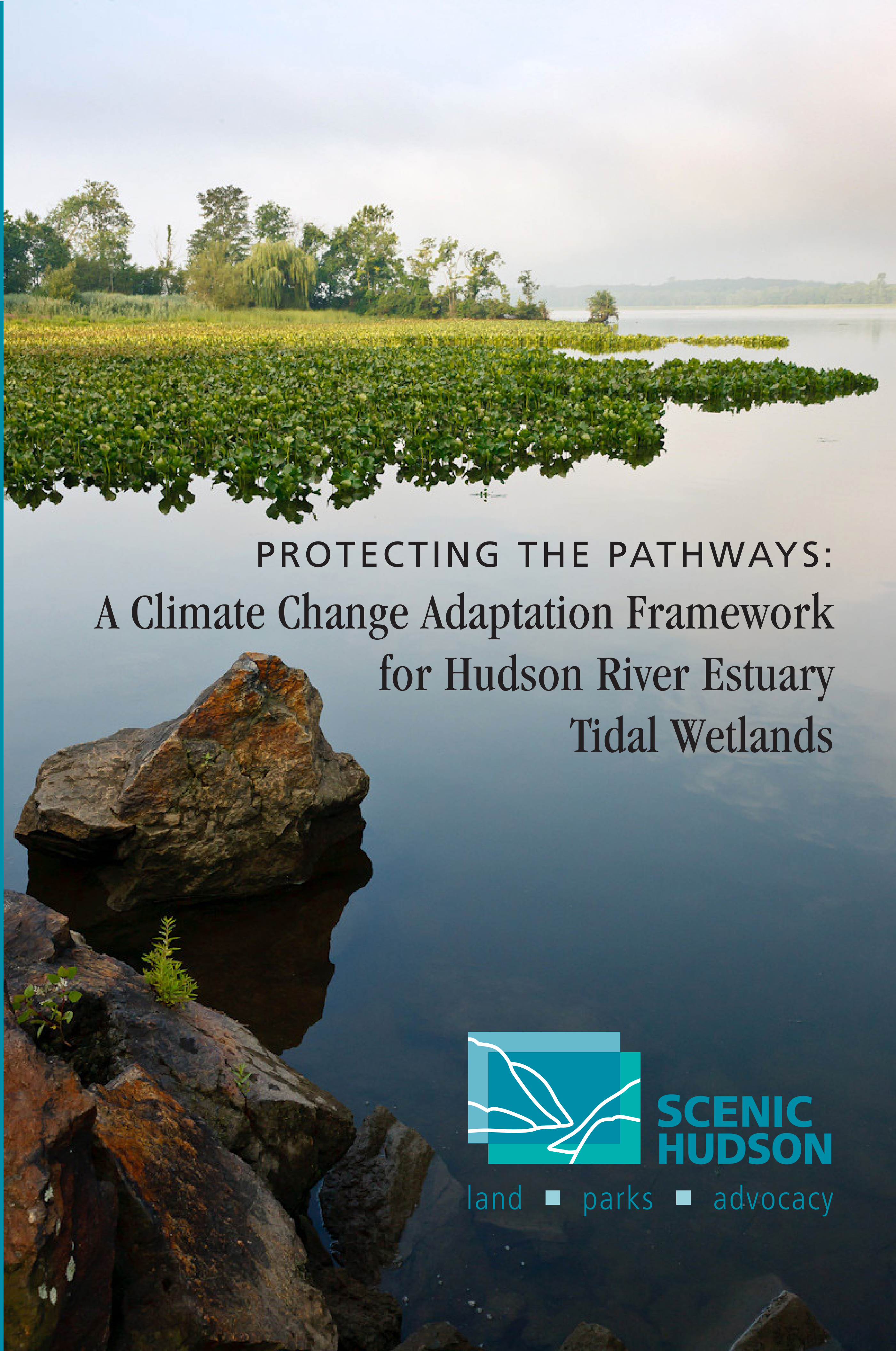

PROTECTING THE PATHWAYS:

A Climate Change Adaptation Framework for Hudson River Estuary Tidal Wetlands

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PROTECTING THE PATHWAYS:
A Climate Change Adaptation Framework for Hudson River Estuary Tidal Wetlands

Scenic Hudson, May 2016

Nava Tabak & Dr. Sacha Spector

Research and planning partners:

New York State Department of Environmental Conservation Hudson River Estuary Program

Hudson River National Estuarine Research Reserve

Cary Institute of Ecosystem Studies

The Nature Conservancy

Hudsonia Ltd.

Warren Pinnacle Consulting, Inc.

Cover Photo: Robert Rodriguez, Jr.

Robert Rodriguez, Jr.

TIDAL WETLAND: KEYSTONE HABITATS OF THE HUDSON

The Hudson River Estuary (HRE), stretching approximately 150 miles from the Battery in Manhattan to the Federal Dam in Troy, is a region of rich biological resources. At the heart of this estuarine ecosystem are approximately 7,000 acres of intertidal wetlands—keystone elements in the Hudson's aquatic and terrestrial ecology. Encompassing both brackish and freshwater tidal habitats such as mud and sand flats, emergent broad-leaf and graminoid-dominated marshes, and shrub and tree swamps, the Hudson's tidal wetlands are fundamentally important to supporting the species and functions of the estuary. They serve as feeding, nursery and refuge areas for the nearly 200 species of fish known from the HRE, including 11 migratory species of sturgeon, herring, bass, and eels that journey between the Hudson and the Atlantic. A myriad of migrating and overwintering shorebirds and waterfowl also depend on these rich tidal habitats. Many species of rare plants and animals, such as golden-club and the secretive least bittern, are specialist occupants of these wetlands.

Tidal wetlands also play vital roles in regulating the water quality and chemistry of the Hudson, removing pollutants like nitrogen, sequestering carbon, and oxygenating the water. Some of the wetlands provide valuable storm buffering services by absorbing floodwaters and dissipating wave energy, increasing the resilience of the adjacent uplands and waterfront communities.

Erik Kiviat/Hudsonia

Golden-club (orontium aquaticum)

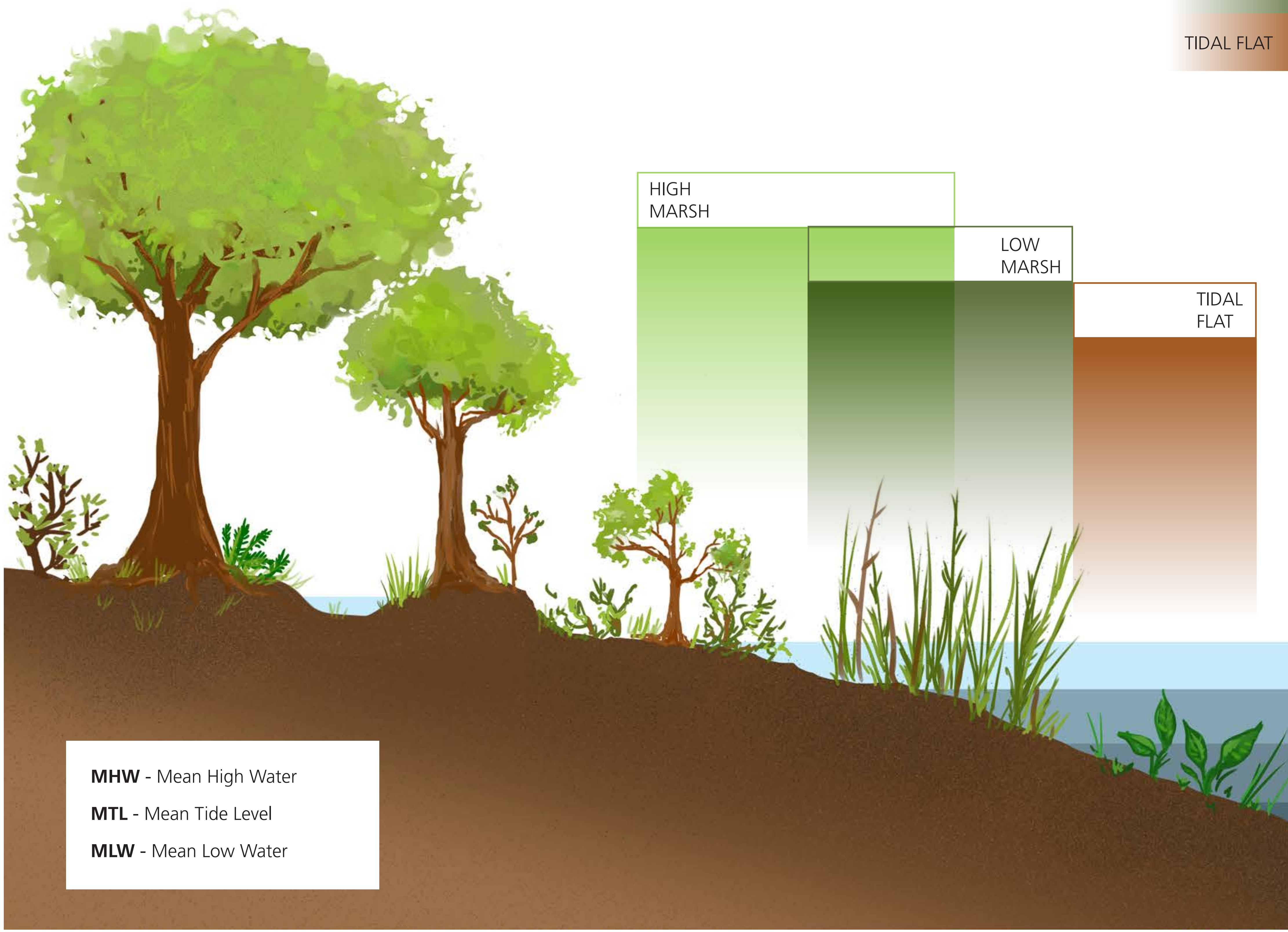
Peter Schoenberger

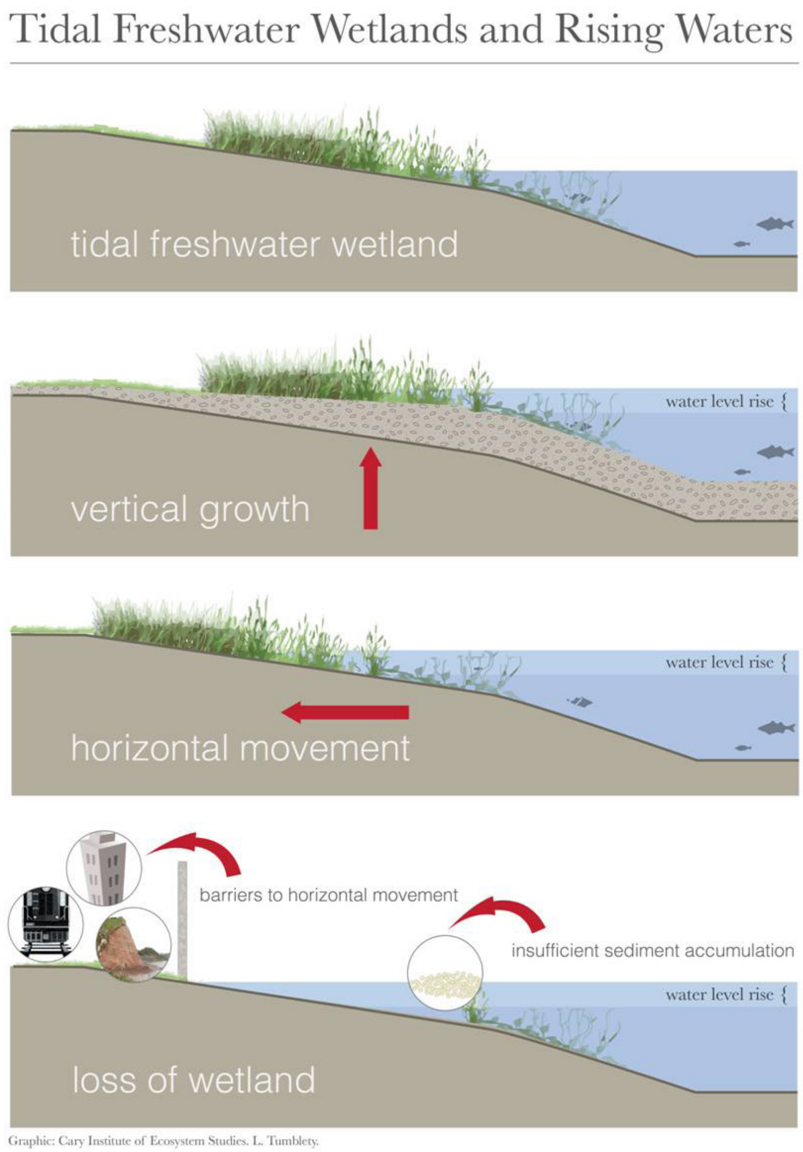
Least bittern

BETWEEN THE TIDES

Tidal wetlands center on the intertidal zone—the area between the reach of high and low tides. The tidal wetland community is comprised of plants and animals uniquely adapted to conditions of periodic inundation and dryness, with distinct assemblages of species that form recognizable wetland types. There are many different types of tidal wetland in the HRE, which can be broadly grouped based on their position in the intertidal zone. Tidal flats occur below mean tide level and thus are only exposed at low tide; low marshes are found above mean tide level and are flooded during most high tides; high marshes flood completely only during the highest of tides.

Tidal flats can be vegetated (above) or unvegetated (below)



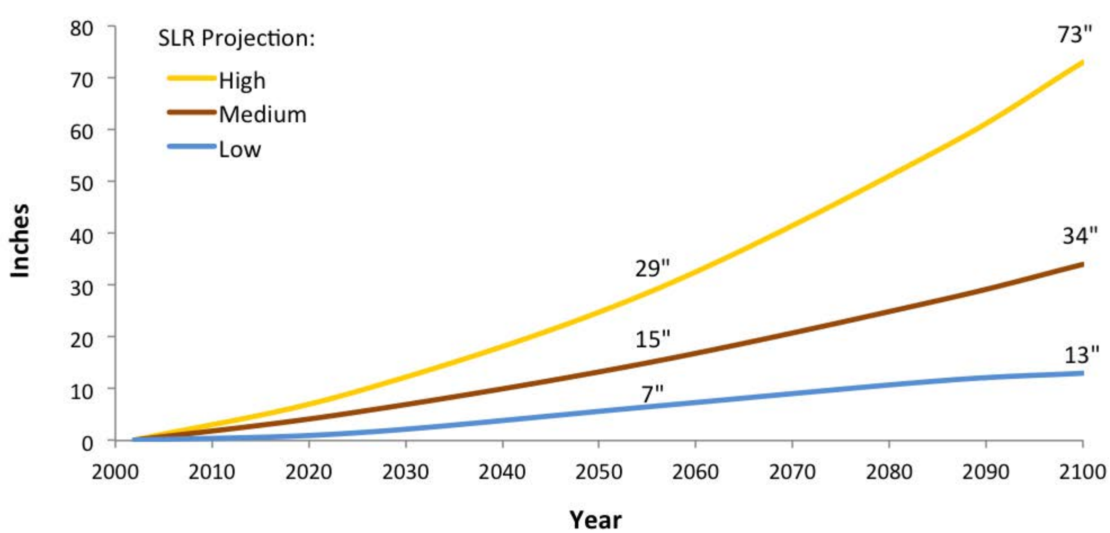


SEA LEVEL RISE AND TIDAL WETLANDS

For thousands of years the Hudson's tidal wetlands have persisted, adapting naturally to gradual changes in sea levels either by accretion—the vertical building up of elevation by trapping of sediment from the river's waters and the accumulation organic material from wetland vegetation—or by migrating horizontally up and down slope to track the changing elevation of the inter-tidal zone. But today and over the coming decades the accelerating pace of Sea Level Rise (SLR) caused by climate change may test the wetlands' natural capacity to adapt.

The HRE is likely to experience 3-6 feet of SLR by the end of the 21st century—a rate faster than any in recent millennia and potentially much faster than the wet-lands' ability to accrete and maintain their position between the tides. Steep slopes and shoreline development may further limit the wetlands' potential to adapt by restricting horizontal movement. Together these factors pose a fundamental challenge to the long term persistence of the HRE's wetland habitats and the health of the entire ecosystem.

PROJECTED HUDSON RIVER ESTUARY SEA LEVEL RISE



Sea level rise projections for the Hudson River Estuary, as described in the 2014 ClimAID technical report update "Climate Change in New York State", and adopted in the state's Community Risk and Resiliency Act in 2016.

RamsHorn Marsh tidal swamp (a)

photos this page: Jeff Anzevino

TODAY: CURRENT STATUS OF HUDSON RIVER TIDAL WETLANDS

The Hudson River Estuary exhibits great variation in physical and ecological characteristics, which are reflected in the character of the tidal wetlands distributed throughout its long reach. Its approximately 7,000 acres of intertidal wetland are concentrated largely within nearly 50 wetland areas.

In the lower estuary, ocean saltwater mixes with the river's fresh water, creating brackish conditions in approximately 20% of the HRE's tidal wetlands. In this brackish reach there is limited wetland migration potential due to intensive neighboring land uses, narrow floodplains, and relatively steep shores. Farther upstream the wetlands continue to experience the regular pulse of tides, but are outside the reach of saltwater. In the northern half of this long freshwater stretch the river is shallow and broad, and undeveloped low-elevation shores are more abundant. Approximately half of the estuary's current tidal wetland area is found in this most northern reach.

Binnen Kill (b)

Tivoli North Bay (c)

Iona Island Marsh (d)

West Flats & Vosburgh Swamp (e)

The HRE's major brackish and freshwater wetland areas

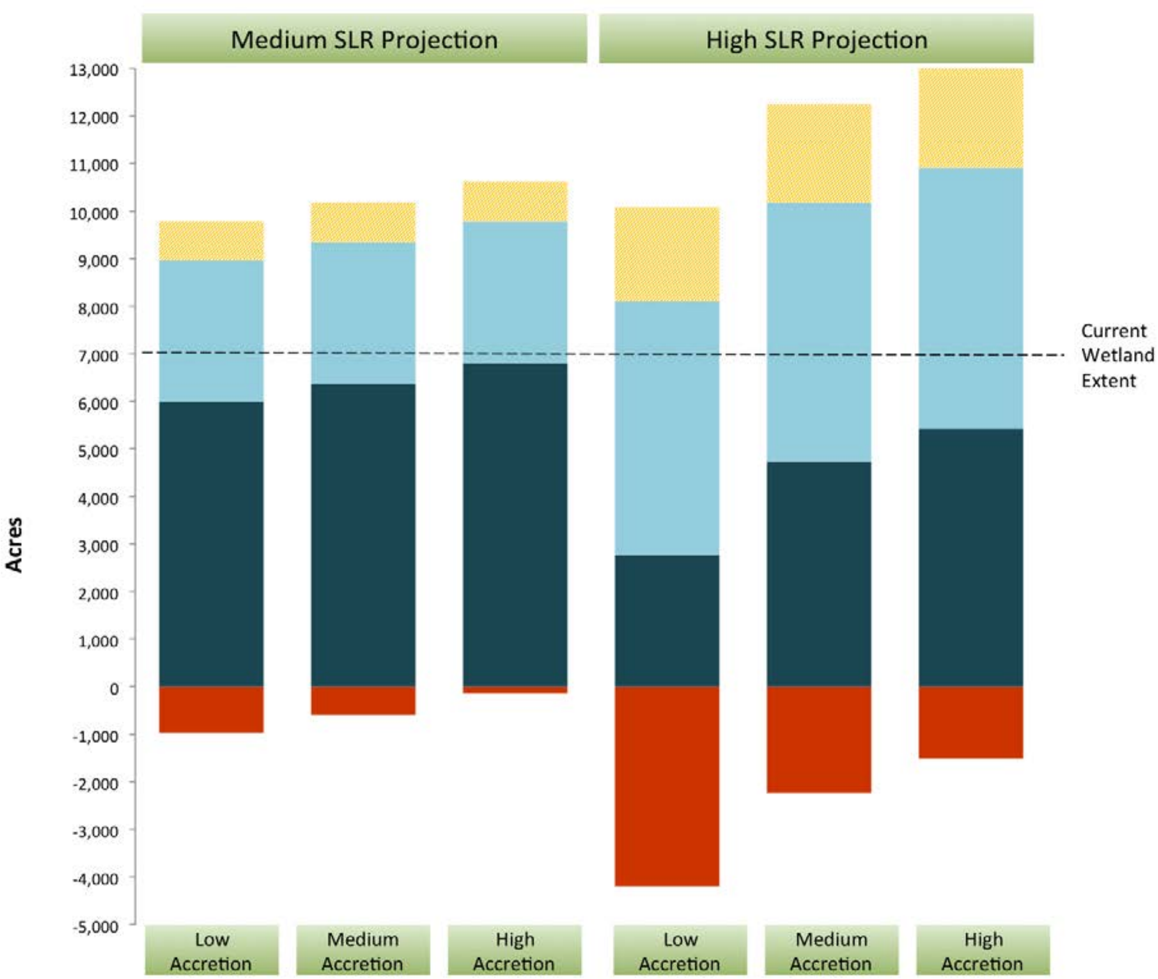
THE FUTURE: PROJECTED TRENDS

Will the tidal wetlands of the Hudson River successfully adapt to the changes in sea level in the coming decades? To begin to answer this question, a 2015 study examined the response of the HRE's wetlands to a range of possible rates of SLR and accretion by the end of the 21st century. The study projected that wetlands in the HRE will experience significant changes in this time span, the magnitude and nature of which will depend on the rate of SLR that is actually realized as well as the capacity of the wetlands to accrete.

> The results of the study are available from Scenic Hudson's website or the journal PLOS ONE:
> www.scenichudson.org • http://journals.plos.org/plosone

Wetland Resilience

The HRE wetland study examined the projected persistence of current wetlands, their loss to inundation, and the formation of new wetlands as measures of the habitat's resilience to SLR. Persistence of the existing wetlands over time was found to depend on both rates of SLR and accretion: higher rates of SLR will negatively impact the resilience of the HRE's current tidal wetlands, while higher rates of accretion will increase their capacity to build up in place and persist. Projected wetland losses range widely—as little as 150 acres or more than 4,000 acres could become permanently inundated by the end of the century depending on rates of SLR and accretion. Under higher rates of SLR tidal wetland resilience in the estuary will depend more heavily on successful horizontal wetland migration into new areas.



Estuary-wide projections of tidal wetland loss, persistence, migration, and conflict with developed areas under the range of SLR and accretion scenarios.

Lost wetland

Persistent wetland

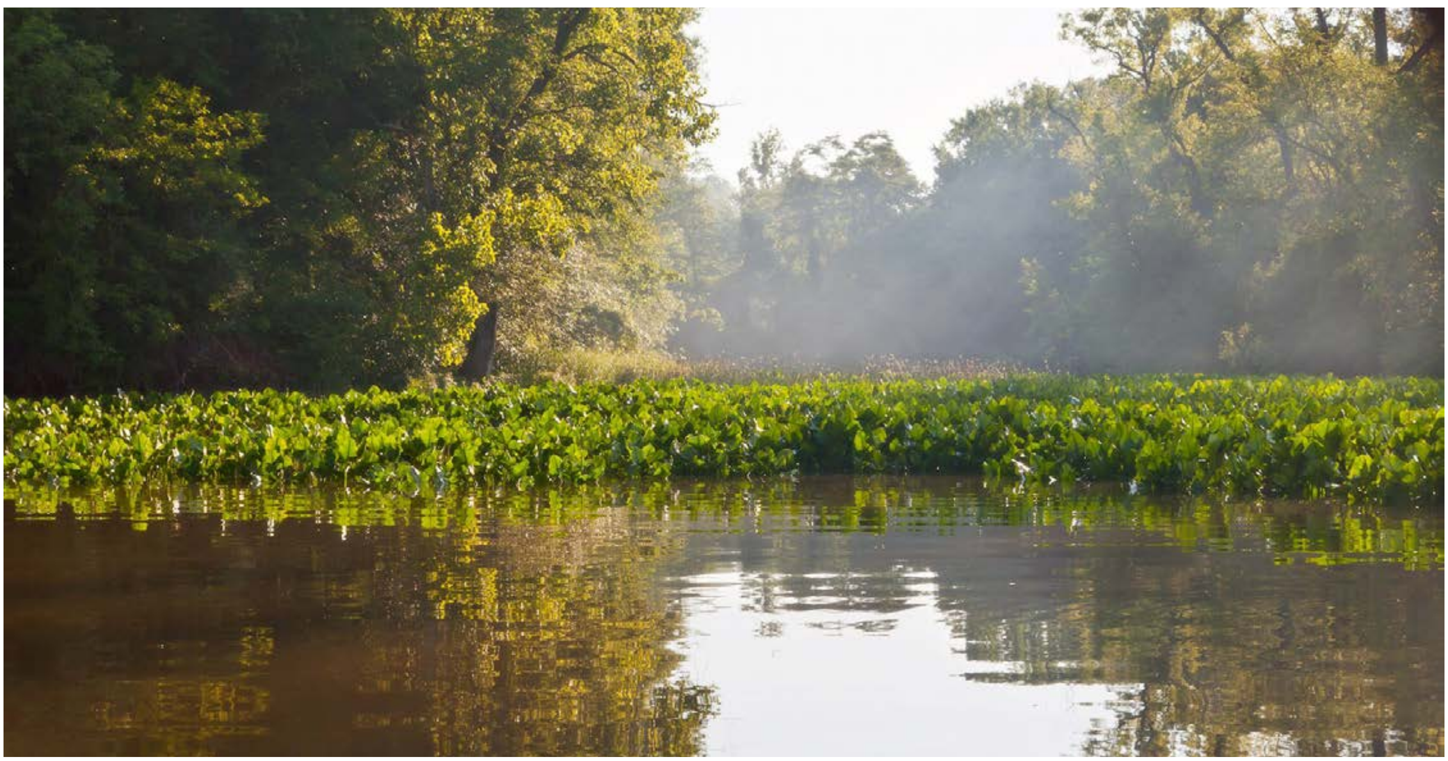
New wetland

New wetland/
Development conflict

New Wetlands

Without the addition of any new shoreline developments, tidal wetland acreage could range roughly 8,000-11,000 by the end of the century, depending on SLR and accretion rates. However, due to wetland losses, even maintaining the current acreage of tidal wetland (7,000 ac) will depend—in some cases heavily—on wetland migration: the horizontal movement of new wetlands into previously undeveloped upland areas. Wetland migration was projected to measure 3,000-5,500 acres across the estuary, while approximately 800-2,100 acres of existing development will likely present barriers to migrating wetlands. Wetland migration will be most pronounced in the northern reach of the estuary, where over 50% of the estuary's tidal wetland expansion will likely be concentrated in only three wetland systems. Throughout the estuary the expansion of existing tidal wetlands will depend on shoreline conditions that are conducive to the formation of new wetlands (e.g., sea walls, bulkhead, and rock ledges will limit the projected wetland migration).

If wetland migration potential is maximized, the estuary could host between 7,500-8,500 acres of tidal wetland by year 2040, and 8,000-11,000 acres by the end of the century.



Robert Rodriguez, Jr.

Geographic Distribution

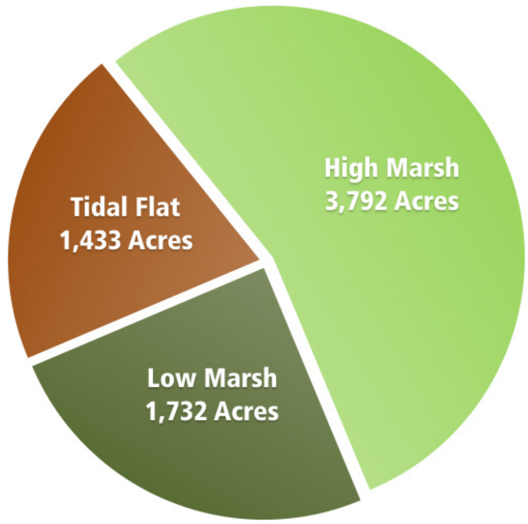
Due to differing physical conditions, current wetland distributions, and projected wetland migrations, changes in wetlands are expected to vary depending on location within the HRE. Based on the combined potential area of wetland projected under different possible SLR and accretion scenarios, the brackish (south) and central parts of the estuary will contribute a smaller proportion to the total wetland area over time, while wetland expansions in the northern estuary (from approximately the City of Hudson and north) will increase its relative contributions to the estuary's wetland portfolio.

	Current	2100
South	19%	17%
Center	31%	27%
North	50%	56%

Wetland Composition

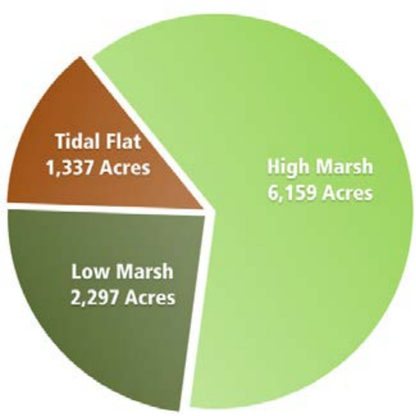
Depending on the realized SLR and accretion rates, the HRE's tidal wetlands could also experience dramatic shifts in the composition of the wetland types over time, with increases in the representation of the two lower elevation types (low marsh and tidal flat). Such changes are likely to impact ecosystem functions, the abundance of specific wetland types such as tidal swamp (a rare habitat which is found in the high marsh zone), and the biota dependent upon specific intertidal zones.

Current Wetland Composition

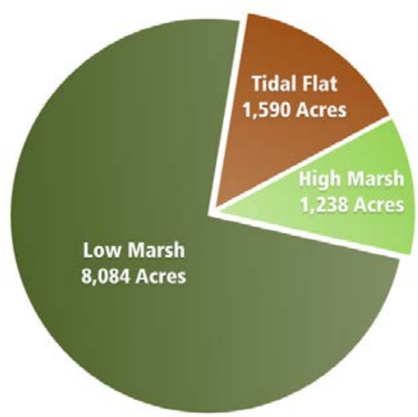


Projected wetland composition by 2100

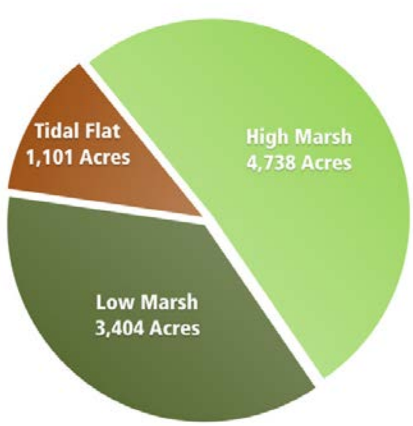
Medium SLR - High Accretion Estimate



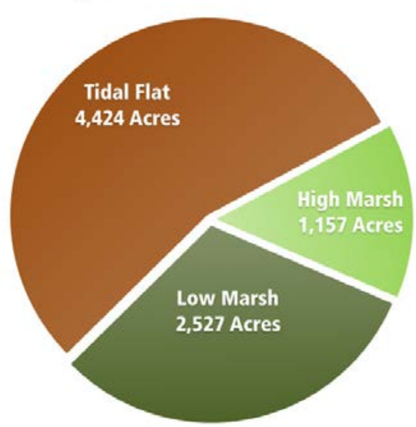
High SLR - High Accretion Estimate



Medium SLR - Low Accretion Estimate



High SLR - Low Accretion Estimate

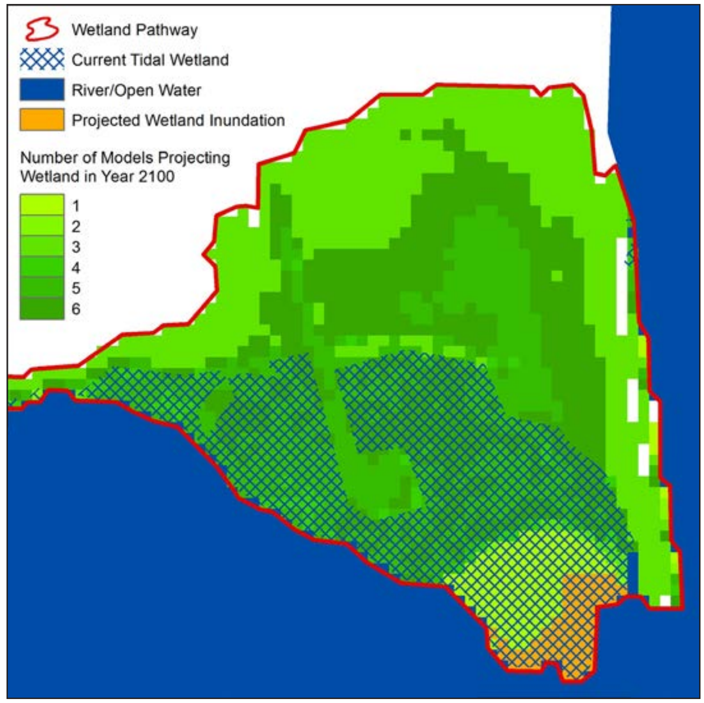


ENSURING A FUTURE FOR THE HUDSON'S TIDAL WETLANDS

The new context of accelerating sea level rise requires a holistic conservation approach to ensure that the Hudson's tidal habitats will be able to respond and adapt. This adaptation framework proposes forward-looking strategies for maximizing the adaptive capacity of these irreplaceable natural resources under a range of possible future scenarios.

Strategy 1: Protect the Pathways

Ensuring that wetlands have the physical room to adapt to rising sea levels is essential to the long-term health of the Hudson River Estuary ecosystem as well as human communities. A land protection strategy that prioritizes undeveloped parcels with the greatest potential for hosting future wetland areas (including persistent current wetlands and wetland migration areas) can serve as a blueprint for action by federal and state agencies, municipalities, land trusts, and other conservation entities. Minimizing future development and infrastructure investments in these areas will also reduce risks to communities and property owners in the changing flood zone.



The Wetland Pathway is the combined area of tidal wetland projected by any one or more of the six scenarios in year 2100.

This approach focuses on the **Wetland Pathway**, which is the combined area of tidal wetland projected in this century under the full possible ranges of SLR and accretion rates examined in the study. The proportion of unprotected tidal wetland pathway is projected to increase from the current 33% to as high as 45% by the end of the century, depending on SLR and accretion rates. At the same time, without protection these areas will very likely become less suitable for wetland migration over time (i.e., new development can be expected over the century on unprotected private properties). Importantly, approximately 52% of the as-of-yet unprotected wetland pathway could be secured by conserving only 125 parcels (out of over 4,500 unprotected parcels along the shore); these parcels represent the highest priority for protecting the pathway. Of these, only 20 parcels include more than 30 acres of the wetland pathway each, and they are concentrated in the Papscanee & Campbell Islands, RamsHorn Marsh/Inbocht Bay, and Binnen Kill wetland areas.

Currently, conservation easements protect a relatively small area of tidal wetland (approximately 200 acres). However, this conservation instrument may become increasingly important in the future, being more financially efficient and obtainable than fee acquisitions, especially for working lands or those properties that include developments or developable areas outside of the wetland pathway. Conservation easements in the HRE have not historically addressed SLR and the need to protect tidal wetland migration pathways in an explicit manner. Future conservation easements can be designed to flex with changing wetland boundaries and to encourage land uses that maximize wetland resilience, and the existing easements (which are projected to encompass over 375 additional acres of wetland pathway by the end of the century) may be amended on an ongoing basis. Explicitly planning for SLR and tidal wetland migration and persistence in easements can work in concert with coastal policy to help balance migrating wetlands with developments and agricultural uses.

Protecting just 125 priority parcels out of the over 4,500 unprotected tax parcels analyzed across the estuary can secure more than half of the unprotected wetland pathway area.

Strategy 2: Manage and Restore

Jeff Anzevino

Stockport Creek Mouth—part of a wetland area where protected and public lands encompass nearly 90% of the wetland pathway.

Most intertidal wetlands at Constitution Marsh are protected, but have a low marsh migration potential and high vulnerability to inundation. These types of places are candidates for active management to increase wetland resilience to SLR.

Nearly half of today's tidal wetlands (approximately 3,300 acres) and up to 5,100 acres of wetland pathway occur in tax parcels that are either protected or in public ownership (e.g., municipal and state properties). Lands protected in fee (ca. 3,100 acres of current wetland), and in particular those owned by state agencies (over 2,100 acres) represent an opportunity to promote successful wetland migration, and to actively work to maintain the composition of wetland types. Explicitly protected or public lands encompass more than 65% in 20 of the major tidal wetland areas in the estuary, providing ample ground for coordinated system-wide management and restoration activities. Such activities can also be prioritized based on projections of wetland loss and persistence across the major tidal wetland areas.

The state's "underwater lands" include both intertidal areas outside of tax parcels and land created from materials dredged from the river, and are owned by the Office of General Services (OGS).Currently more than 20% of existing tidal wetland falls into this category. Dredge spoil lands may be particularly important for securing the wetland pathway and providing restoration opportunities (in comparison with lower-elevation lands that already experience regular inundation). The OGS may legally transfer its lands to one of the state's conservation agencies, or alternately grant such lands to private owners upon petition. Both of these changes in ownership have occurred in the past, resulting in a mix of private holdings and formal protection of some important tidal wetland areas. Given the importance of tidal wetlands to the health of the HRE and the great stressors facing this resource in the coming decades, an initiative to accelerate the transfer of the highest priority "underwater lands" to state conservation agencies is warranted.

The OGS holdings in the Binnen Kill wetland area represent a critical portion of the wetland pathway.

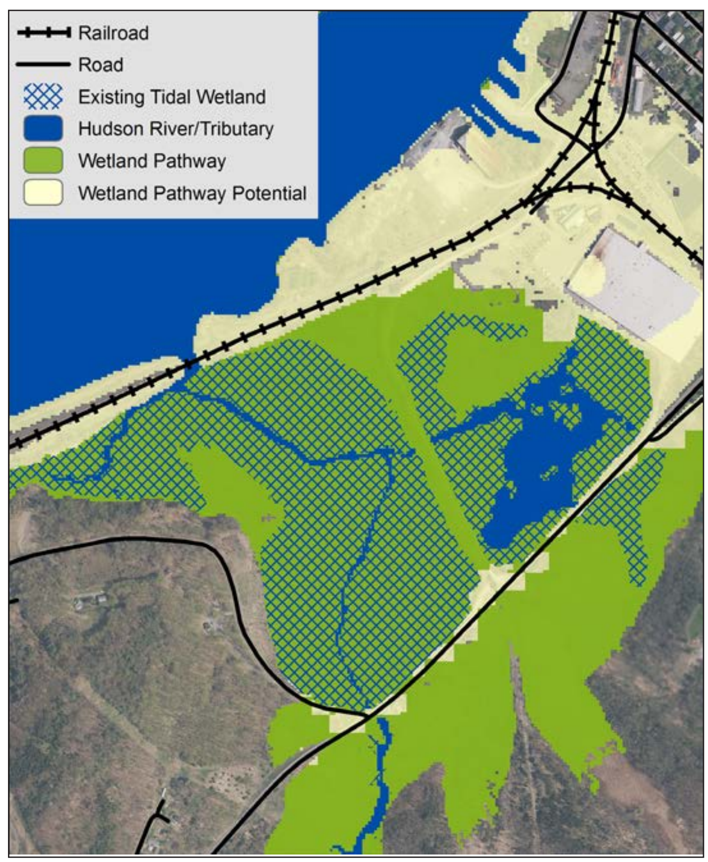
On both protected and publicly-owned properties, restoration of tidal wetlands and their processes can be promoted through the removal of barriers to tidal water, and any other actions that can restore historic tidal hydrologic regimes to low elevation areas. Hardened shorelines, including sea walls and bulkhead, can be replaced by sustainable shores—more complex and gradually sloping surfaces with natural cover—which will enable wetland migration. Side channels and tidal tributary mouths are important for delivering the sediments necessary for accretion in tidal wetlands. These channels and backwater habitats have been dramatically altered, or sometimes destroyed, by the deposition of dredge fill, particularly in the estuary's most northern wetlands; their careful restoration will re-establish the hydrological processes so critical to wetland habitat function and adaptation. Transportation infrastructure is a common type of barrier to the movement of tide waters in the HRE, and can be adapted to better accommodate wetland migration (in concert with upgrades designed to protect this infrastructure from SLR and flooding). Assisted accretion, or the application of sediment to the wetland surface to supplement the natural sediment trapping from tidal water, may be considered if suspended sediment is found to be limiting natural accretion rates in the Hudson River's tidal wetlands.

Shoreline restoration at Esopus Meadows Preserve using sustainable "soft" or nature-based techniques.

Strategy 3: Planning, Policy and Regulation

The future of tidal wetlands in the HRE will depend in part on decisions made by thousands of private landowners, multiple state and federal agencies with permitting or review authority, and dozens of municipalities whose boundaries encompass wetland, shoreline and floodplain zones along the river. Policy and planning approaches will be particularly important for wetland adaptation in the places that are not large enough, suitable or attainable for protection through acquisition or other formal means, but which are key contributors to tidal wetland adaptation.

Improvements to wetland-related policy and planning approaches could help ensure the broad adaptation potential of tidal habitats across the estuary. This strategy highlights issues that deserve attention at multiple levels of oversight and authority, and are consistent with the recommendations of the NYS 2100 Commission report. Given the complexity of factors and stakeholders with influence on tidal wetlands, multiple approaches can be employed in order to improve long-term tidal wetland resilience.



Development, railroad, and road infrastructure can be adapted to increase the potential of tidal wetlands to persist and migrate.

1. Align the regulation of the HRE's tidal habitats with the ecology of the estuary

The HRE's tidal wetlands fall under the oversight of multiple state regulations, which can lead to an uncoordinated approach to their protection. Most notably, legally designated tidal wetlands currently extend only as far north as the Tappan Zee (around the Village of Tarrytown) while the great majority of *actual* tidal habitats are concentrated above that point in the estuary, and are governed instead by freshwater wetland and other water-related regulations. Better aligning state regulation of tidal wetlands with the ecological reality of the HRE would help to ensure more holistic management and protection of this resource.

2. Ensure that regulatory and planning programs identify and protect wetland pathways

Current policy, regulation and planning instruments focus on the static location of tidal wetlands. If tidal wetlands are to successfully adapt to climate-driven changes, it is imperative that the tidal wetland migration pathways and potential impacts to their advancement be included in their delineation and regulation. The issue of dynamic boundaries is directly relevant to tidal wetland regulations, but may also extend to the delineation of the Coastal Zone and Significant Coastal Fish and Wildlife Habitats under the Coastal Management Program.

In addition, land use planning programs and initiatives such as the Local Waterfront Revitalization Program should also work to balance the evolving extents of tidal habitats with waterfront planning and adaptation. Coastal policy also addresses decision-making where existing developments or other active land uses such as agriculture occupy the same geographies as advancing tidal waters and wetlands. This policy could be applied in conjunction with initiatives such as buyout programs to more effectively balance the multiple goals of promoting long-term wetland resilience, farmland viability, reducing risks to coastal residents, and minimizing costs and damage to shoreline investments.

3. Promote the expanded use of natural and nature-based features in shoreline and floodplain zones

As sea level rises throughout the estuary, we can anticipate more frequent action by landowners to fortify and protect shorelines against erosion and flooding. The potential for these new treatments to reduce the quality and function of existing estuarine habitats or to isolate lands from future wetland pathways must be minimized. Natural or nature-based approaches to stabilize shorelines and reduce flood risks provide cost-effective, ecologically preferable alternatives that can be promoted through regulation and policy, such as the Community Risk and Resiliency Act (CRRA) and the state's Coastal Program, as well as the state budget.

Jeff Anzevino

Policy and planning tools can be used to balance future wetlands, developed areas, and agricultural lands that are located within the wetland pathway.

4. Regularly map and classify the tidal habitats of the HRE

As sea level rise accelerates over this century and the tidal wetland communities respond, managers, regulators, and other stakeholders will require high quality information about the changing locations, structure, and composition of tidal systems. Regular remapping and classification of the tidal wetlands and wetland pathway areas, using standardized methods, will provide a steady stream of information for detecting changes and managing the resource adaptively.

5. Outreach and technical support

Since planning and decision-making in the HRE rests with many stakeholders, outreach and education about the importance and benefits of tidal wetlands and ways to protect them is an essential element of successful policy and planning. With information on current and future tidal wetland resources, towns and villages can use their planning and zoning authority to assess shoreline treatments, site future developments, and encourage land uses that either promote or minimize impacts to long-term wetland resilience. Municipalities and conservation entities can provide technical support to private owners of existing developments or farms in the path of rising estuary waters to promote adaptations that are beneficial to tidal wetlands.

Many municipally-owned riverfront properties are managed as public open space (e.g., parks), and others are the sites of municipal infrastructure (or are land banks for future municipal development). Most of these properties are not explicitly conserved (i.e., they are without conservation easements or other restrictions on land uses), and yet they host at least 6% of the wetland pathway in the estuary. Outreach to municipalities could be particularly effective for both informing the planning for unimproved properties that include wetland pathways and managing planned open spaces to support tidal wetlands.

Robert Rodriguez, Jr.

Many municipally owned waterfront properties, such as Scenic Hudson Park at Peekskill Landing, lie within the wetland pathway.

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