habitat patches to those areas. For tidal marsh, beach, and dune habitats, conservation priority focused on the protection of large marsh migration zones. Overall, the recommended focal areas connect with one another to form a gradient from the bays to upland forests, and it will be essential in the coming years to preserve this network in the context of a changing landscape.

OVERALL FOCAL AREAS MAP

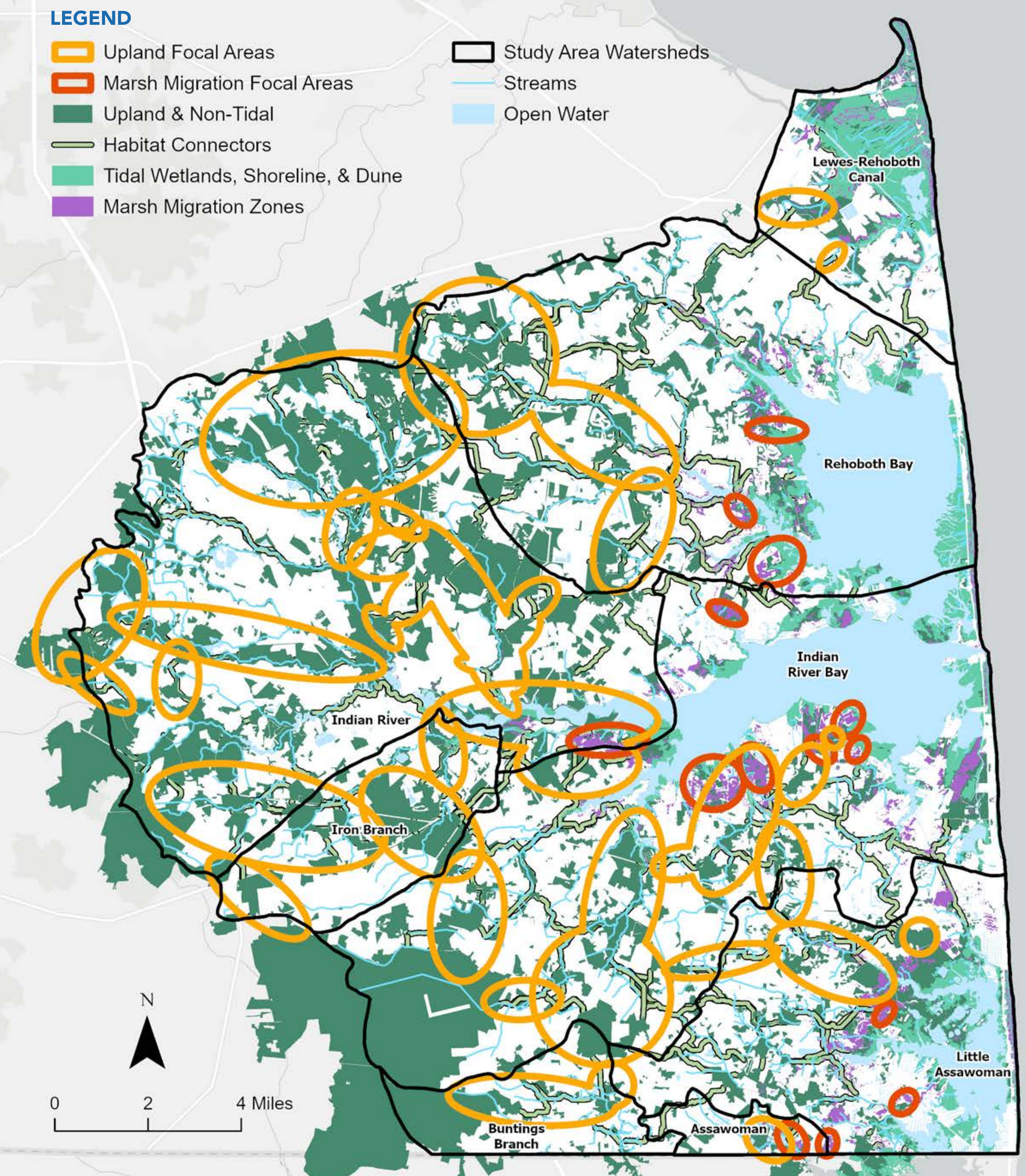


Figure 1.0 Overall focal areas map

SECTION 1
INTRODUCTION

Photo Credit: Driscoll Drones

LAND ACKNOWLEDGEMENT

The Inland Bays watershed is the traditional land of the Nanticoke and Assateague Tribes. We acknowledge these Indigenous peoples as the original stewards of the watershed and affirm their history and traditions, honor their experiences, and recognize their continued relationship with the land and water.

We also acknowledge the history of settler colonialism in the region, and its harm to the Nanticoke, the Assateague, and other communities. We strive to address that history through our present and future actions, including fostering meaningful relationships with tribal partners to protect and restore the Inland Bays and their watershed for both people and wildlife.

Nanticoke means "people of the tidewaters", and the Nanticoke Indian Tribe are continued caretakers of their homelands. The Nanticoke are proud of their ancestors, culture, and their tribal community today. We express our appreciation for the earth and the waters that we inhabit, and the Indigenous peoples who have cared for them throughout the generations.

This land acknowledgment was developed in collaboration with Bonnie Hall active member and representative for the Nanticoke Indian Tribe.

Photo Credit: Driscoll Drones

ECOLOGICAL CONTEXT

Anyone who explores the Delaware Inland Bays' shallow waters can sense the natural rhythms of the landscape and ecology – they are uniquely linked, maintaining a dynamic equilibrium. It's more than the gentle lapping of waves on the shore or the ebb and flow of tide across a marsh. It's the fish runs, the osprey returning, the horseshoe crabs and diamondback terrapins scrambling ashore, the shorebirds arriving, and the waterfowl staging all in predictable rhythms synchronized to the availability of food and habitat. The unique ecologies of the Inland Bays reflect their landscape position and the physical processes that shaped them. Together they create a thriving ecosystem that protects our coastlines, sustains our fisheries, and drives our economy.

The Delaware Inland Bays are three shallow interconnected coastal lagoons in Sussex County, Delaware. Combined, the Indian River, Rehoboth, and Little Assawoman Bays cover 32 square miles, and their watershed spreads inland over 292 square miles (Figure 1.1). A narrow strip of sand buffers the bays from the pounding waves and longshore currents of the Atlantic Ocean, creating a valuable open water refuge. This area, and the neighboring Delaware Bay, are important sources of nutrition and rest for migratory birds along the Atlantic flyway. Saltwater flows through the Indian River Inlet, stirring the sandy bottom and diffusing through the bays into the eight major tidal tributaries, where it mixes with freshwater shed from the upland. This mixing of saltwater and freshwater establishes the salinity gradient that drives the unique ecology in the estuary. From the shallow expanses of the Rehoboth and Indian River Bays to the salt marshes and tidal flats, into the rivers, creeks and wetlands, the variation of aquatic habitats is an inextricable part of the landscape and culture of this area.

The habitats of the Inland Bays are stratified by elevation, water salinity, and energy gradients. The bays' calm open waters provide nursery habitat for fish and other aquatic species. As shifting sands in the estuary deposit, intertidal flats emerge from the open water. These intertidal flats are rich with life and provide important forage for fish and shore birds. At the margins of the estuary, sandy beaches and salt marshes rise above mean low water providing habitat that is critical to the life cycles of many of the iconic Inland Bays species. These marshes give way to the uplands where maritime forests are well adapted to wind and salt and provide important shelter and nesting opportunities.

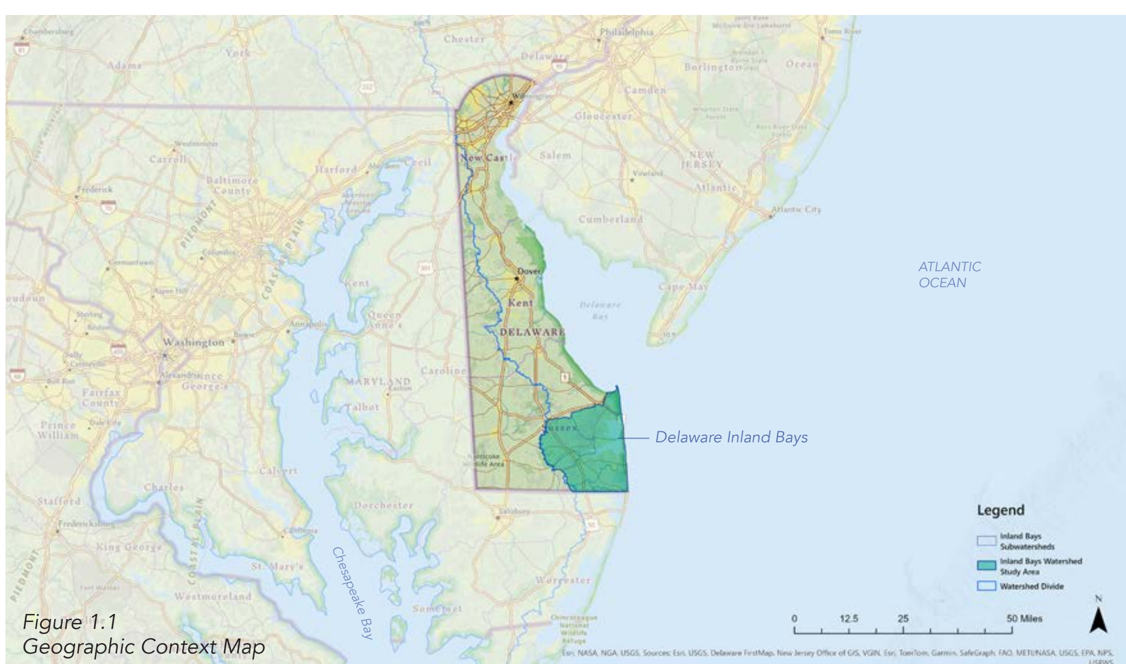


Figure 1.1
Geographic Context Map


Common Loon (*Gavia Immer*). Photo credit: Caitlin Chaney

Moving inland, forest, meadow, and palustrine wetlands dominate in tandem with agriculture and developed land.

Though fragments of these interconnected and diverse ecological communities still exist, they have been and continue to be deeply affected by development, human population growth, water pollution, rising sea levels and invasive species. Years of accumulated nutrient pollution and habitat loss have led to the degradation of the Bays' once plentiful clear waters, and there has been a corresponding decline in aquatic life. Poor water quality has had a cascading effect throughout the ecosystems of the Inland Bays, and the stressors on this landscape continue in feedback loops. The timing, volume, and quality of runoff from the watershed impacts water quality, shifts the salinity gradient, and creates other cascading effects within the estuary that influence the species composition and further habitat degradation. Additionally, climactic variables threaten the region's ecological balance. The increased frequency and intensity of storms threaten the recovery regime of these ecosystems, leading to habitat degradation. Rising seas will result in the eventual transition of maritime forest to saltmarsh, saltmarsh to intertidal flat, and intertidal flat to open water; where human land uses conflict with the inevitable natural shifting of habitats, they will be lost.

Responding to these threats, the Inland Bays Habitat Management Plan aims to conserve and restore a healthy and diverse mosaic of habitat types to protect the biodiversity of the Inland Bays in the context of a changing environment. This plan, in Section 5, identifies focal areas for conservation for each of the Inland Bays' subwatersheds: Assawoman, Buntings Branch, Indian River, Indian River Bay, Iron Branch, Lewes-Rehoboth Canal, Little Assawoman, and Rehoboth Bay. This provides the basis for prioritizing specific patch level strategies for habitat conservation, restoration, and management. These focal areas were identified via a spatial analysis of the Inland Bays current habitat network, its land use and land cover patterns, and potential risk of landuse conversion or habitat loss due to climactic variables on this landscape. This document creates an informed picture of the habitat network of the Inland Bays watershed, so this critical network can be effectively conserved, restored, and managed, not only for the benefit of its diverse flora and fauna, but also for the human communities that depend on and cherish it.

CULTURAL CONTEXT & LANDSCAPE CHANGE IN SUSSEX COUNTY

Archaeological findings demonstrate the presence of human communities in the Inland Bays area between 10,000 and 14,000 years ago. Several Native nations in the greater region of what we today call the Delmarva Peninsula thrived prior to European contact and colonization in the early 1600's. The Inland Bays watershed in particular is the traditional land of the Nanticoke and Assateague Tribes. Native communities practiced complex techniques of ecosystem management that enhanced the natural abundance and productivity of the Inland Bays watershed. For example, they used controlled fire to create woodland openings and encourage the growth of certain nut and fruit-producing trees and shrubs, to feed both themselves and the animals they hunted. The Native peoples of the area traditionally migrated between spring and summer farming and fishing sites closer to the shores and winter hunting grounds farther inland. The Nanticoke were proficient in farming, hunting, gathering, and fishing throughout the diverse forests, fields, wetlands, bays, and waterways of the Inland Bays watershed and lands beyond to the west and south along the Nanticoke River. The Assateague were focused on similar ways of life, with territory extending south of the Inland Bays to the Chincoteague Bay watershed. Both tribes traded goods and developed relations with other tribes in the region. Their deep knowledge of the landscape, along with the natural diversity and abundance of the land and waters, supported their communities along the Bays, tributaries, and beyond.

In 1608, while exploring the Chesapeake Bay and its tributaries, Captain John Smith encountered the Kuskarawaoks, later known as the Nanticoke. This interaction west of the Inland Bays watershed documents the first contact between the Nanticoke and European colonists. Later in 1631, the Dutch established a colony in present-day Lewes. Dutch, British, and Swedish colonists increasingly arrived in the Delmarva region during this period. This marked destructive changes for Native communities and began a period of dramatic modification of Inland Bays ecosystems. Native populations in the Inland Bays area declined rapidly due to European disease, conflicts with colonists, and forced displacement. In 1711, the English colony of Maryland created a 1,000-acre Askekesky reservation for remnant groups of Nanticoke and Assateague people near present-day Millsboro. These people were known to the colonists at the time as the "Indian River Indians." Over the next thirty years their activities and rights were progressively limited, including access to hunting and fishing. The last land from the reservation was sold to surrounding colonial settlers in 1743. The Nanticoke remaining in the Inland Bays area adapted to change, supported others in their community, and became the ancestors of the Nanticoke tribal members living in Sussex County today.

As the colonial era progressed, vast landscape changes accompanied the proliferation of agriculture and industry in the Inland Bays region. Subsistence and production farms bloomed across the landscape; the 1700s and 1800s saw steady immigration from Western Europe, and forcibly from Africa. As populations grew, more forests were cleared for agriculture, firewood, and construction. The 1829 completion of the Chesapeake and Delaware Canal and the construction of railroads boosted the establishment of large cash crop plantations, which were in many cases driven by the labor of enslaved people. Agricultural industries such as peaches, livestock, poultry, and dairy products proliferated, and some of these products remain important segments of Delaware's agricultural industry. The abundance of American holly (*Ilex opaca*) in Sussex County forests allowed the county to become a central producer of holly wreaths. In the 1900s, broiler chicken production, canning, and nylon manufacturing furthered the economic growth of Sussex County, with Seaford becoming the Nylon Capital of the World in 1939. Throughout this time, population growth was steady, reaching 235,000 in 2020.

Today, Sussex County is a thriving and diverse place. It is Delaware's largest county, spanning 938 square miles. Coastal Sussex County is home to numerous seaside amenities, small towns, parks, and industries; tourism is strong in this part of the state. Western Sussex County remains the backbone of Delaware's agricultural industry, with more acres of arable land under cultivation than anywhere else in the state. This habitat plan aims to facilitate the growth and protection of the watershed's diverse wildlife and natural resources, while allowing for its agricultural production and cultural heritage to flourish alongside.

Photo Credit: Caitlin Chaney

SECTION 2

HABITAT

Red-shouldered hawk *(Buteo lineatus)*

Photo Credit: Caitlin Chaney

Section 2 outlines important concepts used throughout the analysis, describes the types of wildlife habitat present in the project area, and summarizes the stressors and threats faced by these ecological communities. A glossary of key terms used in this plan is included in Section 6.

IMPORTANT DEFINITIONS & CONCEPTS

Habitat management requires the understanding that ecosystems are not closed systems, and that flows of energy, materials, people, and matter are constantly being exchanged on the landscape between areas of differing land cover and land use. It is also important to understand how natural systems are currently and have historically been functionally interconnected with one another, how human development has impacted those connections, and what conditions are needed to restore and nourish those connections.

A **habitat** is the area where a living organism makes its home and accesses the resources necessary for it to live and reproduce. All living species have habitat requirements, which can be defined in terms of food, water, cover, and space. For animals, for example, suitable habitat means that sources of nutritious food and clean water are available year-round, that access to shelter or the materials required to build shelter are available. Some animals require minimal sound and light disturbance levels in order to successfully reproduce. For plants, adequate soil conditions, sunlight, moisture, and pollinators must be available for growth and reproduction. The four habitat requirements named above define **habitat value**; the greater the amount and variety of each of these resources, the more valuable the habitat is for a wider range of species.

Generally, the larger the area of contiguous habitat, the more species that habitat can support. This principle is known as the **species-area relationship**, and it is known to hold true across geographic boundaries, regardless of the specific needs of individual species. Establishing habitat areas that are as large as possible is therefore a core aim in ensuring that a landscape meets the needs of the broadest possible range of species. However, habitat management in an urban context faces numerous constraints on the contiguousness of habitat areas. It therefore requires a more nuanced understanding of the life cycle requirements of the species in those communities.

Photo Credit: Caitlin Chaney

Different species have different habitat requirements, both in terms of the forage resources found in the landscape and the spatial extent of a potential habitat. Some species, termed **specialists**, require very specific conditions to carry out their life cycle; they tend to be less commonly found than **generalists**, who can thrive in a broader range of habitat conditions. Both generalist and specialist species establish a **home range,** which is the habitat area needed to sustain an individual. Looking at home ranges, animals can be binned into mobility guilds based on how much space they need and how easily they can traverse the landscape. **Low-mobility species** like a salamander require smaller areas of contiguous habitat but will not readily migrate over longer distances to other habitat areas, while **high-mobility species,** like a fox, have larger contiguous habitat requirements but can tolerate larger gaps between habitat patches. Effective management and establishment of native plant and animal communities, therefore, requires thoughtful interventions on multiple scales, and a framework that accounts for the spatial dynamics between habitat areas and other landscape uses.

This plan uses a landscape analysis approach that is based on the concept of **green infrastructure** and uses a **landscape ecology** framework to understand spatial patterns. Green infrastructure refers to a wide variety of both natural and constructed landscape elements, including but not limited to forests, wetlands, waterways, meadows, vegetated bioswales, gardens, and green roofs. These features provide multiple benefits, including wildlife habitat, nature-based recreational opportunities, water filtration, reduced stormwater runoff, and mitigation of urban heat island effects. As a landscape scale plan, this plan focuses on larger tracts of naturally occurring green infrastructure; however, smaller natural and constructed landscape elements enhance the broader habitat **mosaic** and provide many smaller-scale benefits, especially in more intensely developed or developing areas.

Across a given geographic extent, the totality of these green infrastructure features forms a **green infrastructure network.** It is well established in academic research that when the parts of a green infrastructure network are more interconnected with one another by natural features, ecosystem function improves drastically throughout the network. It is important, therefore, to understand the spatial patterns that both inhibit and facilitate this **landscape connectivity** (Figure 2.1).

Landscape ecology is an academic discipline which analyzes ecological patterns at a landscape scale. Through this lens, landscapes are conceptualized as mosaics of constituent elements, and characterizing those elements helps us understand the relationships between them. Studying these relationships can reveal what is necessary to strengthen the habitat value of the green infrastructure network, create large and interconnected habitat networks, and support robust populations of as many species as possible.

In the context of this analysis, the two most important concepts to draw from landscape ecology are that of **patches** and **corridors**. A patch is an area where the type of land cover is relatively homogeneous over a contiguous area at a given scale, and a corridor is a linear feature which differs from the land on either side of it and connects patches together. "Patch" and "corridor" are general terms that do not necessarily describe natural features, but in the context of green infrastructure planning, they are used to refer to contiguous areas of habitat and the natural linear features that connect them.

Creating robust green infrastructure networks involves protecting, buffering, or restoring habitat patches and corridors. In the context of this plan, **cores** are an important type of patch which consist

Figure 2.1 Habitat connectivity. Credit: Biohabitats

of large, contiguous areas of habitat. They serve a particularly valuable role in the overall network because again, larger patches can support larger populations of resident species, and generally support a more diverse range of species. Animals use corridors to move between core habitats within the network; this connectivity increases the overall resilience of animal populations by giving them access to multiple habitat areas. Corridors also provide connections between smaller habitat patches and can help connect those patches to larger cores.

The establishment and protection of core habitats in a network is especially important because those areas are constantly threatened by **habitat fragmentation** (Figure 2.2). This is one of the most important landscape-level patterns that contributes to habitat degradation in a network over time.

Each time an area of wildlife habitat is divided or cleared for development, the area of edge habitat is increased, and the area of interior habitat is decreased (Figure 2.2). Smaller patches have a larger **edge-to-interior ratio** than larger patches. Given that the probability that a species population will persist in an area increases with the size of the area and its connectivity to other large habitat patches, habitat fragmentation inevitably leads to habitat loss and population decline over time, especially for interior forest species.

In this analysis, **interior forest cores** were defined as contiguous areas of forest or palustrine wetland with a contiguous area greater than or equal to 100 acres, that are at least 300ft (100m) from a forest edge. These areas are mapped in Figure 2.6.

The Vegetated Habitat Patches Map (Figure 2.3) shows the distribution of vegetated habitat patches across the Bay's watershed, which will become the building blocks for a greater green infrastructure network. The vegetated patches shown here encompass both interior and edge habitat and are categorized by overall acreage.

In Section 3.1, the connectivity among these vegetated habitat patches is explored to delineate the greater green infrastructure network and identify focal areas for conservation and restoration.

Figure 2.2 Development leads to habitat fragmentation. Credit: Biohabitats

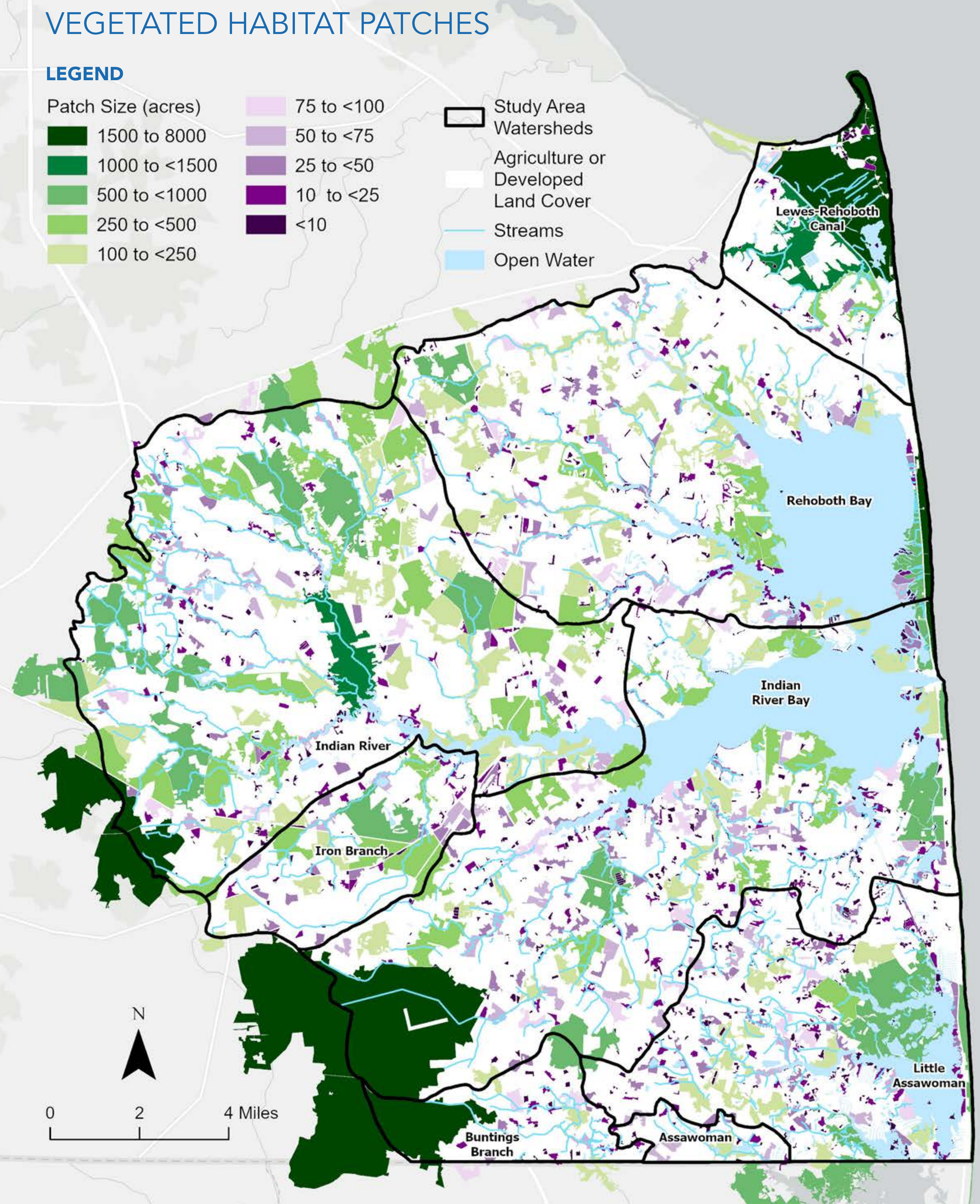


Figure 2.3 Vegetated habitat patches map

SPATIAL FRAMEWORK

As an initial exercise in visualizing the existing areas of human activity and wildlife habitat in the Inland Bays watershed, the study area was broadly spatially delineated using publicly available spatial data. **The General Land Covers map (Figure 2.4) shows the watershed divided into the categories of Vegetated Habitat, Agriculture, Developed, and Open Water.** These categories are further defined to show protected habitat areas, areas where agricultural land preservation stipulations exist, and areas that are at risk of being developed and therefore at risk of losing existing habitat.

The areas defined as "Vegetated Habitat" and "Open Water" on this map were the starting point for a more detailed spatial delineation of habitat types. This spatial framework provides a baseline from which to understand the interface of habitat, agriculture, and developed areas in the Inland Bays, to identify broad spatial patterns, and as a starting point to visualize where habitat conservation, restoration, and enhancement may be needed.

HABITAT CATEGORIES

Given that the types of habitat and associated ecological communities of the Inland Bays vary greatly across a small geographic extent, this analysis divides the watershed into three broad habitat types based on their elevation and relationship to the tides. These types were termed (1) **Upland and Nontidal**, (2) **Tidal Marsh, Beach and Dune**, and (3) **Tidal Rivers and Bays** (Figure 2.5). Within each of these categories, habitat subtypes were delineated based on available vegetation community mapping. A summary of data sources and analysis methods are presented in Appendix 1 and 2, respectively.

Upland and nontidal habitats included all types of forest, palustrine wetlands, early successional forest, scrubland, and nontidal streams, rivers, and ponds (Figures 2.6-2.7). These are the farthest habitats from the bays themselves and occupy the most land area of any of the habitat categories. Tidal marsh, beach and dune habitats are constrained to the sandy beaches, dunes, salt marshes, and intertidal areas (Figure 2.8). Despite the small geographic area they cover, these habitats support many of the most characteristic native animal species of the Inland Bays and are among the most threatened. Tidal river and bay habitats consist of all tidal open waters: the rivers flowing into the bays, and the bays themselves. All these habitats are vitally important to preserving the species diversity and habitat integrity of the Inland Bays.

While this analysis was not focused on species-specific conservation efforts, it did include a process for incorporating species-level data into habitat categories. The Delaware Wildlife Action Plan (DWAP) provides a detailed dataset of over 600 animal species of conservation need in the Inland Bays watershed, and categorized these species into 87 ecological groups. An **ecological group** is a contingent of species which occupy a similar habitat or niche, for example, grassland birds, forest butterflies, or diadromous fish.

GENERAL LAND COVERS

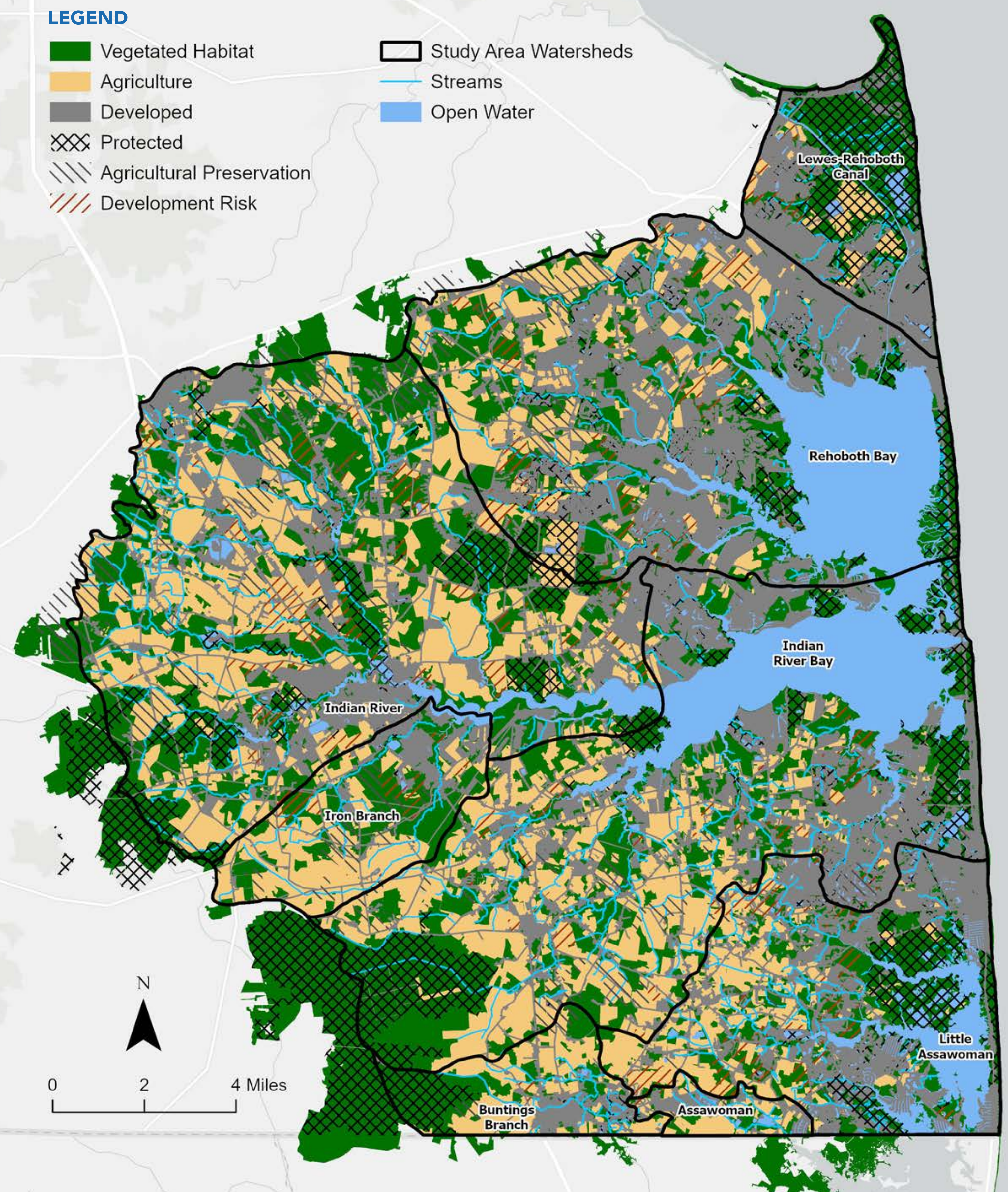


Figure 2.4 General land covers map

To incorporate these groups into the geographic delineation of habitat, the 87 ecological groups were crosswalked with the habitat categories and subcategories described above (Table 2.1).

Some ecological groups were found in multiple habitats, and some were only found in one or a few. For example, the ecological group "marine waterfowl" was categorized only in the tidal rivers and bays habitat, but the group "migratory/wintering raptors" contains various species that can exist in many different habitats. This sorting was important because it shed light on the number of species that could potentially be supported by each habitat subcategory. This exercise resulted in a count of species for each habitat category, based on that habitat's potential ability to support that species. An overview of the number species of greatest conservation need (SGCN) associated with the broad habitat types is provided in Table 2.1 and more detailed information on the associated ecological groups and conservation status of the associated SGCN is presented in Appendix 3.

Representative species were then chosen from each of those representative habitat categories. These species were chosen based on their conservation status as well as their cultural importance. Together, they encompass a broad sampling of the ecological spectrum of the Inland Bays diverse habitats, and considering how to support these species therefore has a wide-ranging effect on the ecosystem.

Table 2.1 SGCN and Representative Habitats

Representative Habitats	Count of Associated SGCN	Count of Specialist SGCN only Associated with Habitat
Inland Bays (Total)	608	
Upland & Nontidal	492	94
Forest	188	45
Early Successional	124	2
Palustrine Wetland	210	18
Nontidal Streams, Rivers, & Ponds	312	29
Tidal Marsh, Beach, & Dune	358	31
Marshes & Wetlands	176	8
Sandy Beaches/ Shorelines	281	23
Tidal Rivers & Bays	147	5

BROAD HABITAT TYPES

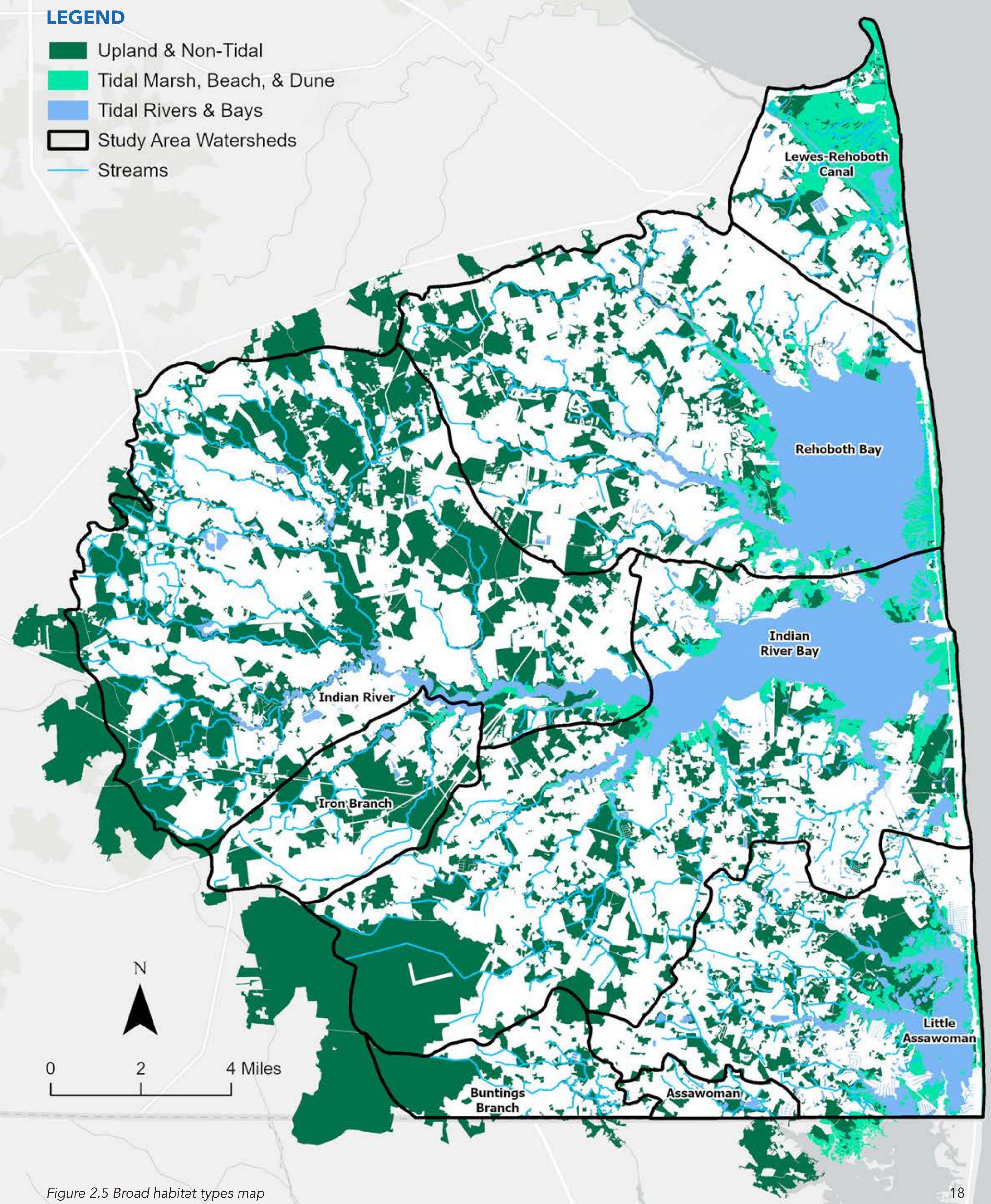


Figure 2.5 Broad habitat types map

Forest fragmentation due to new construction.
Photo Credit: Driscoll Drones

HABITAT STRESSORS AND THREATS

The Inland Bays habitats are not alone in facing a multitude of environmental and anthropogenic (human-caused) stressors and threats. In ecological terms, a **stressor** is any change in landscape condition that compromises the normal functioning or productivity of an ecosystem or species within an ecosystem. Stressors may directly influence a species' ability to survive and reproduce or make certain species more susceptible to damage from other sources. Stressors often affect ecological communities gradually, causing degradation over time; they can affect only a few species in an ecosystem or all species. Some examples of stressors include drought, invasive species, pollution, disease, and nutrient impoverishment. Once a threshold is crossed, a stressor can become a **threat**, which is a process or event that is likely to cause imminent harm or destruction to the health, functioning, or existence of an ecosystem. All the phenomena referred to here as stressors can be understood as potential threats.

Stressors affect ecosystems over varying spans of time and occur at varying scales, often taking their toll through feedback loops. This analysis focuses on analyzing and addressing ecosystem stressors that can be observed at a landscape scale and at a patch scale. Though patch-level stressors tend to be observable on smaller scales, they can also occur in a widespread pattern in multiple patches throughout the landscape, often becoming landscape-level stressors or threats. Conversely, landscape-level stressors also affect ecosystems on a patch scale. In the Inland Bays watershed, some important stressors that are observable at a landscape scale are habitat loss and fragmentation from human development, water quality degradation, and risk of landuse conversion or habitat loss due to climactic variables. Other important stressors, such as invasive species and white-tailed deer herbivory, are more observable at the patch scale.

Landuse conversion or habitat loss due to the cascading effects of **climactic variables** is an overarching threat to ecosystems worldwide, and the Inland Bays are no exception. Rising global temperatures and altered precipitation regimes are leading to the already observable patterns of sea level rise, stronger and more frequent storms, temperature extremes, and severe droughts. In the Inland Bays, sea level rise will force delicately balanced coastal habitats landward, shifting habitat gradients to higher elevations. If those migration patterns are not anticipated and accounted for in development planning, those habitats will be lost along with the species they support. A sea level rise analysis for the Inland Bays watershed delineating at risk habitats can be found in Section 3 and focal areas for habitat migration are defined in Section 5.

Habitat loss and degradation from human development is perhaps the most actionable stressor and threat to Inland Bays' ecological communities, at both patch and landscape levels. Habitat loss comes either directly because of construction and building activity, or indirectly because of habitat fragmentation. Development activities occur on a patch scale as individual properties are acquired and slated for various uses. Those activities, along with the necessary supporting infrastructure like roads and utilities, accumulate to form landscape-scale patterns of habitat fragmentation that degrade habitat quality and ultimately result in a loss of core habitat area in the green infrastructure network. Development is necessary to ensure that the growing population of the Inland Bays watershed has housing and accommodations, but the nature and pattern of development can be tailored to have a less detrimental ecological impact. Patch-level management and ecologically sound development decisions can help maintain habitat connectivity and reduce further ecological stress at a landscape scale. An analysis of Inland Bays watershed development trends and land use changes can be found in Section 3.

Many sources of **pollution** have caused water quality degradation in the Inland Bays watershed. Stormwater runoff is exacerbated when land is changed from a natural, pervious state to impervious surfaces. Pollution is also generated from the excess application of nutrients on agricultural and residential lands and wastewater treatment facilities including septic systems. Naturally vegetated areas like meadows and forests play crucial roles in filtering water, allowing it to slowly percolate and filter through soil and vegetation before reaching waterways. Wetlands, once disregarded as waste landscapes, are now recognized for their vital function in water filtration and stormwater runoff control. When these natural landscapes are cleared for development, the natural **hydrologic cycle** is disrupted; this leads to increased stormwater discharge into water bodies, increased pollutant loading from surface runoff, and increased erosion and sedimentation. Excess nutrient loads cause **eutrophication** and algal blooms, which deplete the dissolved oxygen of water and lead to fish kills and a decline in aquatic habitat quality. **Sedimentation** of streams and rivers causes excess turbidity, which many species cannot tolerate. As water quality declines, more sensitive species begin to die off, leading to a breakdown in aquatic food webs. Aquatic species are not the only ones threatened by these disruptions; all species require sources of clean water for survival, including humans. Although the management of stormwater through state regulations, local ordinances, and improvement management practices have improved in recent years, the legacy effects of past alterations to the landscape continue to be a significant landscape-scale stressor on the Inland Bays watershed today.

As part of the Clean Water Act, the state of Delaware is required to regularly monitor and assess the quality of waterways for impairments. If a body of water is found to be impaired, it is placed on the state's 303(d) list, which triggers another assessment to determine the sources of pollutants and how much these pollutants need to be reduced to achieve the applicable criteria to support the designated uses (i.e. recreation, water supply, support aquatic organisms). This results in a **Total Maximum Daily Load (TMDL)**, also known as a "pollution diet," which is the limit of the amount of pollution that can be discharged into a waterbody while still meeting water quality standards. All the Inland Bays subwatersheds have TMDLs for bacteria, nitrogen and phosphorus. Because of the Indian River Generating Station, the Indian River also has a TMDL for water temperature. Though it is possible to retrofit parts of the built environment to manage stormwater and reduce pollutant loads, the best and most cost-effective stormwater management comes from protecting existing forests and other green infrastructure areas that slow and filter stormwater through natural processes.

An **invasive species** is a species whose historical range is outside of the ecosystem in question, and whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species present yet another important stressor to ecosystems in the Inland Bays and worldwide. Populations of invasive species are often observed on a patch scale, but their effects often reverberate at much larger scales. An invasive species can be any type of organism: a plant, animal, fungus, or microbe. These species often have characteristics that give them competitive advantages over native species or for which native species have no defenses, and this allows them to take up a larger proportion of resources within an ecosystem, which stresses and sometimes eliminates the native species who also need those resources. Additionally, invasive species do not have the same evolutionary relationships with native pollinators as native plant species do. These native pollinators, many of which are species of conservation need in Delaware, often have specific foraging requirements, and if these resources are no longer present in the landscape, the pollinators cannot survive. Invasive species thus have reverberating effects through native food webs and can drastically alter ecosystem function.

When ecosystems are imbalanced, some native species can also become highly problematic. One important example in Delaware and throughout the Eastern U.S. is the white-tailed deer (*Odocoileus virginianus*). White-tailed deer are herbivorous generalists who have shown a great ability to adapt and thrive in edge habitats of fragmented landscapes such as urban and suburban environments. Though their populations were nearly exterminated in colonial times due to hunting and land clearing, they have dramatically rebounded since then and have become overpopulated. Their population growth has been greatly aided by the local elimination of their natural predators (e.g., wolves and mountain lions). Deer overpopulation is an ecological stressor because deer mainly feed on native shrubs and tree saplings, and they rub their antlers on young trees, which often causes physical damage. In a balanced ecosystem with plentiful tree regeneration, this would not be an issue, but with habitat loss, invasive species, and other stressors already inhibiting native plant regeneration, deer pressure presents another layer of stress that can throw ecosystems further out of balance. Some mechanisms, such as herbivory protection fencing and controlled deer hunting, are in place to keep the deer population in check, but the legacy effects that deer overpopulation has had on forested landscapes cannot be overstated.

Erosion and sediment runoff from new construction.
Photo credit: Driscoll Drones

HABITATS OF THE INLAND BAYS

The following sections provide an overview of the characteristics of the three habitat types that were delineated for this analysis: (1) Upland and Non-tidal, (2) Tidal Marsh, Beach, and Dune, and (3) Tidal Rivers and Bays, as well as their subtypes.

UPLAND AND NON-TIDAL HABITATS

The upland and non-tidal habitats of the Inland Bays watersheds contain its interior forests, forested wetlands, early successional and woodland edge communities, and nontidal streams, rivers, and ponds. The quality of the myriad habitats and ecosystems in the upland areas of the Inland Bays watershed is vital to the downstream areas and to the Bays themselves. The maps in this section begin to illustrate the armature of core habitats, patches, and connecting corridors in the Inland Bays green infrastructure network.

FOREST

Inland Bays forests range in species composition based on their elevation and soil conditions, and range from dense interior forests to more open forest edges. Where depressions in the landscape trap rainfall at low elevations, there are large expanses of forested palustrine wetland. Interior forest cores provide deep shade, mature trees, and the expansive acreage required by many specialist animal species. These vegetated ecosystems filter water into a network of freshwater streams, rivers, and ponds, which provide habitat for aquatic species and essential drinking water sources for animals. Freshwater sources flow down slope to eventually meet saltwater, creating the delicate salinity balance that drives the ecology of the Inland Bays.

Interior forests are home to many species of greatest conservation concern in Delaware (SGCN). For example, the endangered Delmarva Fox Squirrel (*Sciurus niger*) makes its home in mature forests adjacent to rivers and streams. Iconic bird species such as the pileated woodpecker (*Dryocopus pileatus*) inhabit large trees and dead tree trunks in interior forests. The forest canopy is occasionally punctuated by canopy gaps, which allow sun-loving species to spring from the seed bank, creating temporary refugia for seekers of pollen and nectar until the trees shade the gap again. Where forest patches are divided, forest edge habitats are created. Though it is an important conservation priority to decrease the edge-to-interior ratio of forests in the overall green infrastructure network, forest edges provide valuable ecotone habitat, particularly when they are not directly adjacent to developed areas.

Delmarva Fox Squirrel
Sciurus niger cinereus

A once endangered species endemic to the Delmarva, this large fox squirrel has recovered due to habitat conservations efforts. Delmarva fox squirrel require mature mixed hardwood forests and forage on mast from oak, maple, hickory, beech, and pine trees.

Photo credit: Adobe stock

The Upland Habitat Cores map (Figure 2.6) shows the spatial distribution of interior and wetland forest cores in the Inland Bays watershed.

Interior forest cores were defined as contiguous forested areas greater than or equal to 100 acres that are at least 300 feet (100 meters) from a forest edge. **Wetland forest cores** were defined as contiguous wetland forest mosaics greater than or equal to 100 acres, but the 300 foot (100 meter) edge consideration was not applied.

The edge definition was not as crucial for wetland forests because the proximity to the forest edge is not inherent in the definition of forested wetlands; these areas can be mosaics of open and closed canopy forest and may include patches of contiguous palustrine or tidal wetlands. Importantly, they also sometimes take the form of "fingers", extending out along landscape features, and these important habitats would not be identified in the analysis if the 100-meter edge was applied. Because of this, not all wetland forest core habitats were categorized as interior forest core habitats, though they do overlap in many instances.

The largest contiguous areas of wetland forests are in the Lewes-Rehoboth Canal (Cape Henlopen State Park), Indian River, Indian River Bay, and Buntings Branch (Great Cypress Swamp) watersheds (Figure 2.6). At the margins of the bays, large complexes of wetland forest fringing and connecting tidal wetlands form valuable habitat, but these forest cores are vulnerable to sea level rise and saltwater intrusion.

Smaller wetland forest core areas are scattered throughout the subwatersheds. The largest interior forest core areas are concentrated in the Indian River Bay and Buntings Branch watersheds, and much of that overlaps with the wetland forest core areas. Smaller interior forest core areas are also scattered throughout, but most of these smaller patches exist in the Indian River watershed. Some portions of these core habitat areas already have land protection, but some are threatened by development pressure. This spatial delineation served as a basis for the analysis of priority areas that would strengthen habitat connectivity throughout the Inland Bays watershed.

UPLAND HABITAT CORES

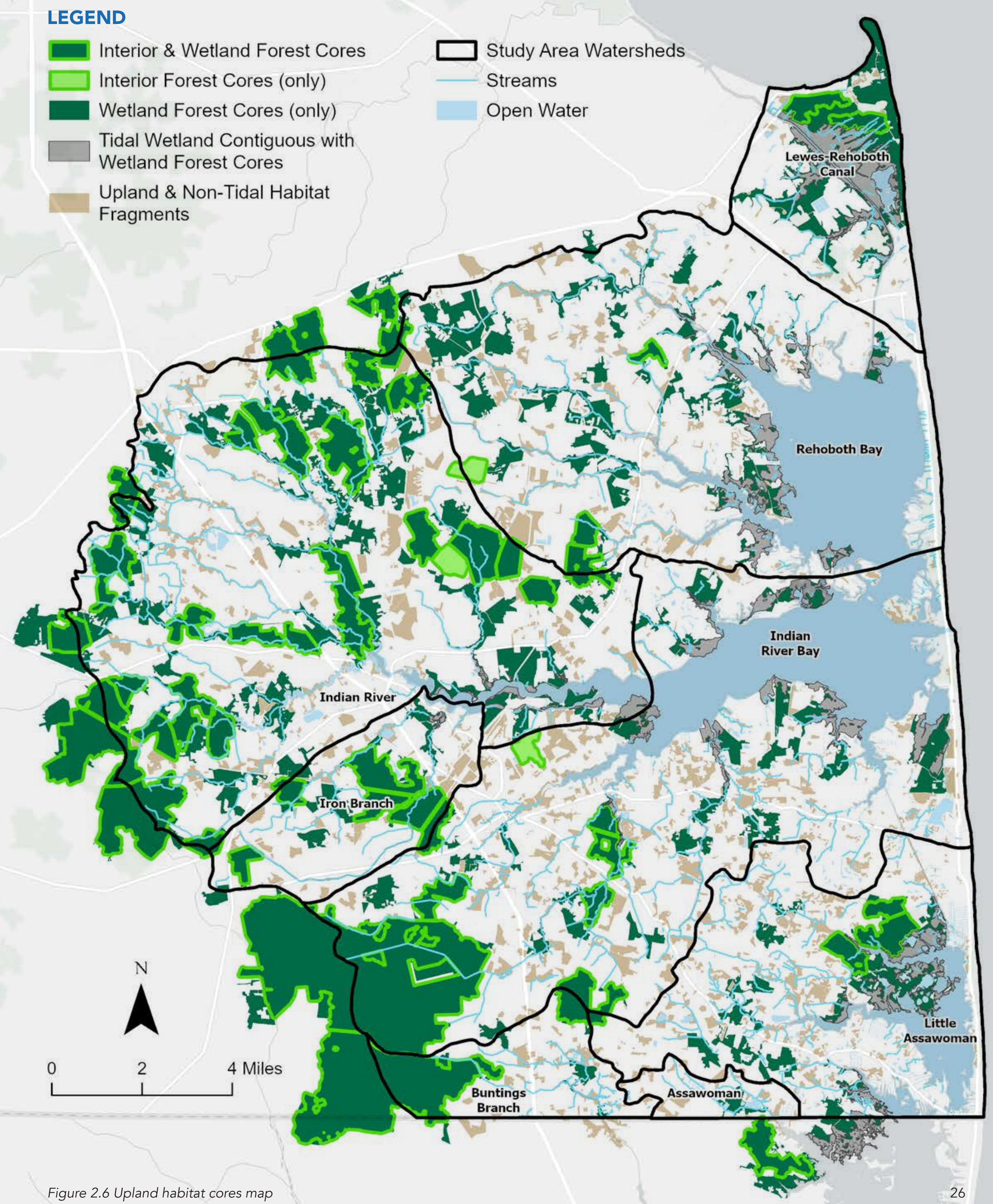


Figure 2.6 Upland habitat cores map

EARLY SUCCESSIONAL HABITATS

In most upland areas of the Inland Bays watershed, non-forested areas left undisturbed for long enough will likely become forests over time. The process of ecological community compositional change over time, which eventually results in a mature ecosystem, is known as **ecological succession**. Natural disturbances such as trees falling, strong storms, floods, and rarely, fires, disrupt successional trajectories and maintain a mosaic of habitats that are in various stages of succession. These natural disturbance regimes maintain habitat diversity, which in turn maintains species diversity as different species find different niches in these variable habitats. Disturbances can become negative when they occur at scales that are too large or unnatural, hindering an ecosystem's ability to recover.

In this analysis, **early successional** habitats include grassland and meadow, early successional forests, and emergent nontidal wetlands. Grasslands and meadows are relatively uncommon ecosystems in East Coast terrestrial habitats; they have historically been and are still maintained by anthropogenic processes. Native American communities used controlled fires to create openings in the woods and to encourage the regeneration of certain types of trees; today, meadows and grasslands are created for agricultural purposes, with some grasslands being maintained for animal grazing and some being left fallow to begin the process of ecological succession. Depending on how long those fields are left undisturbed, they then begin to grow woody vegetation and become early successional habitats. These habitats are especially valuable when they are adjacent to mature forest patches; with those areas as seed sources, early successional forests become mature forests over time.

Meadow plant species such as milkweed *(Asclepias spp.)* support migrating monarch butterflies (shown below) and a wide variety of pollinators. Early successional forests and shrublands are home to bird species such as the American woodcock (*Scolopax minor*) and bobwhite quail (*Colinus virginianus*); many predator bird species hunt in these more open areas where prey is easier to see. Early successional forests, pastures, and meadows in the Inland Bays watershed are distributed in smaller patches throughout the watershed (Figure 2.7). More than other types of habitats, they are in a constant state of change, as the management regime of these habitats depends on land use.

Monarch Butterfly
Danaus plexippus

Due to the loss of early successional habitats, this migratory butterfly is on the cusp. In the Inland Bays, monarchs need patches of milkweed to lay thier eggs and host their caterpillars. When the butterflies emerge ample sources of late season nectar are needed to fuel their migration south each fall.

Photo credit: CIB

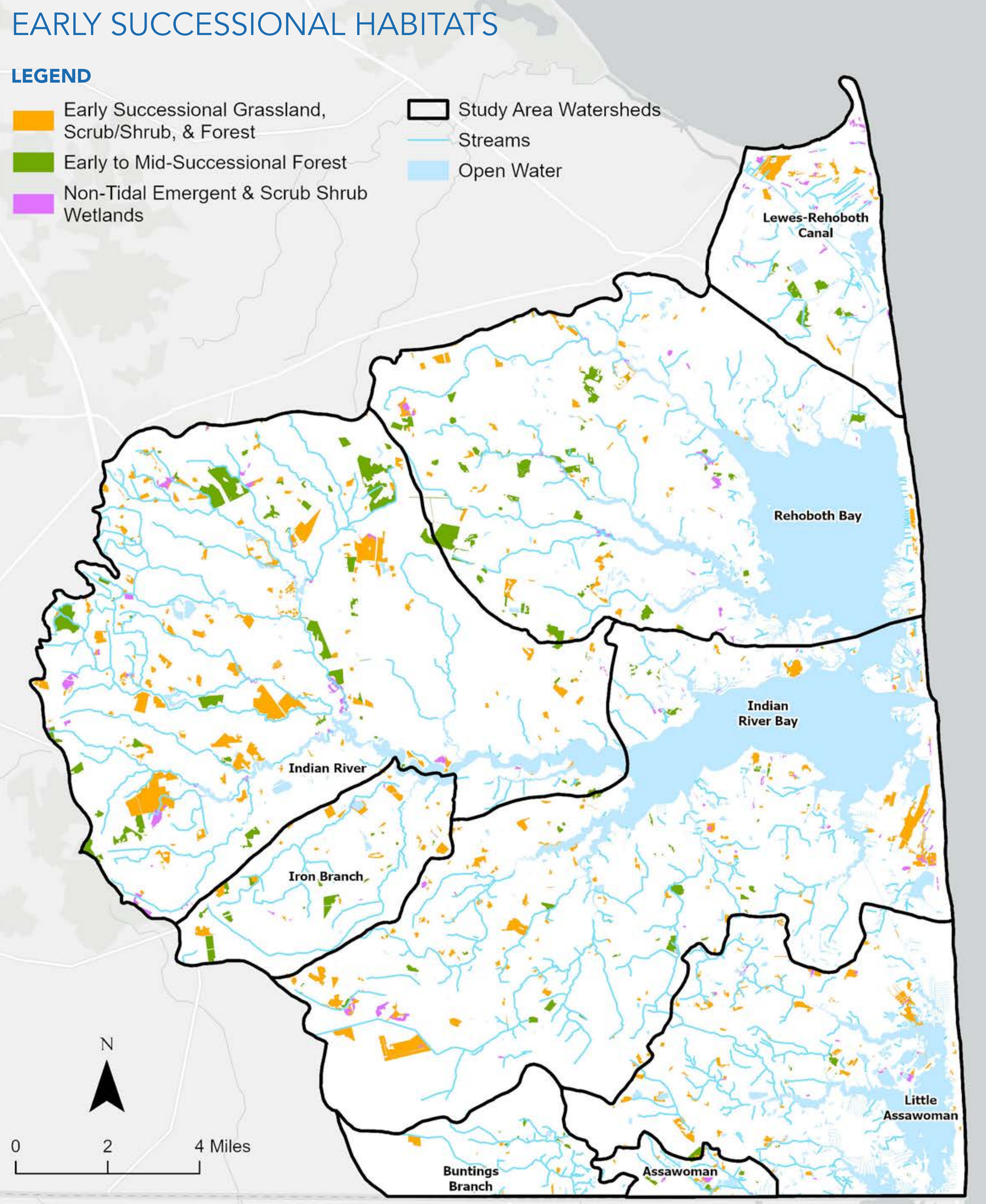


Figure 2.7 Early successional habitats map

STREAMS, RIVERS, & PONDS

Within the watershed's upland habitats lies a network of freshwater streams, rivers, tax ditches, and ponds that flow and percolate through the landscape and feed the estuaries of the Inland Bays (Figure 2.8). Fed by precipitation and groundwater, this dynamic and intricate network of freshwater also sustains forest animals, aquatic species, plant communities, and people. They serve as conduits for nutrient transport, sediment flow, and biotic connectivity.

Streams can be found throughout the Inland Bays watershed, from residential backyards to deep within forested ecosystems. The small headwaters streams of the upland edges of the watershed come together downstream in larger waterways like the Indian River, which carve through the landscape and flow out into the bays. Where the rivers become tidal, their mixing with ocean water creates the vital balance of salinity which nourishes tidal ecosystems. Freshwater marshes and ephemeral ponds in the floodplain act as natural water filters and runoff control, and their slow-moving waters provide habitat for specialized aquatic species.

There is also a vast network of **tax ditches** throughout the Inland Bays watershed, particularly in the Little Assawoman Bay and Indian River Bay watersheds. Tax ditches, though intended to manage water flow in agricultural landscapes, become important emergent wetland habitats when water gathers within them. Though a potentially important habitat, tax ditches are considered a governmental subdivision of the State and are managed by tax ditch organizations. These organizations, which are made up of all landowners of a particular watershed or subwatershed, are responsible for maintaining the tax ditch. Each tax ditch has a right-of-way (ROW) on either one or both sides of the ditch to allow for access for maintenance, including mowing, removal of beaver dams or other debris, and removal of sediment. Because of this, some of the potential restoration opportunities are limited.

Collectively, the streams, including tax and drainage ditches, rivers, and ponds, form a network of interconnected water resources and a complex mosaic of vital freshwater habitats ranging from slow to fast moving, shallow to deep, ephemeral to perennial. This network also provides a vital linkage between the uplands and the bays. This linkage is both a basis for habitat connectivity and a conduit for pollutants making the health of the streams, rivers, and ponds an important indicator for the health of the watershed and the bays.

Eastern Tiger Salamander
Ambystoma tigrinum

Tiger salamanders are large mole salamanders that spend their lives in burrows under the moist forest floor and emerge each spring to travel to their natal vernal pools to breed. Salamanders, like many amphibians, have strong homing instincts and low motility, so entire subpopulations may be isolated to a few hundred acres of forest surrounding a single breeding pool. Consequently, they are highly susceptible to habitat loss or fragmentation. A lack of strong state and federal protections for these unique and valuable wetlands and their buffers places these salamanders and many other species at risk.

Photo credit: Josh More/Flickr CC

STREAMS, RIVERS, & PONDS

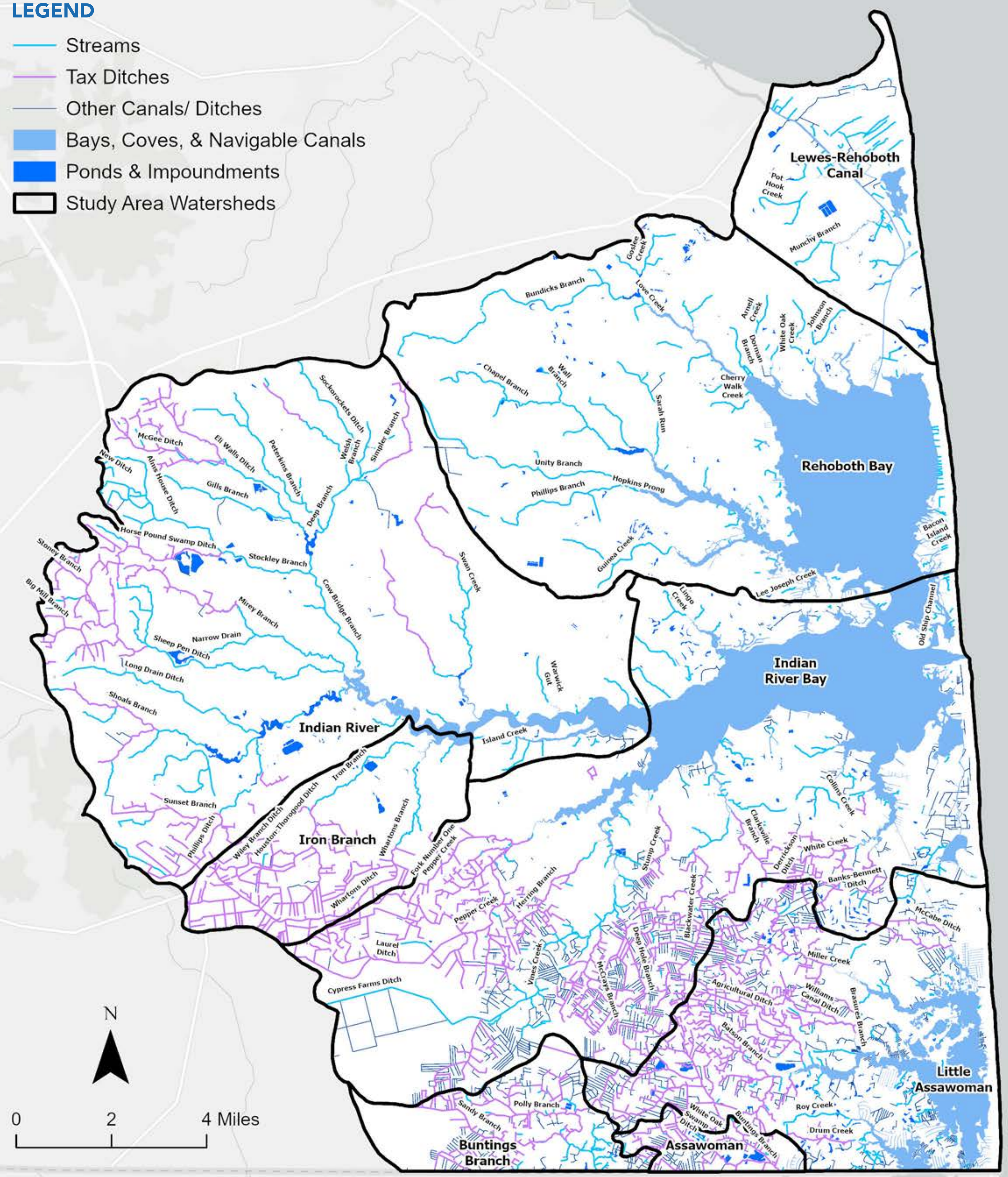


Figure 2.8 Streams, rivers, and ponds map

HIGH CONSERVATION VALUE HABITATS – UPLAND AND NONTIDAL

High conservation value habitats (HCVH) are habitats which, based on the parameters of this analysis, were considered to be both high in ecological quality and importance to the overall green infrastructure network.

High conservation value habitats within upland and nontidal habitats include:

- Forest cores
- Wetland cores
- Fringing forest adjacent to tidal wetlands
- Patches of native grassland and meadow – any size
- Streams, rivers, and ponds and their natural buffers

Priority should be given to contiguous and connected patches.

STRESSORS & THREATS TO UPLAND AND NON-TIDAL HABITATS

Stressors and threats to forest habitats are numerous in the Inland Bays watershed, and when one takes a toll the effects of others are compounded. Though invasive species, climactic variables, and water quality degradation are all important stressors, at the scale of this plan, habitat loss and fragmentation emerge as the largest looming stressors to Inland Bays forests. These stressors quickly evolve into threats when habitat loss occurs because of development activity, and this loss often catalyzes secondary ecosystem degradation in remaining habitats. The deleterious effects of habitat loss and degradation, however, are within our control; they can be ameliorated by conscious modification of development trends, land conservation, and strengthening of habitat connectivity.

As urbanization, road construction, and home building encroaches on forested ecosystems, forested habitats are either lost or fragmented, and ecosystem function is inevitably disrupted. When a forest patch is developed, even if some fragments or mature trees are conserved, the overall functionality of the forested ecosystem is no longer present in that area. The multi-tiered vegetative structure of the forest is lost, and soils are compacted and regraded to accommodate construction. Edge habitats are opened at the expense of interior habitats, and although edge habitats can still provide refuge for some wildlife, the overall pattern of interior forest loss presents a grave threat to local biodiversity. Hydrologic dynamics are also altered irrevocably in this process; stream diversions, soil disturbance, and removal of vegetation disturb aquatic ecosystems and reduce evapotranspiration and infiltration capacity.

The loss of forested habitat triggers secondary effects on nearby ecosystems, even if those patches remain forested. Transitioning from pervious to **impervious** surfaces increases stormwater runoff into adjacent natural areas, leading to increased erosion and water quality degradation. Cutting through existing forest patches creates more forest edge habitat at the expense of interior habitats. Forest edge habitat conditions are sunnier, drier, more disturbed, and windier; many invasive species in the Mid-Atlantic region thrive in these conditions. Many edge-dwelling invasive species can change soil composition, prevent natural regeneration of native edge species, and kill trees, further reducing the area and habitat quality of forest fragments. Development activity that severs habitat corridors confines species to isolated areas, reducing genetic viability, increasing the risk of local extinction, and disadvantaging species with larger area requirements. The accumulation of constraints and stress caused by habitat loss and fragmentation renders the overall habitat network less resilient to potential future stressors, hindering long-term sustainability.

Habitat loss and fragmentation from development therefore pose a multifaceted threat to forested ecosystems in the Inland Bays and beyond, compromising ecological integrity, biodiversity, and resilience to future stressors. These threats can be ameliorated, however, by cultivating an awareness of the impacts of development patterns, safeguarding important habitat patches, and creating state and county ordinances that protect important natural resources.

RECOMMENDED ACTIONS FOR UPLAND AND NON-TIDAL HABITATS

The following actions are recommended for upland and non-tidal habitats of the bays. The applicable recommendations are synthesized in Section 4 where specific actions and timeframes are discussed.

1. Improve the health and resiliency of the High Conservation Value Habitats (HCVH) in the Inland Bays
    - Strengthen land protection policies for HCVH
    - Improve connectivity among identified HCVH
    - Implement nontidal stream and agricultural ditch buffer plantings to benefit habitat, connectivity, water quality and stream temperature (forest and non-forest, respectively)
    - Identify broad patch level management strategies for HCVH
    - Demonstrate benefits of existing incentives program for landowners/developers/agricultural producers
    - Partner with developers to integrate patch level conservation strategies into development plans and/or HOA by-laws (e.g., buffer strips, turf reduction, etc.)
2. Protect and expand the presence of non-forest and early successional habitat on the landscape (e.g., meadow and grassland)
    - Conservation and management of early successional habitat.
    - Convert non-habitat or less valuable habitat types (e.g., plantation forest).
    - Support the implementation of a native landscape/backyard habitat program.
    - Integrate pollinator-friendly practices into the existing cover crop program (provide early and late flowering species and winter forage).
    - Review existing management plans for plantation forest and game lands for consistency with plan goals and engage in efforts to integrate specific habitat objectives.

TIDAL MARSH, BEACH, & DUNE HABITATS

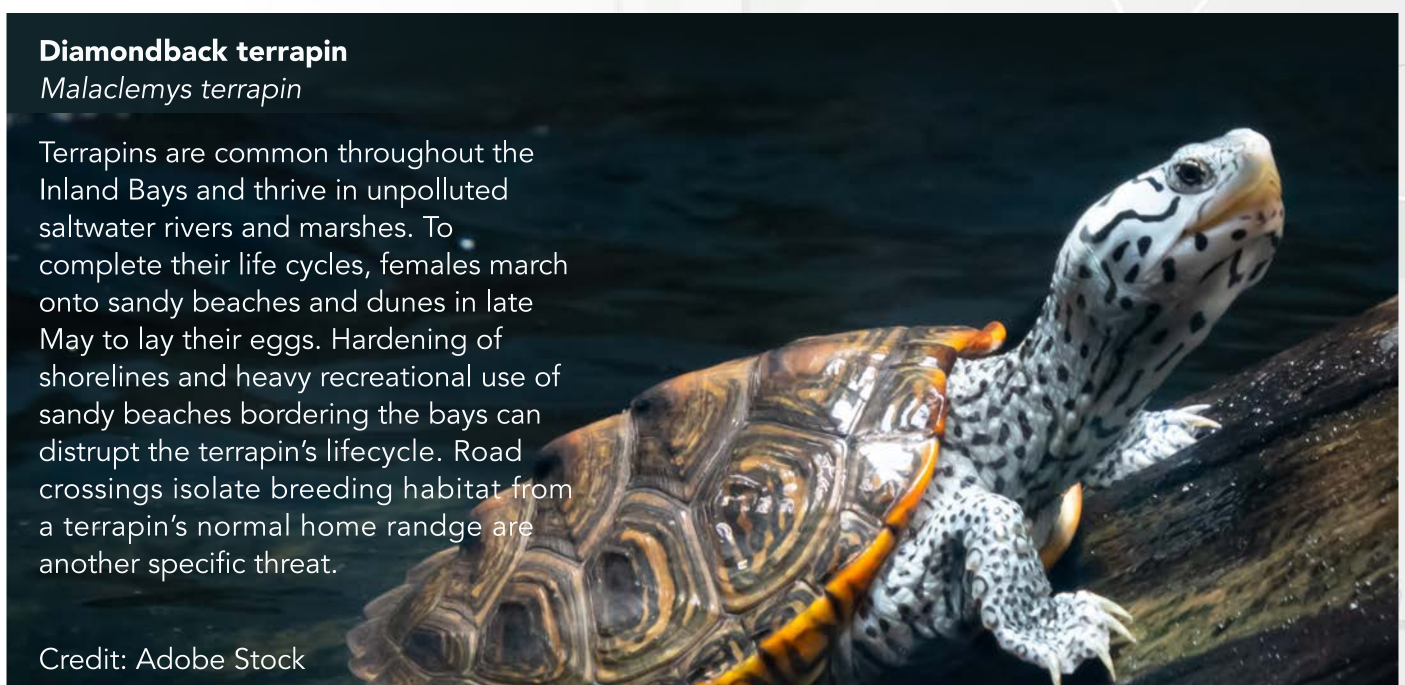
INTERCONNECTED LAND AND WATER

A network of rich habitats form as the maritime forests and coastal uplands yield to dynamic landforms sculpted by the Bay's wind and water. Inland Bays beaches have immense habitat and recreational value, attracting millions of visitors each year. Whether those visitors are humans enjoying the beach, diamondback terrapins laying eggs, or horseshoe crabs coming to shore for their annual migration, sandy beaches are an invaluable part of the habitat network of the Inland Bays.

Where wind and water batter the shores, sandy beaches feed dynamic dune complexes that rise from the shore. The frontal dunes take the brunt of wind and wave energies sheltering the back dunes, which support a more stable ecosystem. In the undulating topography of back dunes, low-lying troughs or interdunal swales can support seasonal freshwater wetlands. These wetlands are like oases that that provide unique and critical habitats for many amphibians and arthropods including the Bethany Beach firefly.

At the fringes between land and sea, salt marshes form, shaped by the constant ebb and flow of the shallow water. Salt marshes play an essential role in coastal protection, helping to buffer the mainland from coastal erosion and storm surge. They also act as natural water filters for the Inland Bays, taking up nutrients and filtering out sediments from water flowing down through the watershed. They are one of the most productive ecosystems on earth, supporting a huge below-ground root biomass that anchors the structure of the bay sediments. Distinctive plant species such as salt meadow cordgrass (*Spartina patens*) provide sheltered breeding grounds for many aquatic species, and specialized shellfish and invertebrates are adapted to the unique tidal cycles of the salt marsh.

Figure 2.9 shows the locations of tidal marsh, beach, and dune habitats in the Inland Bays watershed. It also shows surveyed bird breeding islands and salt marsh sparrow (*Ammodramus caudacutus*) habitat.



Diamondback terrapin
Malaclemys terrapin

Terrapins are common throughout the Inland Bays and thrive in unpolluted saltwater rivers and marshes. To complete their life cycles, females march onto sandy beaches and dunes in late May to lay their eggs. Hardening of shorelines and heavy recreational use of sandy beaches bordering the bays can distrupt the terrapin's lifecycle. Road crossings isolate breeding habitat from a terrapin's normal home randge are another specific threat.

Credit: Adobe Stock

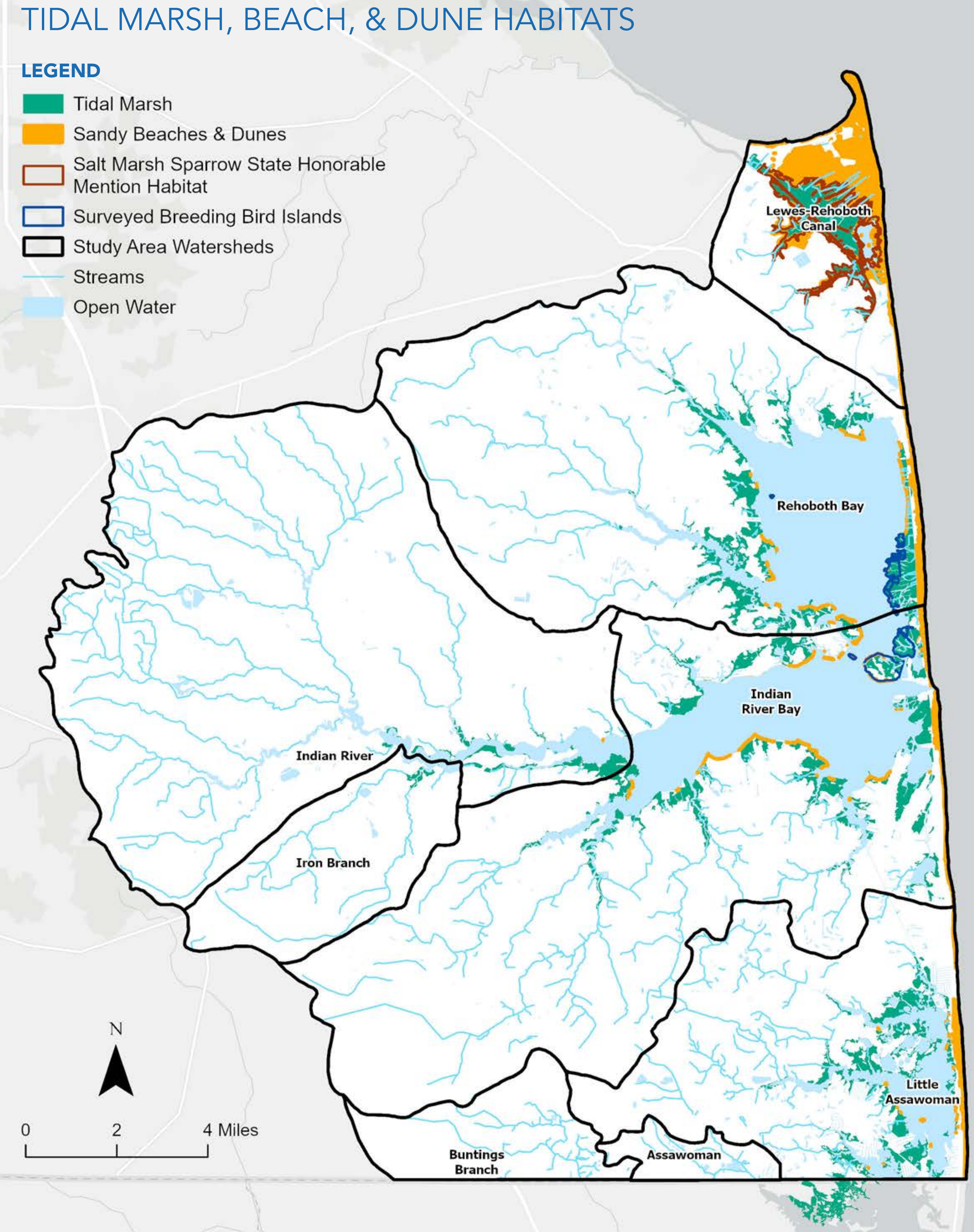


Figure 2.9 Tidal marsh, beach & dune habitats map

Bethany Beach Firefly
Photuris bethaniensis

This Inland Bays native is a habitat specialist that only lives in freshwater interdunal wetlands that occur along the Atlantic coast in Delaware and Maryland. Their narrow habitat requirements make this species extremely susceptible to sea level rise, saltwater intrusion, and habitat loss. A primary threat to this species is habitat loss and degredation due to coastal development.

Photo credit: Adobe stock

Despite the relatively small land mass they cover, beach, dune, and salt marsh habitat support many of the most characteristic animal species of the Inland Bays. In rare interdunal wetlands, which occur in the spaces between undisturbed dunes, the critically endangered Bethany Beach firefly (*Photuris bethaniensis*) makes its home. Other habitat specialists, such as shorebirds, flock to isolated sandy beaches and dunes in the spring and summer months to nest. Colonial waterbirds, such as herons, egrets, and ibis find refuge in the bays islands and in salt marshes buffering the bays, secretive species like the salt marsh sparrow nest just above the tide while many other migratory shore birds forage on the variety of seeds and aquatic life offered by the marsh. At the top of the food chain raptors such as northern harriers (*Circus hudsonius*) glide over the marsh plain in search of their quarry. The tidal marsh, beach, and dune habitats of the Inland Bays watershed embody the interconnectedness of land, water, and biodiversity along Delaware's coast.

The distribution of tidal wetlands and sandy beaches occurs only in the lowland habitats of the watersheds, where land meets water; the spatial distribution of these habitats is shown in Figure 2.9. In the Lewes-Rehoboth Canal watershed, an expansive protected tidal wetland is located within Cape Henlopen State Park. In Rehoboth and Indian River Bays, tidal marshes, beaches, and dunes habitats and salt marshes line the bay shores, both on the edges of tidal rivers and on the inside of the barrier island. Saltwater marshes continue in patches on the banks of the Indian River, extending into the Indian River and Iron Branch watersheds. In Little Assawoman, marshes line another shallow bay in Fenwick Island State Park, which receives saltwater from the Ocean City Inlet to the south. Though many of these habitats are protected as part of Delaware's state park system, some are still threatened directly by development. Moreover, the ecological function of these systems is greatly dependent on their connectivity with healthy and functional upland ecosystems; it is these connections that are most threatened.

HIGH CONSERVATION VALUE HABITATS TO TIDAL MARSH, BEACH & DUNE HABITATS

The High Conservation Value Habitats of the Tidal marsh, beach, and dune include:

- High and low salt marsh
- Breeding bird islands
- Dunes and interdunal wetlands
- Sandy shorelines and beaches
- Marsh migration zones

STRESSORS & THREATS TO TIDAL MARSH BEACH, & DUNE HABITATS

As in upland habitats, habitat loss is a primary stressor and threat facing tidal marsh, beach, and dune habitats. Development pressure in the Inland Bays coastal areas is intense and increasing. Despite sea level rise and the threat it presents to coastal communities, shoreline development and construction near waterways continues to proliferate, with subsequent impacts on water quality and habitat degradation. While many larger expanses of tidal wetland are conserved, smaller patches remain unprotected and vulnerable to development. The relatively small spatial extent of these habitats compounds the effect of habitat loss, reducing potential habitat connectivity and increasing extinction risk for resident species.

The secondary effects of habitat loss anywhere in the watershed are important to name here; even though many tidal marsh, beach, and dune habitat areas are under legal protection, the ecological stability of these habitats depends on the ecosystem function provided by adjacent and upland habitats, and their connectivity to coastal ecosystems. This is principally because upland habitats determine the volume and quality of water flowing into the bays and marshes, and the connection to sources of clean fresh water determines the water quality and salinity of the bays. Moreover, some animal species depend on the vegetative connections between upland and marsh habitats; though not all do, these connections are an important element in the overall connectivity of the landscape.

The other essential stressor and threat to these ecosystems is sea level rise. With rising seas, salt marsh habitats will inevitably be forced to migrate landward, in what is referred to as **marsh migration**. Alongside the salt marshes, other habitats along the gradient from bay to upland will begin to shift landward with sea level rise.

The development patterns surrounding existing tidal marsh, beach, and dune areas, in many cases, cut off important locations where salt marsh migration could occur. Identifying and protecting the areas most likely to experience this type of habitat migration is the only way the habitats along this gradient will be conserved.

An analysis of marsh migration in the Inland Bays as it relates to various sea level rise trajectories and recommendations for focal conservation areas, can be found in Section 3.

RECOMMENDED ACTIONS FOR TIDAL MARSH, BEACH, AND DUNE HABITATS

1. Expand existing strongholds where current patch size is sufficient to support target species, and where breeding populations of shorebirds or other SGCN are documented.
2. Increase the resiliency of existing marshes through large-scale marsh restoration. Focus on areas where marsh area loss has occurred or is likely, where dredge material reuse is feasible, and where marsh migration potential is constrained.
3. Target restoration and conservation activities in areas at risk of becoming too wet or saltwater-inundated for agriculture and/or plant survival.
4. Establish tracts of high marsh habitat for marsh nesting birds.

Saltmarsh Sparrow
Ammodramus caudacutus

These secretive year-round residents of the Inland Bays are habitat specialists that adapted a strategy of nesting in marsh grasses just above the high tide line. Since the 1990s the population has been in a sharp decline which is largely attributed to habitat loss and more frequent flooding of nests due to climactic variables. Marsh restoration and room for marsh migration are needed for the species long-term survival.

Photo credit: Adobe Stock

TIDAL RIVERS AND BAYS

The open water and tidal river habitats of the Inland Bays provide invaluable wildlife habitat and recreational and commercial value for Delaware's residents. Tidal creeks and rivers meander through salt marshes and into the bays. These slow-moving, shallow waterways provide protected breeding grounds and nurseries for juvenile fish, forage resources for osprey and wading birds, and refugia for open ocean mammals like common bottlenose dolphins (*Tursiops truncatus*). Intertidal flats, exposed at low tide, host burrowing shellfish and crab species. The bays are home to over 100 species of fish, as well as Eastern oysters *(Crassostrea virginica)* and blue crabs *(Callinectes sapidus)*, and provide critical overwintering and staging habitat for migratory waterfowl. Commercial and recreational fishing in the bays has key economic and cultural value for Delaware residents. In shallower waters, fish populations are dominated by Atlantic silverside (*Menidia menidia*), mummichog (*Fundulus heteroclitus*), striped killifish (*Fundulus majalis*), and sheepshead minnow (*Cyprinodon variegatus variegatus*). In deeper waters, species such as summer flounder (*Paralichthys dentatus*), striped bass (*Morone saxatilis*), and bluefish (*Pomatomus saltatrix*) support the fishing industry. Eastern oysters *(Crassostrea virginica)*, hard clams *(Mercenaria mercenaria)*, and Atlantic ribbed mussels *(Geukensia demissa)* provide natural water filtration and forage resources. American eels (*Anguilla rostrata*), the only freshwater eel found in North America, can be found migrating between the bay estuaries and the Atlantic Ocean.

Seagrasses (submerged aquatic vegetation or SAV) and seaweeds (marine macroalgae) are important components of the Inland Bays ecosystems, with constantly shifting distributions that serve as reliable indicators of water quality. However, grasses that were once the most abundant and ecologically valuable of the bays, such as eelgrass *(Zostera marina)*, are no longer found in the bays due to water quality degradation. Other native bay grasses remain rare but reappear in instances where water quality is improved.

For the spatial limits of the tidal river and bay habitats, refer to the open water in Figure 11. A more detailed delineation of the subaqueous habitats of the Inland Bays was constrained by fairly ubiquitous shallow depths, dynamic substrates, and lack of readily available spatial data.

Osprey
Pandion haliaetus

Osprey populations have recovered from the brink of extinction after the use of the toxic pesticide DDT was banned. Now osprey are common summer residents of the Bays where they return each year to breed. Their population status is now secure, but linked to food availability and their abundance is an indicator of the health of the bays. Declines in fish populations due to water quality, over harvesting, and other stressors are raising concerns for the future of some osprey populations in the neighboring Chesapeake Bay.

Photo credit: Caitlin Chaney

Breeding Bird Islands

Each summer the Inland Bays' small but mighty islands host colonies of herons, egrets and beach nesting birds like the American oystercatcher. These birds find relative security from predators in unique isolated mosaics of marsh, beach, and maritime forest habitats where they perform raucous courtship displays, nest, and brood their young. While these birds feel secure these islands are slowly being lost to the Bays as sea levels rise and coastal storms and boat wakes threaten to erode their shores. Preservation and restoration of vital breeding bird islands is important to maintaining vibrant populations of these colonial birds in the Bays.

Photo credit: CIB

HIGH CONSERVATION VALUE HABITATS

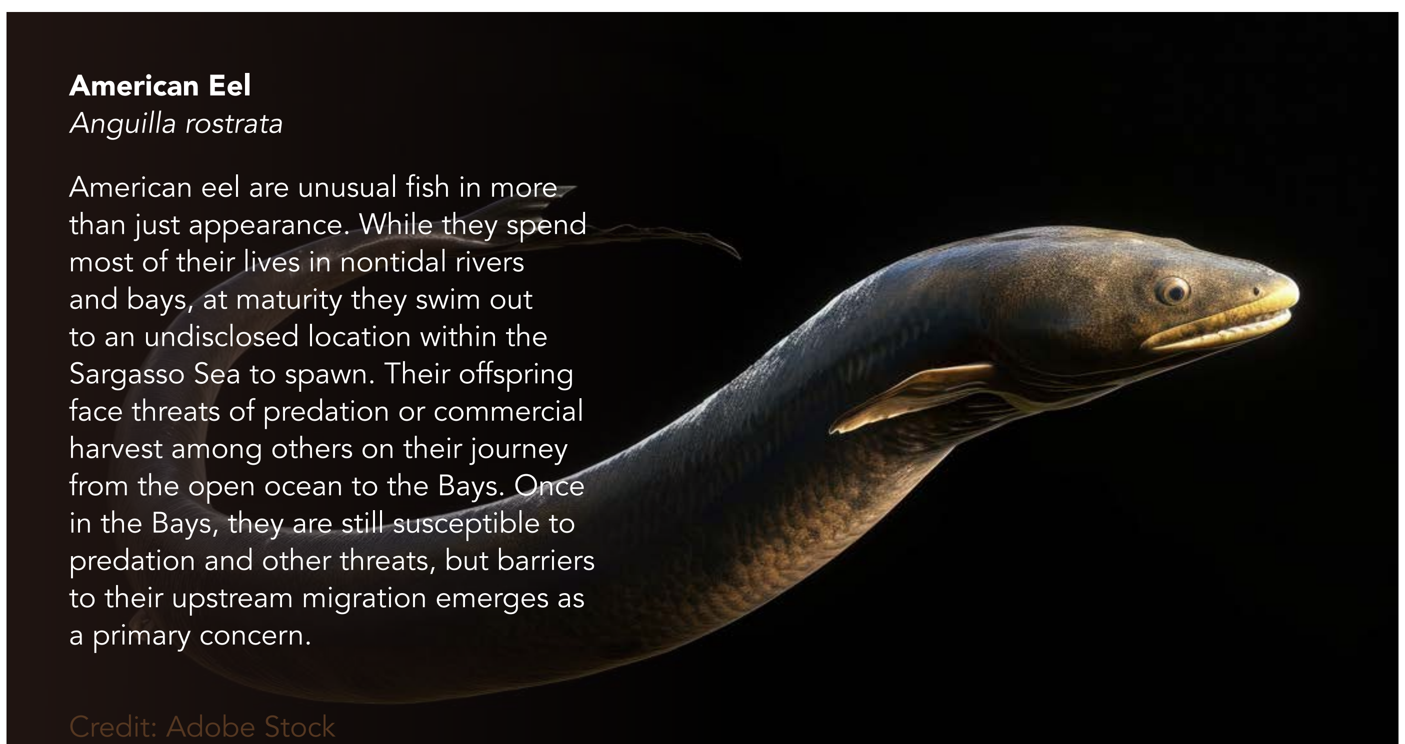
The High Conservation Value Habitats of the Tidal Rivers and Bays region include:

- Breeding bird islands
- Established and/or historic SAV and shellfish beds (oyster, mussel, clam)
- Waterfowl staging areas
- Habitats associated with enhancing water quality found within other habitat types

STRESSORS & THREATS TO TIDAL RIVER AND BAY HABITATS

The primary stressors for Inland Bays open water habitats are water quality degradation, land development, and climactic variables. The habitat value of the Inland Bays is primarily determined by water quality, which has suffered for many years due to both nonpoint and point sources of pollution flowing into the bays. Land use and development in the watershed directly affects water quality in the bays, and different land use types deliver different pollutant loads to waterways. Agricultural lands contribute the highest amount of nutrient pollution per acre, and agriculture comprises roughly 27% of land use in the watershed. More frequent and intense runoff from developed areas with inadequate stormwater management also lead to high nutrient runoff, exaggerated sedimentation, and erosion of natural waterways; land use change in the watershed continues to trend towards increased development. These trends, coupled with consistently poor water quality in the bays, highlight the importance of prioritizing conservation and restoration efforts.

In light of degrading trends in watershed condition, the Center for the Inland Bays, the Delaware Department of Natural Resources and Environmental Control (DNREC) and other partners have implemented conservation and restoration efforts in recent years, leading to some genuine changes and improvements. Over the past 30 years, nearly all the large point sources of pollution in the bays have been removed. Seaweed blooms, though they still hinder the growth of bay grasses, have stabilized and are less frequent now. Due to the stabilization of the Indian River Inlet, open water areas in the bay are regularly flushed, and that has led to improvements in water quality. Bald eagle and osprey nesting activity has rebounded, blue crab populations are stable, and many fish species have exhibited good reproductive success in recent years.



American Eel
Anguilla rostrata

American eel are unusual fish in more than just appearance. While they spend most of their lives in nontidal rivers and bays, at maturity they swim out to an undisclosed location within the Sargasso Sea to spawn. Their offspring face threats of predation or commercial harvest among others on their journey from the open ocean to the Bays. Once in the Bays, they are still susceptible to predation and other threats, but barriers to their upstream migration emerges as a primary concern.

Credit: Adobe Stock

However, pollution loads from nonpoint sources continue to exceed healthy limits, especially in bay tributaries and areas closer to shorelines. Until major changes to land use in the watershed are implemented, the water quality in the bays will likely remain degraded.

The cascading effects of climactic variables present a second overarching stressor to the Inland Bays of Delaware. Rising sea levels and intensified coastal storms will lead to saltwater intrusion, coastal erosion, increased flooding, and habitat migration as described in the previous section. Warming of the shallow estuary can alter the water chemistry, specifically dissolved oxygen levels, and may alter the composition of aquatic communities and displace some resident species with more southern species. Increased exaggeration of drought and flood cycles presents an additional stressor on estuarine ecosystems.

As habitats become inundated, migration patterns of marine and terrestrial species may shift alongside them. Moreover, the effects of ocean acidification on estuaries are complex and uncertain, highlighting the need for further research and a potential additional stressor on these habitats.

To ensure that the Inland Bays are as resilient as possible to these changes, it is instrumental to invest now in restoration and conservation strategies to improve water quality and reverse habitat degradation.

RECOMMENDED ACTIONS FOR TIDAL RIVER AND BAY HABITATS

1. Implement recommendations for Upland and Non-tidal Habitats and Tidal River and Bays Habitats to address pollution sources
2. Pursue nature-based solutions for resilience to optimize habitat potential
3. Support submerged aquatic vegetation (SAV) initiatives in other plans
4. Support non-point source reduction initiatives in the CCMP

SECTION 3

DATA ANALYSIS

Section 3 summarizes the data analyses that were undertaken to better understand the landscape scale patterns of connectivity, land use change, and sea level rise impacts across the Inland Bays and aid in the development of focal areas for implementation of plan recommendations.

Photo credit: Caitlin Chaney

LANDSCAPE CONNECTIVITY ANALYSIS

A **least cost path (LCP)** modeling approach was applied to assess areas of habitat connectivity importance between upland habitat cores. This method finds the most cost-effective path from a start point to a destination. As it goes from start to finish, the chosen path accumulates the least amount of “cost”.

Connectivity between interior forest cores and between wetland forest cores was modeled separately, and the results of both are shown combined in Figure 3.1.

Generalized species movement in response to land cover and landscape features between cores was assigned a **relative resistance value**. Conditions such as highways and dense development create greater resistance to connectivity while natural vegetation such as forests and wetlands have lower resistance. Additionally, heavily trafficked roads create noise and other deterrents to the movement of some species that extend beyond road edges. High resolution land cover data within agricultural and developed areas were incorporated to identify hedgerows and tree canopy stepping stones that could be important to movement through those land uses. Habitat connectors were modeled identifying routes between habitat cores that minimize movement resistance and travel distance- the “paths” with the least “cost” for movement.

Habitat connectors are often narrower, more fragmented habitats. But as they connect larger more intact habitat cores, the loss or degradation of a habitat connector will generally have an outsized negative impact to the overall green infrastructure network. **Where these connectors can be restored and enhanced or their widths expanded, they can greatly benefit the network.**

Habitat connectors were classified according to whether they go through developed land cover, whether they are riparian following stream corridors, or whether they are neither of those conditions, which are labeled as Not Developed-Not Riparian. Habitat connectors may change classification along their route as they go through different conditions. It is important to note that not all habitat connectors will be suitable for all species. Longer lengths of developed habitat connectors may only be used by species that are the most tolerant of those conditions. Riparian habitat connectors may receive some level of existing or future stream buffer protection, but habitat connectors that are not riparian may need other considerations for protections.

Rehoboth Bay watershed is notable for its significant lengths of developed habitat connectors. Within the study area, the large wetland cores of Lewes-Rehoboth Canal watershed are rather isolated, with connections to the smaller cores of Rehoboth Bay watershed traversing significant areas of development.

UPLAND HABITAT CONNECTIVITY

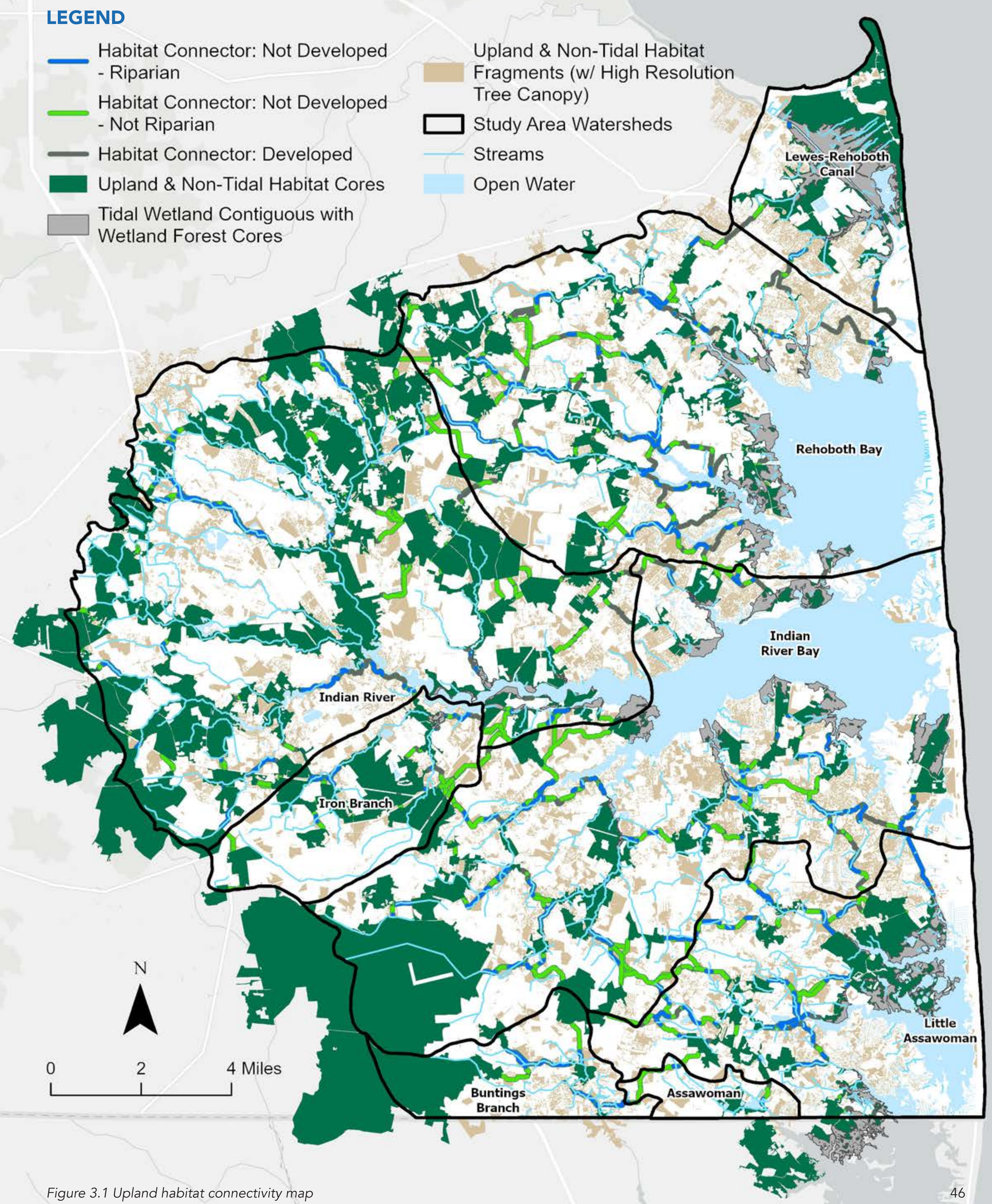


Figure 3.1 Upland habitat connectivity map

LANDUSE/LAND COVER CHANGE ANALYSIS

A landuse/land cover (LU/LC) change analysis was conducted to understand the trends of recent decades and provide context for potential future impacts to habitat. **The analysis focused on development change in five-year increments starting in 1992; areas of development for each 5-year increment are shown in Figure 3.2.**

During this period, development may have occurred on agricultural land or on vegetated habitat. Data for the years from 1992 to 2017 came from the State of Delaware as processed for analysis for the Center by the University of Delaware Water Resources Center. As 2022 state LU/LC data was still pending at the time of the analysis and drafting of this report, a combination of aerial photographs, ESRI Sentinel-2 imagery classification, and permitting data was reviewed to determine development change that occurred since 2017. The 2022 identification was conducted to summarize conditions and is not intended to be an authoritative record.

Additionally, **Areas At Risk for Development** are identified from Sussex County permits and the Preliminary Land Use Service (PLUS) program of the Delaware Office of State Planning Coordination (OSPC). Combined, this data indicates projects that range from pre-planning to fully permitted development. While other areas in the project watersheds are certainly at risk for development, these areas represent a high likelihood for change absent circumstances that change the outcomes of the projects. It is also not a given that all the areas identified in these parcels will be developed, but an aerial photo review of recent development projects revealed that complete or near complete clearing of parcel forests was not uncommon.

Past development in the study area has generally been along the existing road network and in proximity to existing development. However, there are examples of smaller new development parcels that are somewhat more isolated from other developed areas, particularly after 2007.

All watersheds have had new development that has impacted the overall habitat network. Some watersheds have particularly high rates of new development. A spike in development occurred between 2002 and 2007, with all watersheds except Assawoman and Rehoboth Bay having their highest rate of development in that timestep of the study period. Little Assawoman, Rehoboth Bay, and Indian River watersheds had the highest rate of development proportional to their area with 6.3%, 5.7%, and 5.6% respectively of the watershed area converted to development.

Another development spike occurred between 2017 and 2022 with Little Assawoman, Rehoboth Bay, and Assawoman Bay watersheds having their highest rate of development in that timestep. In that period, Rehoboth Bay and Assawoman watersheds had their highest rate and Little Assawoman watershed had its second highest rate of development since 1992. Since 1992, Rehoboth Bay and Little Assawoman watersheds have had the highest overall rate of new development as a percentage of their watershed area.

DEVELOPMENT CHANGE

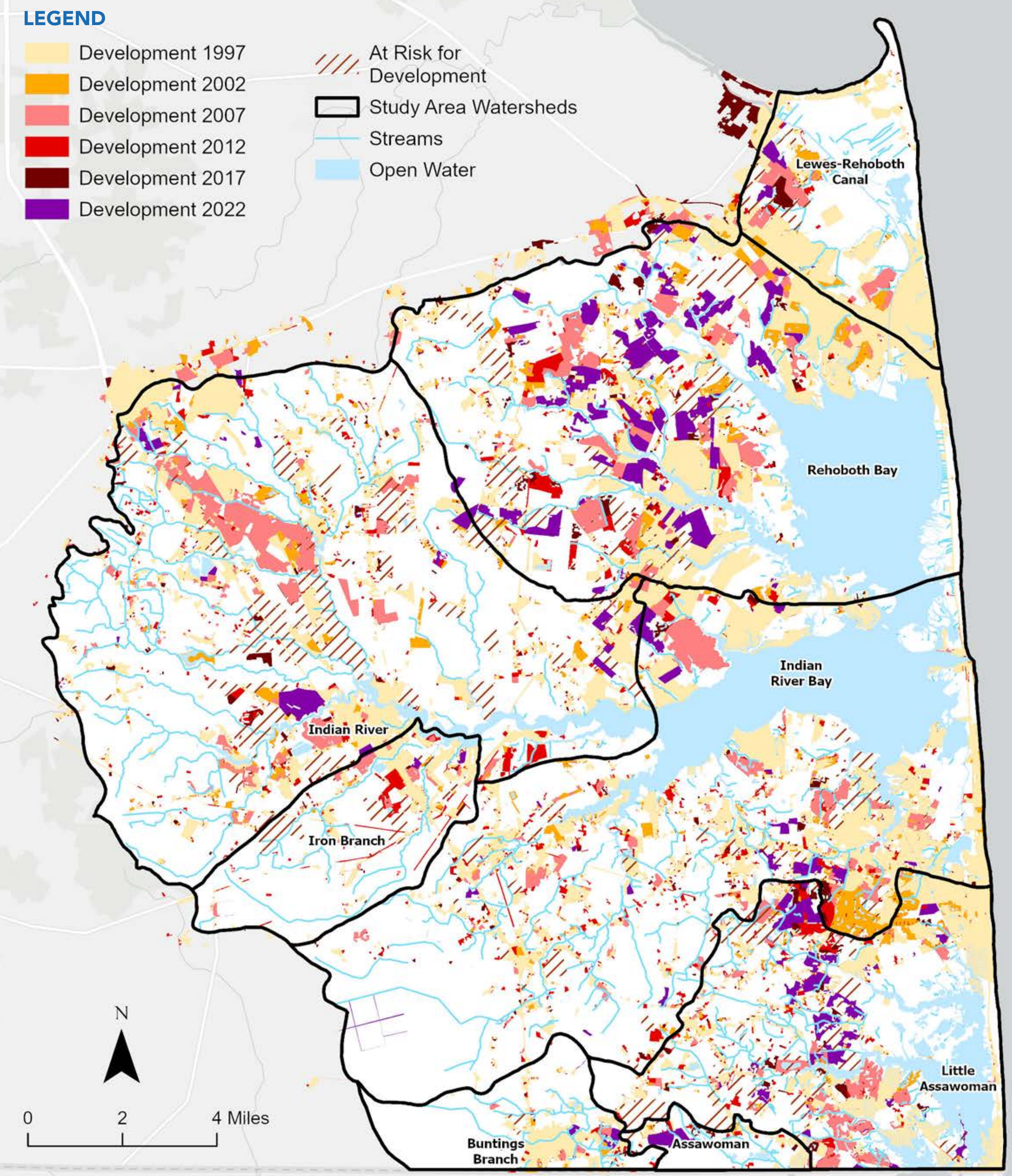


Figure 3.2 Development change map

SEA LEVEL RISE ANALYSIS

To assess the potential future impacts of sea level rise (SLR) to habitats in the study area, the analysis referenced National Oceanic and Atmospheric Administration (NOAA) SLR inundation and SLR marsh migration modeling outputs from 2017 (See Appendix 1 for data sources).

Figure 3.3 shows a range of potential horizontal extents from a SLR vertical increase of 2-feet, 4-feet, and 6-feet. Topography, bay tributaries, and bay and river edge conditions create varying patterns of water extents. Some areas have broad extents of impacts at only 2-feet of sea level rise. Other areas only reach a threshold of more substantial change with greater SLR. At six -feet of SLR, the new presence of water can be as little as 50-feet to almost 1-mile from the edge of current open water conditions. The broadest horizontal extents of SLR are generally adjacent to the bays, but change can also occur far upstream along bay tributaries.

While the data is shown in specific foot increments, tidal fluctuations, storm surges, and subsurface groundwater impacts will create zones of impacts that stretch beyond specific sea level rise extents as shown in this mapping. Historic and current observations, and predictive modeling into the future, indicate that change has been in process and more change is coming, but the exact timing and extent of future change is uncertain.

SEA LEVEL RISE

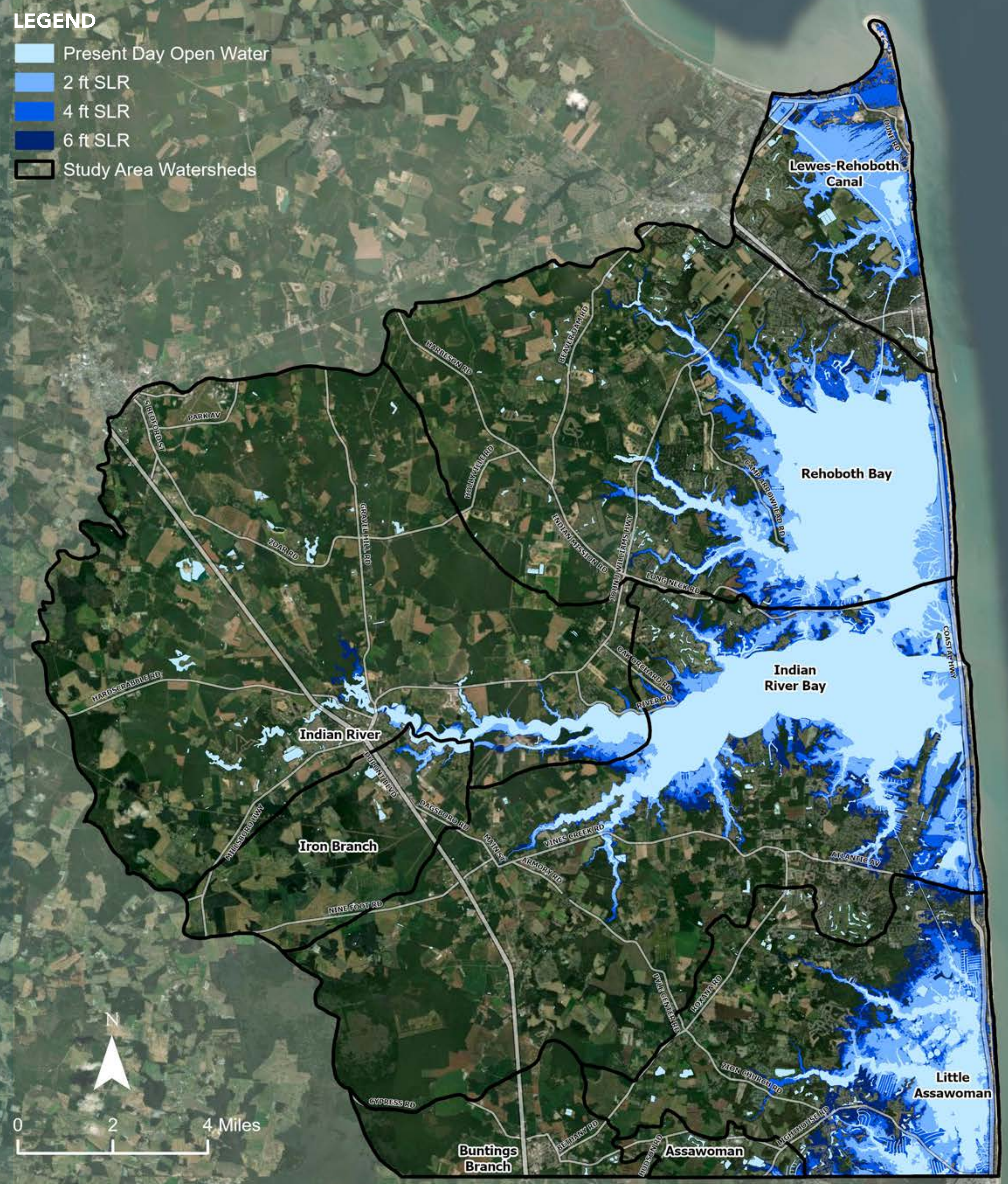


Figure 3.3 Sea level rise map

SEA LEVEL RISE AND HABITAT MIGRATION

To understand habitat changes in more detail, four scenarios of SLR increase were analyzed: 1.5 feet, 3.0 feet, 4.0 feet, and 5.5 feet. According to the NOAA modeling, 1.5 feet of SLR represents a very likely condition for 2050, and at least 3.0 feet represents a very likely 2100 or even a potential higher-change 2050 condition. 4.0 feet and 5.5 feet represent other 2100 SLR scenarios that are still very much within the realm of possibility.

Sea level rise will create dynamic changes in tidal wetland, beach, and dune habitats. Marsh migration modeling at just 1.5 feet of SLR demonstrates significant impacts (Shown in Figure 3.4).

Wetland loss and degradation is extensive along Rehoboth Bay, parts of Indian River Bay, and Little Assawoman Bay. While not as extensive, wetland loss and degradation is also projected for parts of Lewes-Rehoboth Canal, Indian River, and Iron Branch watersheds. Wetland loss in this analysis is indicated by a transition from wetlands to open water, while degradation is generally a transition from vegetated wetlands to extensive areas of unconsolidated shore. While new open water and unconsolidated shore is not without habitat value, it represents a significant change in condition and ecological function. As SLR increases, areas of wetland degradation are the first areas to transition to new open water.

Areas that remain wetland but change in wetland type, such as from emergent to brackish/tidal or from brackish/tidal to estuarine, are also prevalent throughout the study area, but not as extensively as wetland loss and degradation. Wetland type shifts may create disturbance opportunities for invasive species colonization and impact the health and function of existing wetlands.

The NOAA SLR modeling allows for marsh migration into areas of upland habitat and agriculture, but not into developed areas. Hardened shoreline edges and impervious surfaces create barriers for the transition to new wetlands.

Because of these barriers to marsh migration and topographic conditions at the edges of existing wetlands, wetland loss and degradation significantly outpaces new wetlands, making marsh migration areas critical to the long-term presence of these habitats.

Scenarios beyond 1.5 feet of SLR further exacerbate these trends and significantly increase areas of wetland loss and degradation.

HABITAT SHIFTS WITH SEA LEVEL RISE

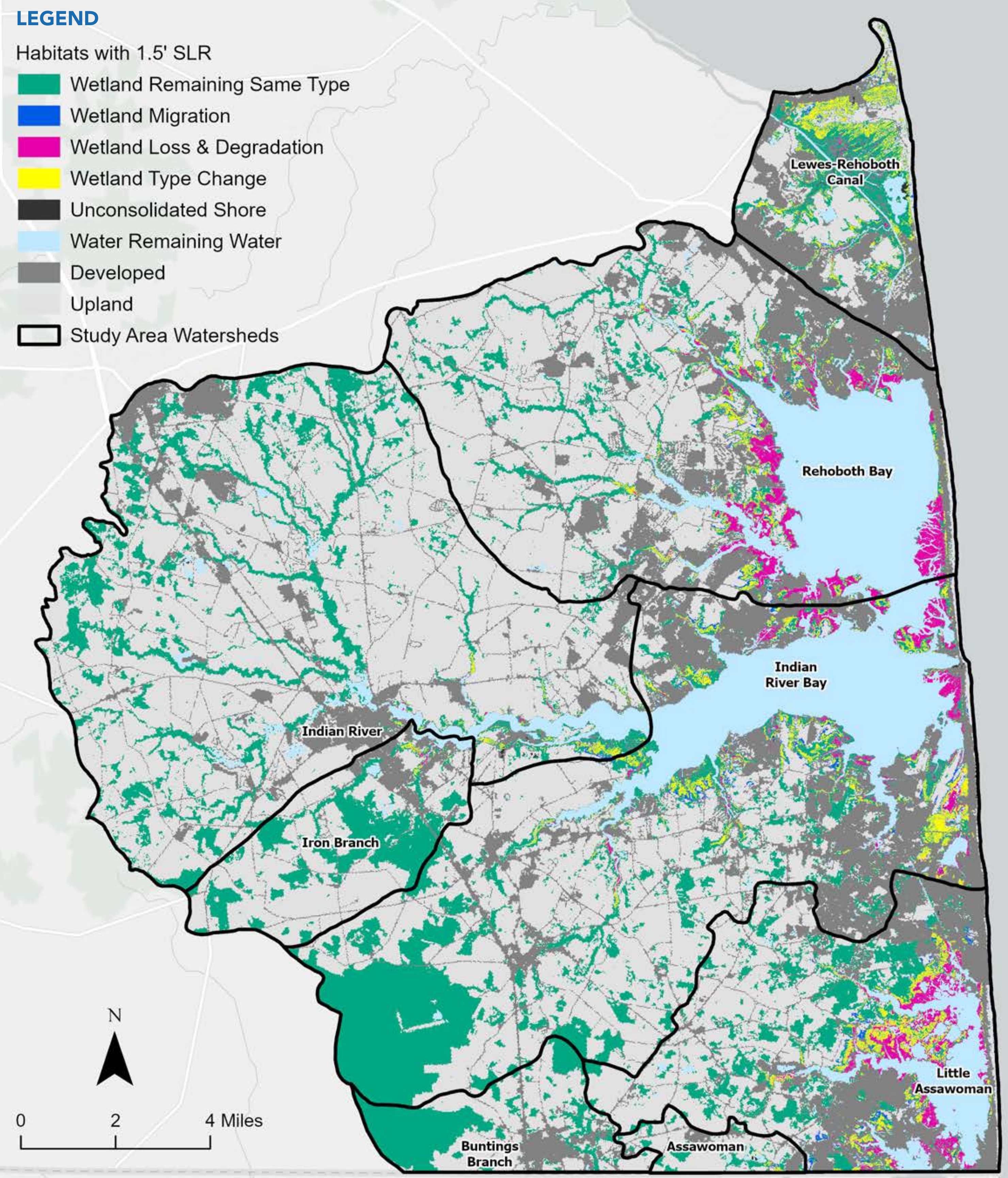


Figure 3.4 Habitat Shifts with sea level rise map

With sea level rise, the tidal wetlands of today will not be the tidal wetlands of the future. Consideration of uncertain future changing conditions and tidal wetland adjacencies will be critical to ensuring future biodiversity and ecological function.

Figure 3.5 shows tidal wetland complexes mapped by size, with the largest contiguous wetland areas in the Lewes-Rehoboth Canal watershed and the eastern shore of Rehoboth Bay. Marsh migration areas were also identified from the NOAA modeling for the four SLR scenarios included in this analysis.

Marsh migration areas are present in both small, scattered configurations and in larger patches. Large contiguous areas of marsh migration that are modeled to be wetlands through all four scenarios, and their adjacent tidal wetland complexes, will be vital to protect tidal wetland habitats into an uncertain future.

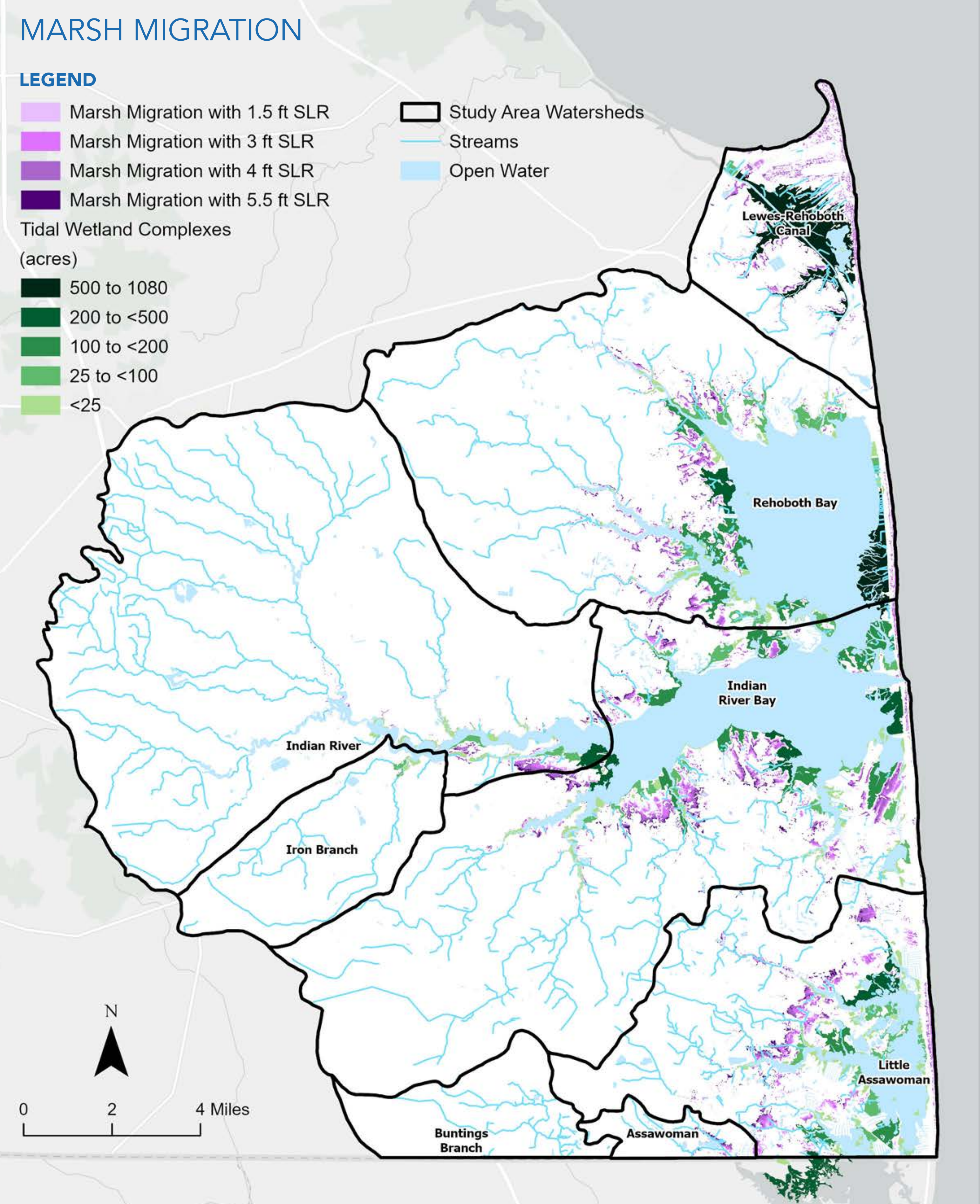


Figure 3.5 Marsh migration map

SYNTHESIS

The following key findings informed the development of the goals and objectives:

- Vegetated habitat and open water presently account for less than 50% of land covers in the Inland Bays watershed and high rates of development continue to chip away and fragment available habitats across large portions of the Bays. Maintaining both core habitats and connectors is critical to preserving a resilient green infrastructure network.
- With the exception of some highly developed sections of Lewes Rehoboth Canal and Rehoboth Bay, opportunities to establish functional habitat connectors along and between waterways are available.
- Wetland loss and degradation from Sea Level Rise is modeled to outpace marsh migration. Nearly 30% of Bays' species of conservation need tidal marsh, beach, and dune habitats for year-round or vital stopover habitat during migration. With development concentrated in areas adjacent to the tidal rivers and bays, establishing marsh migration corridors is necessary to preserve the long-term integrity of these habitats.

Photo Credit: Driscoll Drones

SECTION 4

PLAN GOALS & OBJECTIVES

Section 4 presents the plan goals, objectives, and actions to conserve and restore a healthy and diverse mosaic of habitat types to protect the biodiversity of the Inland Bays in the context of a changing environment. The performance measures found within each objective table presented below in this section will be established based on associated priority assessments, available funding and other implementation considerations.

Photo Credit: Caitlin Chaney

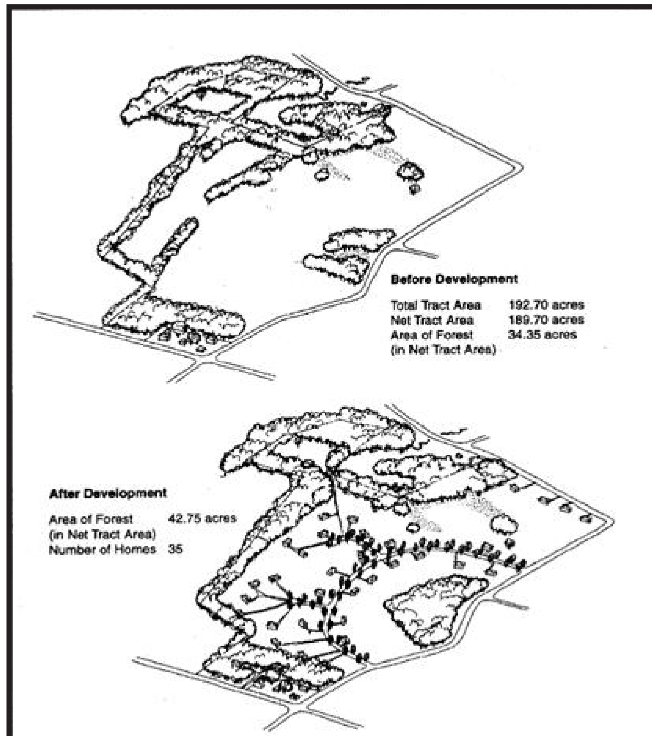
The overarching goal for this plan is to conserve and restore a healthy and diverse mosaic of habitat types to protect the biodiversity of the Inland Bays in the context of a changing environment. The overall plan is a complement to the 2021 Comprehensive Conservation and Management Plan (CCMP) and the supporting goals and objectives are built upon the same framework and definitions. The intent for this plan is to guide decision making and build partnerships to implement the identified actions in support of the following supporting goals and objectives, growing from the foundations set in the CCMP over the next decade. The performance measures found within each objective table presented below in this section will be established based on associated priority assessments, available funding and other implementation considerations. The identified actions do not necessarily constitute a prioritized list, although some actions set the necessary foundations for the implementation of other actions. Focal areas for the implementation of the recommended actions are discussed in Section 5.

GOAL 1

IMPROVE THE HEALTH AND RESILIENCY OF THE HIGH CONSERVATION VALUE HABITATS (HCVH) IN THE INLAND BAYS

Description

The Inland Bays' unique mosaic of natural habitats, agriculture and developed lands is home to nearly 700 species of conservation need. These sensitive species require a functional network of interconnected core and niche habitats for their survival. Conservation of such a network of HCVH across the Inland Bays is critical to building resiliency and preserving biodiversity while providing secondary benefits such as cleaner water.



Model Ordinance: The Maryland Forest Conservation Act

The Maryland Forest Conservation Act (1991) was enacted to integrate the conservation of forest and other sensitive resources into the development planning process. The act also establishes clearing thresholds for projects and mitigation requirements when clearing exceeds the established thresholds. The act encourages responsible development and creates mechanisms to conserve and expand vital green infrastructure networks.

Figure 4.1 Model Ordinance: The Maryland Forest Conservation Act

To combat the threats of habitat loss due to land use change, habitat fragmentation, and sea level rise, conservation and expansion of HCVH across the Inland Bays is the primary strategy to preserve the integrity of this landscape. This is most effectively accomplished through changes in land use policy, education, and outreach. Secondarily, the application of broad level management strategies at the patch level is necessary to maintain the quality of HCVH within the network.

OBJECTIVE 1.1 | STRENGTHEN LAND PROTECTION POLICIES FOR HCVH

Land protection policies have watershed-wide benefits and can profoundly increase habitat area and connectivity.

Table 4.1 Strengthen land protection policies for HCVH (Objective 1.1)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Demonstrate the benefits of expanded buffer regulations.	CCMP AG 3-1: Plant riparian forested and grassed buffers.	Lead: Center Support: SCD, DNREC	Develop mapping to illustrate how expanded regulation could support the goals of this plan Prepare a complementary white paper	Mapping 2026 White Paper 2027	Watershed-wide	$-$$
B. Demonstrate benefits of conservation thresholds for land clearing.	CCMP CM 2-4: Increase protection of land through acquisition or easement…	Lead: Center, STAC Support: DNREC, DDA	Develop case study to illustrate key points	Case study 2028	Non-developed lands in the Inland Bays watershed	$$-$$$
C. Identify opportunities for improving land development ordinances and regulations.	CCMP CM 2-5: Revise the Sussex County Code related to buffers…	Lead: Center, Sussex County, SCD Support: STAC	Review development ordinances and regulations Develop list of opportunities for improving ordinances and regulations. Participate in Comprehensive Plan updates.	Audit 2028 List 2029	Watershed-wide	$-$$
D. Review the definition of "open space" in state and county code and determine what is compatible with habitat conservation defined in this plan	CCMP CM 2-5: Revise the Sussex County Code related to buffers…	Lead: Center, Sussex County Support: DNREC	Complete review Develop recommendations	Review 2028 Recommendations 2029	Watershed-wide	$-$$

**$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M*

OBJECTIVE 1.2 | IMPROVE CONNECTIVITY AMONG IDENTIFIED HCVH

A network of connected habitat cores will make the fish and wildlife populations of the Inland Bays more resilient to identified stressors and threats, like development pressure and cascading effects of climate variables.

Table 4.2 Improve connectivity among identified HCVH (Objective 1.2)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Explore permanent protection for priority1 wildlife corridors	CCMP CM 2-4: Increase protection of land through acquisition or easement	Lead: Center, Sussex County, DNREC, DDA	Number of acres protected	Identify a list of target areas 2027 Initiate acquisition process for one site within 5 years.	Non-developed lands in the Inland Bays watershed	$$-$$$$$ County funds, DE Open Space program funds, U.S. Forest Service funds, USDA funds, DE Aglands Preservation Program
B. Develop wildlife corridor plans for priority1 least-cost paths	N/A	Lead: Center Support: STAC, DNREC	Develop standard assessment methodologies and action thresholds. Develop high-level management strategies.	Develop assessment methodologies 2028 Develop management plan. 2030	Watershed-wide	$-$$$
C. Remove/ mitigate barriers to movement by establishing and maintaining wildlife corridors.	CCMP HB 2-1 Provide access for native migratory fish to upstream areas for use as spawning and/or nursery sites	Lead: Center Support: DNREC, Sussex County	Number of fish passage projects completed. Number of miles of fish habitat restored. Number of upland/ riparian corridor barriers/connections completed	Ongoing	Watershed-wide	$$$ Funding through DelDOT, USFWS, other Grants Section 320 funds, state operating funds.

*$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M

OBJECTIVE 1.3 | IMPLEMENT NONTIDAL STREAM AND TAX DITCH BUFFER PLANTINGS TO BENEFIT HABITAT, CONNECTIVITY, WATER QUALITY, AND STREAM TEMPERATURE (FOREST AND NON-FOREST, RESPECTIVELY)

Buffers on drainage features, including tax ditches, expand the green infrastructure network and provide watershed-wide co-benefits of improving water quality and regulating water temperatures.

Table 4.3 Implement nontidal stream and tax ditch buffer plantings (Objective 1.3)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Develop and implement buffer planting program	AG 3-1 Plant riparian forested and grassed buffers. CM 2-5 Revise the Sussex County Code related to buffers for improved water quality.	Lead: Center Support: SCD, DNREC	Develop program framework Identify funding sources Implement pilot project	Program framework: 2025 Funding sources: 2026 Pilot project 2027	Watershed-wide	$$-$$$ Section 319 grants, Arbor Day Foundation grants, other state and federal grants

OBJECTIVE 1.4 DEVELOP BROAD PATCH-LEVEL MANAGEMENT STRATEGIES FOR HVCH

These broad patch-level management strategies are intended to provide an overview of management activities that may be needed on a rotating basis to ensure that delineated habitat patches are providing functional habitat or maintain a trajectory toward providing functional habitat. These strategies can be coupled with volunteer engagement for assessment of stressors and implementation of strategies.

Table 4.4 Develop broad patch-level management strategies for HCVH (Objective 1.4)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Identify broad patch-level management strategies for HCVH	N/A	Lead: Center	Develop standard assessment methodologies and action thresholds. Develop high-level management strategies.	Identify strategies 2028 Initiate volunteer engagement 2029 Implementation of strategies 2029/ ongoing	Watershed-wide	$-$$

OBJECTIVE 1.5 | DEMONSTRATE BENEFITS OF EXISTING INCENTIVES PROGRAM FOR LANDOWNERS/DEVELOPERS/ AGRICULTURAL PRODUCERS

Incentive programs are intended to offer a benefit to landowners/operators for integrating certain conservation activities on their lands or in their operations. Examples of such programs could be buffer establishment, native plantings, cover cropping, etc.

Table 4.5 Demonstrate benefits of existing incentives program (Objective 1.5)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Develop framework for incentives program	N/A	Lead: Center	Framework developed	2030 One pilot demonstration completed by 2033	Watershed-wide	$-$$

Northern Bobwhite
Colinus virginianus

Northern bobwhite thrive in relatively open early successional habitats and prefer a mosaic of young forest, grasslands, and croplands. This prized game bird was once abundant, but is currently in decline due to habitat loss and shifts in land management practices. Provisioning for natural habitat or buffer strips, reducing pesticide and herbicide use to preserve food bases, and adopting management regimes (e.g. prescribed fire) that mimic natural disturbance on the early successional landscape assist with recovery.

Photo credit: Adobe Stock

OBJECTIVE 1.6 | PARTNER WITH DEVELOPERS TO INTEGRATE PATCH-LEVEL CONSERVATION STRATEGIES INTO DEVELOPMENT PLANS AND/OR HOA BY-LAWS (E.G., BUFFER STRIPS, TURF REDUCTION, ETC.)

Science has demonstrated strong relationships between access to natural spaces and human health. Integration of conservation measures into land development offers opportunities to achieve a triple bottom line – profit, people, and planet.

Table 4.6 Partner with developers (Objective 1.6)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Develop a fact sheet outlining the financial and ecological benefits of conservation planning in the development process (e.g., increased lot value, reduced heat island effect, aesthetics)	CCMP EO 2-1: Develop and implement the PEEP PEEP Objective 3.2 Increase knowledge of and engagement in voluntary actions that improve the health of the natural resources and communities	Lead: Center, SCD Support: CAC	Fact sheet is developed.	Develop fact sheet 2025 Use fact sheet for education purposes ongoing	Watershed-wide	$-$$
B. Profile an exemplary development to provide proof of concept and foster the adoption of policies and practices	CCMP EO 2-1: Develop and implement the PEEP PEEP Objective 3.2 Increase knowledge of and engagement in voluntary actions that improve the health of the natural resources and communities	Lead: Center, SCD Support: CAC	Development is selected. Outreach to other communities.	2025	Watershed-wide	$-$$ CWA Section 320 funds
C. Provide technical assistance in developing and implementing strategies	CCMP CM 2-6: Implement conservation landscape projects in partnership with coastal communities	Lead: Center Support: SCD, DNREC	Framework for providing technical assistance developed Host a workshop to present actions A-C	Framework 2026 -Workshop 2027	Communities in the Inland Bays	$-$$

*$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M

GOAL 2

PROTECT AND EXPAND THE PRESENCE OF NON-FOREST AND EARLY SUCCESSIONAL HABITAT ON THE LANDSCAPE (E.G., MEADOW, GRASSLAND, YOUNG AND TRANSITIONING FOREST)

Description

The migratory songbirds and pollinators of the Inland Bays rely on early successional habitats. In the Inland Bays and throughout the mid-Atlantic, early successional habitats tend to transition to forest habitats and the suppression of natural regulators such as fire, prevent the rejuvenation of these habitats. Consequently, tracts of early successional habitats consisting of native plant species are generally rare on the landscape of the Inland Bays. As a result, active management is necessary to maintain the balance of these habitats in the overall landscape mosaic.

American Kestrel
Falco sparverius

American kestrel are little falcons that specialize in early successional habitats and are often found stalking prey on the margins of agricultural fields. These cavity nesters are opportunistic and will readily find suitable nest sites in trees, rocks, buildings, or nest boxes. While their population is secure, these tiny predators can be impacted by pesticide use, which can destroy their food base, and lead to loss of nesting sites. Buffer management and nest box programs can provide great benefits to the kestrel.

Photo credit: Adobe stock

OBJECTIVE 2.1 | CONSERVATION AND MANAGEMENT OF EARLY SUCCESSIONAL HABITAT

Since natural habitats are limited by other land uses in the Inland Bays, focusing on preserving and enhancing existing early successional habitats is important to maintaining the habitat mosaic.

Table 4.7 Conservation and management of early successional habitat (Objective 2.1)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Confirm and characterize existing patches of early successional habitat.	N/A	Lead: Center	See Below	See Below	See below	See below
i. Develop a standard assessment form to delineate and categorize patches (e.g., agricultural buffer, meadow, grassland, pasture, early successional forest).	N/A	Lead: Center Support: STAC	Assessment methodology and form developed	2027	Watershed wide	$-$$
ii. Develop a checklist of common stressors and threats and an objective qualitative means of ranking the threat severity (e.g., absent, present, extensive).	N/A	Lead: Center Support: STAC	Standard checklist developed	2027	Watershed wide	$-$$
iii. Engage volunteers to help with this strategy and provide training.	CCMP EO 4-1: Direct a volunteer program that provides citizens with opportunities to partner with the Center.	Lead: Center	Number of volunteers engaged annually.	2029 Volunteer engagement increases annually.	Watershed-wide	$$-$$$ Operating funds

*$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M

OBJECTIVE 2.2 | EXPAND THE PRESENCE AND VALUE OF EARLY SUCCESSIONAL HABITAT IN DEVELOPED AND AGRICULTURAL AREAS

Some habitats, such as turf in agriculture buffers and developed areas, can be managed to optimize their habitat value while providing their intended function.

Table 4.8 Expand the presence and value of early successional habitat (Objective 2.2)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Partner with the agricultural community to implement grass and riparian buffers.	Objective 1.1-A CCMP AG 3-1: Plant forested and grassed buffers.	Lead: Center, SCD, DNREC	Total number of acres of forested and grassed buffers planted.	Goal of 3,246 acres of riparian forest buffer and 1,772 acres of grassed buffers.	Agricultural lands in the Inland Bays watershed.	$$-$$$ Section 319 grants, Arbor Day Foundation grants, other state and federal grants
B. Increase the width and appropriate management of buffers adjacent to agricultural fields to support pollinators, migratory birds, and other wildlife.	N/A	Lead: SCD, DNREC Support: Center	Cultivate a pilot project with a willing landowner Hold a workshop to demonstrate management techniques Number of buffer strips established	ID Pilot project 2025 Workshop 2026 Establish buffers - Ongoing	Agricultural lands in Inland Bays watershed	$-$$ (Pilot project) $$-$$$ (Establish buffer strip projects)
C. Integrate pollinator-friendly pest management strategies on ag lands to prevent the drift of pesticides into native habitats.	CCMP AG 2-1c: Encourage use of 4R	Lead: Center Support: DDA	Number of farms utilizing 4R nutrient stewardship approach.	60% of available cropland treated using 4R nutrient stewardship approach annually.	Agricultural lands in Inland Bays watershed	$ Local and state partner grants
D. Support the implementation of a native landscape/ backyard habitat program. **a. Develop guidelines** **b. Provide technical support** **c. Partner with or expand Master Naturalist and/or Gardener programs.**	N/A	Lead: Center Support: STAC, CAC	Guidelines and framework for technical support developed Pilot project developed	Guidelines 2028 Pilot project 2029	Residential lands in Inland Bays watershed	$-$$
E. Offer incentives (e.g., free trees, contests, certification programs, etc.) that tie in with existing programs and explore new programs	N/A	Lead: SCD, DNREC, DE Forest Service Support: Center	Identify existing incentive programs. Framework for incentives program developed	Identify existing incentive programs 2025 Educate the public on existing incentives ongoing Framework for any new incentive programs created by 2035	Watershed-wide	$-$$
F. Integrate pollinator-friendly practices into existing cover crop programs (provide early and late flowering species and winter forage).		Lead: SCD Support: Center	Guidelines for pollinator friendly practices developed Number of acres of cover crops planted annually.	Ongoing - goal of 60% of available acres planted annually. 10% of farms integrate pollinator species into cover crop mix by 2030	Agricultural lands in the Inland Bays watershed.	$$-$$$$ State and federal funding

**$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M*

GOAL 3

ESTABLISH PRIORITY CONSERVATION AREAS IN THE COASTAL ZONE TO ALLOW FOR HABITAT MIGRATION AND THE PRESERVATION AND ESTABLISHMENT OF HCVH

Description

The sea level rise analysis in Section 3 determined that the loss and degradation of saltmarsh and tidal wetland outpaces the establishment of new or expanded wetlands. These results are largely due to encroachments in tidal fringe such as hardened shorelines and land development. As a result, conserving space for tidal marsh migration and shifts in habitat type relative to rising seas is critical to maintaining habitat availability for marsh dependent species like the saltmarsh sparrow.

OBJECTIVE 3.1 | PURSUE LONG-TERM PROTECTION OF FOCAL AREAS

The sea level rise analysis discussed in Section 3 delineated areas where marsh migration and wetland development were likely based on topographic conditions. From these areas, marsh migration focal areas (discussed in Section 5) were delineated. Long-term protection of these areas will be critical to sustaining the Inland Bay's populations of marsh dependent species.

Table 4.9 Pursue long-term protection of focal areas (Objective 3.1)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Expand existing strongholds where: **a. Existing patch size is sufficient to support or at least poses minimal impediments to sustaining target guilds.** **b. Breeding populations of shorebirds or other SGCN are documented**	Objective 1.2.A CCMP CM 2-4: Increase protection of land through acquisition or easement	Lead: Center, Sussex County, DNREC, DDA	Number of acres protected relative to baseline period of 2009-2019	List of target areas developed 2028 Acquisition process initiated for one site within 5 years.	Non-developed lands in the Inland Bays watershed	$$-$$$$$ County funds, Delaware Open Space program funds, foundation grants, U.S. Forest Service funds, USDA funds, DE Aglands Preservation Program
B. Increase the resiliency of existing marshes to SLR through large-scale marsh restoration where: **a. Loss or risk of loss of marsh habitat is documented** **b. Beneficial reuse of dredge materials is feasible** **c. Marsh migration potential is constrained**	N/A	Lead: Center, DNREC	Target area(s) identified Restoration plan developed Funding sought Acres restored	2029 2030 ongoing	Existing marshes	$$$-$$$$ NFWF, NOAA
C. Target restoration and conservation activities in: **a. Areas at risk of becoming too wet for agriculture or development; and/or** **b. Areas where saltwater intrusion could impact plant communities and/ or agricultural production**	CCMP CM 2-4: Increase protection of land through acquisition or easement	Lead: Center Support: DNREC	Number of acres protected relative to baseline period of 2009-2019	List of target areas developed 2026 Acquisition process initiated for one site within 5 years.	Non-developed lands in the Inland Bays watershed	$$-$$$$$ County funds, Delaware Open Space program funds, foundation grants, U.S. Forest Service funds, USDA funds
D. Establish tracts of high marsh habitat for marsh nesting birds	CCMP CM 2-4: Increase protection of land through acquisition or easement	Lead: Center Support: DNREC	Number of acres protected relative to baseline period of 2009-2019	List of target areas developed 2026 Acquisition process initiated for one site within 5 years.	Non-developed lands in the Inland Bays watershed	$$-$$$$$ County funds, Delaware Open Space program funds, foundation grants, U.S. Forest Service funds, USDA funds

**$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M*

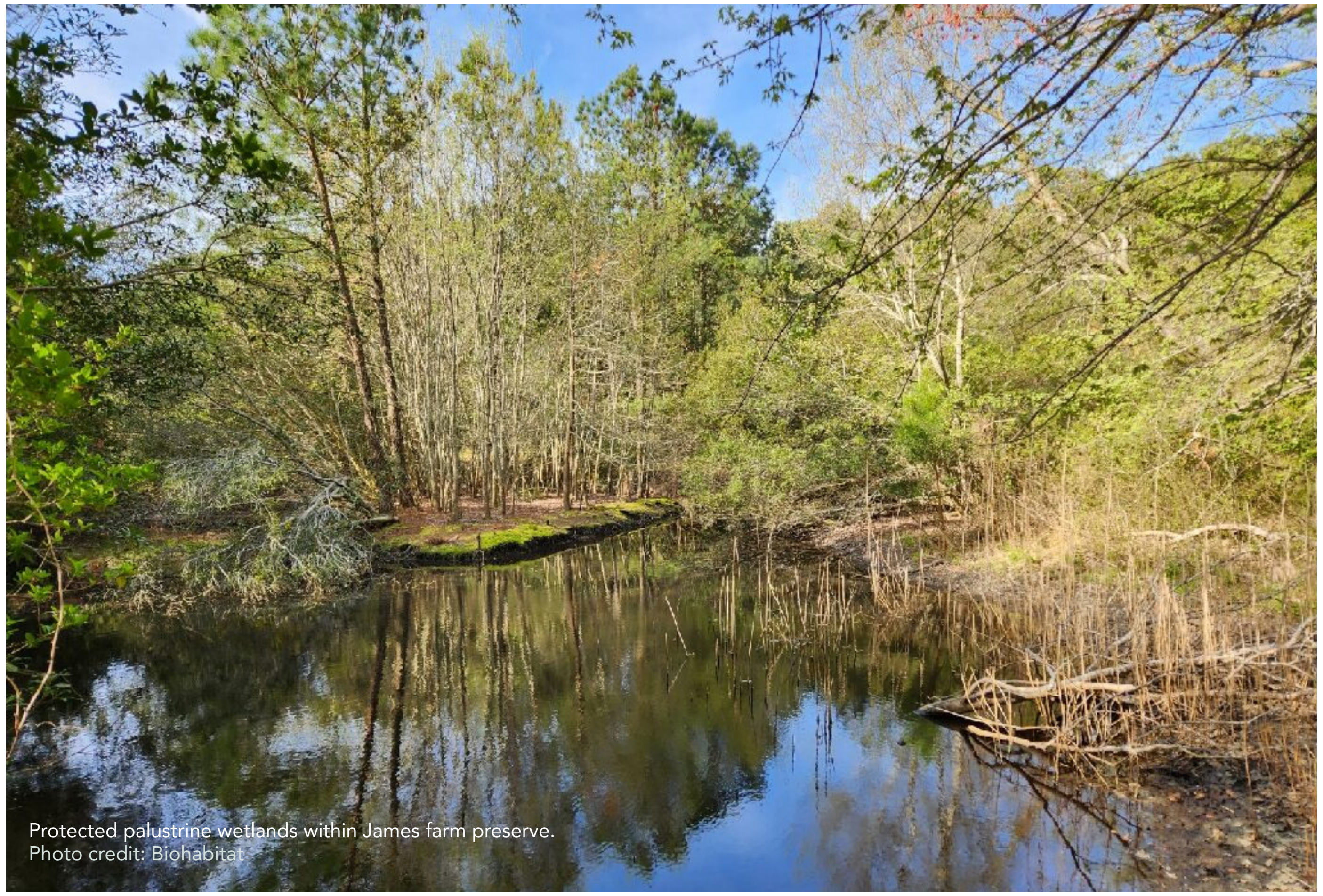
OBJECTIVE 3.2 | DEVELOP MANAGEMENT STRATEGIES FOR PROTECTED LANDS

In addition to conserving land, it is important to develop management strategies for the lands to ensure the investment in these lands meets the established goals. Conserved lands in the Coastal Zone should be evaluated and managed to remove impediments to establishing a trajectory toward tidal marsh or wetland within planned timeframes.

Table 4.10 Develop management strategies for protected lands (Objective 3.2)

Actions	Related Actions	Responsible Parties	Performance Measures	Timeframe & Key Milestones	Location	Costs & Potential Funding Sources*
A. Develop management strategies	Objective 1.4	Lead: Center Support: DNREC	Standard assessment methodologies and action thresholds developed. High-level management strategies developed	2030 develop strategies 2033 initiate volunteer engagement and implementation	Coastal zone	$$-$$$

**$ = less than 25K; $$ = 25-50K; $$$ = 100-500K; $$$$ = 500K-1M; $$$$$ = Over 1M*



Protected palustrine wetlands within James farm preserve.
Photo credit: Biohabitat

Photo credit: CIB

SECTION 5

PRIORITIZATION & FOCAL AREAS

Section 5 identifies focal areas for conservation and restoration activities based on the analysis described in section 3. Patch-level management is not discussed at this scale, but broad strategies for targeted patches within focal areas will be addressed in Objective 1.4.

Photo credit: Caitlin Chaney

DELINEATION OF FOCAL AREAS

The spatial analysis described in Section 3 resulted in the delineation of watershed-scale focal areas for conservation. Within the focal area output maps, certain habitat types are shown because they are the most vulnerable to habitat loss from development, habitat fragmentation, and marsh migration. Due to the scale and complexity of these studies, the maps do not show every habitat subtype that is described in Section 2. However, these habitat subtypes should still be considered implicitly important to the overall mosaic, especially when they are adjacent to other habitat patches within focal areas. For example, when early successional forests (a sub-type of the upland habitat delineation) are found adjacent to core interior forest patches, the two forest habitat types enhance each other's ecological function and quality. Early successional forests buffer interiors from edge effects, storm damage, and anthropogenic disturbances; the interior forest becomes the seed source for the early successional forest to reach maturity. This same principle applies to other habitat areas and subtypes; habitat connection and adjacency is a benefit to the overall diversity of the ecological network, and all habitats listed earlier in this study should be considered integral to the habitat network even if not specifically mapped in focal areas.

These focal areas are intended to create a robust network of natural habitats that complements the Comprehensive Conservation and Management Plan (CCMP). This plan focuses on delineating and conserving this network while the restoration actions in the CCMP coupled with targeted patch level management will serve to enhance and expand the network while providing many associated water quality benefits, especially when focused along waterways.

Figure 5.1 shows all the focal areas. In this section, each watershed's focal areas are mapped at finer scales.

FOCAL AREAS FOR CONSERVATION

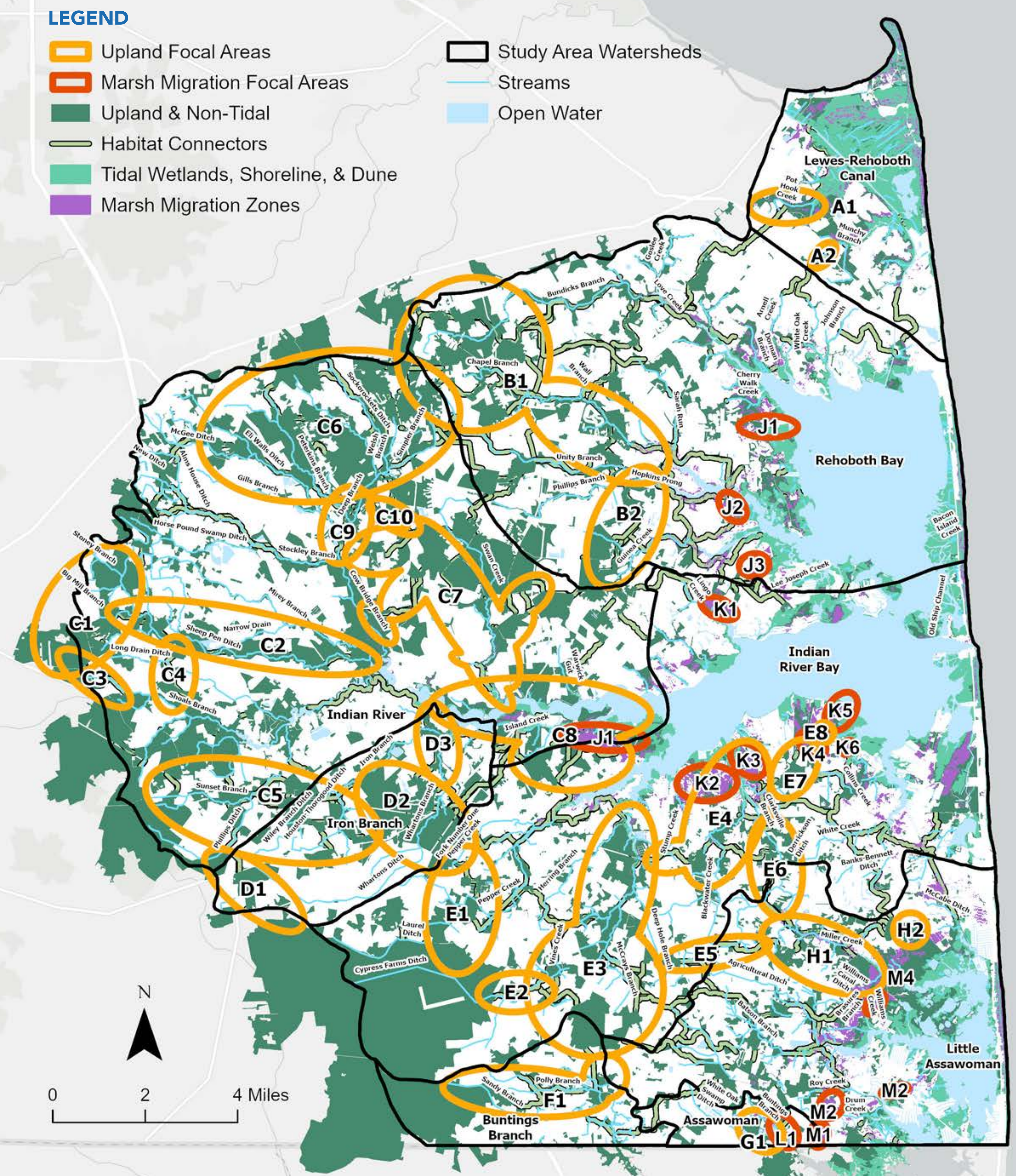


Figure 5.1 Focal areas for conservation map

UPLAND AND NON-TIDAL HABITATS

Priority areas for conservation in upland and nontidal habitats focused on large forested tracts, larger areas of forested wetland, existing protected lands, as well as connections between these patches. Patterns were examined on a watershed basis, leading to the delineation of focal areas where clusters of priority areas emerged. These focal areas were then compared with the state ecological network and rare habitat locations and found to be in general agreement. Early successional habitats, while not mapped in the prioritization, were considered complementary to the priority areas and can function as stepping stones connecting the core habitats within each priority area. Determining the necessary management actions for each priority area will be contingent on the field assessment to be undertaken during the plan implementation phase.

TIDAL MARSH, BEACH AND DUNE

Priority areas for conservation in tidal marsh, beach, and dune habitats combined tidal and adjacent nontidal areas, to account for habitat migration. Many large complexes of tidal marsh habitat are protected, while intermediate to small wetlands remain unprotected. Marsh migration was examined across two time scales, 2050 and 2100, considering sea level rise scenarios. Focal areas with the greatest potential for marsh migration were identified within each watershed. The impact of newer development on limiting migration zones was assessed and focus areas for each watershed were reviewed. Additionally, areas that provide critical habitat to endangered species, such as salt marsh sparrow habitat and breeding bird islands, were identified. The overview of the entire network highlighted the inhibiting effect of development patterns on some connections, emphasizing the importance of connections from tidal fringe to upland for network robustness, even if not critical for all species.

TIDAL RIVERS & BAYS

By their nature, tidal rivers and bays form a robust network of connected habitat limited primarily by water quality. Since water quality is a driver in the condition of the tidal rivers and bays, their health is strongly linked to the upland watershed and shoreline condition; therefore, priority areas for conservation for the tidal rivers and bays include those defined for the upland habitat types with an emphasis on natural land covers buffering waterways, non-tidal wetlands, and marshes that function to trap sediment and process nutrients before they get to the bays. In the tidal rivers and bays themselves, conservation of strongholds or sanctuaries for SAV and shellfish establishment are important for both water quality and habitat provisioning.

Targets for restoration include eroding shorelines and breeding bird islands that are being lost to sea level rise and other climactic variables. In protecting these areas with nature-based strategies, like living shorelines, co-benefits of increasing marsh area, provisioning of substrate for shellfish establishment, and many others provide direct water quality benefits in addition to increasing available habitat and forage for fish, shorebirds, and waterfowl. These nature-based strategies can also be used to make communities more resilient by attenuating wave energy.

Photo credit: CIB

LANDSCAPE SCALE PRIORITIES BY WATERSHED

LEWES-REHOBOTH CANAL

Table 5.1 Lewes-Rehoboth Canal watershed summary statistics

Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
16.75	2.36%	2.23%	4.76%	-1.88%	1.62%	2.17%	1.89	11.26%

NOAA Wetland Type	Baseline Acreage (0.5′ SLR)	1.5′ SLR Acreage	Net gain/loss 0.5′ to 1.5′ SLR	% Change
PL Forested Wetland	555.83	430.90	-124.93	-22.48%
PL Scrub Shrub Wetland	60.61	48.33	-12.28	-20.26%
PL Emergent Wetland	363.71	324.68	-39.03	-10.73%
Brackish/Tidal Marsh	671.33	599.48	-71.85	-10.70%
Estuarine Wetland	1855.40	2107.14	251.74	13.57%
Unconsolidated Shore	97.82	256.13	158.31	161.83%

The Lewes-Rehoboth Canal watershed contains a higher percentage of protected vegetated area than any other watershed in the Inland Bays. The majority of vegetated habitat, which comprises 46.79% of the land cover in this watershed, is protected from development as part of Cape Henlopen State Park. Thirty-nine percent of the watershed is developed, while agriculture comprises 9% and open water 5%.

Cape Henlopen State Park contains a large area of contiguous habitat patches including interior forest cores, wetland forest cores, tidal wetlands, and marsh migration areas. However, dense development associated with Route 1 Coastal Highway limits the habitat connectivity potential from the Lewes-Rehoboth Canal habitat to the adjacent Rehoboth Bay watershed. Pressure on these ecosystems mounts with sea level rise; this area is at risk of most wetland types being lost or transitioned to unconsolidated shore, which represents a degraded habitat condition when compared with current wetlands. With 11.26% of the watershed's area having been developed since 1992, development pressure continues. All these trends make conserving and enhancing existing and unprotected habitat corridors critical. Two focal corridor areas for conservation are identified, both associated with streams. Habitat corridors along Pot Hook Creek (A1) and Munchy Branch (A2) are contiguous with the State Park, providing critical opportunities for species and resource exchange between the core habitats of Cape Henlopen and external smaller habitat patches. Pot Hook Creek has no protection associated with it and faces imminent development risk (as defined in Section 3).

Munchy Branch is also unprotected but does not currently face development risk. No focal areas specifically focused on marsh migration were identified in this watershed, because most potential marsh migration areas are already protected. However, Pot Hook Creek has some scattered marsh migration patches that would benefit from being protected.

FOCAL AREAS: LEWES-REHOBOTH CANAL

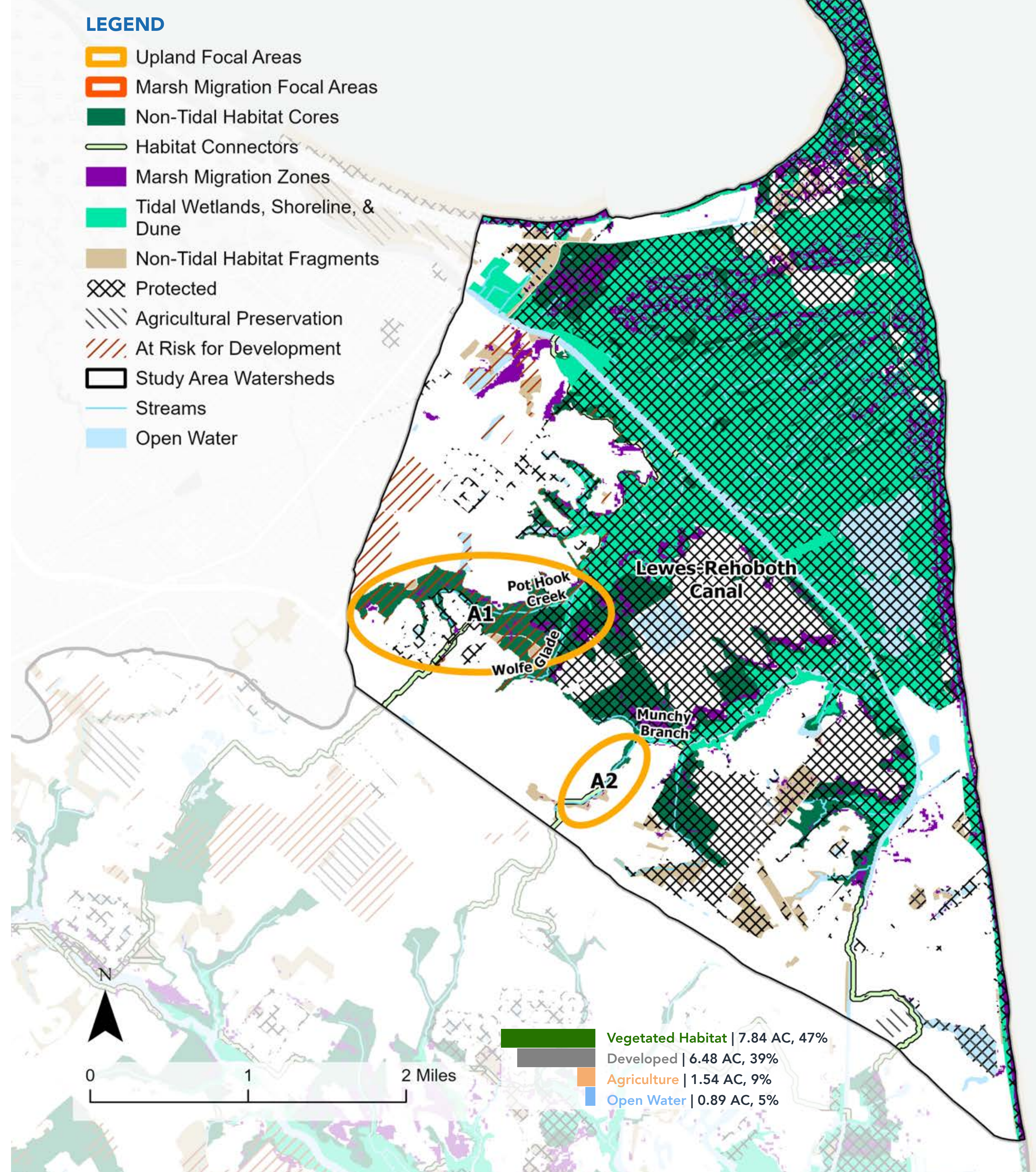


Figure 5.2 Focal areas map: Lewes-Rehoboth Canal watershed

REHOBOTH BAY

Table 5.2 Rehoboth Bay watershed summary statistics								
Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
59.00	2.90%	2.94%	5.66%	0.21%	1.09%	9.76%	13.31	22.55%

NOAA Wetland Type	Baseline Acreage (0.5′ SLR)	1.5′ SLR Acreage	Net gain/loss 0.5′ to 1.5′ SLR	% Change
PL Forested Wetland	3174.39	2957.83	-216.56	-6.82%
PL Scrub Shrub Wetland	190.28	176.13	-14.15	-7.44%
PL Emergent Wetland	364.03	387.11	23.08	6.34%
Brackish/Tidal Marsh	538.03	653.53	115.50	21.47%
Estuarine Wetland	2190.95	891.57	-1299.38	-59.31%
Unconsolidated Shore	126.38	1556.74	1430.36	1131.82%

Because of its bayside proximity, the Rehoboth Bay watershed faces elevated development pressure, with 34% of the watershed already taken up by developed land. Between 1992 and 2022, 22.55% of the watershed's total area was converted to development, a higher percentage than any other watershed in the study area. Today, 48% of the watershed is taken up by vegetated habitat (27%) and open water of Rehoboth Bay (21%), and the remainder is taken up by agricultural land (18%). Sea level rise directly threatens both habitat and human development in this watershed. Forested, scrub shrub, and estuarine wetlands will likely be transitioned to tidal marsh and unconsolidated wetland under current conditions.

Protected areas of vegetated habitat in this watershed predominantly consist of tidal wetlands and adjoining habitats surrounding Rehoboth Bay, as well as the beach and dunes of Delaware Seashore State Park. The delineation of focal areas revealed that significant portions of core habitat remain unprotected in this watershed, presenting an important opportunity for habitat protection. The largest expanses of unprotected upland and non-tidal habitat cores are focal in Focal Area B1, along Chapel Branch and segments of Bundicks Branch, Unity Branch, and Philips Branch.

This focal zone links to interior forest cores in the neighboring Indian River watershed and beyond the study area to the west. Focal Area B2 connects Focal Area B1 to Redden State Forest, a protected interior forest core, but much of this corridor also faces development threat.

Three focal areas for marsh migration were identified adjacent to wetland complexes. Area J1 adjoins protected areas together, while J2 and J3 are more isolated from existing protected zones. Ideally, these marshes and marsh migration areas would be connected via habitat corridors to other upland focal areas. However, existing development alongside Rehoboth Bay has already largely cut off connections from tidal fringe habitats to upland habitats in this area.

FOCAL AREAS: REHOBOTH BAY

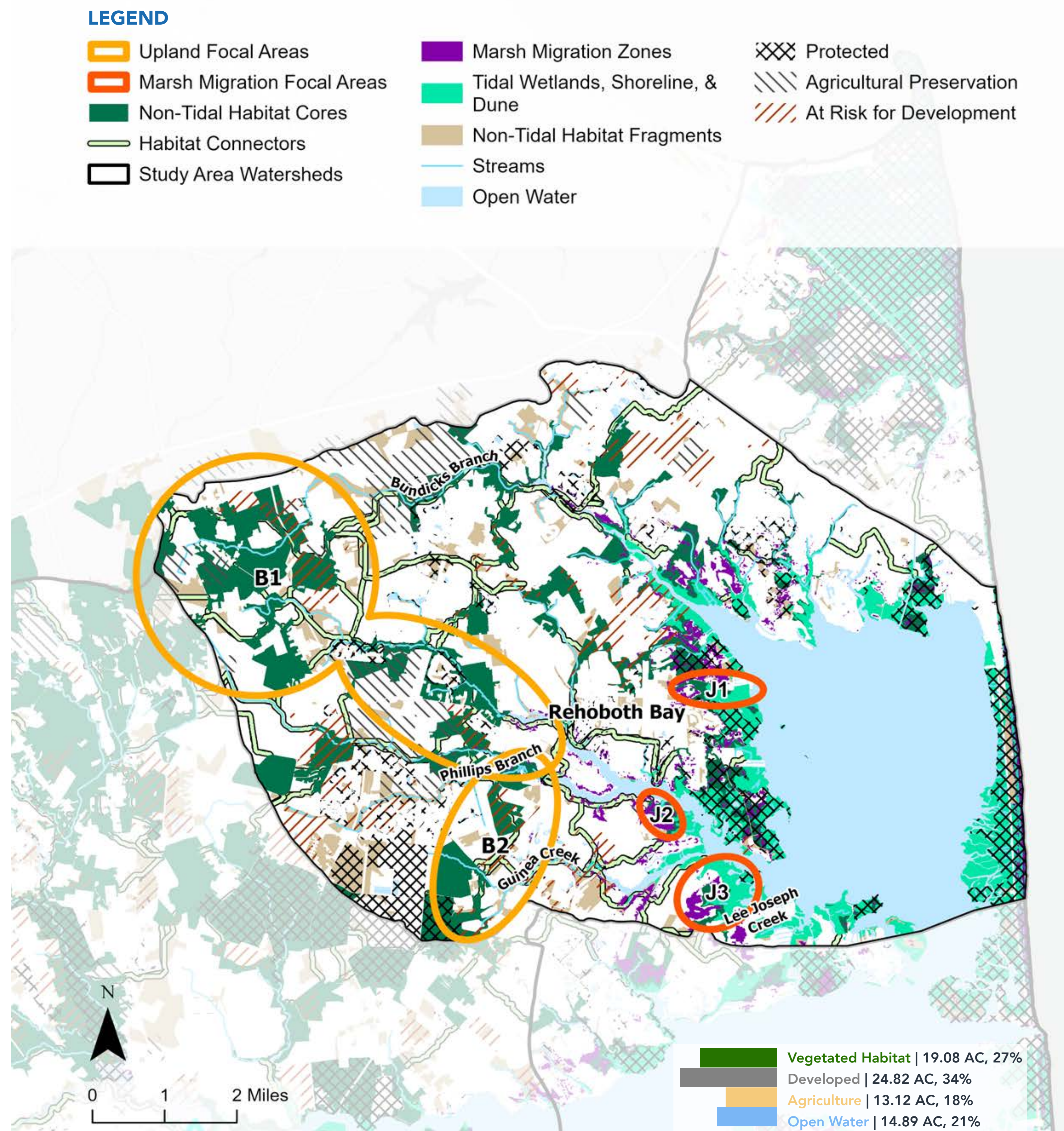


Figure 5.3 Focal areas map: Rehoboth Bay watershed

INDIAN RIVER

Table 5.3 Indian River summary statistics

Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
73.36	1.65%	1.92%	4.06%	1.08%	0.35%	1.87%	8.01	10.92%

NOAA Wetland Type	Baseline Acreage (0.5' SLR)	1.5' SLR Acreage	Net gain/loss 0.5' to 1.5' SLR	% Change
PL Forested Wetland	7111.52	7059.86	-51.66	-0.73%
PL Scrub Shrub Wetland	648.73	644.18	-4.54	-0.70%
PL Emergent Wetland	285.26	290.93	5.67	1.99%
Brackish/Tidal Marsh	107.70	124.71	17.00	15.79%
Estuarine Wetland	481.53	484.59	3.06	0.64%
Unconsolidated Shore	46.06	95.67	49.61	107.72%

The Indian River watershed, at 55,209.91 acres, is the second largest watershed in the study area. Agriculture comprises a comparatively large percentage of the land area of this watershed (36%), while 21% of it is developed. About half of that development (10.92% of the watershed area) has occurred since 1992. Forty percent of the watershed is vegetated habitat, and 3% is open water. Though the percentage of open water cover is small, this watershed importantly contains the headwaters and tributaries of the Indian River, which flows directly into the bays. With sea level rise, this watershed may see an increase in emergent and estuarine wetlands, tidal marshes, and unconsolidated shore, as waters rise along the shores of the Indian River. Those wetlands will only be able to transition over time if the areas adjacent to current wetland habitats remain undeveloped.

Indian River watershed has the largest land area of all watersheds draining to the Inland Bays, and also has the largest area of unprotected interior forest and wetland forest cores. This situation presents many opportunities to expand the green infrastructure network and create true habitat connectivity in this watershed. Clusters of protected areas exist in the southeast and east of the watershed, as well as some in the middle along the Indian River tributaries. Of note is Focal Area C2 along Sheep Pen Ditch. This corridor is composed almost entirely of interior forest and wetland forest cores, whereas many other corridors in the study are more fragmented. Focal Areas C1 and C6 have large clusters of habitat cores at the top of the watershed. Some areas within C1 and C6 are at risk of being developed, but much of this area has some type of agricultural land protection applied to it. Other identified focal areas (C5, C7, C8, C9, C10) generally serve to expand existing protected areas and to connect those areas with C1, C2, and C6.

Despite the relatively small area of tidal marsh in this watershed, J1 exemplifies an ideal opportunity for marsh migration habitat prioritization. There is a large, protected wetland complex at the east end of the watershed on Indian River, with adjacent unprotected tidal wetlands and wetland forest cores. Protecting the large marsh migration area paralleling the Indian River would instantly create contiguous undisturbed habitat in which marsh migration would be facilitated.

FOCAL AREAS: INDIAN RIVER

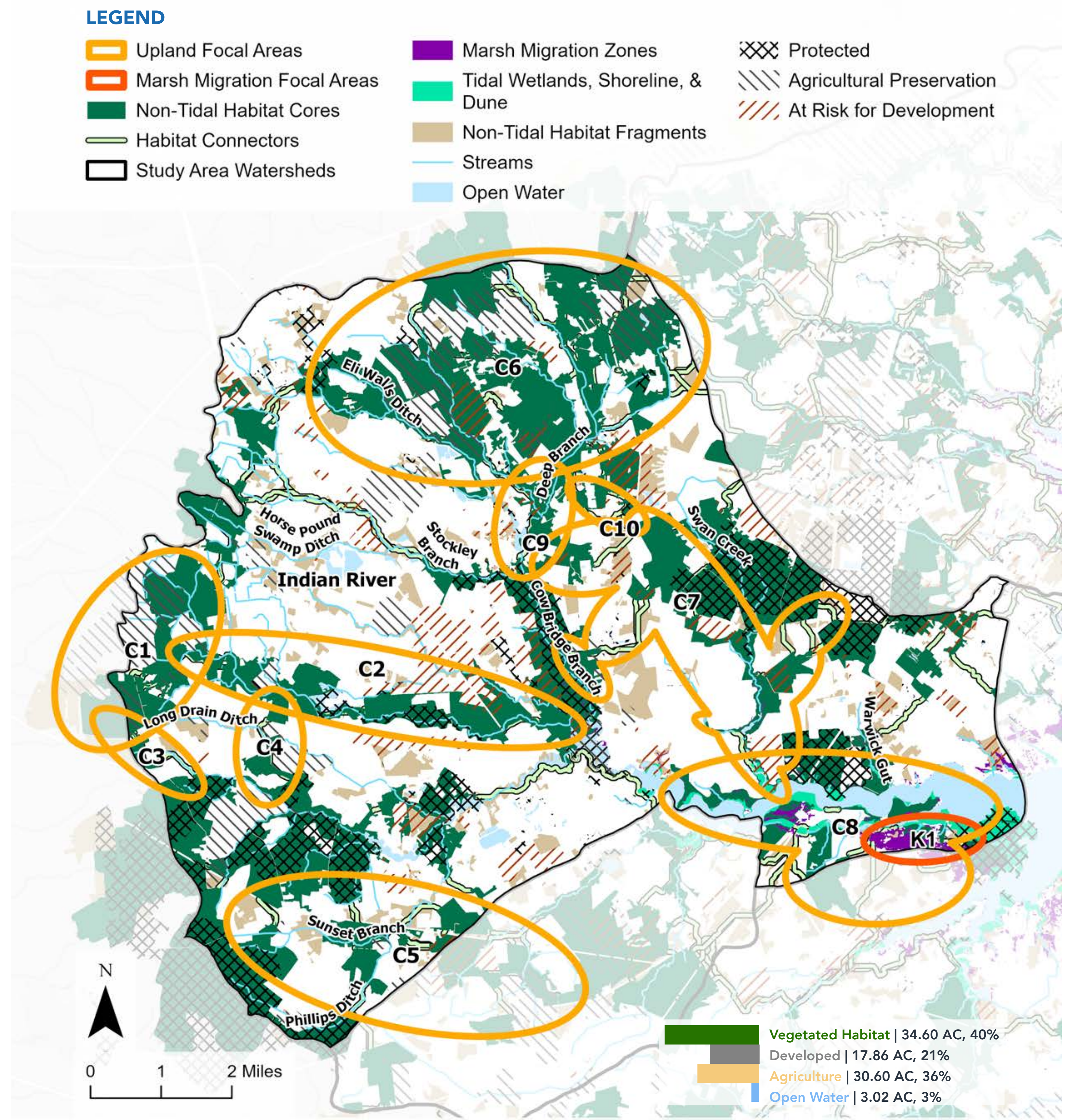


Figure 5.4 Focal areas map: Indian River watershed

IRON BRANCH

Table 5.4 Iron Branch summary statistics								
Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
15.42	0.98%	-0.30%	3.12%	2.50%	-0.98%	1.87%	1.11	7.17%

NOAA Wetland Type	Baseline Acreage (0.5′ SLR)	1.5′ SLR Acreage	Net gain/loss 0.5′ to 1.5′ SLR	% Change
PL Forested Wetland	2339.84	2324.00	-15.84	-0.68%
PL Scrub Shrub Wetland	571.64	570.76	-0.89	-0.16%
PL Emergent Wetland	72.11	72.11	0.00	0.00%
Brackish/Tidal Marsh	23.52	26.17	2.64	11.24%
Estuarine Wetland	47.09	45.50	-1.59	-3.39%
Unconsolidated Shore	9.69	18.60	8.90	91.89%

Iron Branch Watershed has a larger percentage of agricultural land cover than most other watersheds in the study area (44%). Thirty-seven percent of the watershed is vegetated habitat, and 2% is open water, with some of the headwaters and tributaries of the Indian River. Seventeen percent of the land area is developed, the lowest of any watershed in the study area. Though the wetland cover in this watershed is low, similar to the Indian River watershed, there is likely to be some wetland transition as sea levels rise and affect the dynamics of the Indian River. Tidal marshes and unconsolidated shores are the wetland types most likely to increase in this area.

Iron Branch has significant extents of lands with agricultural preservation, which presents abundant opportunities to implement agricultural land buffers and other forms of habitat enhancement in these areas.

Area with habitat protection is much more limited, with some small patches along and near Iron Branch. The large, unprotected areas at the western edges of the watershed extending into Indian River and Indian River Bay watersheds, including Great Cypress Swamp, offer important opportunities for connection with core habitats in the network.

Focal Area D2 contains a large central cluster of interior forest cores. Other focal areas within and overlapping this watershed generally serve to link currently protected areas and Focal Area D2 together. Several large chunks of habitat core in focal areas C5 and D2 already face the imminent threat of development, elevating the importance of habitat connectors to other core areas. Focal Area D3 along Iron Branch and Wharton's Branch offers an opportunity to connect D2 from the uplands to Indian River and some small to moderately sized tidal wetland complexes. No marsh migration focal areas were identified in this watershed.

FOCAL AREAS: IRON BRANCH

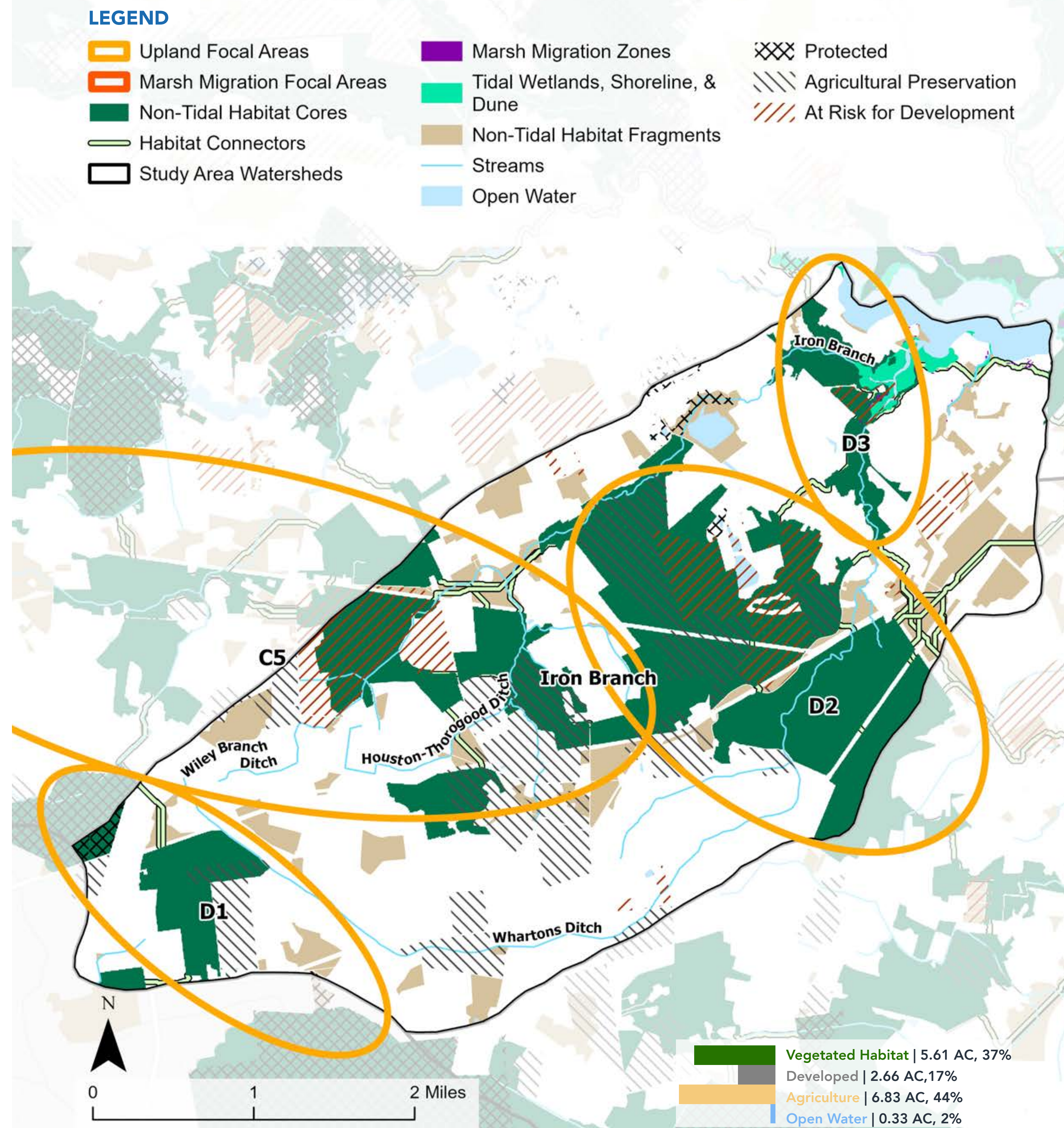


Figure 5.5 Focal areas map: Iron Branch watershed

INDIAN RIVER BAY

Table 5.5 Indian River Bay summary statistics								
Watershed Area Excluding Bays (sq. mi.)	**% Area Converted**						**Total developed since 1992 (sq. mi.)**	**Total Change 1992-2022 (as % of area)**
	1992-1997	**1997-2002**	**2002-2007**	**2007 - 2012**	**2012 - 2017**	**2017 - 2022**		
73.36	1.65%	1.92%	4.06%	1.08%	0.35%	1.87%	8.01	10.92%

NOAA Wetland Type	Baseline Acreage (0.5' SLR)	1.5' SLR Acreage	Net gain/loss 0.5' to 1.5' SLR	% Change
PL Forested Wetland	9705.61	9367.56	-338.05	-3.48%
PL Scrub Shrub Wetland	345.76	323.98	-21.78	-6.30%
PL Emergent Wetland	582.93	659.82	76.89	13.19%
Brackish/Tidal Marsh	691.55	869.81	178.26	25.78%
Estuarine Wetland	2361.67	1839.28	-522.39	-22.12%
Unconsolidated Shore	159.83	993.16	833.34	521.39%

Indian River Bay watershed is the largest watershed out of those in the study area. The open water of the bay and other smaller tributaries comprises 18% of its land cover. Twenty-four percent of it is developed, with much of that development concentrated in the eastern half of the watershed, adjacent to the water. Thirty-three percent of the watershed is vegetated habitat, with much of the protected core forest areas concentrated in the Great Cypress Swamp, and 25% of it is agricultural land. With sea level rise, the large complexes of tidal wetlands at the bay's edges will experience changes. Forested, scrub shrub, and estuarine wetlands are likely to give way to emergent, brackish/tidal wetlands and unconsolidated shore as saltwater levels increase.

Protected areas in the Indian River Bay watershed are generally comprised of the large Great Cypress Swamp nature preserve in the southwest, several protected areas of tidal wetlands along the bay, and a complex of protected areas in the southeast stretching from Beach Cove southward to Salt Pond. Agricultural preservation and some areas at risk for development are scattered throughout the watershed south of the bay.

Larger unprotected interior forest cores that are also wetland forest cores are found in the southwest half of the watershed in Upland Focal Areas E1 and E3. Other upland focal areas are generally comprised of narrower wetland forest cores that create linkages between E1 and E3 to existing protected areas and outside of the watershed. Habitat connectors are a mix of riparian and non-riparian corridor conditions, with all focal areas having some non-riparian length of habitat connectors. Denser development along White Creek and its headwaters limits potential land-based connections to the protected areas of the eastern edge of the watershed.

This watershed has several larger, unprotected marsh migration areas adjacent to moderately sized tidal wetland complexes that are identified as marsh migration focal areas. Many of these connect with upland focal areas, giving the potential for an enduring habitat network stretching from the bay into the uplands along streams such as Vines Creek and Blackwater Creek.

FOCAL AREAS: INDIAN RIVER BAY

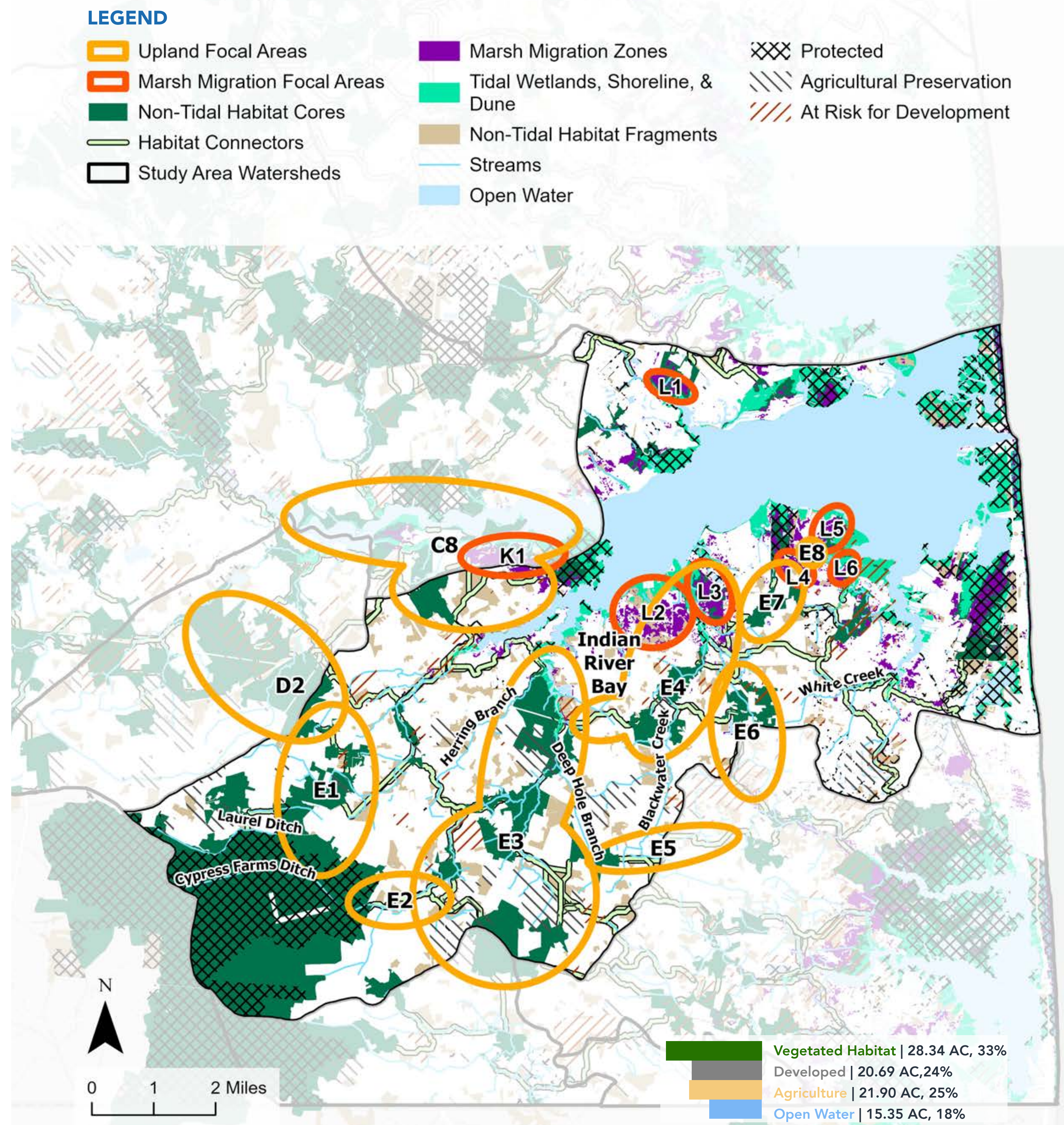


Figure 5.6 Focal areas map: Indian River Bay watershed

BUNTINGS BRANCH

Table 5.6 Buntings Branch summary statistics

Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
9.86	1.94%	0.26%	1.48%	0.12%	0.30%	1.39%	0.54	5.49%

Buntings Branch watershed contains the second-highest percentage of vegetated habitat cover out of the watersheds in the study area (42%). It also has one of the highest percentages of agricultural land cover (40%). 18% of the watershed area is developed, with 5.5% being developed since 1992; this is a comparatively slower rate of development than many other watersheds have experienced. Buntings Branch is not projected to experience any habitat conversions from sea level rise, as it does not include any open water habitat.

A large portion of the Great Cypress Swamp overlaps the western end of Buntings Branch watershed; this is its largest protected habitat area. The much smaller protected areas in the eastern half of the watershed do not overlap with any habitat cores, and many of the habitat cores outside of the Great Cypress Swamp do not have any habitat or agricultural protection. A small exception to this exists in the northern corner of the watershed, where a large agricultural preservation area partially overlaps with a core habitat area.

The focal areas aim to connect the core habitat of the Great Cypress Swamp to smaller habitat patches to the north and east. Focal Area F1 extends eastward from the Great Cypress Swamp along Polly Branch and part of Sandy Branch. It also contains a non-riparian connector to Focal Area E3, which is predominantly in the Indian River Bay watershed and overlaps into the north end of Buntings Branch watershed. With a comparatively low percentage of the focal area being immediately threatened by development, an opportunity exists here to solidify robust habitat corridors within more developed areas into the conserved core habitat of the Great Cypress Swamp.

FOCAL AREAS: BUNTINGS BRANCH

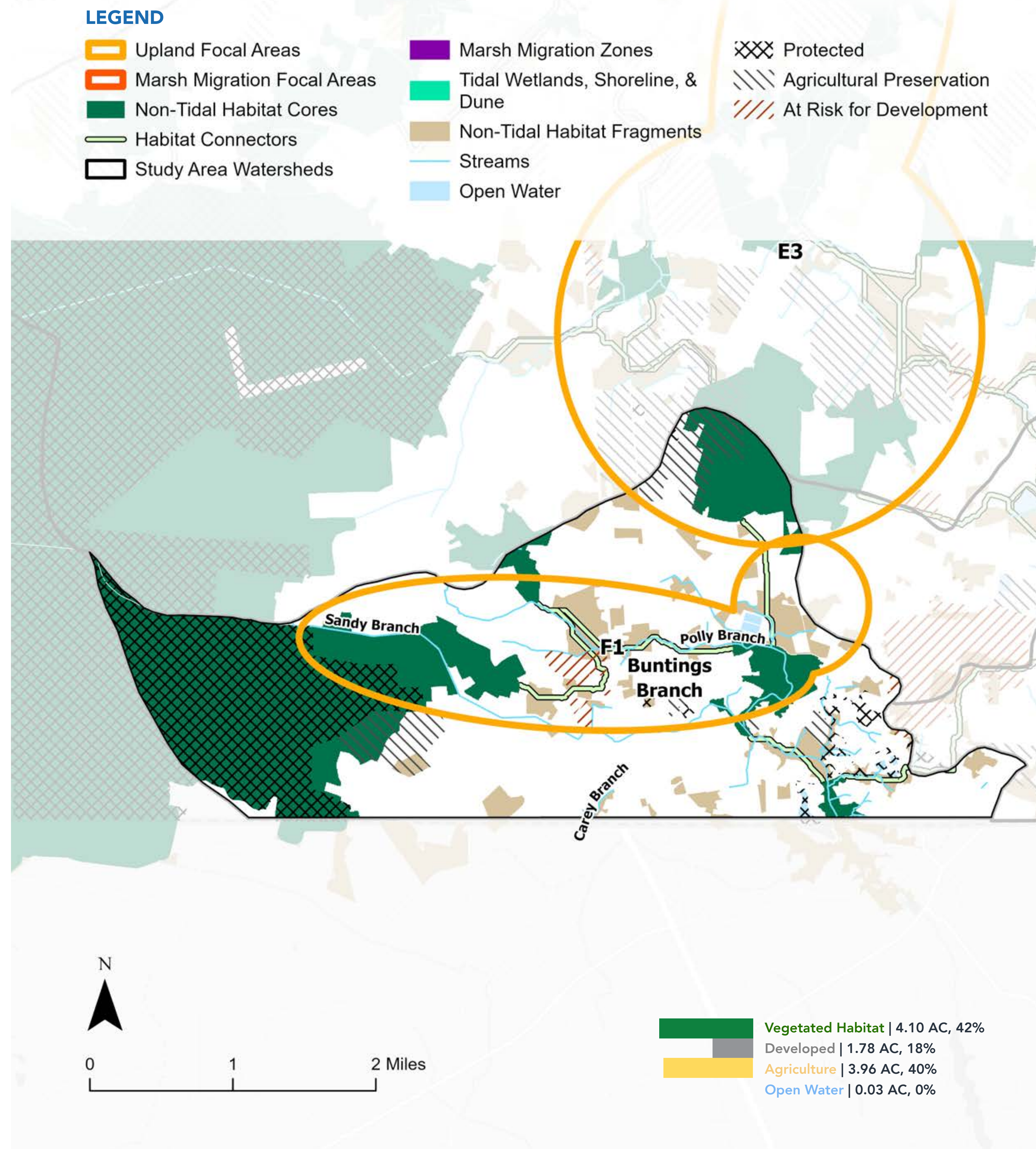


Figure 5.7 Focal areas map: Buntings Branch watershed

ASSAWOMAN

Table 5.7 Assawoman summary statistics

Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
7.01	0.66%	0.29%	0.28%	0.75%	1.19%	5.60%	0.61	8.77%

NOAA Wetland Type	Baseline Acreage (0.5′ SLR)	1.5′ SLR Acreage	Net gain/loss 0.5′ to 1.5′ SLR	% Change
PL Forested Wetland	368.40	355.35	-13.05	-3.54%
PL Scrub Shrub Wetland	17.85	17.77	-0.07	-0.42%
PL Emergent Wetland	15.26	17.89	2.62	17.18%
Brackish/Tidal Marsh	7.60	21.66	14.06	184.96%
Estuarine Wetland	2.25	5.23	2.99	132.79%
Unconsolidated Shore	4.74	5.19	0.44	9.37%

Situated on the border between Delaware and Maryland, Little Assawoman watershed has the smallest area of any of the study area watersheds, at 7.01 square miles. It also has the largest percentage per land area of agricultural land (44%). It is covered by 23% vegetated habitat and 4% open water and is 29% developed land. With 8.77% of that area developed since 1992, it has one of the lower recent development rates out of the study area watersheds. This area is likely to experience a significant increase in wetland areas, specifically tidal marsh and estuarine wetlands, due to sea level rise.

There are no areas in Assawoman watershed that are under habitat protection. Some scattered areas have some agricultural land protection applied, and some if that area overlaps with habitat fragments. The main area of core habitat in the watershed remains unprotected. The northern end of Little Assawoman watershed in the study area drains south and westward outside of the study area into Maryland and the Assawoman Bay. Focal Area G1 includes the single habitat core in the study area, with the potential to connect to the south to a large interior forest core across the border in Maryland.

Focal Area L1 centers on a marsh migration area along Buntings Branch and White Oak Swamp Ditch. Tidal wetlands are not currently present in this watershed within the study area, but sea level rise up these tributaries is projected to create future brackish and saltwater marsh zones.

FOCAL AREAS: ASSAWOMAN

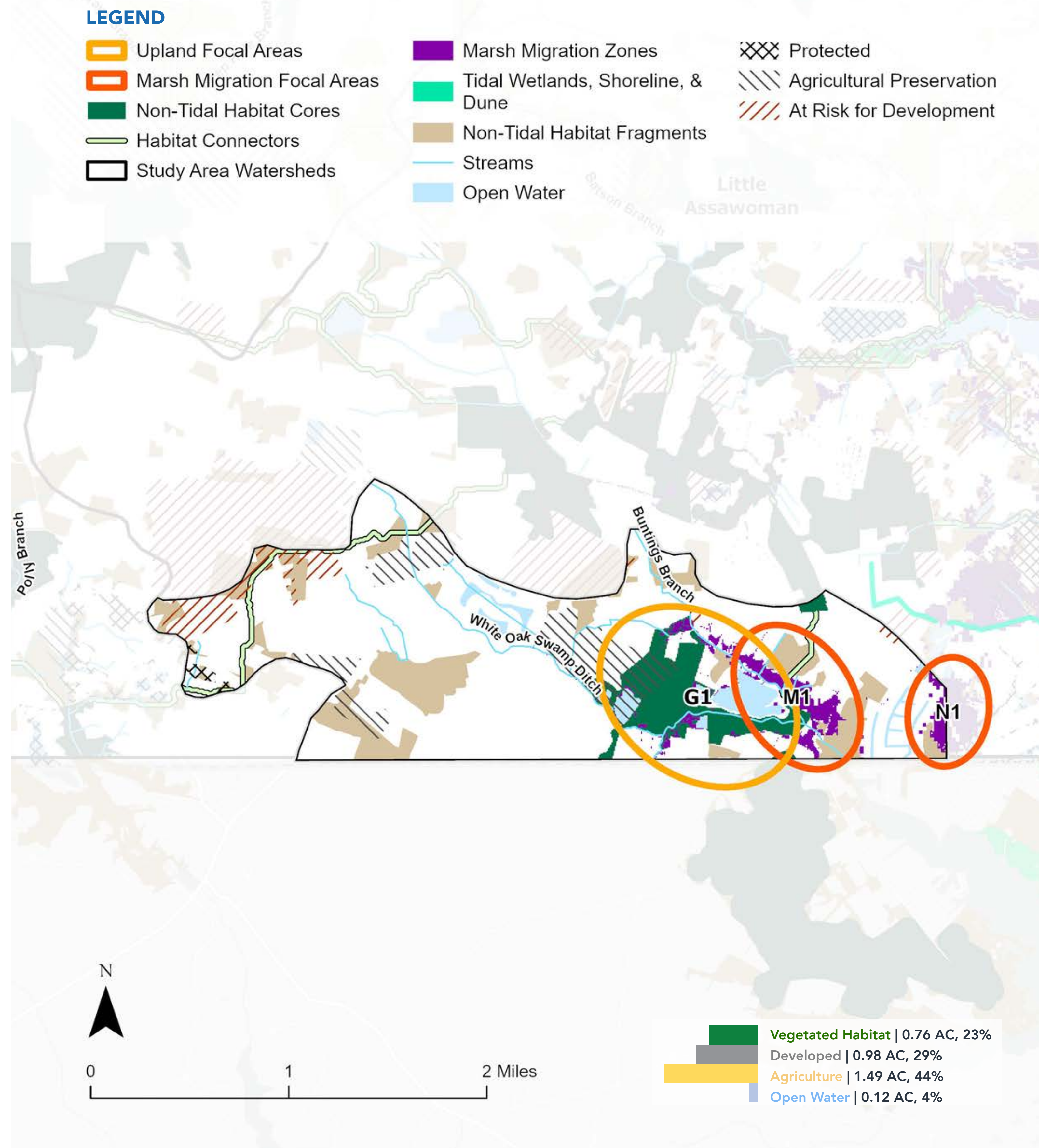


Figure 5.8 Focal areas map: Assawoman watershed

LITTLE ASSAWOMAN

Table 5.8 Little Assawoman summary statistics								
Watershed Area Excluding Bays (sq. mi.)	% Area Converted						Total developed since 1992 (sq. mi.)	Total Change 1992-2022 (as % of area)
	1992-1997	1997-2002	2002-2007	2007 - 2012	2012 - 2017	2017 - 2022		
30.59	2.63%	2.18%	6.29%	0.31%	1.80%	6.17%	5.93	19.37%

NOAA Wetland Type	Baseline Acreage (0.5′ SLR)	1.5′ SLR Acreage	Net gain/loss 0.5′ to 1.5′ SLR	% Change
PL Forested Wetland	3689.35	3418.81	-270.54	-7.33%
PL Scrub Shrub Wetland	118.60	106.15	-12.45	-10.50%
PL Emergent Wetland	404.62	437.84	33.21	8.21%
Brackish/Tidal Marsh	625.83	638.11	12.28	1.96%
Estuarine Wetland	1305.09	731.48	-573.61	-43.95%
Unconsolidated Shore	188.31	860.48	672.17	356.95%

Little Assawoman watershed contains a large portion of the Assawoman Bay, some of which extends southward into Maryland. Open water comprises 15% of the watershed area, and vegetated habitat 31%. The watershed is 33% developed, with 19.37% of that being converted since 1992; this area faces similar development patterns and pressure as other bayside areas. 21% of land area is devoted to agriculture. Wetland areas along the bays in this watershed will be affected by sea level rise; wetlands will transition from forested and scrub shrub conditions to emergent wetlands and mainly unconsolidated shores.

The largest protected area in this watershed is the Assawoman Wildlife Area, along the Little Assawoman Bay. Extending from the western northern, and eastern shores of the bay, this area contains expanses of interior forest core, wetland forest core, tidal wetland, and marsh migration areas. There is also a protected wetland and forest cluster to the south along Roy Creek, which is a tributary to Assawoman Bay.

In the upland areas of this watershed, larger core habitat patches generally are found along tributaries to the Little Assawoman and Assawoman Bays. Most core upland habitats in this area are unprotected, and some are imminently threatened by development. Focal Area H1 centers on the most robust network of unprotected habitat patches in the watershed, moving along Miller Creek and its tributaries. This focal area includes an interior forest core with some risk of development, wetland forest cores, and larger forest fragments. Focal Area H2 highlights the unprotected portion of an interior forest core connected to the Assawoman Wildlife Area. Focal Areas E5 and E6 connect to focal areas in the adjacent Indian River Bay watershed. E6 faces some relevant development risk that threatens to compromise the quality of this habitat connector.

Outside of existing protected areas, land is developed right up to the bays. This limits marsh migration areas and habitat connections to the headwaters. To retain existing potential corridors, four marsh migration Focal Areas are identified. Areas M1 and M2 are located outside of existing protected areas; M2 and M4 are adjacent to the protected wetland and forest complexes alongside Little Assawoman Bay.

FOCAL AREAS: LITTLE ASSAWOMAN

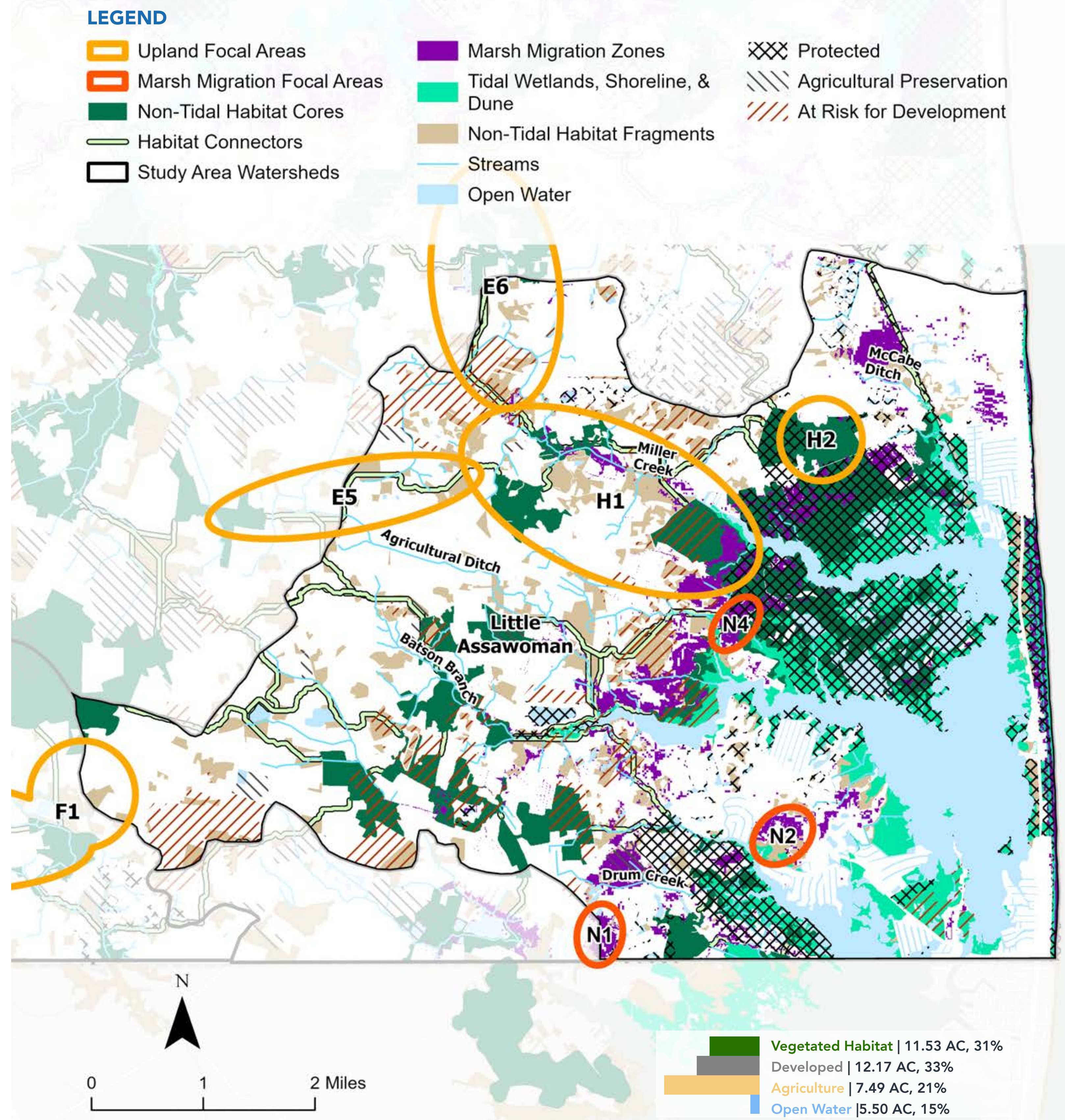


Figure 5.9 Focal areas map: Little Assawoman watershed

SECTION 6

REFERENCES & GLOSSARY

Luna moth *(Actias luna)*

Photo credit: CIB

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GLOSSARY

Agricultural preservation area: An area designated by legal means to continue agricultural production. Agricultural Preservation is identified separately from other Protected Categories. While these lands may include habitat protection, we recognize that the primary intention of this protection is to maintain agricultural production in those areas.

Areas At Risk for Development: At Risk for Development are identified from Sussex County permits and the Preliminary Land Use Service (PLUS) program of the Delaware Office of State Planning Coordination (OSPC). Further discussion of the At Risk for Development category is provided in Land Use / Land Cover Analysis in Section 3.

Clean Water Act: The CWA is the principle law governing pollution control and water quality of the Nation's waterways. The objective of the CWA is to restore and maintain the chemical, physical and biological integrity of the Nation's waters (33 U.S.C. 1251).

Climactic variables: Climactic variables are a complex set of interrelated physical, chemical, and biological factors that are influenced by the atmosphere, land, and oceans and define the prevailing weather patterns (e.g., precipitation, wind speed and direction, temperature).

Core habitat: An important type of patch which consist of large, contiguous areas of habitat.

Corridor: In landscape ecology, a linear feature which differs from the land on either side of it and connects patches together.

Developed area: Dominated by impervious surface, but sometimes contain lawns, gardens, trees, and other vegetation. These areas can provide habitat for species tolerant of developed conditions. However, the scale of this analysis is focused on larger spatial units of habitat.

Early successional forest: In this analysis, early successional habitats include grassland and meadow, early successional forests, and emergent wetlands.

Ecological succession: The process of ecological community compositional change over time, which eventually results in a mature ecosystem.

Ecological group: is a contingent of species which occupy a similar habitat or niche, for example, grassland birds, forest butterflies, or diadromous fish.

Edge to interior ratio: The ratio of forest edge habitat to interior forest habitat in a given forest patch.

Focal Areas for Conservation: Areas defined in each Inland Bays watershed by this analysis as having particular existing or potential value to the green infrastructure network.

Generalists: Species which can carry out their life cycle in a broad range of habitat conditions.

Green infrastructure network: The totality of natural and constructed green infrastructure features across a landscape.

Green infrastructure: Refers to a wide variety of both natural and constructed landscape elements, including but not limited to forests, wetlands, waterways, meadows, vegetated bioswales, gardens, and green roofs. These features provide multiple benefits, including wildlife habitat, nature-based recreational opportunities, water filtration, reduced stormwater runoff, and mitigation of urban heat island effects.

Habitat fragmentation: The phenomenon that each time an area of wildlife habitat is divided, the area of edge habitat is increased, and the area of interior habitat is decreased. This is one of the most important landscape-level patterns that contributes to habitat degradation in a network over time.

Habitat value: The presence of the four habitat requirements, food, water, cover, and space.

Habitat: A habitat is the area where a living organism makes its home and accesses the resources necessary for it to live and reproduce.

High Conservation Value Habitats (HCVH): Habitats which, based on the parameters of this analysis, were considered to be both high in ecological quality and importance to the overall green infrastructure network.

High-mobility species: Species which have larger contiguous habitat requirements but can tolerate larger gaps between habitat patches (e.g. fox).

Home range: the habitat area needed to sustain an individual of a given species.

Hydrologic cycle: The hydrologic cycle involves the continuous circulation of water in the Earth-Atmosphere system. At its core, the water cycle is the motion of the water from the ground to the atmosphere and back again.

Impervious surface: A surface through which water cannot infiltrate.

Interior Forest Core: For this analysis, contiguous areas greater than or equal to 100 acres that are at least 100 meters from a forest edge.

Interior forest: The area of a forest that is not within what is defined as the forest edge. This is commonly defined as being more than 300 feet from the outer edge of the forest.

Intertidal flat: Shallow, often muddy, part of foreshore, which are covered and uncovered by the rise and fall of the tide.

Invasive species: a species whose historical range is outside of that ecosystem in question, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Landscape connectivity: when the parts of a green infrastructure network are more interconnected with one another by natural features, ecosystem function improves drastically throughout the network.

Landscape ecology: An academic discipline within the field of ecology which analyzes ecological patterns at a landscape scale.

Least Cost Path (LCP) Modeling: A method of spatial analysis that finds the most cost-effective path, from a start point to a destination. As it goes from start to finish, the chosen path accumulates the least amount of "cost".

Low-mobility species: Species which require smaller areas of contiguous habitat but will not readily migrate over longer distances to other habitat areas (e.g. salamander).

Marsh migration: A phenomenon in which marshes migrate landward as sea levels rise.

Mosaic: In landscape ecology, the mosaic is the collective pattern of constituent elements that comprise a given landscape. The mosaic is comprised of patches and corridors.

Native species: A native plant is a plant that is a part of the balance of nature that has developed over hundreds or thousands of years in a particular region or ecosystem.

Patch: In landscape ecology, an area where the type of land cover is relatively homogeneous over a contiguous area at a given scale.

Pervious surface: A surface through which water is able to infiltrate.

Relative Resistance Value: a measure of how difficult it is for an animal to traverse a patch. For example, the relative resistance of a lawn for a white-tailed deer may be low, but it may be high for a salamander.

Salt marsh: Coastal wetlands that are flooded and drained by salt water brought in by the tides. They are marshy because the soil may be composed of deep mud and peat.

Sea level rise (SLR): An increase in the total volume of ocean water, resulting from the addition of melting glaciers and polar ice sheets, as well as the natural expansion of water as it warms.

Sedimentation: Sedimentation is the deposition of rock fragments, soil, organic matter, or dissolved material that has been eroded, that is, has been transported by water, wind, ice, or gravity.

Specialists: Species which require very specific conditions to carry out their life cycle.

Species-area relationship: The principle that the larger the area of contiguous habitat, the more species that habitat can support.

Stressor: In ecological terms, any change in landscape condition which compromises the normal functioning or productivity of an ecosystem or species within an ecosystem.

Submerged Aquatic Vegetation (SAV): Also referred to as bay grasses; vascular plants that grow underwater.

Tax Ditch: Landscape features such as grass swales whose purpose is to provide drainage. Tax ditches are so named due to their being owned and stewarded jointly by governmental entities and private landowners. Tax ditches have the potential to become important habitat features.

Threat: In ecological terms, a process or event that is likely to cause imminent harm or destruction to the health, functioning, or existence of an ecosystem. A stressor may become a threat over time.

Tidal Marsh, Beach and Dune Habitats: Sandy beaches, dunes, salt marshes, and intertidal areas.

Tidal marsh: Salt or freshwater coastal wetlands that are flooded and drained by water brought in by the tides.

Tidal River and Bay Habitats: All tidal open waters: the rivers flowing into the bays, and the bays themselves.

Tidal River: An open water body with a flow that is predominantly driven by the daily tidal cycle.

Total Maximum Daily Load (TMDL): Threshold levels of pollutants that cannot be exceeded by law.

Upland and Nontidal Habitats: Upland and nontidal habitats included all types of forest, palustrine wetlands, early successional forest, scrubland, and nontidal streams, rivers, and ponds.

Upland Habitat Core: For this analysis, the areas of interior and wetland forest cores in the Inland Bays watershed.

Vernal Pool: A seasonal freshwater wetland that forms in depressions in the landscape. These unique and valuable wetlands may lack federal protections under the Clean Water Act (1972) like other wetlands because they are not always connected to streams and rivers.

Watershed: An area of land that channels rainfall, snowmelt, and runoff into a common body of water.

Wetland: Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.

Wetland Complex: A mosaic of contiguous wetlands of varying types. This is common in tidal wetlands where the plant communities natural stratify into distinct high and low marsh zones based on frequency and depth of tidal inundation.

Wetland Forest Core: For this analysis, areas of forested wetland with contiguous areas greater than or equal to 100 meters.

APPENDICES

Monarch butterfly *(Danaus plexippus)*

Photo credit: CIB

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Delaware Inland Bays Habitat Management Plan
Appendix 2: Spatial Analysis Methods

This Appendix provides supplementary data and analysis information for Habitat Management Plan maps. Not every map is listed below. If a map is displaying existing data, without additional spatial analysis operations, it is not included in this Appendix.

HABITAT

VEGETATED HABITAT PATCHES

Inputs:
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- For MD, Chesapeake Bay Land Use and Land Cover (LULC) Database 2022 Edition. Representing 2017/2018 conditions
- County Streets, 2023

Methods:
- Delaware Land Use/ Land Cover was the basis for vegetated habitat.
- For MD only, Chesapeake Bay Land Use and Land Cover (LULC) Database 2022 Edition. Representing 2017/2018 conditions was applied for supplemental data for patches crossing the DE and MD state line.
- The following Delaware Land Use/ Land Cover categories were classified as vegetated habitat:

LUC_CODE2	LULC_CATEG
720	Beaches and River Banks
440	Clear-cut
410	Deciduous Forest
420	Evergreen Forest
730	Inland Natural Sandy Areas
430	Mixed Forest
330	Mixed Rangeland
623	Non-tidal Emergent Wetland
610	Non-tidal Forested Wetland
610	Non-Tidal Forested Wetland
622	Non-tidal Scrub/Shrub Wetland
780	Non-tidal Shoreline
320	Shrub/Brush Rangeland
673	Tidal Emergent Wetland
660	Tidal Forested Wetland
672	Tidal Scrub/Shrub Wetland
770	Tidal Shoreline

- For MD, The following Chesapeake Bay Land Use and Land Cover categories were classified as vegetated habitat:

Value	LandUse
16	Bare Shore
32	Harvested Forest Herbaceous
41	Forest
42	Other Tree Canopy
54	Natural Succession Barren
55	Natural Succession Herbaceous
56	Natural Succession Scrub/Shrub
61	Riverine Wetlands Barren
62	Riverine Wetlands Herbaceous
63	Riverine Wetlands Scrub/Shrub
64	Riverine Wetlands Tree Canopy
65	Riverine Wetlands Forest
71	Terrene Wetlands Barren
72	Terrene Wetlands Herbaceous
73	Terrene Wetlands Scrub/Shrub
74	Terrene Wetlands Tree Canopy
75	Terrene Wetlands Forest
91	Tidal Wetlands Barren
92	Tidal Wetlands Herbaceous
93	Tidal Wetlands Scrub/Shrub
94	Tidal Wetlands Tree Canopy
95	Tidal Wetlands Forest

- Development updates between 2017 and 2022 were removed from vegetated habitat (see Development Change analysis below for additional information).
- Roads, railroads, open water, and any land cover not classified as vegetated habitat were "breaks" between patches.
- Contiguous terrestrial habitat was dissolved into patches and acres of each calculated.

GENERAL LAND COVERS

Inputs:
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- Vegetated Habitat from Vegetated Habitat Patches above

- Protected
  - Protected Areas Database of the United States (PAD-US) 4.0
  - National Conservation Easement Database (NCED)
  - DE Protected Natural Resources 2.0
  - Delaware Protected Lands (DNREC)
- Agricultural Preservation
  - Delaware Aglands Preservation Districts 2.0
- Development Risk from Development Change analysis below
- National Hydrography Dataset Plus (NHDPlus)

Methods:
- Vegetated Habitat= from Vegetated Habitat Patches above
- Agriculture, Developed, and Open Water= Categories from Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions

BROAD HABITAT TYPES

Inputs:
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- For MD, Chesapeake Bay Land Use and Land Cover (LULC) Database 2022 Edition. Representing 2017/2018 conditions
- Delaware NVCS, 2010

Methods:
- Upland & Non-tidal= DE Land Use/ Land Cover: Forest and Non-Tidal vegetated habitat land covers; for MD Chesapeake Bay LULC: Forest and Non-Tidal vegetated habitat land covers
- Tidal Marsh, Beach, & Dune= DE Land Use/ Land Cover: Tidal Wetlands, Tidal Shoreline, Inland Natural Sandy Areas; DE NVCS: Beach, Sandy Beaches & Dunes; for MD Chesapeake Bay LULC: Tidal Wetlands
- Tidal Rivers & Bays= DE Land Use/ Land Cover: Open Water

UPLAND HABITAT CORES

Inputs:
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- For MD, Chesapeake Bay Land Use and Land Cover (LULC) Database 2022 Edition. Representing 2017/2018 conditions

Methods:
- Interior Forest Cores
  - Contiguous forested areas greater than or equal to 100 acres
  - 300 ft inward buffer applied to identify interior forest vs edge forest

  - Buffered back out 300 ft to identify full patch of interior forest and its edge buffer= Interior Forest Cores
- Wetland Forest Cores
  - Forest and wetland land covers combined to make wetland forest mosaic
  - Contiguous forested areas greater than or equal to 100 acres= Wetland Forest Cores
- Upland & Non-Tidal Fragments= all vegetated habitat land cover from DE LULC that are not part of Interior Forest Cores or Wetland Forest Cores

Additional Table Output

UPLAND HABITAT CORES	Acres	Percentage of Upland Habitat
Interior and Wetland Forest Cores	20,747	34%
Interior Forest Cores (only)	649	1%
Wetland Forest Cores (only)	22,977	37%
Tidal Wetland Contiguous with Wetland Forest Cores	5,994	NA
Upland & Non-Tidal Habitat Fragments	16,979	28%

EARLY SUCCESSIONAL HABITATS

Inputs:
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- Delaware NVCS, 2010

Methods:
- Early Successional Grassland, Scrub/Shrub, & Forest
  - DE Land Use/ Land Cover: Pasture, Herbaceous Rangeland, Mixed Rangeland, Shrub/Brush Rangeland
  - DE NVCS: Early Successional Forest (Seedling/Sapling), NE Successional Shrubland
- Early to Mid-Successional Forest
  - DE NVCS: Early to Mid-Successional Loblolly Pine Forest
- Non-Tidal Emergent & Scrub Shrub Wetlands
  - DE Land Use/ Land Cover: Non-tidal Emergent, Non-tidal Scrub/Shrub

Additional Table Output

EARLY SUCCESSIONAL HABITATS	Acres	Percentage of Early Successional Habitat
Early Successional Grassland, Scrub/Shrub, & Forest	5,839	52%
Early to Mid-Successional Forest	4,270	38%
Non-Tidal Emergent & Scrub Shrub Wetlands	1,060	9%

STREAMS, RIVERS, & PONDS

Inputs:

- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- National Hydrography Dataset Plus (NHDPlus)
- Delaware Tax Ditches 2.0

Methods:

- Streams
    - NHD Stream/River
    - NHD Connectors
    - NHD Named Canal/Ditch
- Tax Ditches
    - Delaware Tax Ditches 2.0
- Other Canals/ Ditches
    - NHD Unnamed Canal/Ditches that are also not Tax Ditches
- Bays, Coves, & Navigable Canals, from Delaware Land Use/ Land Cover
    - Bays and Coves (Tidal)
    - Cover Waterways/Streams/Canals
- Ponds & Impoundments, from Delaware Land Use/ Land Cover
    - Man-made Reservoirs and Impoundments
    - Natural Lakes and Ponds
    - Non-tidal Open Water

Additional Table Output

STREAMS, RIVERS, AND PONDS	Miles
Streams	245

Tax Ditches	394
Other Canals/ Ditches	326
	Acres
Ponds and Impoundments	1,836
Bays, Coves, & Navigable Canals	23,852

TIDAL MARSH, BEACH, & DUNE HABITATS

Inputs:

- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- Delaware NVCS, 2010
- Saltmarsh Restoration Priorities for the Saltmarsh Sparrow
- National Hydrography Dataset Plus (NHDPlus)
- Colonial Water Bird Survey Locations

Methods:

- Tidal Marsh
    - DE Land Use/ Land Cover: Tidal Wetlands
    - For MD, Chesapeake Bay LULC: Tidal Wetlands
- Sandy Beaches & Dunes
    - DE Land Use/ Land Cover: Inland Natural Sandy Areas
    - DE NVCS: Beach and Dune Communities/ Maritime Dune and Grassland
    - DE NVCS: Beach
- Salt Marsh Sparrow State Honorable Mention Habitat
    - As identified in Saltmarsh Restoration Priorities for the Saltmarsh Sparrow
- Surveyed Breeding Bird Islands
    - Colonial Water Bird Survey Locations

Additional Table Output

TIDAL MARSH, BEACH, & DUNE HABITATS	Acres	Percentage of Tidal Marsh, Beach, and Dune Habitat
Tidal Wetlands	9,829	77%
Sandy Beaches & Dunes	2,879	23%
Salt Marsh Sparrow State Honorable Mention Habitat	1,646	13%

Surveyed Breeding Bird Islands	525	4%

DATA ANALYSIS

UPLAND HABITAT CONNECTIVITY

Inputs:

- Interior Forest Cores from Upland Habitat analysis as described above
- Wetland Forest Cores from Upland Habitat analysis as described above
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions
- Chesapeake Bay Land Use and Land Cover (LULC) Database 2022 Edition. Representing 2017/2018 conditions
- County Streets, 2023

Methods:

- The Linkage Pathways tool in the Linkage mapper connectivity analysis software (McRae & Kavanagh 2011) was applied to identify Habitat Connectors (least cost paths).
- A separate model was run for Interior Forest Cores and for Wetland forest cores.
- Chesapeake Bay LULC was utilized for additional high resolution tree canopy within areas identified as Agricultural or Developed in the DE LULC.
- Habitat Connector: Not Developed- Riparian
    - Segment of habitat connector did not intersect developed land cover from DE LULC AND
    - <= 300 ft from streams and open water
- Habitat Connector: Not Developed- Not Riparian
    - Segment of habitat connector did not intersect developed land cover from DE LULC AND
    - > 300 ft from streams and open water
- Habitat Connector: Developed
    - Segment of habitat connector intersected developed land cover from DE LULC

Resistance Values

Land Cover from DE LULC	Resistance
Airports	Replaced by CB LULC
Bays and Coves (Tidal)	NO DATA= Not Crossable
Beaches and River Banks	100
Clear-cut	1
Communication Antennas	Replaced by CB LULC
Confined Feeding Operations/Feedlots/Holding	100
Cropland	75
Deciduous Forest	1
Evergreen Forest	1
Extraction	1000
Farmsteads and Farm Related Buildings	30
Herbaceous Rangeland	15
Highways/Roads/Access Roads/Freeways/Interstates	Replaced by CB LULC
Idle Fields	75
Industrial	Replaced by CB LULC
Inland Natural Sandy Areas	1
Institutional/Governmental	Replaced by CB LULC
Junk/Salvage Yards	Replaced by CB LULC
Man-made Reservoirs and Impoundments	NO DATA= Not Crossable
Marinas/Port Facilities/Docks	Replaced by CB LULC
Mixed Forest	1
Mixed Rangeland	15
Mixed Single and Multi-Family Residential	Replaced by CB LULC
Mixed Urban or Built-up Land	Replaced by CB LULC
Mobile home Parks/Courts	Replaced by CB LULC
Mobile Home Parks/Courts	Replaced by CB LULC
Multi-Family Dwellings	Replaced by CB LULC
Natural Lakes and Ponds	NO DATA= Not Crossable
Non-tidal Emergent Wetland	1
Non-tidal Forested Wetland	1
Non-Tidal Forested Wetland	1
Non-tidal Open Water	NO DATA= Not Crossable
Non-tidal Scrub/Shrub Wetland	1
Non-tidal Shoreline	NA
Orchards/Nurseries/Horticulture	15
Other Agriculture	15
Other Commercial	Replaced by CB LULC
Other Transportation/Utilities	NOT IN SA
Other Urban or Built-up Land	Replaced by CB LULC
Parking Lots	Replaced by CB LULC
Pasture	15
Railroads	Replaced by CB LULC

Recreational	Replaced by CB LULC
Retail Sales/Wholesale/Professional Services	Replaced by CB LULC
Shrub/Brush Rangeland	15
Single Family Dwellings	Replaced by CB LULC
Tidal Emergent Wetland	4
Tidal Forested Wetland	1
Tidal Scrub/Shrub Wetland	4
Tidal Shoreline	30
Transitional (includes cleared, filled, and gravel)	Replaced by CB LULC
Utilities	Replaced by CB LULC
Vehicle Related Activities	Replaced by CB LULC
Warehouses and Temporary Storage	Replaced by CB LULC
Waterways/Streams/Canals	NO DATA
New Development	150
New Ag	75
Tree Canopy in Developed	Replaced by CB LULC
Water	NO DATA= Not Crossable
North Canal	199
South Canal	198
Additional CB LULC Data with DE LULC Agriculture and Developed	**Resistance**
Bare Shore	10
Roads	150
Structures	500
Other Impervious	150
Tree Canopy Over Roads	5
Tree Canopy Over Structures	5
Tree Canopy Over Other Impervious	5
Tree Canopy Over Turf Grass	5
Turf Grass	30
Transitional Barren	150
Harvested Forest Barren	150
Harvested Forest Herbaceous	150
Solar Field Herbaceous	200
Extractive Barren	1000
Forest	2
Other Tree Canopy	5
Suspended Succession Barren	150

Suspended Succession Herbaceous	30
Suspended Succession Scrub/Shrub	30
Natural Succession Barren	150
Natural Succession Herbaceous	30
Natural Succession Scrub/Shrub	30
Riverine Wetlands Barren	1
Riverine Wetlands Herbaceous	1
Riverine Wetlands Scrub/Shrub	1
Riverine Wetlands Tree Canopy	1
Riverine Wetlands Forest	1
Terrene Wetlands Barren	1
Terrene Wetlands Herbaceous	1
Terrene Wetlands Scrub/Shrub	1
Terrene Wetlands Tree Canopy	1
Terrene Wetlands Forest	1
Cropland Barren	75
Cropland Herbaceous	75
Pasture/Hay Barren	75
Pasture/Hay Herbaceous	15
Pasture/Hay Scrub/Shrub	15
Orchard/Vineyard Barren	30
Orchard/Vineyard Herbaceous	30
Orchard/Vineyard Scrub/Shrub	30
Tidal Wetlands Barren	4
Tidal Wetlands Herbaceous	4
Tidal Wetlands Scrub/Shrub	4
Tidal Wetlands Tree Canopy	1
Tidal Wetlands Forest	1
Roads	**Resistance**
1_Primary	500 with 60m distance decay
2_Secondary	500 with 30m distance decay
3_Local	150
4_Other	35
5_Vehicular_Trail	35

DEVELOPMENT CHANGE

Inputs:

- Delaware Land Use/ Land Cover, 1997 to 2017
- State PLUS Project Areas Methods
- Sussex County Subdivisions
- Sussex County Planning and Zoning Land Use Applications
- Delaware State Parcels 2.0
- Delaware State Imagery 2022 and 2021
- ESRI Basemap and Google Earth Imagery
- ESRI Sentinel-2 Land Use/ Land Cover Time Series, 2017 to 2023

Methods:

- Five-year increments from 1997 to 2017 were directly from DE LULC data.
- State PLUS project, county subdivision, and county planning and zoning land use application data were reviewed with parcels to identify areas of potential development since 2017.
- ESRI Sentinel-2 Land Use/ Land Cover Time Series data were also reviewed and intersected with 2017 DE LULC data to identify areas of potential development since 2017.
- Aerial imagery was reviewed in areas of potential development since 2017 to identify development between 2017 and 2022.
- Areas at Risk for Development
    - State PLUS project, county subdivision, and county planning and zoning land use application data indicated that a parcel is in phase of pre-planning to fully permitted development.
      AND
    - The development change was not yet reflected in aerial imagery.

SEA LEVEL RISE

Inputs:

- NOAA Sea Level Rise (SLR) Data: 0ft, 2ft, 4ft, and 6ft

Methods:

- NOAA SLR data were mapped at the depths identified.

HABITAT SHIFTS WITH SEA LEVEL RISE

Inputs:

- NOAA Marsh Migration: 0.5 ft and 1.5 ft

DEVELOPMENT CHANGE

Inputs:

- Delaware Land Use/ Land Cover, 1997 to 2017
- State PLUS Project Areas Methods
- Sussex County Subdivisions
- Sussex County Planning and Zoning Land Use Applications
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HABITAT SHIFTS WITH SEA LEVEL RISE

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Delaware Inland Bays Habitat Management Plan
Appendix 2
Spatial Analysis Methods
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Methods:
- NOAA modeling of SLR scenarios for Lewes, DE for present-day conditions:
    - In 2020, approximately 0.5 ft (0.46 ft) of SLR from the 2000 baseline of 0 ft of SLR.
    - The 0.5 ft data were used as a baseline for present day conditions.
- NOAA modeling of SLR scenarios for Lewes, DE for future conditions:
    - 1.5 feet of SLR represents a very likely condition for 2050 (Intermediate to Intermediate High scenarios).
    - SLR could be even higher for 2050 (Intermediate High to High Scenarios).
- NOAA data for 0.5 ft and 1.5 ft SLR were compared to categorize the types of changes predicted with 1.5 ft SLR.
- NOAA Marsh Migration categories defined as "Wetland" = Freshwater Forested Wetland, Freshwater Shrub Wetland, Freshwater Emergent, Brackish/Transitional Marsh, and Estuarine Marsh.
- Wetland Remaining Same Type= pixels of wetland type the same between 0.5 ft and 1.5 ft SLR.
- Wetland Migration= Wetland present in 1.5 ft SLR but not at 0.5 ft SLR.
- Wetland Loss and Degradation= Wetland present at 0.5 ft SLR changes to Unconsolidated Shore or Open Water at 1.5 ft SLR.
- Wetland Type Change= Wetland present in both 0.5 ft and 1.5 ft SLR, but the specific wetland type changes.
- Unconsolidated Shore= Unconsolidated Shore present in both 0.5 ft and 1.5 ft SLR. Relatively little area is in this category.
- Water Remaining Water= Open Water present in both 0.5 ft and 1.5 ft SLR.
- Developed= Developed in the NOAA data. The NOAA modeling does not change Development land cover with SLR. It assumed the area is impervious and cannot receive wetland migration.
- Upland= Areas outside of the changes noted above.

MARSH MIGRATION

Inputs:
- NOAA Marsh Migration: 0.5 ft,1.5 ft, 3 ft, 4 ft, 5.5 ft
- Delaware Land Use/ Land Cover, 2017 with selected modifications to 2022 conditions

Methods:
- Areas of wetland for 1.5 ft, 3 ft, 4 ft, 5.5 ft SLR that were not present at 0.5 ft SLR were delineated as Wetland Migration areas.
- Tidal Wetland Complexes
    - Tidal Wetland land cover from DE LULC.
    - Individual Tidal Wetland patches separated by narrow waterways were dissolved into larger Tidal Wetland Complexes.
    - Acres were calculated.

FOCAL AREAS FOR CONSERVATION AND WATERSHED ENLARGEMENTS

Data inputs from other mapping and analyses noted above:
- Upland Habitat Cores
- Upland Habitat Connectivity
- Marsh Migration
- Tidal Marsh, Beach, & Dune Habitats
- Protected Areas as described in General Land Covers
- Development Change
- Delaware Ecological Network 2.0
- DNREC Rare Species and Habitat Data.
- Delaware NVCS, 2010

Methods:
- Focal Areas were delineated within and across watersheds, with the goal of having Focal Areas in each watershed.
- Upland Focal Areas
    - Concentrated on unprotected Non-tidal Habitat Cores and Habitat Connectors that could link and expand protected areas in a habitat network.
- Marsh Migration Focal Areas
    - Concentrated on unprotected areas identified as zones for future marsh migration in the analyses from NOAA models.
    - These Focal Areas had a preference for larger, contiguous marsh migration areas with presence at 1.5 ft, 3 ft, 4 ft, and 5.5 ft SLR.
    - The wetland complexes adjacent to the marsh migration zones were included in the Focal Area.
- The following data were reviewed to confirm and refine Focal Areas
    - Delaware Ecological Network 2.0
    - DNREC Rare Species and Habitat Data
    - Delaware NVCS, 2010- concentrating on representation of mapped vegetation communities with lower spatial coverage (i.e. less common) in the study area.

Royal walnut moth *(Citheronia regalis)*
Photo credit: Dr. Douglas Tallamy, University of Delaware