Coastal Resilience Assessment of the Jacksonville and Lower St. Johns River Watersheds

Suggested Citation: Crist, P.J., J. Oetting, R. White, M. Chesnutt, C. Scott, R. Sutter, P. Cutter, and G. Dobson. Coastal Resilience Assessment of the Jacksonville and Lower St. Johns River Watersheds. 2019. National Fish and Wildlife Foundation.

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Cover Image: John T. Alsop Jr. Bridge, Jacksonville, Florida

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Abstract

The Jacksonville and Lower St. Johns River Watersheds Coastal Resilience Assessment focuses on identifying areas of open space where the implementation of restoration or conservation actions could build human community resilience and fish and wildlife habitat in the face of increasing storms and flooding impacts. The study is important to the area along the St. Johns River in Florida because the majority of the watershed features relatively flat topography at low elevation near the coast, which contributes to a high level of vulnerability. This area is vulnerable on three fronts: inland flooding moving downstream, coastal flooding moving upstream, and sea level rise.

This assessment combines human community assets, threats, stressors, and fish and wildlife habitat spatial data in a unique decision support tool to identify Resilience Hubs, which are defined as large area of contiguous land, that could help protect human communities from storm impacts while also providing important habitat to fish and wildlife if appropriate conservation or restoration actions are taken to preserve them in their current state. The Hubs were scored based on a Community Vulnerability Index that represents the location of human assets and their exposure to flooding events combined with Fish and Wildlife Richness Index that represents the number of fish and wildlife habitats in a given area. Local stakeholders and experts were critical to the assessment process by working with the project team to identify priority fish and wildlife species in the watershed and provide data sets and project ideas that have potential to build human community resilience and fish and wildlife habitat within the Jacksonville and Lower St. Johns River Watersheds.

As part of the assessment process, 36 resilience-related project ideas were submitted through the stakeholder engagement process, of which three are described in detailed case studies in this report. The case studies illustrate how proposed actions could benefit fish and wildlife habitat and human communities that face coastal resilience challenges such as storm surge during extreme weather events.

The products of the assessment process include this report, the Coastal Resilience Evaluation and Siting Tool (CREST) interactive online map viewer, and a Geographic Information System-based decision support tool pre-loaded with assessment datasets. These products provide opportunities for a variety of users, such as land use, emergency management, fish and wildlife, and green infrastructure planners to explore vulnerability and resilience opportunities in the watershed. The products can also be used to guide funding and resources into project development within high scoring Resilience Hubs, which represent areas where human communities are exposed to the greatest flooding threats and where there is sufficient habitat to support fish and wildlife. The decision support tool also allows users to manipulate the community vulnerability and fish and wildlife datasets to identify areas of value based on their own objectives.

Executive Summary

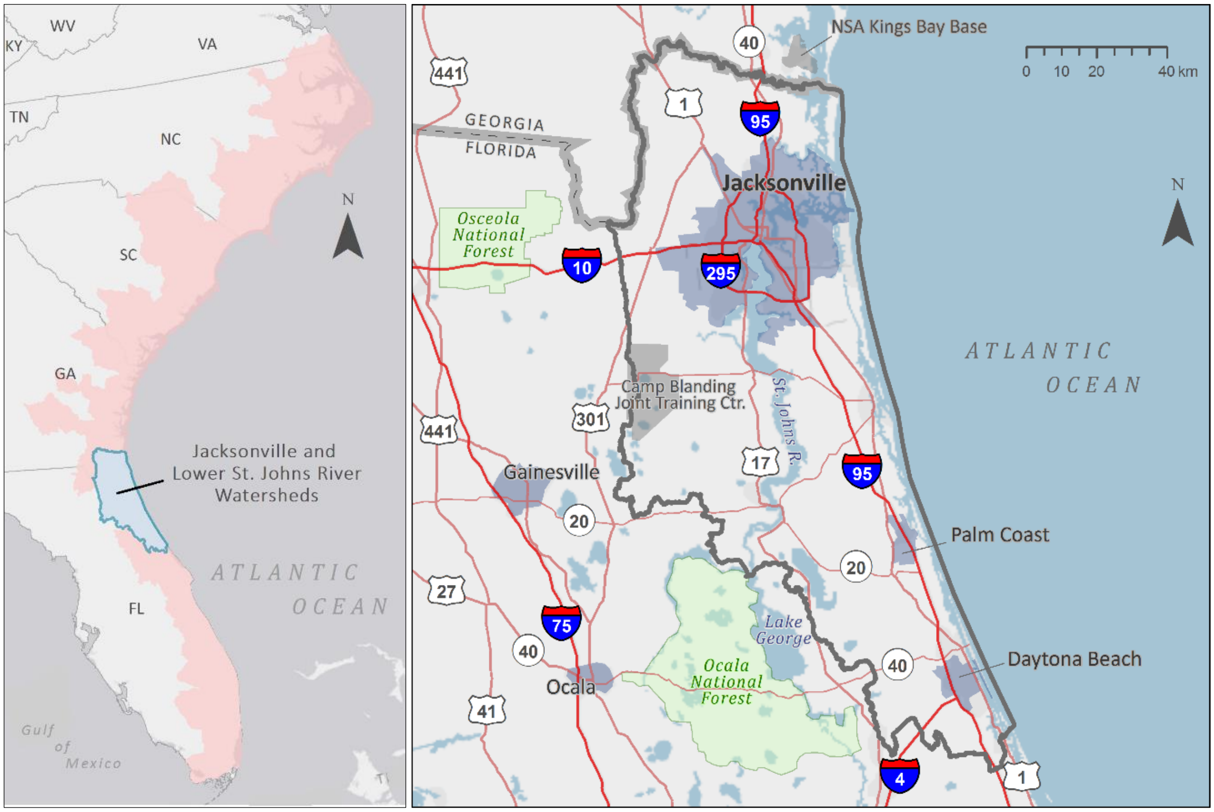
In response to increasing frequency and intensity of coastal storm events, the National Fish and Wildlife Foundation (NFWF) is committed to supporting programs and projects that improve community resilience by reducing communities' vulnerability to these coastal storms, sea-level rise, and flooding through strengthening natural ecosystems and the fish and wildlife habitat they provide. NFWF commissioned NatureServe to conduct coastal resilience assessments that identify areas ideal for implementation of conservation or restoration projects (Narayan et al. 2017) that improve both human community resilience and fish and wildlife habitat before devastating events occur and impact the surrounding community. The assessments were developed in partnership with the National Oceanic and Atmospheric Administration and UNC Asheville's National Environmental Modeling Analysis Center, and in consultation with the U.S. Army Corps of Engineers.

Coastal Resilience Assessments have been conducted at two scales: 1) at a regional level, covering five coastal regions that incorporate all coastal watersheds of the conterminous U.S., and 2) at the local watershed level, targeting eight coastal watersheds. Each of the eight Targeted Watershed Assessments nest within these broader Regional Assessment and provide the opportunity to incorporate local data and knowledge into the larger coastal assessment model.

This assessment focuses on the St. Johns River Watershed in northeast Florida. By assessing this region's human community assets, threats, stressors and fish and wildlife habitat, this Targeted Watershed Assessment aims to identify opportunities on the landscape to implement restoration or conservation projects that provide benefits to human community resilience and fish and wildlife habitat, ensuring maximum impact of conservation and resilience-related investment.

Jacksonville and Lower St. Johns River Watersheds

The Jacksonville and Lower St. Johns River Watersheds study area consists of the entire lower St. Johns Watershed, from Lake George to the river's outflow into the Atlantic Ocean at the City of Jacksonville, Florida. For the purposes of this Assessment, the study area extends beyond the lower St. John Watershed to include the areas north to the state boundary and east to the Atlantic coast to encompass coastal resources and threats that affect the communities in this region. The western edge of the lower St. Johns watershed is defined by the Trail Ridge, which reaches elevations of around 260 feet; however, the majority of the watershed from the river east to the coast is relatively low and flat, with elevations peaking around 33 feet along local ridges to less than three feet for most of the river course and coastal wetland systems. As such, the region is particularly vulnerable to inland flooding from heavy rainfall events, coastal flooding from major tropical systems, and sea level rise.



***Location and boundary of the Jacksonville and Lower St. Johns River Watersheds study area**. The map on the left shows the watershed study area in the context of the South Atlantic Coast Regional Assessment area (pink). In the map on the right, the study area, composed of the lower St. Johns River watershed and adjoining coastline, is shown with the dark gray outline.*

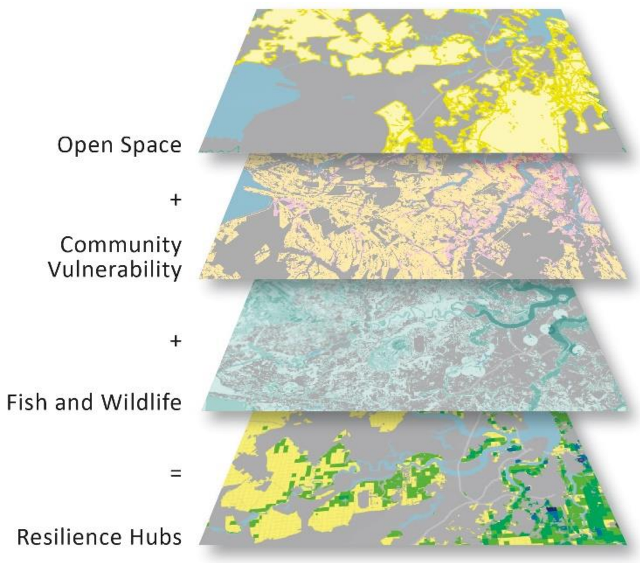
Assessment Objectives

The objectives of this assessment were to:

1. Identify Resilience Hubs or areas on the landscape where implementation of conservation actions will have maximum benefit for human community resilience and fish and wildlife habitat.
2. Account for threats from both coastal and inland storm events.
3. Create contiguous and standardized data sets across the study area.
4. Use local knowledge, data sources, and previously completed studies and plans to customize the Regional Assessment model for this smaller study area.
5. Identify projects in the watershed that have a demonstrated need and local support.
6. Make the products of the assessment broadly available to facilitate integration of resilience planning in a variety of land, resource management, and hazard planning activities.

Assessment Approach

The assessment approach was focused on identifying and evaluating Resilience Hubs, areas of open space and contiguous habitat that can potentially provide mutual resilience benefits to human community assets (HCAs) and fish and wildlife. This assessment was conducted primarily through Geographic Information System (GIS) analyses using existing datasets created by federal, state and local agencies, non-profits, universities, and others. Three categories of data were used as the primary inputs to the assessment: Open Space (protected lands or unprotected privately owned lands), Human Community Vulnerability, and Fish and Wildlife Species and Habitats.



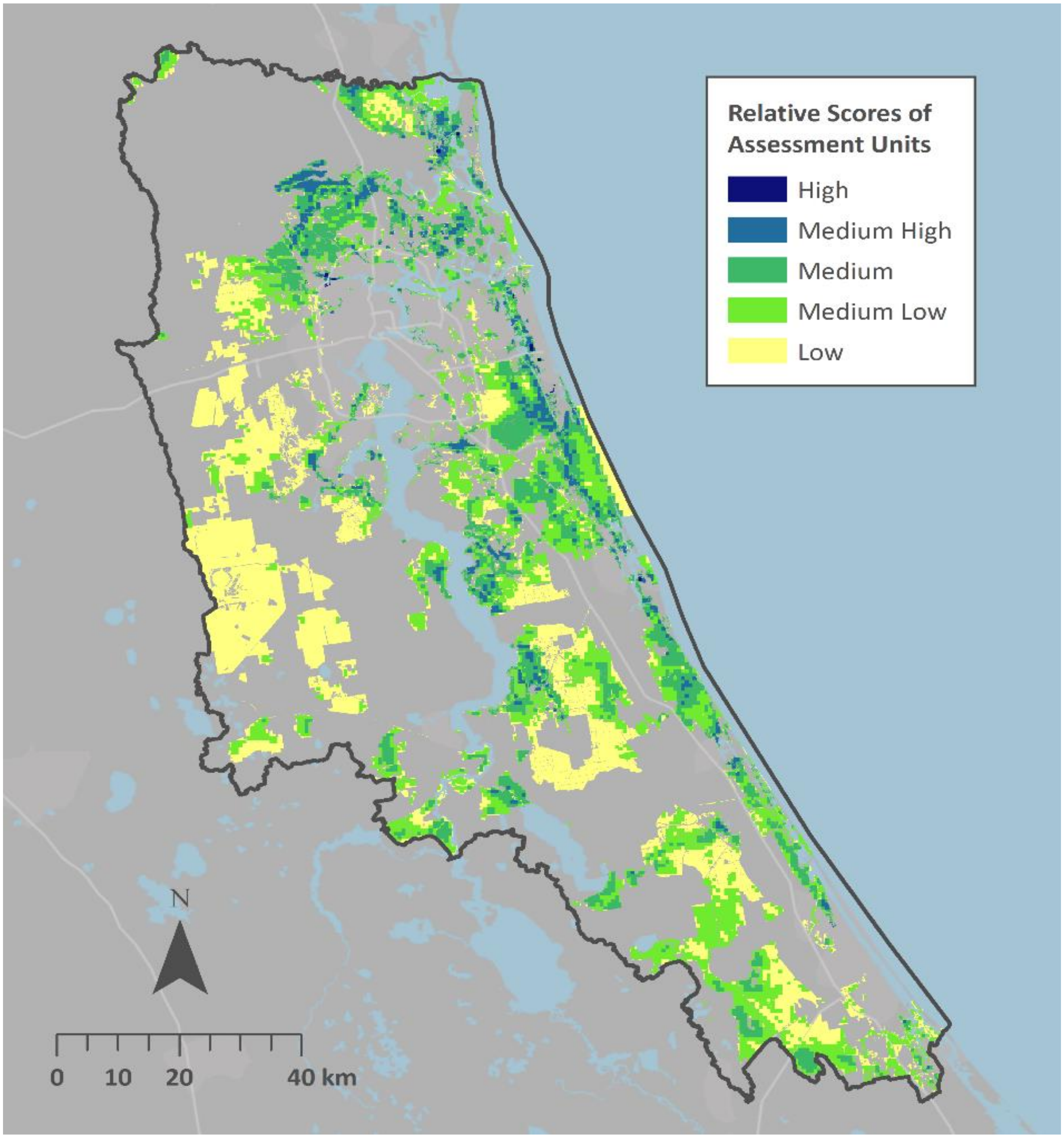
Left: Diagram of the overall approach of this assessment. *Human community asset (HCA) vulnerability and fish and wildlife richness are assessed within all areas of public and private open space. Open space areas in proximity to HCAs with high vulnerability* ***and*** *high fish and wildlife richness are mapped as Resilience Hubs where efforts to preserve or increase resilience to threats are well-justified. From the set of all such Hubs, those scoring highest by these measures represent priority areas for undertaking resilience projects.*

Results

Resilience Hubs

Resilience Hubs are large tracts of contiguous land that, based on the analyses, provide opportunities to increase protection to human communities from storm impacts while also providing important habitat for fish and wildlife. Hubs mapped in the Regional Assessment were evaluated using the Human Community Vulnerability Index and Fish and Wildlife Richness Index. In the map below:

- Parcels in **dark blue** were scored higher because they contain or are near highly vulnerable human population and infrastructure *and* support a diversity of fish and wildlife habitats. It is within or near these higher scoring parcels that restoration projects may be most likely to achieve multiple benefits for human community resilience and fish and wildlife.
- Parcels in **yellow** are scored lower because they are either not proximate to concentrations of HCAs or have low value for the fish and wildlife elements addressed in this assessment.



Resilience Hubs assessment unit relative scores for the Jacksonville and Lower St. Johns River Watersheds study area*. Assessment units are 100-acres grids or smaller parcels. Darker shades have higher scores and thus greater potential to achieve both community resilience and fish and wildlife benefits. Gray areas are outside of Hubs.*

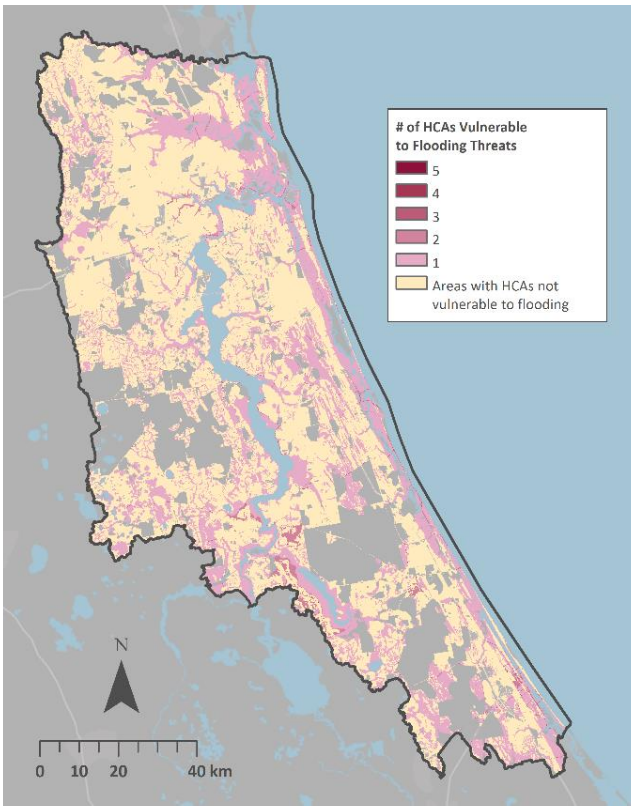
Community Vulnerability

The Community Vulnerability Index (see map below) accounts for approximately half of the scoring of the Resilience Hubs. This index communicates threats to human community assets wherever they occur as well as concentrated areas of threat. Vulnerability is highest in the immediate coastal areas where there are concentrations of populations and infrastructure exposed to most flooding threats.

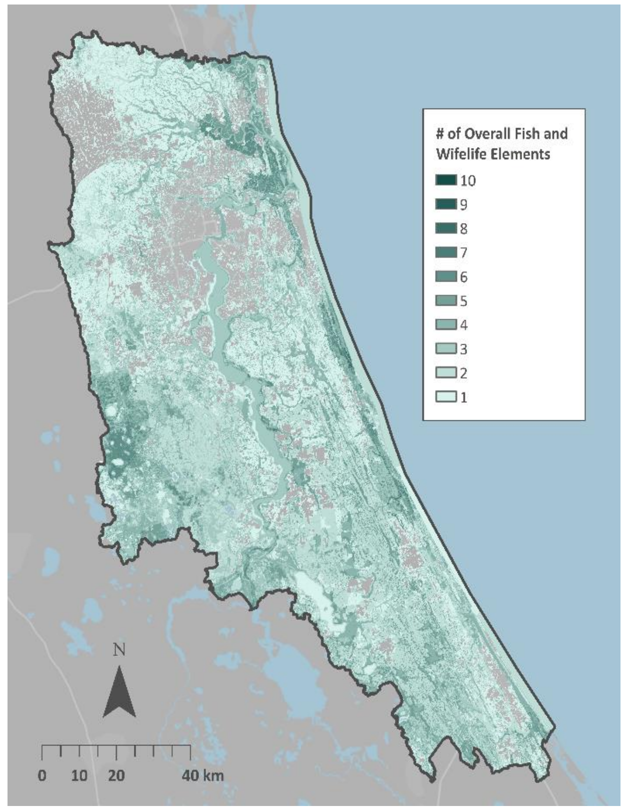
Areas of vulnerability farther inland are largely due to precipitation-caused flooding threats (flood zones and flat areas with poorly draining soils) and not sea-level rise or storm surge.

Fish and Wildlife

A total of 30 unique habitats, species, and species aggregations (referred to in this report as 'fish and wildlife elements' or simply 'elements') were included in this analysis. A Richness Index (see below) represents the concentration of fish and wildlife elements in each location.



Community Vulnerability Index for the Jacksonville and Lower St. Johns River Watersheds*. Pink to red shades indicate the number of Human Community Assets (HCAs) exposed to flooding related threats. Tan areas indicate areas of low to no impact from the flooding threats. Gray areas within the project boundary have no mapped HCAs.*



Richness of fish and wildlife elements in the Jacksonville and Lower St. Johns River Watersheds*. Green shades indicate the number of elements found in a location. Gray areas within the project boundary have no mapped fish or wildlife elements considered in this assessment.*

Resilience Projects

Plans and ideas were gathered from stakeholders for projects that could increase human community resiliency *and* provide fish and wildlife benefits but require funding to implement. The projects were collected to identify conservation and restoration need in the study area and to analyze the utility of the assessment to provide additional information on potential project benefits. The projects span a range of types including resilience planning, conservation of habitats, and habitat restoration. A complete list of projects can be found in Appendix 6. Several project sites were visited before selecting three case studies presented in this report:

- Case Study 1: Hogan's Creek Floodplain Restoration
- Case Study 2: McCoy Creek Floodplain Restoration
- Case Study 3: Porpoise Point Dune Restoration and Stormwater Improvement

Assessment Products

A rich toolbox of products was generated by this assessment and different audiences will find unique value in each of the tools.

Products from this effort can be obtained from www.nfwf.org/coastalresilience/Pages/regional-coastal-resilience-assessment.aspx and include:

- Final reports for the Jacksonville and Lower St. Johns River Watersheds, other local Targeted Watershed Assessments, and the Regional Assessment.
- Coastal Resilience Evaluation and Siting Tool (CREST), an online map viewer and project site evaluation tool that allows stakeholders access to key map products. CREST is available at resilientcoasts.org.
- The GIS data inputs and outputs can be downloaded and used most readily in the Esri ArcGIS platform. Though not required to access or use these data, this project is also enabled with the NatureServe Vista planning software which can be obtained at www.natureserve.org/vista. Vista can support additional customization, assessment, and planning functions.

Products may be used to:

1. Assist funders and agencies to identify where to make investments in conservation and restoration practices to achieve maximum benefits for human community resilience and fish and wildlife.
2. Inform community decisions about where and what actions to take to improve resilience and how actions may also provide benefits to fish and wildlife.
3. Distinguish between and locate different flooding threats that exist on the landscape
4. Identify vulnerable community assets and the threats they face
5. Identify areas that are particularly rich in fish and wildlife species and habitats
6. Understand the condition of fish and wildlife where they are exposed to environmental stressors and how that condition may be impacted by flooding threats.
7. Inform hazard planning to reduce and avoid exposure to flooding threats.
8. Jump start additional assessments and planning using the decision support system.

Introduction

Background

Coastal communities throughout the United States face serious current and future threats from natural events, and these events are predicted to intensify over the short and long term (Bender et al. 2010). Many of these events (e.g., intense hurricanes, extreme flooding) have the potential to devastate both human communities and fish and wildlife, which has been seen in recent years with Hurricanes Florence and Michael (2018); Irma, Harvey, and Maria (2017); Hurricanes Matthew and Hermine and severe storms in coastal LA and Texas (2016).

The National Fish and Wildlife Foundation (NFWF) is committed to supporting programs and projects that improve resilience by reducing communities' vulnerability to these coastal storms, sea-level rise, and flooding events through strengthening natural ecosystems and the fish and wildlife habitat they provide. NFWF's experience in administering a competitive grant program in the wake of Hurricane Sandy (2012), revealed the clear need for thorough coastal resilience assessments to be completed prior to devastating events and that these assessments should include both human community resilience and fish and wildlife benefits to allow grant making to achieve multiple goals. In response, NFWF has developed a Regional Assessment that includes all coastal areas of the contiguous U.S., in addition to Targeted Watershed Assessments in select locations. This will allow for strategic investments to be made in restoration projects today to not only protect communities in the future, but also to benefit fish and wildlife. When events do strike, data and analyses will be readily available for NFWF and other organizations to make informed investment decisions and respond rapidly for maximum impact.

Regional Assessments

Developed through a separate but similar effort, the Regional Assessment (Dobson et al. 2019) explored resilience in five geographic regions of the conterminous United States (**Figure 1**) and aimed to identify areas where habitat restoration, installation of natural and nature-based features (US Army Corps of Engineers 2015), and other such projects that could be implemented to achieve maximum benefit for human community resilience, fish and wildlife populations, and their habitats. The analysis conducted for the Regional Assessment identified Resilience Hubs that represent large areas of contiguous habitat that may provide both protection to the human communities and assets in and around them and support significant fish and wildlife habitat. Enhancing, expanding, restoring, and/or connecting these areas would allow for more effective and cost-efficient implementation of projects that enhance resilience.

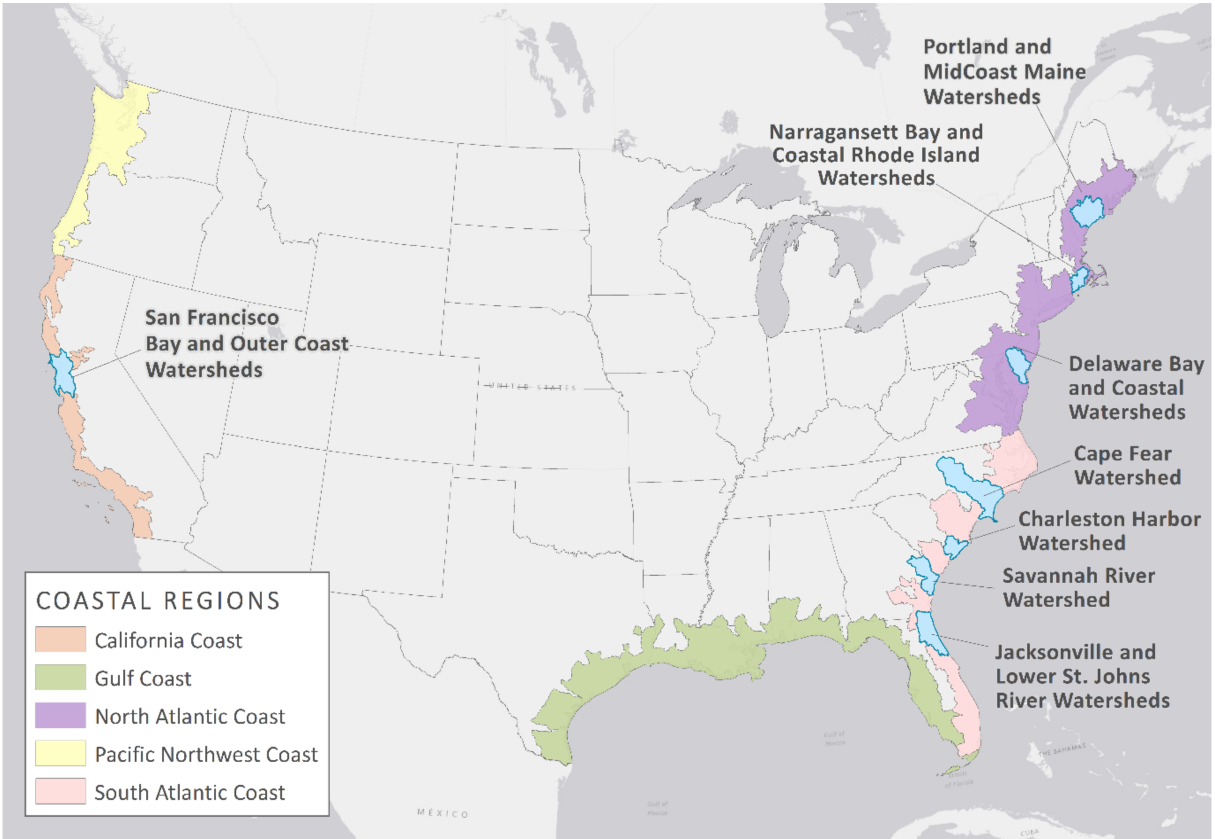


Figure 1. Map showing study areas for the Regional and Targeted Watershed Assessments. *The broad Regional Assessment included five coastal regions. High resolution resilience assessments were carried out in eight coastal Targeted Watershed Assessment study areas (in blue); the Cape Fear Watershed was conducted as a pilot. The Targeted Watershed Assessments were informed in part by the Regional Assessment.*

Targeted Watershed Assessments

Eight smaller areas were identified for additional, in-depth study in order to build upon the concepts developed in the Regional Assessment while allowing for more detailed local data to be incorporated for a truly customized assessment (**Figure 1**). These areas were selected due to their location relative to large population centers and proximity to significant areas of open space that if restored could not only benefit fish and wildlife, but also human community resilience.

Resilience Hubs

In a model used by both the Regional and Targeted Watershed Assessments, areas of open space are identified and analyzed in terms of human community vulnerability and fish and wildlife richness to inform where projects may be ideally sited for restoration or conservation. The Regional Assessment is designed to do this on a larger scale and use only nationally available datasets, whereas the Targeted Watershed Assessments include more state and local, often higher-resolution datasets.

The Regional Assessment created contiguous and standardized datasets, maps and analyses for U.S. coastlines to support coastal resilience assessment planning, project siting, and implementation at a state, regional, or national scale. This ensures planning agencies and other professionals can compare "apples to apples" across the landscape. Unlike previous studies that quantified impacts to only a thin strip of coastline, the Regional Assessment looks at the full extent of coastal watersheds to analyze the potential impacts of both coastal and inland storm events to include every sub-basin that drains to the sea, and in some places, a sub-basin or two beyond that where they are particularly low lying or tidally influenced.

Targeted Watershed Assessment Objectives

The Regional Assessment was an important first step in the development of the assessment model and ensuring standardization of datasets across U.S. coastal watersheds. Targeted Watershed Assessments such as the one described in this report complemented these assessments by: 1) using finer scale, local data—particularly with regard to fish and wildlife, 2) involving local stakeholders in providing expertise and sourcing important information necessary for understanding more detailed patterns and local context, and 3) identifying projects in the watershed that have a demonstrated need and local support. Three of those projects are presented as case studies.

Assessment Products

The following products from this effort can be obtained from www.nfwf.org/coastalresilience/Pages/regional-coastal-resilience-assessment.aspx.

1. This report (and reports from the other Targeted Watersheds), which includes:
    a. Detailed methodology
    b. Resilience Hub map
    c. Community Vulnerability Map
    d. Fish and Wildlife Richness Map
    e. Case studies on three select projects
    f. List of projects submitted by stakeholders in the watershed
2. The Coastal Resilience Evaluation and Siting Tool (CREST), an online map viewer and project site evaluation tool that allows stakeholders access to key map products. CREST is available at resilientcoasts.org.
3. A zipped file that contains all of the Geographic Information System (GIS) data used in this assessment in the form of an ArcMap project (.mxd) with all associated data inputs and outputs (subject to any data security limitations) including many intermediary and secondary products that are available for download in CREST at resilientcoasts.org/#Download. Though not required to access or use these data, this ArcMap project was designed for use with NatureServe Vista™ planning software (Vista DSS, an extension to ArcGIS), which can be obtained for no charge at www.natureserve.org/vista.

Application of the Assessment

This Targeted Watershed Assessment is a tool to identify potential project sites that can most efficiently increase both fish and wildlife and human community resilience. The insights and products generated can be used by practitioners such as planners, state agency personnel, conservation officials, non-profit staff, community organizations, and others to focus their resources and guide funding decisions to improve a community's resilience in the face of future coastal threats while also benefiting fish and wildlife.

The results and decision support system can inform many future planning activities and are most appropriately used for landscape planning purposes rather than for site-level regulatory decisions. **This is neither an engineering-level assessment of individual Human Community Assets (HCAs) to more precisely gauge risk to individual areas or structures, nor a detailed ecological or species population viability analysis for fish and wildlife elements to estimate current or future viability.**

Jacksonville and Lower St. Johns River Watersheds

The Jacksonville and Lower St. Johns River Watersheds is located in northeast Florida. The City of Jacksonville is the locus of population for the region, along with several smaller coastal cities including Daytona, St. Augustine, and Palm Coast. The regional population as of 2017 was approximately 2,012,000 residents. The region has a strong economy including the Port of Jacksonville, tourism, military bases, manufacturing, aviation and aerospace, financial services, and health/life sciences. The Jacksonville port is the sixth largest on the U.S. east coast, and the 35th largest in the U.S. based on 2016 total trade figures (AAPA 2016). The Jacksonville and Lower St. Johns River Watersheds project area is shown in **Figure 2**.

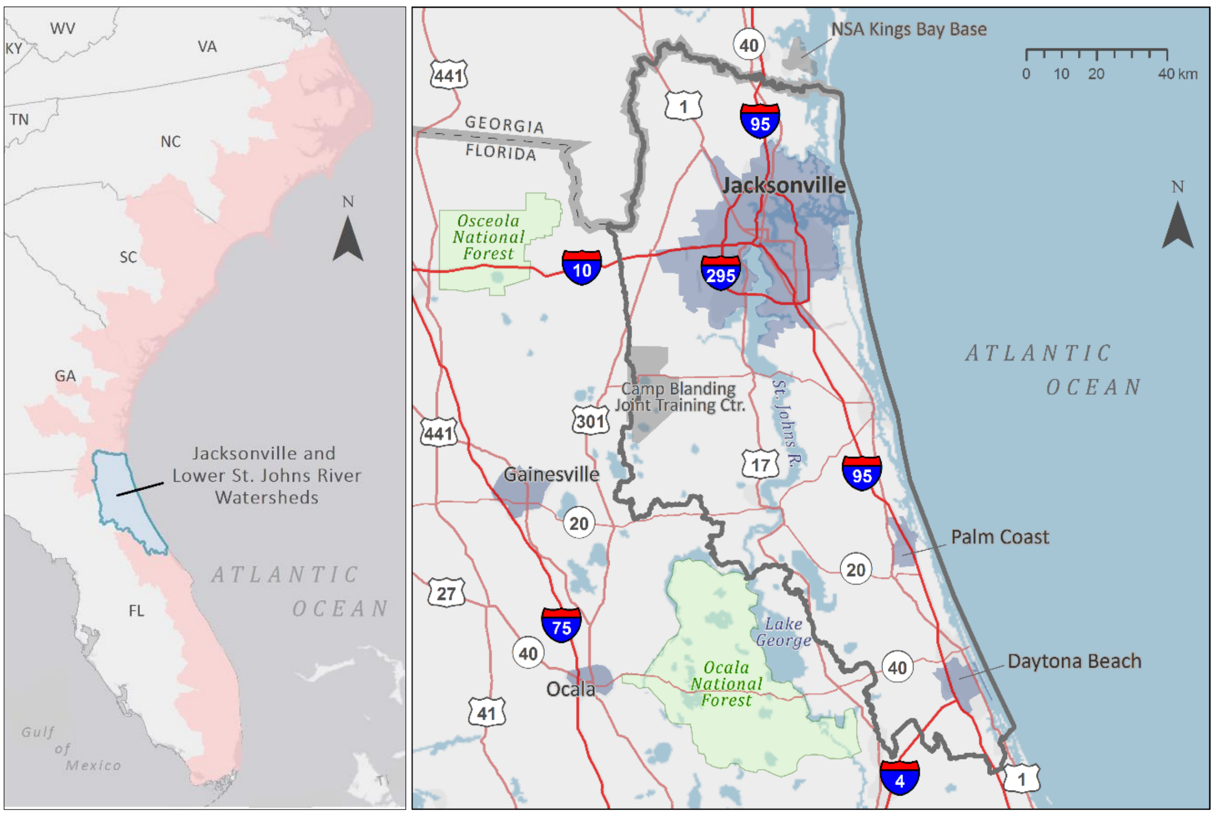


Figure 2. The location and boundary of the Jacksonville and Lower St. Johns River Watersheds study area. *The map on the left shows the watershed in the context of the South Atlantic Coast Regional Assessment area (pink). In the map on the right, the study area, composed of the lower St. Johns River and adjacent coastline, is shown with the dark gray outline.*

The boundary of the study region covers 4,478 square miles and includes three entire United States Geological Survey (USGS) level eight watersheds: the Lower St. Johns, Upper East Coast (FL), and Nassau River. The study boundary extends north to the state line by incorporating three additional level 10 watersheds: the Upper, Middle, and Lower St. Marys River basins within the state of Florida. The dominant watershed feature is the St. Johns River, which enters the watershed just downstream of Lake George, where the river channel widens significantly, and flows north to the Atlantic Ocean. The St. Johns is dredged for navigation by the U.S. Army Corps of Engineers along nearly its entire length within the study area. Due to northeast Florida's relatively flat topography, the St. Johns River is tidally influenced for most of its length in the lower watershed and is considered estuarine as far inland as Jacksonville (**Table 1**). Another significant water feature in this study area is the Intra-Coastal Waterway (ICW), which flows continuously through the region, running between coastal dune ridges or barrier islands on the Atlantic coast, and the mainland. The ICW is significant for commercial and recreational fishing, boating recreation, but can also be a source of flooding by acting as a conduit for storm surge and upstream flooding and sedimentation issues.

Table 1. Summary of major land cover types within the Jacksonville and Lower St. Johns River Watersheds study area. *Source: Florida Cooperative Land Cover v.3.2.5.*

Land Cover	Square Miles	Percent of Study Area
Forested Uplands	510	11%
Scrub	17	0%
Coastal Uplands	12	0%
Other Non-forested Uplands	40	1%
Estuarine Wetlands	134	3%
Forested Wetlands	841	19%
Non-forested Wetlands	208	5%
Agriculture	264	6%
Silviculture	981	22%
Developed	972	22%
Open Water	490	11%

The waterways and associated tidal wetlands of this region offer significant habitat for a variety of fish and wildlife species. Many commercially harvested and recreational fish species use waterways in the region for spawning, juvenile nurseries, or adult habitat. Coastal wetlands offer key habitat for many wading birds along with notable mammals including the round tailed muskrat and Atlantic salt marsh mink. Northeast Florida's sandy shorelines attract an impressive diversity of wildlife, including nesting shorebirds, nesting sea turtles, beach mice, peregrine falcon, and osprey.

Historic Impacts from Flooding

Northeast Florida's flat topography near sea level, coastline exposure, and dense network of waterways have historically combined to create significant flooding issues. The entire downtown area of Jacksonville is less than 30 feet in elevation, while many of the remaining coastal cities in the study area have even lower elevations, often below 15 feet. Some of the region's most significant flooding has occurred in recent years, both from inland rain events and coastal storms:

- In October 2016, Hurricane Matthew skirted the coast of northeast Florida, leaving one million people without power and causing $2.75 billion in damages statewide. The storm dumped 6.75 inches of rain in Jacksonville in just one day and the tidal surge at Mayport near the mouth of the St. Johns River reached 5.22 feet, the highest recorded since 1898. Statewide storm surge peaked at 9.88 feet near Fernandina Beach, north of Jacksonville. Schools were closed for several days throughout the region. Extensive flooding occurred in St. Augustine, and an important regional highway (Highway A1A) was washed out in several areas along the coastline.

- In September 2017, Hurricane Irma ran a course up through the entire Florida peninsula. Northeast Florida faced flooding both from massive inland rainfall and from coastal storm surge. Jacksonville received over 11 inches of rain and water levels reached more than five feet in Jacksonville, requiring hundreds of people to be rescued from homes. Storm surge scoured the coastline causing extensive erosion and loss of coastal homes in areas such as Ponte Vedra and Vilano Beach near St. Augustine. To date, Irma has been the costliest hurricane in Florida history with more than $53 billion in damages.
- In March 2018, a series of Nor'easter storms affected much of the eastern U.S. coast, including northeast Florida. Tides in the region were significantly affected and led to beach erosion, particularly in areas near St. Augustine. Temporary sand berms that were put in place following previous hurricanes were breached, leading to flooding in neighborhoods near the coast.

These same weather events affected fish and wildlife habitat, with inundated beaches, extensive coastal and riparian erosion, submerged marshes, lowered salinity, degraded water quality, and extensive upland flooding of natural communities.

Several organizations are actively involved in addressing the impacts of flooding in this region. In addition to the efforts of local governments, the St. Johns River Water Management District (https://www.sjrwmd.com/) includes flood control as one of their four core missions. The District manages levees and water control structures, regulates stormwater management, and acquires land for floodplain wetlands and for water storage. The Northeast Florida Regional Council (http://www.nefrc.org/) works with seven counties that include almost the entire study region. The Council facilitates local community and regional strategic planning, economic development, and emergency preparedness and planning. The Council released a Regional Action Plan for Sea Level Rise in 2014. Groundwork Jacksonville (http://groundworkjacksonville.org/) is involved in sustainable community development in the Jacksonville region, and is actively working on projects to address neighborhood flooding along urban waterways.

Methods Overview

This overview is intended to provide the reader with sufficient information to understand the results. Details on methods are provided in the appendices as referenced in each section below to provide deeper understanding and/or aid in the use of the available Vista decision support system (Vista DSS). Process diagrams (e.g., **Figure 4**) use the Charleston, SC region as an example and do not represent inputs or results for this watershed; they are only intended to illustrate methods.

Overall Approach

The overall approach aims to identify Resilience Hubs, places where investments made in conservation or restoration may have the greatest benefit for both human community resilience and fish and wildlife (**Figure 3**). Identifying these areas can support resilience planning by informing the siting and designing of resilience projects. This assessment was conducted primarily through GIS analyses using existing datasets created by federal, state and local agencies, non-profits, universities, and others. Three categories of data were used as the primary inputs to the project: Open Space (protected lands or unprotected privately owned lands), Human Community Vulnerability, and Fish and Wildlife Species and Habitats. Bringing these data together generated many useful assessments, which culminated in the mapping and scoring of Resilience Hubs.

The use of a publicly-available decision support system (NatureServe Vista) to conduct the Targeted Watershed Assessments provides a useful vehicle for delivering the full set of inputs, interim products, and key results to users in a way that allows them to update the results with new information and customize the assessments with additional considerations such as additional Human Community Assets (HCAs) and fish and wildlife elements. Details on the components of the approach are described below and supported by Appendices 2-5.

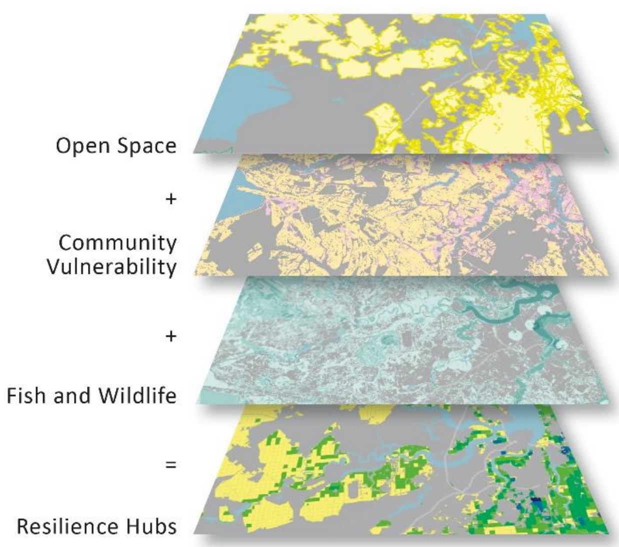


Figure 3. Diagram of the overall approach of this assessment. *Human community asset (HCA) vulnerability and fish and wildlife richness are assessed within all areas of public and private open space. Open space areas with high HCA vulnerability and high fish and wildlife richness are mapped as Resilience Hubs where efforts to preserve or increase resilience to threats are well-justified. From the set of all such Hubs, those scoring highest by these measures represent priority areas for undertaking resilience projects. Diagram represents generic region and is only intended to illustrate methods.*

Stakeholder Participation

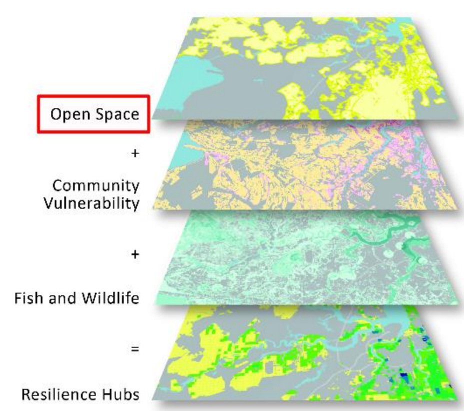
A fundamental part of this Targeted Watershed Assessment was to engage and work with individual and organizational stakeholders and partners within the St. Johns Watershed. Stakeholder involvement can improve the quality of decisions and policy—especially in the context of complex environmental and social challenges (Elliott 2016, Reed 2008). The stakeholder engagement process for the St. Johns Watershed was designed to address four goals: 1) inform a wide array of stakeholders in the watershed of this assessment, its objectives and potential utility, and opportunities to contribute to it; 2) inform the selection of fish and wildlife habitats and species, and their stressors; 3) identify and access the best existing local data to supplement regional and national data to be used in the spatial assessments; and 4) catalog proposed resilience project plans and ideas.

In addition to the overall Coastal Resilience Assessment Technical and Steering Committees that helped to guide the Targeted Watershed Assessment goals and deliverables and provide feedback at key points in the process (such as reviewing the fish and wildlife habitat layers, resilience project sites for site visits, and final case studies), a Jacksonville and Lower St. Johns River Watersheds Committee was formed consisting of local experts from National Oceanic and Atmospheric Administration (NOAA), NFWF, the South Atlantic Landscape Conservation Cooperative (LCC), St. Johns River Water Management District, Northeast Florida Regional Council, Florida Fish & Wildlife Conservation Commission, U.S. Army Corps of Engineers, and NFWF. This committee helped to identify relevant stakeholders to engage, determine times and places of stakeholder workshops, and compile the initial fish and wildlife element list and associated data. Specific individual and institutional roles and contributions are listed in the 'Acknowledgements' section.

Overall, 63 participants including federal and state agency representatives, NGO staff, local elected officials and municipal staff, and citizens representing their communities were engaged in the stakeholder process through web meetings, in-person workshops, and follow-up activities such as site visits to proposed resilience project sites. Additional details on key stakeholder inputs, details about the stakeholder process, and the committee structure that guided the assessment can be found in Appendix 1.

Components of the Assessment

For each component described below, an inset of **Figure 3** above is repeated, identifying in red outline the component being described in relation to the other three components.



Open Space

Large contiguous areas of habitat may provide mutual resilience benefits to HCAs and fish and wildlife elements, especially with the implementation of resilience projects. Identifying these areas of open space serves as a first step in identifying high value Resilience Hubs where prospective conservation and restoration projects could contribute to resilience and benefit fish and wildlife. The method for scoring the value of the Hubs using results from the watershed assessments is further described below.

Mapping Open Space

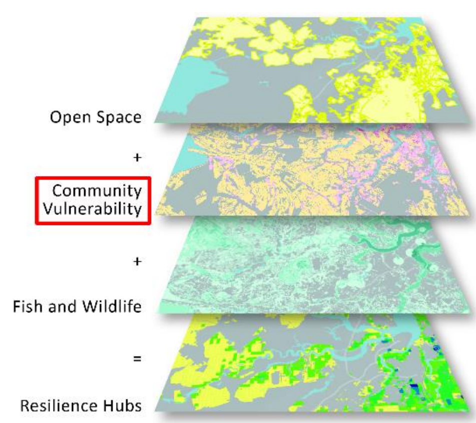
The process of delineating open space is described in the Regional Assessment (Dobson et al. 2019) and incorporates:

1. Protected areas, which are defined as lands that are part of the USGS Protected Areas Database of the United States (PAD-US).
2. Unprotected privately owned lands with contiguous habitat, as identified from the USGS National Land Cover Database (NLCD). The open space areas were further processed to remove impervious surfaces and deep marine areas. Within the Regional Assessment methodology, these areas were also analyzed using a community exposure index to highlight areas of higher exposure and areas that are near or adjacent to communities.

Once open space areas were identified in the Regional Assessment, those open spaces within the target watershed were further refined as follows:

1. Protected areas were augmented with Florida Managed Areas data from the Florida Natural Areas Inventory. All protected area polygons were intersected with the Resilience Hubs as identified in the Regional Assessment to distinguish protected from unprotected areas.
2. Hubs with shorelines (rivers or coastal) were supplemented with the National Hydrography Dataset (NHD) to include waters within a 50-meter buffer to add nearshore habitat areas that could provide locations for aquatic resilience projects such as oyster reefs or marsh protection/restoration.
3. Impervious surfaces were deleted from the Hubs using the National Land Cover Database (Homer et al. 2011) and Topologically Integrated Geographic Encoding and Referencing (TIGER) roads data (U.S. Census 2016). The removed areas might be protected but have pavement or structures in place that would limit restoration actions.

Community Vulnerability



Assessing community vulnerability is a process of examining where and how assets within a community may be impacted by flooding threats. Understanding where people and infrastructure are most exposed and vulnerable to threats can help communities assess where they are most at risk, and where actions may need to be taken to increase resilience.

Human Community Asset Weighted Richness Index

For the purposes of this assessment, Human Community Assets (HCAs) data were selected to represent: 1) critical infrastructure and facilities essential for community recovery post-storm event, 2) areas of dense human population, and 3) socially vulnerable populations. They are not intended to be comprehensive; for example, not all roads are included and instead focus on storm escape routes. The Regional Assessment identified a suite of HCAs that were used in this Targeted Watershed assessment. The selected HCAs are defined below (see also the Regional Assessment Report [Dobson et al. 2019]). **Table 2** provides further breakdown of the HCAs as represented in the spatial assessment and the importance weightings derived from the Regional Assessment. **Table 3** provides additional detail on the critical facilities category and sources of data.

Human Community Asset categories are defined as follows:

Critical Facilities. Schools, hospitals, nursing homes, and fire and police stations are just a few of the types of facilities included as critical facilities. These services are considered critical in the operation of other community infrastructure types, such as residences, commercial, industrial, and public properties that themselves are not HCAs in this assessment. Critical facilities were drawn from the National Structures Dataset and include (see **Table 3** for additional detail):

- Schools or educational facilities (class 730) (often used as shelters during disasters)
- Emergency Response and Law Enforcement facilities (class 740)
- Health and Medical facilities (class 800)
- Government and military facilities (class 830)

Critical Infrastructure. A variety of additional infrastructure is included that may help communities with emergency evacuation, building economic resilience, and identifying infrastructure (e.g., dams) that may require more extensive and long-term planning and permitting (**Table 3**). Other critical infrastructure includes airport runways, primary transportation routes, ports, refineries, hazardous chemical facilities, power plants, etc. Coastal infrastructure is expected to be increasingly at risk due to major inundation from storm surge and sea level rise. Infrastructure that was considered an important economic asset was also included, such as fishing ports.

Population Density. These categories were included because denser populations in high-threat areas will lead to more people being exposed to flooding threats. Density was calculated by Census Block for each region based on the 2010 Census.

Social Vulnerability. Social vulnerability varies geographically in coastal areas where there are large socioeconomic disparities. This input is meant to indicate a community's ability to respond to and cope with the effects of hazards, which is important to consider because more disadvantaged households are typically found in more threatened areas of cities, putting them more at risk to flooding, disease, and other chronic stresses. The input considers certain demographic criteria such as minority populations, low-income, high school completion rate, linguistic isolation, and percent of population below five or over 64 years of age. To account for regional differences and remove any unnecessary bias in the modeling, the source data were processed with a quintile distribution with the Weighted Linear Combination method to rank social vulnerability using a weight value range of 0-5 by Census Block Group at the national level.

Table 1. Human Community Assets included in the assessment and their importance weightings.

Human Community Assets	Description	Adjusted Weight
Critical Facilities	Facilities (i.e., schools, hospitals, fire/police stations) providing services that are critical in the operation of a community.	1
Critical Infrastructure (Rank 1)	**Low** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.).	0.2
Critical Infrastructure (Rank 2)	**Medium** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.).	0.4
Critical Infrastructure (Rank 3)	**High** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.)	0.6
Critical Infrastructure (Rank 4)	**Very High** spatial concentration of infrastructure (i.e., dams, evacuation routes, water treatment plants, energy plants, etc.)	0.8
Social Vulnerability	The resilience of communities when confronted by external stresses on human health, stresses such as natural or human-caused disasters, or disease outbreaks.	0.2
Population Density (Rank 1)	***Low*** total density calculated by Census Block for each region based on the 2010 Census.	0.2
Population Density (Rank 2)	***Low-medium*** total density calculated by Census Block for each region based on the 2010 Census.	0.4
Population Density (Rank 3)	***Medium*** total density calculated by Census Block for each region based on the 2010 Census.	0.6
Population Density (Rank 4)	***Medium-high*** total density calculated by Census Block for each region based on the 2010 Census.	0.8
Population Density (Rank 5)	***High*** total density calculated by Census Block for each region based on the 2010 Census.	1

Table 2. Critical infrastructure categories and sources of data.

Critical Infrastructure Category	Data Source
Ports	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)
Power plants	EIA-860, Annual Electric Generator Report, EIA-860M, Monthly Update to the Annual Electric Generator Report and EIA-923, Power Plant Operations Report (2016 or later)
Wastewater treatment facilities	USGS National Structures Dataset File GDB 10.1 or later
Railroads	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later)
Airport runways	National Transportation Atlas Database (2015 or later)
National Highway Planning Network	National Transportation Atlas Database v11.09 (2015) or later; on behalf of the Federal Highway Administration
Evacuation routes	Homeland Security: Homeland Infrastructure Foundation Level Data (2007 or later)
Major dams	USDOT/Bureau of Statistics' NTAD (2015 or later)
Petroleum terminals and refineries	EIA-815, "Monthly Bulk Terminal and Blender" Report; *Refineries*: EIA-820 Refinery Capacity Report (2015 or later)
Natural gas terminals and processing plants	EIA, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; *Processing Plants*: EIA-757, Natural Gas Processing Plant Survey (2015 or later)
National Bridge Inventory	Federal Highway Administration, NBI v.7, NTAD (2015 or later)
Hazardous facilities & sites	EPA Facility Registry Service (2016 or later)

The HCA weighted richness index expresses values based on the number of HCAs present in a location and their importance weights. The HCAs were combined in the Vista DSS using its Conservation Value Summary function[1] by first assigning a weighting factor that approximated the ranked weights used in the Regional Assessment (**Table 2**). For the purposes of the Targeted Watershed Assessment, the weights used in the Regional Assessments (1=lowest importance, 5= highest) were adjusted to a 0-1 scale (1=0.2, 2=0.4, 3=0.6, 4=0.8, 5=1). Next, the HCAs were overlaid, and their adjusted weights summed for each pixel.

Flooding Threats

Flooding threats were used to assess Community Vulnerability (described below) and Fish and Wildlife Vulnerability (described later). The flooding threats used in the Targeted Watershed Assessment are summarized below and illustrated in **Figure 4**. Additional details and assumptions in their use in the vulnerability assessments is provided in Appendix 2.

- Storm surge (with values of 1-5, which are based on hurricane categories 1-5)

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[1] A Conservation Value Summary is a surface of mapped values that are the output of a Vista DSS overlay function that allows for a wide range of calculations based on element layers and user-specified attributes. Examples include richness (the number of overlapping elements at a location) and weighted richness where, for example, a simple richness index is modified by the modeled condition of elements.

- Flood zones (100 and 500-year floodplains and flood-ways)
- Sea level rise (one foot was used to correspond with an approximate 20-30-year planning time frame)
- Flood prone areas (flat topography with poorly draining soils)
- Moderate to high erosion potential
- Subsidence

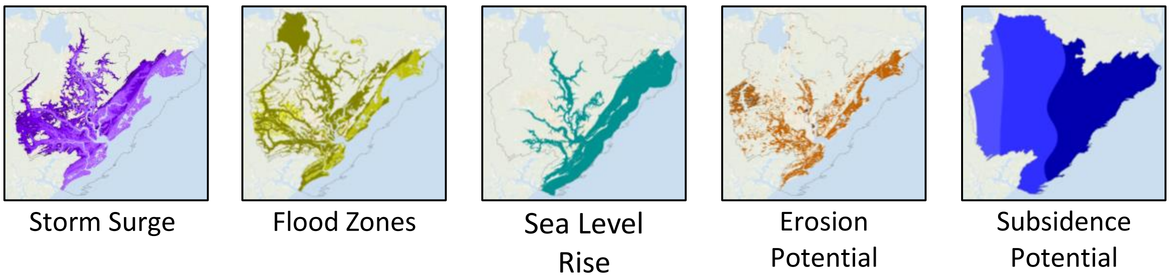


Figure 4. Flooding threats used to assess community vulnerability. *Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

The flooding threats used in the Targeted Watershed Assessments differed slightly from those used in the Regional Assessment. Specifically, the Threats Index used in the Regional Assessment was generated using an ordinal combination method and is presented in the Results section of this report for illustration purposes. Unlike the Targeted Watershed Assessments, all inputs used in the Regional Assessment were ranked on a 0 - 5 scale, representing the risk of impact (not the degree of impact) and included a five-foot sea level rise change. See the Regional Assessment report for more details on methods (Dobson et al. 2019). In this Targeted Watershed Assessment, a one-foot sea level rise change was used.

Community Vulnerability Assessment

Unlike the Regional Assessments, this Targeted Watershed Assessment went beyond assessing exposure (which examines which, if any, threats an HCA overlaps with and may include intensity of the threat at different levels of storm surge) by assessing vulnerability to threats. Assessing vulnerability includes consideration of the sensitivity of an HCA to the threat it is exposed to, and its adaptive capacity to recover from the impact of that threat (IPCC 2007). Therefore, in this assessment the coexistence of a threat with an HCA does not necessarily equate to vulnerability. The method for assessing vulnerability of HCAs is illustrated in **Figure 5** and details are provided in Appendix 2 and Appendix 3. The basic steps, implemented through the Vista DSS and illustrated in **Figure 5** are:

1. Intersect HCAs with the flooding threats
2. Apply the HCA vulnerability model
3. Generate individual HCA vulnerability maps
4. Sum the results across all HCAs to develop the Community Vulnerability Index. This provides a sum of the number of vulnerable HCAs for every location.

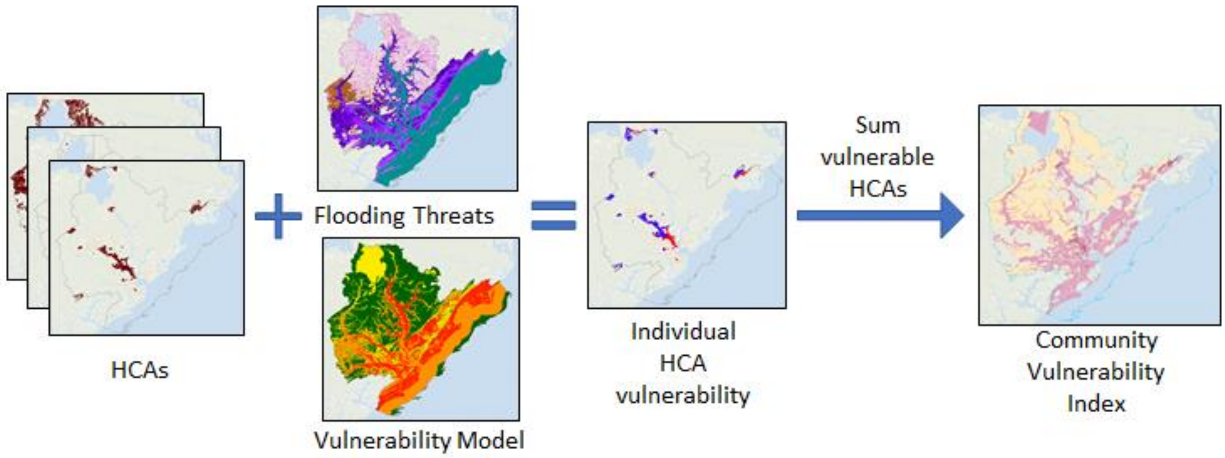
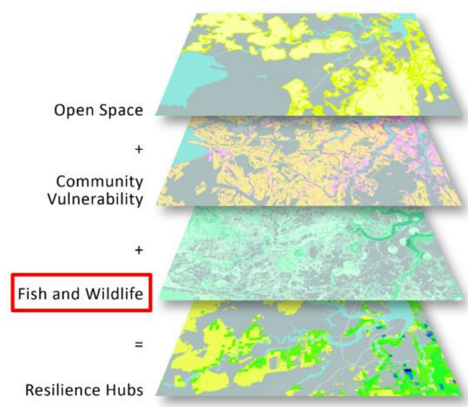


Figure 5. Community vulnerability assessment process. *Human Community Assets (HCAs) are intersected with the flooding threats, a vulnerability model is applied, and individual HCA results are summed to create the Community Vulnerability Index. Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

Fish and Wildlife



The Regional Assessment only used those fish and wildlife data that were available nationwide. While this allowed for consistent data coverage over the entire study area, nationwide fish and wildlife data are very coarse. Therefore, the Targeted Watershed Assessment used local data when available, which facilitated a more accurate and higher resolution fish and wildlife analysis.

To better understand where high value areas of fish, wildlife, and associated habitat exist in the region, several analyses were conducted focused on mappable fish and wildlife species, habitats, and other related features of conservation significance (referred to in this report as "fish and wildlife "elements" or simply "elements"). This section of the report focuses on the fish and wildlife element selection process, and the development of conservation value indices. Specifically, two indices were calculated to inform the Resilience Hubs characterization and scoring used in the Targeted Watershed Assessment (see section below): 1) a Fish and Wildlife Richness Index, and 2) a Fish and Wildlife Condition-Weighted Index. Though not used directly in the hub prioritization, a Fish and Wildlife Vulnerability Index was also conducted and is likely to be of significant interest to stakeholders wanting to extend or further explore coastal resilience and fish and wildlife vulnerability. The Fish and Wildlife Vulnerability Index is described in Appendix 4.

Selection of Fish and Wildlife Elements

To facilitate the identification of areas in the watershed important for fish and wildlife conservation, restoration, and resilience, a set of mapped fish and wildlife elements of interest was first established. This was achieved via the following steps:

1. Establishment of an initial list of fish and wildlife elements based on explicit criteria (see below);
2. Review and refinement of this list based on extensive consultation with a diverse set of local experts and other stakeholders;
3. Identification and evaluation of relevant and appropriate spatial data to represent each element; and
4. Finalization of the element set based on input from local experts, the Watershed Committee, and other stakeholders.

For step one, national and local experts applied several criteria to establish an initial set of target fish and wildlife species, species groups, species habitat segments (e.g., migratory, breeding, or rearing habitat), or broad habitat units of significance occurring in this watershed. For inclusion, elements had to: 1) satisfy at least one of the inclusion criteria listed below, and 2) be mappable via relevant and available spatial data of sufficient coverage and accuracy to fairly represent the element (as determined by expert review).

For inclusion, elements must meet one or more of the following criteria:

- A NOAA Trust Resource[2]
- A formally recognized at-risk species based on its inclusion in one of the following categories at the time of this assessment including:
    - A species listed as 'endangered', 'threatened', or 'candidate' under the provisions of Endangered Species Act (ESA)[3]
    - A species with a NatureServe global imperilment rank of G1, G2, or G3[4]
    - A species with a NatureServe state imperilment rank of S1, S2, or S3
    - A State Species of Greatest Conservation Need (SGCN) as recorded in current State Wildlife Action Plans
- A distinctive ecological system or species congregation area that represents habitat important to at-risk species and/or species of significance to stakeholders in the region. Examples might include heron rookeries that represent important wading bird habitat or tidal marsh representing shrimp nursery areas and diamondback terrapin habitat; or

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[2] NOAA trust resources are living marine resources that include: Commercial and recreational fishery resources (marine fish and shellfish and their habitats); Anadromous species (fish, such as salmon and striped bass, that spawn in freshwater and then migrate to the sea); Endangered and threatened marine species and their habitats; marine mammals, turtles, and their habitats; Marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and Resources associated with National Marine Sanctuaries and National Estuarine Research Reserves (NOAA 2015).

[3] These categories are established by the **US Endangered Species Act of 1973, as amended through the 100th Congress**. (United States Government 1988) (See this factsheet for further explanation: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf)

[4] These categories, used throughout the Americas are documented in the publication **NatureServe Conservation Status Assessments: Methodology for Assigning Ranks (Faber-Langendoen et al. 2012)** (Available here: http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusmethodology_jun12_0.pdf)

- A species or population of commercial, recreational, or iconic importance in the watershed. This includes:
    - Fish or wildlife species or populations of significant commercial value,
    - Fish or wildlife-related features that confer resilience to biodiversity or human assets (such as oyster beds which have high economic significance as a fishery component and/or play a valuable role in coastal resilience by virtue of their physical structure which in many cases mitigates destructive wave action and storm surge impacts),
    - Fish or wildlife populations or wildlife habitat-related features that provide unique recreational opportunities (such as Atlantic Beach and Dune habitat that provides key habitat while also providing recreational opportunities for visitors), and/or
    - Iconic species that define the watershed and/or distinguish it from other geographies and represent species that have conservation support.

Elements were organized into the following broad categories: NOAA Trust Resources, At-Risk Species and Multi-species Aggregations, Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species, Fish or Wildlife-related Areas of Key Economic, Cultural or Recreational Significance, and Cross-cutting Elements.

Stressors

Current fish and wildlife stressors were identified during stakeholder workshops and available data were identified to represent each. These stressors include land use and infrastructure, roads, dredging material placement areas, and water quality (**Figure 6**). The complete list, descriptions, and data sources for fish and wildlife stressors included in this assessment are presented in Appendix 2.

The response of the fish and wildlife elements to these stressors results in a calculation of current condition as described further in the Fish and Wildlife Vulnerability Assessment section and in Appendix 2 and Appendix 3. The individual fish and wildlife element condition scores are then added together for each location to create the Fish and Wildlife Condition-Weighted Richness Index.

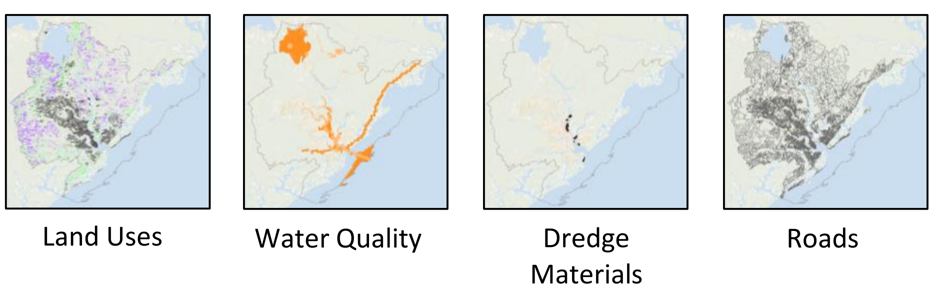


Figure 6. Fish and wildlife stressors used to model current habitat condition. *Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

Fish and Wildlife Indices

The Fish and Wildlife Richness Index results from a simple overlay and sum of the number of elements occurring in each location. The method for generating the Richness Index is illustrated in **Figure 7** and was conducted using the Conservation Value Summary function in the Vista DSS.

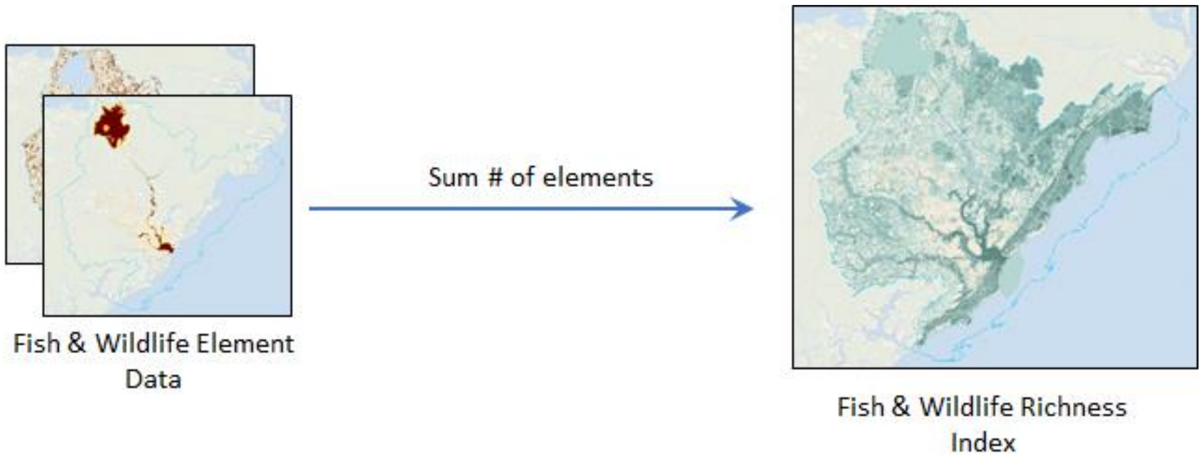


Figure 7. Method for generating the Fish and Wildlife Richness Index. *All elements are overlaid and the sum of elements occurring in a location is calculated. Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

Condition-Weighted Fish and Wildlife Richness Index

The Condition Weighted Fish and Wildlife Richness Index is a sum of the condition scores for each fish and wildlife element at a location. While the richness index described above conveys the value of a location as a factor of how many fish and wildlife elements occur there, this index modifies the value to consider the current condition of the elements. Condition scores are generated as an intermediate step in a vulnerability assessment modeling process described in Appendix 4. The method is illustrated in **Figure 8**. It consists of the following steps which are further described in Appendix 2 and Appendix 3.

1. Intersect fish and wildlife elements with the fish and wildlife stressors.
2. Apply the relevant element vulnerability models (see Appendix 3 for parameters and assumptions).
3. Generate individual element condition maps.
4. Sum the condition scores of each element in each pixel to calculate the Index.

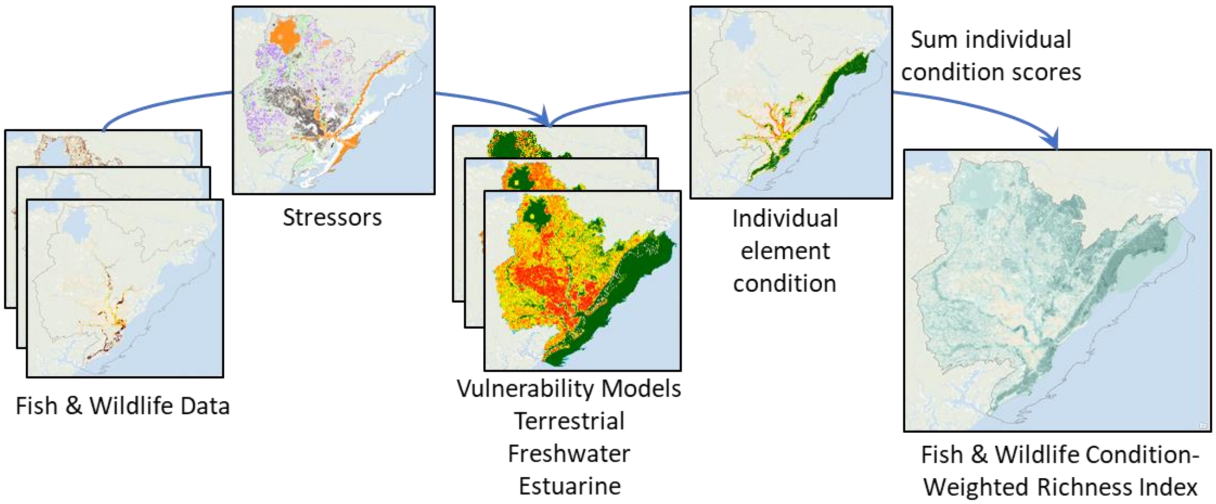
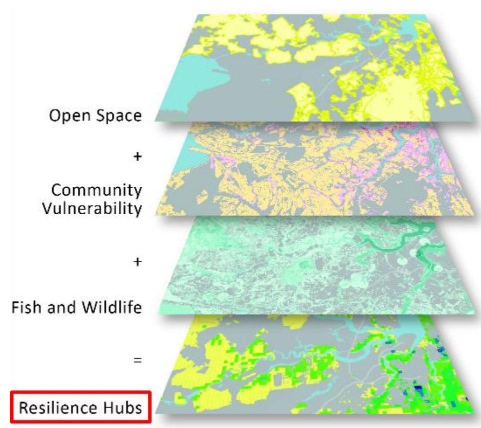


Figure 8. Method for generating the Fish and Wildlife Condition-Weighted Richness Index. *Fish and wildlife elements are intersected with stressors, the vulnerability model is applied, and individual element condition results are summed. Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

Resilience Hub Characterization and Scoring



Once open space areas were delineated as described above, they were segmented into assessment units. Assessment units are approximately 100-acre subdivisions of the Resilience Hubs to facilitate scoring and understanding of how resilience values differ across the Hubs. Hubs were subdivided by first intersecting the protected areas (USGS GAP 2016) polygons; then remaining polygons larger than 100 acres were segmented by a 100-acre fishnet grid. This provided a relatively uniform size for the assessment units and, therefore, more consistency in scoring (i.e., a very large unit does not accrue a higher value than much smaller units because it contains more fish and wildlife elements as a factor of its size). The 100-acre assessment units provide a reasonable size for distinguishing differences in value across the watershed and directing those developing resilience project proposals to appropriately-sized areas.

Each assessment unit was then assigned a value (using the formula below) for their potential to provide mutual community resilience and fish and wildlife benefits. The scores range from 0.0-1.0 with 1.0 being the highest or most desirable value for the resilience objectives. The methods are illustrated by **Figure 9**.

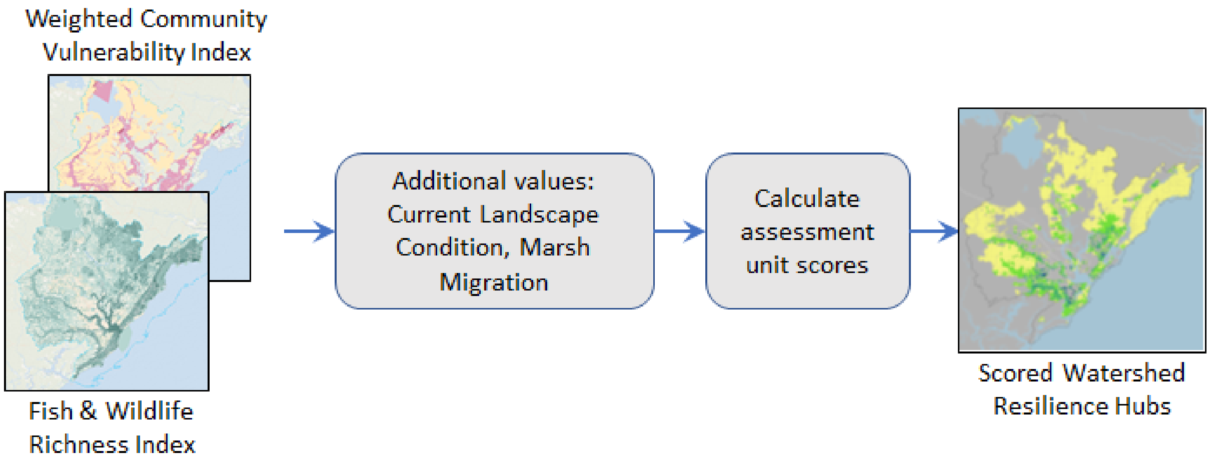


Figure 9. Method for scoring watershed Resilience Hubs. *Resilience Hub assessment units were scored based on their community resilience and fish and wildlife. Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

The values assigned to each assessment unit are:

- **Weighted Community Vulnerability**: The weighted richness of HCAs with vulnerability to flooding threats falling within each assessment unit. This is a combination of the Community Vulnerability Index and HCA Weighted Richness Index. This attribute was used as a strong attractor of resilience projects to increase resilience to HCAs modeled to be vulnerable. The index has a value of zero if the HCA Flooding Threats Exposure Index is zero, otherwise it is the value from the HCA Weighted Richness. Focal statistics were used to summarize this combined map using a 1 km (0.62 mi) radius and these results were summed to each assessment unit using zonal statistics. This is an intermediate product used only to score Resilience Hubs and therefore not depicted in the Results section.
- **Fish and Wildlife Richness Index**: The number of fish and wildlife elements falling within each assessment unit. This attribute was used to increase the value of areas that could benefit more fish and wildlife elements relative to places with fewer elements.
- **Future Marsh Migration Index**: This attribute is based on NOAA's three-foot sea level rise marsh migration models (NOAA 2018). The rationale is that areas modeled to support future marsh habitat will be able to provide ongoing fish and wildlife value with at least three-feet of sea level rise. While changes (e.g., one foot of sea level rise) may not occur until well into the future, conservation and restoration of these areas should begin now to prepare for future changes. Areas were assigned a one (1) if the assessment unit was projected to have estuarine marshes.
- **Restorability Index:** This attribute is based on the current condition as modeled from the existing fish and wildlife stressors as well as its protection status. Scores the value of an assessment unit based on the average.
    - The protected areas assessment units are of interest for ***restoration*** to improve the viability of elements within them (as they are already protected from conversion to more intensive uses). Therefore, they were scored as:

        - 1 (high priority) if the elements are in moderate condition (score > 0.3 and < 0.7) and can be improved through significant restoration action,
        - 0.5 (medium priority) if the elements are currently in good condition (score > 0.7), requiring no to little restoration, or
        - 0 (low priority) for low condition (score < 0.3), considered to have lower prospects/higher cost for successful restoration.
    - Private open space areas would benefit from both conservation and restoration and/or protection. Therefore, they were scored as:
        - 1 (high priority) for all moderate to good conditions (score > 0.3), or
        - 0 (low priority) for low condition (score < 0.3), considered to have lower prospects/higher cost for successful restoration and would hold little conservation value.

A final score was calculated for each hub using the above indices. A higher score indicates a higher value. The algorithm used to combine the indices values is:

$$((C/\max(C)) * 4) + (((F/\max(F)) + M) * R)$$

Where: *C* is the Weighted Community Vulnerability
F is the Fish and Wildlife Richness Index
M is the Future Marsh Migration Index and
R is the Restorability Index

The score multipliers in the algorithm emphasize the relative importance of vulnerable HCAs in/near the hub assessment units and restorability of habitat. While the scoring emphasized the objectives of this Targeted Watershed Assessment, the component values from the indices in the assessment units are contained in the Resilience Hubs GIS map and can be used to support other objectives. For example, those most interested in protecting HCAs will be interested in hub areas with highest community vulnerability scores. Similarly, those most interested in fish and wildlife conservation and restoration can likewise find areas to support that objective.

Resilience Projects

Location data and descriptive information about resilience project plans and ideas were gathered from stakeholders (see Stakeholder and Partner Engagement methods and Appendix 1). It is hoped that this list of projects can help match conservation and resilience need to appropriate funding sources and interested implementers. While an extensive outreach effort was conducted to identify relevant projects, it is possible that, at the time of this assessment, additional relevant project plans and ideas existed but were not submitted or otherwise brought to the attention of the project team.

The submitted projects were reviewed for relevance to the assessment objectives, focusing on their ability to provide mutual benefits for community resilience and fish and wildlife. Relevant projects with sufficient ancillary information—including their location and geographic extent—were retained for further evaluation and consideration. Each project was evaluated for the following attributes.

- Calculated size in acres: The size in acres of the polygon representing the project area. Alternatively, submitters could enter an estimated size if project boundaries had not been developed.
- Alignment with NOAA's mission, programs, and priorities
- Alignment with USACE's mission, programs, and priorities
- Addressing stressors and threats mapped in the project polygon
- Project addresses the main threats: Assessed by comparing the list of threats to the proposed actions of the project
- Project proximity to a resilience hub: A Yes/No indicator for whether the project falls within one km (0.62 miles) of any resilience hub
- Community Vulnerability Index: The average value of the regional Community Vulnerability Index for the project polygon
- Number of HCAs found within the project polygon
- List of the HCAs mapped within the project polygon
- Number and percentage of the HCAs within the project polygon that are designated non-viable in the Coastal Threats scenario evaluation
- Number of fish and wildlife elements found within the project polygon
- List of the fish and wildlife elements mapped within the project polygon
- Number and percentage of the fish and wildlife elements vulnerable to flooding threats

This information was used to select a subset of projects for site visits and case studies (see Results section). The complete list of projects submitted is presented in Appendix 7.

Site Visits

Five projects were selected for site visits of which three were developed into the case studies found in the Results section. A spreadsheet containing information on all projects provided by the proponents and corresponding indices calculated using the above steps was provided to NFWF. The Technical and Steering Committees analyzed the project information to identify projects most appropriate for site visits. Once selected, site visits were scheduled with project proponents. Watershed and Technical Committee members were invited to participate.

Site visits were conducted by representatives from NOAA, NFWF, and NatureServe. For each site visit, the assessment team spent two to four hours taking photos and compiling answers to a set of questions meant to increase understanding of the project's potential benefits and implementation challenges. Information gathered from the site visits was used to select three projects to be used as the focus for detailed case studies (see Case Studies section below).

Results

This section portrays the key set of products primarily focused on the resulting Resilience Hubs and key indices. Many map and tabular products were generated for this Targeted Watershed Assessment. In addition to this report, key results may be viewed in the Coastal Resilience Evaluation and Siting Tool (CREST), which is an interactive online mapping tool that includes results for the Regional Assessment and each of the eight Targeted Watersheds (available at resilientcoasts.org). CREST can also be used to download data including the Jacksonville and Lower St. Johns River Watersheds NatureServe Vista decision support project, which includes the input data and useful intermediate products that can be updated and customized. Prior to using these results for any decisions, please see the limitations described in the Conclusions section.

Flooding Threats

The effects of the flooding threats on the vulnerability of Human Community Assets (HCAs) and fish and wildlife elements are treated individually in the assessment model (see Appendix 2); therefore, a separate threats index was not generated. An analog to a threats index can be found in Appendix 2, which contains the results of four models of how wildlife stressors and flooding threats may cumulatively impact the condition of HCAs, terrestrial wildlife, freshwater fish and wildlife, and estuarine fish and wildlife. The Threat Index generated in the Regional Assessment is provided below (**Figure 10**) to illustrate the accumulation of flooding threats across the Jacksonville and Lower St. Johns River Watersheds. The Threats Index used in the Regional Assessment is a combination of the number and probability of occurrence of the flooding threats in each location (see Dobson et al. 2019 for more information).

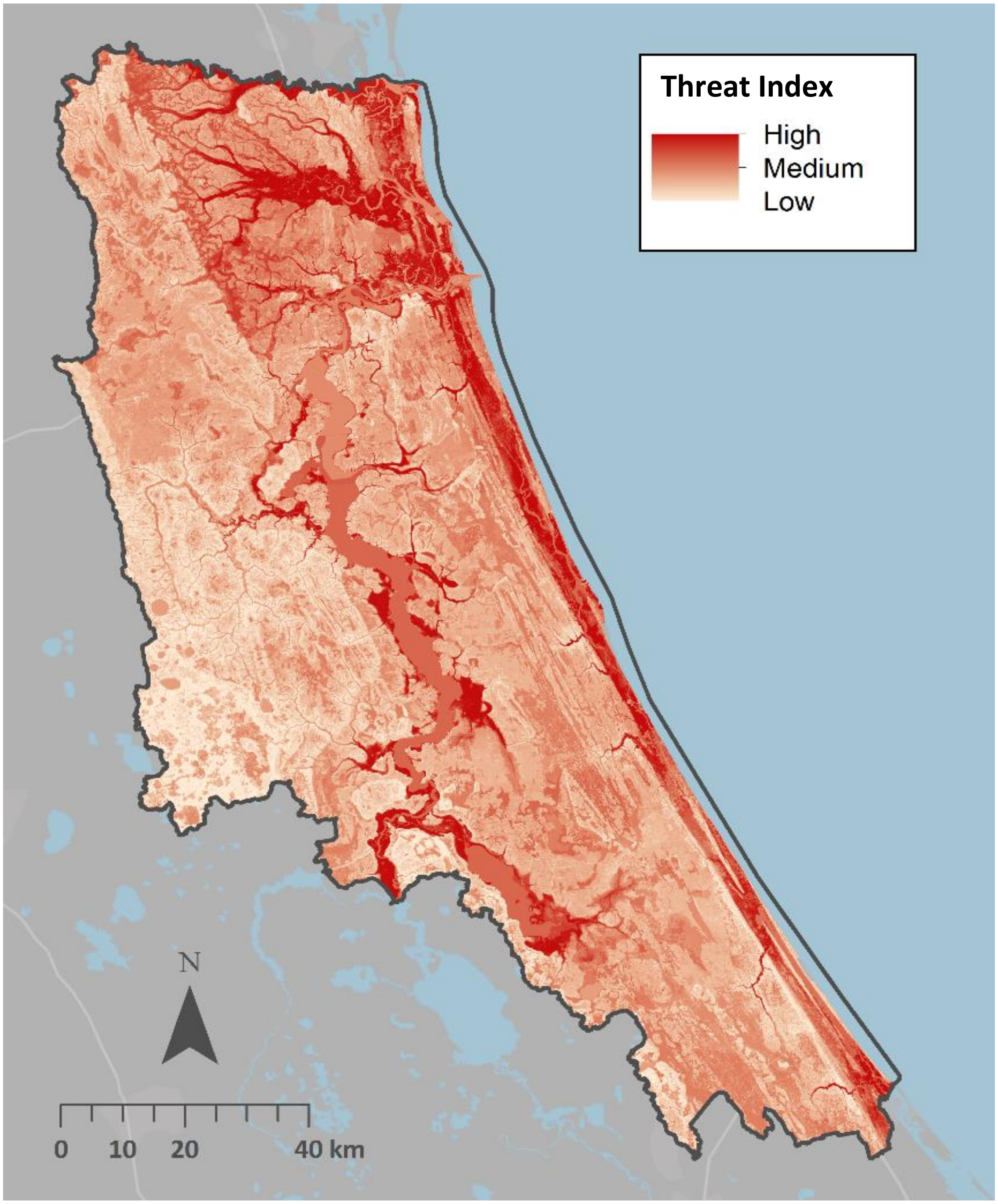


Figure 10. Weighted Threat Index for the Jacksonville and Lower St. Johns River Watersheds. *Map shows the number of overlapping threats modified by a weighting based on their probability of occurrence.*

Suggested Uses

Understanding which threats occur in a location can inform whether action needs to be taken, whether proposed actions can mitigate all threats anticipated for an area, and what measures would be most appropriate to mitigate threats if mitigation is even feasible.

Human Community Assets

HCA Weighted Richness Index

This index indicates areas of HCA concentrations (**Figure 11**). Darker shades can be an indication of overlapping HCAs, higher or lower importance weightings, or both.

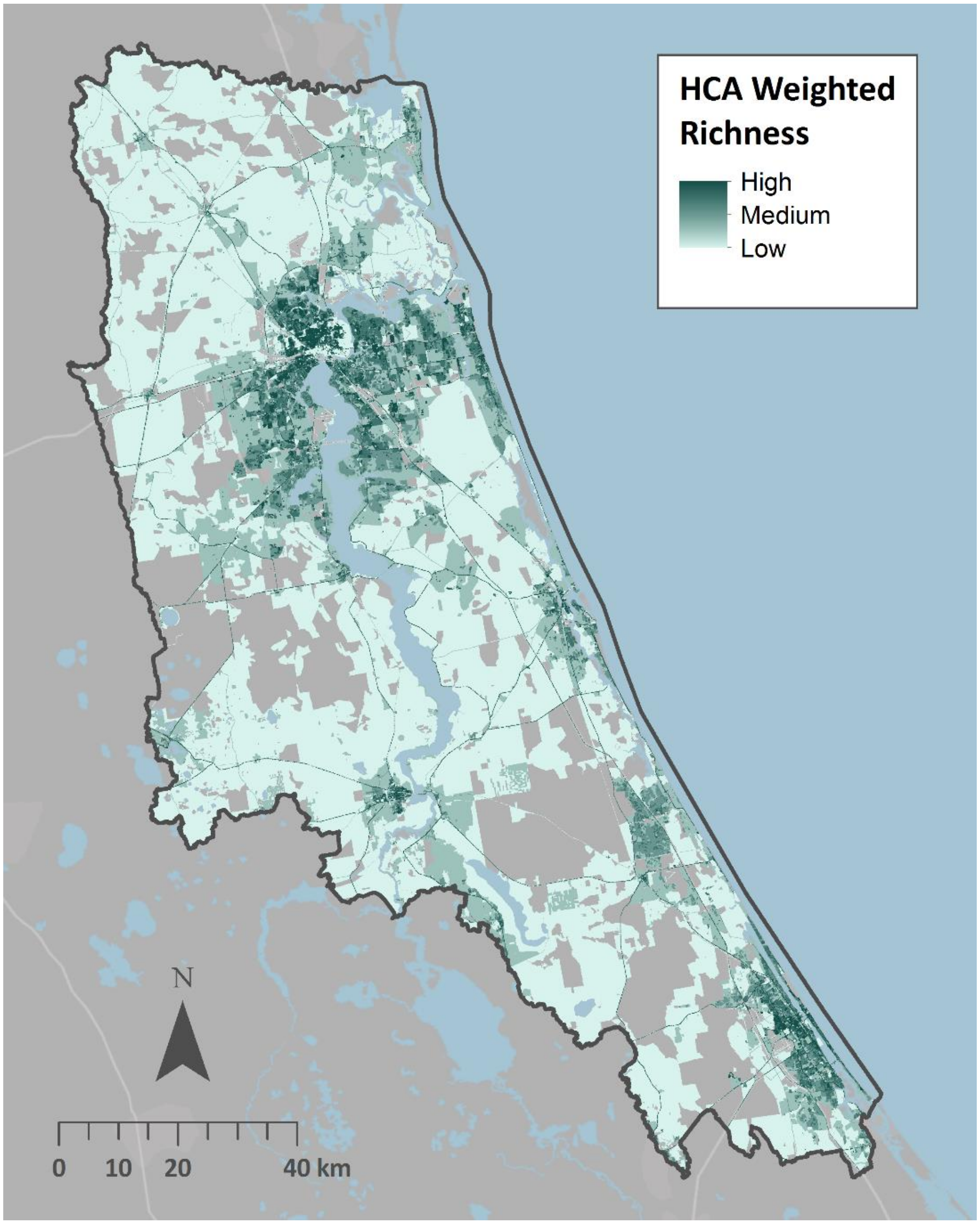


Figure 11. Human Community Asset (HCA) Weighted Richness Index for the Jacksonville and Lower St. Johns River Watersheds. *Darker shades indicate higher value based on the number and importance weightings of HCAs in each location. Gray areas within the project boundary represent areas with no mapped HCAs.*

Community Vulnerability Index

This assessment evaluated the vulnerability of the HCAs to flooding threats. The score of any location in the index is based on the number of vulnerable HCAs at that location (**Figure 12**).

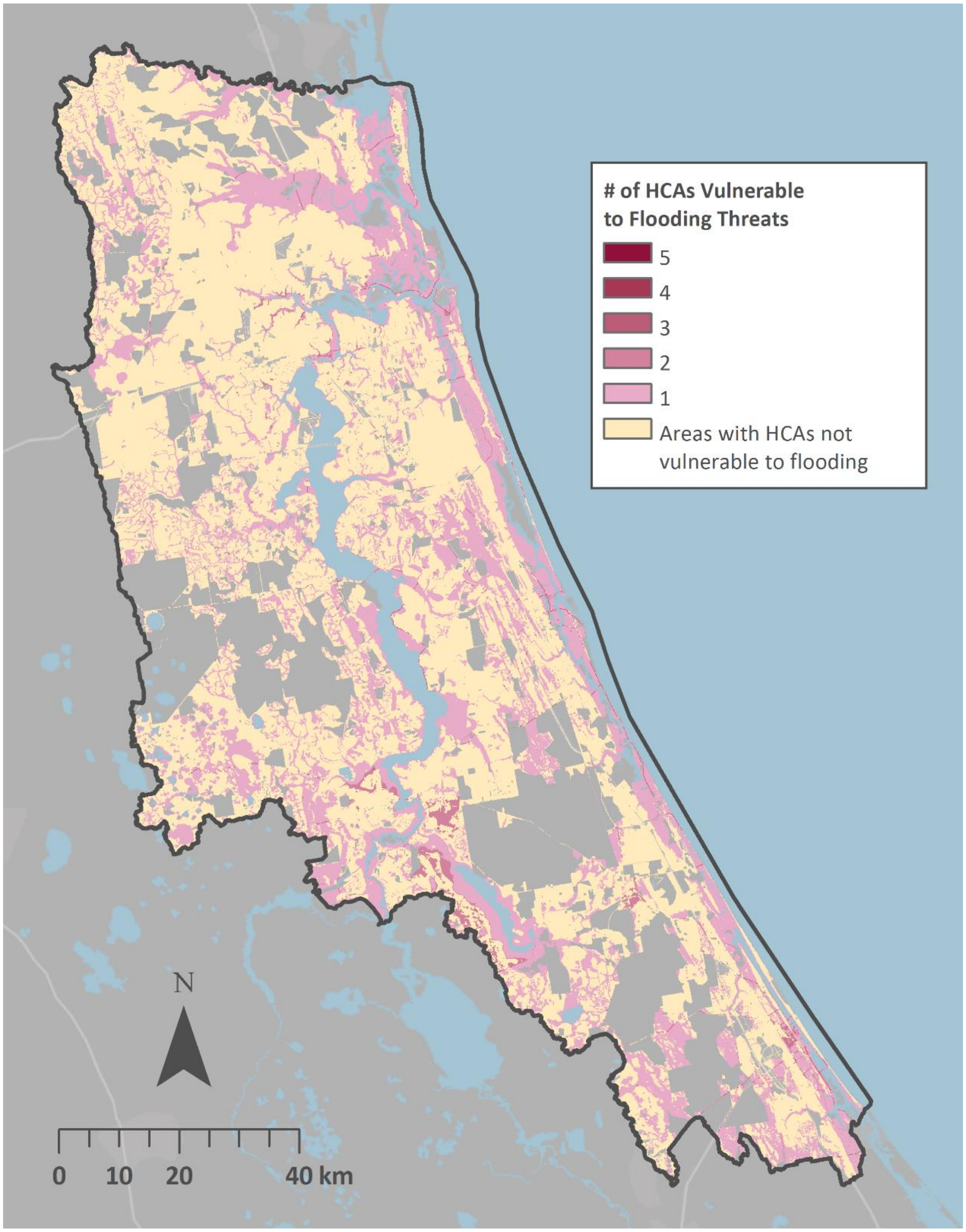


Figure 12. Community Vulnerability Index results for the Jacksonville and Lower St. Johns River Watersheds. *Pink to red shades indicate the number of Human Community Assets (HCAs) exposed to threats. Tan areas indicate areas of low to no impact from the flooding threats. Gray within the project boundary represents areas with no mapped HCAs.*

Vulnerability is highest in the immediate coastal areas and along the St. Johns River, particularly in cities where there are concentrations of HCAs exposed to the most flooding threats. Areas of vulnerability farther inland are largely due to precipitation-caused flooding threats (flood zones and flat areas with poorly draining soils). The highest areas of vulnerability can be seen in central Jacksonville, St. Augustine, and Daytona Beach. Smaller coastal communities such as Port Orange, Ormond Beach, Palm Coast, Jacksonville Beach, and Fernandina Beach also represent local concentrations of vulnerable HCAs. The City of Palatka is an inland peak of vulnerability due to its location on the St. Johns River.

Suggested Uses

The HCA Weighted Richness Index can focus planning efforts by directing planners to the areas with concentrations of highest weighted assets or those most important to rebuilding or responding to threats. The Community Vulnerability Index communicates threat to human community assets wherever they occur as well as concentrated areas of threat. Therefore, it can support the intended objectives of siting and designing resilience projects to reduce threats to HCAs. It can also support coastal hazard/emergency management and land use planning to proactively address risks by understanding threatened assets, areas, and types of threats.

Fish and Wildlife Value Indices

Fish and wildlife indices are overlays or combinations of the fish and wildlife elements intended to express value based on where the elements are mapped.

Richness of Fish and Wildlife Elements

This index (**Figure 13**) represents the number of elements that overlap in any location. It conveys value through the concept that areas with more elements (darker green shades) will provide more opportunities for conserving/restoring fish and wildlife than areas with a low number of elements (lighter green shades).

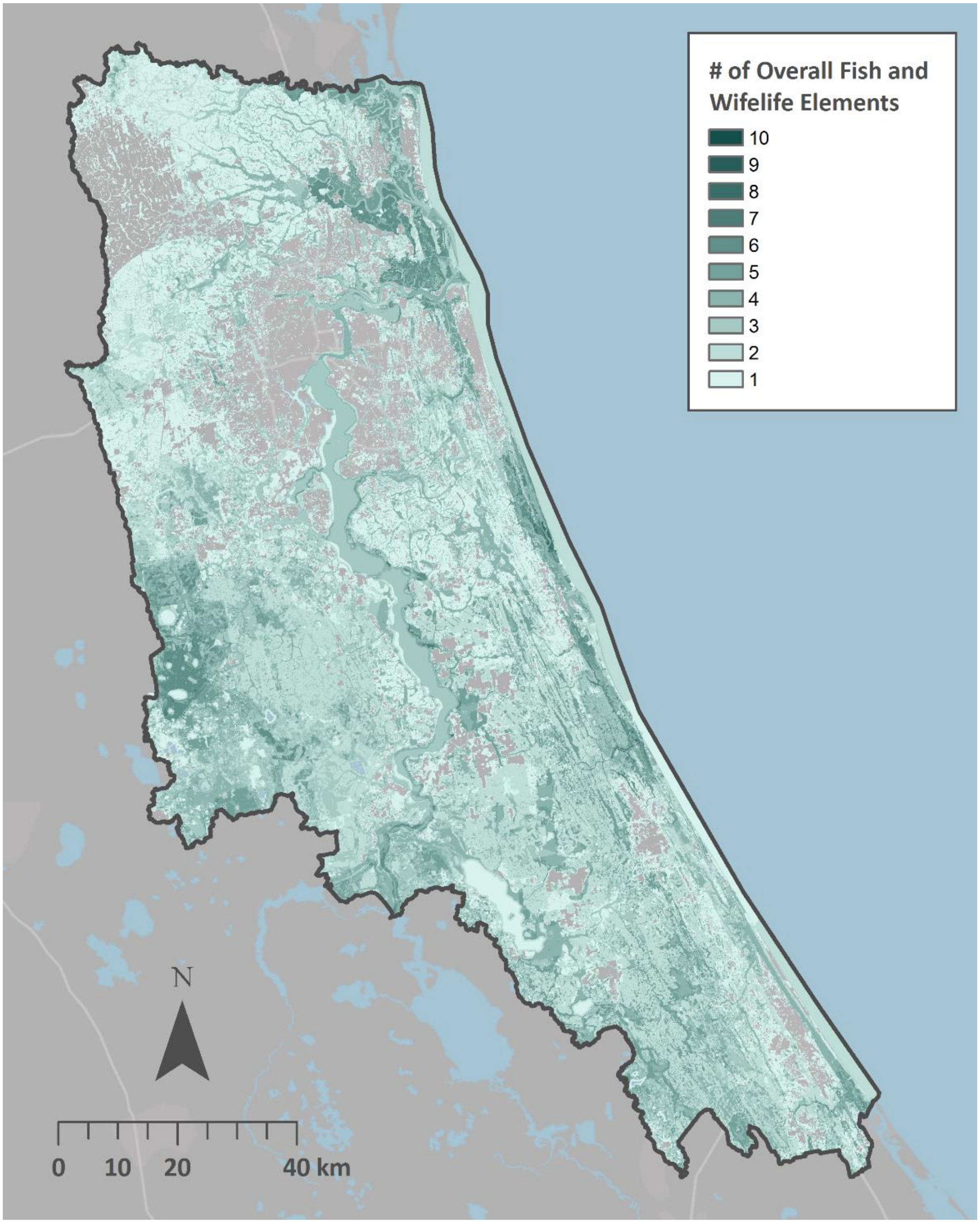


Figure 13. Richness of fish and wildlife elements in the Jacksonville and Lower St. Johns River Watersheds. *Green shades indicate the number of elements found in a location. Gray within the project boundary are areas with no fish and wildlife elements considered in this assessment.*

Condition-weighted Richness of Fish and Wildlife Elements

The Fish and Wildlife Condition-weighted Richness Index (**Figure 14**) modifies the richness map above by incorporating the modeled condition of elements that overlap in any location. This analysis used a sum of the condition scores of all elements overlapping in a pixel. It conveys value through the concept that areas with more elements of higher condition are important to conserve, while areas with moderate scores may provide opportunities for restoration. Areas of low scores either have few elements or the elements present are in poor condition and therefore, may not represent the highest priorities for future projects with a goal of maximizing fish and wildlife benefits.

Both the simple richness and condition-weighted richness models highlight five areas across the region with high index scores: 1) the salt marsh and tidal wetlands extending from the mouth of the St. Johns River north through the Nassau River and to the state line, 2) the coastal habitats and waterways of the Guana-Tolomato-Matanzas Reserve, 3) the wetlands and waters along the Matanzas River south of St. Augustine, 4) extensive forested wetlands at the mouth of Deep Creek where it joins the St. Johns, and 5) the interior upland sandhill landscape on Camp Blanding. The condition model serves to further emphasize areas of importance to wildlife that are also impacted by current stressors. A stretch of the St. Johns River south of Jacksonville is impacted by water quality issues.

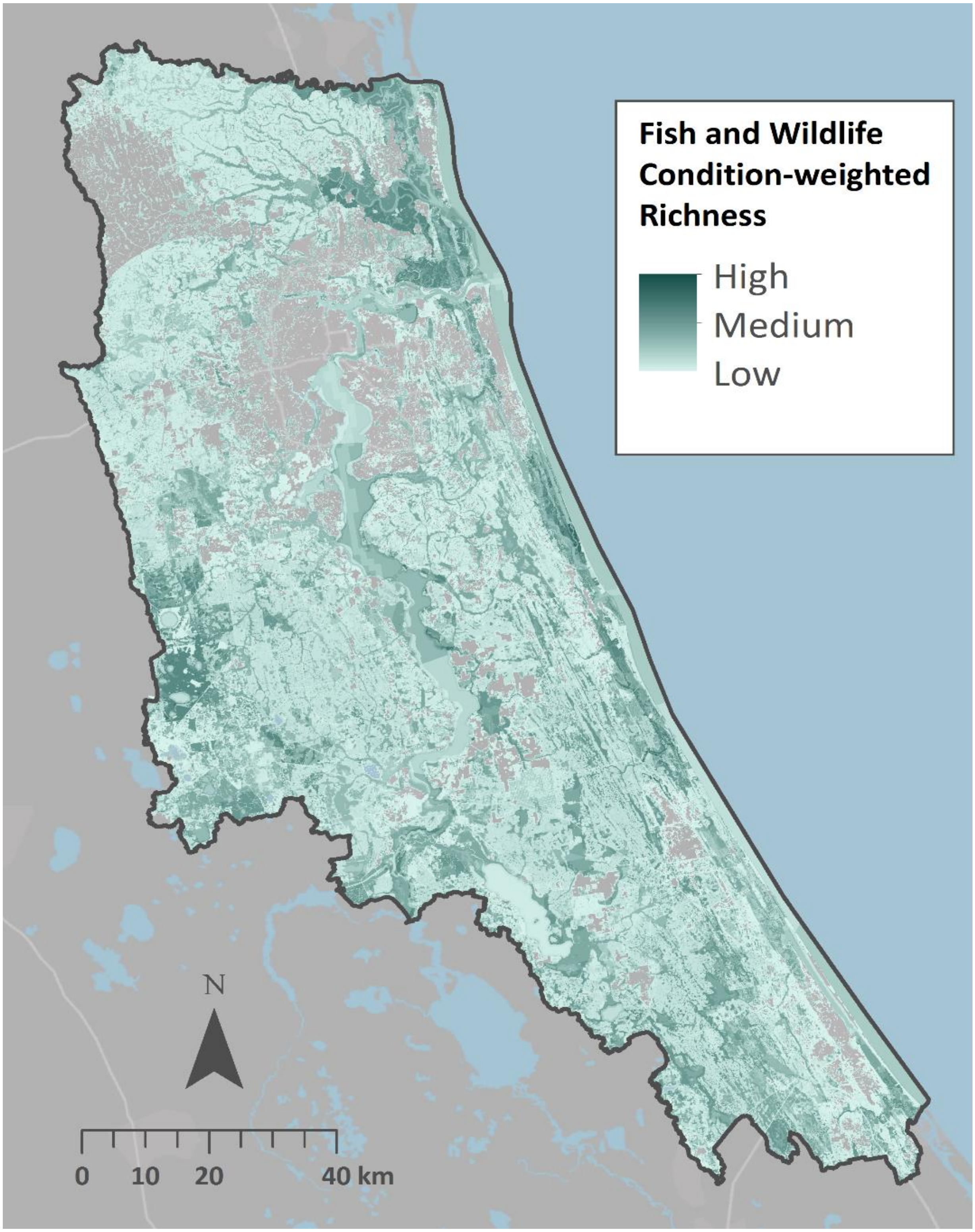


***Figure 14. Fish and Wildlife Condition-weighted Richness Index results for the Jacksonville and Lower St. Johns River Watersheds**. Green shades indicate the added condition scores of the elements found in a location, with a maximum value of one per element. Grey areas within the project boundary signify areas with no mapped fish and wildlife elements.*

Suggested Uses

The primary use of these indices, besides informing the scoring of Hubs and resilience project attributes, is to support fish and wildlife conservation decisions (subject to the limitation that these indices only apply to the elements selected for this assessment). Richness informs areas to target larger numbers of elements. Conversely, the condition-weighted index adds information as to whether a location is amenable to simple protection efforts because it is already in good condition, or if a location may benefit from restoration because its condition and/or function is impaired or less than pristine.

Resilience Hubs

Resilience Hubs are areas of opportunity for conservation actions, such as resilience projects, that have the potential for providing mutual benefits for HCAs and fish and wildlife elements.

The Hubs incorporate community vulnerability and wildlife value, and therefore, they can be an important input to planning for more resilient land use, emergency management, and green infrastructure. As an integrative product, the Resilience Hubs also serve as a vehicle for collaborative planning and action among different agencies and/organizations. Such collaborative approaches can leverage multiple resources to achieve more objectives with significantly greater benefits than uncoordinated actions.

Resilience Hubs are based on undeveloped open spaces of protected or unprotected privately owned lands and waters (**Figure 15**) that are in proximity to concentrations of vulnerable HCAs. These open space areas were segmented into distinct Resilience Hubs based on the Regional Assessment (Dobson et al. 2019). For this Targeted Watershed assessment, Hubs were further segmented into assessment units (100-acre areas) and scored (**Figure 16**) as explained in the Methods Overview. Scores convey value based on project objectives for siting resilience projects with mutual benefits for HCAs and fish and wildlife. Scoring the assessment units is important because value is not uniform across a Hub; it changes based on proximity to vulnerable HCAs and richness of fish and wildlife elements.

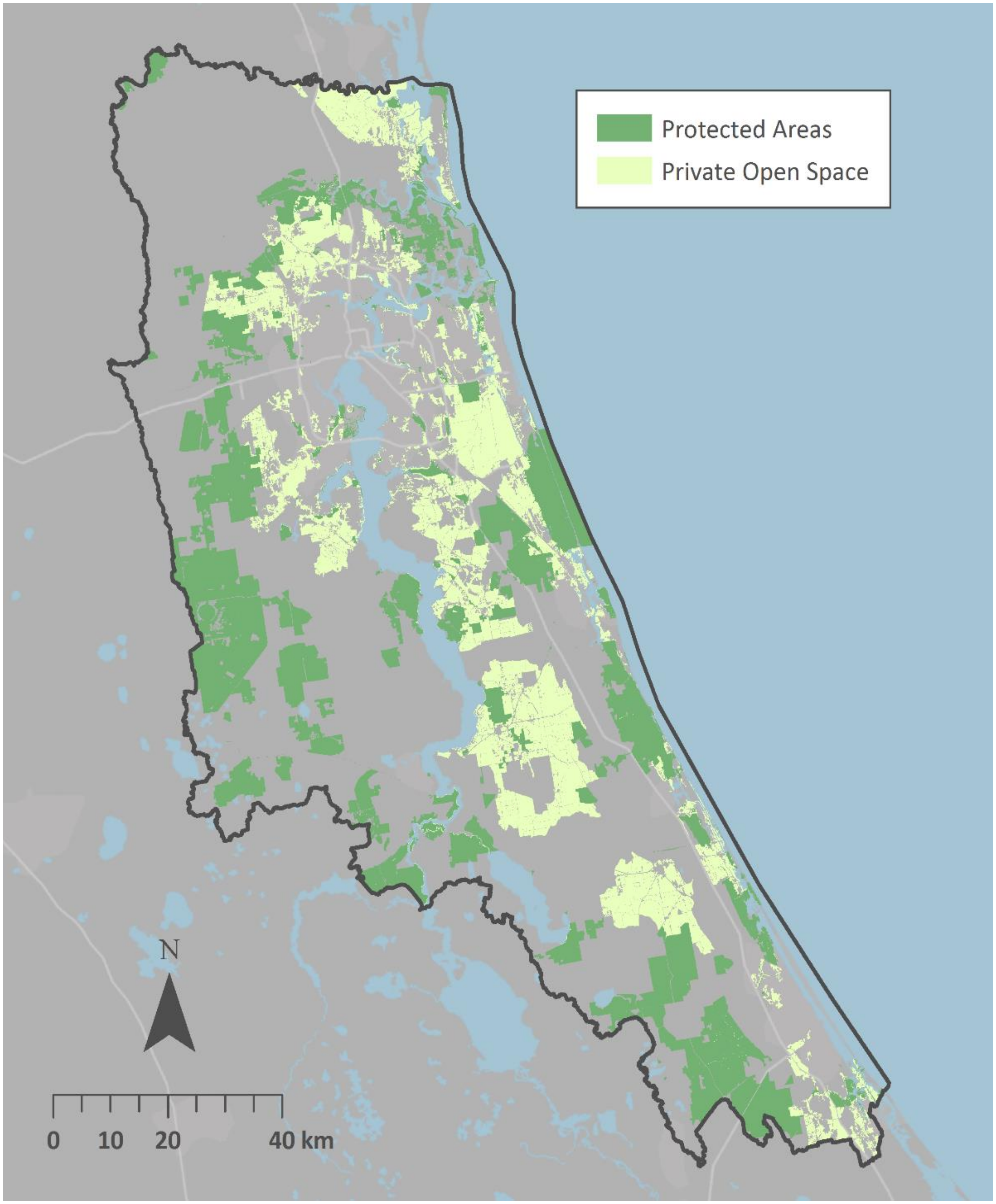


Figure 15. Undeveloped protected areas and unprotected privately owned areas of open space in the Jacksonville and Lower St. Johns River Watersheds. *Map displays the distribution these areas within Resilience Hubs identified in the study area and therefore does not include all such areas within the study area.*

By design, Resilience Hubs occur where concentrations of vulnerable HCAs are proximate to open space areas. The size of a Hub does not equate to importance and instead is a factor of available open space near HCA concentrations (see **Figure 16** with assessment unit scoring). Identifying which portions of Hubs are already protected determines what actions may be most suitable. Expanding, restoring the condition of, or increasing connectivity between protected areas can increase resilience in these areas. Unprotected sites, if in good condition, may only need added protection to ensure long-term resilience benefits. In places where conditions are impaired, restoration is often the most appropriate path to increase resilience.

Resilience Hubs Assessment Unit Scores

The scoring of the assessment units of the Resilience Hubs, as described in the Methods Overview, was intended to convey the differing values for providing resilience and fish and wildlife benefits within the Hubs. In total, 18,273 assessment units were analyzed and scored within the Charleston Harbor Watershed. Highest scoring assessment units, in dark blue, are located nearest concentrations of vulnerable HCAs, whereas areas that have little benefit to human community resilience or benefit to fish and wildlife are in yellow (**Figure 16**).

As expected, the highest scoring portions of the Resilience Hubs cluster in and around concentrations of high vulnerability of HCAs near open space. These include the extensive floodplains of Duval County north of Jacksonville, much of the Intra-Coastal Waterway from Amelia Island to Daytona Beach, and areas of St. Johns River floodplain southeast of Green Cove Springs, around Hastings, and north of Crescent Lake. Three high scoring areas of resilience hubs are featured below and are associated with the case study resilience projects.

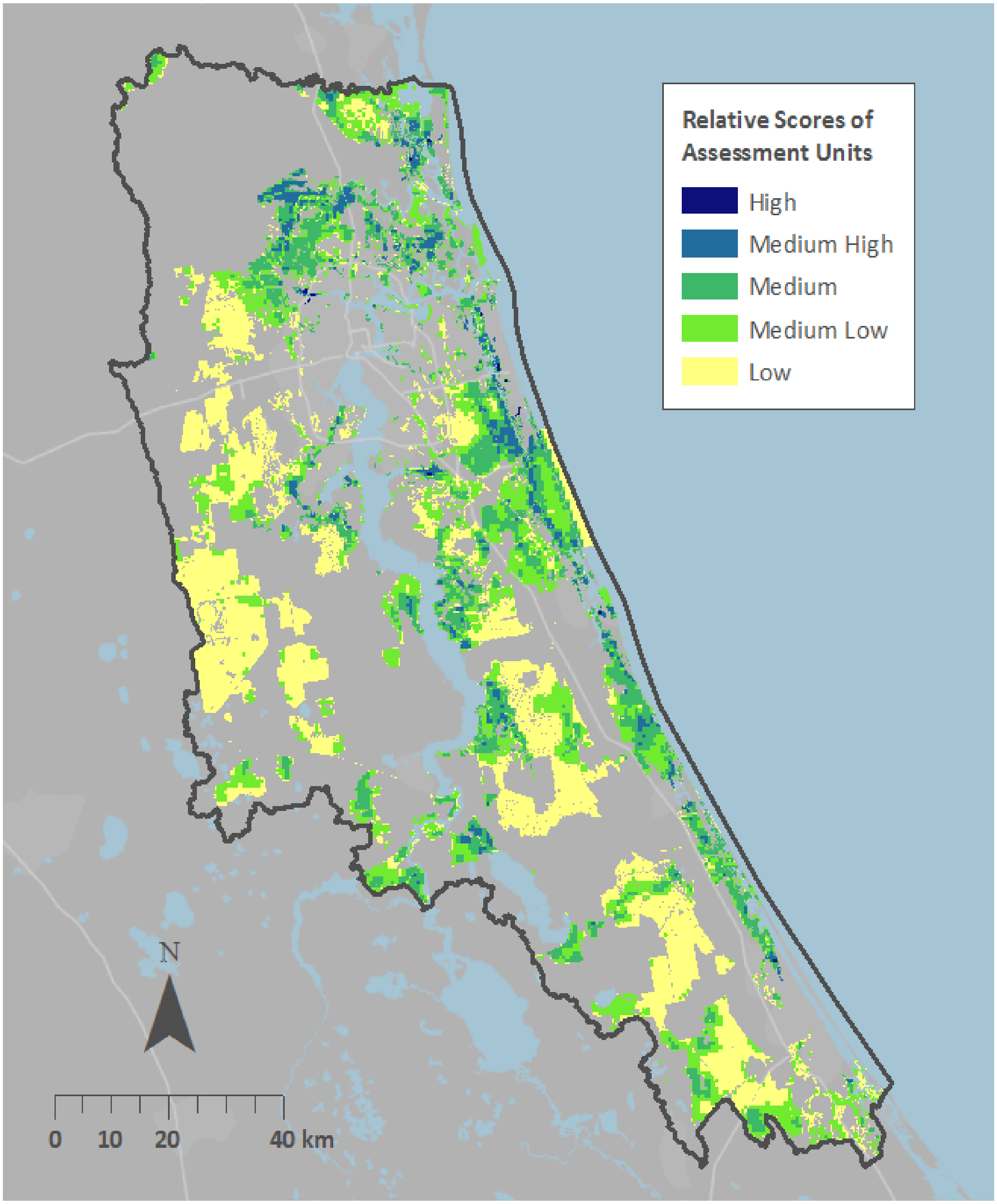


Figure 16. Resilience Hubs assessment unit relative scores for the Jacksonville and Lower St. Johns River Watersheds. *Assessment units are 100-acre grids or smaller parcels. Darker shades have higher scores or greater potential for community resilience and fish and wildlife benefits.*

Suggested Uses

The Resilience Hubs map for the Jacksonville and Lower St. Johns River Watersheds incorporates many of the key analyses described herein and therefore can inform many uses. The most direct use, as described in the project objectives, is to inform design and siting of, and investment in, resilience projects in areas where they can contribute to community resilience and benefit fish and wildlife. In addition to siting or evaluating the potential benefits of projects, decisions about what type of actions would be most appropriate given the community context, fish and wildlife present, and threats can be supported. This can be done by reviewing the scoring attributes found in the Hubs GIS map, and/or viewing the map in the context of other outputs such as the Community Vulnerability Index. While the scoring emphasizes areas providing mutual benefits, the individual inputs can assist users in identifying areas of value based on other objectives, such as focusing only on community resilience needs or areas that maximize fish and wildlife benefits.

Resilience Hubs Example Areas

Three of the highest scoring areas of the Resilience Hubs are characterized below to illustrate how the assessment identified potentially valuable places for resilience projects. Note that these results were provided to illustrate how the model scores a location and are not field validated. Additionally, they do not attempt to suggest specific actions that should be taken to increase resilience.

Nine Mile Creek Resilience Hub Area Example

This hub area near downtown Jacksonville scored highly for resilience potential because it is located within an area that contains both tidal salt marsh and densely populated areas that can benefit both human assets and fish and wildlife (**Figure 17**). This area is also likely to retain at least a portion of these benefits under three feet of sea level rise because it was modeled to be a site for marsh migration. This hub is in relatively good condition although water quality is impaired in this watershed. This site could benefit from additional protection through land acquisition or easement acquisition since it is not currently protected. Although it is not heavily channelized, this site bears similarities in terms of resource values and threats to two of the resilience project case studies: Hogan's Creek and McCoy Creek, both in downtown Jacksonville (see case studies featured in this report for more information).

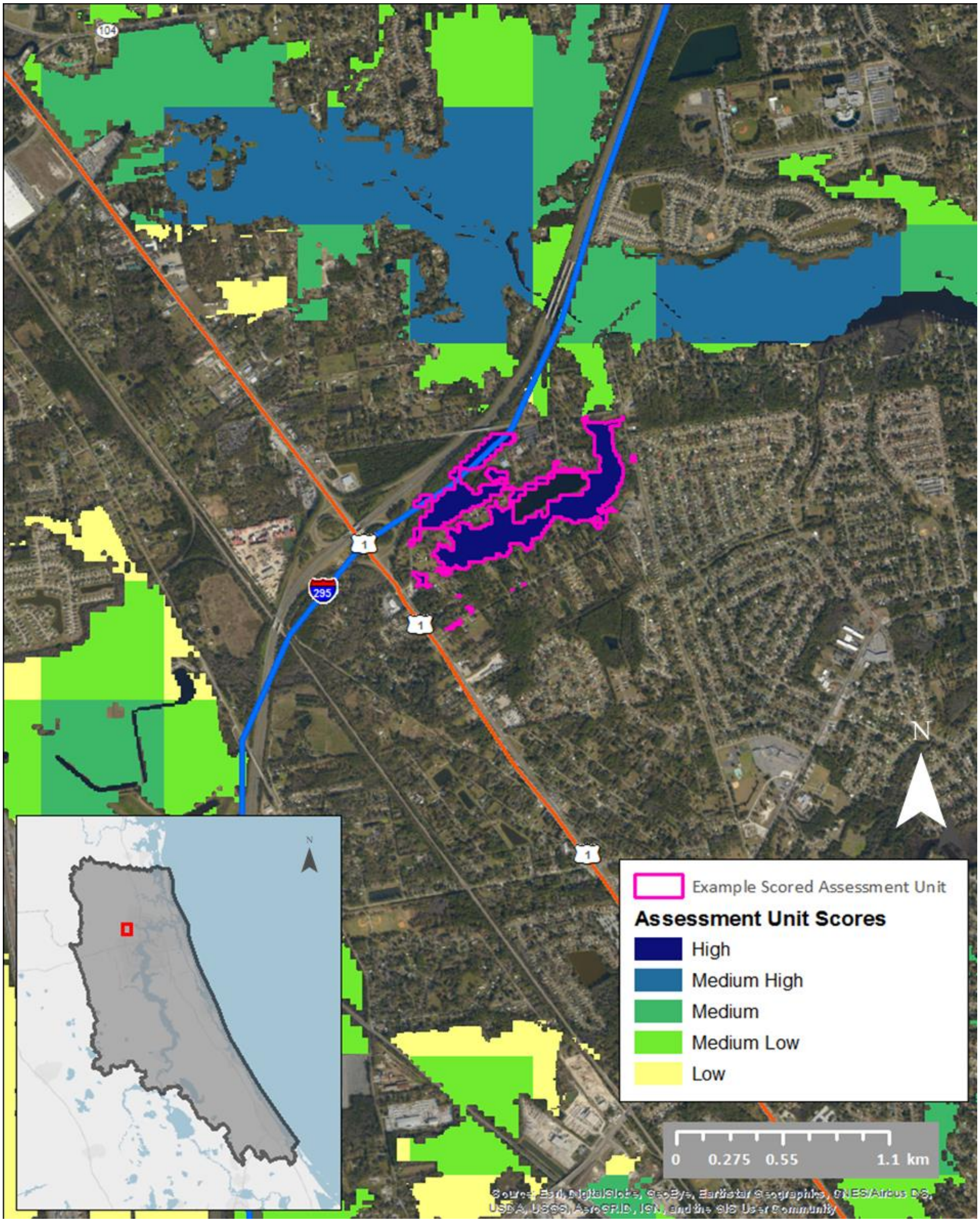


Figure 17. Nine Mile Creek Resilience Hub area example. *The yellow-blue shaded areas are the scored resilience hub assessment units. The hub assessment unit outlined in pink is the one used to characterize the values in this example.*

Elements in this assessment unit:

- Estuarine water
- Freshwater tidal wetlands
- Interior scrub
- Eastern indigo snake potential habitat
- Interior wetlands
- Painted bunting
- Salt marsh/tidal flats
- Shrimp Essential Fish Habitat
- Snapper/Grouper Essential Fish Habitat
- Wading birds
- Wood stork

HCA elements in or near assessment unit:

- Critical Infrastructure Rank 1 (bridge over Nine Mile River)
- Critical Facilities (likely an emergency shelter of some type)
- Population Density 1, 2, 3, 4 (Jacksonville suburbs)
- Social Vulnerability

Table 4. Attributes used to calculate the final score for the Nine Mile Creek Resilience Hub assessment unit example. *The values for each scoring attribute and the final score correspond to the hub assessment unit outlined in pink in **Figure 17**. See the Methods section for additional details on each scoring attribute.*

Description of Scoring Attributes	Score
Fish and wildlife richness (# of fish/wildlife elements out of 30 possible)	11
Presence of modeled marsh migration	1 (yes)
Weighted Human asset vulnerability (normalized to 0-1, mean value of 0.12, standard deviation 0.16)	0.77 (very high)
Restorability	1 (good candidate for protection)
Average Condition (1= current very high condition)	0.67 (moderate)
Final score	**4.68 (rank #4 out of 18,273 units)**

South Ponte Vedra Beach Resilience Hub Area Example

This hub is located on the Atlantic Coast barrier island north of St. Augustine. Although it doesn’t score as high in the hub assessment as the other examples, this hub features conditions that are typical along the barrier islands in northeast Florida: a marine beachfront that provides habitat for sea turtles, shorebirds, and beach mice; moderately dense housing with commercial development along Highway A1A; and estuarine salt marsh facing the Intra-Coastal Waterway providing key habitat for wading birds and a variety of fish species. The adjacent Guana River is a listed impaired waterway, and its position along the coast makes this area vulnerable to storm surge and sea level rise. In this case, the hub is located within the boundary of the Guana Tolomato Matanzas National Estuarine Research Reserve (GTM-NERR), affording it the benefits of active management for habitat protection (**Figure 18**). This location highlights opportunities for a coastal managed area like the GTM-NERR to serve as collaborative sites for adaptation strategies to address water quality and mitigate changing environmental conditions.

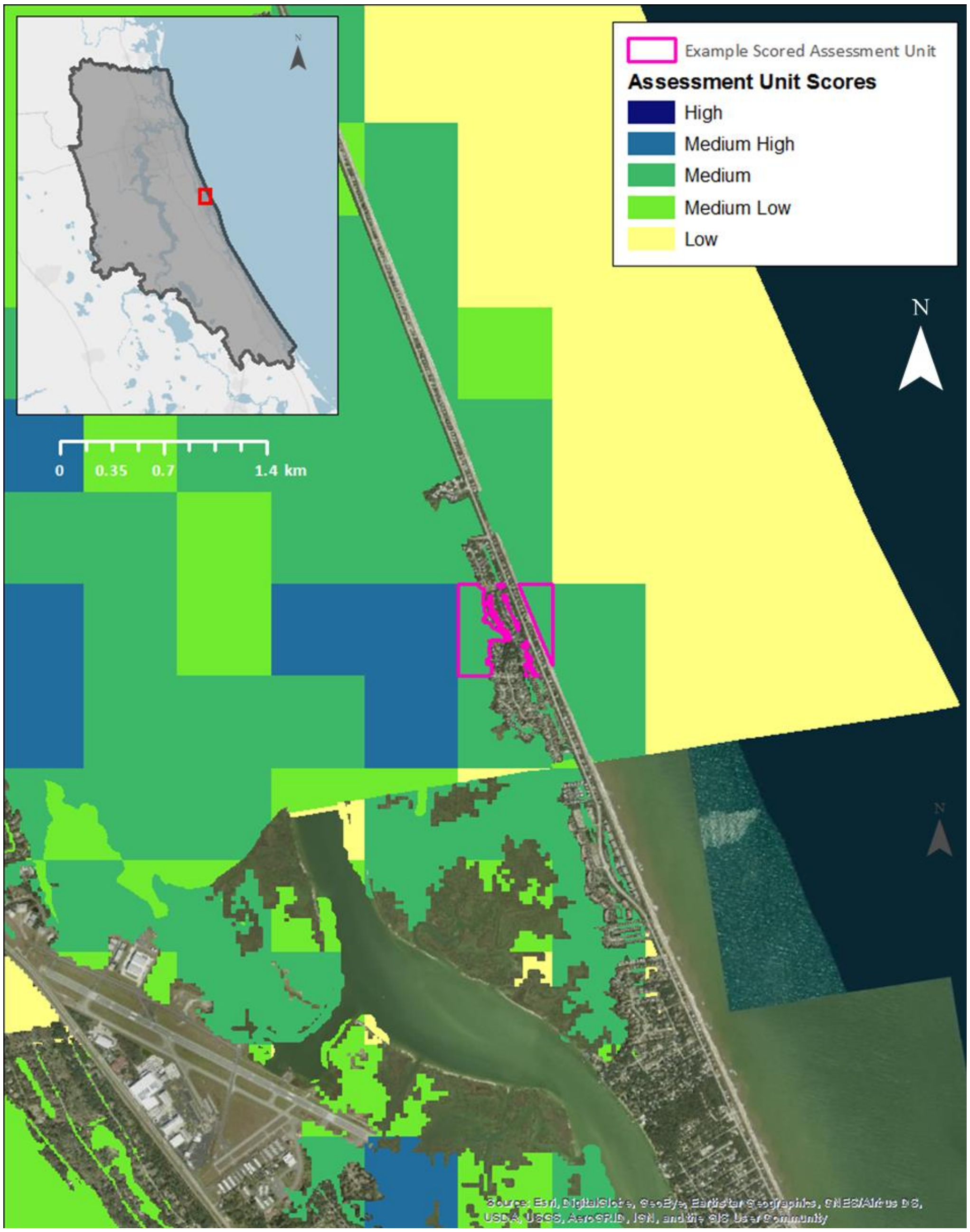


Figure 18. South Ponte Vedra Beach Hub area example. *The yellow-blue shaded areas are the scored Resilience Hub assessment units. The hub assessment unit outlined in pink is the one used to characterize the values in this example.*

Elements in this assessment unit:

- Bottomland floodplain wetlands
- Estuarine water
- Eastern indigo snake
- Federally listed element occurrences (Anastasia Island beach mouse)
- Audubon Important Bird Area
- Marine beach
- Salt marsh/tidal flat
- Sharks Essential Fish Habitat
- Shrimp Essential Fish Habitat
- Snapper/Grouper Essential Fish Habitat
- Wading birds
- Wood stork

HCA elements in or near assessment unit:

- Critical Infrastructure Rank 1, 2, 3 (Highway A1A)
- Critical Facilities (shelter or school)
- Population Density 2, 4, 5 (coastal subdivision)

Table 5. Attributes used to calculate the final score for the South Ponte Vedra Beach Resilience Hub assessment unit example. *The values for each scoring attribute and the final score correspond to the hub assessment unit outlined in pink in Figure 18. See the Methods section for additional details on each scoring attribute.*

Description of Scoring Attributes	Score
Fish and wildlife richness (# of fish/wildlife elements out of 30 possible)	12
Presence of modeled marsh migration	1 (yes)
Weighted Human asset vulnerability (normalized to 0-1, mean value of 0.12, standard deviation 0.16)	0.24 (high)
Restorability	1 (good candidate for protection)
Average Condition (1= current very high condition)	0.68 (moderate)
Final score	**3.12 (rank #642 out of 18,273 units)**

Mill Creek Swamp Resilience Hub Area Example

Mill Creek is a small tributary of Six Mile Creek, which flows into the St. Johns River southeast of Green Cove Springs (**Figure 19**). This location features a moderately large, mixed wetland hardwood swamp adjacent to a rapidly expanding low/moderate density subdivision (the housing directly north of the hub was an agricultural field as recently as 1999). Tributary swamps like this provide habitat for wading birds and contribute directly to water quality of the St. Johns watershed. It's location along the floodplain also threatens adjacent developed areas with both tidal flooding as well as flooding from inland rainfall. Additionally, Mill Creek is located within an impaired water basin. Acquisition of this area could help limit additional development near or even within the existing wetland footprint. The North Florida Land Trust has proposed a Six Mile Creek land acquisition project that extends into this hub and is included as one of the resilience projects submitted for the St. Johns River portfolio discussed below in this report.

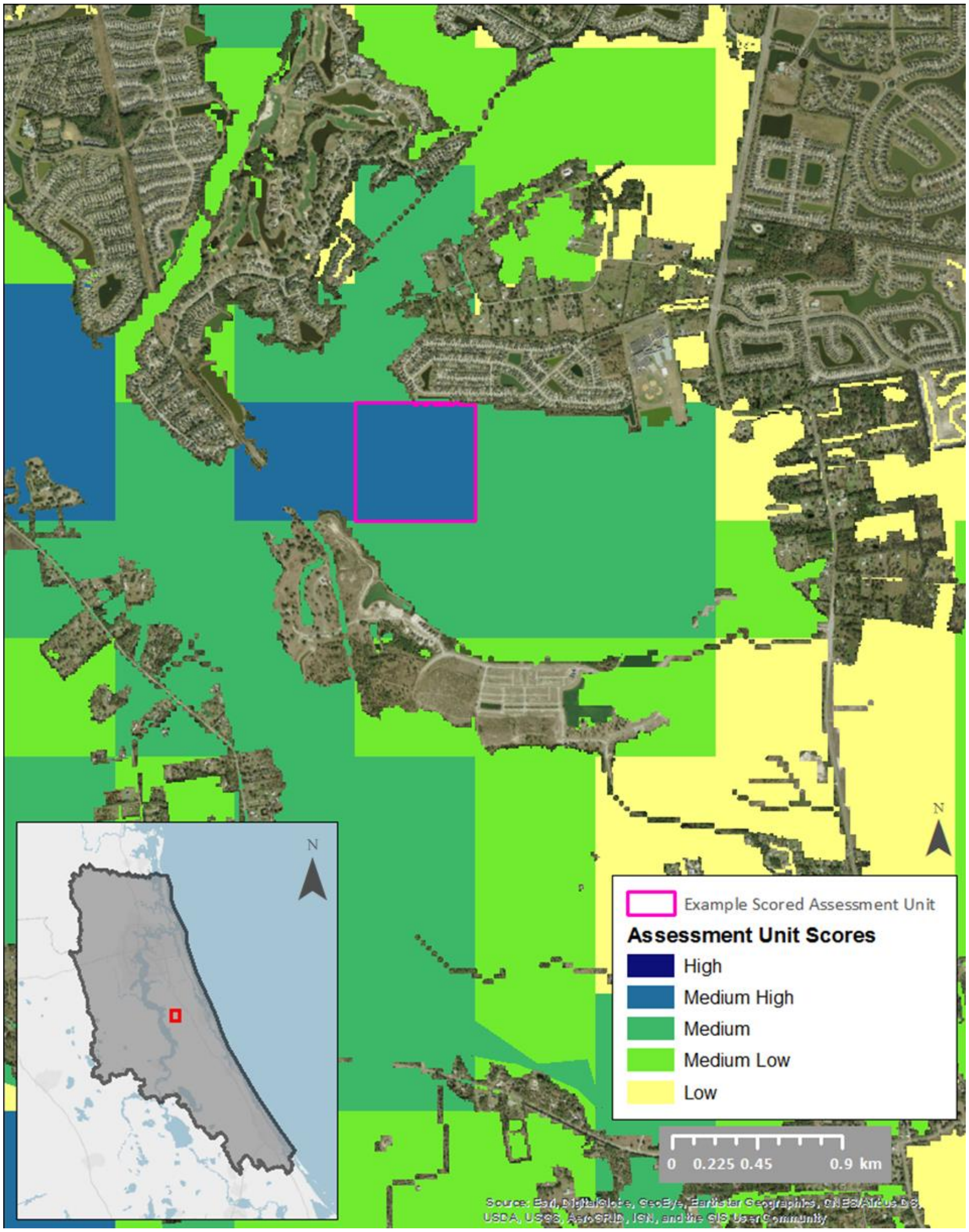


Figure 19. Mill Creek Swamp Resilience Hub area example. *The yellow-blue shaded areas are the scored Resilience Hub assessment units. The hub assessment unit outlined in pink is the one used to characterize the values in this example.*

Elements in this assessment unit:

- Freshwater tidal wetlands
- Eastern indigo snake
- Interior wetlands
- Wading birds
- Wood stork

HCA elements in or near assessment unit:

- Critical Facilities (Pacetti Bay Middle School)
- Critical Facilities (likely an emergency shelter)
- Population Density 1,2,4,5 (dense subdivision)

Table 6. Attributes used to calculate the final score for the Mill Creek Swamp Resilience Hub assessment unit example. *The values for each scoring attribute and the final score correspond to the hub assessment unit outlined in pink in Figure 19. See the Methods section for additional details on each scoring attribute.*

Description of Scoring Attributes	Score
Fish and wildlife richness (# of fish/wildlife elements out of 30 possible)	5
Presence of modeled marsh migration	1 (yes)
Weighted Human asset vulnerability (normalized to 0-1, mean value of 0.12, standard deviation 0.16)	0.64 (very high)
Restorability	1 (good candidate for protection)
Average Condition (1= current very high condition)	0.96 (very high)
Final score	**3.84 (rank #97 out of 18,273 units)**

Fish and Wildlife Elements

The final list of elements explicitly represented in the Jacksonville and Lower St. Johns River Watersheds analysis is shown in **Table 7** with a brief description of each element's conservation significance, information about data sources used to represent their distributions, and data sources used. See Appendix 5 for a more detailed description of data sources that were and were not used in this assessment.

Table 7. Final list of elements used in Jacksonville and Lower St. Johns River Watersheds assessment.

Fish/Wildlife Element	***Description/Significance***
NOAA Trust Resources	
Coastal dunes and grasslands	Includes active coastal dunes landward of beaches and flat grasslands behind dunes. Species represented by this habitat include rare invertebrates, the Anastasia Island beach mouse, and the southeastern weasel.
Estuarine waters	Includes saltwater and brackish open water bodies located between outer barrier islands and the mainland, including estuarine lagoons and the intra-coastal waterway. Several NOAA Trust species rely on estuarine waters, including shrimp, snapper, manatee, herring, shad, bottlenose dolphin, and sturgeon. Other key species include wading birds, blue crab, bald eagle, and a variety of recreational fish species.
Freshwater bodies	Primarily focused on the St. Johns River and its many smaller tributaries. This habitat is key for many NOAA Trust species that range from marine to estuarine and freshwater systems, including herring, shad, sturgeon, and American eel. In the summer, manatees can also use this habitat. Wading birds, black creek crayfish, and many rare invertebrates also rely on freshwater systems.
Marine Beaches and Shoreline	Key for sea turtle nesting as well as shorebirds, beach mice, and horseshoe crab.
Estuarine beach	Sandy beaches found along estuarine waters specifically, and provide habitat for shorebirds, osprey, and peregrine falcon.
Salt Marsh and Tidal Flats	Critical to a wide variety of species, including wading birds, shorebirds, roseate spoonbill, muskrat, salt marsh mink, salt marsh snake, diamondback terrapin, as well as nursery habitat for many fish species.
Freshwater tidal wetlands	Includes wetlands located along the St. Johns River and other tidal riverine systems in the region. These wetlands provide important feeding and nursery areas for a variety of NOAA Trust fish species, including herring, shad, sturgeon, and snapper. Wading birds, spoonbills, and muskrat also rely on these wetlands.
Mangrove tidal swamp	Reaches its northernmost Atlantic coast extent within the St. Johns watershed study area. Found along estuarine shorelines between barrier islands and the mainland, generally along the Intracoastal Waterway. Mangrove swamps are critical habitat for a variety of species including wading birds, osprey, roseate spoonbill, and offer nursery habitat for many fish species including NOAA Trust Species such as snapper.
Oyster Reefs and Rakes	An iconic feature of the watershed and commercially important habitat. This feature also can harbor habitat for other key fish species, especially as nursery habitat.
Snapper/Grouper Essential Fish Habitat	Defined as those waters and substrate necessary for spawning, breeding, feeding or growth to maturity. This layer is meant to represent snapper/grouper species but also other key commercial species that require similar habitat.
Shrimp Essential Fish Habitat	Defined as those waters and substrate necessary for spawning, breeding, feeding or growth to maturity. In this analysis, it is used to represent all penaeid shrimp species. Shrimp are important commercially as well as within the marine food chain.

Fish/Wildlife Element	*Description/Significance*
NOAA Trust Resources	
Sandbar Shark and Sand Tiger Shark Essential Fish Habitat	Defined as those waters and substrate necessary for spawning, breeding, feeding or growth to maturity. These sharks are increasingly important indicators of both the health of the nursery habitat and the overall health of populations of these declining species. The layers also represent a unique dataset focused on top predators in the ecosystem.
Florida manatee	Both an iconic species in the region and a taxonomically rare and distinct species, as there are only three distinct species within the entire mammalian family Trichechidae. Manatees also serve as an ecological umbrella species, as their habitat supports many other estuarine species.
At-Risk Species and Multi-species Aggregations	
Federally listed threatened or endangered terrestrial and aquatic species	Aggregated information on all known locations of federally listed Threatened or Endangered Terrestrial and Aquatic Species
Terrestrial and aquatic species listed as imperiled, rare, or uncommon at the global or state level	Aggregated information on all known locations of imperiled, rare, or uncommon terrestrial and aquatic species at the global or state level.
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Bottomland/floodplain wetlands	Defined here as wetlands located within or near the 100-year floodplain of major riverine systems and their tributaries. These communities provide habitat for a wide range of rare species, including wading birds, bald eagles, reptiles and amphibians including timber rattlesnake and many-lined salamander, Rafinesque's big-eared bat, and several invertebrates.
Coastal interdunal swales	Typical linear-shaped wetlands nestled between dune systems on barrier islands. They provide important habitat for wading birds among other species.
Interior wetlands	Encompass the broad range of wetlands located inland from the coast and from major estuarine and riverine systems. Both forested (swamps) and non-forested (marshes) are included.
Wading bird habitat	Includes habitat for the following species: little blue heron, snowy egret, tricolored heron, yellow-crowned night-heron, black-crowned night-heron. This is an important focal group as their habitat encompasses a variety of coastal and inland wetlands.
Coastal scrub	Small-patch xeric upland natural community that is rare and declining in Florida, and provides critical habitat for many rare species, including southeastern weasel and Florida mouse. Coastal scrub is found primarily on barrier islands east of the Intra Coastal Waterway.
Maritime hammock	Coastal woodland community occurring on stabilized dunes. In the St. Johns region, maritime hammocks are temperate with canopy dominated by live oak. Maritime hammocks in this region provide habitat for swallow-tailed kites and eastern diamondback rattlesnake among other species.
Interior scrub	Small-patch xeric upland natural community that is rare and declining in Florida, and provides critical habitat for many rare species, including Florida scrub-jay and a wide variety of rare plants and invertebrates. Interior scrub is found throughout the mainland inland from the Intra Coastal Waterway.

Fish/Wildlife Element	*Description/Significance*
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species	
Sandhill	Xeric upland community typically dominated by longleaf pine and turkey oak. Sandhill provides habitat for a broad range of species in the region, including gopher tortoise, burrowing owl, striped newt, pine snake, Sherman's fox squirrel, Florida mouse, and many rare invertebrates.
Wood stork	A federally listed species that relies on a variety of wetlands in the vicinity of rookeries for foraging.
Eastern indigo snake	A large wide-ranging snake found in a variety of habitats ranging from xeric uplands (scrub and sandhill) to wetlands (wet prairies and mangrove swamps). The indigo snake is often regarded as an umbrella species because it requires large landscape-scale protection that benefits many other species.
Southern hognose snake	A relatively small snake found primarily in xeric uplands including scrub, sandhill, xeric hammock, and old fields. This species is declining due to loss of upland habitat.
Painted bunting	A small colorful passerine bird that is declining throughout its range in the southeastern U.S., Central America, and the Caribbean. The painted bunting is found throughout Florida in winter but breeds only in the northeastern portion of the state, particularly in the St. Johns study area.
Red-cockaded woodpecker	An iconic species of southeastern longleaf pine forests. The RCW requires mature, open pine forests and serves as a key indicator of healthy longleaf forest systems.
Florida black bear	The black bear is a wide-ranging habitat generalist that requires large intact landscapes including a variety of forested habitats. These large natural areas benefit many other species throughout Florida.
Cross-cutting Elements	
Continental and global Important Bird Areas	Areas of key importance for bird species.

Resilience Projects Portfolio

A portfolio of resilience projects within the Jacksonville and Lower St. Johns River Watersheds was compiled from plans and other project documents submitted by stakeholders (**Table 8**). A total of 36 projects were submitted for this watershed. Beyond a review of project documents, projects were further evaluated using several data layers created in the GIS assessments.

Through the process of reviewing resilience projects, visiting sites, and meeting with key stakeholders in the region about resilience project ideas, several themes emerged.

1. Agency, NGO, and extension staff in this region have a great deal of capacity to implement coastal resilience projects where funding is available.
2. Project leaders recognize the need to engage neighbors and community stakeholders upfront in planning and decision-making for projects that directly affect their areas of interest to ensure there is initial and ongoing support for long-term projects.
3. Citizens in the region are particularly aware of both short-term and long-term threats due to the history of high impact hurricanes (Hugo, Joaquin, Matthew, Irma, etc.) and king tide effects, so there is substantial evidence of political will to support projects that can minimize impacts to human communities while also providing benefits to the fish and wildlife resources.

Table 8. Summary of resilience-related projects identified for the Jacksonville and Lower St. Johns River Watersheds study area. *Table shows the implementation stage of each project at the time of compilation.*

Project Type	**Project Phase**				
	Conceptual	**Planning Complete**	**Design Complete**	**Ready to Implement**	**Total**
Beach or dune restoration				1	1
Community resilience planning	2			1	3
Aquatic Connectivity	1				1
Land Preservation				8	8
Upland Restoration				2	2
Living shoreline	1	1		1	3
Green Infrastructure	7				7
Riparian and floodplain restoration	4			2	6
Landscape Connectivity				2	2
Wetlands restored/enhanced		3			3
Totals	**15**	**4**	**0**	**17**	**36**

As can be seen in **Figure 20**, the 36 submitted resilience projects are distributed throughout the St. Johns study area. Many of the inland projects are from the North Florida Land Trust, who submitted 14 projects from their preservation portfolio (North Florida Land Trust 2019). Overall the projects were submitted by a wide array of stakeholders, including: 10 from cities, five from local NGOs (in addition to the NFLT projects), and three each from state government agencies and county governments. Project sizes ranged from small living shoreline installations of less than one acre to a solar panel installation at the Fernandina Beach municipal airport to more than 400,000 acres for acquisition and/or easements in the Ocala to Osceola large landscape corridor project.

The submitted projects also represent a variety of potential actions. Fifteen projects feature land acquisition/preservation as a primary goal, seven are focused on green infrastructure, four on living shorelines, four on riparian floodplain restoration, two on beach and dune restoration, two on wetland restoration, and one on dam removal. A full list of these submitted projects and summary information about each is in Appendix 6.

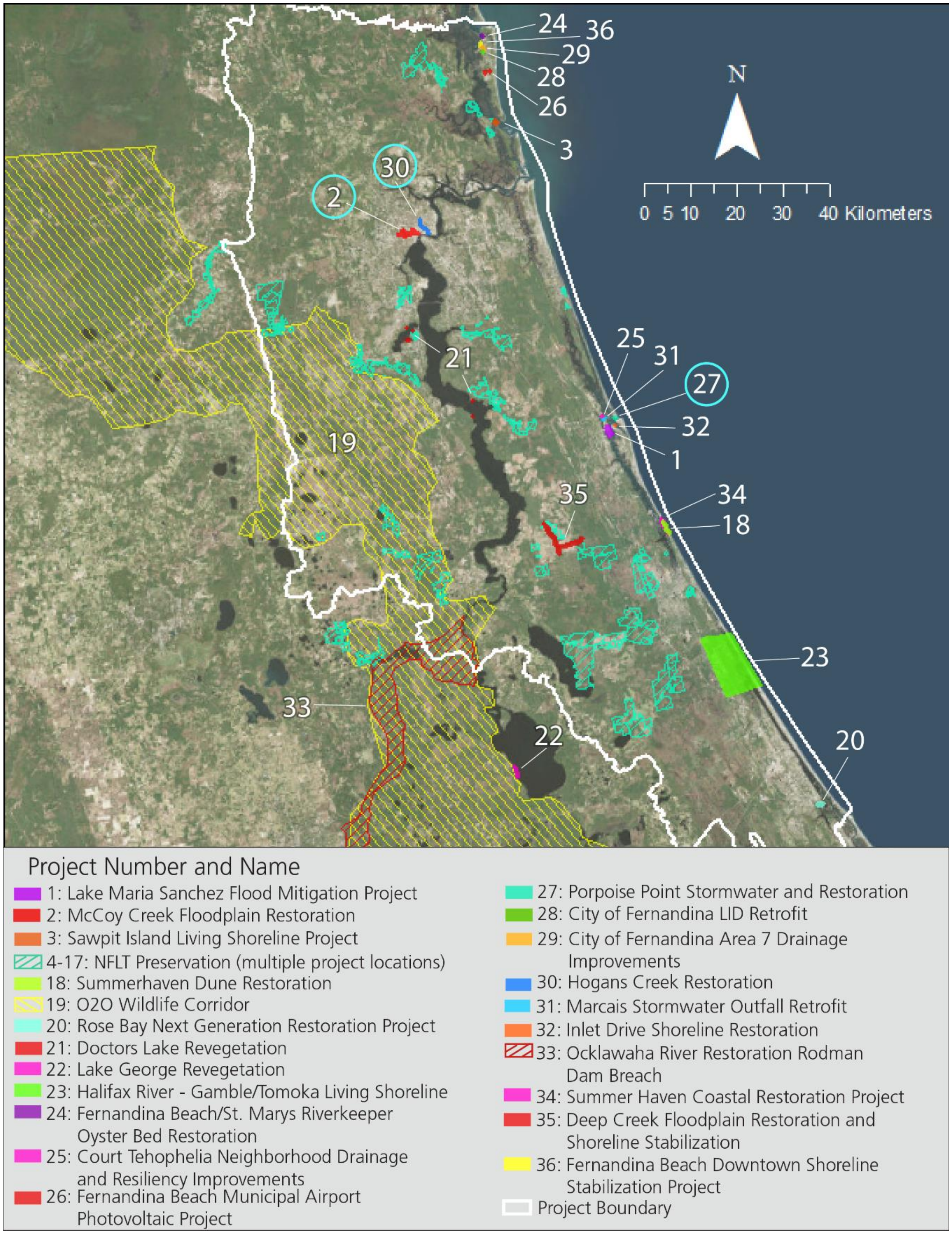


Figure 20. Map showing the boundaries of resilience projects compiled for the Jacksonville and Lower St. Johns River Watersheds. *Projects #2, #27, and #30 for which detailed case studies were developed are indicated with a blue circle around the project number. See Appendix 6,* ***Table A6-1*** *for full list of projects.*

Suggested Uses

The resilience projects database (Appendix 6) provides the names, project boundaries, and summary information about projects that were identified by stakeholders as those that could potentially increase human community resilience and/or enhance fish and wildlife habitat. These projects could potentially be implemented rapidly to recover from a flooding event, a high intensity tropical storm, or proactively improve resilience before the next major event.

Case Studies

The three case studies that follow illustrate how proposed resilience projects may benefit fish and wildlife habitat and human communities faced with serious coastal resilience challenges. The case studies highlighted in the Jacksonville and Lower St. Johns River Watersheds provide a range of resilience activities:

- Two of the projects focus on riparian restoration and flood mitigation in downtown Jacksonville.
- One project offers a combination of green infrastructure improvements for flood mitigation, and beach and dune restoration.
- All three projects have initiated project scoping and community planning efforts with a clearly defined set of actions.
- All three projects have potential benefits for a variety of fish and wildlife species in addition to human community benefits.

The three case studies are good examples of the types of projects proposed in the watershed that could potentially benefit both human assets and fish and wildlife populations facing increasing coastal threats.

Case Study 1: McCoy Creek Floodplain Restoration

Figure CS1-1. Photo of McCoy Creek showing direct stormwater inflow and channel restricted by bridge.

Project Overview

Location: Jacksonville, FL

Date Visited: May 22, 2018

Contact: Kay Ehas, Groundwork Jacksonville, Inc.

The McCoy Creek floodplain (**Figure CS1-1** and **Figure CS1-2**), including McCoy Creek Boulevard itself, is subject to frequent inundation from rain events, in addition to the effects of tropical systems as they pass through the region. There are many homes and businesses within the 100-year flood zone. Previous stormwater improvement planning efforts addressed small portions of the creek system, but not the entire watershed. Groundwork Jacksonville is working with the City of Jacksonville and local neighborhood groups to develop a comprehensive approach to McCoy Creek that would address not only flood mitigation, but also water quality and hydrological connectivity, shoreline habitat restoration, and recreational hiking/biking and paddling trails.

This project site has contaminated sediments (as determined through a previous review by the U.S. Army Corps of Engineers), which the project seeks to address within the larger planning framework being proposed. The City of Jacksonville and Groundwork Jacksonville have begun the overall planning process for McCoy Creek and are in the process of selecting a consultant with expertise in both green infrastructure and brownfields to begin the planning effort.

More specifically, the project proposes to:

- Reduce the extent of damaging inundation from major storm and flood events.
- Restore 50 acres of floodplain (subject to acquisition), including stormwater retention to reduce and/or eliminate direct stormwater inflows into the creek.
- Remove three stream barriers and restore shoreline habitat.
- Potentially close McCoy Creek Boulevard to provide additional stormwater retention areas and lengthen or raise current bridges constraining the creek channel.
- Establish five miles of greenway multi-use trails and navigable non-motorized water trail and redevelop four urban parks.
- Address the need for contaminated sediment remediation as part of the planning process.

Figure CS1-2. Overview map of McCoy Creek Resilience project site. *Sponsor-provided project boundary in red.*

Estimated Cost of the Project

The project partners estimate total project cost would be $40 million. Twenty million dollars has already been identified for the project through the City's Capital Improvements Plan and/or potential matching funds.

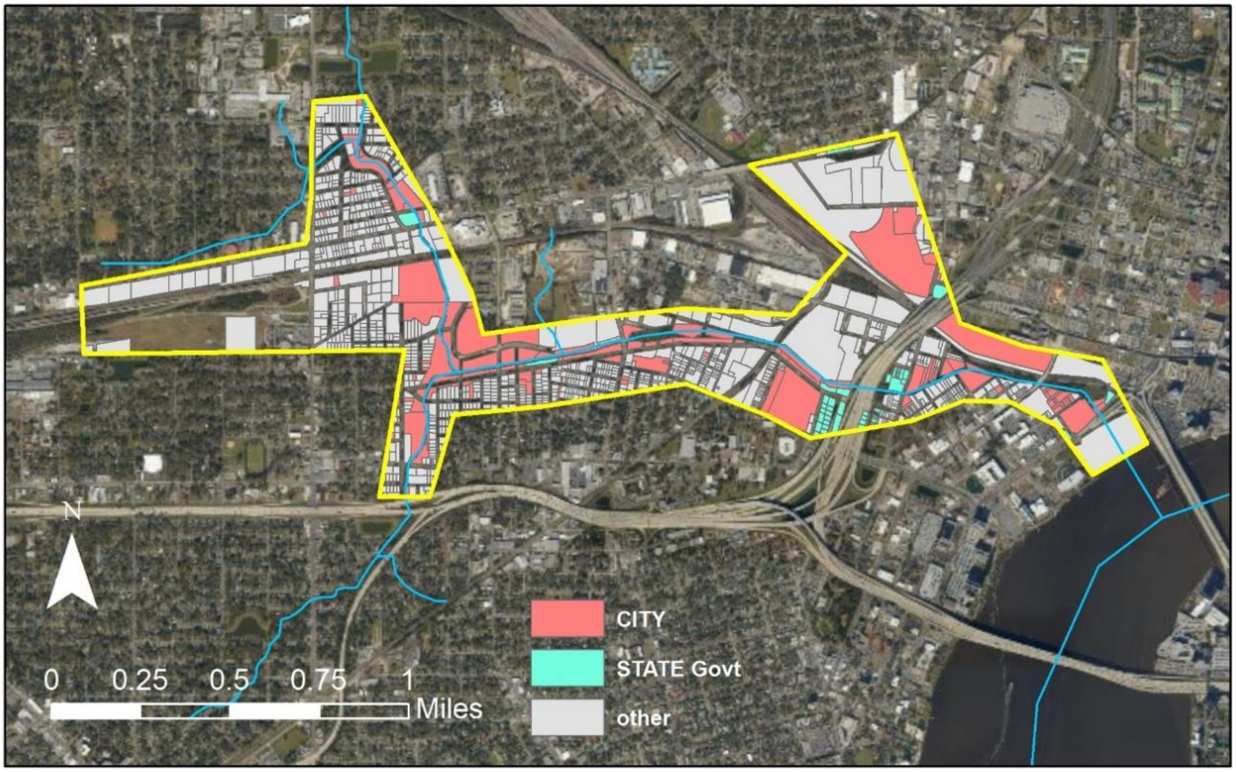


Figure CS1-3. Land parcels within McCoy's Creek project illustrating public and private landownerships. *Project boundary in yellow. (Source: FL Dept. of Revenue 2017 – some road and rail infrastructure are not included in parcel data.)*

Stressors and Threats

This site contains a high concentration of existing stressors on fish and wildlife as well as flooding threats to both fish and wildlife and human communities. Existing stressors include roads that bisect important habitat and developed areas such as high/medium density housing (**Table CS1-1** contains a list of stressors and floodplain threats). Fish and wildlife and HCAs are also vulnerable to flooding threats including 100-year and 500-year floods, sea level rise, storm surge, poorly drained soils, and high potential for subsidence. In particular, the low-lying populated areas adjacent to McCoy Creek are likely to see more flooding in the future as sea level rise progresses.

Table CS1-1. Stressors and flooding threats identified in and near the project site.

Existing Stressors
High-Medium Density Housing
Commercial/Industrial Land Use
Developed Open Spaces
Utility Lines
Rail Lines
Low, Moderate Water Quality
Primary, Secondary, Local Roads
Flooding Threats
100-year Floodplain
1 Foot - Sea Level Rise
500-Year Floodplain
Storm Surge Categories 1-5
Somewhat Poorly Drained Soils
Frequent Flooded Spaces
Very Poorly Drained Soils
Moderate Subsidence

Human Community Assets

This site and surrounding areas contain a high concentration of important HCAs including high population density, socially vulnerable populations, and critical infrastructure and facilities such as major highways, rail lines, and a fire station (**Table CS1- 2**). Interstate 95 bisects the project, and the intersection of Interstate 10 with Interstate 95 are just south of the project boundary; both highways serve as hurricane evacuation routes. **Figure CS1- 4** (below) shows (in varying shades of red) areas where there are high concentrations of HCAs that are also potentially highly impacted by the stressors/threats listed above.

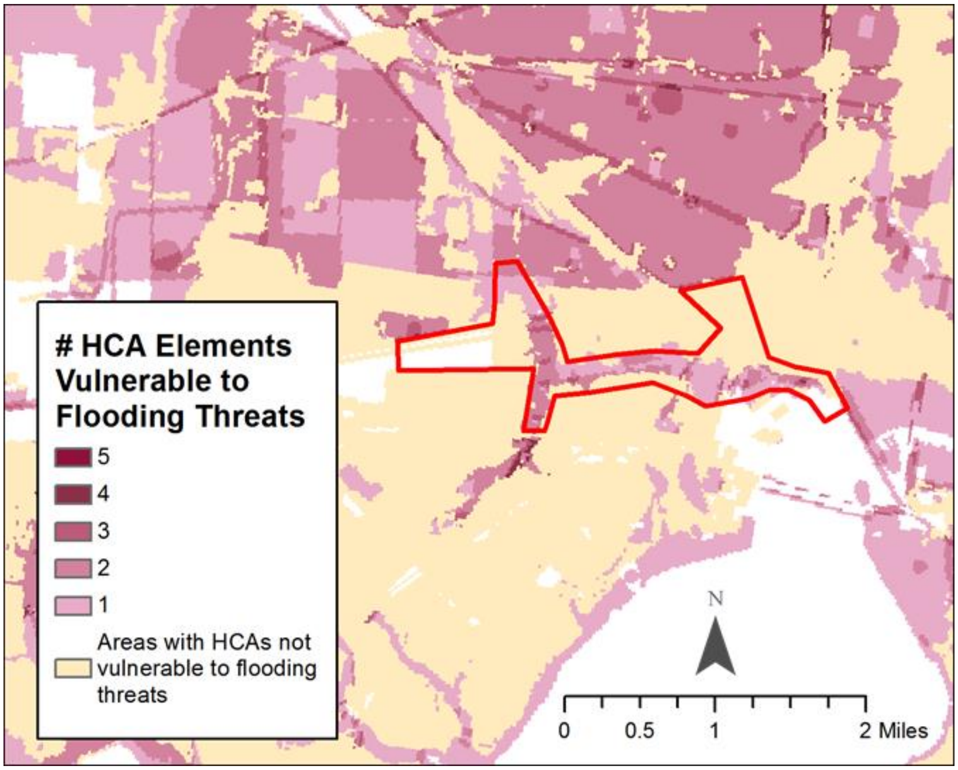


Figure CS1-4. Human Community Asset (HCA) elements vulnerable to flooding threats. *Map of areas where there are vulnerable HCAs (darker pink/red signifies concentrations of vulnerable HCA elements) within and around the McCoy Creek project. Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment.*

Table CS1-2. Human Community Assets identified within the project boundary.

Categories of Human Assets Identified within Project Boundary
Densely populated areas
Critical facilities
Critical infrastructure (Railways, Major Highways, Evacuation Routes)
Vulnerable Populations
Evacuation Route/Highways
Mapped Community/Human Assets within Project Boundary
Fire Station No. 5

Fish and Wildlife

This site contains important habitat (and/or potential habitat) for priority fish and wildlife species, including many species highly valued by regional stakeholders (**Table CS1-3**, **Figure CS1-5**). In addition, restoration work on this site has the potential to positively impact species and habitat beyond the project boundary since some species (such as manatees, sturgeon, and eels) would benefit from better water quality and improved buffers between human assets and habitat.

Table CS1-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area*.

Fish/Wildlife Habitat *	**Species of Interest to Stakeholders that may be Represented by these Habitat Types ****
Bottomland floodplain wetlands	little blue heron, snowy egret, swallow-tailed kite, bald eagle, merlin, timber rattlesnake
Estuarine waters	shrimp, snapper/grouper, Atlantic sturgeon, manatee, wading birds, recreational fish
Freshwater bodies	manatee, Atlantic sturgeon, American eel
Freshwater tidal wetlands	peregrine falcon, white ibis, osprey, roseate spoonbill, painted bunting
Interior wetlands	wood stork, Florida sandhill crane, little blue heron, snowy egret, swallow-tailed kite

**Based on modeled data, so some of these habitats may not actually exist in the project boundary area or may be potential future or historic occurrences)*

*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

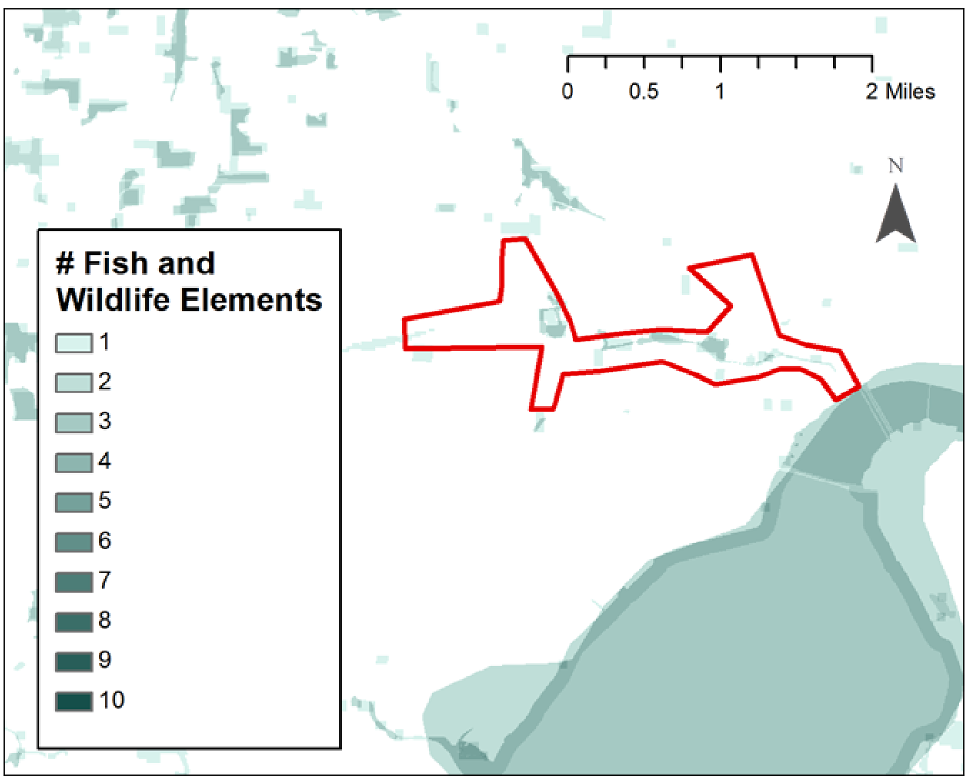


Figure CS1-5. Density of fish and wildlife elements in project area. *Map of all fish and wildlife elements combined for project area (darker green signifies more elements/value). Project boundary shown in red.*

Expected Project Impact

The proposed flood mitigation and restoration of habitat and hydrology for McCoy Creek will have immediate positive impacts to human communities and fish/wildlife habitat. This project will reduce chronic upstream flooding from heavy rain events and provide additional flood attenuation during storm surge events. It will also improve water quality through stormwater retention and riparian habitat restoration, thereby improving habitat for a variety of fish and wildlife. The project will improve hydrological connectivity to allow more fish and wildlife passage along the stream system. The local community will benefit from recreational trails, including a paddling trail made possible by the removal or redesign of current stream barriers. Improved water quality and habitat will also benefit downstream recreational and commercial fisheries in the St. Johns River. Finally, the project offers an opportunity for the city to address remediation of contaminated sediments as part of the larger planning effort.

Figure CS1-6. McCoy Creek Boulevard at Hollybrook Park, an area subject to frequent flooding. *Several low-grade bridges like the one shown restrict the stream channel and three are targeted for replacement.*

Figure CS1-7. Degrading bulkhead along a central segment of McCoy Creek. *This area is also within the known soil contamination zone.*

Figure CS1-8. Stream channelization and restriction has reduced natural flow and led to sediment buildup. *Vegetation is now growing on some of these "sediment islands".*

Case Study 2: Hogan's Creek Floodplain Restoration

Figure CS2-1. Aging balustrades along Hogan's Creek in downtown Jacksonville.

Project Overview

Location: Jacksonville, FL

Date Visited: May 22, 2018

Contact: Kay Ehas, Groundwork Jacksonville, Inc.

The Hogan's Creek floodplain (**Figure CS1-1** and **Figure CS1-2**) offers many similarities to the McCoy Creek site outlined above. Hogan's Creek is subject to frequent inundation from rain events. There are many homes and businesses within the 100-year flood zone. The creek is highly channelized with little riparian habitat for wildlife or flood attenuation. Groundwork Jacksonville is working with the City of Jacksonville and local neighborhood groups to develop a comprehensive approach to Hogan's Creek that would address not only flood mitigation, but also water quality and hydrological connectivity, shoreline habitat restoration, and recreational hiking/biking and paddling trails.

This project site is known to have contaminated sediments based on previous review by the U. S. Army Corps of Engineers. The applicants are aware of the contamination issue and are seeking to address it in the within the larger planning framework being proposed.

More specifically, the project proposes to:

- Remove sediment accumulations and invasive exotic vegetation in the creek bed.
- Identify opportunities for and install green infrastructure for stormwater retention and flood attenuation.
- Restore portions of shoreline and adjacent wetland habitats. Portions of historical balustrades along the creek channel will likely be maintained for cultural value.
- Add to existing creekside greenway recreational trails and establish a paddling trail along the creek.
- Address the need for contaminated sediment remediation as part of the planning process.

Figure CS2-2. Overview map of Hogan's Creek project site. *Sponsor-provided project boundary in red.*

Estimated Cost of the Project

The project partners estimate total project cost around $5 million. No funding has been allocated to date (this project is not included in the City of Jacksonville's current Capital Improvement Plan).

Stressors and Threats

This site contains a high concentration of existing stressors on fish and wildlife as well as flooding threats to fish/wildlife and human communities. Existing stressors include roads that bisect important habitat and developed areas such as high/medium density housing (**Table CS2- 1** contains a list of stressors and floodplain threats). Fish and wildlife and HCAs are also vulnerable to flooding threats including 100-year and 500-year floods, sea level rise, storm surge, poorly drained soils, and moderate potential for subsidence. In particular, the low-lying populated areas adjacent to the creek are likely to see more flooding in the future as sea level rise progresses.

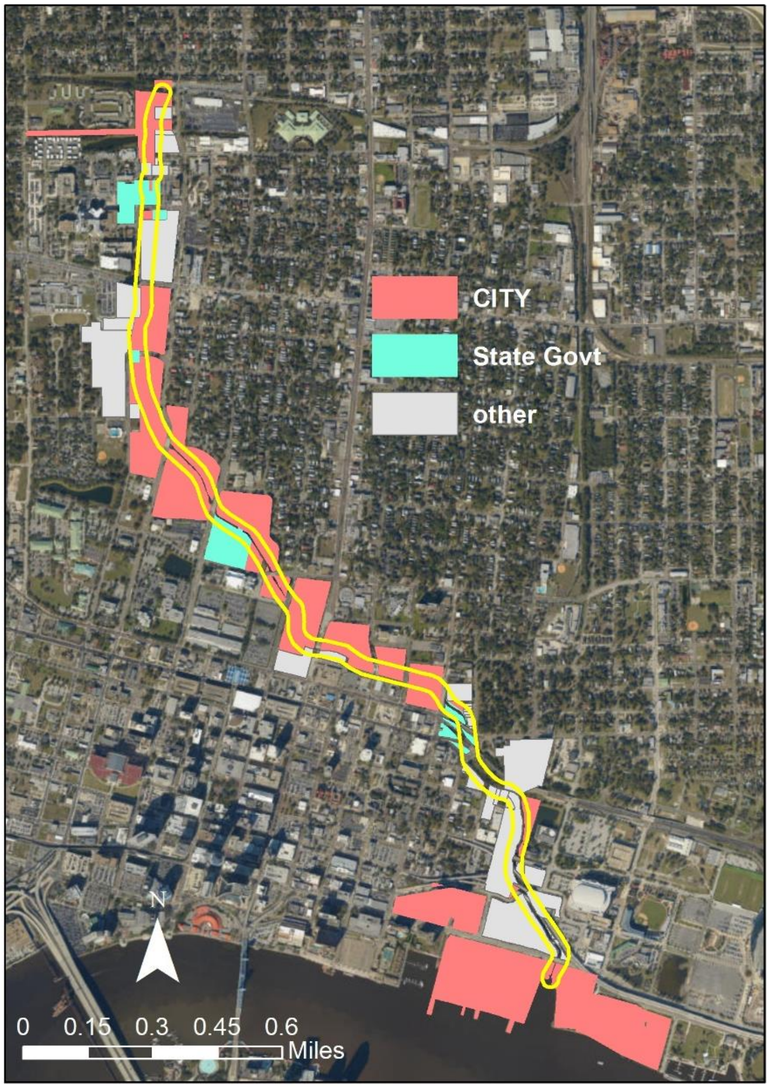


Figure CS2-3. Land parcels within Hogan's Creek project illustrating public and private landownerships. *Project boundary in yellow. (Source: FL Dept. of Revenue 2017–some road and rail infrastructure are not included in parcel data.)*

Table CS2-1. Stressors and flooding threats identified in and near the project site.

Existing Stressors
High-Medium Density Housing
Commercial/Industrial Land Use
Developed Open Spaces
Utilities
Rail Lines
Low and Moderate Water Quality
Secondary and Local Roads
Flooding Threats
100-year Floodplain
500-year Floodplain
1-ft Sea Level Rise
Storm Surge Categories 1-5
Somewhat Poorly Drained Soils
Very Poorly Drained Soils
Frequent Flooded Spaces
Moderate Subsidence

Human Community Assets

This site and surrounding area contain a high concentration of important HCAs, including high population density, socially vulnerable populations, and critical infrastructure and facilities such as highways and rail lines (**Figure CS2- 4**, **Table CS2- 2**). Several major roads cross over Hogan's Creek within the project boundary, and a college, university medical school, and fire station are adjacent to the creek. **Figure CS2- 4** shows (in varying shades of red) areas where there are high concentrations of human community assets that are also highly vulnerable to the threats listed above.

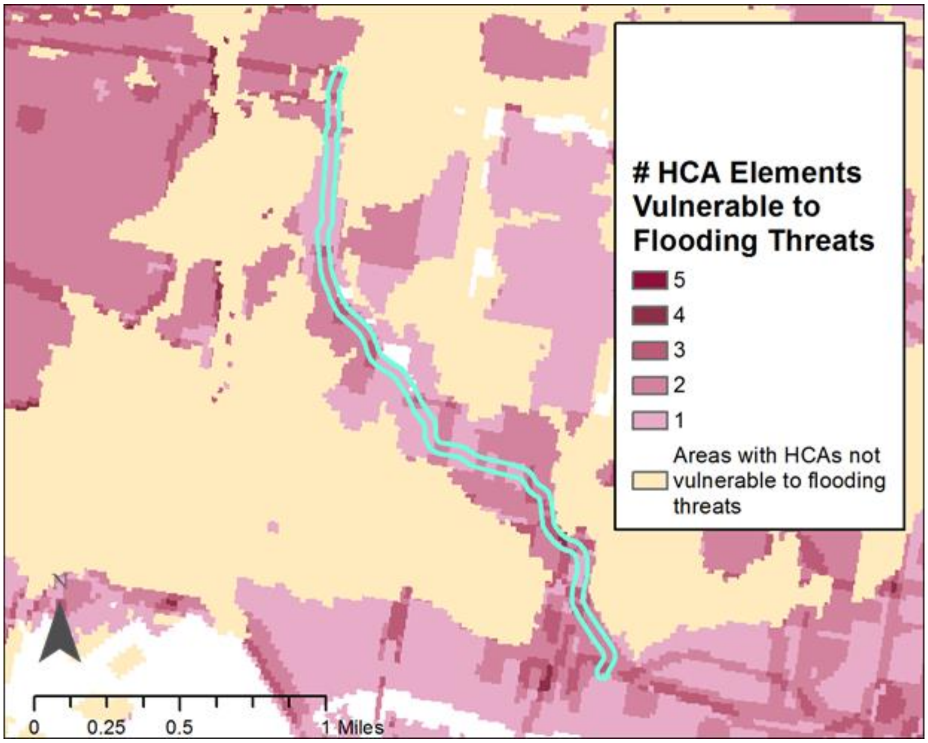


Figure CS2-4. Human Community Asset (HCA) elements vulnerable to flooding threats. *Map of areas where there are vulnerable HCAs (darker pink/red signifies concentrations of vulnerable HCA elements) within and around the Hogan's Creek project. Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment.*

Table CS2-2. HCAs identified within the project boundary.

Categories of Human Assets Identified within Project Boundary
Densely populated areas
Critical facilities
Critical infrastructure (Railways, Major Highways, Evacuation Routes)
Vulnerable Populations
Mapped Community/Human Assets within Project Boundary
Jacksonville Fire Station No. 1
Florida State College at Jacksonville Downtown Campus
UF Health & UF College of Medicine – Jacksonville

Fish and Wildlife

This site contains important habitat (and/or potential habitat) for priority fish and wildlife species, including many species highly valued by the stakeholders of the region (**Table CS2- 3**, **Figure CS2- 5**). In addition, restoration work on the site has the potential to positively impact species and habitat beyond the project boundary since some species (especially shrimp, snapper, and grouper) have nursery areas in estuarine waters that can benefit from improved water quality and enhanced buffers between human assets and habitat.

Table CS2-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area*.

Fish/Wildlife Habitat *	Species of Interest to Stakeholders that may be Represented by these Habitat Types **
Estuarine waters	shrimp, snapper/grouper, Atlantic sturgeon, manatee, wading birds, recreational fish
Freshwater bodies	manatee, Atlantic sturgeon, American eel
Freshwater tidal wetlands	peregrine falcon, white ibis, osprey, roseate spoonbill, painted bunting

** Based on modeled data, so some of these habitats may not actually exist in the project boundary area or may be potential future or historic occurrences).*

*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

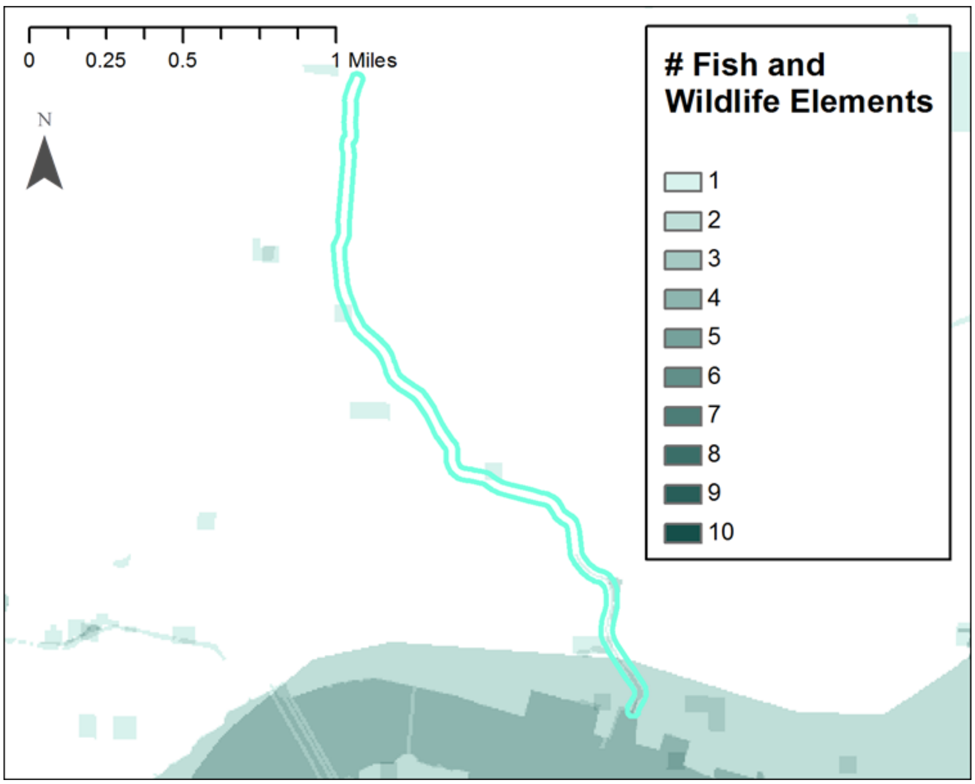


Figure CS2-5. Density of fish and wildlife elements in project area. *Map of all fish and wildlife elements combined for project area (darker green signifies more elements/value). Project boundary shown in blue.*

Expected Project Impact

The proposed flood mitigation and restoration of habitat and hydrology for Hogan's Creek will have direct positive impacts to human communities and fish and wildlife habitat. This project will reduce chronic upstream flooding from heavy rain events and provide additional flood attenuation during storm surge events. It will also improve water quality through stormwater retention and riparian habitat restoration, thereby improving habitat for a variety of fish and wildlife both within the project footprint and downstream from it, where even more fish/wildlife elements exist. The project will improve hydrological connectivity to allow more fish and wildlife passage along the stream system. The local community will benefit from recreational trails, including a paddling trail made possible by the removal or redesign of current stream barriers. Improved water quality and habitat will also benefit downstream recreational and commercial fisheries in the St. Johns River: in particular, nursery habitat for key species such as shrimp, snapper, and grouper. Finally, the project offers an opportunity for the city to address remediation of contaminated sediments as part of the larger planning effort.

Figure CS2 6. Hogan's Creek near outflow into the St. Johns River. *Near its mouth, the creek is highly channelized and surrounded by industrial/commercial land uses.*

Figure CS2-7. Erosion has heavily damaged portions of historical balustrades along the creek.

Figure CS2-8. Water quality of Hogan's Creek is indicated by a health advisory sign.

Figure CS2-9. Recreational trails are already in place along portions of Hogan's Creek, and are seeing active use from neighborhood residents.

Case Study 3: Porpoise Point Dune Restoration and Stormwater Improvement

Figure CS3-1. Google Maps aerial photo of Porpoise Point subdivision showing beach dune before 2017-2018 storms.

Project Overview

Location: Vilano Beach, FL

Date Visited: May 23, 2018

Contact: Jay Brawley, St. Johns County.

Porpoise Point is a residential subdivision located at the southern end of Vilano Beach adjacent to the St. Augustine Inlet (**Figure CS3-2**). The neighborhood has seen increased flooding in recent years from both heavy rain events and storm surge from hurricanes and tropical storm events. The existing stormwater swales are inadequate for storage or drainage. In addition, the Vilano Point Beach has been highly eroded from recent storm events, including a beach dune that was largely leveled by recent storms. This project proposes to improve the current stormwater swale system and add infrastructure for pumping water offsite during flooding events. The project also proposes dune restoration with sand renourishment and native vegetation planting.

More specifically, the project proposes to:

- Re-establish approximately 12,000 linear feet of swales.
- Construct three new 15-inch cross culverts to allow equalization of swales.
- Establish a wet well area for use with a portable pump during heavy rainfall events. The pump can be moved to other locations throughout the county as needed.
- Add height and stability to the Vilano Point dunes by adding "beach quality" sand.
- Plant native vegetation including sea oats to help stabilize the dune system.

Figure CS3-2. Overview map of Porpoise Point Resilience project site. *Sponsor-provided project boundary in yellow shows just the stormwater swale locations. Red lines indicate general extent of project.*

Estimated Cost of the Project

The project partners estimate total project cost would be around $2 million, including design, permitting, and construction.

Stressors and Threats

This site contains a high concentration of existing stressors on fish and wildlife as well as flooding threats to fish and wildlife and human communities. Existing stressors include the dense subdivision, areas of low and moderate water quality through the Inlet, and shellfish harvesting in the inlet (**Table CS3-1**). Fish and wildlife and HCAs are also vulnerable to flooding threats including 100-year and 500-year floods, sea level rise, storm surge, and poorly drained soils. The entire Porpoise Point subdivision is likely to experience more flooding in the future as sea level rise progresses and storm surge impacts increase.

Table CS3-1. Stressors and flooding threats identified in and near the project site.

Existing Stressors
High-Medium Density Housing
Low, Moderate Water Quality
Local Roads
Shellfish Harvesting
Flooding Threats
100-year Floodplain
1 Foot - Sea Level Rise
500-Year Floodplain
Storm Surge Categories 1-2
Frequent Flooded Spaces
Very Poorly Drained Soils

Human Community Assets

The primary HCA in this project area is moderate to high population density associated with Porpoise Point and surrounding subdivisions. Just to the north is a key hurricane evacuation route from the barrier island to St. Augustine. **Figure CS3-3** shows (in red) the area of high population density that is also highly vulnerable to the threats listed above.

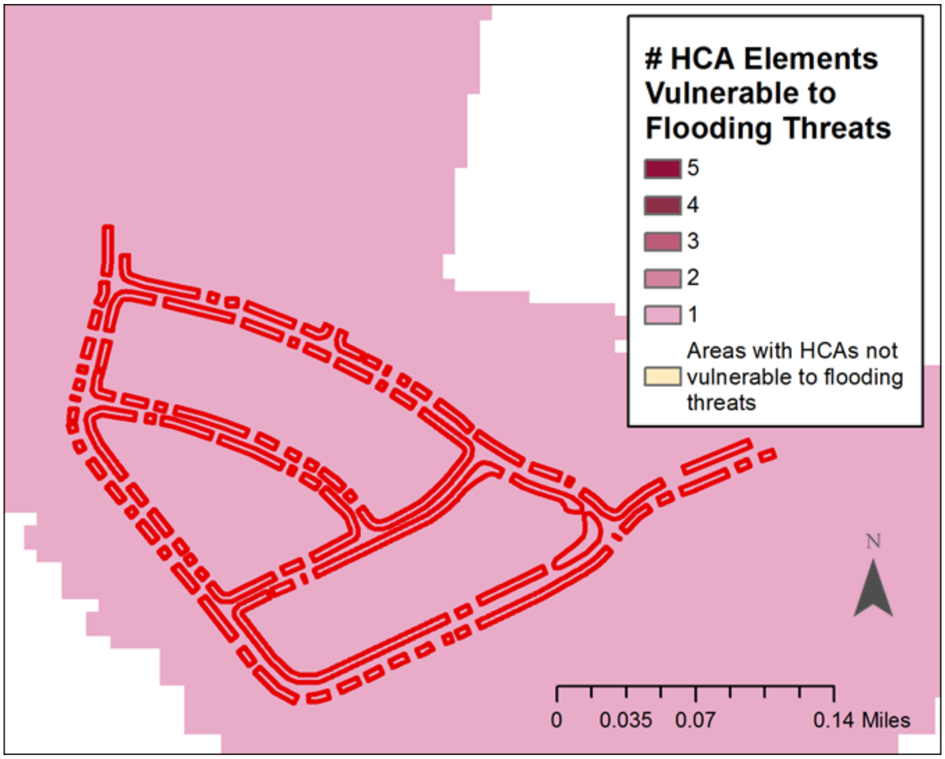


***Figure CS3-3. Human Community Asset (HCA) elements vulnerable to flooding threats**. Map of areas where there are vulnerable HCAs (darker pink/red signifies concentrations of vulnerable HCA elements) within and around the Porpoise Point project. Tan color indicates areas with HCAs that are not categorized as vulnerable for the purposes of this assessment.*

Table CS3-2. HCAs identified within the project boundary.

Categories of Human Assets Identified within Project Boundary
Densely populated areas
Mapped Community/Human Assets within Project Boundary
n/a

Fish and Wildlife

This site contains important habitat (and/or potential habitat) for priority fish and wildlife species, including many species highly valued by regional stakeholders (**Table CS3-3, Figure CS3- 4**). In particular, nesting sea turtles and shorebirds would directly benefit from beach restoration if beach vehicular access is controlled.

*Table CS3-3. Fish and wildlife habitats and example species for each habitat that potentially occur in the project area**

Fish/Wildlife Habitat *	Species of Interest to Stakeholders that may be Represented by these Habitat Types **
Coastal Dune/Grassland	Beach mice, southeastern weasel
Estuarine Beach	Beach mice, shorebirds, marine turtles
Estuarine Waters	shrimp, snapper/grouper, Atlantic sturgeon, manatee, wading birds, recreational fish
Salt Marsh/Tidal Flat	Wading birds, wood stork, plovers, terns, Atlantic salt marsh mink, Atlantic salt marsh snake

**Based on modeled data, so some of these habitats may not actually exist in the project boundary area or may be potential future or historic occurrences)*

*** Not meant to be an exhaustive list of all species that benefit from this habitat, but instead contains some example species that are likely represented by this layer of information and identified by stakeholders as priority species in the watershed.*

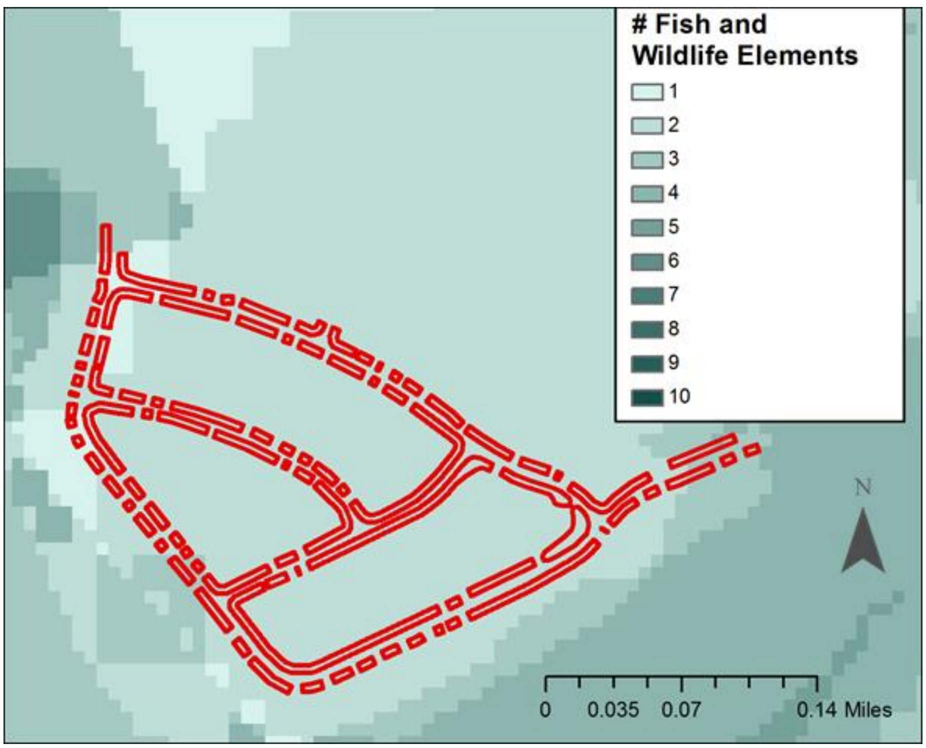


Figure CS3-4. Density of fish and wildlife elements in project area. *Map of all fish and wildlife elements combined for project area (darker green signifies more elements/value).*

Expected Project Impact

The proposed stormwater improvements and dune restoration at Porpoise Point will have immediate positive impacts to human communities and fish/wildlife habitat. This project will reduce neighborhood flooding from both heavy rain events and storm surge. It will also restore a beach dune system that offers habitat for a range of shoreline species. Nesting shorebirds and marine turtles, in particular, will benefit from a stabilized beach and dune habitat. The local community will benefit from reduced flooding and improved beach access.

Figure CS3-5. View of the former beach dune at Vilano Point. *The dune was largely leveled by recent storms, including Hurricane Matthew in October 2016, Hurricane Irma in September 2017, and a series of Nor'easters in March 2018. The dune did serve to prevent major damage to homes situated inland of it.*

Figure CS3-6. A temporary sand berm has been placed at the end of a street in Porpoise Point. *During recent storms, storm surge overwashed the beach and funneled into the subdivision at this location.*

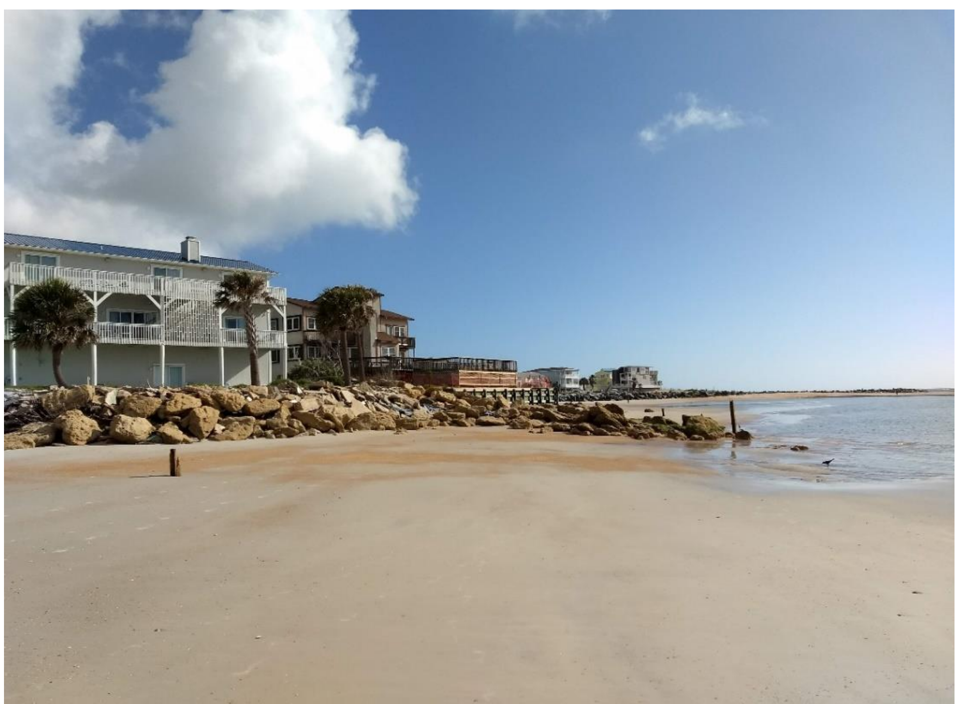


Figure CS3-7. Significant beach erosion has occurred at Vilano Point due to the recent hurricanes and Nor'easters. *County staff indicated that prior to 2017 the rock berm shown here was entirely covered by sand.*

Figure CS3-8. Example of current stormwater swales at Porpoise Point.

Figure CS3-9. Example of current stormwater swales at Porpoise Point.

Conclusions

This report and accompanying products are the result of an approximately 12-month stakeholder engagement and rapid assessment process. Using a combination of expert-identified and stakeholder-nominated data, the assessment aims to: 1) understand the value and vulnerability of human community assets and fish and wildlife elements (habitats and species), 2) map areas with potential for improving resilience (Resilience Hubs) for these assets and elements, and 3) gather and characterize stakeholder-proposed resilience projects.

The mapping of the Resilience Hubs is intended to inform potential new locations for resilience projects that can provide mutual benefits to community resilience and fish and wildlife. The large spatial extent of open space areas in the Jacksonville and St. Johns River region generated many Resilience Hubs and potential opportunities for improving resilience in the watershed. The final scoring of the Resilience Hubs and their assessment units indicate several focal areas of particularly high potential for offering natural and nature-based resilience.

The Jacksonville and Lower St. Johns River Watersheds Coastal Resilience Assessment and associated datasets are intended to support the development of additional resilience project ideas and can provide the basis for analyses to support project siting, planning, and implementation. The accompanying Coastal Resilience Evaluation and Siting Tool (CREST) was developed to allow users to view, download, and interact with the inputs and results of this assessment (available at resilientcoasts.org). Furthermore, the use of the Vista decision support system (DSS) will enable a variety of additional planning activities to integrate these data into plans for land use, conservation, emergency management, and infrastructure as well as supporting local customization.

Key Findings

The spatial analyses in this assessment confirm what is generally known and routinely experienced in the Jacksonville and Lower St. Johns River Watersheds—that community vulnerability in the watershed is very high owing to its exposure to flooding threats from both heavy inland rainfall events and coastal storms. Hurricane Irma in 2017 demonstrated this combined vulnerability, as the storm subjected communities along the St. Johns River to flooding from extremely heavy inland rainfall, while battering the northeast Florida coast with winds and storm surge. Urban areas along the coast and along the St. Johns River are all particularly exposed to these threats, including Fernandina Beach, Jacksonville, St. Augustine, Palm Coast, Daytona Beach, and Palatka.

Unlike many densely population regions along the U.S. east coast, northeast Florida's shoreline and inland river banks are largely non-hardened, offering a wide range of opportunities for nature-based resilience improvement projects. The resilience projects submitted for this assessment demonstrate this range of opportunities. The three case studies highlight several important opportunities for improving resilience while benefiting fish and wildlife such as:

- riparian habitat restoration that improves aquatic habitat onsite and downstream while reducing flooding in adjacent populated areas;
- improved neighborhood stormwater swales and floodwater management that reduces property impacts and improves water quality of stormwater runoff; and

- beach and dune restoration designed to enhance habitat can benefit many shoreline nesting species and provides a buffer for adjacent communities against storm surge and winds.

The case studies are meant to highlight a few options for nature-based actions to build resilience and, combined with the full database of all resilience projects submitted, can serve as a starting point for agencies and funders interested in supporting projects. In addition, the case studies and other submitted projects can serve as examples of potential project ideas that can be implemented within the areas that the analysis identified as Resilience Hubs.

Summary of Limitations

This project conducted a rapid assessment using available data. As such, there are several limitations to be aware of when applying these results to decision-making or other applications. Despite these limitations, the project represents an important set of data and results that can inform many applications and be further refined, updated, and applied to local purposes.

1. This assessment is not a plan and is not intended to assess or supplant any plans for the area (such as those summarized in Appendix 7. Summary of Additional Studies and Plans).
2. The modeling of vulnerability of HCAs and fish and wildlife elements used a simple model and expert knowledge to set parameters of how stressors and threats impact select features. This is neither an engineering-level assessment of individual HCAs to more precisely gauge risk to individual areas or structures, nor a detailed ecological or species population viability analysis for fish and wildlife elements to estimate current or future viability.
3. The spatial data used in this assessment are those that could be readily obtained and that were suitable for the analyses. In general, secondary processing or modeling of the data was not conducted. In a GIS analysis, data availability, precision, resolution, age, interpretation, and integration into a model undoubtedly result in some areas being mistakenly identified for providing natural and nature-based resilience. As with all GIS analyses, the results should be ground-truthed prior to finalizing decisions at the site level.
4. Precise and complete water quality data were not available for this area. The project relied on three sources and methods for approximating water quality: EPA Impaired Waters data was used along with commercial vessel traffic data. This was supplemented with an offsite or distance effect setting in the Vista DSS landscape condition model that extrapolates impacts of nearby stressors (i.e., land uses) to aquatic elements (see Appendix 2 and Appendix 3 for details on this method). This approach has some limitations such as extrapolating impacts in all directions instead of only downslope, only affecting water bodies within the distance effect (e.g., no mixing), and not accounting for downstream accumulation or mixing.
5. The selection of fish and wildlife elements was geared to the specific objectives of this assessment and, therefore, does not represent biodiversity generally or necessarily all fish and wildlife of conservation interest. Not all nominated elements could be represented at the preferred level of precision. A list of elements for which data was not available or was deemed insufficient for appropriately representing the element is provided in Appendix 5. That said, no elements can be assumed to have complete and accurate distributions. The Vista DSS project can be amended with additional elements of interest.

Putting this Assessment to Work

The products represented by this report, the online viewer and portal, and the Vista decision support system (DSS) provide opportunities for application by a variety of users. Potential uses range from those interested in becoming more informed about vulnerability and resilience opportunities in the watershed to those that wish to conduct additional assessment and planning. The use of the online map viewer or the decision support system can allow further exploration of the results and inputs across the watershed or for particular areas of interest.

Addressing the flooding threats assessed in this project is one of the most daunting activities for communities. Fortunately, concepts, examples, and guidance have been in development for several years and continue to improve as more communities confront these challenges. Some potential directions and implementation resources that may be useful include:

- Utilizing a community engagement approach to discuss specific ways to act on the findings of this assessment. One source for information on how to do this can be found here, including guidance on running a community workshop: https://www.communityresiliencebuilding.com/.
- Reviewing the U.S. Climate Resilience Toolkit (https://toolkit.climate.gov/) to explore other case studies, guidance, and tools to incorporate.
- Implementing living shorelines instead of relying on expensive shoreline armoring. Guidance for Considering the Use of Living Shorelines found at https://www.habitatblueprint.noaa.gov/wp-content/uploads/2018/01/NOAA-Guidance-for-Considering-the-Use-of-Living-Shorelines_2015.pdf.
- Weighing nature-based options for addressing shoreline erosion. For individual property owners a good starting point is: Weighing Your Options: How to Protect Your Property from Shoreline Erosion found at https://www.nccoast.org/wp-content/uploads/2014/12/Weighing-Your-Options.pdf.
- Exploring ideas from other regions to see if they can be applied to Jacksonville and Lower St. Johns River Watersheds. Many guides and reports developed for other areas may also provide great examples and ideas to adapt for local application. For example this one from New Jersey found at https://www.nwf.org/CoastalSolutionsGuideNJ.

Above all, readers are encouraged to embrace this assessment as a useful tool to build community resilience using natural and nature-based solutions. Ample recent experience and forecasts tell us that more frequent and more serious flooding threats will occur, and that seas are rising. The best time to plan for resilience is before the next event turns into catastrophe. Data, tools, guidance, and support exist to inform and plan actions that can build resilience in ways that can also benefit the watershed's fish and wildlife resources.

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Acknowledgements

Funders

This assessment and publication was commissioned by the National Fish and Wildlife Foundation and funded by the National Oceanic and Atmospheric Administration. It was conducted in consultation with the National Oceanic and Atmospheric Administration and the U.S. Army Corps of Engineers.

Workshop Venue Sponsors

Local partner engagement in the form of the in-person workshops was a key aspect in ensuring that the final analysis would include the types of data and information that would give us the best and most useful product possible. This high level of stakeholder engagement would not have been possible without venue space for workshops provided by the Guana Tolomato Matanzas National Estuarine Research Reserve and the Northeast Florida Regional Council in Jacksonville.

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Additional Stakeholders

Representatives from the following organizations, agencies, and other institutions contributed their time, expertise, data, and invaluable perspective to this process and we are grateful for their valuable inputs.

- Audubon Florida
- City of Jacksonville, FL
- Defenders of Wildlife
- FL DEP Coastal Office Wekiva/SJR/Tomoka Marsh Aquatic Preserves
- FL Department of Environmental Protection
- Estuaries Foundation
- Florida Fish and Wildlife Conservation Commission
- Florida Natural Areas Inventory
- Florida Park Service
- Florida Park Service/ Talbot Islands State Parks
- Florida Wildlife Federation
- FWC / Peninsular Florida LCC
- FWC Fish and Wildlife Research Institute
- Groundwork Jacksonville, Inc.
- Guana Tolomato Matanzas National Estuarine Research Reserve
- GTM Research Reserve, Coastal Training Program
- Hatch

Jacksonville Environmental Protection Board
Jacksonville GIS
Jacksonville Electric Authority
Marine Discovery Center
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Volusia County Environmental Management
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Appendices

Appendix 1. Watershed Committee and Stakeholder Engagement Mechanisms and Process

Local guidance and meaningful stakeholder participation were a key part of the Targeted Watershed Assessment process. Their input provided critical information and insights reflecting local knowledge and priorities.

Watershed Committee

The purpose of the Watershed Committee was to provide guidance to the assessment in terms of:

- Identifying dates and venues for initial stakeholder webinars and in-person workshops;
- Developing an inclusive list of individuals invited to participate as stakeholders;
- Approving the final list of fish and wildlife elements and priorities to be included in the assessment; and
- Providing initial leads for appropriate datasets for representing fish and wildlife elements and other data used in the assessment (Appendix 5).

By including a broad range of participants from different organizations (see Acknowledgements for full list), the committee was able to represent the interests and perspectives of the national organizations involved in the assessment as well as those of local watershed organizations.

Stakeholders

Stakeholders provided relevant plans and studies to establish baseline context, ideas, and feedback on the selection of relevant fish and wildlife elements, identification of key stressors and threats, and identified the most appropriate data sets for use in the assessment. In addition, stakeholders were the key source of coastal resilience project plans and ideas. The stakeholder engagement process was designed to be as inclusive as possible and to maximize involvement of participants who could contribute a range of opinions and inputs. Stakeholders were defined as those individuals or groups who have one or more of the following:

- an interest in using and/or providing data to improve the assessment,
- expertise in and/or are working to conserve fish and wildlife species and habitat,
- are involved in designing, constructing, or funding resilience projects, especially nature-based resilience projects, or
- are leading efforts to improve resilience within their communities.

Representatives from federal and state agency personnel, non-profit organizations, local government agencies, academic institutions, and interested private citizens were all invited to participate in the assessment process. Of the 274 invited participants, a total of 63 people participated in the in-person stakeholder workshops, but many others followed up with additional information and input after the workshops, providing critical data leads and resilience project ideas. (See Acknowledgments section for a list of the agencies represented in the stakeholder process.)

Project Outreach and Coordination Resources

Several resources were developed to inform and support input by stakeholders.

- National and watershed-specific fact sheets to convey project goals.
- A Data Basin portal (https://databasin.org/) for the watershed to keep all stakeholders informed and to provide an online space for information submission, etc. (sign up was required via the South Atlantic LCC Conservation Planning Atlas).
- Dynamic project submission forms with step by step instructions for contributing data and resilience projects.
- A draft list of fish and wildlife data elements that were targets for inclusion in the project.

Watershed Webinars and Stakeholder Workshops

Webinars and in-person workshops were scheduled to maximize involvement from stakeholders throughout the watershed and to keep participants informed about project progress throughout the project timeline. Stakeholders were invited to attend one of three workshops which were preceded by an introductory webinar to provide background in advance of the workshops (see **Table A1- 1** for more information on specific engagement opportunities and the Acknowledgements section for more information on the groups represented in the stakeholder process). The three workshops were generously hosted by: Margo Moehring at Northeast Florida Regional Council, Kaitlyn Dietz at Guana Tolomato Matanzas National Estuarine Research Reserve, and staff at the Volusia County Emergency Management Facility.

After an initial introduction to the proposed analysis and the project timeline, participants were offered a variety of mechanisms in which to provide input, ideas, and comments. In particular, participants were encouraged to:

- Submit ideas for fish and wildlife elements of particular importance in this watershed.
- Highlight important datasets to use in the analysis (both on fish and wildlife, stressors, and coastal threats).
- Submit resilience project ideas.

Table A1-1. List of webinars and in-person meetings with watershed committee and/or stakeholders.

Name of Engagement Activity	Participation	Date
First Watershed Committee meeting (by webinar)	Watershed Committee	June 26, 2017
Pre-stakeholder webinar	Stakeholders, Watershed Committee	September 26, 2017
In-person stakeholder workshops	Stakeholders, Watershed Committee	October 10-12, 2017
Post workshop follow-up to summarize workshop results	Watershed Committee	Nov 7, Dec 21, 2017
Review of fish and wildlife and vulnerability assets	Watershed Committee	April 12, 2018
Draft results webinar to discuss GIS analysis and obtain final input from all stakeholders that wish to participate	Stakeholders, Watershed Committee	April 19, 2018

Post-workshop Activities

Workshop input and discussion was used to finalize fish and wildlife species and project submissions for the assessment. In addition, the workshops helped to:

- Identify iconic or culturally/economically important species and any other species nominated by stakeholders to the list of fish and wildlife elements for consideration in the assessment.
- Aggregate the fish and wildlife species list into habitat groupings and/or guilds to ensure key habitats were covered in the analyses.
- Capture resilience project ideas submitted during the stakeholder workshops so that core team members could follow-up with project proponents later to collect all information to properly represent each resilience project in the database.

Once these steps were completed, the Watershed Committee and stakeholders were given updates on the process via webinars to review draft products (**Table A1- 1**).

Gathering Candidate Projects

Candidate resilience projects were gathered from stakeholders both at the in-person workshops and afterwards via the online portal, email, and phone. These project submissions became the pool from which several were selected for site visits and ultimately the final three case studies featured in this report.

Appendix 2. Condition and Vulnerability Technical Approach and Modeling Methods

This appendix provides additional detail to the Methods Overview and is supported by Appendix 3, which describes the vulnerability assessment model parameters and assumptions. These appendices also provide the details for the condition modeling, which generated some of the indices as an intermediate product of the vulnerability assessment. Not all technical details are described, for more extensive explanation of these, see the Vista Decision Support System (DSS) user manual (see GIS Tools section below). The vulnerability assessment methods for Human Community Assets (HCAs) and fish and wildlife elements were the same and used the same technical approach in the Vista DSS. *Elements* is the common term used in the Vista DSS for all features of assessment and planning interest, so from here-on, *elements* will be used to refer to both HCAs and fish and wildlife elements.

GIS Tools

The extensive and complex spatial assessments required for this project were conducted using the following Geographic Information Systems (GIS) tools:

ArcMap 10.6 is a geographic information system (GIS) developed by Esri (http://www.esri.com) as part of their ArcGIS Desktop product. The Spatial Analyst extension was required for this project.

NatureServe Vista (http://www.natureserve.org/conservation-tools/natureserve-vista) is an extension to ArcGIS that supports complex assessment and planning. Vista was used because it has the functions to support the types of analyses required to meet project objectives. It also serves as a platform to deliver the spatial data, results, and support additional work by stakeholders such as updating, re-prioritizing, and/or expanding the analyses to meet specific planning objectives.

Modeling Approach

A key concept in the Targeted Watershed Assessments is that the Vista DSS uses a *scenario-based* approach. This means that stressors and threats are aggregated into specific scenarios against which vulnerability of elements is assessed. These scenarios were illustrated in the stressor and threat groupings (**Figure 6**) in the Methods Overview. To assess vulnerability, condition of the elements must first be modeled by applying the model parameters in Appendix 3 to the scenario of interest. These condition results were used in several indices. From there, a condition threshold is applied to the condition map and values below the threshold are marked as vulnerable (non-viable in Vista DSS terminology).

The process steps used are listed and described below.

1. Define the scenarios in which stressors and threats are compiled
2. Build response models for how elements respond to the stressors and threats within the scenarios
3. Model condition of elements under each scenario
4. Apply the element condition thresholds and generate vulnerability maps of each element
5. Create vulnerability indices for element groups by summing the number of vulnerable elements at each location (pixel)

Definition of Scenarios

A scenario is a collection of maps of all the stressors and threats identified by stakeholders (for which adequate data existed) that can affect the condition of the elements. These stressors and threats are described as either fish and wildlife *stressors* (such as water quality) that only affect fish and wildlife elements and flooding *threats* that may affect all elements differentially (e.g., soils subject to flooding may affect HCAs but not the natural habitat already adapted to flooding that may occur there). Stressors and threats' effects on elements are evaluated using the assessment models described in the next section. Three scenarios were created and assessed, details on stressors and threats within each are described below.

1. **Baseline** depicts the current stressors within the watershed and supports assessment of the current condition of the fish and wildlife elements to understand how element condition may change in the future based on future threats or restoration actions.
2. **Threats** only includes the flooding threats and supports assessment of how these threats alone may impact element condition. In other words, without considering the current baseline condition, to what extent is a given element impacted by flooding threats.
3. **Combined** combines the baseline and threats scenarios into a cumulative scenario to understand how current and flooding threats may combine to impact fish and wildlife element condition.

Scenarios were built within the Vista DSS using the Scenario Generation function where data attributes were cross-walked to a classification of scenario stressors and threats. Data layers were added and grouped as to whether a feature overrode or dominated stressors and threats below it or combined with other stressors and threats. The objective of that process is to provide the most accurate scenario in terms of whether scenario stressors and threats co-occur in the same location or the presence of a feature precludes the presence of another feature (e.g., where there is a road there is not also agriculture). A large volume of stressor and threat data were gathered, evaluated, and integrated in the Vista DSS to map each of the scenarios. Details on scenario data are described below and the use of individual stressors and threats in each scenario is shown in **Table 2** and **Figure 6** in the Methods Overview.

Table A2-1. List of Stressors and threats indicating in which scenarios each was used.

Fish?Wildlife Stressors	Scenario		
	Baseline	**Threats**	**Combined**
Land use, including different levels of housing development, commercial/industrial areas, agriculture, and forestry	X		X
Infrastructure, including different size roadways, railroads, dams, pipelines, and electrical transmission corridors	X		X
Energy, including oil and gas extraction and renewable energy	X		X
Terrestrial and aquatic invasive species	X		X
Water quality or stressors that can affect water quality	X		X
Dredge Material Placement Areas	X		X
Flooding Threats	**Baseline**	**Threats**	**Combined**
Sea level Rise		X	X
Storm surge potential		X	X
Subsidence		X	X
Erosion potential		X	X
Flat and poorly drained soils		X	X
Flood prone areas		X	X

Stressor and Threat Data

The full list of stressors and threats used in the vulnerability assessments is in **Table A2- 2** at the end of this appendix, along with the data source used. If no data source was found for a stakeholder-identified fish and wildlife stressor that is noted. This assessment used the flooding threats data developed in the Regional Assessment (Dobson et al. 2019). The following is a brief description of each flooding threat included.

Soil Erodibility

To assess the erodibility of soils throughout the coastal watersheds, the USDA-NRCS Soil Survey Geographic Database (SSURGO) classification kffact was used. The kffact score represents the susceptibility of soil particles to detachment by water. Soil erosion resulting from flooding can drastically alter the landscape and impact wildlife habitat. Erosion can be devastating in extreme flood events. In this assessment, soil erodibility varies tremendously across regions and is dependent on soil type. Also highlighted in this input are beaches and dunes that are migratory by nature. Although these landforms can help buffer a community from flooding, the risk of erosivity is fairly high.[5]

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[5]Gornitz, V.M., Daniels, R.C., White, T.W., and Birdwell, K.R., 1994, The development of a Coastal Vulnerability Assessment Database: Vulnerability to sea-level rise in the U.S. Southeast: Journal of Coastal Research Special Issue No. 12, p. 330.

Impermeable Soils

This input was included because it influences the period of time that coastal lands are inundated after a storm event. Poorly drained soils are typically wetland soils or clays and high density development is also considered very poorly drained because of pavement and rooftops. In many cases the USDA-NRCS SSURGO database is lacking data in urban areas. To account for the obvious impermeable nature of these areas, the National Land Cover Database developed land cover classes are included. To be considered a “very high” rank, the landscape must be a poorly or very poorly drained soil type and mapped as a developed land use.

Sea Level Rise

Sea level rise is occurring at different rates across the U.S. Coasts, for example relative sea level rise along the western portion of the Gulf Coast and a large portion of the North Atlantic Coast will be greater than the Pacific Northwest Coast as a result of groundwater and fossil fuel withdrawals.[6] The sea level rise scenarios modeled by NOAA can inform coastal decision-makers and wildlife managers. Gornitz et al. (1994) cited many studies as early as 1989 that demonstrated the potential vulnerability of the barrier islands and wetlands within the South Atlantic region to changing environmental conditions and other episodic flood events.[7] Scenarios for a 1-5 foot rise in sea level were used in the Regional Assessment but a lower level was used in this Targeted Watershed Assessment (see Methods Overview).

Storm Surge

Surge from hurricanes is the greatest threat to life and property from a storm. Like sea level rise, storm surge varies by region. The width and slope of the continental shelf play an important role in the variation between regions. A shallow slope will potentially produce a greater storm surge than a steep shelf. For example, a Category 4 storm hitting the Louisiana coastline, which has a very wide and shallow continental shelf, may produce a 20-foot storm surge, while the same hurricane in a place like Miami Beach, Florida, where the continental shelf drops off very quickly, might see an eight- or nine-foot surge.

Areas of Low Slope

As the slope of the terrain decreases, more land areas become prone to pooling of water, which can allow for prolonged coastal flooding. This input was created using the Brunn Rule, which indicates that every foot rise in water will result in a 100-foot loss of sandy beach. In this case, a one percent slope or less is likely to be inundated with a one-foot rise in water. This rule provides insight for low-lying coastal areas that are more susceptible to inundation and changing coastal conditions.

Additional stressors on fish and wildlife were identified by stakeholders in the workshops (Appendix 1). Distribution data were submitted by stakeholders and evaluated against data criteria and other regional/national datasets known to the GIS team. The best available data were then used to build each scenario based on currency, completeness, and resolution. Stakeholders, Watershed Committee

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[6]NOAA, *Global and Regional Sea Level Rise Scenarios for the United States* (2017), 30.

[7]Gornitz, V.M., Daniels, R.C., White, T.W., and Birdwell, K.R., 1994, The development of a Coastal Vulnerability Assessment Database: Vulnerability to sea-level rise in the U.S. Southeast: Journal of Coastal Research Special Issue No. 12, p. 330.

members, and attendees of any of the review sessions were invited to review data sources and gaps. They were provided with a link to an online form allowing them to enter information on additional data sources that might be of use as well as a link to a Dropbox folder for uploading data. Requirements for data submissions included:

- Data must be georeferenced and use a defined projection.
- Data should be complete for the full extent of project area and not just a subset of it.
- Data must either be represented as an area (e.g., polygon shapefile, raster) or, if in point or line format, have an explicit buffering rule (either a single distance from all features or variably calculated based on an attribute of each feature).
- Data should be submitted to contain FGDC compliant metadata (strongly preferred). Exceptions were made, but most data lacking metadata did not make it through the initial screening process.

All data sources were further evaluated according to project data requirements. Evaluation included completeness of data across the watershed, precision of data, and accuracy of data compared to other sources or imagery. Where necessary, data were projected to the project standard, clipped/masked to the project boundary, and rasterized if necessary. For readers interested in using these datasets, they can be found in the packaged NatureServe Vista project resource available through NFWF's Coastal Resilience Evaluation and Siting Tool (CREST), available at resilientcoasts.org.

Table A2-2. Fish and wildlife stressors and threats identified by stakeholders. *Table identifies the primary category, secondary category (which was mapped if suitable data was found), data sources identified (if any), and the scenarios in which each was used.*

Stressor/Threat Primary & Secondary Categories		Data Sources	Scenarios
Residential & Commercial Development	High/Medium Density Housing (high imperviousness > 50%)	Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission.	Baseline, Combined
	Low Density Housing (moderate imperviousness 20%-40%)		
	Developed Open Spaces (parks, cemeteries, etc.) (low imperviousness < 20%)		
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission. National Transportation Atlas Database (2015 or later); *Petroleum terminals and refineries (2015 or later)*: Terminals: EIA-815, "Monthly Bulk Terminal and Blender" Report; Refineries: EIA-820 Refinery Capacity Report; *Natural Gas Terminals and Processing Plants (2015 or later)*: *Terminals*: EIA, Federal Energy Regulatory Commission, and U.S. Dept. of Transportation; *Processing Plants*: EIA-757, Natural Gas Processing Plant Survey	
Agriculture and Aquaculture	Silviculture – Sustainable	No data	N/A
	Silviculture – Intensive	Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission.	Baseline, Combined
	Intensive Agriculture		
	Ruderal (maintained pasture, old field)		
	Aquaculture	No data	N/A
Energy Production and Mining	Solar Arrays	Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission (mining only).	N/A
	Wind		
	Oil and Gas Fields		
	Mining		
Transportation and Service Corridors	Primary Roads	Tiger roads (U.S. Census 2016)	Baseline, Combined
	Secondary Roads		
	Local, neighborhood and connecting roads, bridges/culverts		
	Dirt/Private roads/culverts		
	Railroads, bridges, culverts	USDOT/Bureau of Transportation Statistics' National Transportation Atlas Database (2015 or later); Federal Highway Administration, NBI v.7, NTAD (2015 or later)	

Stressor/Threat Primary & Secondary Categories		Data Sources	Scenarios
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission.	N/A
Dredge Material Placement Areas		Florida Cooperative Land Cover (CLC) version 3.2.5: Florida Fish and Wildlife Conservation Commission.	Baseline, Combined
Dams & Reservoirs		USDOT/Bureau of Statistics' NTAD (2015 or later)	Baseline, Combined
Sea Level Rise – 1 ft		NOAA Sea-level Rise Senarios	Flooding Threats, Combined
Storm Surge	Category 1	FEMA National Flood Hazard Layer	Flooding Threats, Combined
	Category 2		
	Category 3		
	Category 4		
	Category 5		
Water Quality	Moderate	EPA Impaired Waters; FL Dept. of Environmental Protection 303(d) Impaired Watersheds. AIS Commercial Vessel Traffic Density (*MarineCadaster.gov, 2012*, obtained from Rua Mordecai pers. comm.)	Baseline, Combined
	Low		
Invasive Species	Terrestrial	No data	N/A
	Aquatic		
Landslide Susceptibility	High Susceptibility, Moderate Incidence	USGS Landslide Susceptibility Data	Flooding Threats, Combined
	High Incidence		
Subsidence	Moderate	UNAVCO Subsidence Data	Flooding Threats, Combined
	High		
	Very High		
Poorly drained areas	Flat & Somewhat Poorly Drained	NRCS SSURGO	Flooding Threats, Combined
	Flat & Poorly or Very Poorly Drained		
Erosion	High Erodability	NRCS SSURGO Soil Erodibility Data	Flooding Threats, Combined
	Very High Erodability		
Flood Prone Areas	Occasional Flooded Soils	FEMA National Flood Hazard Layer	Flooding Threats, Combined
	Frequent Flooded Soils		
	500-year Floodplain		
	100-year Floodplain		
	Floodway*		

**A "Regulatory Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (https://www.fema.gov/floodway).*

Building Element Response Models

Response models reflect how each element responds in the presence, or within a certain distance, of a scenario feature. Four response models were developed to model element condition and assess their vulnerability. One model was developed for HCAs; fish and wildlife elements were put into three groups, assuming that the elements within a group respond similarly to the stressors and threats: a Terrestrial Elements model (models condition of all terrestrial wildlife elements), a Freshwater Elements model (models condition of all freshwater wetlands, stream and lake habitats, and aquatic freshwater animal species), and an Estuarine Elements model (models condition of all elements adapted to brackish and saltwater conditions—wetland, submerged aquatic habitats, estuarine habitats, and aquatic marine animal species). For each of these four groups of elements, parameters for the models included an element condition threshold (where condition drops below a state viable for the element), site intensity impacts (within the immediate footprint of stressors/threats relevant to a given scenario), and distance effects (to what extent impacts from a given stressor or threat extend out from mappable features). The threshold score is a subjective value (between 0.0 and 1.0) that is assigned based on the perceived relative sensitivity of the element category such that a high threshold (e.g., 0.8) would indicate an element that is very intolerant of disturbance, whereas a low threshold, (e.g., 0.5) would indicate an element that can remain viable with a considerable amount of disturbance. In the case of this project, "viable" should be interpreted as the ability to persist if conditions remain constant regarding a given scenario or the ability to recover from impacts without intervention in a relatively short time. Settings for each parameter were informed by Hak and Comer (2017), Powell et al. (2017), and prior experience of the NatureServe assessment team with input from the Jacksonville and Lower St. Johns River Watersheds Committee and other stakeholders. Model inputs and assumptions are described in Appendices 2 and 3.

Model Element Condition

Modeling element condition is the first step to assess vulnerability, but the intermediate product of element condition was also used in the Fish and Wildlife Condition-Weighted Index and as a factor in the ranking of *Resilience Hubs*. The spatial analyses were conducted using the "landscape condition model" (LCM) within the Vista DSS, which is based on a model developed by Hak and Comer (2017). The condition of each element was assessed under the relevant scenarios described above by applying the appropriate response model to generate a set of condition maps that cover the entire watershed. HCAs were only assessed against the *threats scenario* with the assumption that current HCAs are compatible with other human development and wildlife stressors and are only impacted by the flooding threats. Fish and wildlife elements were assessed against all three scenarios to inform their current condition under the baseline scenario, the potential impacts from just the flooding threats, and the cumulative impacts of the stressors in the baseline scenario and the flooding threats in the Combined Scenario.

The LCM calculates the condition score of every pixel in the watershed as depicted in the four maps below (**Figure A2- 1**) using the relevant response models per above without regard to locations of elements to which the scores will be applied. The LCM first calculates the response scores on each individual scenario feature (site intensity within the scenario feature footprint and the distance effect offsite) and then overlapping feature responses are multiplied to calculate a cumulative effect. For example, where a condition score of 0.7 in a pixel resulting when one stressor overlaps with a condition score of 0.6 from another overlapping stressor, the scores are multiplied to obtain a combined score of 0.42 reflecting the cumulative impact of the two stressors. Vista then intersects the watershed-wide condition map with each relevant element distribution map to attribute the element's condition on a pixel basis (every pixel within an element's distribution receives a condition score). The condition maps and intermediate layers for each element are available in the Vista DSS project.

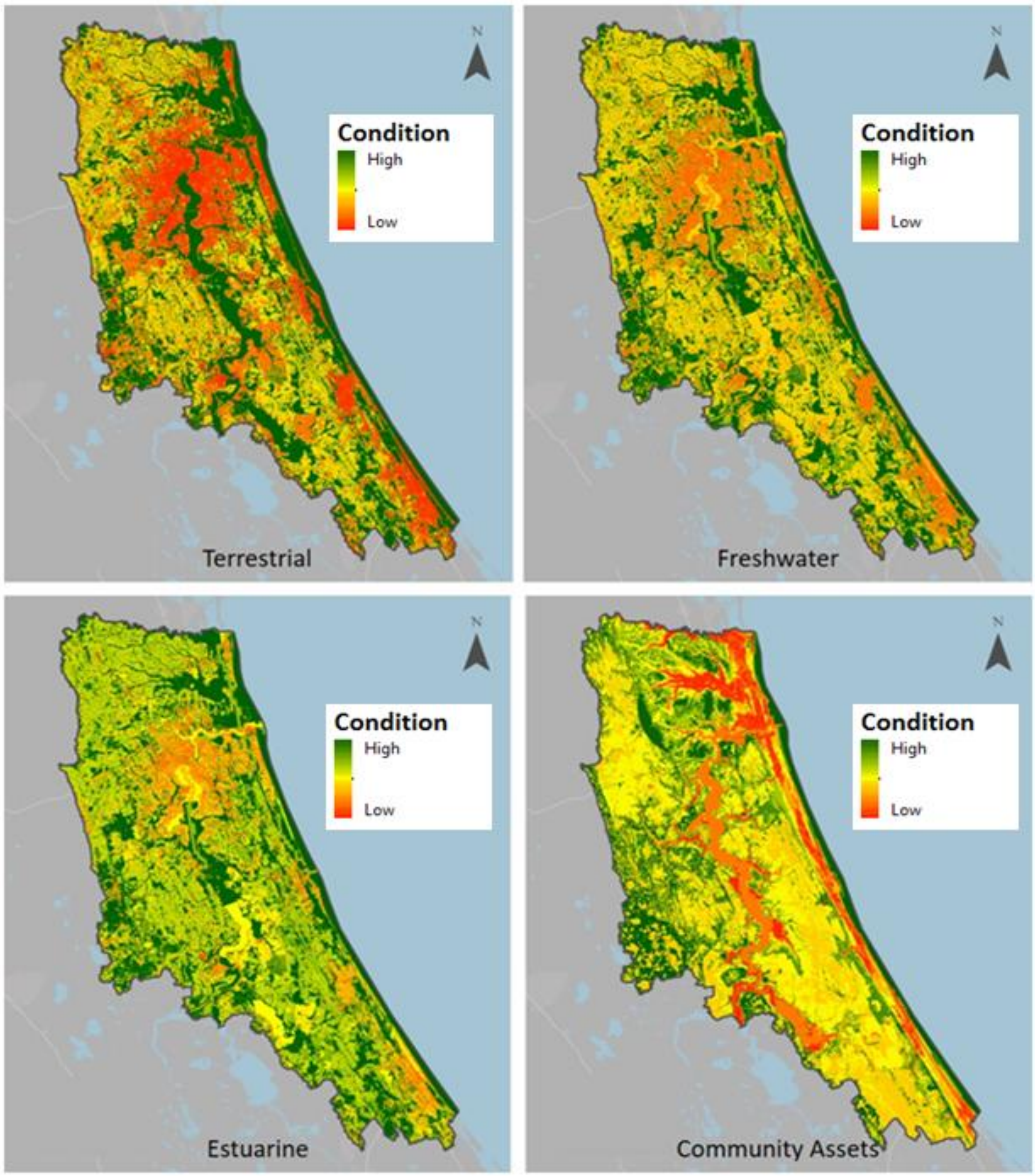

Figure A2-1. Landscape condition model outputs for the Jacksonville and Lower St. Johns River Watersheds. *These maps depict the watershed-wide results of each of the four landscape condition models used in the assessments.*

Model Element Vulnerability

To assess vulnerability, the individual element results from the condition modeling above were subjected to the condition threshold for the same element groups described above in Building Element Response Models (see Appendix 3 for thresholds). All pixels below the threshold were attributed as non-viable (vulnerable); those above as viable (not vulnerable). For example, all HCAs were assigned a condition threshold of 0.5 indicating that when enough cumulative stressors reduce the condition of a pixel below 0.5, any HCAs falling within that pixel would be marked as non-viable. The elements were overlaid together and the non-viable pixels were summed across elements to generate a raster index where the value of a pixel is the count of the number of vulnerable elements in each pixel. This resulted in the Human Community Vulnerability Index and the Fish and Wildlife Vulnerability Index (described further in Appendix 4). The Vista DSS also accommodates the use of a minimum viable patch/occurrence size for elements to further define viability, but this was not used in the project. For example, one can specify a minimum size for a marsh type at 100 acres. A patch would then need to have at least 100 acres of viable pixels to be viable or the entire patch is marked vulnerable. That function is available for users to add that parameter to the model and update the results.

Appendix 3. Structure, Parameters, and Assumptions for Condition and Vulnerability Models

This appendix provides the model settings and details established in the condition modeling and vulnerability assessments (Appendix 4) so users may better understand the results and may consider refining the settings based on additional local knowledge or different objectives. Hereon, the term *elements* is used to describe both fish and wildlife and HCAs as that is the functional term used in the Vista DSS for all features of assessment/planning interest. While some literature was used to inform the model parameters, these are primarily subjective, expert knowledge-informed settings for which empirical data do not generally exist. Instead, assumptions are provided so they may be challenged and refined when better information or knowledge becomes available.

The four models' parameters described in the tables below are provided as four separate tables in the following order:

1. **Table A3-1**: Terrestrial Vulnerability Model
2. **Table A3-2**: Freshwater Vulnerability Model
3. **Table A3-3**: Estuarine Vulnerability Model
4. **Table A3-4**: Human Asset Vulnerability Model

While Vista allows response models tailored to individual elements, for this rapid assessment, grouping the elements was an efficient way to generate reasonable models and end products. Each table is organized according to the following column headings and categories.

- ***Key Assumptions of this Model***: Describes which elements the model applies to and the general assumption for how effects of scenario stressors and threats were scored.
- ***Importance Weighting:*** Only applicable to HCAs (**Table A3-4**) and only for the weighted richness index, but weights can be assigned to any of the elements if desired.
- ***Element Condition Threshold***: Score, between 0.0 and 1.0, representing the relative sensitivity of an element to stressors and threats. Relatively high numbers (e.g., 0.8) indicate high sensitivity/low adaptive capacity to disturbance while low numbers (e.g., 0.4) would indicate low sensitivity/high adaptive capacity.

The next section of each table provides the classification of the stressors and threats including both Primary Category and Secondary Category, the response parameters of the elements in the group to those stressors and threats, and the assumptions made in those responses. The following column headings indicate:

- ***Response Type***: Column represents one of three possible parameter types used in the Vista Scenario Evaluation model:
    - ***Categorical Response*** is set as negative (negative impact from the stressor/threat) neutral (no effect), and positive (a beneficial effect—this only applies to the list of actions established for resilience projects). This response was not directly used in the assessment but serves two purposes—first to inform the setting of the other responses by narrowing whether they should be above or below the condition threshold; second to support use of the Vista project for planning purposes where it

allows rapid testing of proposed actions at the site scale (in the Vista DSS see the Site Explorer function).

  - ***LCM Site Intensity*** indicates how much of an element's condition would be left if the stressor/threat fell directly on the element. This setting assumes a starting condition of 1.0 (high or perfect condition in the absence of other stressors). This is an important assumption to understand in Vista, that without a mapped stressor, condition will be perfect. While ultimately whether the score is above or below the threshold determines viability of the element at a location, the gradient is useful to understand how much above or below the threshold the element condition is to inform decisions about conservation and restoration. The model does not allow a setting of 0.0, so .05 is generally used to indicate complete removal/reduction of condition.
  - ***LCM Distance*** indicates the distance in meters from the edge of a stressor that the impacts may extend. The LCM does not use a buffer but instead models an S-shaped curve where the impacts start off high from the edge, drop off steeply, then level out to no effect at the specified distance.

- ***Responses:*** Column indicates the settings established by the project team.
- ***Response Assumptions:*** Provides a short description of the team's assumptions of the setting.

Storm surge effects modeling

Because only a single threats scenario was assessed in this rapid assessment, all 5 categories of storm surge had to be combined and treated simultaneously. The scores for the site intensity (impact) for each category of storm surge were, therefore, set with this combination in mind versus scoring each independently. The scores are described in the tables below, but the general logic of the combination is that where category 1 surge overlaps with all other categories and, therefore, deeper flooding and higher energy water movement, the impact is highest; where there is category 5 surge (not overlapping any other categories) and thus the shallowest, lowest energy fringe area of flooding (furthest inland), the impact is lowest. Categories 2-4 will have intermediate levels of impact from high to low respectively. While the individual impact scores are not severe, the multiplication of them, where they overlap, equates to high impact. To illustrate, the impact on human assets from a category 5 surge that overlaps with the category 1-4 surges (that area closest to the coast) would be scored as category 1 (.65) x category 2 (.7) x category 3 (.75) x category 4 (.8) x category 5 (.85) = a cumulative impact score of .23 which is far below the vulnerability threshold of 0.5. If the Vista DSS user wished to create separate scenarios for each category of storm surge, the settings should be adjusted to reflect the anticipated level of each category independently.

Table A3-1. Terrestrial Exposure Model Structure and Assumptions.

<table>
<tr><th colspan="4">Key Assumptions of this Model</th></tr>
<tr><td colspan="2">Applies to Terrestrial Habitats and Species</td><td colspan="2">Is focused more on keeping the habitat intact for resilience to flooding impacts and understanding current condition relative to flood mitigation than for biotic component retention</td></tr>
<tr><td>Importance Weighting (Optional, used only for the CVS)</td><td>Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided</td><td>n/a</td><td>Importance weighting not set for fish and wildlife elements. Assumption is that all are equally important.</td></tr>
<tr><td>Element Condition Threshold</td><td>Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience to stressors and nearing 1.0 indicates increasing sensitivity.</td><td>0.6</td><td>Sensitivity Assumptions: Terrestrial habitats may sustain significant impacts from stressors and threats and still provide the desired functions for controlling runoff volume and pollutants and generally maintaining same habitat type but not necessarily all ecosystem biotic components.</td></tr>
<tr><td colspan="4">Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.</td></tr>
</table>

<table>
<tr><th>Primary Category</th><th>Secondary Category</th><th>Response Types</th><th>Responses</th><th>Response Assumptions</th></tr>
<tr><td rowspan="6">Residential & Commercial Development</td><td rowspan="3">High/Medium Density Housing (high imperviousness >50%)</td><td>Categorical Response</td><td>Negative</td><td rowspan="2">Assume total loss.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.05</td></tr>
<tr><td>LCM Distance</td><td>100</td><td>Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.</td></tr>
<tr><td rowspan="3">Low Density Housing (moderate imperviousness 20-49%)</td><td>Categorical Response</td><td>Neutral</td><td rowspan="2">In NLCD, individual houses or groups of houses are mapped as this type, so habitat type may have significant modification and fragmentation, considerable runoff and pollution can impact nearby aquatic systems. Impact less than high/moderate density because pixels do incorporate adjacent undeveloped areas. If local data suggests different densities of development and imperviousness, these assumptions and scores can be modified.</td></tr>
<tr><td>LCM Site Intensity</td><td>0.2</td></tr>
<tr><td>LCM Distance</td><td>100</td><td>Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.</td></tr>
</table>

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)	Categorical Response	Negative	Assume nearly complete conversion to maintained landscape but with some potential for restoration, particularly to land cover with more habitat value if not original habitat type. Some increased runoff generated in volume and pollutants from landscape maintenance.
		LCM Site Intensity	0.3	
		LCM Distance	50	Relatively small distance effect because of vegetative cover reducing pollutant runoff.
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Assume total loss.
		LCM Site Intensity	0.05	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
Agriculture and Aquaculture	Silviculture - Sustainable	Categorical Response	Neutral	Not significant impact on ecosystem process/hydrologic function, some impact on habitat quality/diversity, but would remain viable in absence of other stressors. High restorability
		LCM Site Intensity	0.7	
		LCM Distance	0	Negligible distance effect because of expected continuous vegetation coverage.
	Intensive Agriculture	Categorical Response	Negative	Complete habitat conversion, but some maintenance of hydrologic function. Potential long-term restorability.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Ruderal (maintained pasture, old field)	Categorical Response	Negative	Near complete conversion to managed landscape, but with some significant natural vegetation maintained in portions. May have herbicide applied for weed control, but otherwise hydrologic function would be closer to natural than more intensive agriculture types.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Aquaculture	Categorical Response	Neutral	Only assesses impact of adjacent aquaculture on terrestrial habitat vs. conversion to aquaculture. Assume clearing and hydrologic process impacts, difficult to restore to original habitat type.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Cleared but not paved footprint, potential for restoration.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Wind	Categorical Response	Negative	Assumption is for a wind field, not individual wind towers. Less footprint clearing and maintaining than solar and greater restorability with more remaining natural cover.
		LCM Site Intensity	0.4	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance impacts will be highly variable.
	Oil and Gas Fields	Categorical Response	Negative	Assumptions for well field, not individual pads. Assume dispersed clearing, maintained dirt pads, roads, noise but with mostly natural habitat in between and fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Mining	Categorical Response	Negative	Assumption for pit type mining. Effects can include complete removal of habitat, deep excavation, noise, dust, runoff of sediment, vehicle traffic. Difficult to restore to original ecosystem type.
		LCM Site Intensity	0.1	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Negative	Complete clearing, pavement, vehicular visual and noise disturbance, wildlife mortality, fragmentation, loss of connectivity.
		LCM Site Intensity	0.05	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Secondary roads, e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Somewhat reduced footprint and traffic impacts than a primary road but still highly significant.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a habitat type change.
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Similar effects as secondary road.
		LCM Site Intensity	0.2	
		LCM Distance	50	Smaller distance effect due to narrower footprint and reduced traffic volume.
	Dirt/Private roads/culverts	Categorical Response	Negative	Very narrow footprint, very low traffic volume, and can have continuous forest canopy over road, higher potential for restorability than wider/public roads.
		LCM Site Intensity	0.4	
		LCM Distance	30	Narrow footprint, low traffic volume, and potential for continuous forest canopy means smaller distance effect.
	Railroads, bridges, culverts	Categorical Response	Negative	Similar effects as secondary road.
		LCM Site Intensity	0.2	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a change to the existing habitat type.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Negative	Localized clearing and maintained artificial clearing but not paved, variable effects on animal behavior, potential for invasive introductions, fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a change to the existing habitat type.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dredge Material Placement Areas	Locations where dredge material is permanently deposited	Categorical Response	Negative	Assumption that any habitat is likely to experience recurring dredge deposition with associated salt and other pollutants. Moderate effort required to restore vegetative cover.
		LCM Site Intensity	0.3	
		LCM Distance	0	Assume no offsite effects on terrestrial elements.
Dams and Reservoirs	Any mapped dams and reservoirs	Categorical Response	Negative	Conversion from natural habitat but some potential for restoration through restored connectivity/dam removal.
		LCM Site Intensity	0.3	
		LCM Distance	100	Edge effects can have long-term effects on microclimate, exotic species invasion, species diversity, and dominance (among other impacts) resulting in a change to habitat type.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Complete and irreversible habitat conversion.
		LCM Site Intensity	0.05	
		LCM Distance	50	Some typical edge effect of habitat conversion, plus allowance for groundwater backup and/or saltwater intrusion causing effects beyond the inundation point.
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Water Quality - Low	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Invasive Species - Aquatic	Categorical Response	Neutral	Assume no effect on terrestrial elements.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Invasive Species - Terrestrial	Categorical Response	Negative	
		LCM Site Intensity	0.6	Effects can change biotic composition and sometimes habitat structure, which may lead to increased erosion, occasionally change an entire habitat type (to invasives dominated). Score is at threshold, so viability will be retained, but will benefit from control of invasives.
		LCM Distance	100	Indicates potential for spread over relatively short time without control depending on species.
	High Subsidence (Rank 4)	Categorical Response		
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response		
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response		Assume slightly less impact than for Very High Erodibility below.
		LCM Site Intensity	0.95	
		LCM Distance		
	Very High Erodibility	Categorical Response		Assume exposure to Category 3 storm surge in combination with very erodible soils would result in reduction of condition to just below threshold necessitating restoration for near term recovery. See assumptions for storm surge categories.
		LCM Site Intensity	0.9	
		LCM Distance		Assume no offsite effect.
Flood Prone Areas	500-year Floodplain	Categorical Response	Negative	Assume enough damage to habitat through soil erosion or deposition to require some restoration to bring back habitat and species viability or several years for natural recovery.
		LCM Site Intensity	0.5	
		LCM Distance	n/a	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	100-year Floodplain	Categorical Response	n/a	Assume elements are adapted to this flood level.
		LCM Site Intensity	n/a	
		LCM Distance	n/a	Assume no offsite effect.
	Floodway	Categorical Response	n/a	Assume elements are adapted to this flood level.
		LCM Site Intensity	n/a	
		LCM Distance	n/a	Assume no offsite effect.
Conservation Areas	Areas limited to conservation use	Categorical Response	Positive	No stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Resilience Project Protection/ Restoration Actions	Living shoreline implementation	Categorical Response	Positive	Project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, restoration, or enhancement of vegetated or non-vegetated shoreline habitats. Restoration practices uniformly indicating positive response for human assets, understanding that in some cases some individual structures might potentially be removed for purposes such as allowing for marsh expansion, but at this time it is quite unlikely.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions. May reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Marsh restorations.	Categorical Response	Positive	Projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities that are designed to enhance ecological assets may reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Restoration of aquatic connectivity	Categorical Response	Positive	Projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Upland restoration	Categorical Response	Positive	Projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means that are designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Riparian and floodplain restoration	Categorical Response	Positive	Projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means that are designed to enhance ecological assets will reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Storm Surge	Category 1	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
	Category 2	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Category 3	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.7	
		LCM Distance	0	Assume no offsite effect.
	Category 4	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	Category 5	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.

Table A3-2. Freshwater Exposure Model structure and assumptions.

Key Assumptions of this Model			
Applies to any consistently wet habitats or species adapted to freshwater environments.	Responses to stressors focused on water quality impacts, increased salinization, physical impacts on submerged aquatic vegetation, and the potential for other biotic impacts.		
Importance Weighting (Optional, used only for the CVS)	Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided.	n/a	Importance weighting is not set for fish and wildlife elements. Assumption is that all fish and wildlife elements are equally important.
Element Condition Threshold	Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.	0.7	Assumption is that freshwater elements have less adaptive capacity to the stressors and threats in this assessment (flooding scour, erosion, salinization) than terrestrial elements. Therefore, they require better condition to maintain function.
Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.			

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Residential & Commercial Development	High/Medium Density Housing (high imperviousness >50%)	Categorical Response	Negative	Developed/armored shorelines, heavy runoff volume and pollutants, lack of shading with temperature increases. Low restorability.
		LCM Site Intensity	0.2	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Low Density Housing (moderate imperviousness 20-49%)	Categorical Response	Neutral	Septic tank pollutants, effects of clearing such as loss of tree cover and temperature increases, and increased runoff volume and landscape chemicals. Low restorability in general although there is potential to restore hydrologic connectivity and vegetation along streams.
		LCM Site Intensity	0.3	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)	Categorical Response	Negative	Clearing and temperature increases, human access, and landscaping (runoff volume, pollutants) will degrade habitat below threshold but high restorability potential.
		LCM Site Intensity	0.5	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Developed/armored shorelines, heavy runoff of freshwater and pollutants may include effects such as waterfowl hazing and noise impacts that would greatly reduce condition Very low potential for restoration.
		LCM Site Intensity	0.2	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Agriculture and Aquaculture	Silviculture - Intensive	Categorical Response	Neutral	Periodic clearing with high impacts on habitat, some impacts on hydrology through sedimentation and potential chemical application. In-wetland harvesting occurs in the St. Johns area and would stress habitats well below the viability threshold and require significant wetland restoration.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Silviculture - Sustainable	Categorical Response	Neutral	Small runoff effects from these practices.
		LCM Site Intensity	0.9	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Intensive Agriculture	Categorical Response	Negative	Agricultural chemical runoff, sediment runoff, and shoreline erosion may stress elements below the viability threshold. Where agriculture occurs directly on wetlands, significant restoration would be required to bring it back.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Ruderal (maintained pasture, old field)	Categorical Response	Negative	NOAA indicated some agriculture chemicals used on pastures. Runoff is anticipated to be low but sediment may runoff depending on uses, and shoreline erosion may stress these elements up to their viability threshold.
		LCM Site Intensity	0.7	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Aquaculture	Categorical Response	Negative	Habitat alteration, infrastructure, ongoing impacts of waste, nitrogen, and pathogens but high restorability.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Assessed for impacts from adjacent solar arrays, not within the aquatic elements. More intensive clearing and maintaining of barren ground affects temperature, sedimentation, and some herbicide runoff but with fairly high restorability to natural vegetative cover.
		LCM Site Intensity	0.4	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
Energy Production and Mining: assume on land	Wind	Categorical Response	Negative	Assumption is for a wind field not individual wind towers. Less footprint clearing and maintaining than solar and greater restorability with more remaining natural cover, but height and visual/noise effects may lead to overall similar effect as solar.
		LCM Site Intensity	0.4	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance impacts will be highly variable.
	Oil and Gas Fields	Categorical Response	Negative	Assumptions for well field, not individual pads. Assume dispersed clearing, maintained dirt pads, roads, noise but with mostly natural habitat in between. Some pollutant runoff expected but fairly high restorability.
		LCM Site Intensity	0.4	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Mining	Categorical Response	Negative	Assumption for pit type mining. Effects can include complete removal of habitat, deep excavation, noise, dust, runoff of sediment, vehicle traffic. Difficult restorability and typically to different ecosystem type.
		LCM Site Intensity	0.1	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Negative	Complete clearing, pavement, vehicular visual and noise disturbance, wildlife mortality, fragmentation, loss of connectivity, and pollutant runoff.
		LCM Site Intensity	0.05	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Transportation and Service Corridors	Secondary roads, e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Assume over water assume bridge with in water and shoreline structures, and clearing leading to altered hydrology, shading, and noise impacts. Assume these impacts will drop immediate area to just below viability threshold.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Assume culvert instead of bridge with in water and shoreline structures, and clearing, altered hydrology, shading, and noise impacts, in addition to the loss of ecological connectivity. Likely denser than other road types. Assume these impacts will drop immediate area to just below viability threshold.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Dirt/Private roads/culverts	Categorical Response	Negative	Assume culverts with intensive onsite impact, shoreline structures, and clearing, altered hydrology, shading, noise, dirt runoff, and impacted connectivity. Assume some restorability.
		LCM Site Intensity	0.5	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Railroads, bridges, culverts	Categorical Response	Negative	Over water assume bridge with in-water and shoreline structures, and clearing, altered hydrology, shading, and noise impacts. Assume these impacts will drop immediate area to just below viability threshold and low restorability.
		LCM Site Intensity	0.6	
		LCM Distance	50	Smaller distance effect with assumed smaller size, volume, and runoff.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Neutral	Assume over water feature with in-water support structures, infrequent maintenance, and noise impacts. High restorability.
		LCM Site Intensity	0.9	
		LCM Distance	20	Very small distance effect.
Dredge Material Placement Areas		Categorical Response	Negative	Assumption is not for dredge materials to be placed within aquatic systems but that offsite effects would include chemical and sediment runoff. Moderate restorability to vegetative cover that would reduce impacts to adjacent aquatic systems.
		LCM Site Intensity	0.3	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dams & Reservoirs	All dams and reservoirs	Categorical Response	Negative	Significant change of ecosystem type, hydrology, connectivity, long term sedimentation and significant costs to restore.
		LCM Site Intensity	0.2	
		LCM Distance	300	Fairly long-distance effect in terms of changed water chemistry and temperature, disrupted connectivity, and reduced natural sedimentation.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Conversion to saline adapted habitat, no ability to restore.
		LCM Site Intensity	0.05	
		LCM Distance	30	Distance effects include groundwater backup and saline intrusion, and edge effects of habitat conversion. Impacts will be highly variable based on topography and groundwater formations.
Storm Surge	Category 1	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.75	
		LCM Distance	0	Assume no offsite effect.
	Category 2	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	Category 3	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.85	
		LCM Distance	0	Assume no offsite effect.
	Category 4	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
	Category 5	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume moderate water quality will just maintain viability.
		LCM Site Intensity	0.7	
		LCM Distance	100	For partial water quality data, distance effect can extrapolate further, optional distance effect depending on the nature of data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Water Quality - Low	Categorical Response	Negative	These levels set to indicate restoration even with improved water quality may be difficult to remediate, since contaminated sediments have ongoing long-term effects.
		LCM Site Intensity	0.4	
		LCM Distance	100	For partial water quality data, distance effect can extrapolate further, optional distance effect depending on the nature of data.
	Invasive Species - Aquatic	Categorical Response	Negative	Aquatic species cause biotic and sometimes habitat level effects and are difficult to control.
		LCM Site Intensity	0.5	
		LCM Distance	300	Indicates potential for spread of invasives over a large distance depending on species and conditions.
Subsidence	Moderate Subsidence (Rank 3)	Categorical Response	Neutral	Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have a small multiplicative effect.
		LCM Site Intensity	0.99	
		LCM Distance	0	Assume no offsite effect.
	High Subsidence (Rank 4)	Categorical Response	Neutral	Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have a small multiplicative effect.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response	Neutral	Freshwater wetland systems would be less exposed to erosion events, so in combination with Storm Surge Category 4 would drop below viability threshold.
		LCM Site Intensity	0.85	
		LCM Distance		Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Freshwater wetland systems would be less exposed to erosion events, so in combination with Storm Surge Category 4 would drop below viability threshold.
		LCM Site Intensity	0.85	
		LCM Distance		Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Flood Prone Areas	500-year Floodplain	Categorical Response	Negative	Impact at just below viability threshold to indicate that some restoration action and/or years may be needed to restore viability from erosion, sedimentation, deposition of pollutants and anthropogenic debris, dispersal of invasives, and other severe impacts on species life histories/populations.
		LCM Site Intensity	0.6	
		LCM Distance	n/a	No offsite effect.
Conservation Areas		Categorical Response	Positive	No stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Resilience Project Protection/ Restoration Actions *(categories needed for Scenario breakouts)*	Living shoreline implementation	Categorical Response	Neutral	Project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, and restoration or enhancement of vegetated or non-vegetated shoreline habitats. Restoration practices uniformly indicate positive response for human assets, but in some cases individual structures may be removed to allow for marsh expansion in the future, for instance.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions may reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Marsh restorations	Categorical Response	Positive	Projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrologic restoration and thin layer sediment deposition can enhance ecological assets and reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing the effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Restoration of aquatic connectivity	Categorical Response	Positive	Projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Upland restoration	Categorical Response	Positive	Projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Riparian and floodplain restoration	Categorical Response	Positive	Projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets may reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Table A3-3. Estuarine exposure model structure and assumptions.

Key Assumptions of this Model			
Applies to any consistently wet habitats or species adapted to brackish conditions but not necessarily ocean-level salinity so may be sensitive to storm surges and sea level rise.		Responses to stressors focused on water quality impacts, increased salinization, physical impacts on submerged aquatic vegetation, and the potential for other biotic impacts.	
Importance Weighting (Optional, used only for the CVS)	Values range from: 0.0 (Low) to 1.0 (High). There may be as many weighting systems as desired based on rarity, cultural or economic value, etc. Value based on G-rank can be automatically populated if G-rank attribute is provided.		Importance weighting not set for fish and wildlife elements. The assumption is all are equally important.
Element Condition Threshold	Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.	0.6	Assume that saltwater/brackish habitats for this project's consideration are better adapted to the types of flooding impacts and will have greater connectivity and ability to recover from impacts.
Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.			

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Residential & Commercial Development	High/Medium Density Housing (high imperviousness>50%)	Categorical Response	Negative	Developed/armored shorelines, clearing, heavy runoff volume and pollutants (more dilution capability than FW systems assumed), very low restorability.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Low Density Housing (moderate imperviousness 20-49%)	Categorical Response	Neutral	Assume primary impacts are septic tank pollutants, effects of clearing such as loss of tree cover and temperature increases, and increased runoff volume and landscape chemicals. In brackish systems, impacts may also include shoreline armoring and dock structures within habitats. Some restoration possible depending on density of development to restore hydrologic connectivity and shoreline vegetation.
		LCM Site Intensity	0.5	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Developed open spaces (parks, cemeteries, etc.) (low imperviousness <20%)	Categorical Response	Neutral	Assume clearing and temperature increases, human access, and landscaping (runoff volume, pollutants) will degrade below viability threshold but high restorability.
		LCM Site Intensity	0.5	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Commercial & Industrial Areas (e.g., airports, energy transfer terminals, etc.)	Categorical Response	Negative	Assume developed/armored shorelines and heavy runoff of freshwater and pollutants may cause effects, such as waterfowl hazing and noise that would greatly reduce condition below viability. Substantial restoration required to bring back viability, and in some cases successful restoration might not be possible.
		LCM Site Intensity	0.2	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Agriculture and Aquaculture	Silviculture - Intensive	Categorical Response	Neutral	Assume periodic clearing with high impacts on habitat, some on hydrology, sedimentation, and from chemical application. Some in-wetland harvesting occurs in the St. Johns area. It would induce stress well below the viability threshold and require significant restoration.
		LCM Site Intensity	0.6	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Silviculture - Sustainable	Categorical Response	Neutral	Small runoff effects from these practices.
		LCM Site Intensity	0.9	
		LCM Distance	100	Moderate distance effect to compensate for lack of water quality data.
	Intensive Agriculture	Categorical Response	Negative	Assume no agriculture directly in brackish elements, so expect sediment and pesticide runoff from adjacent land use. Estuarine elements assumed to have somewhat less sensitivity to runoff than freshwater elements. Restoration potential is high.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Ruderal (maintained pasture, old field)	Categorical Response	Negative	NOAA indicated some agriculture chemicals used on pastures. Runoff is anticipated to be low, but some sediment may runoff depending on uses, and shoreline erosion may stress these elements to their viability threshold making them not viable.
		LCM Site Intensity	0.7	
		LCM Distance	300	Long distance effect to compensate for lack of water quality data.
	Aquaculture	Categorical Response	Negative	Assume habitat alteration, infrastructure, ongoing impacts of waste, nitrogen, and pathogens. Somewhat less impact relative to the viability threshold than on freshwater habitats due to dilution effect. High restorability.
		LCM Site Intensity	0.5	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Energy Production and Mining: assume on land	Solar arrays	Categorical Response	Negative	Assessed for impacts from adjacent solar arrays, not within the aquatic elements. Assume more intensive clearing and maintaining of barren ground affects temperature, sedimentation, and potential for some herbicide runoff but with fairly high restorability to natural vegetative cover.
		LCM Site Intensity	0.4	
		LCM Distance	50	Moderate distance effect to compensate for lack of water quality data.
	Wind	Categorical Response	Neutral	Assume a wind generation field, not individual turbines that can have intensive site impacts that take condition to the viability threshold but with high restorability.
		LCM Site Intensity	0.6	
		LCM Distance	300	Height of towers leading to larger visual and noise avoidance by some species.
	Oil and Gas Fields	Categorical Response	Negative	Assume well field, not individual pads, requires clearing, maintained dirt pads, roads affecting hydrology (changed grades, culverts), and creates noise. These activities are likely to increase runoff, sedimentation, and toxins, potentially armored shorelines. Moderate restorability.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
	Mining	Categorical Response	Negative	Assume land-based mining. Effects can include noise, dust, runoff of sediment, vehicle traffic, and the installation of culverts. Hydrological restoration is difficult; restoration efforts often result in different hydrological conditions or even a different ecosystem type.
		LCM Site Intensity	0.3	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.
Transportation and Service Corridors	Primary roads, e.g., Interstates, high traffic/volume, wide roads, bridges	Categorical Response	Neutral	Assume over water bridge will have in-water and shoreline structures, shoreline clearing, altered hydrology, shading, and noise impacts. The impacts will drop immediate area to just below viability threshold. Restorability unlikely for public roads.
		LCM Site Intensity	0.4	
		LCM Distance	50	Somewhat longer distance effect when lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Secondary roads e.g., moderate traffic/volume state highways, bridges	Categorical Response	Negative	Assume over water bridge will have in-water and shoreline structures, shoreline clearing, altered hydrology, shading, and noise impacts. The impacts will drop immediate area to just below viability threshold. Restorability unlikely for public roads.
		LCM Site Intensity	0.5	
		LCM Distance	30	Relatively small distance effect.
	Local, neighborhood and connecting roads, bridges/culverts	Categorical Response	Negative	Assume mostly culverts instead of bridges with in-water and shoreline structures, clearing, altered hydrology, shading, and noise impacts, and loss of ecological connectivity. Likely more dense than other road types causing the immediate area to drop just below the viability threshold.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Dirt/Private roads/culverts	Categorical Response	Negative	Assume culverts with intensive onsite impact, shoreline structures, clearing, altered hydrology, shading, noise impacts, dirt runoff, and impacted connectivity. Assume some restorability possible.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Railroads, bridges, culverts	Categorical Response	Negative	Assume bridge with in-water and shoreline structures, clearing, altered hydrology, shading, and noise impacts. Assume these impacts will drop immediately affected area to just below viability threshold.
		LCM Site Intensity	0.5	
		LCM Distance	50	Relatively small distance effect.
	Utility & Service Lines (overhead transmission, cell towers, etc.)	Categorical Response	Neutral	Assume over-water feature with some in-water support structures, but infrequent maintenance or noise. High restorability.
		LCM Site Intensity	0.9	
		LCM Distance	20	Relatively small distance effect.
Dredge Material Placement Areas		Categorical Response	Negative	Assume dredge materials will not be placed within aquatic systems. Offsite effects could include chemical and sediment runoff. Moderate restorability for vegetative cover that would reduce impacts to adjacent aquatic systems.
		LCM Site Intensity	0.4	
		LCM Distance	1000	Long distance effect to compensate for lack of water quality data.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Dams & Reservoirs	Any mapped dams and reservoirs	Categorical Response	Negative	Assume dam is on a stream that feeds into an estuarine habitat (although GIS only assessing distance effect from dam itself). Impacts include changes in hydrology/freshwater flow, reduction of sediment, temperature changes, potential increased salinity, and reduced connectivity for anadromous fish. Some potential for restoration through restored connectivity/dam removal.
		LCM Site Intensity	0.4	
		LCM Distance	300	Distance effect in terms of changed water chemistry and temperature, disrupted connectivity, and reduced natural sedimentation.
Sea Level Rise	See flooding threats table for level used.	Categorical Response	Negative	Assume water column will deepen affecting light, increased salinity and wave action. For the SLR level used in assessment, assume some adaptive capacity for marshes to accrete and maintain elevation, but habitat type conversion is likely. Total loss is not expected. The effect will be highly variable depending on the location and type of element. Restorability possible for techniques such as thin layer deposition to assist adaptation.
		LCM Site Intensity	0.4	
		LCM Distance	30	Distance effects include groundwater backup and saline intrusion, and edge effects of habitat conversion. The effects will be highly variable based on topography and groundwater formations.
Storm Surge	Category 1	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.75	
		LCM Distance	0	Assume no offsite effect.
	Category 2	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.85	
		LCM Distance	0	Assume no offsite effect.
	Category 3	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Category 4	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
	Category 5	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
Other threats	Water Quality - Moderate	Categorical Response	Neutral	Assume moderate water quality is just above element viability threshold, so viability is maintained. Restoration is possible if sources impairing water quality are addressed.
		LCM Site Intensity	0.7	
		LCM Distance	100	Extrapolates incomplete water quality data to surrounding waters.
	Water Quality - Low	Categorical Response	Negative	Assume impact relative to threshold is somewhat less than freshwater. It assumes greater dilution/flushing action. Restorability is possible if sources impairing water quality are addressed.
		LCM Site Intensity	0.5	
		LCM Distance	100	Extrapolates incomplete water quality data to surrounding waters.
	Invasive Species - Aquatic	Categorical Response	Negative	Assume aquatic species are much more difficult to control in an open marine/estuarine system compared to streams/lakes. Restorability is low because it is difficult to manage and effectively remove aquatic species from a given habitat.
		LCM Site Intensity	0.3	
		LCM Distance	300	Indicates a potentially large distance of spread of invasives depending on species and conditions.
	Invasive Species - Terrestrial	Categorical Response	Neutral	No anticipated effect.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Subsidence	Moderate Subsidence (Rank 3)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restoration generally not feasible.
		LCM Site Intensity	0.99	
		LCM Distance	0	Assume no offsite effect.
	High Subsidence (Rank 4)	Categorical Response	Neutral	Assumption: Minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restoration generally not feasible.
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response	Neutral	Assume minor effect due to high uncertainty of occurrence, but risk coupled with other threats and stressors would have small multiplicative effect. Restorability not feasible.
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response	Neutral	Assume estuarine wetland systems are better adapted to currents from tidal action so the element would be above the viability threshold, however if erosion is combined with Storm Surge Category 3, it would drop below the viability threshold. Restorability is high.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response	Neutral	Assume estuarine wetland systems are better adapted to currents from tidal action so the element would be above the viability threshold, however if erosion is combined with e Storm Surge Category 3, it would drop below the viability threshold. Restorability is high.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
Flood Prone Areas	500-year Floodplain	Categorical Response	Negative	Assume impact right at viability threshold. Experience from Hurricane Harvey indicated nearshore (and deeper) habitat impacts from high levels of freshwater input that occurred for an extensive period of time and traveled long distances in plumes. Assume will recover on own over time. Other impacts can include sedimentation, deposition of pollutants and anthropogenic debris, some impacts on species life histories/populations, and vegetation from freshwater exposure. Note: Because floodplain effects not mapped into marine areas, not capable of mapping the distance effect currently. Restorability would require extensive work and investment.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.
Conservation Areas		Categorical Response	Positive	Assume no stressors inherent in this use other than those overlapping from other categories. Supports condition and allows for natural restoration. Restorability is high.
		LCM Site Intensity	1	Assume no offsite effect.
		LCM Distance	0	
Resilience Project Protection/ Restoration Actions *(categories needed for Scenario breakouts)*	Living shoreline implementation	Categorical Response	Positive	Assume project enacts a management strategy for controlling erosion and enhancing water quality by providing long-term protection, and restoration or enhancement of vegetated or non-vegetated shoreline habitats. Restoration practices uniformly indicate positive response for human assets, but in some cases individual structures may be removed to allow for marsh expansion in the future.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Assume projects with on-the-ground actions focused on improving beach or dune conditions may reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions
	Marsh restorations.	Categorical Response	Positive	Assume projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities are designed to enhance ecological assets. They may reduce flooding by slowing and lowering height of storm surge, reducing coastal erosion, and reducing effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Restoration of aquatic connectivity	Categorical Response	Positive	Assume projects with on-the-ground actions in riverine settings that remove/replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	Assume no offsite effect.
		LCM Distance	0	
	Upland restoration	Categorical Response	Positive	Assume projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Riparian and floodplain restoration	Categorical Response	Positive	Assume projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets should reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Table A3-4. Human Asset Exposure Model Structure and Assumptions

Key Assumptions of this Model			
Applies to all human community assets		Responses to stressors focused on physical damage/loss from flooding	
Note: elevated roads/bridges were not separated from surface roads is the source data, so they are treated equally.			
Importance Weighting (Optional, used only for the CVS)	Values range from: 0.0 (Low) to 1.0 (High). These ratings were approximated from those used in the regional coastal resilience assessment.	.2	Critical Infrastructure (Rank 1)
		.2	Environmental Justice Rank 1
		.2	Population Density (Rank 1)
		.4	Critical Infrastructure (Rank 2)
		.4	Population Density (Rank 2)
		.6	Critical Infrastructure (Rank 3)
		.6	Population Density (Rank 3)
		.8	Population Density (Rank 4)
		1.0	Critical Facilities
		1.0	Population Density (Rank 5)
Element Condition Threshold	Values range from: 0.0 (Low) to 1.0 (High). This value will determine the LCM result threshold under which a species is no longer viable in a pixel. Nearing 0.0 indicates increasing resilience and nearing 1.0 indicates increasing sensitivity.	0.5	Assume human assets have moderate sensitivity owing to their ability to repair/rebuild vs. ecological features that can rarely be restored to original type/health or take a very long time to recover naturally.
Land Use Intents (term used in Vista 3.x for all land uses, infrastructure, other stressors and threats, and conservation management and practices anticipated under any scenario). The IUCN/CMP classification list (v3.1, 2011) of direct threats and conservation practices was modified to meet the needs of this project.			

Primary Category	**Secondary Category**	**Response Types**	**Responses**	**Response Assumptions** *(Restorability is not included because assets are not natural features to be restored.)*
Sea Level Rise	Use 1-foot SLR in targeted watersheds to represent 2050 timeframe for planning purposes.	Categorical Response	Negative	Assume severe impact but not complete loss if there is built protection for key assets. This may include raising structures, converting key roads to causeways, etc.
		LCM Site Intensity	0.2	
		LCM Distance	50	Distance indicating impacts from backup of groundwater can flood/destabilize foundations of structures and increase susceptibility to wave action.
Storm Surge	Category 1	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.65	
		LCM Distance	0	Assume no offsite effect.
	Category 2	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.7	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions *(Restorability is not included because assets are not natural features to be restored.)*
	Category 3	Categorical Response	Negative	See assumptions in Appendix introduction.
		LCM Site Intensity	0.75	
		LCM Distance	0	Assume no offsite effect.
	Category 4	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.
	Category 5	Categorical Response	Neutral	See assumptions in Appendix introduction.
		LCM Site Intensity	0.85	
		LCM Distance	0	Assume no offsite effect.
Subsidence	Moderate Subsidence (Rank 3)	Categorical Response		
		LCM Site Intensity	0.99	
		LCM Distance	0	Assume no offsite effect.
	High Subsidence (Rank 4)	Categorical Response		
		LCM Site Intensity	0.97	
		LCM Distance	0	Assume no offsite effect.
	Very High Subsidence (Rank 5)	Categorical Response		
		LCM Site Intensity	0.95	
		LCM Distance	0	Assume no offsite effect.
Flat (Slope <=0.75%) & Poor Drainage	Flat & Somewhat poorly drained	Categorical Response		Assume areas of flattest slope and somewhat poorly draining soils under extreme precipitation events will lead to flooding. It could approach the 100-year floodplain in level of impact.
		LCM Site Intensity	0.6	
		LCM Distance	0	Assume no offsite effect.
	Flat & Poor or Very poorly drained	Categorical Response		Assume areas of flattest slope and poorest draining soils under extreme precipitation events may lead to flooding approaching that of a 100-year floodplain.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
Erosion	High Erodibility	Categorical Response		Assume only a minor impact on human community assets that may require some remediation.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
	Very High Erodibility	Categorical Response		Assume that in combination with Storm Surge Category 3, expect condition to drop below the viability threshold.
		LCM Site Intensity	0.8	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	Response Assumptions *(Restorability is not included because assets are not natural features to be restored.)*
Flood Prone Areas	Occasional Flooded Soils	Categorical Response	Neutral	Assume structures may be vulnerable but will remain viable unless there are additional stressors or threats in these areas.
		LCM Site Intensity	0.5	
		LCM Distance	0	Assume no offsite effect.
	Frequent Flooded Soils	Categorical Response	Negative	Assume conditions should indicate older structures as just barely non-viable because newer structures built in floodplain areas are probably designed for them.
		LCM Site Intensity	0.4	
		LCM Distance	0	Assume no offsite effect.
	500-year Floodplain	Categorical Response	Negative	Assume similar impacts to full cumulative storm surge.
		LCM Site Intensity	0.2	
		LCM Distance	0	Assume no offsite effect.
	100-year Floodplain	Categorical Response	Negative	Assume structures in these areas will sustain some damage bringing them to just below the viability threshold. Therefore, if flooded, the structures would require repair to remain viable.
		LCM Site Intensity	0.4	
		LCM Distance	0	Assume no offsite effect.
	Floodway	Categorical Response	Negative	Assume it is highly unlikely to have human community assets directly within the floodway. A score of .9 was applied to assets in the floodway. They are vulnerable, however, likely to remain viable because they were designed with the anticipation of flooding in the area.
		LCM Site Intensity	0.9	
		LCM Distance	0	Assume no offsite effect.
Conservation Areas	Areas designated for conservation use	Categorical Response	Positive	Assume no stressors inherent in this use other than those overlapping from other categories. Conservation areas will support condition and allow for natural restoration.
		LCM Site Intensity	1.0	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	**Response Assumptions** *(Restorability is not included because assets are not natural features to be restored.)*
Resilience Project Protection/ Restoration Actions *(categories needed for Scenario breakouts)*	Living shoreline implementation	Categorical Response		Assume project enacts a shoreline management strategy for controlling erosion and enhancing water quality by providing long-term protection, restoration, or enhancement of vegetated or non-vegetated shoreline habitats.
		LCM Site Intensity	1	Restoration practices uniformly indicating positive response for human assets, understanding that in some cases individual structures might be removed in the future to promote and maintain resilience of the human or natural communities, e.g., marsh expansion that would help mitigate flooding.
		LCM Distance	0	Assume no offsite effect.
	Beach or dune restoration	Categorical Response	Positive	Projects with on-the-ground actions focused on improving beach or dune conditions. May reduce impacts of storm surge and effects of sea level rise and coastal erosion.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect
	Marsh restorations	Categorical Response	Positive	Assume projects with on-the-ground actions that improve marsh conditions and/or expand marsh area by means of hydrology and thin layer dredge activities are designed to enhance ecological assets. They may reduce flooding by slowing and lowering the height of storm surge, as well as reducing coastal erosion, and the effects of sea level rise.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.
	Restoration of aquatic connectivity	Categorical Response	Positive	Assume projects with on-the-ground actions in riverine settings that remove or replace man-made barriers to water flow and fish movement (e.g., dams and culverts) may reduce flooding threats and culvert/road failures.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Primary Category	Secondary Category	Response Types	Responses	**Response Assumptions** *(Restorability is not included because assets are not natural features to be restored.)*
	Upland restoration	Categorical Response	Positive	Assume projects with on-the-ground actions that improve upland conditions and/or expand natural upland area by means designed to enhance ecological assets may reduce flooding effects from precipitation-caused flooding upstream
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.2
	Riparian and floodplain restoration	Categorical Response	Positive	Assume projects with on-the-ground actions to improve conditions and/or expand floodplain or riparian area by means designed to enhance ecological assets may reduce/prevent erosion and may reduce flooding effects.
		LCM Site Intensity	1	
		LCM Distance	0	Assume no offsite effect.

Appendix 4. Fish and Wildlife Vulnerability Index

The purpose of the fish and wildlife vulnerability index analyses is to understand how condition (and therefore vulnerability) of the fish and wildlife elements may be impacted from the stressors and threats. The modeling of the elements' current condition informed scoring of the Resilience Hubs but vulnerability to stressors and threats was also modeled. These assessments can be informative for several uses. Most directly, they can inform resilience project design to understand what stressors and threats fish and wildlife located at the project site may be subject to and, therefore, what actions will be needed to mitigate those threats. The flooding threats assessment can also inform the potential lifespan of resilience projects relative to fish and wildlife; in particular, whether the area is subject to sea level rise over the 20-30-year timespan of this assessment. Separate from the intended co-benefits of building nature-based community resilience projects, this index can also be very useful for those organizations primarily concerned with fish and wildlife conservation by informing areas of high value but also vulnerability and the nature of stressors and threats in those areas.

Methods

Vulnerability is calculated based on the effect of stressors and threats on condition, subject to application of a threshold where condition scores below a specified level equate to vulnerability. The three scenarios under which vulnerability were assessed are:

1. Current vulnerability (where elements are subject to current stressors such as land uses and impaired water quality),
2. Vulnerability to flooding threats (where elements are subject to flooding threats only), and
3. Combined vulnerability (where elements are subject to the cumulative effects of all stressors and threats).

This analysis goes beyond an exposure assessment by combining element exposure, sensitivity, and adaptive capacity in the model. Specifically, the objectives were to:

1. Understand the current condition for selected fish and wildlife elements by assessing their vulnerability to the fish and wildlife stressors. The current condition of elements can help inform actions for areas based on: 1) whether protection alone is adequate to maintain the viability of elements (good condition), 2) areas where restoration is practical and would return elements to a viable state (intermediate condition), and 3) areas that may have a poor return on conservation or restoration investment (poor condition) because mitigation of stressors is either not practical or cost prohibitive.
2. Understand where and how element condition may change from flooding threats. This analysis can inform how these threats alone may impact element viability, if action is practical in threatened areas, and, if so, what type of action and over what time frame may be effective.
3. Understand where and how current stressors and flooding threats may act cumulatively to further reduce condition of elements to non-viable states. For example, where an element is currently viable, but experiencing moderate impacts from water quality such that it may become non-viable when the threat of storm surge is added. This information can inform decisions about actions in terms of the ability to keep elements in a viable state when

stressors and threats combine and for what duration a viable state may be sustained (i.e., relative to the assessed sea level rise).

The method for assessing vulnerability under each group of stressors and threats is the same as described and depicted in the steps and **Figure A4-1** below.

The steps of the process, detailed in Appendix 2 and Appendix 3, are outlined below:

1. Assemble fish and wildlife element distribution data and viability requirements.
2. Compile the relevant fish and wildlife stressors (stressors) and flooding threats (threats) data in scenarios to be assessed (current stressors, threats, combined stressors, and threats).

Steps to model element vulnerability under each scenario:

1. Select fish and wildlife elements to be assessed.
2. Select the stressors and threats scenarios to assess the elements' vulnerability.
3. Populate vulnerability (condition) models (not shown) of how each element group (terrestrial, freshwater, estuarine) responds to each stressor and threat that can occur in a scenario (see Appendix 3 for model parameters).
4. Apply the vulnerability models to the scenario to generate watershed-wide vulnerability maps.
5. Intersect fish and wildlife distributions with the resulting watershed condition maps to generate vulnerability maps for each element and apply the condition threshold (see Appendix 3) to each element condition map to identify areas falling below the threshold. This indicates what areas of the element's distribution is vulnerable.
6. Sum the vulnerable elements in each area to generate the index.

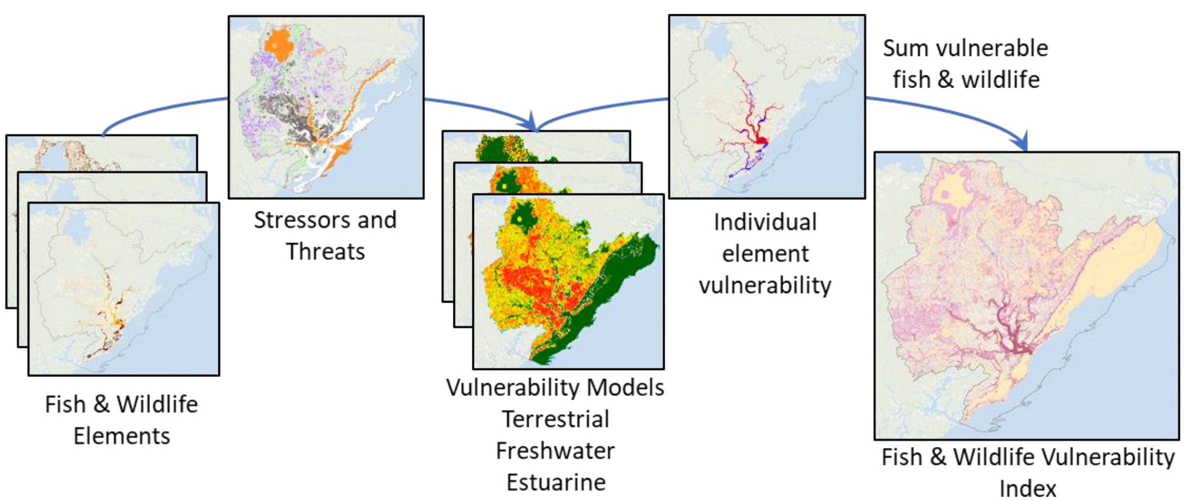

Figure A4-1. Method for calculating fish and wildlife vulnerability indices. *Elements are intersected with stressors and/ or threats, the vulnerability model is applied, and individual element vulnerability results are summed to create each index. Diagram represents the Charleston, SC region as an example and is only intended to illustrate methods.*

Results

This set of analyses represents vulnerability of fish and wildlife elements based on current stressors in the watershed, flooding threats, and the combination of those stressors and threats to model the potential synergies among them. Each of these analyses, illustrated and described below, provides unique information to inform actions to conserve or restore fish and wildlife habitat.

1. **Baseline Vulnerability Analysis.** This analysis evaluated the effects of current stressors on fish and wildlife elements and illustrates currently impacted areas that may be targeted for mitigation of stressors and restoration actions.

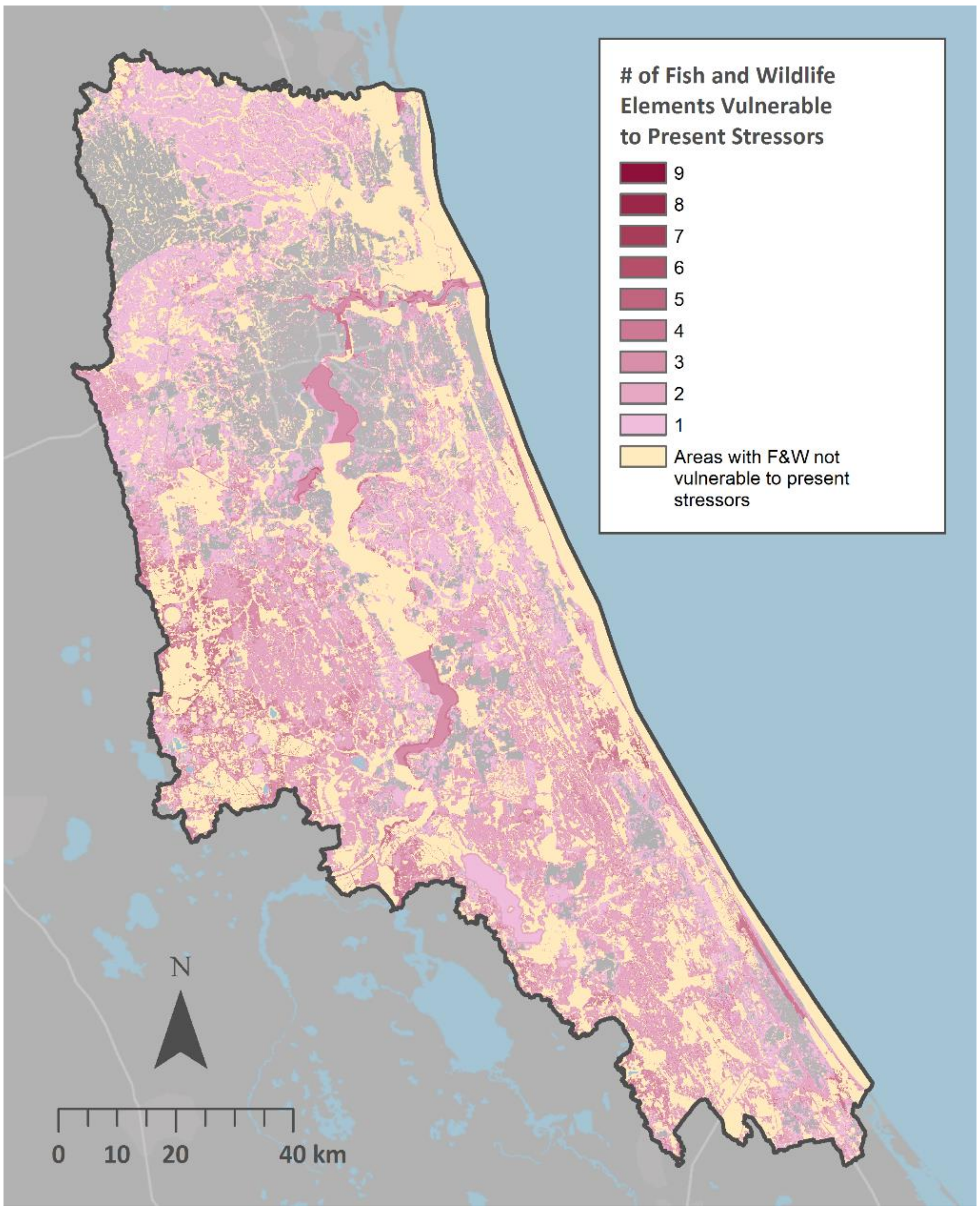

Figure A4-2. Fish and Wildlife Baseline Vulnerability for the Jacksonville and Lower St. Johns River Watersheds. *This map is an overlay or index of all fish and wildlife elements that are vulnerable to the existing mapped stressors. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

2. **Fish and wildlife vulnerability to flooding threats**. This index models the vulnerability of fish and wildlife elements to flooding threats. It illustrates areas where, regardless of current condition, fish and wildlife populations and habitat may be significantly impacted by flooding threats (for example, bird nesting habitat and fish spawning substrate may be altered or destroyed). It also identifies areas where the benefits of conservation or restoration actions may ultimately be reduced by flooding.

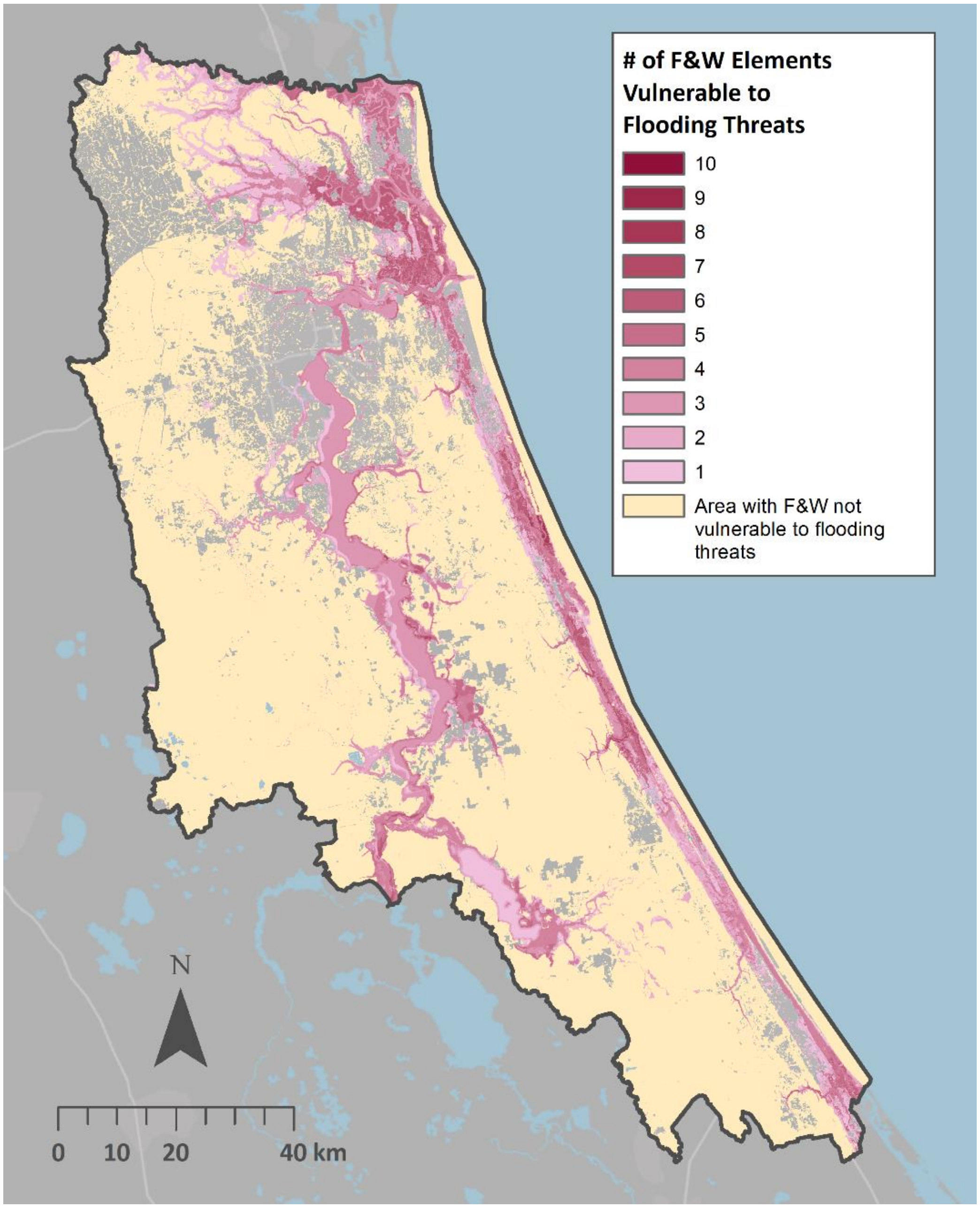

Figure A4-3. Fish and wildlife vulnerability to flooding threats in the Jacksonville and Lower St. Johns River Watersheds. *Pink to red shades indicate the number of elements vulnerable to flooding threats. Tan areas indicate areas of low to no impact. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

3. **Combined Fish and Wildlife Vulnerability Index**. This index combines the results of the above two analyses to model the cumulative effects of current stressors and flooding threats. This index illustrates areas where cumulative effects may increase the vulnerability of fish and wildlife.

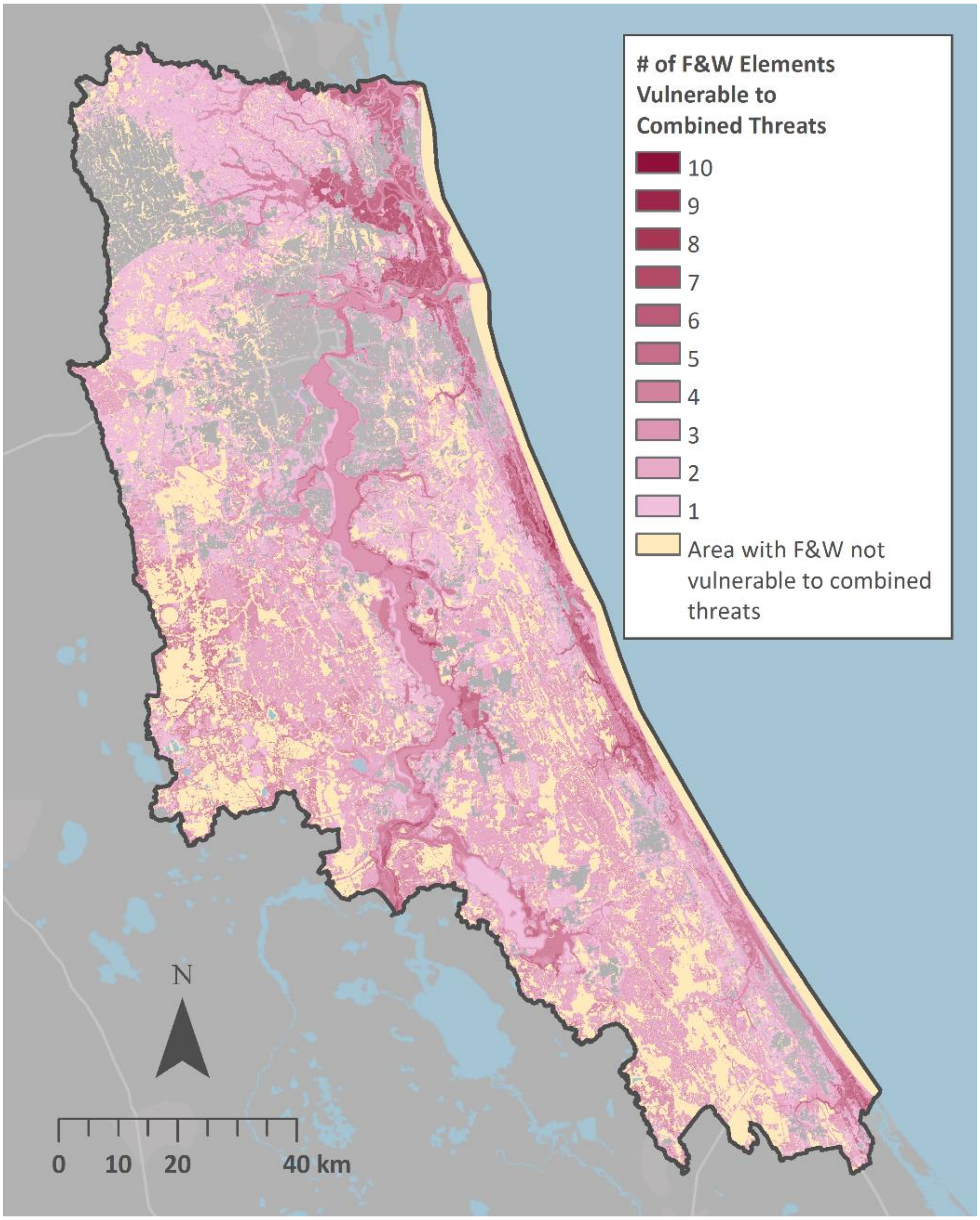

Figure A4-4. Fish and wildlife elements vulnerability to combined stressors and flooding threats for the Jacksonville and Lower St. Johns River Watersheds. *Pink to red shades indicate the number of elements vulnerable to threats. Tan areas indicate areas of low to no impact from the baseline threats. Gray areas within the project boundary represent areas with no mapped fish and wildlife elements.*

As observed in these results, there are areas of vulnerability to stressors associated with human uses and impaired water quality throughout much of the watershed. The combination of stressors and flooding threats intensifies vulnerability in the areas closest to the coast and extending up the rivers.

These results may be accessed through the Vista project.

Limitations

These analyses are subject to limitations of the available data and decisions about the selection of fish and wildlife stressors and the flooding threats. The vulnerability indices used a relatively simple model. Limitations expressed in the Fish and Wildlife Assessments methods are incorporated in these limitations. In addition to those limitations, the setting of condition thresholds for the three fish and wildlife groups (terrestrial, freshwater, and estuarine) is subjective; whether an element is calculated as vulnerable in a location is highly sensitive to the threshold set.

Appendix 5. Fish and Wildlife Element Selection and Inventory of Elements

This appendix includes additional detailed information about the fish and wildlife elements used in this assessment as well as those data sources considered but not ultimately used in this assessment.

Table A5-1. Data sources and preparation notes for spatial data used to represent fish and wildlife elements used in this assessment. *For the 'Data Source(s) Used' column, the following notation is used:* Name of Data Source (Source Agency or Organization) [Attributes used].

Fish/Wildlife Element	Data Source(s) Used	Data Sources Not Used and Why
NOAA Trust Resources		
Coastal dunes/grasslands	Cooperative Land Cover v3.2.5 (FWC/FNAI) [classes: 1600 – on ocean side only, 1610, 1620, 1630, 1640, 1660]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Estuarine waters	Cooperative Land Cover v3.2.5 (FWC/FNAI) [classes: 4160, 5000]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Freshwater bodies	Cooperative Land Cover v3.2.5 (FWC/FNAI) [CLC riverine waters, edited to remove estuarine and small isolated polygons]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Marine beaches/shoreline	Cooperative Land Cover v3.2.5 (FWC/FNAI) [classes 1670, 5222. Separated marine from estuarine polygons]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Estuarine beach	Cooperative Land Cover v3.2.5 (FWC/FNAI) [classes 1600, 1610, 1630, 1640. Added 1831 Rural open for several spoil islands]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Salt marsh/tidal flats	Cooperative Land Cover v3.2.5 (FWC/FNAI) [classes 5210, 5212, 5220, 5221, 5240]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Freshwater tidal wetlands	Cooperative Land Cover v3.2.5 (FWC/FNAI) [all CLC wetlands adjacent to tidal waters (excluding salt marsh and mangrove). Deleted wetlands on barrier islands (east of ICW) and directly adjacent to ICW – presumed brackish]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Mangrove tidal swamp	Cooperative Land Cover v3.2.5 (FWC/FNAI) [5250, removed some polygons around Nassau R. that were freshwater]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Oyster reefs/rakes	NCB Intercoastal Oysters (SJRWMD)	FWC Oyster Beds - Shapes are identical to SJWMD data used
Snapper/grouper	Essential Fish Habitat Snapper/Grouper, and Habitat Areas of Particular Concern (NOAA)	N/A
Shrimp	Shrimp Essential Fish Habitat, and Habitat Areas of Particular Concern (NOAA)	N/A

Fish/Wildlife Element	Data Source(s) Used	Data Sources Not Used and Why
NOAA Trust Resources		
Sand bar shark, sand tiger shark	Essential Fish Habitat for Sand Bar and Sand Tiger Sharks (NOAA)	N/A
Manatee	State Manatee Protection Areas (FWC)	FNAI Occurrence-Based Habitat Model - Focused on upland buffers rather than actual water bodies.
At-Risk Species		
Threatened & endangered aquatic species	FNAI Element Occurrence polygon data for species occurring in the study area (FNAI)	N/A
Threatened & endangered terrestrial species	FNAI Element Occurrence polygon data for species occurring in the study area (FNAI)	N/A
FNAI G1-G3/S1-S3 aquatic species	FNAI G1-G3/S1-S3 Element Occurrence polygon data for species occurring in the study area (FNAI)	N/A
FNAI G1-G3/S1-S3 terrestrial species	FNAI G1-G3/S1-S3 Element Occurrence polygon data for species occurring in the study area (FNAI)	N/A
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species		
Bottomland/ Floodplain Wetlands	Cooperative Land Cover v3.2.5 (FWC/FNAI) [Floodplain >25 acres and intersecting NHD natural flowlines – FFCNA_floodplain_riverine. Selected CLC wetlands intersecting riverine floodplain. Erased Freshwater Tidal Wetlands]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
	100-year Floodplain (FEMA)	
Coastal interdunal lakes	Cooperative Land Cover v3.2.5 (FWC/FNAI) [class 2122 (coastal interdunal swale), but also including any 2120s east of IC if linear and associated with hammock, strand, dunes, etc]	N/A
Interior wetlands	Cooperative Land Cover v3.2.5 (FWC/FNAI) [All CLC wetlands not included in salt marsh, mangrove, tidal, or floodplain categories.]	National Wetlands Inventory - Not as precise or accurate as CLC land cover in Florida
Wading bird group	2016 potential habitat model (FWC)	N/A
Coastal scrub	Cooperative Land Cover v3.2.5 (FWC/FNAI) [5 (class 1214 only) and FFCNA Coastal Scrub/Scrubby Flatwoods 2015 data; FNAI defines coastal scrub as only occurring on barrier islands (seaward of ICW in this region), so removed some CLC "coastal scrub" located on mainland]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida

Fish/Wildlife Element	Data Source(s) Used	Data Sources Not Used and Why
Distinctive Ecological Systems and Species Congregation Areas Supporting One or More Species		
Maritime hammock	Cooperative Land Cover v3.2.5 (FWC/FNAI) [class 1650 with a few small polygon edits]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Interior scrub	Cooperative Land Cover v3.2.5 (FWC/FNAI) [started with FFCNA NatCom scrub/scrubby flatwoods working file from 2015. Compared to current CLC Scrub – deleted a few polygons that are now cleared/developed. Removed Coastal Scrub]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Sandhill	Cooperative Land Cover v3.2.5 (FWC/FNAI) [FFCNA NatCom sandhill working file 2015 vs. current FFCNA sandhill and CLC sandhill. Added a few polygons from current CLC]	National Land Cover Data - Not as precise or accurate as CLC land cover in Florida
Wood stork	2013 Occurrence-Based Potential Habitat Model (FNAI)	Breeding Bird Survey Data/Bird Atlas - More precise/accurate models available for all bird elements in study.
Eastern indigo snake	2013 Occurrence-Based Potential Habitat Model (FNAI)	N/A
	2017 Predictive Distribution Model, threshold 0.21 (FWC)	N/A
Southern hognose snake	2017 Predictive Distribution Model, threshold 0.19 (FWC)	SALCC predictive distribution model - Does not cover entire St Johns study area; FWC model available for entire region
Painted bunting	2016 Potential Habitat Model (FWC)	Breeding Bird Survey Data/Bird Atlas - More precise/accurate models available for all bird elements in study.
Red-cockaded woodpecker	2012 Occurrence-Based Habitat Model (FNAI)	Breeding Bird Survey Data/Bird Atlas - More precise/accurate models available for all bird elements in study.
	2016 potential habitat model (FWC)	
Florida black bear	2013 Potential Habitat Model (FNAI)	N/A
	2016 Bear Range - Abundant and Common Zones (FWC)	N/A
	2016 Potential habitat model (FWC)	N/A
Cross-cutting Elements		
Continental and global Important Bird Areas	Audubon Important Bird Areas (Audubon)	N/A

Table A5-1. Fish and wildlife elements proposed but ultimately <u>not included</u> in this assessment. *For each element, a brief description is provided explaining why it was not included.*

Fish/Wildlife Element Proposed for Inclusion	Reason Element Not Included in Assessment
Piping plover	Encompassed by Marine and Estuarine Beaches Elements
Diamondback terrapin	Encompassed by Marine and Estuarine Beaches Elements
Black Creek crayfish	Encompassed by Freshwater Bodies Element
Gopher tortoise	Habitat addressed by Sandhill and wide-ranging species Elements.
Longleaf Pine	Habitat addressed by Sandhill and wide-ranging species Elements.
Snook, redfish, shad, blueback herring; prey fish for commercial fishing species	Encompassed by Freshwater, Estuarine, and Essential Fish Habitat Elements.

Table A5-2. Threatened and Endangered Animal Species. *To construct the "Threatened & Endangered Aquatic Species" and "Threatened & Endangered Terrestrial Species" elements, FNAI element occurrence data was compiled and combined for all animal species listed under the Endangered Species Act as being either threatened or endangered within the study area and for which data was available (below). These were combined into separate terrestrial and aquatic layers for analysis.*

Common Name of Species used in Assessment	Scientific Name	G-rank	S-rank	ESA Status
Shortnose sturgeon	*Acipenser brevirostrum*	G3	S1	E
Atlantic sturgeon	*Acipenser oxyrinchus*	G3T3	S1	E
American alligator	*Alligator mississippiensis*	G5	S4	T (threatened due to similarity of appearance)
Florida scrub-Jay	*Aphelocoma coerulescens*	G2	S2	T
Loggerhead sea turtle	*Caretta*	G3	S3	T
Piping plover	*Charadrius melodus*	G3	S2	T
Green sea turtle	*Chelonia mydas*	G3	S2S3	T
Etonia rosemary	*Conradina etonia*	G1	S1	E
Rugel's pawpaw	*Deeringothamnus rugelii*	G1	S1	E
Leatherback sea turtle	*Dermochelys coriacea*	G2	S2	E
Eastern indigo snake	*Drymarchon couperi*	G3Q	S3	T
Wood stork	*Mycteria americana*	G4	S2	T
Atlantic salt marsh snake	*Nerodia clarkii taeniata*	G4T1Q	S1	T
Anastasia Island beach mouse	*Peromyscus polionotus phasma*	G5T1	S1	E
Red-cockaded woodpecker	*Picoides borealis*	G3	S2	E
Chapman's rhododendron	*Rhododendron chapmanii*	G1	S1	E
West Indian manatee	*Trichechus manatus*	G2	S2	T

Table A5-3. G1-G3/S1-S3 Terrestrial Animal Species Element Occurrences. *To construct the "FNAI G1-G3/S1-S3 Aquatic Species" and "FNAI G1-G3/S1-S3 Terrestrial Species" elements, FNAI element occurrence data was compiled and combined for all G1-G3/S1-S3 rank animal species within the study area *not included in the combined ESA species element above* for which data was available (below). These were combined into separate terrestrial and aquatic layers for analysis.*

Common Name of Species used in Assessment	Scientific Name	G-rank	S-rank
Dusky roadside-skipper	*Amblyscirtes alternata*	G2G3	S2
Small pocket gopher *aphodius* beetle	*Aphodius aegrotus*	G3G4	S3?
Surprising pocket gopher *aphodius* beetle	*Aphodius dyspistus*	G3G4	S3?
Hubbell's pocket gopher *aphodius* beetle	*Aphodius hubbelli*	GNR	S3?
Large pocket gopher *aphodius* beetle	*Aphodius laevigatus*	G3G4	S3?
Broad-sided pocket gopher *aphodius* beetle	*Aphodius platypleurus*	G2G3	S2
Florida olive hairstreak	*Callophrys gryneus sweadneri*	G5T2	S2
Frosted elfin	*Callophrys irus*	G3	S1
Spring azure	*Celastrina ladon*	G4G5	S2?
Wilson's plover	*Charadrius wilsonia*	G5	S2
Worthington's marsh wren	*Cistothorus palustris griseus*	G5T3	S2
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	G3G4	S2
Eastern diamondback rattlesnake	*Crotalus adamanteus*	G4	S3
Timber rattlesnake	*Crotalus horridus*	G4	S3
Eastern tailed blue	*Cupido comyntas*	G5	S2
Snowy egret	*Egretta thula*	G5	S3
Swallow-tailed kite	*Elanoides forficatus*	G5	S2
St. Johns elephantear	*Elliptio monroensis*	G2G3	S2S3
Creole pearly eye	*Enodia creola*	G3G4	S1
Wild indigo duskywing	*Erynnis baptisiae*	G5	S2S3
Berry's skipper	*Euphyes berryi*	G2	S2
Dion skipper	*Euphyes dion*	G4	S2S3
Calhoun's skipper	*Euphyes dukesi calhouni*	G3T1	S1
Merlin	*Falco columbarius*	G5	S2
Peregrine falcon	*Falco peregrinus*	G4	S2
Southeastern American kestrel	*Falco sparverius paulus*	G5T4	S3
Gopher tortoise	*Gopherus polyphemus*	G3	S3
American oystercatcher	*Haematopus palliatus*	G5	S2
Bald eagle	*Haliaeetus leucocephalus*	G5	S3
Seminole skipper	*Hesperia attalus slossonae*	G3G4T3	S3
Eastern Meske's skipper	*Hesperia meskei straton*	G3G4T3	S2S3
Southern hognose snake	*Heterodon simus*	G2	S2
Caspian tern	*Hydroprogne caspia*	G5	S2
Berner's microcaddisfly	*Hydroptila berneri*	G4G5	S3
Purple skimmer	*Libellula jesseana*	G1	S1
Gopher frog	*Lithobates capito*	G3	S3
Cofaqui giant-skipper	*Megathymus cofaqui*	G3G4T3	S2S4
Ordway melanoplus grasshopper	*Melanoplus ordwayae*	G1G2	S1S2

Common Name of Species used in Assessment	Scientific Name	G-rank	S-rank
Round-tailed muskrat	*Neofiber alleni*	G3	S3
Atlantic salt marsh mink	*Neovison vison lutensis*	G5T3	S3
Striped newt	*Notophthalmus perstriatus*	G2G3	S2
Yellow-crowned night-heron	*Nyctanassa violacea*	G5	S3
Black-crowned night-heron	*Nycticorax*	G5	S3
Mourning cloak	*Nymphalis antiopa*	G5	S2
Osprey	*Pandion haliaetus*	G5	S3S4
Painted bunting	*Passerina ciris*	G5	S3
Bachman's sparrow	*Peucaea aestivalis*	G3	S3
Pine snake	*Pituophis melanoleucus*	G4	S3
Roseate spoonbill	*Platalea ajaja*	G5	S2
Yehl skipper	*Poanes yehl*	G4	S2S3
Florida mouse	*Podomys floridanus*	G3	S3
Tawny sanddragon	*Progomphus alachuensis*	G3	S3
Schwarz' pocket gopher ptomaphagus beetle	*Ptomaphagus schwarzi*	G3	S3
Black skimmer	*Rynchops niger*	G5	S3
Appalachian brown	*Satyrodes appalachia*	G4	S2S3
Rosemary grasshopper	*Schistocerca ceratiola*	G2G3	S2S3
Sherman's fox squirrel	*Sciurus niger shermani*	G5T3	S3
Red-legged purse-web spider	*Sphodros rufipes*	G4	S3
Many-lined salamander	*Stereochilus marginatus*	G5	S1
Least tern	*Sternula antillarum*	G4	S3
Royal tern	*Thalasseus maximus*	G5	S3
Sandwich tern	*Thalasseus sandvicensis*	G5	S2
Florida black bear	*Ursus americanus floridanus*	G5T2	S2

Table A5-4. Examples of species that rely on fish and wildlife elements explicitly included in this assessment. *ESA Status refers to species status under the U.S. Endangered Species Act.*

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
Coastal scrub	Eastern diamondback rattlesnake	*Crotalus adamanteus*	N	G4	S3
	Southeastern weasel	*Mustela frenata olivacea*	N	G5T4	S3?
	Florida mouse	*Podomys floridanus*	N	G3	S3
Coastal dunes & grasslands	An Ataenius Beetle	*Ataenius wenzelii*	N	G3G5	S2S3
	Southeastern weasel	*Mustela frenata olivacea*	N	G5T4	S3?
Estuarine waters	Shortnose sturgeon	*Acipenser brevirostrum*	E	G3	S1
	Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	E	G3T3	S1
	Blueback herring	*Alosa aestivalis*	0	0	0
	Alewife	*Alosa pseudoharengus*	0	0	0
	American shad	*Alosa sapidissima*	0	0	0
	American eel	*Anguilla rostrata*	0	0	0
	River goby	*Awaous banana*	N	G5	S1S2
	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
	White ibis	*Eudocimus albus*	N	G5	S4
	Bald eagle	*Haliaeetus leucocephalus*	N	G5	S3
	Schoolmaster snapper	*Lutjanus apodus*	0	0	0
	Opossum pipefish	*Microphis brachyurus*	SC	G4G5	S2
	West Indian manatee	*Trichechus manatus*	E, PT	G2	S2
	Bottlenose dolphin	*Tursiops truncatus*			
	Common snook	*Centropomus undecimalis*			
	Redfish	*Sciaenops ocellatus*			
	American shad	*Alosa sapidissima*			
	Blueback herring	*Alosa aestivalis*			
	Blue crab	*Cardisoma guanhumi*			
	Shrimp spp.				
	Freshwater/Estuarine recreational fish spp.				
Bottomland/ floodpain wetlands	Rafinesque's big-eared bat	*Corynorhinus rafinesquii*	N	G3G4	S2
	Timber rattlesnake	*Crotalus horridus*	N	G4	S3
	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
	Creole pearly eye	*Enodia creola*	N	G3G4	S1
	Berry's skipper	*Euphyes berryi*	N	G2	S2
	Calhoun's skipper	*Euphyes dukesi calhouni*	N	G3T1	S1
	Merlin	*Falco columbarius*	N	G5	S2
	Bald eagle	*Haliaeetus leucocephalus*	N	G5	S3
	Southeastern weasel	*Mustela frenata olivacea*	N	G5T4	S3?
	Florida long-tailed weasel	*Mustela frenata peninsulae*	N	G5T3	S3

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
	Many-lined salamander	*Stereochilus marginatus*	N	G5	S1
Freshwater bodies	Shortnose sturgeon	*Acipenser brevirostrum*	E	G3	S1
	Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	E	G3T3	S1
	Spring-loving psiloneuran caddisfly	*Agarodes libalis*	N	G3	S3
	American alligator	*Alligator mississippiensis*	SAT	G5	S4
	Blueback herring	*Alosa aestivalis*			
	Alewife	*Alosa pseudoharengus*			
	American shad	*Alosa sapidissima*			
	Snail bullhead	*Ameiurus brunneus*	N	G4	S3
	Squaremouth Amnicola snail	*Amnicola rhombostoma*	N	GH	SH
	American eel	*Anguilla rostrata*			
	Hirsute mayfly	*Attenella attenuata*	N	G5	S1S2
	River goby	*Awaous banana*	N	G5	S1S2
	A mayfly	*Baetisca gibbera*	N	G5	S1S2
	Florida cernotinan caddisfly	*Cernotina truncona*	N	G4	S3
	Floridian finger-net caddisfly	*Chimarra florida*	N	G4	S3S4
	Spotted turtle	*Clemmys guttata*	N	G5	S2S3
	Say's spiketail	*Cordulegaster sayi*	N	G3	S3
	Southeastern spinyleg	*Dromogomphus armatus*	N	G4	S3
	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
	White ibis	*Eudocimus albus*	N	G5	S4
	Creek siltsnail	*Floridobia fraterna*	N	G2	S2
	Green Cove springsnail	*Floridobia porterae*	N	G1	S1
	Bald eagle	*Haliaeetus leucocephalus*	N	G5	S3
	Berner's microcaddisfly	*Hydroptila berneri*	N	G4G5	S3
	Molson's microcaddisfly	*Hydroptila molsonae*	N	G2G3	S2
	Purple skimmer	*Libellula jesseana*	N	G1	S1
	Opossum pipefish	*Microphis brachyurus*	SC	G4G5	S2
	Tavares white miller caddisfly	*Nectopsyche tavara*	N	G3	S3
	Rasmussen's neotrichia caddisfly	*Neotrichia rasmusseni*	N	G1G2	S1S2
	Umber shadowfly	*Neurocordulia obsoleta*	N	G5	S2
	Daytona long-horned caddisfly	*Oecetis daytona*	N	G3	S2S3
	Porter's long-horn caddisfly	*Oecetis porteri*	N	G3G4	S2S3
	Short orthotrichian microcaddisfly	*Orthotrichia curta*	N	G4	S2S3

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
	Dentate orthotrichian microcaddisfly	*Orthotrichia dentata*	N	G2G3	S1S2
	Gold Head Branch caddisfly	*Oxyethira chrysocara*	N	G1	S1
	Elerob's microcaddisfly	*Oxyethira elerobi*	N	G3G4	S2S3
	Florida cream and brown microcaddisfly	*Oxyethira florida*	N	G1G2	S1S2
	Pescador's bottle-cased caddisfly	*Oxyethira pescadori*	N	G3G4	S3
	Black Creek crayfish	*Procambarus pictus*	N	G2	S2
	Tawny sanddragon	*Progomphus alachuensis*	N	G3	S3
	Bluenose shiner	*Pteronotropis welaka*	N	G3G4	S3S4
	A mayfly	*Stenacron floridense*	N	G3G4	S3S4
	Many-lined salamander	*Stereochilus marginatus*	N	G5	S1
	West Indian manatee	*Trichechus manatus*	E, PT	G2	S2
Coastal interdunal swales	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
Oyster reefs & rakes					
Marine beaches & shoreline	Loggerhead sea turtle	*Caretta caretta*	T	G3	S3
	Piping plover	*Charadrius melodus*	T	G3	S2
	Wilson's plover	*Charadrius wilsonia*	N	G5	S2
	Green sea turtle	*Chelonia mydas*	T	G3	S2S3
	Leatherback sea turtle	*Dermochelys coriacea*	E	G2	S2
	Hawksbill turtle	*Eretmochelys imbricata*	0	0	0
	Peregrine falcon	*Falco peregrinus*	N	G4	S2
	American oystercatcher	*Haematopus palliatus*	N	G5	S2
	Caspian tern	*Hydroprogne caspia*	N	G5	S2
	Kemp's ridley turtle	*Lepidochelys kempii*	0	0	0
	Osprey	*Pandion haliaetus*	N	G5	S3S4
	Anastasia Island beach mouse	*Peromyscus polionotus ph asma*	E	G5T1	S1
	Black skimmer	*Rynchops niger*	N	G5	S3
	Least tern	*Sternula antillarum*	N	G4	S3
	Royal tern	*Thalasseus maximus*	N	G5	S3
	Sandwich tern	*Thalasseus sandvicensis*	N	G5	S2
	Red knot	*Calidris canutus*			
	Horseshoe crab	*Limulus polyphemus*			
Maritime hammock	Florida olive hairstreak	*Callophrys gryneus sweadneri*	N	G5T2	S2
	Eastern diamondback rattlesnake	*Crotalus adamanteus*	N	G4	S3
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
Estuarine beach	Peregrine falcon	*Falco peregrinus*	N	G4	S2
	American oystercatcher	*Haematopus palliatus*	N	G5	S2

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
	Caspian tern	*Hydroprogne caspia*	N	G5	S2
	Osprey	*Pandion haliaetus*	N	G5	S3S4
	Least tern	*Sternula antillarum*	N	G4	S3
Salt Marsh & Tidal Flats	Macgillivray's seaside sparrow	*Ammodramus maritimus macgillivraii*	N	G4T3	S2
	Piping plover	*Charadrius melodus*	T	G3	S2
	Wilson's plover	*Charadrius wilsonia*	N	G5	S2
	Worthington's marsh wren	*Cistothorus palustris griseus*	N	G5T3	S2
	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
	White ibis	*Eudocimus albus*	N	G5	S4
	Merlin	*Falco columbarius*	N	G5	S2
	Peregrine falcon	*Falco peregrinus*	N	G4	S2
	American oystercatcher	*Haematopus palliatus*	N	G5	S2
	Round-tailed muskrat	*Neofiber alleni*	N	G3	S3
	Atlantic salt marsh mink	*Neovison vison lutensis*	N	G5T3	S3
	Atlantic salt marsh snake	*Nerodia clarkii taeniata*	T	G4T1Q	S1
	Osprey	*Pandion haliaetus*	N	G5	S3S4
	Roseate spoonbill	*Platalea ajaja*	N	G5	S2
	Black skimmer	*Rynchops niger*	N	G5	S3
	Royal tern	*Thalasseus maximus*	N	G5	S3
	Sandwich tern	*Thalasseus sandvicensis*	N	G5	S2
	Diamondback terrapin	*Malaclemys terrapin*			
Interior scrub	Florida scrub-jay	*Aphelocoma coerulescens*	T	G2	S2
	Eastern diamondback rattlesnake	*Crotalus adamanteus*	N	G4	S3
	Sand pine scrub ataenius beetle	*Haroldiataenius saramari*	N	G3G4	S3S4
	Seminole skipper	*Hesperia attalus slossonae*	N	G3G4T3	S3
	Eastern Meske's skipper	*Hesperia meskei straton*	N	G3G4T3	S2S3
	Three spotted pleasing fungus beetle	*Ischyrus dunedinensis*	N	G2G3	S2S3
	Red widow spider	*Latrodectus bishopi*	N	G2G3	S2S3
	East Coast scrub grasshopper	*Melanoplus indicifer*	N	G1	S1
	Ordway melanoplus grasshopper	*Melanoplus ordwayae*	N	G1G2	S1S2
	Southeastern weasel	*Mustela frenata olivacea*	N	G5T4	S3?
	Florida Long-tailed weasel	*Mustela frenata peninsula e*	N	G5T3	S3
	Florida	*Peltotrupes profundus*	N	G3	S3

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
	deepdigger scarab beetle				
	Workman's jumping spider	*Phidippus workmani*	N	G2G3	S2S3
	Elongate june beetle	*Phyllophaga elongata*	N	G3	S3
	Pine snake	*Pituophis melanoleucus*	N	G4	S3
	Florida mouse	*Podomys floridanus*	N	G3	S3
	Round-necked romulus long-horned beetle	*Romulus globosus*	N	G1G2	S1S2
	Rosemary grasshopper	*Schistocerca ceratiola*	N	G2G3	S2S3
	Scrub palmetto flower scarab beetle	*Trigonopeltastes floridana*	N	G2G3	S2S3
Sandhill	Gopher tortoise acrolophus moth	*Acrolophus pholeter*	N	G1	S1
	Dusky roadside-skipper	*Amblyscirtes alternata*	N	G2G3	S2
	Small pocket gopher aphodius beetle	*Aphodius aegrotus*	N	G3G4	S3?
	Surprising pocket gopher aphodius beetle	*Aphodius dyspistus*	N	G3G4	S3?
	Hubbell's pocket gopher aphodius beetle	*Aphodius hubbelli*	N	GNR	S3?
	Large pocket gopher aphodius beetle	*Aphodius laevigatus*	N	G3G4	S3?
	Broad-sided pocket gopher aphodius beetle	*Aphodius platypleurus*	N	G2G3	S2
	Gopher tortoise aphodius beetle	*Aphodius troglodytes*	N	G2G3	S2
	Florida burrowing owl	*Athene cunicularia floridana*	N	G4T3	S3
	Frosted elfin	*Callophrys irus*	N	G3	S1
	Eastern diamondback rattlesnake	*Crotalus adamanteus*	N	G4	S3
	Eastern tailed blue	*Cupido comyntas*	N	G5	S2
	Wild indigo duskywing	*Erynnis baptisiae*	N	G5	S2S3
	Merlin	*Falco columbarius*	N	G5	S2
	Southeastern American kestrel	*Falco sparverius paulus*	N	G5T4	S3
	Gopher tortoise	*Gopherus polyphemus*	C	G3	S3
	Seminole skipper	*Hesperia attalus slossonae*	N	G3G4T3	S3
	Eastern Meske's skipper	*Hesperia meskei straton*	N	G3G4T3	S2S3

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	Scientific Name			
	Rosemary wolf spider	*Hogna ericeticola*	N	G1	S1
	Florida hypotrichia scarab beetle	*Hypotrichia spissipes*	N	G3G4	S3S4
	Gopher frog	*Lithobates capito*	N	G3	S3
	Cofaqui giant-skipper	*Megathymus cofaqui cofaqui*	N	G3G4T3	S2S4
	Florida long-tailed weasel	*Mustela frenata peninsulae*	N	G5T3	S3
	Striped newt	*Notophthalmus perstriatu s*	C	G2G3	S2
	Punctate gopher tortoise onthophagus beetle	*Onthophagus polyphemi*	N	G2G3T2 T3	S2
	Florida deepdigger scarab beetle	*Peltotrupes profundus*	N	G3	S3
	Bachman's sparrow	*Peucaea aestivalis*	N	G3	S3
	Workman's jumping spider	*Phidippus workmani*	N	G2G3	S2S3
	Skelley's june beetle	*Phyllophaga skelleyi*	N	G2	S2
	Pine snake	*Pituophis melanoleucus*	N	G4	S3
	Florida mouse	*Podomys floridanus*	N	G3	S3
	Schwarz' pocket gopher ptomaphagus beetle	*Ptomaphagus schwarzi*	N	G3	S3
	Rosemary grasshopper	*Schistocerca ceratiola*	N	G2G3	S2S3
	Sherman's fox squirrel	*Sciurus niger shermani*	N	G5T3	S3
	Florida cebrionid beetl e	*Selonodon floridensis*	N	G2G4	S2S4
	Large-jawed cebrionid beetle	*Selonodon mandibularis*	N	G2G4	S2S4
	Alachua pleasing fungus beetle	*Triplax alachuae*	N	G2G4	S2S4
Freshwater tidal wetlands	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
	White ibis	*Eudocimus albus*	N	G5	S4
	Berry's skipper	*Euphyes berryi*	N	G2	S2
	Merlin	*Falco columbarius*	N	G5	S2
	Peregrine falcon	*Falco peregrinus*	N	G4	S2
	Round-tailed muskrat	*Neofiber alleni*	N	G3	S3
	Osprey	*Pandion haliaetus*	N	G5	S3S4
	Roseate spoonbill	*Platalea ajaja*	N	G5	S2
Interior wetlands	Frosted flatwoods salamander	*Ambystoma cingulatum*	T	G2	S2
	Florida sandhill crane	*Antigone canadensis pratensis*	N	G5T2T3	S2S3
	Little blue heron	*Egretta caerulea*	N	G5	S4
	Snowy egret	*Egretta thula*	N	G5	S3

Fish/Wildlife Element	Species Represented		ESA Status	G-rank	S-rank
	Common Name	**Scientific Name**			
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
	Berry's skipper	*Euphyes berryi*	N	G2	S2
	Dion skipper	*Euphyes dion*	N	G4	S2S3
	Striped newt	*Notophthalmus perstriatus*	C	G2G3	S2
	Appalachian brown	*Satyrodes appalachia*	N	G4	S2S3
Mangrove tidal swamp	Snowy egret	*Egretta thula*	N	G5	S3
	Swallow-tailed kite	*Elanoides forficatus*	N	G5	S2
	White ibis	*Eudocimus albus*	N	G5	S4
	Merlin	*Falco columbarius*	N	G5	S2
	Schoolmaster snapper	*Lutjanus apodus*	0	0	0
	Osprey	*Pandion haliaetus*	N	G5	S3S4
	Roseate spoonbill	*Platalea ajaja*	N	G5	S2

Appendix 6. Resilience Project Information

Appendix provides additional information about the resilience projects submitted by stakeholders.

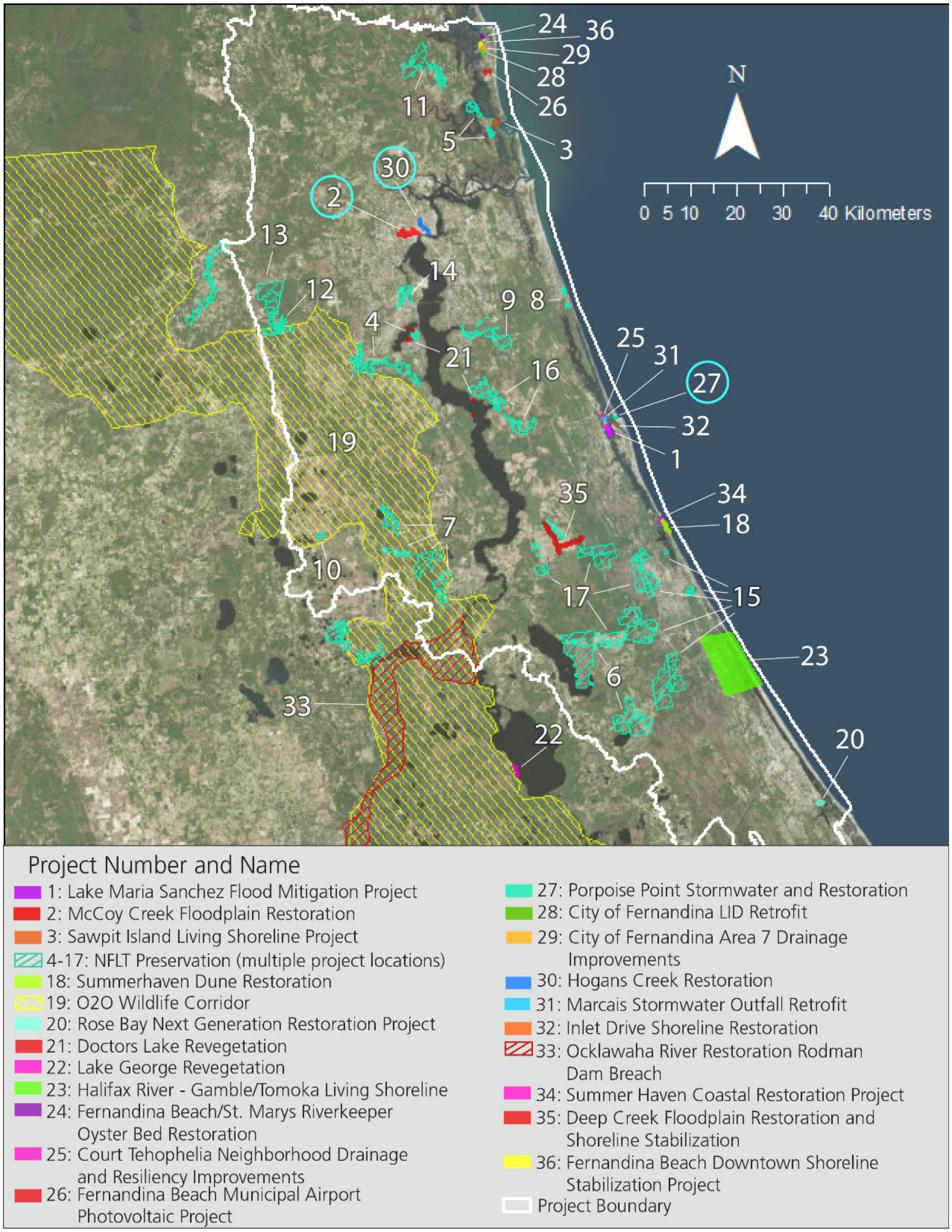

Figure A6-1. Map showing the boundaries of resilience projects compiled for the Jacksonville and Lower St. Johns River Watersheds. *Projects 2, 27, and 30 for which case studies were written are circled in blue. See* ***Table A6-1*** *for a full list of projects submitted. For a full list of North Florida Land Trust Preservation sites, see: [https://www.nflt.org/preservation-portfolio/.](https://www.nflt.org/preservation-portfolio/)*

Resilience Projects Information as Submitted by Stakeholders

A summary of all resilience project submitted for the Jacksonville and Lower St. Johns River Watersheds can be found in **Table A6- 1**. More detailed information about each project are also included below.

Table A6-1. All resilience projects submitted for Jacksonville and Lower St. Johns River Watersheds and the number of assets/elements mapped within each project boundary. *Sorted in order of Community Exposure Index, from greatest to least. A zero in any column indicates that those features were not found within the project boundary as provided but may exist or may exist nearby.*

Project Name	Community Exposure Index	Number of Human Assets Mapped	Fish/Wildlife Elements within Project Boundary	Map ID Number
Inlet Drive Shoreline Restoration	9	1	6	32
Lake Maria Sanchez Flood Mitigation Project	8.36	8	9	1
Macaris Stormwater Outfall Retrofit	8.05	2	2	31
Porpoise Point Stormwater and Restoration	7.89	2	6	27
Court Theophelia Neighborhood Drainage and Resiliency Improvements	7.21	3	5	25
Summerhaven Dune Restoration	5.72	3	15	18
Hogan's Creek Restoration Project	4.81	8	8	30
Doctors Lake Revegetation	4.52	2	9	21
NFLT Preservation Portfolio: Guana River	4.51	1	1	8
NFLT Preservation Portfolio: Ortega River	4.46	7	8	14
Rose Bay Next Generation Restoration Project	4.17	7	12	20
COFB Area 7 Drainage Improvements	4.08	5	2	29
McCoy Creek Floodplain Restoration	3.11	9	8	2
Fernandina Beach Downtown Shoreline Stabilization Project	3.07	2	8	36
Sawpit Island Living Shoreline Project	3.04	2	13	3
NFLT Preservation Portfolio: Black Hammock Island	2.81	2	1	5
Deep Creek Floodplain Restoration and Shoreline Stabilization	2.62	5	8	35
NFLT Preservation Portfolio: Julington Durbin Creek	2.61	0	0	9
NFLT Preservation Portfolio: Black Creek	2.55	8	15	4
Fernandina Beach/St. Marys Riverkeeper Oyster Bed Restoration	2.50	1	5	24
City of Fernandina LID Retrofit	2.50	0	0	28
Halifax River - Gamble/Tomoka Living Shoreline Restoration Project	2.35	8	26	23
NFLT Preservation Portfolio: Lofton Creek	2.29	0	0	11

Project Name	Community Exposure Index	Number of Human Assets Mapped	Fish/Wildlife Elements within Project Boundary	Map ID Number
NFLT Preservation Portfolio: Crescent Lake	1.90	4	2	6
Ocklawaha River Restoration and Rodman Dam Breach	1.88	4	2	33
NFLT Preservation Portfolio: Sixmile Creek	1.80	4	13	16
Fernandina Beach Municipal Airport Photovoltaic Project	1.67	0	0	26
NFLT Preservation Portfolio: Palm Coast Growth Buffer	1.62	8	18	15
NFLT Preservation Portfolio: Tri County Agricultural Area	1.46	5	10	17
O2O Wildlife Corridor	1.36	11	13	19
NFLT Preservation Portfolio: Etoniah Greenway	1.29	7	11	7
NFLT Preservation Portfolio: Long Branch Creek (Duval)	1.26	4	6	13
NFLT Preservation Portfolio: Long Branch Creek (Clay)	1.11	5	7	12
NFLT Preservation Portfolio: Keystone Heights	1.00	2	1	10
Lake George Revegetation	Not in project study area boundary	Not in project study area boundary	Not in project study area boundary	22
Summer Haven Coastal Restoration Project	Not in project study area boundary	Not in project study area boundary	Not in project study area boundary	34

Project ID# 1
Name: Lake Maria Sanchez Flood Mitigation Project
Submitted by: Jessica Beach, P.E.
Organization: City of St. Augustine
Project Type: Green infrastructure implementations, Living shoreline implementation, Upland restoration, Flood mitigation/Hazard Mitigation, SLR Adaptation
Description: Implement a series of adaptive measures aimed towards mitigating flooding in the historic core of the City of St. Augustine. Improvements include combination of shoreline and marsh restoration and buffering, isolating storm water collection from tidal influences and new stormwater pump station and stormwater collection system.

Project ID# 2
Name: McCoy Creek Floodplain Restoration
Submitted by: Colin Moore
Organization: City of Jacksonville, FL
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration
Description: The McCoy Creek floodplain, including McCoy Creek Boulevard itself, is subject to frequent inundation from rain events, not to mention tropical systems. There are many homes and businesses in the flood zone. A master storm water plan was prepared in the early 2000's which basically divided the system into three zones- the tributaries north and west of Hollybrook Park, Hollybrook to Mrytle (McCoy Creek Blvd section) and Myrtle to the river outfall. The improvements evaluated in each area have positive benefits in the immediate area but little upstream benefit. For example, opening the creek to free flow at the St. Johns outfall does not provide benefit upstream along McCoy Creek Boulevard but does provide benefit in the Brooklyn/LaVilla areas. The two most cost effective solutions are the closure of McCoy Creek Boulevard (lengthening and raising the Stockton and King Street bridges over the creek) and restoring the wider floodplain along this section (14M+) and opening the channel from Myrtle to the river (removing the TU deck or diverting channel around TU site) (14M+ if we have to re-route creek and divert channel). Each of these options has discrete benefits and can be implemented without the other and each removes numerous structures and parcels from the flood zone.

Project ID# 3
Name: Sawpit Island Living Shoreline Project
Submitted by: Meghan Harris
Organization: FDEP/Talbot Islands State Parks
Project Type: Beach or dune restoration, Living shoreline implementation, Marsh restoration, Oyster Reef construction
Description: Sawpit Island is located in northeast Florida in northern Duval County along the Nassau Sound and bordered by Sawpit Creek and the Atlantic Intercoastal Waterway on the south and west. The island is approximately 200 acres and historically was largely dominated by saltmarsh with small coastal scrub hammock areas. The north end of the island is owned by the State of Florida as part of the Talbot Islands State Parks and the southern half of the island is owned by the private, not for profit, North Florida Land Trust (NFLT). Project will restore at least 12 acres of resilient coastal saltmarsh habitat as well as provide numerous critical wildlife benefits.

The proposed project will remove upland vegetation, remove spoil material, re-establish historical saltmarsh elevation, and restore native saltmarsh vegetation. At the north end of Sawpit Island approximately 10 acres of saltmarsh will be restored with approximately 30,000 cubic yards of dredge spoil sand material being placed on the northeast facing shoreline that will enhance beach and dune habitat to assist management of an important diamondback terrapin nesting colony.

On the south end of Sawpit Island five smaller spoil piles will be managed to remove upland vegetation and to consolidate the smaller amounts of upland spoil on site. The spoil pile elevations will be recontoured to maximize restoration of saltmarsh habitat and the resulting spoil material will be placed to an elevation and configuration that provide the maximum habitat benefit for important shorebird species and other wildlife. Saltmarsh vegetation will be re-established and at least 2 additional acres of saltmarsh on the south end of Sawpit Island will be restored.

The project had been fully permitted, but funding couldn't be secured by the permit's expiration date

Project ID# 4
Name: NFLT Preservation Portfolio: Black Creek
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted the results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 5
Name: NFLT Preservation Portfolio: Black Hammock Island
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 6
Name: NFLT Preservation Portfolio: Crescent Lake
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 7
Name: NFLT Preservation Portfolio: Etoniah Greenway
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation

Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 8
Name: NFLT Preservation Portfolio: Guana River
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 9
Name: NFLT Preservation Portfolio: Julington Durbin Creek
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 10
Name: NFLT Preservation Portfolio: Keystone Heights
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience

assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 11
Name: NFLT Preservation Portfolio: Lofton Creek
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 12
Name: NFLT Preservation Portfolio: Long Branch Creek (Clay)
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 13
Name: NFLT Preservation Portfolio: Long Branch Creek (Duval)
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 14
Name: NFLT Preservation Portfolio: Ortega River
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 15
Name: NFLT Preservation Portfolio: Palm Coast Growth Buffer
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 16
Name: NFLT Preservation Portfolio: Sixmile Creek
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation
Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 17
Name: NFLT Preservation Portfolio: Tri County Agricultural Area
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Riparian and floodplain restoration, Upland restoration, Wetlands restored/enhanced, Land Preservation

Description: The Preservation Portfolio is the strategic conservation plan for the North Florida Land Trust and outlines 112,000 target acres within Northeast Florida for preservation, restoration and management. When creating the plan, NFLT put a heavy emphasis on identifying watershed protection and biodiversity and habitat preservation, then weighted our results based on those natural resources resiliency to sea level rise and threat from development and growth. Incidentally we believe our priorities perfectly overlap with the coastal resilience assessment program, identifying a number of high biodiversity and watershed significant land areas, resilient to sea level rise and approximate to growing cities and towns.

Project ID# 18
Name: Summerhaven Dune Restoration
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Beach or dune restoration, Beach Dune Acquisition and Restoration
Description: The Summerhaven River is a natural side channel that runs parallel to the Matanzas River, between the Matanzas River and the Atlantic Ocean, and at places is within and adjacent to the Guana-Tolomato-Matanzas National Estuarine Research Reserve. The morphology of the Summerhaven River has been in constant flux, and since 2008 has experienced several dune breakthroughs, siltation and major wash-outs at considerable expense to the county and homeowners along the river. At the heart of the issue has been 62 residential lots, with 28 homes on them, on a strip of land between the river and the ocean which is rapidly washing away. St. Johns County is looking to acquire all of the so-described private lots, in part to avoid ongoing maintenance of Old A1A which frequently costs the county up to $1 million/year to maintain, but to also avoid Emergency Management Issues, as the area is prone to impact from Hurricanes and Tropical Storms. The silting in of the river after a dune-breakthrough also cause all of the discussed homes to lose riparian access for their docks, forcing a $2.8 million dredging project to return the river back to its original condition. The area is also of high significance to a number of coastal nesting and wading birds, sea turtles and rare and endangered beach mice, wherein the allowed obsolescence of the road, removal of the homes and naturalization of the size would be a huge boon to those endangered species. The project going forward would largely be one of land acquisition and demolition of the homes and associated roadway. A dune restoration plan will be needed post acquisition and demolition of the homesites.

Project ID# 19
Name: O2O Wildlife Corridor
Submitted by: Marc Hudson
Organization: North Florida Land Trust
Project Type: Community resilience planning, Green infrastructure implementations, Upland restoration, Wetlands restored/enhanced
Description: The Ocala-to-Osceola (O2O) wildlife corridor is a 1.6 million-acre landscape of natural and rural lands that connects two large National Forests and a large military installation (Camp Blanding), and provides critical wildlife habitat for wildlife and at-risk species. The region is a matrix public lands interspersed with private timberlands, much of which is in large ownership tracts. The O2O wildlife corridor has been long recognized for its conservation importance and includes all or parts of seven land conservation projects that have been approved by Florida Forever, the State's premier conservation land protection program. The O2O Florida Forever projects comprise approximately 236,000 acres important for regional biodiversity at the species and landscape levels, as well as landscape connectors for natural resource protection and resilience. Although recognized as important for conservation, acquisition of these lands depends on funding availability. NFLT and other partners strive to bring funding opportunities to this project.
The O2O Wildlife Corridor project strategically addresses natural resource and socio-economic concerns through land protection approaches that are compatible with continued commercial timber production and military

readiness. The O2O is a natural and rural landscape with local industry dependent on natural resources (mainly timber production). However, development pressures affect the area as the NE Florida population continues its rapid growth. Accelerated land conservation will ameliorate growth pressures that continue to threaten natural resource sustainability, rural communities and military training capacity in the O2O. Many NE Florida waterways originate in the O2O, including four major blackwater streams and several headwaters and tributaries, and the region contains areas critically important for groundwater recharge of the Florida aquifer. Conservation of regional water sources will protect precious groundwater needed in neighboring counties.
The O2O project centers on two strategies: 1) increased land protection and 2) improved management and restoration practices on private lands. We employ existing landowner assistance programs and partnerships to identify conservation lands and leverage funds for land protection. As part of Strategy #1, we will pursue acquisition of fee properties and conservation easements via several State and Federal programs: Army Compatible Use Buffer (ACUB) program, the State Rural and Family Lands Protection Program (RFLPP) and Florida Forever programs, and the USDA Healthy Forests Reserves Program (HFRP). For Strategy #2, we work with State and Federal cost share programs that help landowners implement land management and restoration practices for wildlife habitat and water quality protection. Our strategies help implement land management goals of the USDA Natural Resource Conservation Service's Gopher Tortoise and Longleaf Pine initiatives. To this end, NFLT and other O2O partners have initiated a targeted landowner assistance programs under the NRCS Regional Conservation Partnership Program, starting in 2018.

Project ID# 20
Name: Rose Bay Next Generation Restoration Project
Submitted by: Dr. Katie Tripp
Organization: Save the Manatee/Harbor Oaks Neighborhood Assn./ Volusia Soil & Water Conservation District
Project Type: Community resilience planning, Green infrastructure implementations, Living shoreline implementation, Upland restoration
Description: More than half of the 5,800-acre Rose Bay watershed in East Volusia County, Florida is developed. Rose Bay benefitted from two decades of restoration activities totaling $50 million, which removed septic, connected the adjacent Harbor Oaks community to sewer, and removed earthen causeways and muck. As a result, Rose Bay's water quality improved and shoreline habitats began to recover. However, intertidal areas remain degraded along the hardened northern shoreline. Intertidal zones of oyster shell and native vegetation will be augmented or created waterward of existing armor along 1.6 miles containing more than 50 privately owned parcels. The project also entails exotic vegetation control; storm water conveyance retrofit; upland landscape management; and long-term, community-led monitoring and management. Multiple partners are engaged, and community residents have a vital role in achieving the first community-wide living shoreline in Florida. We hope to encourage community-scale estuarine restoration and management in coastal neighborhoods throughout the region.

Project ID# 21
Name: Doctors Lake Revegetation
Submitted by: Annie Roddenberry and Dale Jones
Organization: Florida Fish and Wildlife Conservation Commission
Project Type: Wetlands restored/enhanced, Restoration of SAV community
Description: Doctors Lake is a large body of water connected directly to the St. Johns River in Clay County, Florida. A popular destination for fishing and boating, the lake is utilized by Florida manatees for foraging, and has been identified as "Critical Manatee Habitat" by the US Fish and Wildlife Service. Submerged aquatic vegetation in Doctors Lake has declined in the last few years, so FWC is proposing to plant eelgrass and giant bulrush in strategic locations to reestablish high quality habitat within the lake. FWC staff identified three planting sites, as well as locations of two nearby donor sites within the St Johns River. Permits applications were

submitted to construct three enclosures to protect transplanted eelgrass from herbivory, and discussions are underway with Florida Department of Environmental Protection regarding permits. In Spring 2018, FWC will transplant 10,000 giant bulrush plants from a nearby donor site to three planting sites within Doctors Lake. Plantings will be monitored by FWC staff.

Project ID# 22
Name: Lake George Revegetation
Submitted by: Annie Roddenberry
Organization: Florida Fish and Wildlife Conservation Commission
Project Type: Wetlands restored/enhanced, Restoration of Aquatic Vegetation
Description: Lake George is the second largest lake in Florida and is largely surrounded by protected upland habitat. Hurricanes Matthew and Irma severely impacted the submerged aquatic vegetation in Lake George. Dense eelgrass beds and giant bulrush that previously flourished along the western side of the lake are no longer present or exist in sparse patches. The loss of eelgrass beds and bulrush stands leaves minimal habitat for fish and other aquatic organisms. In addition, all of Lake George and Silver Glen Springs, which flows directly into Lake George, are designated as Critical Habitat for the Florida manatee by the US Fish and Wildlife Service. This project aims to restore bulrush stands on the western side of Lake George. The bulrush revegetation will begin just north of the mouth of Silver Glen Springs and continue north for approximately 1.4 miles. Planted bulrush will improved aquatic habitat and establish conditions amenable to eelgrass recovery.

Project ID# 23
Name: Halifax River - Gamble/Tomoka Living Shoreline Restoration Project
Submitted by: Dr. Gregory Wilson, Chief Scientific Officer
Organization: Riverside Conservancy
Project Type: Living shoreline implementation
Description: The focus of the current project is restoration and management of shoreline along the Halifax River near Gamble Rogers Memorial State Recreation Area down to Tomoka State Park/Tomoka Marsh Aquatic Preserve, using living shoreline restoration techniques. The lead partner in this initiative is Riverside Conservancy, a nonprofit organization chartered to undertake living shoreline restoration and management in select areas of coastal Florida. Other anticipated partners in this project were listed previously. The specified area of the Halifax River has been greatly impacted by shoreline erosion, particularly due to boat wake in the Atlantic Intracoastal Waterway. Some restoration has been undertaken to date, but more needs to be done to minimize further shoreline damage. The current project proposes utilizing locally-sourced oyster bags (from volunteer bagging at these parks), marsh grass sourced from the FWC nursery at Marine Discovery Center in New Smyrna Beach and black mangrove seedlings to create living shoreline habitat in the Halifax River in these areas to prevent further erosion and to restore sustainable habitat. More than hardwall structures, living shoreline restoration will also provide resiliency to future storms and natural adaptation to climate change and associated sea level rise.

Project ID# 24
Name: Fernandina Beach/St. Marys Riverkeeper Oyster Bed Restoration
Submitted by: Len Kreger
Organization: City of Fernandina Beach
Project Type: Community resilience planning, Restoration of aquatic connectivity, Small Oyster Bed Restoration
Description: Small 500x50 foot Oyster Bed Restoration using crab trap-type structures. (PVC)

Project ID# 25
Name: Court Theophelia Neighborhood Drainage and Resiliency Improvements
Submitted by: Jessica Beach
Organization: City of St. Augustine
Project Type: Green infrastructure implementations, Living shoreline implementation
Description: This neighborhood is on the City's 5-year Capital Improvement Plan, with preliminary design scheduled for FY2018. The neighborhood is subject to frequent tidal flooding, where the streets are impassable due to high/king tide or nor'easter events. The frequent tidal flooding has rapidly deteriorated the streets. The City is looking to incorporate a number of best management practices in this project, such as low impact development (LID), reduction in stormwater runoff, green engineering design and sustainability practices coupled with implementation of strategic adaptation and resiliency components where practical. This could include the installation of tide check valves in the stormwater outfall to prevent tidal flooding, creating a living shoreline or passive recreational use areas to buffer the neighborhood, reduction in the amount of impervious surface and associated runoff, providing stormwater treatment to improve water quality prior to discharging into the Matanzas River.

Project ID# 26
Name: Fernandina Beach Municipal Airport Photovoltaic Project
Submitted by: Nathan Coyle
Organization: City of Fernandina Beach
Project Type: Community resilience planning, Green infrastructure implementations
Description: The Fernandina Beach Municipal Airport currently averages 10,200 kWh per month to support 24/7 airport operations. The total annual cost of energy used and funded by the airport is estimated at $20,000 in fiscal year 2017/2018. Installation and use of a photovoltaic energy would reduce the cost of energy consumption at the airport and provide a cleaner energy source to support airport operations.

Project ID# 27
Name: Porpoise Point Stormwater and Restoration
Submitted by: Jay Brawley
Organization: St. Johns County
Project Type: Beach or dune restoration, Green infrastructure implementations, Stormwater Management
Description: The area known as Porpoise Point, located at the southern tip of Vilano Beach and within the St. Augustine Inlet, has seen an increase in flooding. The residential area south of Vilano Road is bordered by the Atlantic Ocean, St. Augustine Inlet, and the Tolomato River. This area experiences flooding regularly due to poor drainage during rain events as well as severe flooding from storm surge during large events that have recently impacted Northeast Florida, including Hurricanes Matthew and Irma. The residential area has a roadway swale system which does not have the storage volume or capacity to serve the drainage needs of the community, which consists of approximately 40 acres of single-family residential land (Porpoise Point Drainage Evaluation). The swale system does not have a positive outfall and therefore must recover through percolation, however the high-water table in the area creates a low capacity for soil percolation. Since the swales were established, wind-blown sands have continued to accrete and have lowered the storage area to approximately 4 acre-feet, thereby limiting conveyance. St. Johns County examined several potential solutions to the flooding in Porpoise Point. This project implements one of the proposed drainage solutions while increasing resilience to storm surge by implementing dune restoration to fill in dune breaches caused by recent storms as well as footpaths that have been created over time. To address the drainage issue, approximately 12,000 linear feet of swales will be reestablished and three new 15" cross culverts constructed to allow for equalization of swales. The project will also establish a wet well area for use with a portable pump, which can be placed prior to heavy rainfall and also utilized at other areas throughout the county. The project will address resiliency to storm surge by adding height

and stability to the dunes by placing "beach quality" sand within the breaches and along the highest point of the current dune structure. The current foot path used for access may be replaced by a dune walkover, depending on feasibility study and permitting. Sand placement would be followed by planting and establishing native vegetation, including sea oats, to assist in stabilization of the newly placed sand. Dune restoration efforts will need to be studied before an accurate funding estimate can be provided. This area of beach has been known to serve as a nesting site for several species with conservation consideration including least terns (*Sternula antillarum*) and piping plover (*Charadrius melodus*). The area has also had nests for 3 species of sea turtle including Loggerheads (*Caretta caretta*), green sea turtles (*Chelonia mydas*), and leatherbacks (*Dermochelys coriacea*). In addition, St. Johns County has had 3 Kemp's Ridley (*Lepidochelys kempii*) nests within the past few years so this beach could serve as a nesting site for that species.

Project ID# 28
Name: City of Fernandina LID Retrofit
Submitted by: Andre Desilet, P.E.
Organization: City of Fernandina Beach
Project Type: Green infrastructure implementations, Stormwater and Low Impact Development education
Description: The City of Fernandina Beach Utility Administration and Billing office is an existing facility located at 1180 S 5th St. Existing asphalt pavement would be removed and replaced with various pervious paving materials to demonstrate current technology available for low impact development. This would also bring the facility inin to compliance with current land development regulations requiring pervious parking. The existing dry retention area will be modified as a rain garden to showcase native planting options and bio-retention features that are applicable to development projects and residential landscape planning. Educational literature and signage will be produced to provide information on the features installed and general stormwater best management practices.

Project ID# 29
Name: COFB Area 7 Drainage Improvements
Submitted by: Andre Desilet, P.E.
Organization: City of Fernandina Beach
Project Type: Stormwater management is flood prevention
Description: The field review showed evidence that the area mostly consists of old and deteriorated pipes throughout the system. The drainage infrastructure conveys the stormwater west towards the Amelia River. The existing infrastructure will be upgraded with piping and structures being updated. A pump station with a pond will be constructed to manage the stormwater runoff and convey it to the west side of the railroad into the existing outfall ditch draining to the Amelia River. The pond will provide treatment and storage and will minimize/ eliminate flooding.

Project ID# 30
Name: Hogan’s Creek Restoration Project
Submitted by: Kay Ehas
Organization: Groundwork Jacksonville, Inc.
Project Type: Community resilience planning, Green infrastructure implementations, Marsh restoration, Restoration of aquatic connectivity, Riparian and floodplain restoration, Wetlands created, Wetlands restored/enhanced
Description: Restore a healthy aquatic habitat (remove sediment accumulations, remove exotic vegetation, create wetland habitats), remediate pollution, mitigate flooding, identify and install green infrastructure for water quality and stabilization; ideally make the creek fishable and navigable by kayak and canoe. Additionally, to provide community spaces for the surrounding neighborhoods providing recreation and educational

opportunities, and to increase the connectivity and linkages to downtown, the river and the adjacent urban neighborhoods.

Project ID# 31
Name: Macaris Stormwater Outfall Retrofit
Submitted by: Jessica Beach
Organization: City of St. Augustine
Project Type: Prevention of nuisance tidal flooding
Description: Tidal flooding significantly impacts this road and neighborhood adjacent to the Florida School for the Deaf and Blind. The City is currently under design to install tidal back flow prevention devices by retrofitting the existing stormwater infrastructure. This will also include construction of a baffle box type system to reduce sediment and associated nutrient loading to the receiving marsh while also preventing tidally influenced water from backing up into the city-owned streets.

Project ID# 32
Name: Inlet Drive Shoreline Restoration
Submitted by: Jessica Beach
Organization: City of St. Augustine
Project Type: Living shoreline implementation, Upland restoration, Wetlands restored/enhanced, Nuisance tidal flooding reduction
Description: The City currently has erosion due to damage caused by Hurricane's Matthew and Irma. This shoreline is City owned and fronts City road. The City is looking at two options to address the eroded shoreline, (1) restore the area through construction of a rip rap system back to its pre-storm condition or (2) mitigate the area by raising the elevation of the rip rap system with enhanced mangrove plantings or similar for a living shoreline component. Both options would involve the replacement of the storm drainage pipe and inlets that currently discharge into the shoreline area with installation of a tide check valve to prevent nuisance tidal flooding from entering the roadway system.

Project ID# 33
Name: Ocklawaha River Restoration and Rodman Dam Breach
Submitted by: Lisa Rinaman
Organization: St. Johns Riverkeeper
Project Type: Dam removal/fish passage, Restoration of aquatic connectivity, Riparian and floodplain restoration, Wetlands restored/enhanced, Eco-restoration
Description: Breaching the dam to allow natural flows to return to the Ocklawaha River would improve habitat for many fish and wildlife species, including Atlantic sturgeon, shortnose sturgeon, American eel, American shad, Florida striped bass, and others. Manatee would also benefit by removing the lock that they must pass through to access the Silver River and Silver Springs, which are warm water winter refuge habitats. Removal of the dam would restore flows to 8,000 acres of forested floodplain below the dam and will restore 7,500 acres of forested floodplain currently submerged in the Rodman Pool. In addition, restoration of a free-flowing Ocklawaha will improve water quality conditions, improve downstream productivity of fish and shellfish in the Ocklawaha and St. Johns River, aid in the restoration of iconic Silver Springs, reduce the spread of exotic species, and reduce impacts to the St. Johns River from sea level rise and saltwater intrusion. The Rodman Pool covers 20 natural springs which would also be restored by breaching the dam. The current pool maintenance activities have negative effects on downstream waters, including nutrient pulses during the routine drawdown that is necessary to manage the exotic vegetation that chokes the pool. Current pool maintenance costs up to $500,000 annually and the dam serves only to impound Rodman Pool and is not used for other purposes such as hydropower or flood control. The dam was constructed in 1968 and is showing dangerous signs of decay. Restoration of the

Ocklawaha will also save the public high cost of repair. The Ocklawaha River remains below the pool, ready to be restored.

Project ID# 34
Name: Summer Haven Coastal Restoration Project
Submitted by: Jay Brawley
Organization: St. Johns County
Project Type: Beach or dune restoration, Community resilience planning, Riparian and floodplain restoration, Wetlands restored/enhanced
Buyback Program
Description: The unincorporated area of St. Johns County known as "Summer Haven" has a dynamic shoreline which has been impacted by storms since Hurricane Dora in 1964, after which the Florida Department of Transportation relocated State Road (S.R.) A1A west of the residential homes. An access road known as "Old A1A" runs in front of the properties and continues to deteriorate due to impacts from severe storms and nor'easters. Mitigation efforts have included FEMA-authorized dune projects and sand placement projects conducted by the U.S. Army Corps of Engineers to combat erosion issues. Repeated breaches of the dune have led to sedimentation and shoaling in the Summer Haven River which lies west of the properties. Local advocacy led to the restoration of the river and berm; however, subsequent storm events have caused further breaches and dune loss. The continued impacts to the dune and berm have resulted in a loss of access for residents and property damage. Impacts to the access road have resulted in limited availability of public services, such as a potable water system, and the continued degradation will limit the capability of emergency services to reach residents. Due to repetitive losses and continued issues in the area, retreat may be the most sustainable and resilient course of action. The County proposes a buyout program for the private properties in Summer Haven to mitigate for repetitive loss and allow for shoreline dynamics east of S.R. A1A which will allow storm surge protection for roads and properties west of Summer Haven. Through the Flood Insurance Reform Act of 2004 (FIRA 2004), Congress directed FEMA to develop a program to reduce future flood losses. The Severe Repetitive Loss (SRL) Grant Program provides funding for a variety of flood mitigation activities. Under this program, FEMA provides funds to state and local governments to make offers of assistance to NFIP-insured SRL residential property owners for mitigation projects that reduce future flood losses through acquisition or relocation of at-risk structures and conversion of property to open space, elevation of existing structures, or dry flood-proofing of historic properties. The County's proposed project would fund the planning, and potentially contribute to the implementation of, a County buyout program to address properties in areas where acquisition would reduce loss of property and increase resiliency with a return to open space. Additionally, an acquisition program could increase the County's Community Rating System (CRS) score, lower insurance rates for residents, protect critical infrastructure such as S.R. A1A, increase open space, and public access. Open space may also be utilized for beach access parking, which could assist the County in lowering their cost-share of beach nourishment projects in the area. Acquisition will also increase ecological resilience by providing habitat migration corridors and allowing for the seasonal and long-term sediment dynamics to go unimpeded. Open space will also provide critical nesting areas for species of concern.

Project ID# 35
Name: Deep Creek Floodplain Restoration and Shoreline Stabilization
Submitted by: Jay Brawley
Organization: St. Johns County
Project Type: Riparian and floodplain restoration, Nutrient capture and Shoreline stabilization
Description: Deep Creek is a tributary of the Lower St. Johns River that provides the sole drainage basin for much of the Hastings, Florida area. The area is primarily agricultural and rural residential containing many locally owned small to mid-size farms. This area also contains natural areas, including tributaries of the Lower St. Johns

River like Deep Creek, floodplain swamps, mesic flatwoods, and freshwater wetlands. Deep Creek Conservation Area, which is managed by the St. Johns River Water Management District (SJRWMD), receives significant stormwater run-off from the agricultural lands and contributes to water quality concerns in the St. Johns River. Hastings and the surrounding area experience flooding from storm events and long residence time of flood waters due to inadequate drainage, which was particularly severe during the recent storms experienced in Northeast Florida, including Hurricanes Matthew and Irma. The Deep Creek sub-basin serves as the sole drainage outfall for thousands of acres of agricultural, commercial and residential lands. Flooding in the area has disrupted agricultural operations, commerce and caused property damage and loss. State Road 207 runs through the area and serves as a major evacuation route for Evacuation Zone A and is a vital part of the transportation network of St. Johns and Putnam Counties. The creek has likely accumulated debris and sediments from run-off, erosion and storm surges from the river. A design phase and study are needed to determine the most effective course of action for this project and development of a long-term maintenance plan to ensure that the project continues to serve its function in the future. The proposed project would request $2 Million to design, permit and begin to execute the restoration of hydrologic function through desnagging, debris removal, dredging for conveyance to historic state, and stabilizing banks or creating wetlands to reduce sedimentation of the creek, increase water storage capacity and capture nutrient runoff that contributes to impairment of Deep Creek and the Lower St. Johns River.

Project ID# 36
Name: Fernandina Beach Downtown Shoreline Stabilization Project
Submitted by: Dale Martin
Organization: City of Fernandina Beach
Project Type: Shoreline Stabilization
Description: Portions of the City’s existing seawall is over five decades old, and, according to several professional estimates, has likely surpassed its useful service life. The diminishing effectiveness of the seawall is demonstrated almost daily by the creation of several sizeable holes on the landward side of the seawall. These holes are likely attributable to the undermining of the current seawall. The recurrence of the holes, often in differing locations, threatens public safety and the stability of City improvements on the site. Options for stabilization are varied, but a preliminary recommendation is to reinforce and raise the existing seawall, primarily through the seaward installation of sheet piling. This effort would minimize disturbance of the existing seawall and allow for establishing a higher elevation to account for projected storm surges and sea level rise. More detail about the problems associated with the City’s existing seawall and proposed solutions are provided in the enclosed report Fernandina Harbor Marina’s Failing Seawall.

Appendix 7. Summary of Additional Studies and Plans

A component of the Targeted Watershed Assessment was to compile and summarize existing studies and plans to serve as an inventory and quick reference for stakeholders. The table below is the result of a rapid assessment to identify and summarize relevant documents through requests to the Watershed Committee and stakeholders.

Table A7-1. A review of plans to identify key resilience concerns in terms of areas, key infrastructure features, species, and habitats.

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Florida's State Wildlife Action Plan (SWAP) 2012 (Revision expected Summer 2018) Florida Fish and Wildlife Conservation Commission. 2012. Florida's Wildlife Legacy Initiative: Florida's State Wildlife Action Plan. Tallahasssee, Florida, USA. http://myfwc.com/conservation/special-initiatives/fwli/action-plan/	State of Florida	Taxonomic groups: amphibians, mammals, reptiles, birds, fish, invertebrates. 1036 species on the State's List of Species with the Greatest Conservation Need.	Addresses benefits to wildlife, threats, land management, and conservation actions for agriculture, commercial pineland, managed lakes/reservoirs, and urban/developed land.	Primarily focused on sea level rise, with some discussion of temperature and precipitation changes. NatureServe CCVI assessments completed for 24 species.
North Florida Land Trust Preservation Portfolio North Florida Land Trust. Unspecified date. Preservation Portfolio. Jacksonville, FL. http://www.nflt.org/preservation-portfolio/	Seven counties in northeast Florida covering nearly all of St Johns study area.	Based on compiled natural resource priorities primarily from Florida's CLIP database (see below). Include broad range of plants and animals; aquatic and terrestrial; vertebrate and invertebrate species.	Water quality and agricultural soil productivity were included in the assessment of conservation priorities.	SLAMM models were used to assess sea level rise impacts. These results were factored into threats in their conservation priorities analysis.
Critical Lands and Water Identification Project (CLIP): version 4.0, 2016. Oetting, J., T. Hoctor, M. Volk. 2016. Critical Lands and Waters Identification Project (CLIP): Version 4.0 http://www.fnai.org/clip.cfm	State of Florida	Includes FWC Strategic Habitat Conservation Areas assessing 34 vertebrate species; FNAI Rare Species Habitat Conservation Priorities assessing 281 plant and animal species.	Significant Surface Waters layer includes priorities for protection of water supply and shellfish harvesting areas. Floodplain priorities contribute to flood mitigation. Aquifer recharge	Alternative species habitat prioritization was conducted based on sea level rise projections; not included in main priorities.

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
			layer addresses water quality and supply.	
Adapting to Rising Tides. Coastal Resilience in St. Augustine: Baseline of Our Past, Beacon for Our Future. University of Florida Resilient Communities Initiative. April 2016. Adapting to Rising Tides – Study Narrative. Gainesville, FL. http://www.citystaug.com/document_center/index.php	The City of St. Augustine	No direct assessment of impacts to wildlife.	Assessment of Sea Level Rise impacts to land cover and land use types; critical infrastructure and assets; and historical and cultural resources	Assessment of 1-ft, 3-ft, and 5-ft sea level rise impacts to the City.
River Report: State of the Lower St. Johns River Basin, Florida. Univ of North Florida. 2016. River Report. Jacksonville, FL. http://sjrr.domains.unf.edu/	Lower St. Johns Basin (includes most of study area except coastal portion)	Includes health indicators for fisheries and aquatic life, including aquatic vegetation, wetlands, macroinvertebrates, T&E species, and non-native aquatic species.	Primarily focused on water quality, with comprehensive overview of DO, nutrients, algal blooms, turbidity, bacteria, salinity, and contaminants.	Some discussion of long-term trends in salinity due in part to sea level rise.
Essential Fish Habitat Assessment U.S. Army Corps of Engineers, Jacksonville District. 2011. Essential Fish Habitat Assessment: Jacksonville Harbor Navigation Study. Jacksonville, FL. http://www.saj.usace.army.mil/	Jacksonville Harbor, Duval County FL.	Penaeid shrimp, bluefish, summer flounder, south Atlantic snapper-grouper complex, coastal migratory pelagics complex, highly migratory Atlantic species, and associated invertebrates and fishes.	Jacksonville Harbor and associated shipping channels in St. Johns River.	Not addressed.
Summary and Regional Action Plan: A Report of the Emergency Preparedness Committee on Sea Level Rise Regional Community Institute of Northeast Florida, Inc. 2013. Summary and Regional	Northeast Florida Planning Region: Baker, Clay, Duval, Flagler, Nassau, Putnam, St. Johns Counties	Not addressed.	General consideration of potential impacts to property and different commercial sectors	Defines actions to improve preparedness and decision-making in regard to sea level rise.

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Action Plan. Report to the Northeast Florida Regional Council. http://www.nefrc.org/				
Strategic Directions: The Northeast Florida Strategic Regional Policy Plan Northeast Regional Council. 2014. Strategic Directions. Jacksonville, FL. http://www.nefrc.org/strategic-regional-policy-plan/	Northeast Florida Planning Region: Baker, Clay, Duval, Flagler, Nassau, Putnam, St. Johns Counties	Chapter on natural resources includes Regionally Significant Resources, but no mention of individual species.	Sections on economic development, emergency preparedness, energy, healthcare, and transportation.	Section on Resilience of the Built Environment addresses sea level rise with a plan objective "A Resilient Region", and "Determine and Address the Vulnerability of the Region".
Lower St. Johns River Basin Surface Water Improvement and Management (SWIM) Plan. St. Johns River Water Management District. 2008. Lower St. Johns Basin Surface Water Improvement and Management Plan. Palatka, FL. https://www.sjrwmd.com/documents/plans/	Lower St. Johns River basin – matches current study area without coastal region.	Addresses Biological Health Initiative including biological indicator spp. and submerged aquatic vegetation; assessment and monitoring of fisheries.	Focused on water quality, including pollution, algal blooms, aquifer recharge, biological health, turbidity. Also land use and water withdrawals.	Not addressed.
Strategic Beach Management Plan – Northeast Atlantic Coast Region. Division of Water Resource Management, Florida Department of Environmental Protection. 2015. Strategic Beach Management Plan. Tallahassee, FL. https://floridadep.gov/water/beaches-inlets-ports/content/strategic-planning-and-coordination#sbmp	Nassau, Duval, St. Johns, Flagler, Volusia Counties.	Brief discussion of impacts of dredging and beach re-nourishment on wildlife including marine turtles, right whales, beach mice, shorebirds, and their habitats.	Focused on beach erosion and inlet management.	Primarily focused on erosion due to hurricanes and other strong storms, and inlet management.

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Basin Management Action Plan (BMAP) – Lower St. Johns River Basin Main Stem. Lower St. Johns River TMDL Executive Committee. 2008. Basin Management Action Plan. Tallahassee, FL. https://floridadep.gov/dear/water-quality-restoration/content/basin-management-action-plans-bmaps	Lower St. Johns River Basin. Matches study area without coastal region.	Only indirect benefits to wildlife of water quality.	Primarily water quality. Includes point and non-point source impacts, atmospheric deposition by Seminole Electric, and urban stormwater. Describes water quality trading framework in the basin.	Not covered.
Planning for Sea Level Rise in the Matanzas Basin: Opportunities for Adaptation. Frank, K., M. Volk, D. Jourdan. 2015. Planning for Sea Level Rise in the Matanzas Basin. Report to the GTMNERR. Ponte Vedra Beach, FL. https://planningmatanzas.org/	Matanzas River basin, St. Johns and Flagler Counties, FL.	Biodiversity, wildlife habitat, fisheries all identified as area values by stakeholders. CLIP Biodiversity Priorities.	Storm surge buffering, water quality, residential neighborhoods all identified as area values by stakeholders. SLAMM impacts on land use categories and specific assets: fire stations, hospitals, law enforcement, school, emergency operations center.	Sea Level Rise and Sea Level Affecting Marshes Modeling (SLAMM).
Predicting and Mitigating the Effects of Sea Level Rise and Land Use Changes in Imperiled Species and Natural Communities in Florida. Hoctor, T., R. Noss, J. Oetting, J. Reece, M. Volk. 2014. Predicting and Mitigating the Effects of Sea Level Rise and Land Use Changes in Imperiled Species and Natural Communities in Florida. Final report to Florida Fish and Wildlife Conservation Commission. Tallahassee: FL.	State of Florida	Assessed impacts of climate change and sea level rise to a broad range of species, primarily coastal imperiled species. Vulnerability assessments completed for 325 plant and animal species; spatial habitat model overlay on SLR and SLAMM projections for ~300 species and ~30 natural communities.	SLAMM models assessed impacts to general human land use categories from sea level rise.	Explicit assessments of sea level rise both spatially and ecologically. Basic assessment of other climate change impacts ecologically.

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
Regional Reports				
Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment Carter, L. M., J. W. Jones, L. Berry, V. Burkett, J. F. Murley, J. Obeysekera, P. J. Schramm, and D. Wear, October 2014: Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0NP22CB. http://nca2014.globalchange.gov/report/regions/southeast	The Southeast and Caribbean	Coral reefs.	Cities, metropolitan areas; roads, railways, ports, airports; oil and gas facilities, water supplies, stormwater drainage systems; homes and infrastructure in low-lying areas; fishery habitat; coastal water control structures and water management systems, flood control facilities; porous aquifers and drinking water wells.	Sea level rise, increasing temperatures and the associated increase in frequency, intensity, and duration of extreme heat events, increased droughts and wildfires, projected increase in ground-level ozone, public health threats from climate-sensitive diseases, expected increase in harmful algal blooms and disease-causing agents, expected change in spread of non-native invasive species, increased tree stress, shifting phenology, and altered insect and pathogen lifecycles, hurricanes, decreased water availability, change in projected precipitation, saltwater intrusion.
University of Florida GeoPlan Center: Sea Level Scenario Sketch Planning Tool https://sls.geoplan.ufl.edu/ https://sls.geoplan.ufl.edu/documents-links/ https://sls.geoplan.ufl.edu/tools/			Help identify transportation infrastructure vulnerable to current and future flood risks.	The tool analyzes and visualizes current flood risks (100-year and 500-year floodplains and hurricane storm surge zones) as well as future flood risks using sea level rise (SLR) scenarios from the U.S. Army Corps of Engineers (USACE) and the National Oceanic and

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
				Atmospheric Administration (NOAA)/ National Climate Assessment
Florida Department of Economic Opportunity – Adaptation Planning, Planning for Coastal Flooding and Sea Level Rise FDEO Coastal Vulnerability Assessment: City of St. Augustine 2014 https://www.flseagrant.org/wp-content/uploads/Franklin_SLR_2016-09-21_FINAL.pdf http://www.floridajobs.org/community-planning-and-development/programs/community-planning-table-of-contents/adaptation-planning	Areas of Critical State Concern		Adaptation to sea level rise are the steps a community takes to become more resilient to the impacts of rising seas over a period of time.	SLR and Coastal Flooding
Guana Tolomato Matanzas National Estuarine Research Reserve Management Plan 2009 http://publicfiles.dep.state.fl.us/cama/plans/aquatic/GTM-NERR-Management-Plan-2009.pdf	GTM Research Reserve	16 species that are fished or harvested commercially and 18 species that are fished recreationally	Public Use, Watershed Land Use, Cultural resources	Global Processes
South Atlantic Conservation Blueprint 2.2. South Atlantic Landscape Conservation Cooperative. 2017	Piedmont, coastal plain, and ocean	Indicators designed to cover all terrestrial and aquatic species of the region.	Historic districts and infrastructure, Urban open space, shoreline alteration	Sea-level Rise, Urban growth, Climate change

Title, Citation, and Link (if available)	**Geography Covered**	**Fish and Wildlife Relevance**	**Human Asset Relevance**	**Flooding Threats Relevance**
http://www.southatlanticlcc.org/blueprint/ https://www.sciencebase.gov/catalog/file/get/59cd4b7be4b00fa06fefecf0?name=Blueprint_2_2_Development_Process.pdf https://www.sciencebase.gov/catalog/file/get/59fb6c57e4b0531197b1684d?name=BlueprintImplemen%20tationStrategy.pdf	from Southeast VA to North FL	Multiple approaches to terrestrial and freshwater resilience for these species		

Glossary and Key to Acronyms and Abbreviations Used in this Report

At-risk species: All species formally included in one of the following categories at the time of this assessment:

- A species listed as 'endangered', 'threatened', or 'candidate' under the provisions of Endangered Species Act (ESA)[8]
- A species with a NatureServe global imperilment rank of G1, G2, or G3[9]
- A species with a NatureServe state imperilment rank of S1, S2, or S3
- A State Species of Greatest Conservation Need (SGCN) as recorded in current State Wildlife Action Plans [10]

Community Vulnerability Index: An index of the number of Human Community Assets (HCAs) with vulnerability to flooding threats.

Condition: The results obtained from applying the landscape condition model to either the fish and wildlife elements or the HCAs to calculate a condition score for fish and wildlife elements or HCAs ranging from 0.0 (low condition) to 1.0 (high condition).

Conservation Value Summary: Mapped values that are the output of a Vista DSS overlay function that allows for a wide range of calculations based on element layers and user-specified attributes. Examples include richness (the number of overlapping elements at a location) and weighted richness where, for example, a simple richness index is modified by the modeled condition of elements. Several indices calculated for this assessment are conservation value summaries.

CVS: See Conservation Value Summary.

Distance effect: The off-site impacts from a stressor or threat used in the Landscape Condition Model (LCM) to estimate the condition of elements and assets.

Distinctive ecological systems: Mid- to local- scale ecological units useful for standardized mapping and conservation assessments of habitat diversity and landscape conditions. Ecological systems reflect similar physical environments, similar species composition, and similar ecological processes.

Element: A fish or wildlife habitat type, species, or species aggregation.

Element Occurrence (EO): An area of land and/or water in which a species or natural community is, or was, present. An EO should have practical conservation value for the element as evidenced by potential continued (or historical) presence and/or regular recurrence at a given location.

EO: See Element Occurrence.

EPA: Environmental Protection Agency

ESA: Endangered Species Act

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[8] These categories are established by the **US Endangered Species Act of 1973, as amended through the 100th Congress**. (United States Government 1988) (See this factsheet for further explanation: https://www.fws.gov/endangered/esa-library/pdf/ESA_basics.pdf)

[9] These categories, used throughout the Americas are documented in the publication **NatureServe Conservation Status Assessments: Methodology for Assigning Ranks (Faber-Langendoen et al. 2012)** (Available here: http://www.natureserve.org/sites/default/files/publications/files/natureserveconservationstatusmethodology_jun12_0.pdf)

[10] The basis for this designation varies by state.

Essential Fish Habitat (EFH): Those waters and substrate necessary for the spawning, breeding, feeding, or growth to maturity of a species of fish.

GIS: Geographic information system

G-Rank or Global Rank: NatureServe rank based on assessment of how imperiled a species or community is throughout its entire range (G1-G5 with G1 being most imperiled and G5 being most secure).

Habitat Area of Particular Concern (HAPC): NOAA-designated areas that provide important ecological functions and/or are especially vulnerable to degradation. HAPCs are a discrete subset of the Essential Fish Habitat for a species of fish.

HCA: See Human Community Asset.

HUC: See Hydrologic unit code.

HUC8 Units (also called Level 4 hydrologic units or subbasins): A hierarchical 'level' of hydrologic unit often used for establishing the boundaries in natural resource and agricultural assessment, planning, management, and monitoring. HUC8 units served as the framework for defining targeted watersheds in this assessment. They have an average size of approximately 700 square miles.

Hydrologic Unit Code (HUC): A systematic code used as a unique identifier for hydrological units of different scales. There are six levels of units that nest within each other in a spatial hierarchy. (For more information, see this useful resource: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1042207.pdf)

Human Community Asset (HCA): Human populations and/or critical infrastructure or facilities.

Important bird areas: Areas identified using an internationally agreed set of criteria as being globally important for the conservation of bird populations.

LCC: See Landscape conservation cooperative.

Landscape condition model: A model of ecological condition reflecting information about the interaction of one or more conservation targets with phenomena known or estimated to impact their condition in an explicit way (change agents). A landscape condition model uses available spatial data to transparently express interactions between targets and change agents. Change agent selection and effects can be based on published literature and/or expert knowledge.

Landscape Conservation Cooperative: A cooperative effort that brings stakeholders together around landscape-scale conservation objectives that require broad coordination (often at the scale of multiple states).

LCM: See Landscape condition model.

Living shoreline: A broad term that encompasses a range of shoreline stabilization techniques along estuarine coasts, bays, sheltered coastlines, and tributaries. A living shoreline has a footprint that is made up mostly of native material. It incorporates vegetation or other living, natural "soft" elements alone or in combination with some type of harder shoreline structure (e.g. oyster reefs or rock sills) for added stability. Living shorelines maintain continuity of the natural land–water interface and reduce erosion while providing habitat value and enhancing coastal resilience.

National Hydrography Dataset: "A comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of surface water (lakes, ponds, and reservoirs), paths through which water flows (canals, ditches, streams, and rivers), and related entities such as point features (springs, wells, stream gages, and dams)" (USGS 2017).

Natural and Nature-Based Solutions: "Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" as defined by IUCN.

NatureServe Vista: A software extension to ArcGIS used in this assessment to store, manage, and conduct a variety of analyses with relevant spatial data.

NEMAC: National Environmental Modeling and Analysis Center

NFWF: National Fish and Wildlife Foundation

NHD: see National Hydrography Dataset.

NOAA: National Oceanic and Atmospheric Administration

NOAA Trust Resource: Living marine resources that include: commercial and recreational fishery resources (marine fish and shellfish and their habitats); anadromous species (fish, such as salmon and striped bass, that spawn in freshwater and then migrate to the sea); endangered and threatened marine species and their habitats; marine mammals, turtles, and their habitats; marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and resources associated with National Marine Sanctuaries and National Estuarine Research Reserves.

NWI: National Wetlands Inventory (USFWS product)

Resilience: The ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events, as defined by the National Academies of Science. For fish and wildlife, this can mean the ability to recover to a viable and functioning state, either naturally or through restoration actions.

Resilience Hub: Large patches of contiguous, natural areas that provide communities with protection and buffering from the growing impacts of sea-level rise, changing flood patterns, increased frequency and intensity of storms, and other environmental stressors while supporting populations of fish and wildlife habitat and species.

Resilience Project: A planned or proposed nature-based project that has not yet been undertaken and that would have mutual benefits for human community assets and fish and wildlife elements when implemented.

SGCN: See Species of Greatest Conservation Need.

Site Intensity: The on-site condition remaining in the presence of a stressor/threat used in the Landscape Condition Model (LCM). Values range from 0 (low condition) to 1 (high condition) and are applied to the footprint of the stressor/threat as defined by the scenario.

SLR: Sea level rise

Species congregation area: A place where individuals of one or more species congregate in high numbers for nesting, roosting, or foraging.

Species of Greatest Conservation Need: Those species identified by state wildlife agencies as priorities for conservation in their State Wildlife Action Plans.

S-Rank or State rank: NatureServe rank based on assessment of how imperiled a species or community is within Florida (S1-S5 with S1 being most imperiled and S5 being most secure).

TNC: The Nature Conservancy

USACE: U.S. Army Corps of Engineers

USFWS: U.S. Fish and Wildlife Service

Vista DSS: See NatureServe Vista, DSS stands for Decision Support System

Vulnerability: The risk or possibility of an HCA or element to experience stressors and/or threats causing its condition to drop below a defined threshold of viability.

Watershed: A region or area bounded by a divide and draining ultimately into a watercourse or body of water, often mapped with HUCs.