St. Lucie County
Resilience Vulnerability Assessment
Phase II – Other Hazards (RVA-OH)
Final Report



This project was funded in part by the
Florida Department of Commerce through a
U.S. Department of Housing and Urban Development
Community Development Block Grant -Mitigation

TETRA TECH

January 2026

ACKNOWLEDGEMENTS

The Project Team would like to thank the following individuals for serving on the St. Lucie Community Resilience Steering Committee and providing their input and expertise in this Resilience Vulnerability Assessment Report:

ST. LUCIE COMMUNITY RESILIENCE STEERING COMMITTEE (current and past)

St. Lucie County

Benjamin Balcer, SLC Planning

Paulette Bell, SLC Utilities

Patrick Dayan, SLC Public Works

Chris Lestrange, SLC Public Works

Nick Linehan, SLC Public Works

Michael Manning, SLC Innovation, Resilience & Performance

Jennifer McGee, SLC Environmental Resources

Rebecca Olson, SLC Solid Waste & Utilities

Joshua Revord, SLC Port, Inlet & Beaches

City of Fort Pierce

Jack Andrews, FP Engineering

Venetia Barnes, FP Engineering/Stormwater

Shaun Coss, FP Building Dept.

Kev Freeman, FP Planning

Paul Thomas, FP Building Dept.

Public Safety & Emergency Operations

Oscar Hance, SLC Public Safety

Sonji Hawkins, SLC Public Safety

Shane Ratliff, PSL Emergency Management

Billy Weinshank, PSL Emergency Management

City of Port St. Lucie

Marissa Da Breo-Latchman, PSL Planning

John Eason, PSL Utilities

Bret Kaiser, PSL Public Works

Teresa Lamar-Sarno, PSL Planning

Peter May, PSL Public Works

Kevin Matyjaszek, PSL Utilities

Kate Parmelee, PSL Strategic Initiatives

Colt Schwerdt, PSL Public Works

St. Lucie Village

Carl Peterson, SLV Building Official/Floodplain Manager

William Thiess, SLV Mayor

Agencies

Peter Buchwald, St. Lucie Transportation Planning Organization

Yi Ding, St. Lucie Transportation Planning Organization

Stefanie Myers, Florida Health Dept-SLC

Laurie Owens, Florida Health Dept-SLC

Terry Ann Paulo, Treasure Coast Regional Planning Council

Marty Sanders, St. Lucie School District

Jessica Seymour, Treasure Coast Regional Planning Council

Rachel Tennant, Fort Pierce Utilities Authority

Peter Tesch, SLC Economic Development Council

Stephanie Torres, St. Lucie Transportation Planning Organization

WITH SPECIAL GRATITUDE

To the residents, businesses, organizations and leaders of
St. Lucie County, Port St. Lucie, Fort Pierce, and St. Lucie Village

This work was funded, in part, through a Community Development Block Grant-Mitigation (CDBG-Mit) program agreement (#MT-031) with the Florida Department of Commerce. The CDBG-Mit grant provided $600,000 or 75% of total project cost.

PROJECT CONSULTANT TEAM

Tetra Tech, Inc.

Erin L. Deady, P.A.

Clearview Geographic, LLC

The Balmoral Group, LLC

Lori Lehr, Inc.

Search, Inc.

HDR, Inc.

The Firefly Group, LLC

EXECUTIVE SUMMARY

Community resilience refers to the ability of governments, individuals, organizations, institutions, and businesses to anticipate, respond to, endure, and recover from both immediate and prolonged pressures stemming from natural hazards, like hurricanes, flooding and extreme heat events.

St. Lucie County (SLC), the City of Port St. Lucie (PSL), the City of Fort Pierce (FP) and St. Lucie Village (SLV) joined together to take a collaborative approach toward short- and long-term resilience planning, beginning with the development of comprehensive Resilience Vulnerability Assessments (RVA). Phase I of the RVAs, completed in June 2025, focused on flooding hazards (RVA-Flood). This assessment, Phase II, focuses on 'Other Hazards' (RVA-OH), including coastal erosion, extreme heat, drought, wind, wildfires, storm surge, inland flooding, and sea level rise (SLR).

Together, the RVAs represent a foundational step in developing a community-wide resilience plan, by taking a local, data-driven approach to evaluate the vulnerability of community-wide assets to various natural hazards. The forthcoming Regional Resilience Plan (RRP) will build from the work completed in the RVAs and will identify strategies that can be implemented to ensure a resilient future for the region.

SLC and the municipalities have a long history of collaborating to address a wide range of issues and implement initiatives that promote sustainability and resilience. From the acquisition and restoration of natural areas to the development of stormwater storage and conveyance systems, septic-to-sewer projects, water quality improvement efforts, and disaster preparedness, the St. Lucie community is well-positioned to continue to enhance its resilience to future threats.

Like many communities in Florida, SLC faces significant challenges from a rapidly growing population, loss of green space, and increasing impacts from natural hazards, including coastal erosion and flooding from SLR, extreme rainfall events and storms. For example, recent record rainfall events from Hurricanes Ian (2022) and Milton (2024) have highlighted vulnerabilities to flooding throughout much of SLC. In addition, marsh systems create a dynamic buffer attenuating impacts of SLR, while mangrove forests excel at stabilizing shorelines against erosion. This has led to a focus on more integrated stormwater management, wetlands and ecosystem protection, and low-impact development practices, all of which provide opportunities to build greater resilience.

The modeling results and analyses developed in this report are intended to help SLC better understand some of the challenges it faces, while at the same time helping the community and decision-makers identify key opportunities for moving forward toward a more resilient future.

This RVA and RRP together represent a critical initiative funded by the Florida Department of Commerce Community Development Block Grant Mitigation Program, through the U.S. Department of Housing and Urban Development. The project aims to address hazards and disaster risks throughout the County, aligning with Federal Emergency Management Agency (FEMA) community lifelines. The RVA scope represents a comprehensive approach to identifying hazards, evaluating vulnerabilities, and identifying potential mitigation opportunities.

The RVA includes a systematic process to identify the potential vulnerabilities of the community to adverse impacts from hazards. It incorporates scientific data from multiple federal, state, and local sources, as well as input from residents and organizations. Data collection for the project was extensive, incorporating public assets, networks, and essential systems crucial for the well-being of the community. Critical county, municipal and regionally significant assets were evaluated in four categories: Transportation and Evacuation Routes; Critical Infrastructure; Community and Emergency Facilities; and Natural, Cultural, and Historic Resources.

To identify the most impacted geographic areas and vulnerable assets throughout the County and municipalities, the RVA analyzed present day and future scenarios for the years 2040 and 2070, based on best-available science and data, including geographic information system (GIS) database details, modeling and mapping, and critical asset evaluation. Findings from this RVA will form the foundation for a SLC RRP addressing actions to increase the County's and the municipalities' adaptive capacity to chronic and acute stressors; prioritize needs of the community; identify funding sources; and provide guidance on proactive responses to potential risks and impacts. The RVA and subsequent RRP will ultimately provide the data, vulnerability analysis, strategic planning, adaptation evaluation, and community engagement, to create a more resilient and sustainable future for the County and municipalities.

SLC's diverse natural and coastal ecosystems, including forests, wetlands, mangroves, and beaches, play a critical role in environmental resilience, offering storm protection, water filtration, and habitat for wildlife. However, these systems face growing threats from sea level rise, extreme weather, and rapid development. Using the Sea Level Affecting Marshes Model (SLAMM), this analysis (Part II) evaluates how coastal habitats may shift over time, identifies vulnerable areas, and explores conservation and adaptation strategies to enhance long-term resilience. It emphasizes the importance of open space preservation, green infrastructure, and integrated planning to mitigate flood risks and safeguard ecosystem services. The analysis provides actionable insights for decision-makers, planners, and environmental managers, highlighting the urgent need for proactive measures and flexible strategies to protect communities and natural resources.

Public stakeholders and steering committee members played a vital role in shaping the RVA by providing essential input and feedback. More than two dozen meetings or workshops were held to provide information on resilience planning and the development of the RVA, eliciting input from 11 different groups from neighborhood associations and non-profit organizations to government and agency boards and committees. SLC and the municipalities established a resilience steering committee of key collaborators, comprising representatives from diverse backgrounds. The resilience steering committee assisted in shaping the resilience project by reviewing goals, offering input on study direction, identifying geographic context, guiding modeling methodologies, pinpointing available data and resources, providing specific asset information, and reviewing project findings. The steering committee represented various St. Lucie County, Port St. Lucie, Fort Pierce and St. Lucie Village departments including Planning & Development Services, Public Works, Utilities & Solid Waste, Engineering, Emergency Operations, and Environmental Resources. The resilience steering committee was also comprised of various member agencies, including representatives from SLC Florida

Department of Health, SLC School District, SLC Economic Development Council, St. Lucie Transportation Planning Organization, and the Treasure Coast Regional Planning Council.

The modeling results and analyses developed in this report are intended to help SLC and its municipalities better understand some of the challenges it faces, while at the same time helping the community and decision-makers identify key opportunities for moving forward toward a more resilient future. It's an important step in developing a comprehensive approach to adapt to and mitigate the effects of chronic and acute natural hazards, recognizing that identifying and addressing vulnerabilities, especially those related to critical assets, before they fail is the most fiscally responsible strategy approach to long-term resilience. By adopting a forward-thinking philosophy, the County and municipalities foster a sense of ownership and shared responsibility for addressing risks, while enhancing preparedness and responsiveness.

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

°F	degrees Fahrenheit
AMS	Annual Maximum Series
ATSDR	Agency for Toxic Substances and Disease Registry
CDBG-MIT	Community Development Block Grant Mitigation
CDC	Center for Disease Control
CLIP	Critical Lands and Waters Identification Project
County	St. Lucie County
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FP	Fort Pierce
F.S.	Florida Statute
GIS	geographic information system
gSSURGO	Gridded Soil Survey Geographic Database
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HUD	U.S. Department of Housing and Urban Development
LAI	Location Affordability Index
Municipalities	Port Saint Lucie, Fort Pierce, and Saint Lucie Village
MRP	mean return period
NCEI	National Centers for Environmental Information
NIH	NOAA intermediate-high (sea level rise projection)
NIL	NOAA intermediate-low (sea level rise projection)
NOAA	National Oceanic and Atmospheric Administration
PDS	partial duration series
PSL	Port St Lucie
RRP	Regional Resilience Plan
RVA	Resilience Vulnerability Assessment
RVA-OH	Resilience Vulnerability Assessment – Other Hazards
SFWMD	South Florida Water Management District
SLAMM	Sea Level Affecting Marshes Model
SLC	St. Lucie County
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SLR	Sea Level Rise
SLV	St. Lucie Village
T&E	threatened and endangered species
WUI	Wildland Urban Interface

Glossary

Adaptation: The process of adjustment to actual or expected threats and impacts, in order to moderate harm or exploit beneficial opportunities. Adaptive capacity is the ability to make these adjustments based on feedback loops.

Assets: People, resources, ecosystems, infrastructure, and the services they provide. Assets are the tangible and intangible items that St. Lucie County residents and communities value.

Bathtub Method/Model: A methodology that calculates and/or models the addition of water on the landscape to determine existing and future risks to flooding. The bathtub model looks at water on the land based on topography without regard to current or future stormwater infrastructure nor underground hydrology dynamics.

Critical Assets/Infrastructure: Public assets, networks, and essential systems crucial for the well-being of St Lucie County and the municipalities. Disruption or damage to critical infrastructure would lead to negative community, environmental, and/or economic consequences.

Days of Tidal Flooding: The number of days that the water level exceeds mean higher high water at (in this study) the Virginia Key Tide Gauge, when that water level is adjusted for sea level rise.

Exposure: The presence of people, assets, and ecosystems in places where they could be adversely affected by hazards.

Flood Mitigation: Structural changes to reduce the frequency and severity of flood damages.

Hazard: An event or condition that may cause injury, illness, or death to people or damage to assets or otherwise impede their normal function.

Hazard Mitigation: When used by the Federal Emergency Management Agency (FEMA), the actions taken to reduce loss of life and property by lessening the impact of near future disasters.

Hazus: A GIS-based software tool that applies engineering and scientific risk calculations to provide defensible damage and loss estimates.

Impacts (negative impacts in this discussion): Effects on natural and human systems that result from hazards. Evaluating potential impacts is a critical step in assessing vulnerability.

Infrastructure: Fundamental physical and organizational structures (man-man and natural) and facilities necessary for the functionality of a community.

Likelihood: The probability of an asset being impacted by a hazard based on its geographical position.

Mitigation: A human intervention to reduce impacts from current or future impacts.

Mean Return Period: The average amount of time expected between occurrences of a specific event, such as a hurricane or flood, based on historical data and probability.

Nature-based Solutions: Efforts to safeguard, sustainably manage, and restore or augment natural or altered ecosystems as an effective way to reduce the risks posed by natural hazards, such as flooding, extreme heat, and coastal erosion. Nature-based solutions can provide effective mitigation, while simultaneously enhancing human well-being and biodiversity.

Planning Horizon: The projected conditions at a future date, in this study the planning horizons are 2040 and 2070.

Projections: Potential future conditions simulated by complex computer-based models of the earth's systems. Projections are based on potential scenarios and various factors under different assumptions about natural processes and human activity and are crucial for informing adaptation and mitigation strategies, as well as community preparedness.

Regionally Significant Assets: Vital facilities within the County that cater to a wider geographic scope, spanning neighboring communities, and may be but are not inherently under the county or municipal ownership and maintenance.

Resilience: The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.

Risk: The potential total cost if something of value is damaged or lost, considered together with the likelihood of that loss occurring. Risk is often evaluated as the probability of a hazard occurring multiplied by the consequences that would result if it did happen.

Scenarios: A set of assumptions about the future regarding the level and effectiveness of mitigation efforts and other physical processes, each with a level of uncertainty.

Sea Level Rise (Absolute Sea Level Rise): An increase in the height of the ocean surface above the center of the earth, without regard to whether nearby land is rising or falling.

Section 380.093(3), F.S.: A Florida statute passed in 2021, 380.093(3), F.S. pertains to vulnerability assessments related to flooding and sea level rise in the state of Florida. It requires the state to compile a comprehensive statewide assessment of specific risks posed by flooding and sea level rise.

Sensitivity: The degree to which a system, population, or resource is or might be affected by hazards.

Storm Surge: An abnormal rise in seawater level generated by a storm, over and above the predicted astronomical tide. It is primarily caused by strong winds pushing water toward the shore and can result in extreme coastal flooding, especially when coinciding with high tide.

Tidal Flooding: Defined in Florida Statute (F.S.), Subparagraphs 380.093(3)(d)1. and 380.093(3)(d)2., F.S. as "Depth of tidal flooding, including future high tide flooding. The threshold for tidal flooding is 2 feet above mean higher high water."

Uncertainty: The inability to predict, with 100 percent accuracy, a particular outcome because future weather conditions and system dynamics arise from the complexity of variables.

Urban Heat Island Effect: A phenomenon where urban areas experience significantly higher temperatures than surrounding rural areas due to the concentration of buildings, roads, and other infrastructure that absorb and retain heat. Limited vegetation and increased human activity further intensify this effect.

Vulnerability: The propensity or predisposition of assets (human, ecological, and man-made) to be adversely affected by hazards. Vulnerability encompasses the degree of exposure, sensitivity, risk, potential impacts, and adaptive capacity.

Vulnerability Assessment: A systematic, data-driven process for analyzing hazard exposure, hazard sensitivity, and adaptive capacity to identify who or what is vulnerable to certain conditions, the level and extent of impacts, and the potential adaptations that can be implemented to lessen risk.

100-Year Event: A statistical term used to describe an event (such as a flood or storm) that has a 1 percent chance of occurring in any given year. It reflects the probability based on historical data and modeling.

24-Hour Rainfall: A calculation of the amount of rainfall over 24-hours. This parameter is often used when calculating storm rainfall events that generally occur once every 25 or 100 years.

PART I: MULTI-HAZARD VULNERABILITY ANALYSIS

1.0 INTRODUCTION

1.1 Project Background

St. Lucie County (SLC), the City of Port St. Lucie (PSL), the City of Fort Pierce (FP) and St. Lucie Village (SLV) joined together to take a collaborative approach toward short- and long-term resilience planning, beginning with the development of comprehensive Resilience Vulnerability Assessments (RVA). Phase I of the RVAs, completed in June 2025, focused on flooding hazards (RVA-Flood). This assessment, Phase II, focuses on 'Other Hazards' (RVA-OH), including coastal erosion, extreme heat, drought, wind, wildfires, storm surge and inland flooding. The St. Lucie Regional RVAs increase our understanding of our community's vulnerabilities. They serve as the foundation for evaluating natural hazard risks and identifying strategies for improved preparedness and responsiveness to crises, while informing future decision-making.

The RVAs are the first step to develop a SLC Regional Resilience Plan (RRP), using a systematic data-driven approach to evaluating the vulnerability of community-wide critical assets and populations to various natural hazards. Critical assets are public assets, networks, and essential systems crucial for the well-being of SLC and its municipalities. The core project milestones are delineated in **Figure 1-1**. The RVA utilized scientific data from technical sources, topographic and elevation data, and asset data to analyze current and future risks. In addition, supplemental information in existing local studies was utilized. The RVA incorporated critical county, municipal, and regionally significant assets organized into four categories: Transportation and Evacuation Routes; Critical Infrastructure; Community and Emergency Facilities; and Natural, Cultural, and Historic Resources.

The forthcoming Regional Resilience Plan (RRP) will be designed to provide an informed roadmap for SLC to enhance community resilience. The RRP will include an evaluation of the County's and municipalities' capability to adapt, delineate strategies, and identify potential investments to eliminate or reduce risk and minimize response timeframes. In essence, the RRP creates a conceptual plan for addressing, mitigating, and alleviating the impacts highlighted in the RVAs. Hazard mitigation efforts, emergency preparedness, land use planning, code and policy development, infrastructure fortification, and public health policies and programs will be considered as part of the RRP.

Figure 1-1. Project Milestones

The modeling results and analyses developed in this report are intended to help SLC and its municipalities better understand some of the challenges it faces, while at the same time helping the community and decision-makers identify key opportunities for moving forward toward a more resilient future. It's an important step in developing a comprehensive approach to adapt to and mitigate the effects of chronic and acute natural hazards, recognizing that identifying and addressing vulnerabilities, especially those related to critical assets, before they fail is the most fiscally responsible strategy approach to long-term resilience. By adopting a forward-thinking philosophy, the County and the municipalities foster a sense of ownership and shared responsibility for addressing risks, while also enhancing preparedness and responsiveness.

1.2 St. Lucie County, Port St. Lucie, Fort Pierce, St. Lucie Village Background

1.2.1 Geographical Setting and Characteristics

St. Lucie County, located along Florida's Treasure Coast, is known for its beautiful beaches, vibrant communities, and rich agricultural history. St. Lucie County is home to a mix of urban and suburban communities, economic hubs, agricultural lands, and protected natural areas. The largest city, Port St. Lucie, is one of the fastest growing cities in Florida, while Fort Pierce and St. Lucie Village are smaller and have a more historic and maritime character.

Spanning approximately 688 square miles, natural resources have defined the culture of the community throughout its history. There are more than two dozen natural areas within St. Lucie County encompassing more than 25,000 acres of parks and preserves, from pristine beaches to cypress hammocks and freshwater marshes. With 21 miles of Atlantic coastline, as well as the North Fork St. Lucie River and the Indian River Lagoon within its boundaries, water is a way of life in St. Lucie County.

The Indian River Lagoon is a shallow-water estuary that spans 156 miles from Brevard County to just south of St. Lucie County. It is one of North America's most diverse estuaries with more than 4,400 species of plants and animals, including 35 that are listed as threatened or endangered. For more than a century, people have been drawn to the Lagoon for its biodiversity, temperate climate, and proximity to the Atlantic Ocean. The Indian River Lagoon supports commercial and recreational fisheries and acts as an economic engine for the region. The annual economic value of the Lagoon was estimated to be $7.6 billion in 2016, which included nearly 72,000 jobs, and recreational opportunities for more than 7.4 million visitors per year (Indian River Lagoon Economic Valuation Report 2016).

The North Fork St. Lucie River was designated as a state aquatic preserve in 1972 and is a freshwater system upstream and a brackish system near the St. Lucie Estuary. The North Fork St. Lucie River supports a variety of federally and state protected species such as American alligators, manatees, wood storks, and tricolored herons. The North Fork is home to more species of fish than any other river in the state and provides important habitat for the juvenile phases of commercially important species such as blue crabs, snook, snapper, drum, and shrimp. The North Fork St. Lucie River drains an area of approximately 108,165 acres (169 square miles) in eastern St. Lucie County and northeastern Martin County. Historically, it was a slow-moving and meandering river in a largely forested catchment until dredge-and-fill operations to "straighten" the river were completed in the early 1900s. These activities combined with accelerated growth in SLC have resulted in long-standing impacts, including loss of natural stormwater storage and filtration, severe erosion of channel banks, and increased sedimentation, all of which increase the risk of flooding in surrounding areas. Working collaboratively, the County and municipalities launched the Environmentally Significant Lands Program in 1994, following overwhelming citizen approval of a $20 million local bond referendum. The goal of the Program is to conserve and safeguard ecosystems in their natural condition while allowing for appropriate public access. Through additional partnerships and leveraging bond funding, more than two dozen preserves have been established totaling over 11,000 acres.

1.2.2 Economic & Demographic Overview

Together, St. Lucie County and the municipalities have a population of approximately 385,746 residents (Florida Bureau of Economic and Business Research, 2024 current population estimate). The County has a relatively diverse economy, with tourism, healthcare, retail, and agriculture representing its major sectors. Proximity to the coast makes tourism and recreational industries important contributors to the local economy, with visitors drawn to the county's beaches, parks, and fishing spots. Additionally, the county benefits from a strong retail and service sector, which caters to both residents and tourists.

The County's demographic landscape features a balanced age distribution, with around 19.6 percent of the population under the age of 18 and approximately 24.8 percent aged 65 and older. Ethnically, the County's population is comprised of about 54 percent White, 23 percent Black or African American, 22 percent Hispanic or Latino, and a smaller percentage of other racial groups (U.S. Census Bureau 2023).

Educational attainment shows that roughly 88.6 percent of the population holds a high school diploma or higher, while about 25.4 percent have a bachelor's degree or advanced degree. Economically, St. Lucie County's median household income stands at $69,027, with a poverty rate of about 10 percent (U.S. Census Bureau 2023). Countywide housing is characterized by 77.7 percent of residents owning their homes and 22.3 percent renting. The housing market in SLC reflects the rising demand for coastal living, with rental and home ownership costs steadily increasing, contributing to a dynamic but increasingly competitive housing landscape.

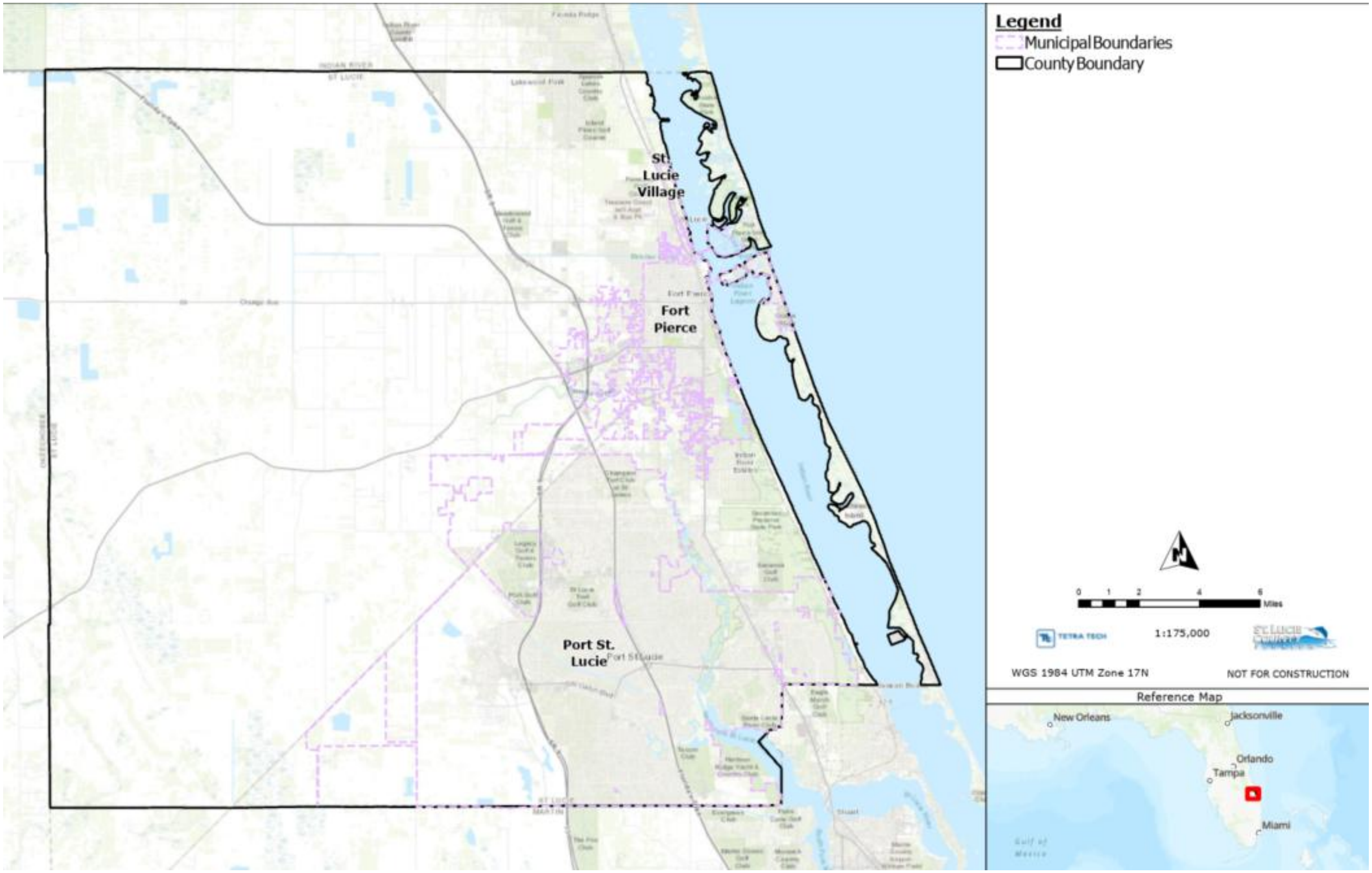


Figure 1-2. St. Lucie County Boundary

1.2.3 St. Lucie County Vulnerabilities

As a low-lying coastal community, SLC and the municipalities are at the forefront of potential impacts from chronic and acute natural hazards, highlighting the need for proactive planning to safeguard its residents, assets, and resources.

In the context of SLC and the municipalities, the RVA's primary goal is to understand these unique conditions, the interaction of various systems and the complex array of challenges to assess and develop appropriate and proactive responses. With rising atmospheric and oceanic temperatures, shifting weather patterns, and increased frequency of extreme events, these changes create direct and indirect impacts across different areas in SLC and the municipalities, affecting various facets of the region's environment, economy, and society.

Moreover, the heightened occurrence and severity of storms including nor'easters, hurricanes and tropical cyclones represent a significant threat to SLC's coastal regions. Higher ocean temperatures fuel hurricane intensity as they approach the coast, while elevated sea level amplifies the impact of storm surge, heightening the likelihood of severe inundation, and coastal erosion during storm events.

2.0 RESILIENCE VULNERABILITY ASSESSMENT OVERVIEW

2.1 Project Goals and Objectives

The County received a grant from the Department of Commerce through the Community Development Block Grant Mitigation (CDBG-MIT) program to prepare a countywide Resilience Vulnerability Assessment (RVA) and Regional Resilience Plan (RRP). The objective of the CDBG-MIT Program is to protect Florida from future disasters by developing and improving state, regional, and local plans and improving state and local mitigation planning mechanisms.

The following are the key primary goals and objectives of the RVA and RRP:

- Identify vulnerability of various County and municipal assets
- Understand the exposure level of assets to the threats identified
- Gather and incorporate public and stakeholder input
- Develop a range of adaptation strategies to protect and adapt vulnerable assets
- Incorporate results into County and municipal planning initiatives

Figure 2-1. Overview of Resilience Planning Initiative

2.2 Steering Committee

Collaboration played a central role in this project, involving a diverse range of stakeholders to ensure both technical expertise and community insights were considered. SLC and the municipalities established a resilience steering committee of key collaborators, comprising representatives from diverse backgrounds and associations. The resilience steering committee played a vital role in shaping the project by reviewing goals, offering input on study direction, identifying geographic context, guiding modeling methodologies, pinpointing available data and resources, providing specific asset information, and reviewing project findings. The steering committee represented various County and municipal departments including Planning & Development Services, Public Works, Utilities & Solid Waste, Engineering, Emergency Operations, and Environmental Resources. The resilience steering committee was also comprised of various member agencies, including representatives from SLC Florida Department of Health, SLC School District, SLC Economic Development Council, St. Lucie Transportation Planning Organization, and the Treasure Coast Regional Planning Council. The resilience steering committee met throughout the process to review information, recommendations, and discuss key project milestones and decisions.

2.3 Public Engagement

Community resilience refers to the ability of governments, individuals, organizations, institutions, and businesses to anticipate, respond to, endure, and recover from both immediate and prolonged pressures stemming from unpredictable weather patterns and extreme events, rising sea levels, increased flooding frequency, and heightened storm severity. To establish community resilience, it is essential to actively engage stakeholders when shaping planning efforts and determining adaptation strategies and infrastructure priorities.

Public involvement for the RVA was focused on sharing resilience information and the findings of the RVA and gathering feedback from community members. Information was provided to and received from members of the community through public meetings and workshops. Public engagement and outreach efforts for this project were geared toward communicating relevant science-based information that engaged the public, community leaders, and subject matter experts, regardless of education and technical background. Utilizing various methods and multimedia tools collaboratively, the outreach initiatives aimed to enhance community understanding and involvement.

Public input and feedback were actively sought in public workshops and various relevant websites, calendars, and social media platforms. The Project Team evaluated the information gathered from the community and coordinated efforts to integrate the input into the project, while documenting the engagement outcomes to provide a transparent record of the community's contributions.

2.3.1 Stakeholder and Public Outreach Events

St. Lucie County hosted more than three dozen engagement sessions within the community between 2022 and 2025 to introduce the vulnerability assessment and resilience planning efforts. The purpose of these meetings was to allow the public to enter a dialogue where they were able to ask questions and provide community-specific input on the results of the analyses.

3.0 HAZARDS

3.1 Hazard Inventory

The County and municipalities are committed to protecting their future against various hazards such as coastal erosion, drought, extreme heat, inland flooding, storm surge, wildfire, and wind. Impacts resulting from any of these events pose a significant threat to SLC and the municipalities (**Figure 3-1**). To assist communities experiencing these increasing threats, the CDBG-MIT program has been strategically designed to guide the County and municipalities as they adapt to risks and ensure a resilient future.

Figure 3-1. Hazards Evaluated within the CDBG-MIT RVA-OH

3.2 Hazard Evaluation

The factors that influence each hazard's frequency, severity, and extent varies, and these factors are affected by anticipated environmental changes. In recognition of these differences, the exposure and sensitivity methods are tailored to each natural hazard in the community (see Sections 4.0 and 5.0 for further details).

This RVA employs a sequential methods approach, first characterizing vulnerability as a function of exposure and then asset sensitivity:

- **Exposure** – exposure refers to the presence of assets, ecosystems and populations in areas where they could be adversely affected by hazards. This RVA assessed exposure levels to each hazard for two planning horizons: 2040 and 2070.
- **Sensitivity** – the degree to which a system, resource or population is or might be affected by hazards.

Within the analysis, 27,211 assets primarily owned or maintained by the County and the municipalities were classified as critical assets. The asset types include emergency facilities, healthcare facilities, community support buildings, water infrastructure, schools, historic structures, and similar resources.

The following sections outline the framework and general process for exposure and sensitivity methods, and hazard-specific methods are detailed in corresponding results sections.

SLC and the municipalities conducted an evaluation of each hazard to better understand and communicate the potential magnitude, frequency, impact severity, and extent of the impact of each hazard. The hazards include consideration of the potential effects of chronic stressors and extreme weather events on the site-specific operational viability of assets, infrastructure, and programs. These hazards can lead to impacts affecting SLC and the municipalities' critical facilities, infrastructure, public health, housing, economies, emergency response capabilities, transportation systems, and community resources. Both near-term impacts and long-term ramifications have been considered within this RVA.

3.3 Summary of Hazards

3.3.1 Coastal Erosion

Coastal erosion is caused by wind, waves, and longshore currents and can negatively affect buildings, shoreline, and infrastructure along the coast. Coastal erosion adversely affects the economy, particularly the tourism industry, a significant economic driver that supports multiple ancillary businesses. Coastal "hardening" measures such as seawalls or revetments may be installed to protect buildings and infrastructure. However, these measures are likely to increase erosion rates and interrupt the natural retreat of beaches. Coastal property losses have totaled about $500 million annually in the United States due to coastal erosion (U.S. Climate Resilience Toolkit 2021). SLC currently has five areas of eroded shoreline, three that are considered critically eroded by the Florida Department of Environmental Protection data sources (FDEP 2023). Eroded shorelines can also leave adjacent upland areas vulnerable to other hazards including storm surge and over-wash events.

3.3.2 Drought

A drought is an extended period of abnormally low precipitation that increases water demand and can result in water supply shortages that affect everyday life. While droughts are naturally occurring phenomena, they are increasing in both frequency and severity. They can contribute to various secondary impacts such as public health and safety issues. Both weather and human factors influence the severity and geographic extent of a drought. For example, unusually low precipitation over several months or longer can create or worsen a water deficit in affected regions, but so too can a large influx of development to an area with limited water infrastructure or availability. The RVA focused on weather-driven droughts, excluding current or future human-driven factors.

Rising atmospheric temperatures contribute to an increase in the rate of soil moisture loss, resulting in a likely increase in drought intensity (Runkle et al. 2022). This can be further magnified by population growth and land-use changes that increase competition for water (Runkle et al. 2022).

Since 1990, there has been about one severe and widespread drought in Florida each decade (Florida State University n.d.a). Reduced availability of water, caused by drought, has several implications for the County and municipalities. Prolonged periods of drought can increase wildfire hazards that not only destroy property but also reduce air quality. Heightened public health hazards are linked to reduced air quality, food scarcity and drinking water shortage.

Drought also contributes to environmental and agricultural disruptions. In SLC, rainfall, local watersheds and underground freshwater aquifers are the main sources of water. When the normal water cycle is disrupted by drought, one of the most economically damaging effects can be substantial crop loss. Drought in SLC is also linked to increased insect infestations, plant disease and wind erosion. The frequency of wildfires also increases during extended droughts, which then leads to human and wildlife populations being at risk.

3.3.3 Extreme Heat

Annual average temperatures across the United States have been rising consistently at an accelerated rate since the 1970s (**Figure 3-2**). In fact, historical records since 1850, show the 10 warmest years have occurred since 2013.

According to the National Weather Service, heat stress is the leading cause of weather-related deaths in the United States each year. Due to the subtropical humid climate of Florida, the entire state has historically been vulnerable to extreme events and leads the nation in heat-related illnesses.

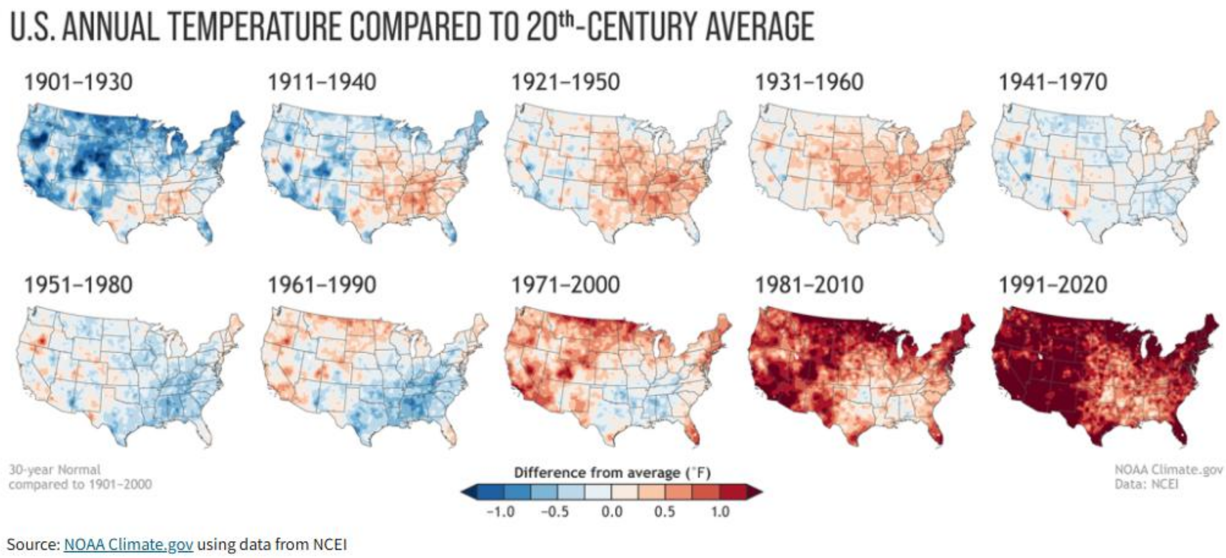


Figure 3-2. Change in U.S. Annual Temperature 1901-2020

Extreme heat events can affect anyone, but a broad range of the population can have a higher susceptibility to heat-related illness, including adults over age 65, children and infants, people with chronic illnesses or disabilities, low-income households, and people who are unhoused. In addition, jobs that require outdoor work or are in high-heat conditions pose more risk to heat related complications.

Florida leads the nation in heat-related illnesses. In addition to heat-related health risks, extreme heat can impact tourism and recreational activities, lead to other environmental impacts such as harmful algal blooms, reduction in agricultural production, and an increase in demand for energy and other utilities which strain household costs and the systems that support cooling operations.

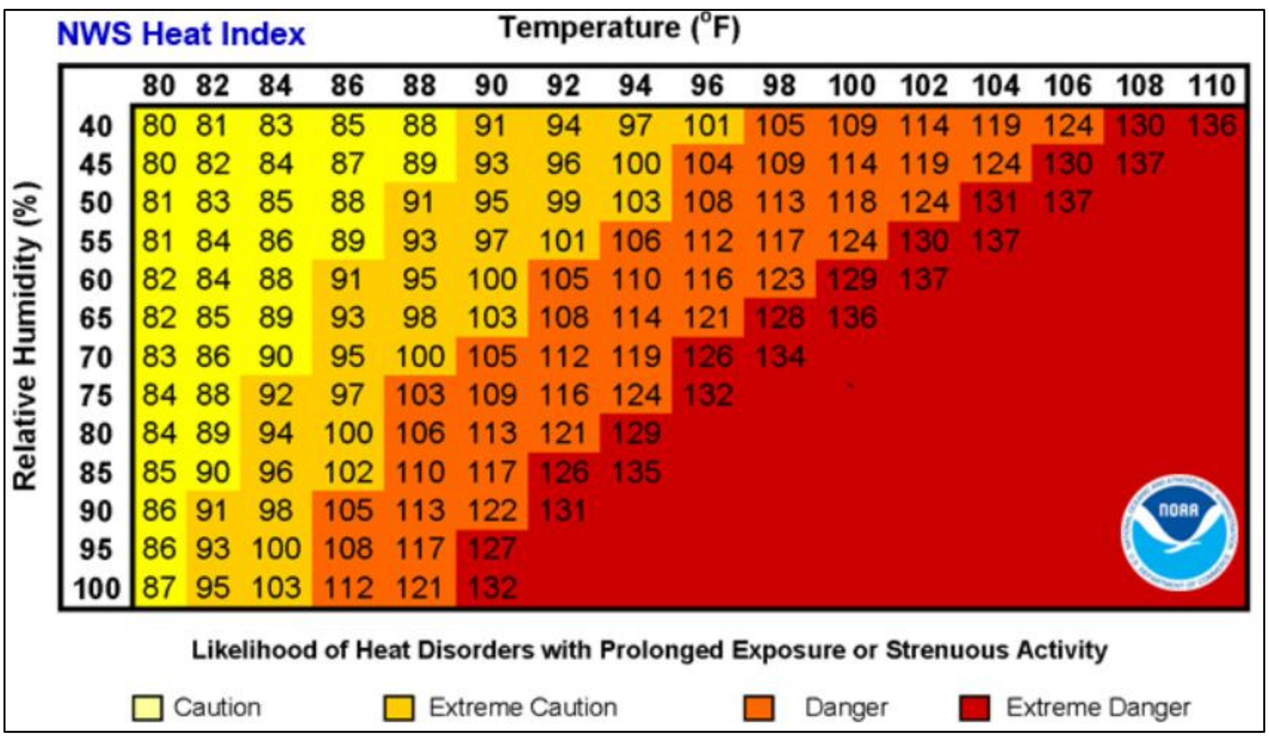
Additional impacts from increased heat relate to storm-related or extreme rainfall events that may cover large areas or be very localized. Florida typically experiences fewer days than other states where the temperature reaches 95˚F or greater due to its proximity to large water bodies and wetlands. However, that proximity also increases the humidity. As the air temperature warms, water is evaporated into the atmosphere, causing a rise in humidity, average rainfall, and the frequency of heavy rainstorms in many places (Florida Enhanced State Hazard Mitigation Plan 2023). A detailed meteorological attribution study of Hurricane Ian suggests that the modern rise in average temperatures increased the storm's overall rainfall total in Florida by about 18 percent (Reed and Wehner 2023).

Extreme heat events are defined in a number of ways, including:

- days where the temperature equals or exceeds 95°F;
- as a summertime temperature that is much hotter and/or humid than average; or
- as defined by the Department of Homeland Security, a period of high heat and humidity with temperatures above 90°F for at least 2 to 3 days.

Different tools are used to measure heat and the potential for heat-related illnesses. For example, the heat index, also known as the apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature. When faced with hot weather conditions, the body regulates its internal temperature by sweating. Sweat absorbs heat from the body and sheds it through evaporation, cooling the skin. However, this process becomes significantly less effective in humid environments, where the air is already saturated with moisture and sweat cannot evaporate efficiently. This leads to increased physiological stress, dehydration, and a higher risk of heat-related illnesses such as heat exhaustion and heat stroke.

In the heat index chart shown below (**Figure 3-3**), the red area indicates extreme danger. Health alerts are issued when the heat index is expected to exceed 105 to 110°F for at least two consecutive days.



RH (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Figure 3-3. National Weather Service Heat Index Chart

The wet-bulb temperature is a more recent approach to understanding how the apparent temperature (heat index) acts on the body, by determining the lowest temperature at which air can be cooled by evaporation. For years, it was believed that the upper survivable limit, the point at which the human body can no longer effectively shed heat through sweating, was around 95°F at 100 percent humidity or 115°F at 50 percent humidity. However, recent research from Penn State University has shown that this threshold may be lower than previously thought. In controlled laboratory conditions, young, healthy adults began to experience dangerous levels of heat stress at temperatures of 87°F at 100 percent humidity (Penn State 2022). For older adults and individuals with pre-existing health conditions, the threshold is likely lower. This means that extreme heat events may become life-threatening at lower temperatures than once assumed, especially in regions with high humidity.

3.3.4 Inland Flooding

Flooding results from three major sources in SLC and the municipalities: coastal areas subject to inundation from tidal flooding; ocean storm surges during hurricanes and tropical storms; and inland areas that become flooded during rainfall events when water accumulates in low, flat areas and the storage and capacity of the existing drainage system is exceeded.

Three factors play into the increasing risk from flooding. First, historical and ongoing population growth is associated with substantial land use change, increasing amounts of impervious land cover and the loss of natural functioning wetlands and floodplain areas (Volk et al. 2017). Such land use change factors are known to increase the risks in magnitude and extent of rainfall-induced flooding within urban, suburban, and peri-urban areas (Blum et al. 2020; Liao et al. 2022). Second, sea level rise is an exacerbating factor directly corresponding to higher storm surge potential, reducing ability of existing stormwater conveyance systems to remove rainfall-driven water from inland communities and tidally-connected waterways, including the St. Lucie River and ancillary creeks and canals. Third, data suggests that eastern Florida may already be undergoing a trend toward more frequent occurrences of extreme precipitation events, defined as rainfall episodes that significantly exceed historical averages in intensity or duration, often overwhelming drainage systems and increasing the likelihood of flash flooding (Obeysekera et al. 2021). Taken together, these factors bring the likelihood of higher flood damage risks for built areas that are already designated as flood-prone, while also potentially creating novel flood exposure hazards within areas historically thought to have minimal flood risk (Sohn et al. 2020; Panos et al. 2021; Clearview Geographic LLC 2025).

Wet season rainfall patterns coupled with the hurricane season make SLC more susceptible to flooding associated with late-season tropical storms and hurricanes, because they typically occur when the water table is high and the ground is saturated. Flooding can have numerous and wide-ranging impacts, including impacts on public safety, infrastructure, the economy, agriculture, and housing. Within SLC, non-coastal flooding can result from a buildup of ground and surface water levels over time, or from intense localized precipitation that exceeds storage and drainage capacities.

3.3.5 Storm Surge Flooding

Storm surge is the abnormal rise of seawater levels during a storm, caused by intense sustained onshore winds that push ocean water toward the coast and low atmospheric pressure that allows the sea surface elevation to increase during extreme weather events. It can occur during major storms such as hurricanes and often results in severe flooding extending to inland areas of the County. This impact from surging seas is especially pronounced for assets along coastlines on the open ocean and along other tidally influenced canals, rivers, and waterways where it quickly overwhelms stormwater drainage systems. Storm surge can lead to widespread and rapid inundation of the County's shoreline, causing extensive damage to infrastructure, homes, and critical facilities. It further threatens the shoreline as it accelerates coastal erosion, reducing the protection afforded by a healthy beach and dune system where they exist, and can compromise the stability of other coastal protection structures such as rock revetments and seawalls. Additionally, surges can introduce saltwater into freshwater systems, posing risks to natural ecosystems and water supplies, further accelerating the deterioration of infrastructure components.

The height and extent of the storm surges associated with hurricanes Irma, Nicole, and Milton were enhanced by approximately nine inches of sea level rise since 1971, based on long-term tide gauge data from NOAA (NOAA Tides and Currents 2025). Legacy coastal stormwater drainage systems that discharge into tidal water bodies also have inherently less capacity to convey water due to increased infiltration from the rising sea. During Irma and Milton, the combination of storm surge, SLR, and extreme rainfall resulted in the complete failure of some legacy stormwater systems in St. Lucie County and associated municipalities. As SLR continues to accelerate, associated flood risks from storm surge, failure of current coastal stormwater drainage systems can be expected to increase (Clearview Geographic LLC 2025).

3.3.6 Wind

Florida is the most susceptible state in the country to the impacts caused by hurricanes and tropical storms due to the frequency of storms, the length of the coastline, and the relatively low and flat ground elevations. Hurricanes and tropical storms are of particular significance during the 6-month Atlantic hurricane season, June 1 through November 30, with the peak occurring between mid-August and late October (Florida State University n.d.b). The 2021 Florida Atlantic Hurricane Season ranked third among the state's most active seasons with a reported 21 tropical storms, 7 hurricanes, and 4 major hurricanes (Powell 2022).

Impacts from hurricanes can include wind, storm surge and flooding. Roofs, vegetation, and power lines are often damaged by winds occurring in the hurricane eyewall. Hurricane winds can reach speeds of more than 155 mph and often remain at strong levels due to Florida's generally flat terrain. Large hurricanes can produce winds extending more than 150 miles from the eyewall (Florida Gulf Coast University n.d.). As a hurricane moves onshore, water is pushed toward the shoreline, which is known as storm surge. Storm surges can reach heights of 15 feet and create deadly waves and water levels. Worldwide, 90 percent of hurricane-related casualties are a result of drowning incidents within the storm surge or the associated flooding areas (Florida State University n.d.b). In addition, slow-moving tropical storms have a direct correlation to higher flooding levels, as they produce larger amounts of rain. Slow-moving Hurricane Frances in 2004 caused extensive flooding and wind damage, with sustained winds reaching up to 105 mph and storm surge flooding affecting coastal areas significantly.

A study at Florida State University outlines potential changes in hurricanes in a report titled: "Understanding Past, Present, and Future Tropical Cyclone Activity", (Carstens, Uejio and Wing 2022):

- Coastal flooding from storm surge is expected to increase regardless of changes in storm intensity due to future SLR.
- There is agreement between theory and model projections that flooding rain associated with hurricanes will become more hazardous. It is more difficult to evaluate historical trends in hurricane rainfall, but a notable trend of slower-moving storms has recently emerged.
- While the mean intensity of hurricanes has not changed significantly, warmer oceans raise the ceiling for intensity. A larger proportion of storms have reached major hurricane (Category 3 to 5) strength in recent years, along with an increase in rapid intensification events.

Stronger hurricanes and tropical storms can result in increased damage to buildings and homes, threats to infrastructure, undermining of energy, water, and sewer systems, erosion of beaches, and damage to flood management structures. Stronger hurricanes also pose a risk to public health and human lives. Problems with water supplies and power systems can cause waterborne illness, environmental contaminants, mosquito-borne illnesses, and can result in hospital closures. In addition to direct damage to infrastructure, the potential for crop damage and economic disruption from hurricanes and tropical storms are also significant.

3.3.7 Wildfire

Most of Florida's natural systems are adapted to periodic wildfires and even depend on them to maintain a balanced and sustainable ecosystem. However, in urbanized areas, naturally occurring wildfires are suppressed to protect life and property. Without management strategies, this results in the build-up of dead or decaying vegetation that provides fuel when a fire occurs and can lead to rapid acceleration and increased danger to surrounding areas.

Wildfires can be classified by how they move through the environment. Ground fires or subsurface fires occur when dead vegetation, peat or tree roots burn underground. This type of fire moves very slowly and tends to smolder rather than produce flames. Given these conditions, a ground fire can continuously spread for months.

Surface fires are common but are usually low intensity. They partially consume the "fuel layer" while presenting little danger to mature trees and root systems. The buildup of fuel and vegetation on the forest floor can create surface fires of higher intensity. In drought conditions, surface fires can transition into damaging ground fires.

Crown fires are fast-moving fire in the upper canopy of vegetation and involve the burning of vegetation both at the surface and crown (treetop) layer. Because crown fires affect multiple levels of vegetation, they are often fast moving and extreme intensity fires. Wind conditions have a larger impact on the spread of canopy level fires.

Florida experiences its peak number of wildfires from January to mid-June annually. In 2020, there were 2,381 wildfires in Florida with a total of 99,413 acres burned, attributing to Florida ranking as fifth in the nation for the number of wildfires. As droughts continue to intensify, it will likely trigger more wildfires in the future (Runkle et al. 2022).

Wildfires can cause significant property and infrastructure damage, and potential health risks can arise from diminished air quality. Soil erosion and altered water quality and supply levels can also result from wildfires.

4.0 EXPOSURE ANALYSIS OVERVIEW

The exposure analysis estimated how a hazard intersects with County and municipal land, assets, and residents in terms of event likelihood and severity. Exposure depends on the type of hazard relate to the item (i.e., land, assets, or residents) being studied.

In total, 27,211 assets were evaluated in this analysis including emergency facilities, healthcare facilities, community support buildings, water infrastructure, schools, historic structures, and similar resources.

4.1 Data Types and Methods

The quality and amount of data on physical exposure and relevant asset characteristics vary by hazard and critical asset type. Where possible, the RVA integrated spatial and quantitative data, supported by qualitative information on historical events and the County's and municipalities' natural environment. Analytical reviews were conducted for all hazards to develop a broad understanding of how each hazard has historically affected the County and to what extent environmental changes may influence future event frequency and severity. For hazards lacking spatial extent data, the review evaluated the types of land, and assets that are most likely to be exposed to the hazard. For hazards with spatial data, the level of analysis depended on the quality and quantity of available resources.

4.2 Exposure Levels

The loss estimations derived from the RVA methodology are grounded in a robust analysis of vulnerability and exposure levels across key community elements, including populations, buildings, and critical infrastructure systems. By integrating these factors, the RVA provides a nuanced and data-driven framework for evaluating the potential impacts of a wide range of natural hazards. This approach enables local governments, including both County and municipal entities, to identify and prioritize at-risk assets, assess the scale and scope of potential damages, and develop informed strategies for risk reduction and resilience planning. Ultimately, the RVA supports a more comprehensive understanding of community vulnerability, facilitating proactive decision-making to safeguard residents, essential services, and infrastructure.

5.0 SENSITIVITY ANALYSIS

Sensitivity refers to the degree to which a system, population or resource is or might be affected by hazards. This RVA includes a sensitivity analysis on assets for all hazard scenarios that evaluated the degree to which an area, asset, or population will experience adverse impacts, such as habitat loss, structural damage, or business closures. Adverse impacts vary based on the type of hazard and the item being studied.

5.1 Data Types and Methods

The quality and amount of data on physical sensitivity and asset characteristics vary by hazard and asset type. Where possible, the sensitivity analysis leveraged quantitative data to calculate expected structural damage, measured in dollars. For hazards with future-condition scenarios available, the change in structural damage was calculated to illustrate the increase in sensitivity due to changing conditions. **Figure 5-1** illustrates the sensitivity analysis' overall approach and integration of qualitative and quantitative information.

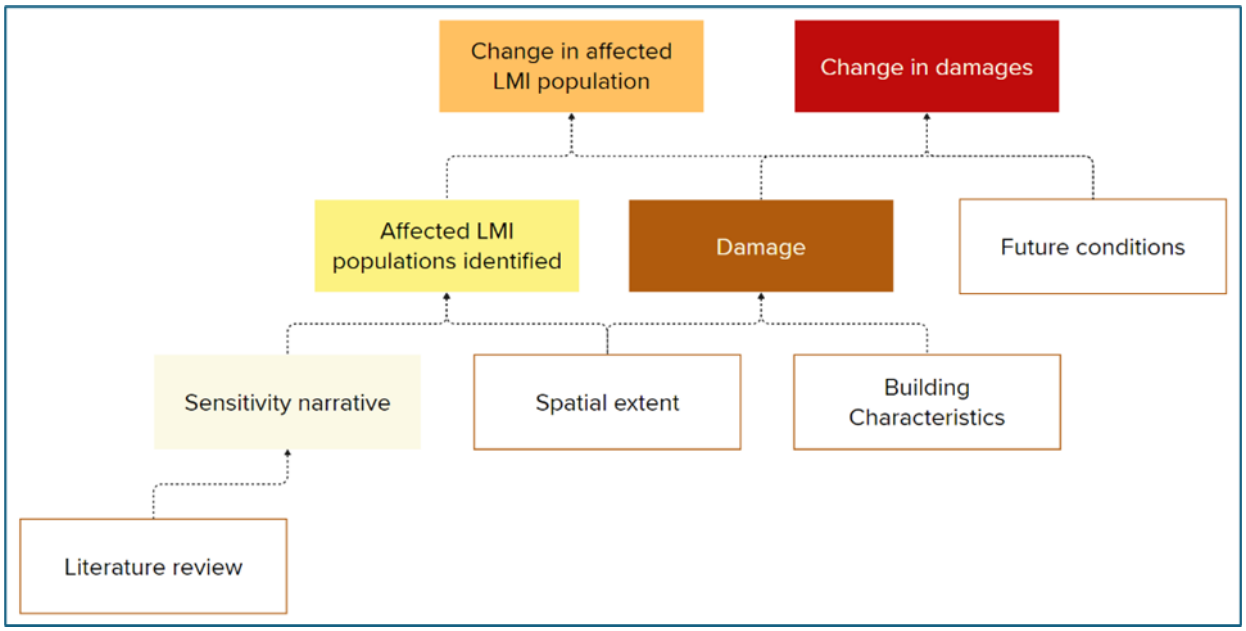


Figure 5-1. Sensitivity Analysis Framework

5.2 Determining Sensitivity

A population's sensitivity to adverse impacts depends on demographic characteristics such as income, age, or preexisting health conditions. For some populations, these adverse impacts may be disproportionate compared to the larger population or more likely to trigger cascading events, such as economic hardship or temporary displacement that can have increased impacts on vulnerable populations. If affected by a hazard, these populations may struggle to recover due to limited income to pay for home repairs or alternative shelter, inability to commute or work, or limited access to healthcare and medical services.

To identify sensitive populations, the HUD Low-to-Moderate Income (LMI) data was leveraged, which is available at the Census Tract level. Block Groups with higher shares of LMI populations may experience more severe impacts than those with lower shares. Individuals or households are considered LMI if their household income is no more than 80 percent of the median income for the area. For hazards with spatial data, sensitivity was evaluated by determining what share of a Block Group's LMI households are exposed.

Tracts with a Ranking Percentile Variable greater than 0.8 were extracted to identify the general highly vulnerable population areas. An area analysis was conducted on the remaining tracts by calculating the total square mileage of the tract, identifying the municipalities that are tied to the specific tracts, and performing an additional square mileage calculation of the smaller subset of tracts by jurisdiction. From there, a percentage was calculated that identified the percent of the LMI population for each segment of the tracts, delineated by jurisdiction. This provides an estimate of total vulnerable population within each jurisdiction. For hazards with spatial data, sensitivity was evaluated by performing an exposure assessment by area analysis. LMI populations were clipped down to the specific hazard of concern spatial extent, and total square mileage was leveraged to calculate a percentage to apply to the overall vulnerable population statistics. This process identifies the estimated LMI populations within each jurisdiction, by hazard of concern.

The HUD LMI database and mapping tools can assist with emergency preparedness in several ways. They can be used to estimate the amount of necessary supplies, such as food, water, medicine, and bedding, as well as the number of emergency personnel needed to assist at specific sites. The tool can also identify areas in need of emergency shelters and aid in the preparation of evacuation plans, accounting for those with special needs, and highlighting communities that may need continued support to recover from a natural disaster.

Economic vulnerability is a significant factor in resilience. Individuals earning a low percentage of the median household income may have less financial flexibility to recover from hazard-related damage or to invest in preventative measures such as insurance or home improvements that reduce hazard risk. In addition, households with limited incomes may also face challenges evacuating and accessing medical care or health resources following an event.

An individual's susceptibility to various hazards, like flooding, extreme heat, high winds and wildfire, is highly influenced by their housing conditions.

Mobile homes are an affordable form of housing in St. Lucie County, and they are distributed throughout the County, in rural as well as urban areas. There are 8,921 mobile home spaces and 1,184 recreational vehicle spaces throughout the County (SLC Planning & Development Services 2021). Manufactured housing is typically built on land that has been stabilized to ensure a sufficient anchoring system to serve as the unit's foundation (FEMA 2009). However, if the area is affected by storm surge or flooding, these anchoring systems could be weakened or damaged, increasing the risk for potential damage or other harm. In addition, people who reside in manufactured housing may lack air conditioning or struggle to keep their units cool, depending on the building's materials and insulation efficiencies (Bernard and Proano 2022), making them more susceptible to the impacts of extreme heat events and health risks.

Public housing units tend to be older, meaning they were built before more resilient design standards were implemented, making them more susceptible to flooding, storms and extreme heat. Moreover, the types of individuals who rely on public housing may also experience additional demographic factors, such as age or access to healthcare, that compound these risks (Gabbe and Pierce 2020). If their unit is damaged due to flooding, this could lead to compounding impacts, such as increased likelihood of mold and reduced indoor air quality, or difficulty finding temporary shelter elsewhere due to the unit's conditions.

In the context of hazard risk, the correlation between higher rates of renters in a community and increased vulnerability is critical. Renters often reside in areas more susceptible to hazards such as flooding, either due to the lower cost of housing in such locations or limited availability of affordable options in safer areas. This situation places them at a disproportionate risk during hazard-related events, not only in terms of immediate physical danger but also regarding the longer-term repercussions on their stability and well-being. The transient nature of rental housing means that renters may have less knowledge about local hazard risks and less incentive to invest in long-term hazard preparedness measures.

6.0 ASSESSMENT MODELING AND METHODOLOGIES

6.1 Overview of Modeling Approach

The Project Team conducted the RVA by exploring various future scenarios across the County and municipalities. The geospatial exploration conducted is intended to aid the County and municipalities in making decisions that bolster resilience against hazard impacts. The analyzed hazard scenarios provide projections for both general predictions and characterizations of current conditions.

The RVA uses an adaptive mixed-methods approach leveraging the best available data for SLC and the municipalities. The RVA modeling approach characterizes vulnerability, the extent to which an area, asset, or population could be harmed by a hazard, as a function of two components:

- **Exposure,** which refers to the spatial presence of populations, assets, or systems in locations that are susceptible to specific hazards. It quantifies the potential for these elements to be physically affected based on their geographic proximity to the hazard source and the nature of the asset or area under consideration. Exposure is fundamentally determined by location and the distribution of elements at risk.
- **Sensitivity,** which denotes the degree to which an exposed population, asset, or system is likely to experience negative consequences when subjected to a hazard. It reflects the intrinsic characteristics or conditions—such as structural robustness, ecological fragility, or number of residents—that influence the severity of impact. Sensitivity is hazard-specific and varies according to the vulnerability profile of the element being assessed.

The RVA uses quantitative and qualitative data to comprehensively characterize SLC and the municipalities' vulnerability to hazards. **Figure 6-1** illustrates the RVA's overall framework.

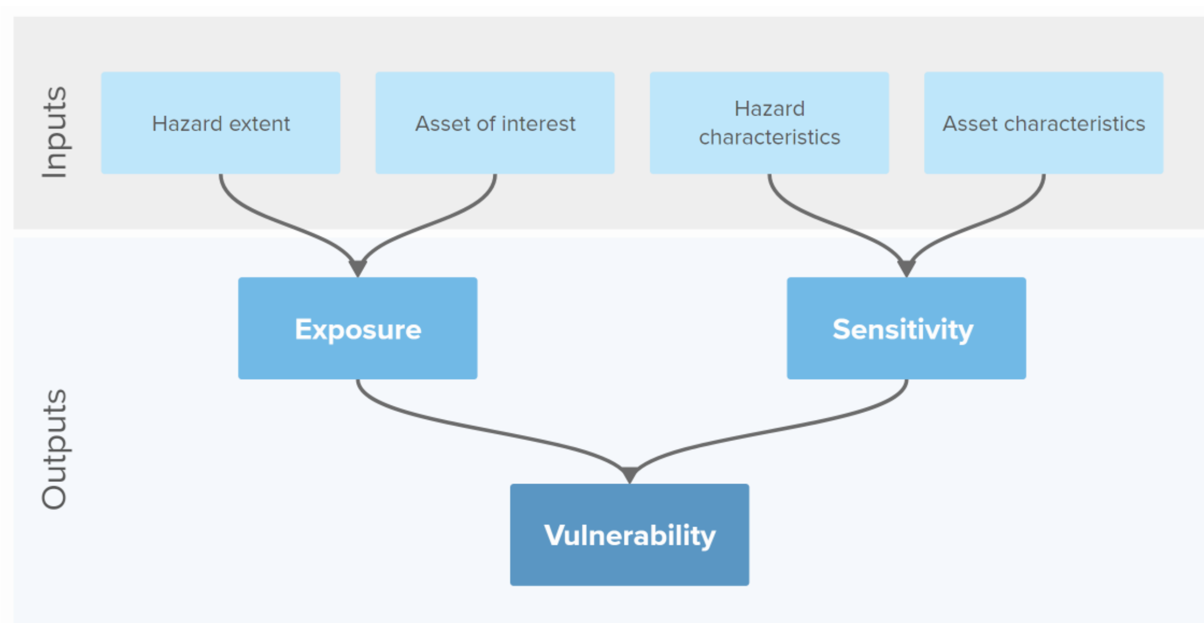


Figure 6-1. Regional Vulnerability Assessment Approach Framework

6.2 Hazard Modeling and Results

The following sections describe the modeling approach for each hazard and the exposure and sensitivity results. Recommendations are discussed in Section 8.0.

6.2.1 Coastal Erosion

This assessment evaluates the geographic distribution of coastal erosion risk in St. Lucie County using data from two primary sources: the Florida Department of Environmental Protection's Coastal Critical Erosion Area data (2024) and the U.S. Geological Survey (USGS) National Shoreline Change short-term linear regression rates (2021). These rates reflect changes in shoreline position from the 1970s to 2018 and include both erosion (land loss) and accretion (land gain).

6.2.1.1 Coastal Erosion Exposure Analysis

The County's oceanfront habitats form its first line of defense against storms and rising seas. Beach systems naturally buffer inland areas from wave energy, while providing critical nesting habitat for sea turtles. Rocky intertidal zones create stable shoreline anchors and support diverse marine life. These systems show high vulnerability to erosion and storms but demonstrate a moderate capacity to adapt through natural processes when given sufficient space and sediment supply.

To assess risk, County and municipal assets—such as infrastructure and population centers—were overlaid with the areas identified as vulnerable to erosion (**Figure 6-2** and **Figure 6-3**). The analysis estimated the following:

- Length (in miles) of shoreline projected to be affected by erosion
- Acreage of erosion zones
- Number of critical assets exposed
- Population count in erosion zones
- Overall land area impacted under two future time horizons: 2040 and 2070

This modeling approach assumes erosion continues at a constant rate, based on historical trends, without considering the influence of future coastal storms, sea level rise, or the construction of protective infrastructure such as breakwater structures, beach renourishment, or revetments. The resulting data defines a projected impact zone and illustrates expected erosion boundaries: pink for 2040 and green for 2070. However, because the model excludes real-world variables such as mitigation efforts and extreme weather events, its outputs should be used strictly as planning references. The actual process of erosion is expected to be continuous, uneven, and variable across locations.

Figure 6-2. South St. Lucie County Coastal Erosion Hazard Area

Figure 6-3. Central St. Lucie County Coastal Erosion Hazard Area

Land, Assets, and Population Exposure to Coastal Erosion

Land Exposure

Across the County, areas expected to face additional exposure to erosion are limited. By 2040, the number of acres exposed to erosion will grow by 24.7 acres, and by 2070 will increase to 92.8 acres.

Asset Exposure

Of the 27,211 critical assets evaluated across the county, 52 miles of transportation and evacuation routes by 2040 and 193 miles by 2070 could be impacted by coastal erosion. This represents 0.1 percent and 0.2 percent respectively of County-wide transportation and evacuation route miles. Two Natural, Cultural, and Historic assets face exposure to 2070 landward coastal erosion.

Population Exposure

Due to the limited geographic extent of the Critical Coastal Erosion Areas and shoreline data, less than 0.1 percent of the total population will be directly exposed to coastal erosion in 2040 and 2070, representing 61 people and 230 people respectively.

Coastal Erosion Sensitivity Analysis

Coastal erosion and accretion are continual and cyclical with net sand losses due to the interruption of sand by manmade inlets as well as natural processes. FDEP has identified St. Lucie County at a medium-high risk to erosion. The beaches of Florida will continue to shift and change over time, especially when faced with current levels of development and future changes in frequency and severity of storm events. The probability of future beach erosion in St. Lucie County is high. Erosion is exacerbated by tropical storms, winter storms, and hurricanes and is anticipated that there will be at least one storm event on an annual basis that will contribute to erosion (SLC Department of Public Safety Division of Emergency Management 2021). Erosion can have the following potential impacts within a community:

- Degradation of sandy beaches, dunes, mangroves and other critical environmental resources, impacting beach access, habitats for many species of plants and animals, and losses in tourism, shipping, trade, fishing, and other industries;
- Navigable waterway impairment;
- Damage to infrastructure;
- Higher rates of runoff, shedding of water, and pollutants;
- Limitation to new development in some coastal areas;
- Creation of new water channels from spoil deposits, and flooding of areas previously not impacted; and
- Stormwater drainage impairment.

Florida's Atlantic coastline will face a consistent threat of erosion from nuisance flooding and more extreme events as sea levels rise. Without offsetting changes in natural sediment supply, SLC's sandy beaches will rapidly erode and migrate toward the mainland. Additionally, increased frequency and intensity of extreme precipitation and/or drought events can elevate the risk of erosion by destabilizing soils on the coast and inland. While projections regarding the frequency of hurricanes remain uncertain, there is strong scientific consensus that hurricane-associated rainfall will increase as the atmosphere continues to warm. Warmer air holds more moisture, leading to heavier rainfall during tropical storms and hurricanes (Papacek, et al. 2024). This means that even lower-category storms could produce torrential rainfall, resulting in significant erosion and flooding impacts, including vulnerable coastal zones.

A recent example is Hurricane Nicole in November 2022. Although it was a Category 1 storm, Nicole caused widespread coastal erosion along Florida's east coast, including areas in and around St. Lucie County. The storm's slow movement and prolonged rainfall, lasting over 48 hours, was exacerbated by Hurricane Ian's extreme rainfall that in the region just weeks earlier. Nicole's impact highlighted how cumulative storm effects and slower-moving systems can dramatically increase erosion and infrastructure vulnerability, even when storm intensity is relatively low (Massachusetts Institute of Technology 2020).

These events usually cause damage to structures located along the beaches and Lagoon, especially if there is no dune or marsh system to slow down the wave action. Where structures are not present, the over wash process that happens when surge or waves overtop dune systems allows those systems to migrate inland. While this migration of barrier islands is a natural process, the installation of structures like homes, roads, and other infrastructure requires that this movement be managed. Without the implementation of mitigation strategies, rising sea level will further threaten the stability of the coastline and increase the potential for more damage during a future event. Beyond damage to the beach, dune systems and coastlines, the survival of coastal wetlands is also threatened when they cannot adapt fast enough to offset the rising sea (see Part II: SLAMM Analysis). This could have disastrous consequences to fishery ecosystems, biodiversity, and tourism that St. Lucie's economy relies upon (Florida Division of Emergency Management 2023).

6.2.2 Drought

The drought hazard assessment consisted of a qualitative analysis, drawing upon a range of data sources such as water supply and use, projected population growth estimates, historical monetary losses due to drought, historical drought events and future climate projections, and precipitation estimates. Historical data included regional plans and studies, as well as national sources. The analysis identified areas of high susceptibility to drought based on historical information and the potential effects of drought.

6.2.2.1 Drought Exposure Analysis

Droughts generally affect broad regions with drier than normal conditions. For the drought assessment, it is assumed the entire County is equally exposed to drought. According to the U.S Drought Monitor, St. Lucie County and its municipalities are expected to experience 9 to 10 weeks of drought per year based on the average weeks of annualized drought in the County from 2000 to 2022.

The map uses five categories to depict the location and intensity of drought: Abnormally Dry (D0), showing areas that may be going into or are coming out of drought, and four levels of drought (D1-D4).

Since 2000, the U.S. Drought Monitor has documented more than 560 drought events in St. Lucie County. The worst drought (D4 extreme) occurred from May 1, 2011 until October 2011. When compared with the rest of the nation, FEMA's National Risk Index rates the County's expected annual loss due to drought as "relatively moderate" with $1.3 million in projected annual losses (FEMA 2025). The National Risk Index forecasts an annualized frequency of 18 events per year based on historical data from 2000 to 2021. St. Lucie County's 2021 Unified Local Mitigation Strategy assesses future probability of drought as "high" based on past occurrences and the cyclical nature of drought in the County.

The impacts of drought can be difficult to measure because it affects many sectors of the local economy. Industries that rely on ecological health—such as agriculture, landscaping, recreation, and tourism—can experience impacts ranging from minor to severe. Impacts on agriculture in St. Lucie County includes hay, haylage, and livestock such as cattle and sheep. Droughts may result in reduced surface and groundwater availability. Water demand (particularly in industry sectors such as agriculture or hydropower), precipitation and runoff, groundwater withdrawals, and aquifer recharge may all be affected. Buildings and facilities are typically not considered vulnerable to drought conditions. However, drought conditions increase the risk of wildfires that can threaten buildings, homes and property (see Section 6.2.7).

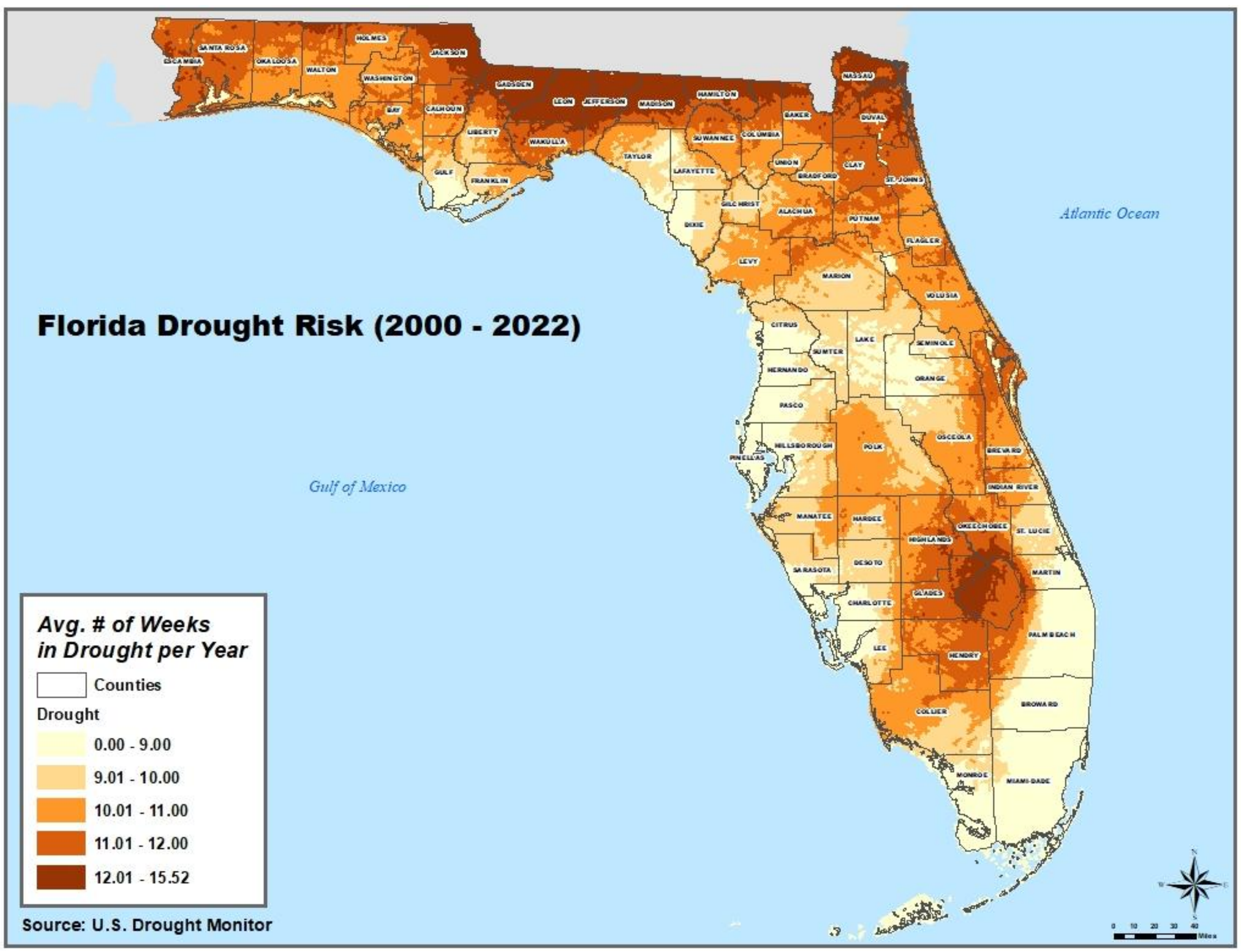


Figure 6-4. Average Number of Drought Weeks per Year 2000-2022

Category	Description	Possible Impacts
D0	Abnormally Dry	**Going into drought:** Short-term dryness slowing planting and growths of crops/pastures **Coming out of drought:** Some lingering water deficits; pastures/crops not fully recovered
D1	Moderate Drought	Some damage to crops/pastures Streams, reservoirs, or wells low, water shortages developing Voluntary water-use restrictions requested
D2	Severe Drought	Crop/pasture losses likely Water shortages common Water restrictions imposed
D3	Extreme Drough	Major crop-pasture losses Widespread water shortages or restrictions
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses Shortages of water in reservoirs, streams, and wells creating emergencies

Figure 6-5. U.S. Drought Monitor Drought Categories

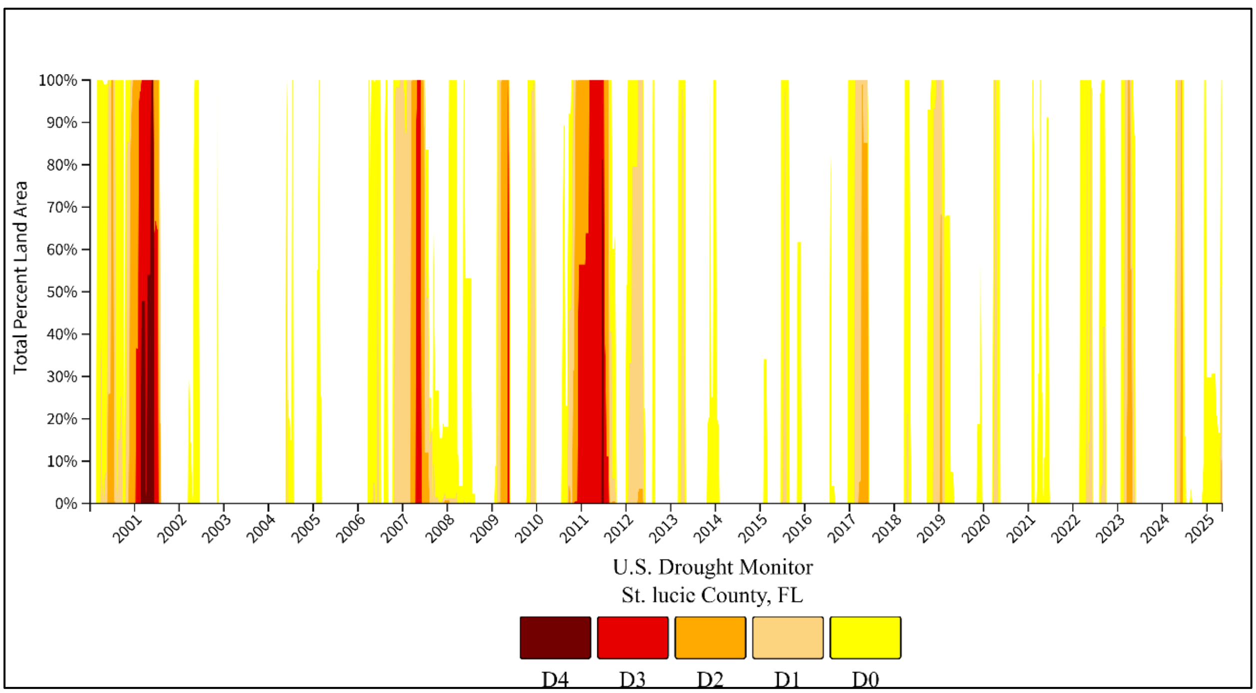


Figure 6-6. Historical Conditions for St. Lucie County 2000-2025

In addition to these economic and ecological impacts, drought conditions can also increase the risk of sinkhole formation. Although buildings and facilities are typically not considered vulnerable to drought conditions directly, the increased potential for sinkholes poses a secondary hazard to infrastructure. This risk is particularly relevant in areas with known karst geology, where even minor shifts in groundwater levels can lead to ground subsidence or collapse (Thompson Earth Systems Institute 2022). The geologic subdistrict known as the Green Ridge Loxahatchee Karst area, located in central and south St. Lucie County, is more prone to dissolution, forming sinkholes, springs, and underground conduits. This karst system typically allows rapid infiltration, with stormwater draining into the subsurface. However, if sinkholes clog or conduits become overloaded, drainage is impeded, and surface flooding can result. The complex, uneven underground drainage creates unpredictable flood patterns, sometimes causing flash flooding far from the rainfall source. In this subdistrict, the geology creates both rapid drainage routes and hidden flood risks when those pathways fail (see Part II: SLAMM Analysis) (Clearview Geographics LLC.).

6.2.2.2 Drought Sensitivity Analysis

St. Lucie County will continue to be exposed to droughts in the future, with drought events potentially becoming more severe and prolonged than in the past. By mid- to late-century, the County is expected to receive a minimal net increase in annual precipitation as it does today in both low- and high-emission scenarios (NOAA 2025b). Overall, the County and its municipalities are expected to experience higher temperatures year-round. As temperatures rise, the rate of soil moisture loss will accelerate, meaning the minimal increase in annual rainfall and shift in the dry season is unlikely to lessen the impacts of increased temperatures (NOAA 2022).

In early 2025, parts of Florida experienced the most severe drought in nearly a quarter-century. By May 2025,more than 84 percent of the state including SLC, was under dry conditions ranging from abnormally dry to extreme drought (Skinner 2025) (**Figure 6-7**).

During this event, the U.S Drought Monitor classified 49 percent of the county as “abnormally dry” (D0), 41 percent as “moderate drought” (D1), and 11 percent as “severe drought” (D2), totaling approximately 52 percent of the county in an active drought area (National Drought Mitigation Center 2025).

Over the previous 30 days of this drought event, precipitation across most of the County was 25 to 50 percent of the historical average, and zero to 25 percent in some areas, as compared to the same date range from 1991 to 2020 (**Figure 6-8**).

These conditions led to increased wildfire risks, with multiple brush fires reported across SLC and the broader Treasure Coast region. In tandem with the dry weather, more than 1,600 wildfires burned nearly 75,000 acres of land across South and Central Florida since the start of the year, according to Florida Forest Service wildfire data. The combination of below-average rainfall and higher-than-average temperatures strained local agriculture in St. Lucie County, particularly citrus groves that were already facing increased risk of citrus greening disease due to drought conditions.

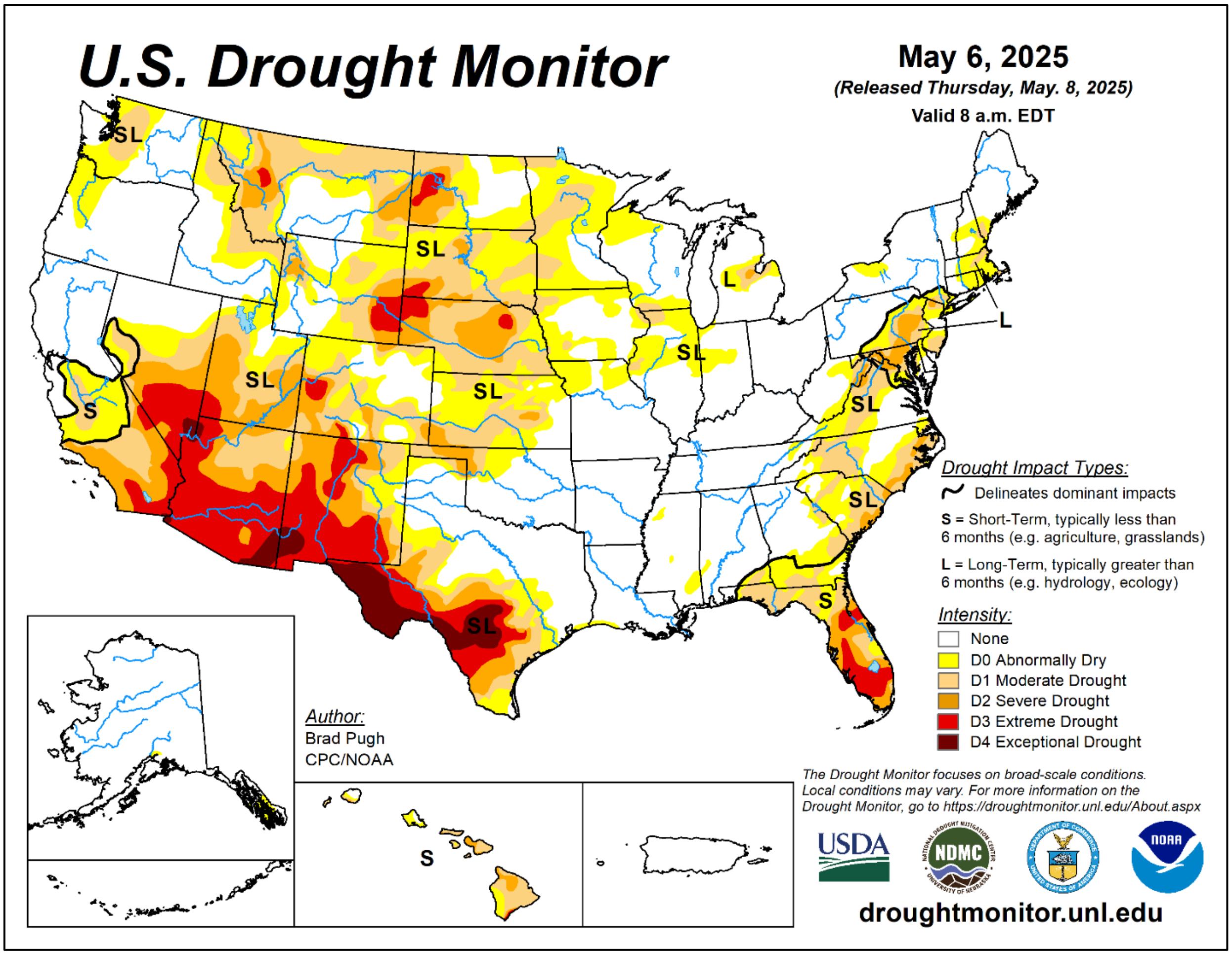


Figure 6-7. U.S. Drought Conditions May 2025

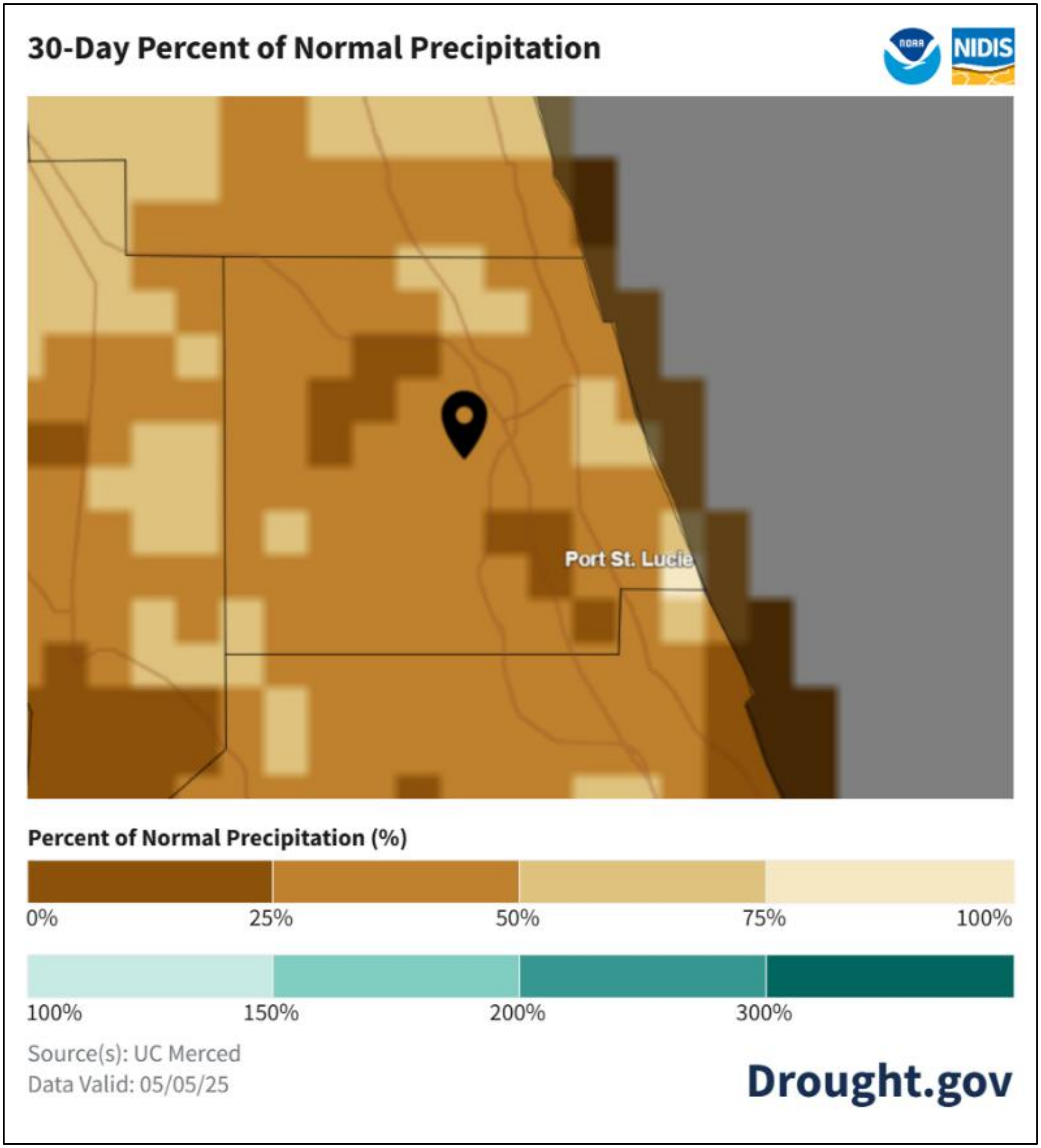


Figure 6-8. St. Lucie County 30-Day Precipitation April 2025

6.2.3 Extreme Heat

To evaluate exposure to extreme heat, the heat assessment used the average number of days per year that exceed 95ºF in St Lucie County, in conjunction with areas that have historically experienced the urban heat island effect. Using the Trust for Public Land's Urban Heat Island Severity Index, assets were overlaid with the extreme heat hazard data (low, medium, and high). An area analysis was performed that identified the total acreage exposed to the extreme heat hazard.

6.2.3.1 Extreme Heat Exposure Analysis

Florida is known for its high humidity and heat, which combine to affect its population. Due to its proximity to large water bodies and wetlands, Florida typically experiences fewer days than other states where the temperature reaches 95˚F or greater. However, that proximity also increases the humidity. As the air temperature warms, water is evaporated into the atmosphere, causing a rise in humidity, average rainfall, and the frequency of heavy rainstorms in many places (Florida Enhanced State Hazard Mitigation Plan 2023). The heat index, also known as the 'apparent temperature' is a measure of the actual temperature as felt by the human body. A high heat index decreases the body's ability to dissipate heat, which can lead to heat exhaustion, heat stroke, dehydration and cardiovascular and nervous systems impacts.

In Florida, the average air temperature has increased over 2°F since the beginning of the twentieth century (Runkle et al. 2022). Seventy years from now, most of the state is likely to experience 45 to 90 days per year with temperatures above 95°F, compared to less than 15 days per year today. In addition, Florida's summer heat index is expected to experience the largest increase in the United States with an increase of 8°F to 15°F (Runkle et al. 2022).

The urban heat island effect further compounds this issue in many densely populated areas of the County with high amounts of impervious surface as compared to outlying areas. These surfaces absorb and re-emit the sun's heat into the atmosphere, increasing localized temperatures. In contrast, vegetated and natural areas re-emit less heat and provide more shade (EPA 2023) reducing the heat island effect.

The National Centers for Environmental Information (NCEI) reports that the average annual temperature across the contiguous U.S. in 2024 was 55.5 degrees Fahrenheit, 3.5 degrees above the 20th-century average, ranking as the nation's warmest year in NOAA's 130-year climate record (NOAA 2025).

Future Climate Indicators

Indicator	Modeled History (1976 - 2005)	Early Century (2015 - 2044)		Mid Century (2035 - 2064)		Late Century (2070 - 2099)	
		Lower Emissions	Higher Emissions	Lower Emissions	Higher Emissions	Lower Emissions	Higher Emissions
	Min - Max	Min - Max	Min - Max	Min - Max	Min - Max	Min - Max	Min - Max
Temperature thresholds:							
Annual days with maximum temperature > 90°F	60 days 60 - 72	119 days 77 - 150	124 days 89 - 143	138 days 92 - 169	154 days 116 - 182	157 days 113 - 186	201 days 155 - 235
Annual days with maximum temperature > 95°F	2 days 1 - 3	17 days 2 - 42	21 days 5 - 39	33 days 7 - 72	53 days 15 - 98	56 days 10 - 97	121 days 51 - 163
Annual days with maximum temperature > 100°F	0 days 0 - 0	0 days 0 - 1	0 days 0 - 1	1 days 0 - 5	2 days 0 - 10	3 days 0 - 5	26 days 3 - 85
Annual days with maximum temperature > 105°F	0 days 0 - 0	0 days 0 - 0	0 days 0 - 0	0 days 0 - 0	0 days 0 - 0	0 days 0 - 0	1 days 0 - 7
Annual temperature:							
Annual single highest maximum temperature °F	96 °F 95 - 96	98 °F 96 - 100	98 °F 96 - 100	99 °F 97 - 101	100 °F 98 - 102	100 °F 97 - 102	104 °F 101 - 107
Annual highest maximum temperature averaged over a 5-day period °F	93 °F 93 - 94	96 °F 94 - 97	96 °F 94 - 97	97 °F 95 - 99	98 °F 96 - 100	98 °F 95 - 100	101 °F 98 - 104
Cooling degree days (CDD)	3405 degree-days 3294 - 3542	4,086 degree-days 3,622 - 4,708	4,147 degree-days 3,735 - 4,518	4,402 degree-days 3,781 - 5,072	4,701 degree-days 4,058 - 5,183	4,746 degree-days 4,053 - 5,364	5,710 degree-days 4,777 - 6,499

N/A = Data Not Available for the selected area

Source: (NOAA n.d.)

Figure 6-9. St. Lucie County Extreme Heat Days Through 2099

This 'extreme heat' assessment evaluates the change in the average annual number of days that reached or exceeded 95°F from the present day up to 2099 in St. Lucie County, based on relatively low carbon emissions (RCP 4.5) and relatively high (RCP 8.5) carbon emission scenarios. The Lower Emissions Scenario, RCP 4.5, is a possible future in which heat-trapping emissions are drastically reduced by 2040. The Higher Emissions Scenario, RCP 8.5, is a possible future in which emissions continue to trend higher throughout this century.

As maximum and minimum temperatures rise, so does the possibility of extreme heat events and urban heat islands. Over the next 65 years, these patterns in SLC are expected to intensify due to projected future conditions.

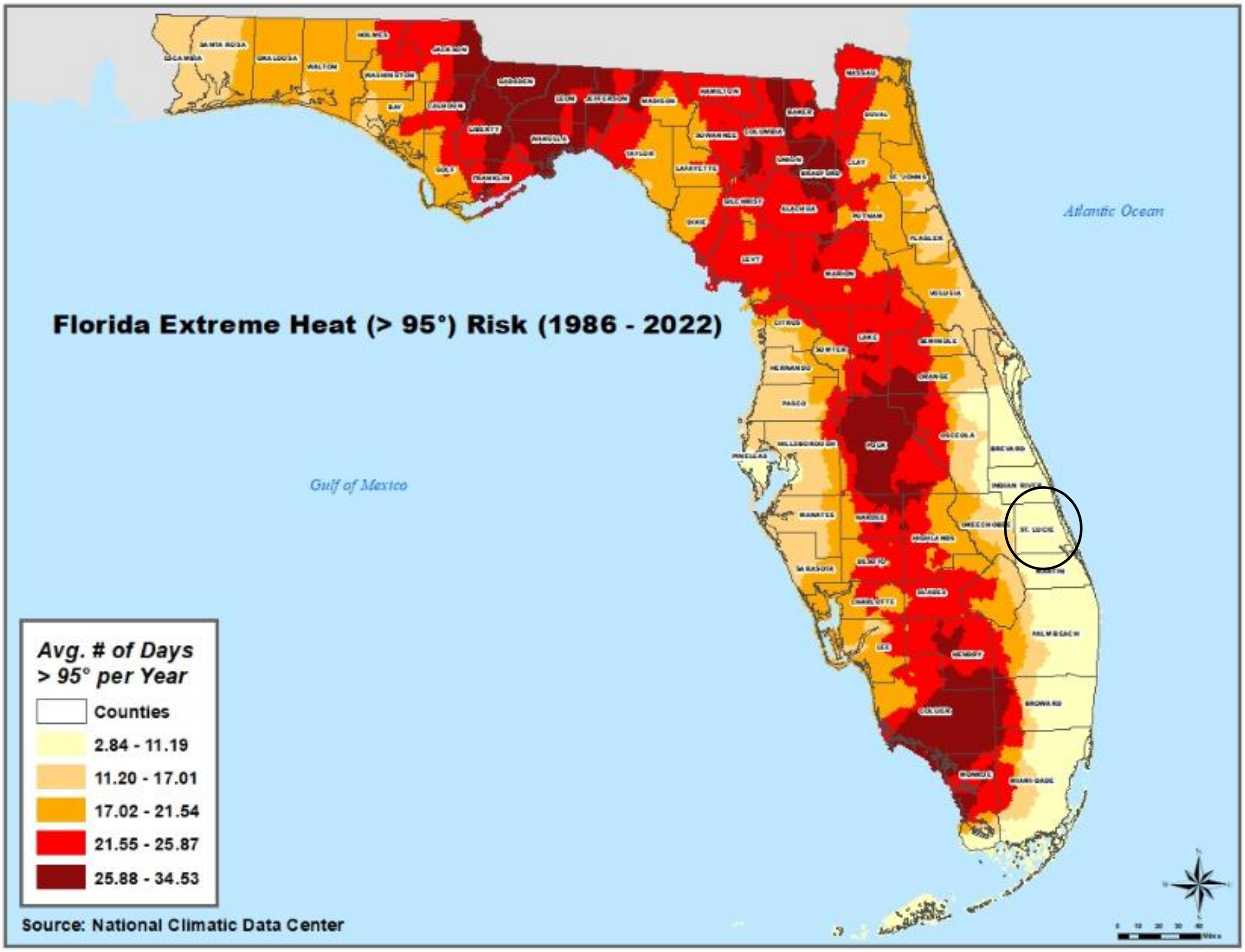
As shown in **Figure 6-9**, the County experienced less than 3 days each year in which maximum temperatures reached or exceeded 95°F. Projections for the early 21st century, through 2044, jump from an average of 2 days in the modeled history (1976-2005) to 17 days in the lower emissions scenario and 21 days in the higher emissions scenario. By the late century, 2070-2099, the average number of annual days with maximum temperatures above 95°F is projected to increase to 56 days and 121 days in the respective scenarios.

Land, Assets and Population Exposure

Land Exposure

All of St. Lucie County and its municipalities are exposed to extreme heat, but certain topographies and development patterns increase the likelihood of urban heat islands. An urban heat island is an area with a high ratio of impervious surfaces (such as buildings and roadways) relative to green spaces. These locations usually experience higher maximum daytime temperatures and less nighttime cooling, effectively becoming isolated areas (e.g., "islands") of temperatures that are several degrees hotter than other areas.

According to the Florida Department of Transportation's 2018 Florida Population Growth report, roughly 88 percent of Florida's population resides in urban areas (FDOT 2019). The Florida Extreme Heat Risk Map, as displayed in **Figure 6-10**, shows the average number of days with temperatures above 95 degrees each year. Even though there are large concentrations of urban areas along the coast, proximity to the ocean generally keeps these areas cooler than the more interior regions of Florida (Florida Division of Emergency Management 2023).



Please note: St. Lucie County indicated by black circle.

Figure 6-10. Florida Extreme Heat Risk Map

To evaluate exposure to extreme heat, the heat assessment identified areas in the County that have historically experienced urban heat island effects. Using the Trust for Public Land's Urban Heat Island Severity Index, assets were overlaid with the extreme heat hazard data. The purpose of this layer is to show where certain areas of cities are hotter than the average temperature for that same city as a whole. This 30-meter raster was derived from Landsat 8 imagery band 10 (ground-level thermal sensor) from the summer of 2023 (The Trust for Public Land 2024). An area analysis was performed that identified the total acreage of the County exposed to the extreme heat hazard (Figure 6-11). For the purposes of these analyses the Urban Heat Island Severity Index rankings, 1 (mild) to 5 (severe), we categorized as low (1 or mild), medium (2 or mild to moderate, 3 or moderate) and high (5 or severe).

As shown in **Table 6-1**, approximately 63,200 acres of the entire County are considered exposed to extreme heat, representing 17 percent of the total land area. The data and maps associated with the extreme heat hazard should be used as a reference and for planning purposes only.

Table 6-1. Land Area Exposure to Extreme Heat

Jurisdiction	Total Land Area (Acres)	Land Area (Acres) Exposed to Extreme Heat					
		Low	Percent of Total	Medium	Percent of Total	High	Percent of Total
Fort Pierce (C)	15,663.3	2,659.9	17.0%	7,897.5	50.4%	81.8	0.5%
Port St. Lucie (C)	75,850.8	14,301.1	18.9%	28,868.9	38.1%	8.2	<0.1%
St. Lucie Village (T)	524.0	51.6	9.8%	105.5	20.1%	15.8	3.0%
Unincorporated St. Lucie County	274,265.0	4,379.3	1.6%	4,861.0	1.8%	169.5	0.1%
St. Lucie County (Total)	**366,303.2**	**21,391.9**	**5.8%**	**41,732.9**	**11.4%**	**275.3**	**0.1%**

Unincorporated St. Lucie County primarily consists of relatively undeveloped rural land, natural vegetation, wetlands and surface waters, leading to minimal exposure from extreme heat, with just 3.4 percent exposure across all scenarios, with about 2 percent under medium-level extreme heat **Figure 6-11**.

Nearly 70 percent of Fort Pierce's total land mass is exposed to extreme heat across all scenarios, with about 50 percent ranked as medium-level extreme heat as visualized in orange in **Figure 6-12**.

Approximately 56 percent of Port St. Lucie's total land cover (43,178 of 75,850 acres) is exposed to extreme heat across all scenarios, with 38 percent ranked as medium-level extreme heat. (**Figure 6-13**).

About 32 percent of St. Lucie Village's total land mass is exposed to extreme heat across all scenarios, with 20 percent ranked as medium-level extreme heat (**Figure 6-14**).

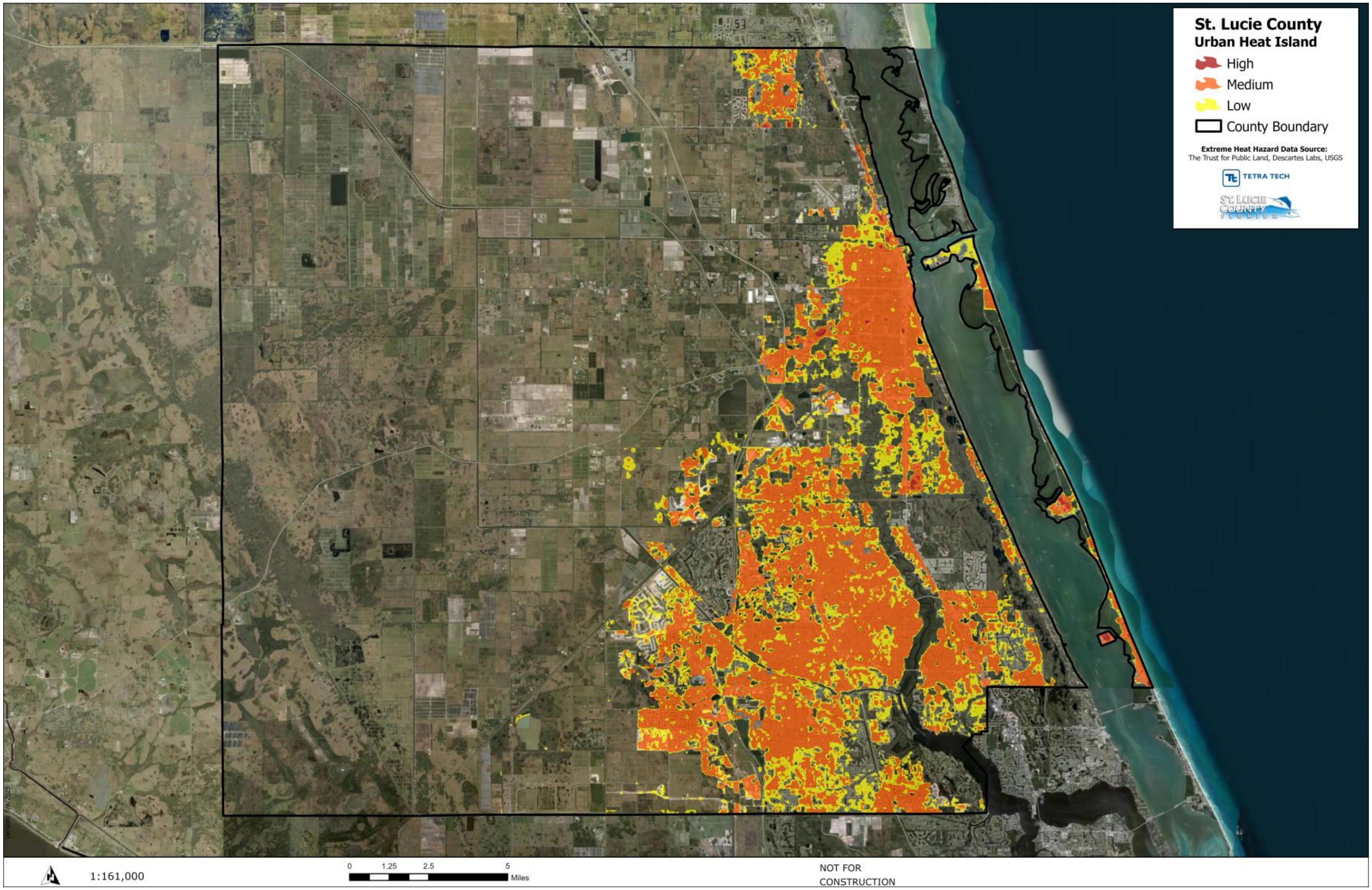


Figure 6-11. St. Lucie County Extreme Heat Hazard Area

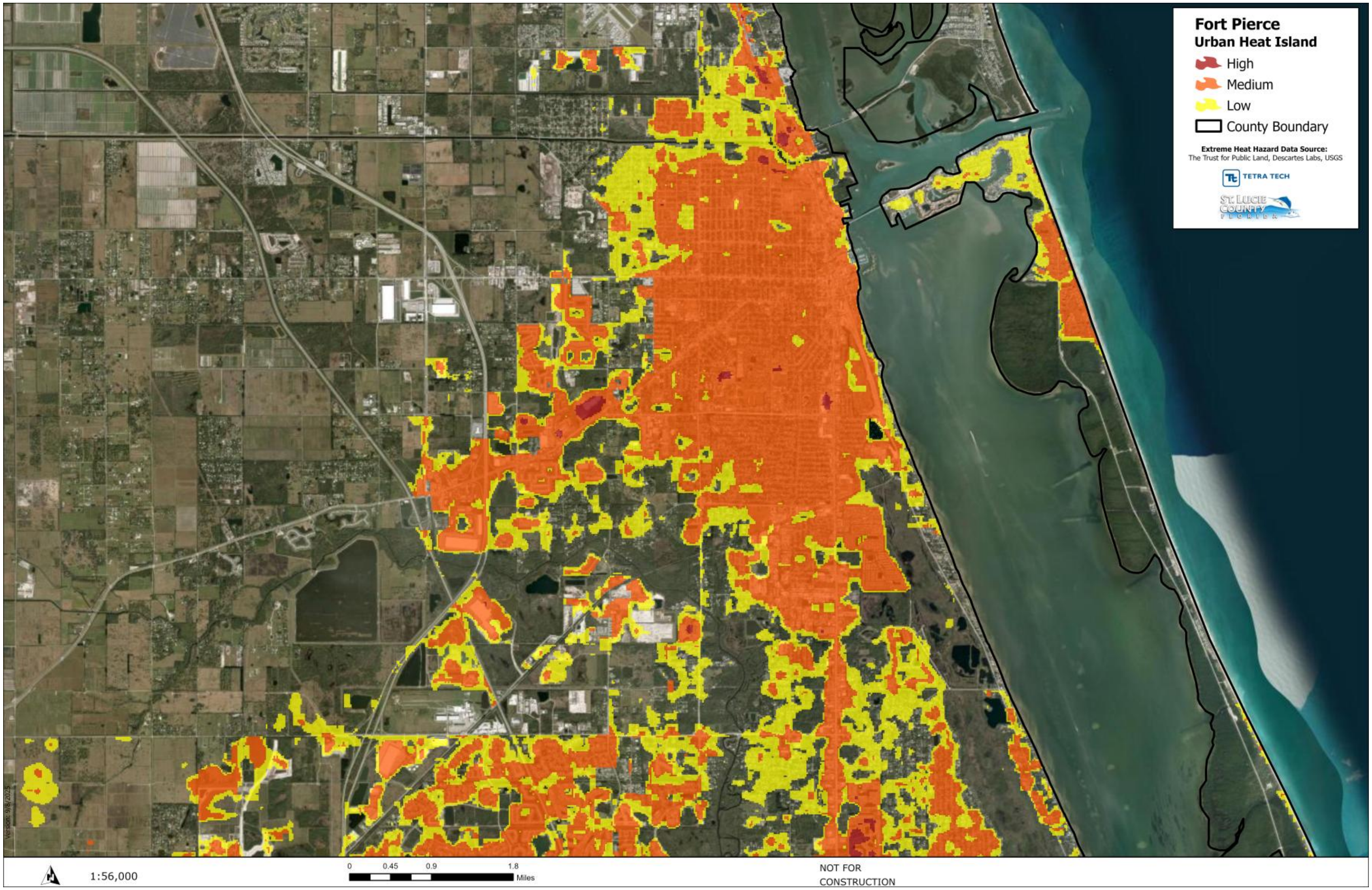


Figure 6-12. Fort Pierce Extreme Heat Hazard Area

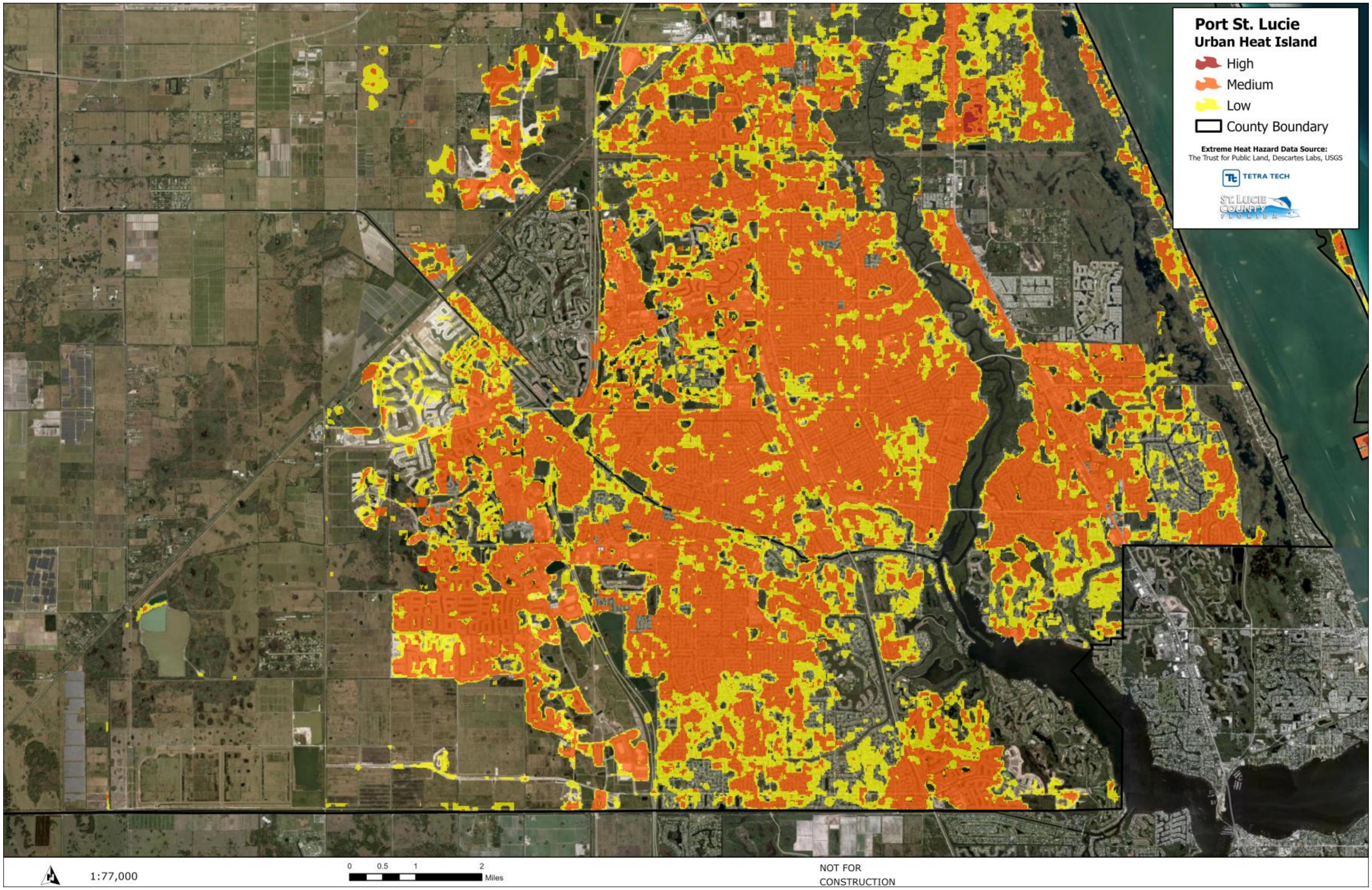


Figure 6-13. Port St. Lucie Extreme Heat Hazard Area

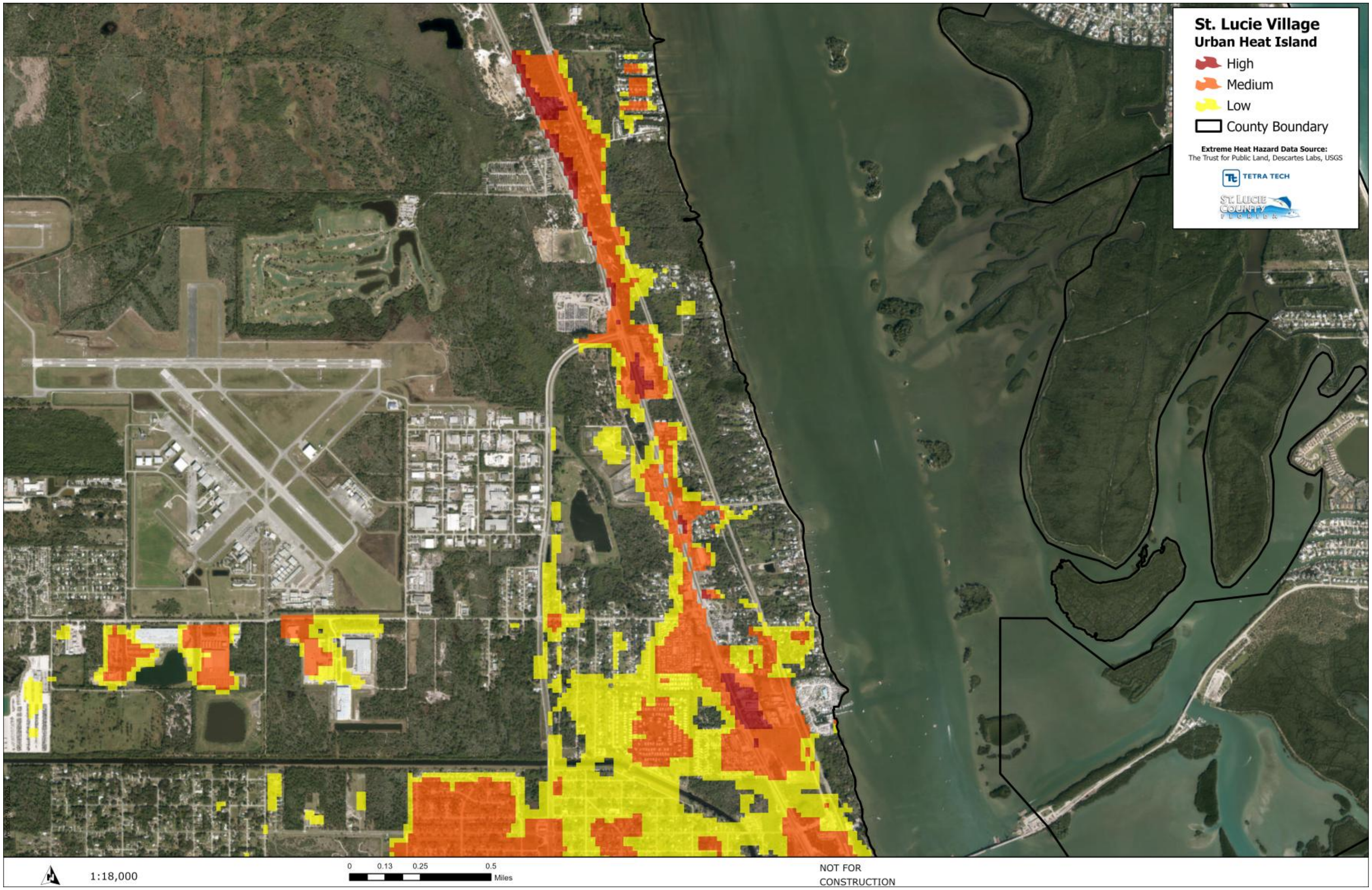


Figure 6-14. St. Lucie Village Extreme Heat Hazard Area

Asset Exposure

Although facilities themselves are not typically vulnerable to extreme heat, the areas or regions that the facilities are in may be susceptible to extreme heat. Additionally, the efficiency at which a building operates may be affected if the building is in an area vulnerable to extreme heat. For example, extreme heat conditions can result in less efficient cooling systems or systems that must run constantly to effectively cool a building. This can lead to utility failure and energy infrastructure disruption.

Extreme heat can also have serious implications for transportation infrastructure, particularly roadways. High temperatures cause asphalt to soften and deform, leading to rutting, cracking, and pothole formation, especially under the weight of heavy vehicles. When temperatures reach around 100°F, road surface temperatures can exceed 140°F, causing the bitumen in asphalt to become pliable and sticky. This not only increases maintenance costs but also creates safety hazards such as reduced tire grip and vehicle instability. In some cases, roads can become buckled or melted, requiring emergency repairs and temporary closures.

Assets that intersected the extreme heat hazard area are considered exposed. The analysis determined the extent (in miles) of shoreline, the extent (in acreage) of critical asset areas, count of critical assets and population, and land area affected by the extreme heat hazard.

As shown in **Table 6-3**, 27,211 critical assets countywide were assessed. Roughly 14 percent are classified as low exposure, 47 percent as medium exposure, and 0.9 percent as high exposure to extreme heat. A total of 945 Critical Community and Emergency Facilities assets, or 70.3 percent, and 15,837 Critical Infrastructure assets, or 67.5 percent, are classified as medium extreme heat exposure.

A total of 18,654 critical assets in the City of Fort Pierce were assessed for exposure to extreme heat. Of these approximately 11 percent are classified as low exposure, 76 percent as medium exposure, and 0.88 percent as high exposure to extreme heat across all asset categories. The largest total number of assets exposed are Critical Infrastructure; nearly 14,000 of these assets are exposed in the medium extreme heat scenario.

A total of 805 critical assets in the City of Port St. Lucie were assessed. Of these, approximately 26 percent are classified as low exposure, 47 percent as medium exposure, and zero percent as high exposure to extreme heat across all asset categories. The largest total number (250) of assets assessed in Port St. Lucie are Critical Community and Emergency Facilities facing medium extreme heat exposure.

The Town of St. Lucie Village includes 445 critical assets analyzed for extreme heat exposure. Approximately 44 percent are classified as low exposure, 25 percent as medium exposure and 1.28 percent as high exposure to extreme heat across all asset categories. A total of 138 Critical Infrastructure assets are exposed to medium extreme heat.

In the unincorporated areas of the County 7,307 critical assets are included in this analysis. Approximately 9 percent are classified as low exposure, 52 percent as medium exposure and 0.78 percent as high exposure to extreme heat. A total of 1,558 Critical Infrastructure assets face medium extreme heat exposure.

Table 6-2. Number of Critical Assets Exposed to Extreme Heat

Jurisdiction	Critical Asset Category	Total Critical Assets Evaluated	Number of Critical Assets Exposed to Extreme Heat					
			Low	% of Total	Medium	% of Total	High	% of Total
Fort Pierce (C)	Critical Community and Emergency Facilities	714	26	3.6%	641	89.8%	23	3.2%
	Critical Infrastructure	17,152	2,069	12.1%	13,989	81.6%	37	0.2%
	Natural, Cultural, and Historic Resources	761	64	8.4%	589	77.4%	1	0.1%
	Transportation and Evacuation Routes	27	5	18.5%	15	55.6%	0	0.0%
Port St. Lucie (C)	Critical Community and Emergency Facilities	343	61	17.8%	250	72.9%	0	0.0%
	Critical Infrastructure	275	55	20.0%	152	55.3%	0	0.0%
	Natural, Cultural, and Historic Resources	124	24	19.4%	54	43.5%	0	0.0%
	Transportation and Evacuation Routes	63	29	46.0%	10	15.9%	0	0.0%
St. Lucie Village (T)	Critical Community and Emergency Facilities	5	3	60.0%	1	20.0%	0	0.0%
	Critical Infrastructure	435	75	17.2%	138	31.7%	22	5.1%
	Natural, Cultural, and Historic Resources	4	0	0.0%	2	50.0%	0	0.0%
	Transportation and Evacuation Routes	1	1	100.0%	0	0.0%	0	0.0%
Unincorporated St. Lucie County	Critical Community and Emergency Facilities	283	26	9.2%	53	18.7%	6	2.1%
	Critical Infrastructure	5,595	1,192	21.3%	1,558	27.8%	57	1.0%
	Natural, Cultural, and Historic Resources	1,373	45	3.3%	31	2.3%	0	0.0%
	Transportation and Evacuation Routes	56	2	3.6%	2	3.6%	0	0.0%
St. Lucie County (Total)	**Critical Community and Emergency Facilities**	**1,345**	**116**	**8.6%**	**945**	**70.3%**	**29**	**2.2%**
	Critical Infrastructure	**23,457**	**3,391**	**14.5%**	**15,837**	**67.5%**	**116**	**0.5%**
	Natural, Cultural, and Historic Resources	**2,262**	**133**	**5.9%**	**676**	**29.9%**	**1**	**<0.1%**
	Transportation and Evacuation Routes	**147**	**37**	**25.2%**	**27**	**18.4%**	**0**	**0.0%**

As shown in **Table 6-3**, 42.5 percent of the countywide transportation route miles are exposed, and 29 percent of countywide critical infrastructure asset miles—referring to other linear systems—are exposed to extreme heat.

Table 6-3. Total Miles of Critical Linear Assets Exposed to Extreme Heat

Jurisdiction	Critical Infrastructure Miles				Transportation Route Miles			
	Total	Low – % of Total	Medium - % of Total	High - % of Total	Total	Low - % of Total	Medium - % of Total	High - % of Total
Fort Pierce (C)	53.9	14.4%	56.6%	0.0%	52.6	15.5%	74.0%	0.2%
Port St. Lucie (C)	99.4	15.2%	23.2%	0.0%	133.7	23.1%	51.2%	0.0%
St. Lucie Village (T)	2.2	1.6%	67.0%	29.0%	2.1	22.2%	36.1%	0.55
Unincorporated St. Lucie Co.	169.3	2.8%	5.7%	.8%	271.1	6.0%	10.8%	0.7%
St. Lucie County (Total)	**324.8**	**8.5%**	**19.9%**	**0.6%**	**459.4**	**12.2%**	**29.9%**	**0.4%**

Population Exposure

Florida has the highest rate of heat-related illness (ranging from heat rash to exhaustion to heat stroke) and the 6th highest rate of heat-related deaths in the United States; an estimated 150 Florida residents died due to heat-related illness between 2017 and 2021. Between 2018 and 2022, Florida recorded over 26,000 emergency room visits and nearly 5,000 hospitalizations due to heat-related illnesses (Tsoukalas and Sela 2024). The prevalence of HRI is likely underestimated, especially among working people who fear retaliation or lack of meaningful follow-through if they report to their supervisors (e.g., immigrants and temporary workers). This is concerning because once someone experiences a heat-related incident, their body's ability to tolerate heat is often significantly reduced, making repeat heat-related illness even more likely (Tsoukalas and Sela 2024).

HRI also hurts businesses and the economy by reducing labor productivity. For example, at 77degrees Fahrenheit with 30 percent humidity, the average person can work at 95 percent capacity; at 95 degrees Fahrenheit with 50 percent humidity, work capacity drops to 68 percent. In Florida, two of the top three outdoor jobs are key drivers of its economy — construction along with amusement and recreation. Due to heat-related illness, Florida loses an estimated $11 billion annually in productivity (Tsoukalas and Sela 2024).

Extreme heat events can also result in local or regional health and medical systems becoming overloaded. Energy systems and power grids may also exceed capacity, making electricity availability unreliable for air conditioning and refrigeration of food and medications. Finally, heatwaves can cause more instances of unrest and conflict which increases the need for law enforcement resources and emergency services (Florida Division of Emergency Management 2023).

As shown in **Table 6-4**, about 215,000 total residents, or 63 percent of people living in St. Lucie County, its jurisdictions, and unincorporated areas, are exposed to extreme heat.

Table 6-4. Population Exposure to Extreme Heat

Jurisdiction	Total Population	# Low	% of Total	# Medium	% of Total	# High	% of Total
Fort Pierce (C)	48,094	4,992	10.4%	29,245	60.8%	260	0.5%
Port St. Lucie (C)	220,453	46,012	20.9%	112,051	50.8%	7	<0.1%
St. Lucie Village (T)	818	45	5.5%	71	8.7%	18	2.2%
Unincorporated St. Lucie County	76,872	9,823	12.8%	12,613	16.4%	345	0.4%
St. Lucie County (Total)	**346,237**	**60,872**	**17.6%**	**153,980**	**44.5%**	**630**	**0.2%**

As shown in **Table 6-5**, the largest portion (54.1 percent) of low to moderate income residents throughout SLC are exposed to medium level extreme heat.

The City of Fort Pierce has the largest share of LMI residents across all exposure levels in both the total number and percentage; with nearly 39,000 people, or 81 percent of the total population of the City. A total of 74 percent of LMI residents, or nearly 29,000 people, are exposed to medium level extreme heat.

The City of Port St. Lucie has around 4,000 LMI residents, of which about 62 percent, or 2,382 people are exposed to medium level extreme heat.

St. Lucie Village has 132 LMI residents, of which about 30 percent or 39 people are exposed to medium-level extreme heat.

Unincorporated St. Lucie County has about 22,000 low to moderate income residents, of which 17.6 percent or 3,883 are exposed to medium level extreme heat.

Table 6-5. LMI Population Exposure to Extreme Heat

Jurisdiction	# of Low to Moderate Income (LMI) Population	# Low	% of LMI	# Medium	% of LMI	# High	% of LMI
Fort Pierce (C)	38,933	4,517	11.6%	28,824	74.0%	255	0.7%
Port St. Lucie (C)	3,853	650	16.9%	2,382	61.8%	0	0.0%
St. Lucie Village (T)	132	30	22.7%	39	29.5%	14	10.6%
Unincorporated St. Lucie County	22,063	3,509	15.9%	3,883	17.6%	68	0.3%
St. Lucie County (Total)	**64,981**	**8,706**	**13.4%**	**35,128**	**54.1%**	**337**	**0.5%**

6.2.3.2 Extreme Heat Sensitivity Analysis

Extreme heat events can affect anyone, but a broad range of the population has increased susceptibility to heat-related illness, including the elderly, children and infants, people with chronic illnesses or disabilities, low-income households, and people who are unhoused. In addition, jobs that require outdoor work or are in high-heat conditions pose more risk to heat related complications. For example, according to the U.S. Bureau of Labor Statistics, 490,710 Floridians work in outdoor-dominant professions. Among these, construction, landscaping, and amusement / recreation are the top outdoor industries in the state. Men are three times more likely to suffer from heat-related incidents at work than women; and people under 30 are twice as likely to experience HRI than older working people (Tsoukalas and Sela 2024). In addition, compelling data suggests that people with minimum- and other low-wage jobs are particularly prone to HRI. The Institute of Labor Economics finds that working people in the bottom 20 percent of wages suffer five times as many heat-related injuries as those in the highest 20 percent. This is partly because those working in lower-wage jobs may lack other opportunities and job prospects, giving them less negotiating power for additional safety measures to be implemented (Tsoukalas and Sela 2024).

6.2.4 Inland Flooding

The heart of St. Lucie County's natural infrastructure lies in its extensive wetland networks. Mangrove forests excel at stabilizing shorelines along inland waterways while providing essential nursery habitat for fisheries. The marsh system, comprising transitional, regular, and irregular flooding zones, creates a dynamic buffer that naturally adapts to changing water levels. These wetlands show promising adaptation potential through vertical accretion and inland migration given sufficient time to transform naturally or using some form of artificial augmentation. Freshwater-dependent ecosystems face increasing stress from saltwater intrusion and changing rainfall patterns. Preservation of these inland natural ecosystems is crucial for natural flood protection and maintaining water quality and availability for inland communities.

Inland flood used scenarios for 100- and 25-year events under 2040 and 2070 timelines, based on rainfall and other change factors. Rainfall-induced flooding was examined using the SFWMD standard rainfall distribution for four 24-hour events, and NOAA Atlas 14 precipitation. Future rainfall precipitation change factors were derived from the SFWMD and U.S. Geological Survey and applied appropriately. A HEC-RAS (Hydrologic Engineering Center – River Analysis System) rain-on-grid modeling approach was integrated with SLC Light Detection and Ranging (LiDAR) elevation data. The HEC-RAS model was developed to estimate depth of ponding due to heavy rainfall events. It did not evaluate riverine flooding or account for culverts and other stormwater infrastructure.

The HEC-HMS (Hydrologic Engineering Center – Hydrologic Modeling System) model was used to develop the precipitation file for the HEC-RAS model. The HEC-HMS model was prepared to simulate nine design storms representing 2040 rainfall patterns and 2070 rainfall depths both evaluated for 100- and 25-year return interval, 24-hour design storms.

Rainfall depths representing each 24-hour hypothetical storm event were taken from NOAA Atlas 14 annual maximum series to represent rainfall patterns (NOAA 2023a). Zonal statistics were calculated for the two-dimensional flow area from the Atlas 14 rasters and the mean rainfall depth was used. Future 2070 rainfall depths were computed using the current depths and the multiplier published in Technical Memorandum: Adoption of Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida (SFWMD 2022).

6.2.4.1 Inland Flooding Exposure Analysis

NOAA Atlas 14 utilizes two primary methods for analyzing precipitation frequency: the Annual Maximum Series (AMS) and the Partial Duration Series (PDS). The AMS method involves selecting the single largest precipitation event for each year and is a simplified analysis based on one event per year. **Table 6-6** includes precipitation estimates, in inches, for varying recurrence intervals utilizing the AMS approach. For infrastructure projects where the focus is on the most extreme events (e.g., dam spillways) AMS-based estimates are typically sufficient.

Table 6-6. Atlas 14 AMS-based Precipitation Estimates

Hypothetical Storm Event	Current Atlas 14 Mean Rainfall Depth (inches) – 24-hour duration	Current Atlas 14 Mean Rainfall Depth (inches) – 72-hour duration
100-year	13.3	15.1
25-year	9.86	11.3

The PDS method includes all precipitation events that exceed a specific threshold, regardless of how many events occurred in a single year. Since it includes multiple events per year, this method offers a more comprehensive view of precipitation extremes. In scenarios where understanding the frequency of multiple significant events within a year is critical (e.g., urban drainage systems) PDS-based analyses may offer more detailed insights. Estimates using the PDS approach resulted in nearly identical outputs (NOAA 2025d)

Land Exposure

Inland flooding refers to flooding driven by rainfall that cannot be absorbed by the soil or transported by existing drainage systems or natural features. Extreme rainfall occurs when precipitation amounts experienced by a region are more intense and prolonged than average. In low-lying areas, this phenomenon often results in flash flooding, overwhelming stormwater management systems and leading to widespread damage to many types of infrastructure. The asset types that may be impacted can include roads, bridges and buildings, as well as homes and businesses. Extreme rainfall can interrupt essential services and transportation networks. While SLC can experience rainfall anywhere, not all areas are equally vulnerable to inland flooding, due to variations in elevation, drainage capacities of physical and natural systems, and existing waterbodies and streamflow patterns.

Sea level rise, as well as storm surge, impact inland areas where rivers, creeks and canals are connected to the coast and whose capacity is thereby tidally influenced. Two NOAA sea level projections were used for future inland flood analysis: NOAA Intermediate Low (NIL) and NOAA Intermediate High (NIH). **Table 6-7** provides an overview of flooding that results from extreme precipitation with volumes equal to 25- and 100-year rainfall events in the present day and under future conditions in 2040, 2070, and 2100. **Figure 6-15**, **Figure 6-16**, **Figure 6-17**, and **Figure 6-18** show two present day scenarios and two 2070 scenarios – precipitation volumes equal to a 100-year rainfall event at NOAA Intermediate Low and Intermediate High projections.

Table 6-7. Inland Flooding Mean Inundation Depth

Timescale	Scenario		Mean Inundation (inches)	Maximum Inundation (inches)
Present Day	--	25-Year 24-Hour	11.52	164.28
Present Day	--	100-Year 24-Hour	14.4	278.76
2040	NIL	25-Year 24-Hour	12.48	271.32
2040	NIL	100-Year 24-Hour	15.72	280.8
2040	NIH	25-Year 24-Hour	12.72	279.96

Timescale	Scenario		Mean Inundation (inches)	Maximum Inundation (inches)
2040	NIH	100-Year 24-Hour	15.96	289.44
2070	NIL	25-Year 24-Hour	12.96	279.36
2070	NIL	100-Year 24-Hour	16.68	289.32
2070	NIH	25-Year 24-Hour	13.92	303.72
2070	NIH	100-Year 24-Hour	17.52	313.68
2100	NIL	25-Year 24-Hour	13.32	286.44
2100	NIL	100-Year 24-Hour	18	297.72
2100	NIH	25-Year 24-Hour	15.72	337.2
2100	NIH	100-Year 24-Hour	20.04	348.48

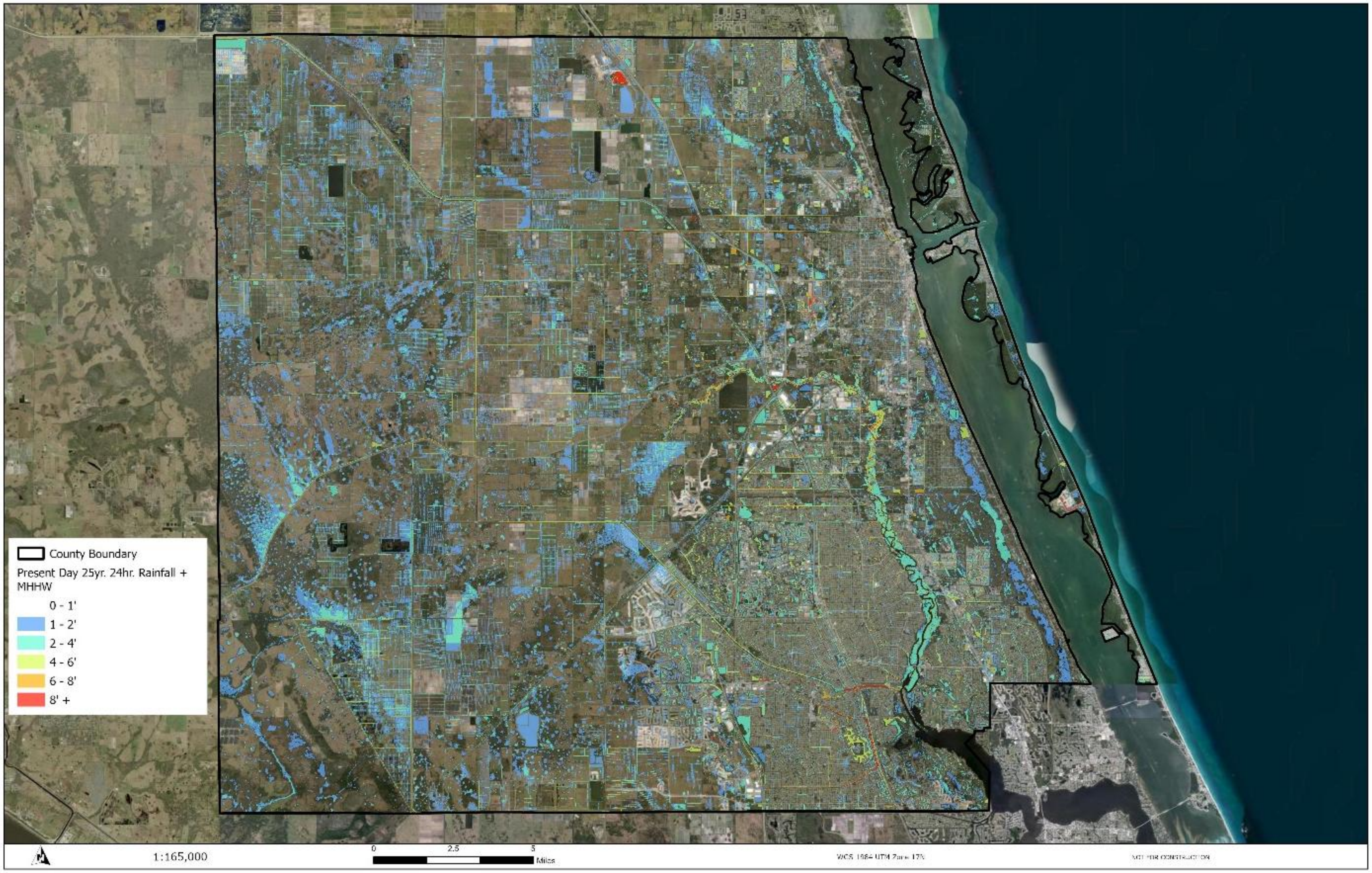


Figure 6-15. 25-Year 24-Hour Rainfall-Induced Flooding Depths – Present Day

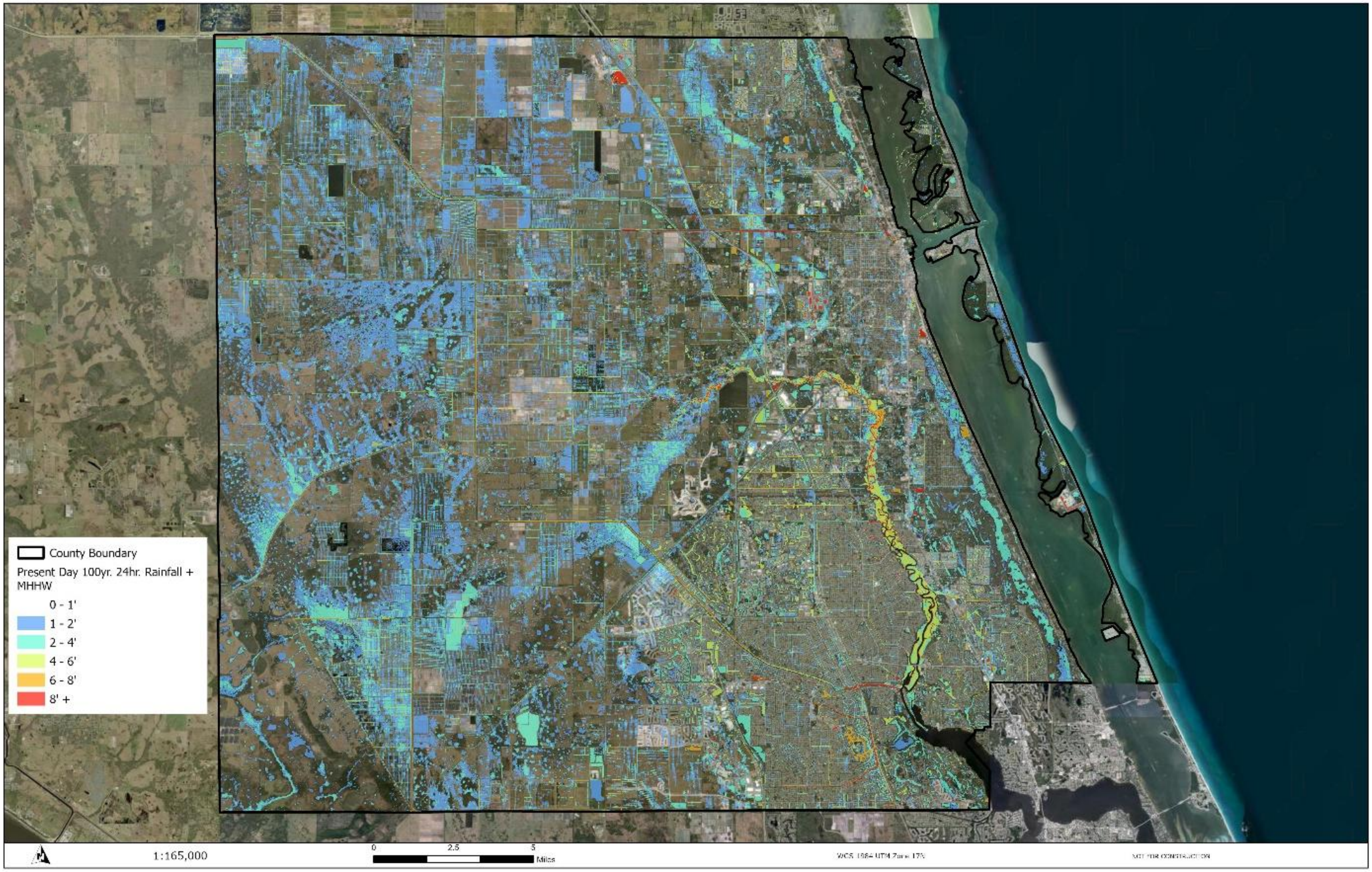


Figure 6-16. 100-Year 24-Hour Rainfall-Induced Flooding Depths – Present Day

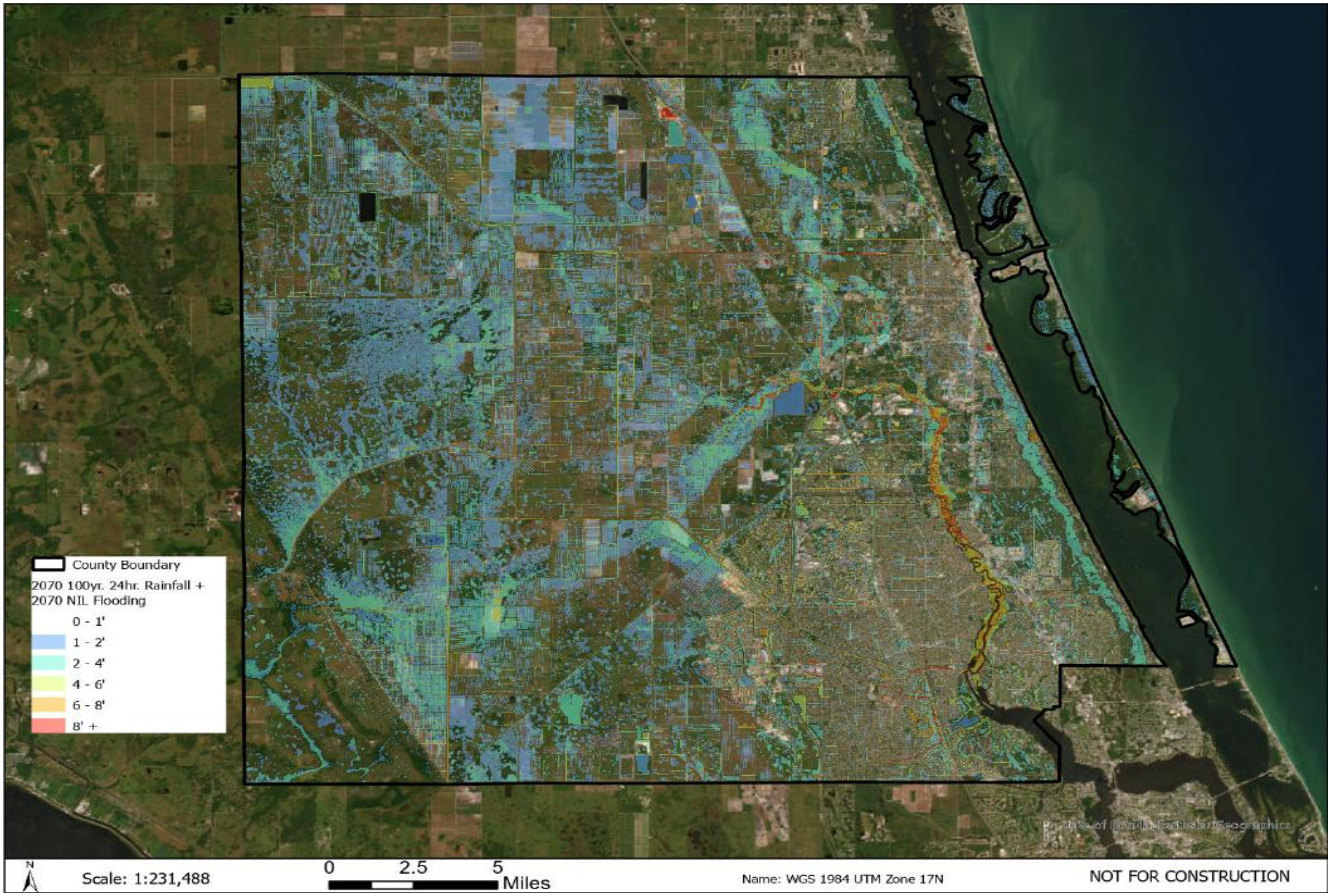


Figure 6-17. 100-Year 24-Hour Rainfall-Induced Flooding Depths – 2070 NOAA Intermediate Low Sea Level

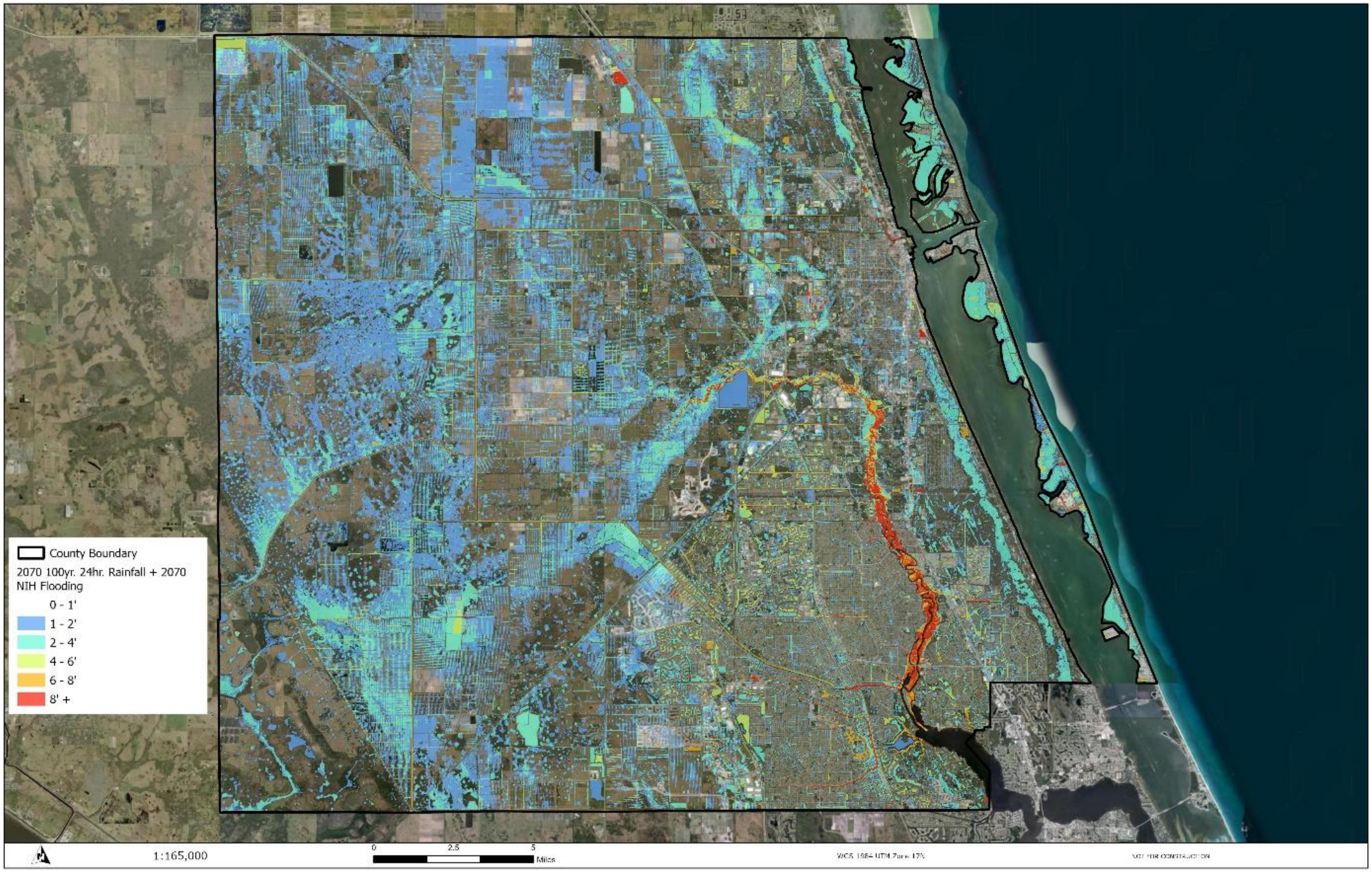


Figure 6-18. 100-Year 24-Hour Rainfall-Induced Flooding Depths – 2070 NOAA Intermediate High Sea Level

6.2.4.2 Inland Flooding Sensitivity Analysis

Tropical cyclones can produce widespread and heavy rains, which can result in life-threatening and damaging floods. Tropical cyclones pose significant flooding threats for people who live inland. Flooding impacts can occur hundreds of miles away from the center of a storm and can last much longer than storm surge-related flooding. Rainfall can cause flash flooding and flooding on rivers and streams that can persist for several days after the storm. Rainfall amounts are related to the speed and size of tropical cyclones, not the intensity. This is because a slower moving and larger tropical cyclone has a longer and larger capacity to produce more rainfall (Florida Division of Emergency Management 2023).

In addition, flood damage can be very costly. Just 1 inch of flooding can cause $26,000 in damage and lead to mold or other health concerns (NLIHC & PAHRC 2021). Despite this risk, flood insurance coverage remains low across Florida. Only 13 percent of Florida's 11 million households carry flood insurance, meaning roughly 8 out of 10 homes are uninsured against flood damage. This gap is especially concerning given that 25 percent of all flood claims come from moderate- to low-risk areas, where residents may not perceive the need for coverage.

6.2.5 Storm Surge

The threat of severe storms can encompass a range of weather events, including tornadoes, extreme precipitation, hurricanes, and tropical storms. The assessment of these events focused on storm surge. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model was used to assess impacts under two hurricane scenarios: Category 1 and Category 5.

6.2.5.1 Storm Surge Exposure Analysis

Strong storms, including hurricanes and tropical cyclones, can result in greater tidal and wave action that pushes water further inland and above typical tide levels. For the purposes of this assessment, areas are exposed to storm surge if they intersect with the spatial extents of SLOSH Categories 1 and 5 storm surges. For reference, Hurricane Nicole in 2022 was a Category 1 storm, whereas Hurricanes Irma (2017), Dorian (2019), and Ian (2022) were Category 5.

The SLOSH Category scenarios represent bracketing storm surge events, from least (Category 1) to most severe (Category 5). Category 1 exposure is categorized into two levels based on storm surge heights: zero to 3 feet (Low), and 3 to 5 feet (Moderate). Category 5 includes an additional category, greater than 5 feet (High). However, the SLOSH system's primary purpose is to identify areas that may require evacuation during certain events, rather than measure flood risks. FEMA products such as the Flood Insurance Rate Maps are the primary source of information to evaluate flood risks as well as flood insurance rates. SLOSH was selected to represent storm surge due to its inclusion of parameters that consider atmospheric pressure, wind speed, and storm size that influence the degree of flooding during severe storm events (National Hurricane Center n.d.).

The two sub-levels under Category 1 (Low and Moderate) and three sub-levels under Category 5 (Low, Moderate and High) do not overlap. Therefore, total land, asset and population impacts are not reflected as cumulative. Instead, Moderate and High quantities are in addition to the lower level surge impacts.

Land, Assets and Population Exposure

Land

As shown in **Table 6-8** and **Figure 6-19**, under both scenarios in a Category 1 hurricane, slightly more than 1.5 percent of countywide land area is expected to be impacted by storm surge. However, some areas along the County's coastline, where storm surge occurs, face significant exposure. Nearly 35 percent of St. Lucie Village is exposed to Category 1 Low (zero to 3 feet storm surge), with an additional 2 percent exposed to Moderate inundation (3 to 5 feet) (**Figure 6-20**).

Other areas of the County with less land area directly exposed to the coast are projected to experience limited storm surge impacts during Category 1 events. Under the combined Low and Moderate scenarios, the City of Port St. Lucie has the least exposure to storm surge, approximately 1.3 percent of the total land area (**Figure 6-21**), followed by unincorporated SLC at 1.6 percent, and the City of Fort Pierce at 2.5 percent storm surge exposure (**Figure 6-22**).

Table 6-8. Land Area Exposure to SLOSH Category 1 Hazard Area in Acres

Jurisdiction	Total Land Area (Acres)	Acres Exposed to SLOSH Category 1 Storm Surge (Acres)			
		0-3 feet *Low*	Percent of Total	3-5 feet *Moderate*	Percent of Total
Fort Pierce (C)	15,663.3	316.1	2.0%	75.9	0.5%
Port St. Lucie (C)	75,850.8	1,023.4	1.3%	34.1	<0.1%
St. Lucie Village (T)	524.0	182.3	34.8%	10.4	2.0%
Unincorporated St. Lucie County	274,265.0	2,616.3	1.0%	1,557.5	0.6%
St. Lucie County (Total)	**366,303.2**	**4,138.1**	**1.1%**	**1,677.8**	**0.5%**

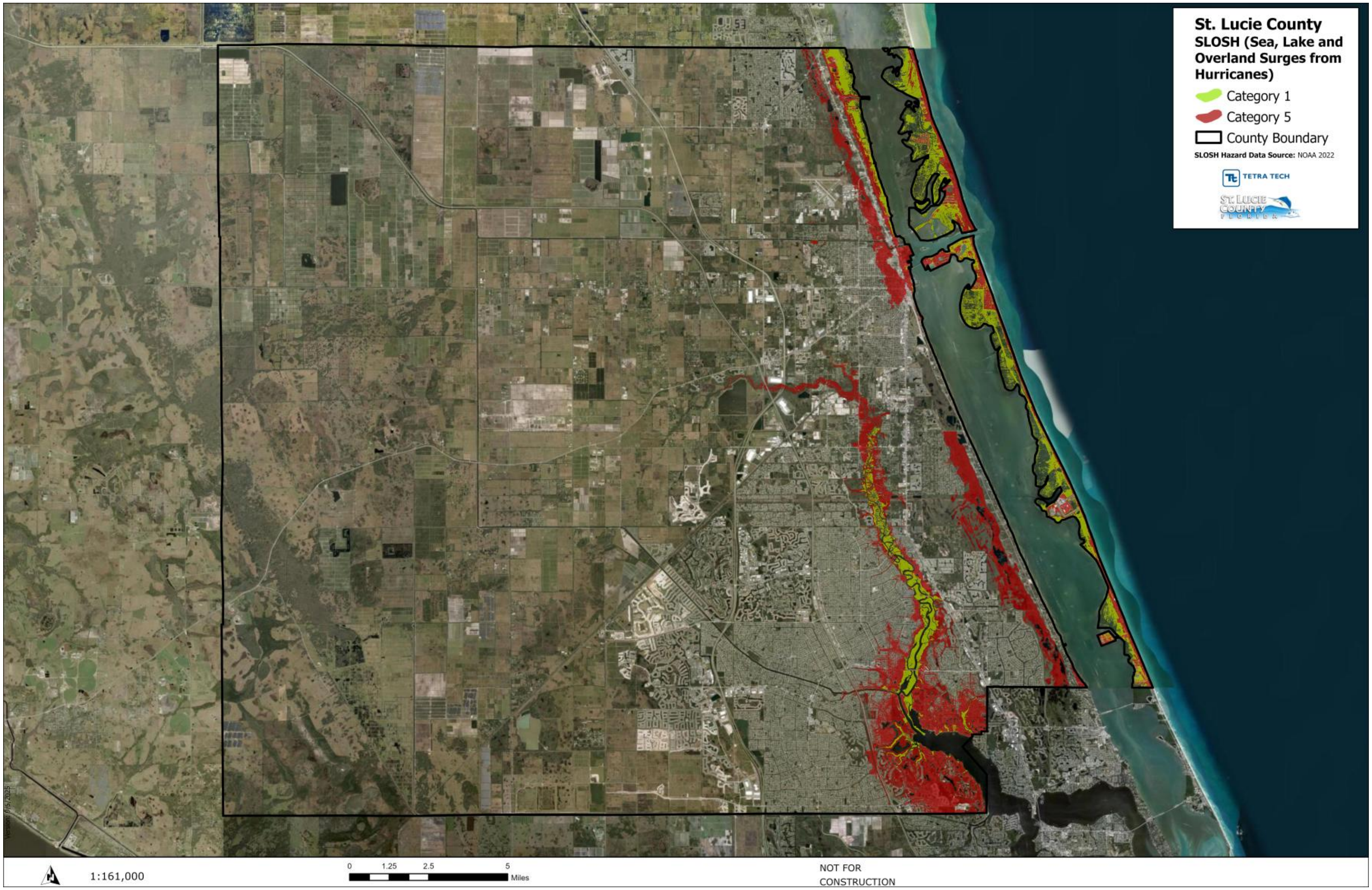


Figure 6-19. Countywide Land Area Exposure to SLOSH Category 1 and Category 5

Figure 6-20. St. Lucie Village Land Area Exposure to SLOSH Category 1 and Category 5

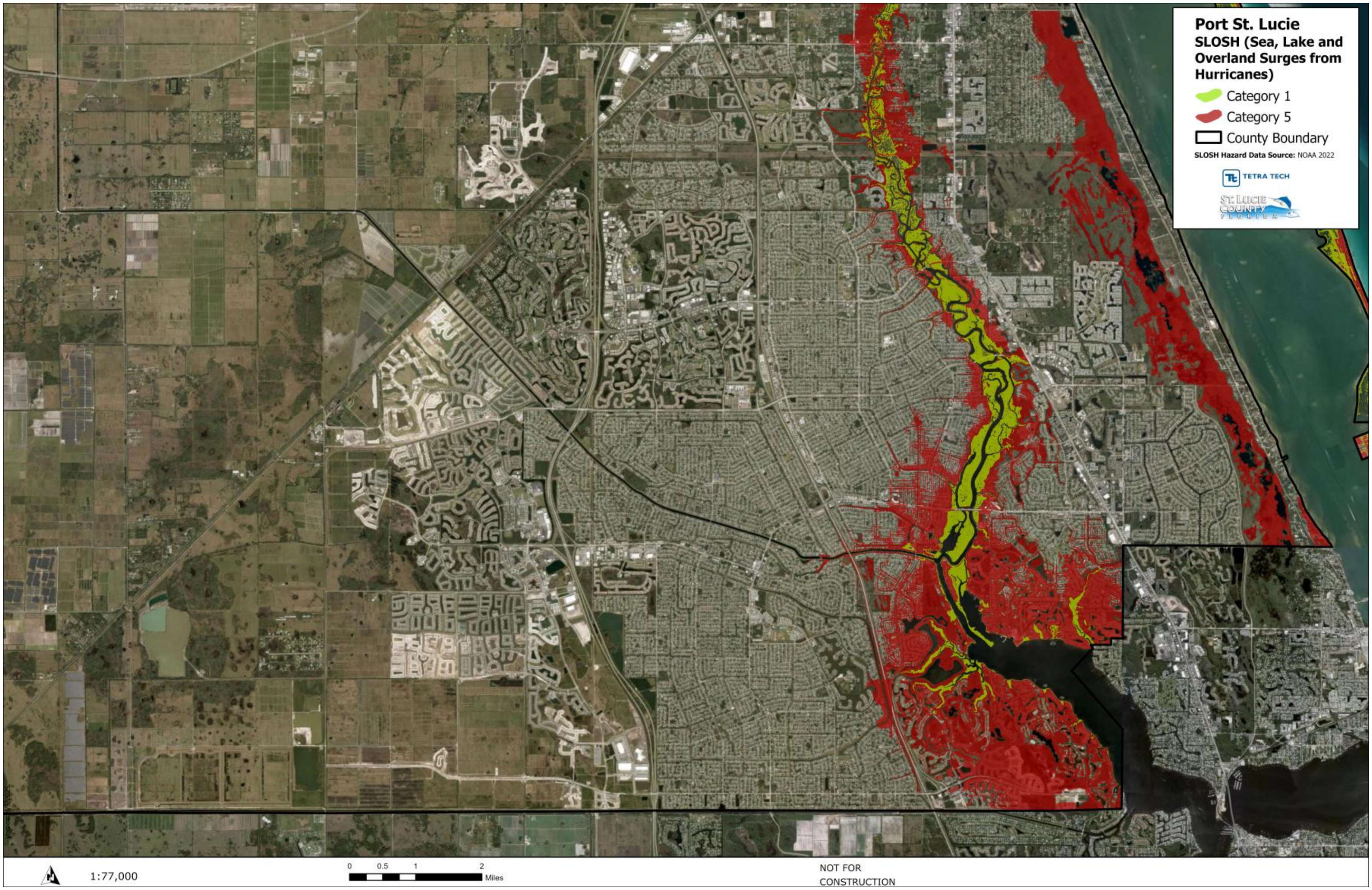


Figure 6-21. Port St. Lucie Land Area Exposure to SLOSH Category 1 and Category 5

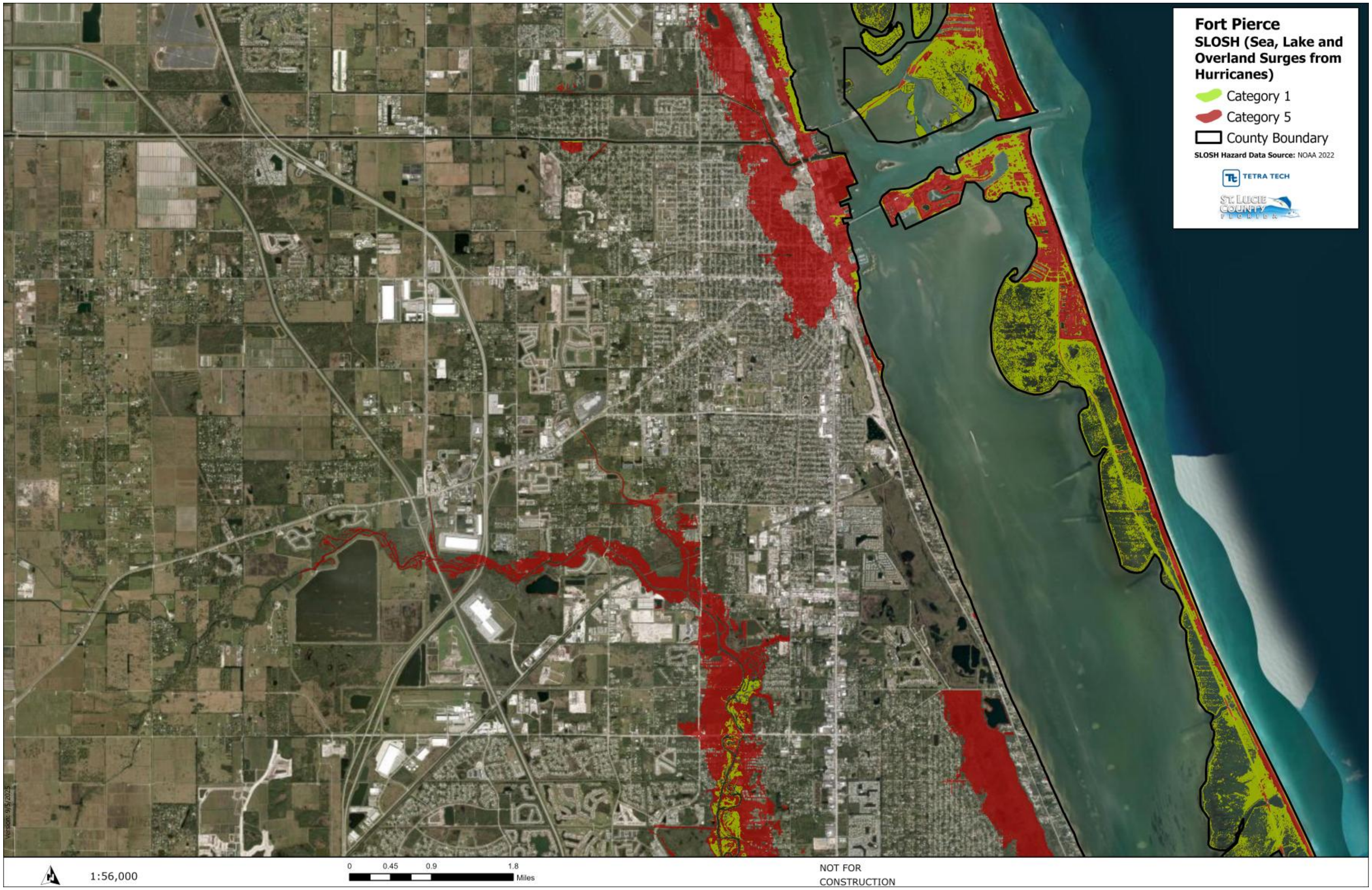


Figure 6-22. Fort Pierce Land Area Exposure to SLOSH Category 1 and Category 5

As shown in **Table 6-9** and **Table 6-10**, the number of county-wide acres exposed to storm surge increases to 5.9 percent across Category 5 combined scenarios; a 4.4 percent increase across Category 1 storm surge combined scenarios.

Table 6-9. Land Area Exposure to SLOSH Category 5 Hazard Area in Acres

Jurisdiction	Total Land Area (Acres)	Acres Exposed to Category 5 Storm Surge					
		0-3 feet *Low*	Percent of Total	3-5 feet *Moderate*	Percent of Total	>5 feet *High*	Percent of Total
Fort Pierce (C)	15,663.3	616.0	3.9%	255.5	1.6%	1,299.6	8.3%
Port St. Lucie (C)	75,850.8	3,730.1	4.9%	1,626.2	2.1%	2,539.5	3.3%
St. Lucie Village (T)	524.0	26.5	5.1%	15.3	2.9%	396.6	75.7%
Unincorporated St. Lucie County	274,265.0	3,032.4	1.1%	1,418.2	0.5%	6,712.8	2.4%
St. Lucie County (Total)	**366,303.2**	**7,405.0**	**2.0%**	**3,315.1**	**0.9%**	**10,948.5**	**3.0%**

Asset Exposure

This section provides an assessment of countywide critical assets that are exposed to storm surge hazards, specifically focusing on Category 1 and Category 5 hurricane levels. The assets are categorized into four main groups: Critical Community and Emergency Facilities, Critical Infrastructure, Natural, Cultural, and Historic Resources, and Transportation and Evacuation Routes.

The SLOSH model analysis of storm surge vulnerability reveals significant variability in critical asset exposure across SLC (**Table 6-10**). Out of 27,211 critical assets analyzed, 10.1 percent of community and emergency facilities, 23.7 percent of critical infrastructure, 28.8 percent of natural, cultural, and historic resources, and 25.2 percent of transportation routes (by quantity, not mileage) are exposed to Category 5 storm surge. While exposure under Category 1 scenarios is notably lower, critical infrastructure and cultural resources still show vulnerability even under low-surge conditions.

Fort Pierce exhibits the highest number of exposed assets, particularly in critical infrastructure, where 24.2 percent are vulnerable under a Category 5 surge. Notably, 59.3 percent of transportation routes in the city could be inundated, with a significant portion exposed to high surge levels. Port St. Lucie shows relatively limited exposure overall, with only 1.8 percent of community facilities and 6.1 percent of infrastructure exposed under Category 5 conditions. The smallest jurisdiction, St. Lucie Village demonstrates the highest proportional exposure, with 73.5 percent of critical infrastructure at risk under Category 5 storm surge conditions.

Table 6-10. Number of Critical Assets Exposed to the SLOSH Category 1 and 5 Hazard Area

			Critical Assets Exposed to Category 1 Storm Surge					Critical Assets Exposed to Category 5 Storm Surge						
Jurisdiction	Critical Asset Class	Total Critical Assets Evaluated	0-3 feet *Low*	% of Total	3-5 feet *Mod.*	% of Total	Total	0-3 feet *Low*	% of Total	3-5 feet *Mod*	% of Total	>5 feet *High*	% of Total	Total
Fort Pierce (C)	Critical Community and Emergency Facilities	714	0	0.00%	0	0.00%	0.00%	30	4.20%	16	2.20%	52	7.30%	13.70%
	Critical Infrastructure	17,152	641	3.70%	0	0.00%	3.70%	1,212	7.10%	620	3.60%	2,320	13.50%	24.20%
	Natural, Cultural, and Historic Resources	761	23	3.00%	2	0.30%	3.30%	35	4.60%	17	2.20%	101	13.30%	20.10%
	Transportation and Evacuation Routes	27	4	14.80%	0	0.00%	14.80%	0	0.00%	2	7.40%	14	51.90%	59.30%
Port St. Lucie (C)	Critical Community and Emergency Facilities	343	0	0.00%	0	0.00%	0.00%	4	1.20%	2	0.60%	0	0.00%	1.80%
	Critical Infrastructure	275	0	0.00%	0	0.00%	0.00%	10	3.60%	5	1.80%	2	0.70%	6.10%
	Natural, Cultural, and Historic Resources	124	4	3.20%	1	0.80%	4.00%	9	7.30%	2	1.60%	8	6.50%	15.40%
	Transportation and Evacuation Routes	63	0	0.00%	0	0.00%	0.00%	3	4.80%	1	1.60%	1	1.60%	8.00%
St. Lucie Village (T)	Critical Community and Emergency Facilities	5	0	0.00%	3	60.00%	60.00%	0	0.00%	0	0.00%	2	40.00%	40.00%
	Critical Infrastructure	435	149	34.30%	0	0.00%	34.30%	17	3.90%	14	3.20%	289	66.40%	73.50%
	Natural, Cultural, and Historic Resources	4	2	50.00%	0	0.00%	50.00%	0	0.00%	0	0.00%	4	100.00 %	100.00 %
	Transportation and Evacuation Routes	1	1	100.00 %	0	0.00%	100.00%	0	0.00%	0	0.00%	1	100.00 %	100.00 %
Unincorporated St. Lucie County	Critical Community and Emergency Facilities	283	4	1.40%	22	7.80%	9.20%	7	2.50%	4	1.40%	20	7.10%	11.00%
	Critical Infrastructure	5,595	168	3.00%	15	0.30%	3.30%	405	7.20%	206	3.70%	462	8.30%	19.20%
	Natural, Cultural, and Historic Resources	1,373	119	8.70%	0	0.00%	8.70%	15	1.10%	41	3.00%	419	30.50%	34.60%

			Critical Assets Exposed to Category 1 Storm Surge					Critical Assets Exposed to Category 5 Storm Surge						
Jurisdiction	Critical Asset Class	Total Critical Assets Evaluated	0-3 feet *Low*	% of Total	3-5 feet *Mod.*	% of Total	Total	0-3 feet *Low*	% of Total	3-5 feet *Mod*	% of Total	>5 feet *High*	% of Total	Total
	Transportation and Evacuation Routes	56	4	7.10%	1	1.80%	8.90%	2	3.60%	4	7.10%	9	16.10%	26.80%
St. Lucie County (Total)	Critical Community and Emergency Facilities	1,345	4	0.30%	25	1.90%	2.20%	41	3.00%	22	1.60%	74	5.50%	10.10%
	Critical Infrastructure	23,457	958	4.10%	15	0.10%	4.20%	1,644	7.00%	845	3.60%	3,073	13.10%	23.70%
	Natural, Cultural, and Historic Resources	2,262	148	6.50%	3	0.10%	6.60%	59	2.60%	60	2.70%	532	23.50%	28.80%
	Transportation and Evacuation Routes	147	9	6.10%	1	0.70%	6.80%	5	3.40%	7	4.80%	25	17.00%	25.20%

Population Exposure

As shown in **Table 6-11**, population exposure is limited countywide, with only 0.5 percent of residents directly exposed to Category 1 storm surge.

Exposure for each jurisdiction under both Category 1 scenarios combined show:

- 111 people in St. Lucie Village are exposed (13.6 percent of 818 residents),
- 5,150 people in unincorporated areas are exposed (6.7 percent of nearly 77,000),
- 2,816 people in Port St. Lucie are exposed (1.3 percent of more than 220,000), and
- 409 people in Fort Pierce are exposed (0.8 percent of nearly 48,100).

Table 6-11. Population Exposure to the SLOSH Category 1 Hazard Area

Jurisdiction	Total Population	Population Exposed to Category 1 Storm Surge		
		0-3 feet *Low*	3-5 feet *Moderate*	Percent of Total
Fort Pierce (C)	48,094	359	50	0.8%
Port St. Lucie (C)	220,453	2,766	50	1.3%
St. Lucie Village (T)	818	106	5	13.6%
Unincorporated St. Lucie County	76,872	3,381	1,769	6.7%
St. Lucie County (Total)	**346,237**	**6,612**	**1,874**	**0.5%**

Population exposure to Category 5 storm surge countywide is 4.3 percent of the total population under low storm surge, 1.8 percent under moderate storm surge, and 4.6 percent under high storm surge (**Table 6-12**).

A small number of LMI residents across all jurisdictions are exposed to Category 1 storm surge, less than 0.3 percent (194 of nearly 65,000 LMI residents), which represents 0.05 percent of the total population of St. Lucie County. Proportionally, LMI residents within St. Lucie Village are the most exposed at 38.6 percent (51 people). Even with much larger populations of LMI residents, Fort Pierce and the unincorporated areas have very low exposure rates overall, 0.02 percent (72 people) and 0.03 percent (71 people), respectively (**Table 6-13**).

Table 6-12. Population Exposure to the SLOSH Category 5 Hazard Area

Jurisdiction	Total Population	Population Exposed to Category 5 Storm Surge					
		0-3 feet *Low*	Percent of Total	3-5 feet *Moderate*	Percent of Total	>5 feet *High*	Percent of Total
Fort Pierce (C)	48,094	2,224	4.6%	915	1.9%	1,808	3.8%
Port St. Lucie (C)	220,453	8,660	3.9%	3,133	1.4%	5,586	2.5%
St. Lucie Village (T)	818	11	1.3%	8	1.0%	218	26.7%
Unincorporated St. Lucie County	76,872	4,087	5.3%	2,016	2.6%	8,254	10.7%
St. Lucie County (Total)	**346,237**	**14,982**	**4.3%**	**6,072**	**1.8%**	**15,866**	**4.6%**

Table 6-13. LMI Population Exposure to the SLOSH Category 1 Hazard Area

Jurisdiction	# of LMI Residents	# and % of Low to Moderate Income Residents Exposed to Category 1 Storm Surge		
		0-3 feet *Low*	3-5 feet *Moderate*	Percent of Total
Fort Pierce (C)	38,933	65	7	0.2%
Port St. Lucie (C)	3,853	0	0	0.0%
St. Lucie Village (T)	132	49	2	38.6%
Unincorporated St. Lucie County	22,063	66	5	0.3%
St. Lucie County (Total)	**64,981**	**180**	**14**	**<0.3%**

There are varying degrees of exposure to Category 5 storm surge among LMI populations across different jurisdictions within St. Lucie County. Across St. Lucie County, 4.5 percent of the LMI population is exposed to low storm surge, 1.9 percent to moderate storm surge, and 2.2 percent to high storm surge.

Fort Pierce has the largest number and percentage of LMI residents, with nearly 39,000 or 80 percent of the total population of the City). Of these residents, slightly more than 4,000 are exposed to Category 5 storm surge. St. Lucie Village has the highest percentage of LMI residents that are exposed to high storm surge (greater than 5 feet) at 69.7 percent. Port St. Lucie has no highly vulnerable population exposed to any level of storm surge (**Table 6-14**).

Table 6-14. LMI Population Exposure to the SLOSH Category 5 Hazard Area

Jurisdiction	# of LMI Residents	# and % of Low to Moderate Income Population Exposed to Category 5 Storm Surge					
		0-3 feet *Low*	Percent of Total	3-5 feet *Moderate*	Percent of Total	>5 feet *High*	Percent of Total
Fort Pierce (C)	38,933	2,224	5.7%	906	2.3%	903	2.3%
Port St. Lucie (C)	3,853	0	0.0%	0	0.0%	0	0.0%
St. Lucie Village (T)	132	2	1.5%	3	2.3%	92	69.7%
Unincorporated St. Lucie County	22,063	693	3.1%	308	1.4%	404	1.8%
St. Lucie County (Total)	**64,981**	**2,919**	**4.5%**	**1,217**	**1.9%**	**1,399**	**2.2%**

6.2.5.2 Storm Surge Sensitivity Analysis

Storm surge is an extremely dangerous hazard associated with hurricanes and tropical storms and is defined as an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. It is a phenomenon that can raise the water level several feet or more, causing flooding in normally dry areas many miles from the shore, especially in low-lying areas. Just one foot of moving water can carry a small car, but during storm surge, many feet of water can move onshore. The force of this water can sweep houses and buildings from their foundations. As a result, damage from storm surge can be catastrophic. Historically, about half of the direct deaths in landfalling tropical cyclones in the United States are from storm surge.

Storm surge due to tropical cyclone events can impact the stability of community services and critical infrastructure, especially near or at the coastline. Fuel, electricity and communications services may be interrupted. Transportation networks, especially evacuation routes and bridges are extremely vulnerable to damage from storm surge, disrupting access to health and medical lifelines including emergency services.

In addition, the impact to hazardous materials, such as nuclear power plants, wastewater treatment infrastructure, and HAZMAT facilities, could cause major damage or contamination based on the level of storm surge. A more common occurrence is the failure of wastewater pumps and lift stations, causing the surrounding areas and potentially the groundwater to be contaminated (Florida Division of Emergency Management 2023).

It is likely that storm surges from tropical cyclone events will be higher in the coming decades, mainly due to rising sea levels. Mean sea level in St. Lucie County has already risen about 11 inches since 1950, and 7.65 inches since 1990 according to NOAA tidal gauge data. Researchers expect SLR to accelerate as hotter temperatures cause polar ice sheets to melt faster. Over the next century, South Florida could see more than 6 feet of SLR (NOAA) with a correlating increase in storm surge, making the total water elevation higher as it approaches the coast and allowing storm surge to reach further inland.

6.2.6 Wind

The Hazus software was utilized to depict and analyze St. Lucie County's vulnerability to hurricane winds. Two recurrent interval events were assessed—the 100-year wind event and the 500-year wind event—using data from the NOAA Saffir Simpson Hurricane Wind scale. To create a comprehensive profile, the wind hazard analysis involved historical information from other sources.

6.2.6.1 Wind Exposure Analysis

For the purposes of this wind assessment, it is assumed that the entire County is exposed to high wind events. As a coastal community, St. Lucie County is exposed to strong winds associated with tropical depressions (maximum sustained surface winds of less than 39 miles per hour), tropical cyclones (maximum sustained winds of at least 39 mph), hurricanes (maximum sustained winds above 74 mph), and tornadoes.

According to data from the NCEI Storm Event Database, and data from 2012 to 2022, the state of Florida experienced an average of 5.80 tropical storm events and 0.90 hurricane events each year. **Figure 6-23** depicts historical hurricane tracks for 67 storms that have occurred within a buffer distance of 25 miles of St. Lucie County since the late 1800s (NOAA 2025c) Ten of these events occurred between 2004 and 2022. The City of Fort Pierce, St. Lucie Village, and areas along the intracoastal waterway or St. Lucie River are highly vulnerable to wind damage related to these storms (SLC Department of Public Safety Division of Emergency Management 2021).

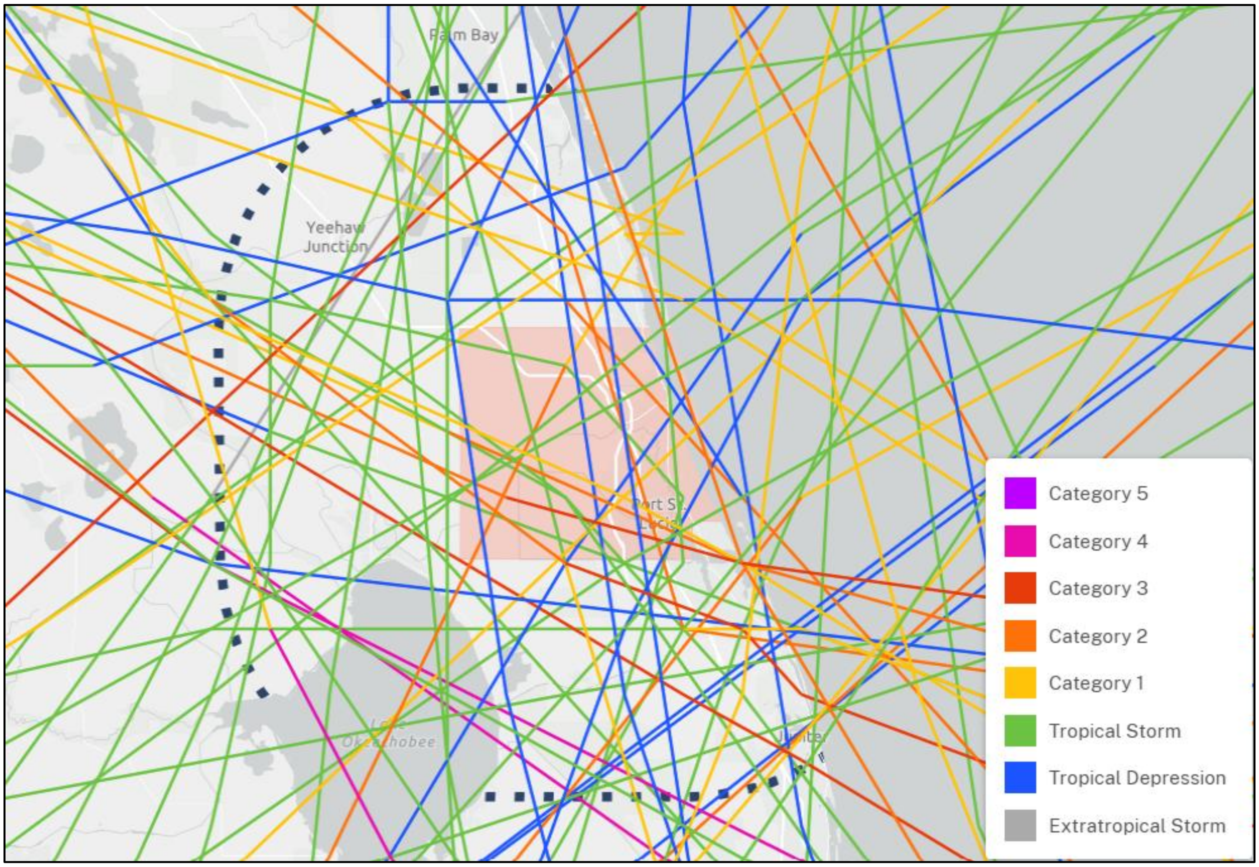


Figure 6-23. Historical Tropical Storm Tracks Near St. Lucie County (since late 1800s)

The 2023 Florida State Hazard Mitigation Plan includes probabilistic hurricane wind scenarios for the 10-, 20-, and 50- year return periods. The return period—also known as the recurrence interval—is a statistical estimate of the average time between events of a certain intensity or magnitude. For example, a 10-year return period indicates a 1-in-10 (or 10 percent) chance of that event occurring in any given year. The mean return period is the average interval between occurrences of a specific event, based on historical data and probabilistic modeling. It does not guarantee that the event will occur precisely every 10, 20, or 50 years, but rather reflects the long-term likelihood.

The return period scenario maps (**Figure 6-24**, **Figure 6-25**, and **Figure 6-26**) show that St. Lucie County will experience Category 1 force winds at least once within 10 years, Category 2 force winds in the 20-year scenario, and Category 3 force winds in the 50-year scenario. St. Lucie County's location bordering the Atlantic Ocean coupled with generally low coastal elevations and moderate-to-high coastal urban development, makes the County vulnerable to high wind events.

Studies show that the rapid intensification of hurricanes has increased over the last 40 years. It is very likely that changing conditions associated with warmer temperatures will cause an increase in the proportion of major hurricanes (Category 3 through 5) in the future. The frequency of hurricanes worldwide, however, is not expected to increase and will remain unchanged or even decrease. This is due to weakening ocean currents that help hurricanes form. When looking regionally, exposure to fewer but more intense storms in the future can be expected.

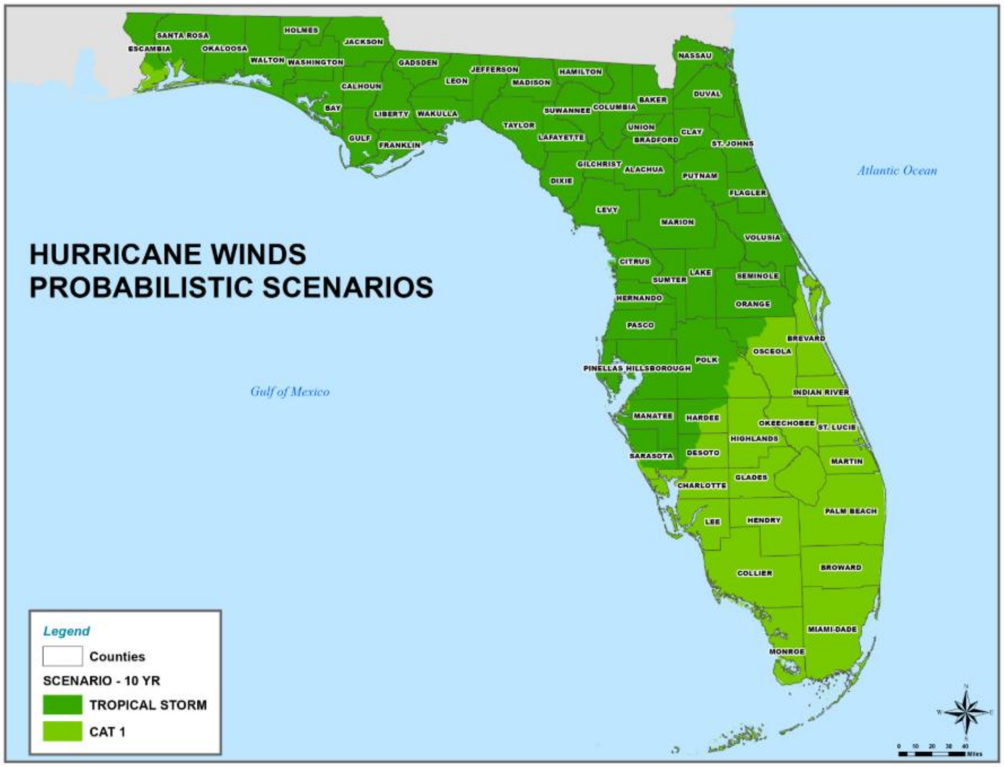


Figure 6-24. 10-Year Probable Hurricane Wind Scenario

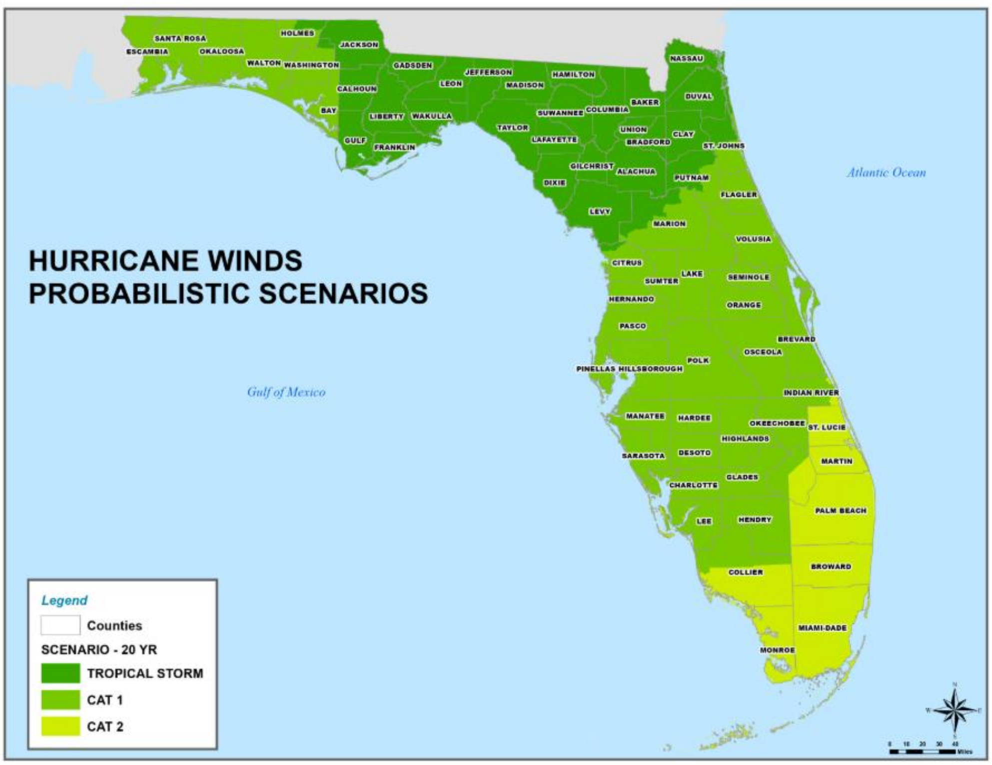


Figure 6-25. 20-Year Probable Hurricane Wind Scenario

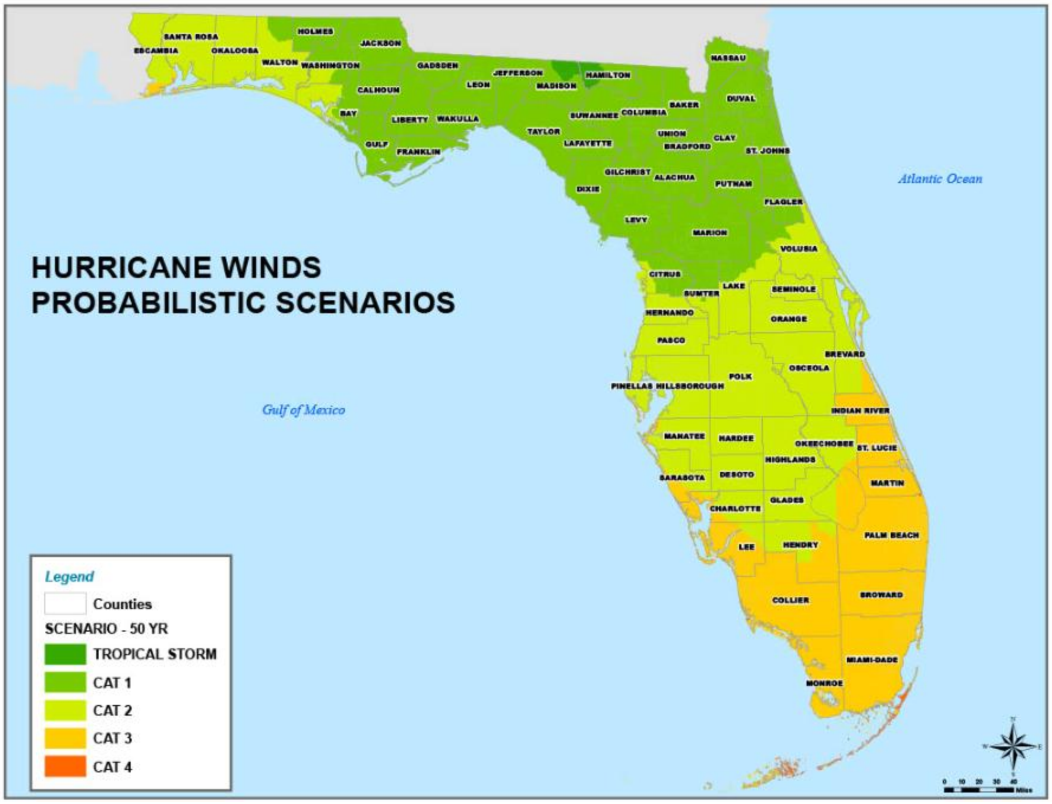


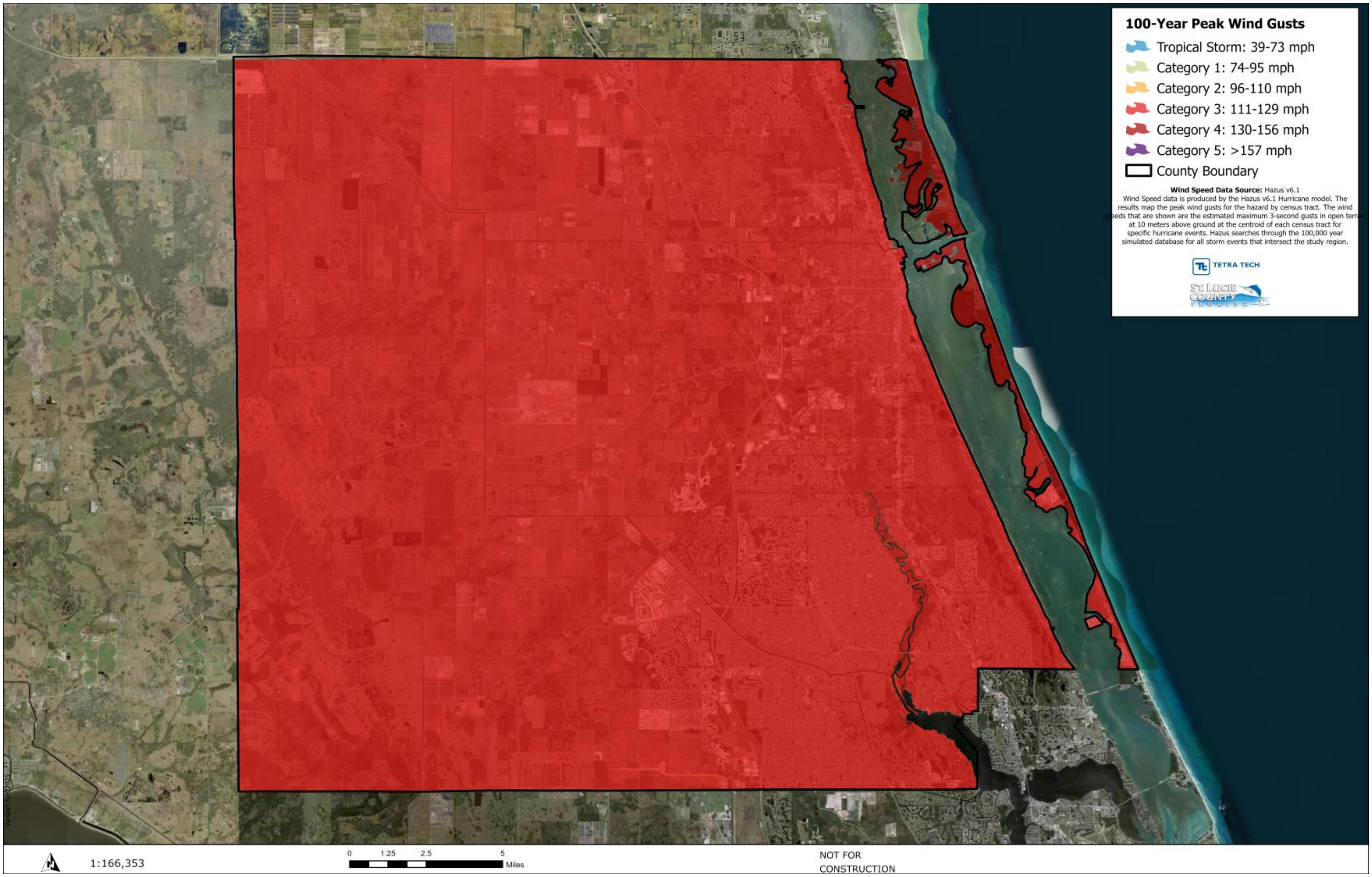
Figure 6-26. 50-Year Probable Hurricane Wind Scenario

The 100-year peak wind gust event scenario model performed for this RVA projects Category 3, with 111 to 129 mph sustained winds, for almost the entire County except for a small area along the coast in the northeastern portion of the County, which would be impacted by Category 4, with sustained winds of 130 to 156 mph (**Figure 6-27**). According to the Saffir-Simson Hurricane Wind Scale, both Categories 3 and 4 are considered "major" hurricane events.

During a Category 3 event, devastating damage is projected to occur, including the possibility of major damage to well-built framed homes and removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.

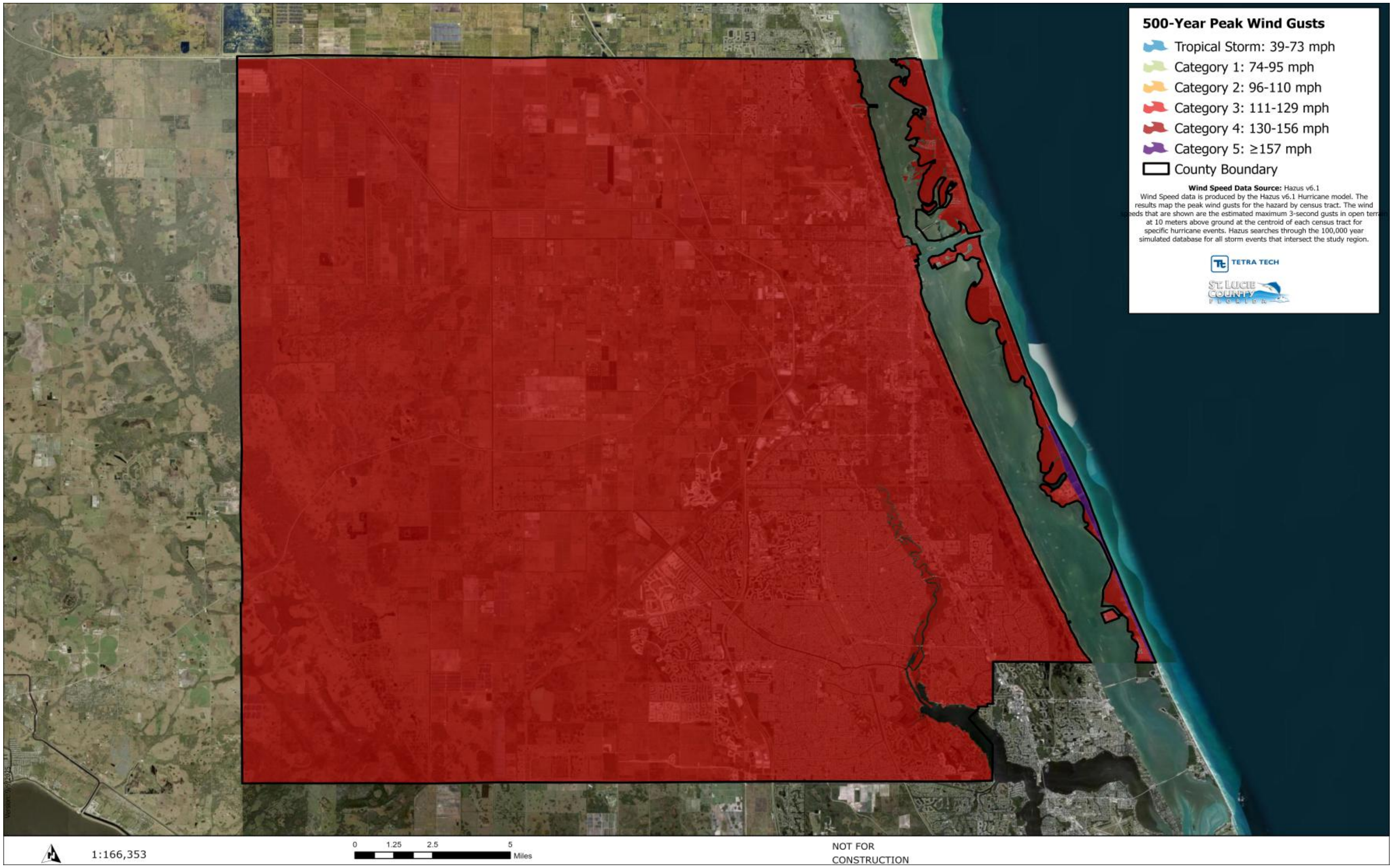
During a Category 4 event, catastrophic damage is projected to occur: well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, with power outages potentially lasting several weeks. Many areas will be uninhabitable.

In hurricanes, gusts of wind can be expected to exceed the sustained wind velocity by 25 to 50 percent. This means a hurricane with sustained winds of 130 miles per hour (mph) can have wind gusts between 162 and 195 mph. **Figure 6-28** shows that the entire county is vulnerable to Category 4 wind gusts in the 500-year event.



Note: Wind speed data is produced by Hazus v6.1 Hurricane model. The results map the peak wind gusts for the hazard by census tract. The wind speeds displayed are the estimated maximum 3-second gusts in open terrain at 10 meters above ground at the centroid of each census tract for specific hurricane events. Hazus searches through the 100,000 year simulated database for all storm events that intersect the study region.

Figure 6-27. St. Lucie County 100-Year Peak Wind Gusts



Note: Wind speed data is produced by Hazus v6.1 Hurricane model. The results map the peak wind gusts for the hazard by census tract. The wind speeds displayed are the estimated maximum 3-second gusts in open terrain at 10 meters above ground at the centroid of each census tract for specific hurricane events. Hazus searches through the 100,000 year simulated database for all storm events that intersect the study region.

Figure 6-28. St. Lucie County 500-Year Peak Wind Gusts

Tornadoes are a significant threat during tropical cyclones and have been present in most events that have affected Florida. Florida ranks third in the United States in the number of tornado strikes, and first in the number of tornadoes per square mile (SLC Department of Public Safety Division of Emergency Management 2021). The NOAA NCEI Storm Database reports 48 tornado events between 1960 and 2024 in St. Lucie County, 29 of which resulted in property damage. Total property damage for this period is estimated at $501 million, though it is likely higher (NOAA, Storm Events Database 2025a).

Until the 2024 tornadoes spawned by Hurricane Milton, tornadoes in St. Lucie County had mainly been of lower magnitude (EF-0 or EF-1), resulting in light to moderate damage. Light damage can range from peeled surface off roofs, damage to gutters or siding, branches broken off trees, and shallow-rooted trees pushed over. Moderate damage can include severely stripped roof, overturned or badly damaged mobile homes, loss of exterior doors, and broken windows and other glass.

Most recently, Hurricane Milton in 2024 triggered an historic tornado outbreak across South Florida, with multiple confirmed tornadoes touching down in St. Lucie County and surrounding areas, prompting numerous emergency warnings throughout the region, and causing significant damage and multiple deaths.

6.2.6.2 Wind Sensitivity Analysis

Asset Sensitivity

Generally, it is the wind that produces most of the property damage in dollar terms associated with tropical storms, hurricanes, and tornadoes. Although high winds can exert tremendous pressure against a structure, a large percentage of high wind damage is caused not from the wind itself, but from flying debris. Tree limbs, signs and signposts, roof tiles, metal siding, and other loose objects can become airborne missiles that penetrate the outer shells of buildings, destroying their structural integrity and allowing the hurricane winds to act against interior walls not designed to withstand such forces (SLC Department of Public Safety Division of Emergency Management 2021).

The external and internal pressures generated against a structure vary greatly with increases in elevation, shapes of buildings, openings in the structures, and the surrounding buildings and terrain. Buildings at ground level experience some reductions in wind forces simply because of the drag exerted by the ground against the lowest levels of the air column. Recent studies estimate that wind speed increases by approximately 37 percent just 15 feet above ground level. High-rise buildings, particularly those located along the beachfront, will receive the full strength of a hurricane's winds on their upper stories.

Excessive wind events generate massive quantities of debris that can easily exceed a community's entire solid waste capacity by three times or more and are cost- and time-intensive for municipalities to remove before beginning to repair and recover after a hazard event. Debris removal is an integral first step toward recovery, and as such, must be a critical concern of all those tasked with emergency management and the restoration of community services (Florida Division of Emergency Management 2023).

As seen in **Table 6-15**and **Figure 6-29**, a 100-year wind event is expected to impact 3.7 percent of assets countywide, with the total estimated total replacement cost valued at $15 trillion.

The 500-year wind event projections are substantially higher for all jurisdictions and the unincorporated areas of the County, with 13.2 percent of assets being impacted countywide at a total replacement cost valued at $53 trillion (**Table 6-15** and **Figure 6-30**).

Table 6-15. Critical Asset Sensitivity to Hurricane Wind

Jurisdiction	Total Replacement Cost Value of Critical Assets Evaluated	100-year Mean Return Period		500-year Mean Return Period	
		Building Damages	Percent of Total	Building Damages	Percent of Total
Fort Pierce (C)	$134,571,612,529	$5,487,615,448	4.1%	$19,558,698,438	14.5%
Port St. Lucie (C)	$45,592,032,539	$1,328,121,291	2.9%	$5,569,795,194	12.2%
St. Lucie Village (T)	$3,042,642,605	$192,708,758	6.3%	$776,817,797	25.5%
Unincorporated St. Lucie County	$220,504,524,380	$8,068,842,639	3.7%	$27,311,357,730	12.4%
St. Lucie County (Total)	**$403,710,812,054**	**$15,077,288,136**	**3.7%**	**$53,216,669,159**	**13.2%**

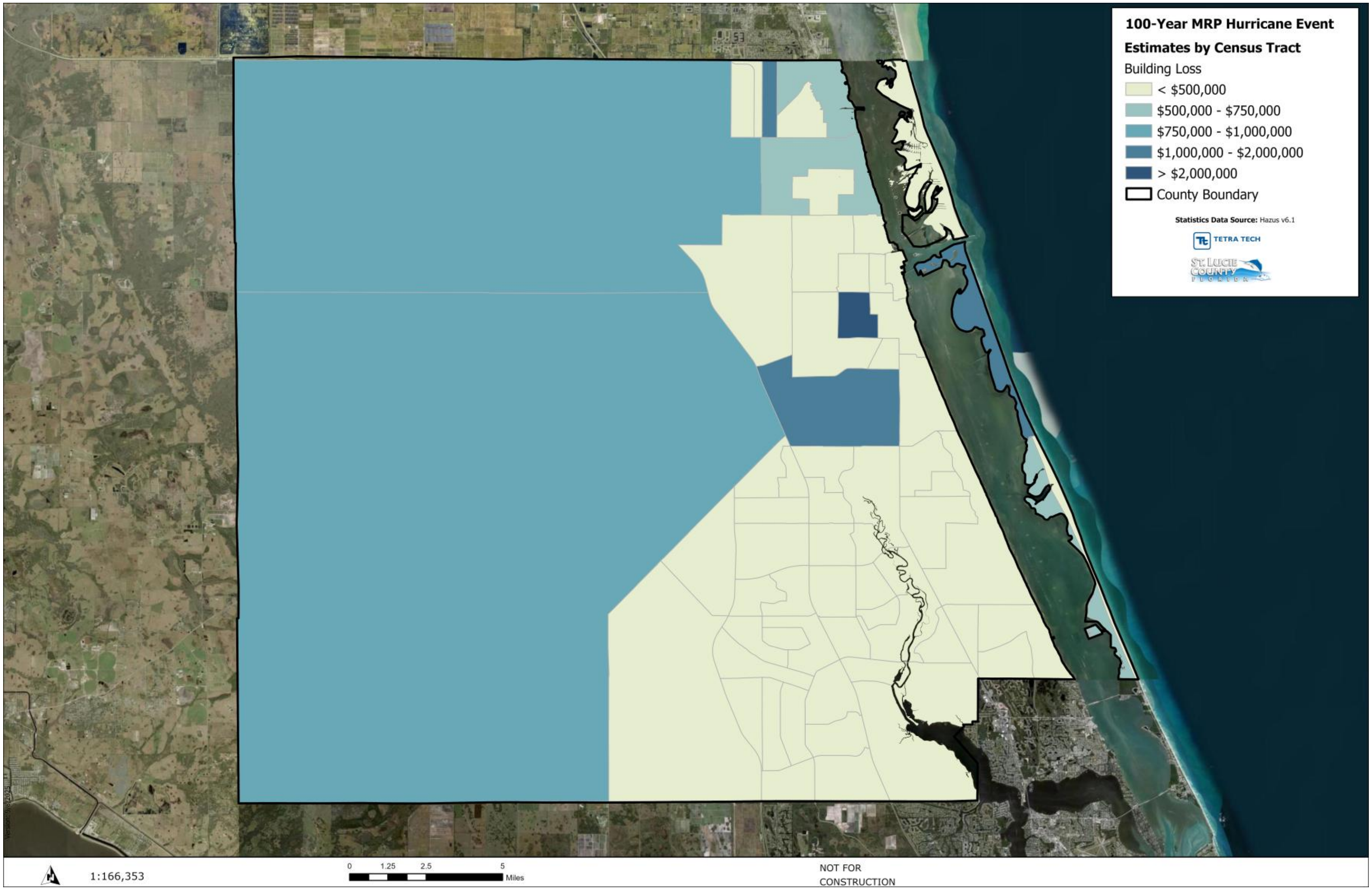


Figure 6-29. St. Lucie County Estimated Building Loss from 100-Year Hurricane Event

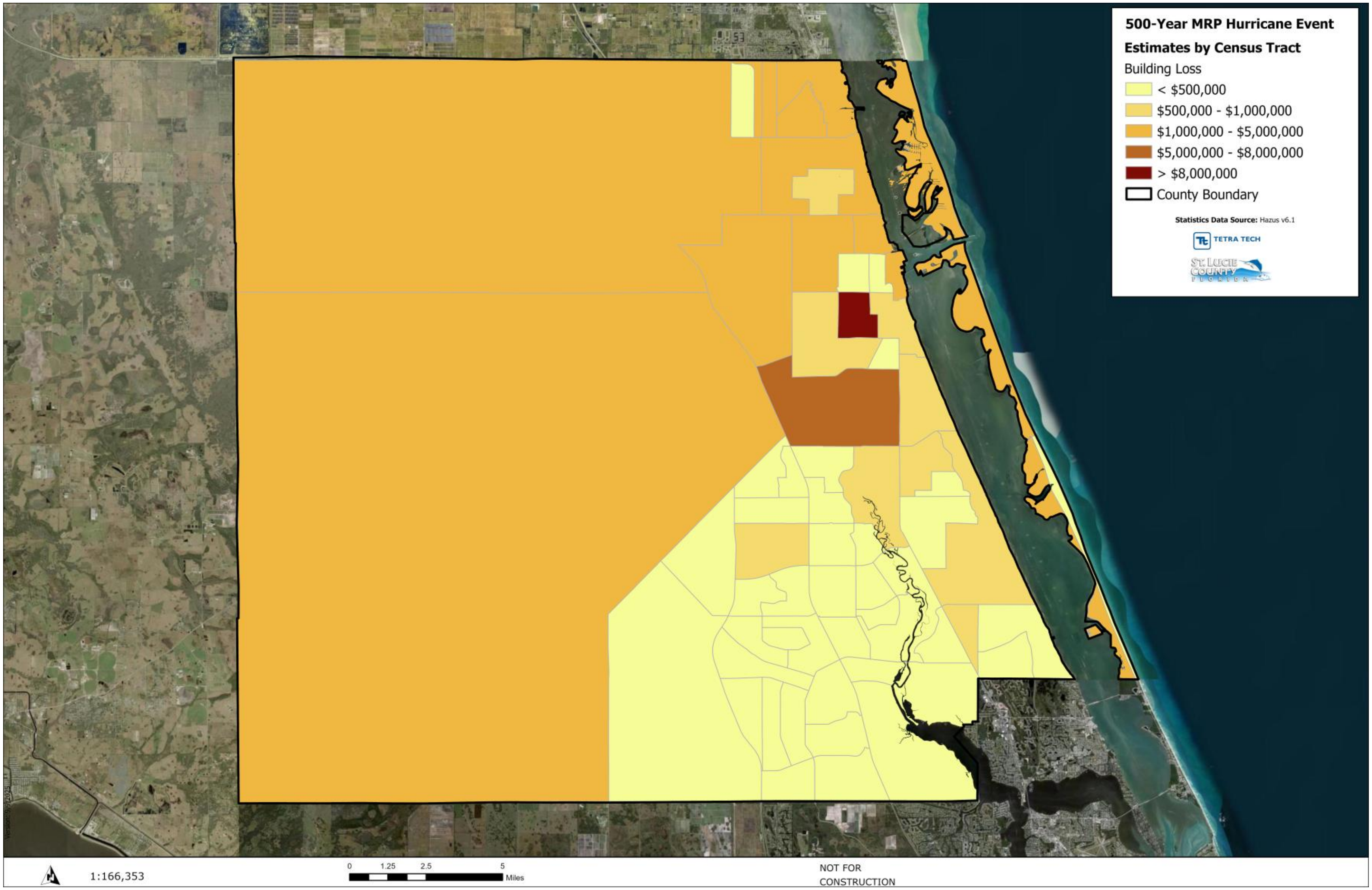


Figure 6-30. St. Lucie County Estimated Building Loss from 500-Year Hurricane Event

Population Sensitivity

Single-family residential construction is particularly vulnerable because less engineering oversight is applied to its design and construction. As opposed to hospitals and public buildings, which are considered “fully engineered,” and office and industrial buildings, which are considered “marginally engineered,” residential construction is considered “non-engineered.” Historically, the bulk of wind damage experienced nationwide has occurred to residential construction. Fully engineered construction usually performs well in high winds due to the attention given to connections and load paths.

St. Lucie County’s vulnerability to high winds is compounded by the high concentration of mobile home residents in large mobile home communities in both incorporated and unincorporated areas. There are 8,921 mobile home spaces and 1,184 recreational vehicle spaces throughout the County (SLC Planning & Development Services 2021). Mobile homes are an affordable form of housing in St. Lucie County, and they are distributed in both rural and urban areas. Although the number of mobile homes within the County has been reduced over the last 5 years, they remain the most vulnerable to tornadic activity.

During a 100-year event (i.e., 1 percent annual probability), an estimated 3,192 people (0.9 percent of the total population) would need to evacuate countywide, with nearly 2,759 (0.8 percent) of those requiring short term shelter to house them during the time they are displaced (**Figure 6-13** and **Table 6-16**). These numbers increase significantly during a 500-year event (i.e., 0.2 percent annual probability) to 19,763 (5.7 percent of the total population) displaced residents and 17,622 (5.1 percent) requiring short term shelter countywide (**Figure 6-32** and **Table 6-17**).

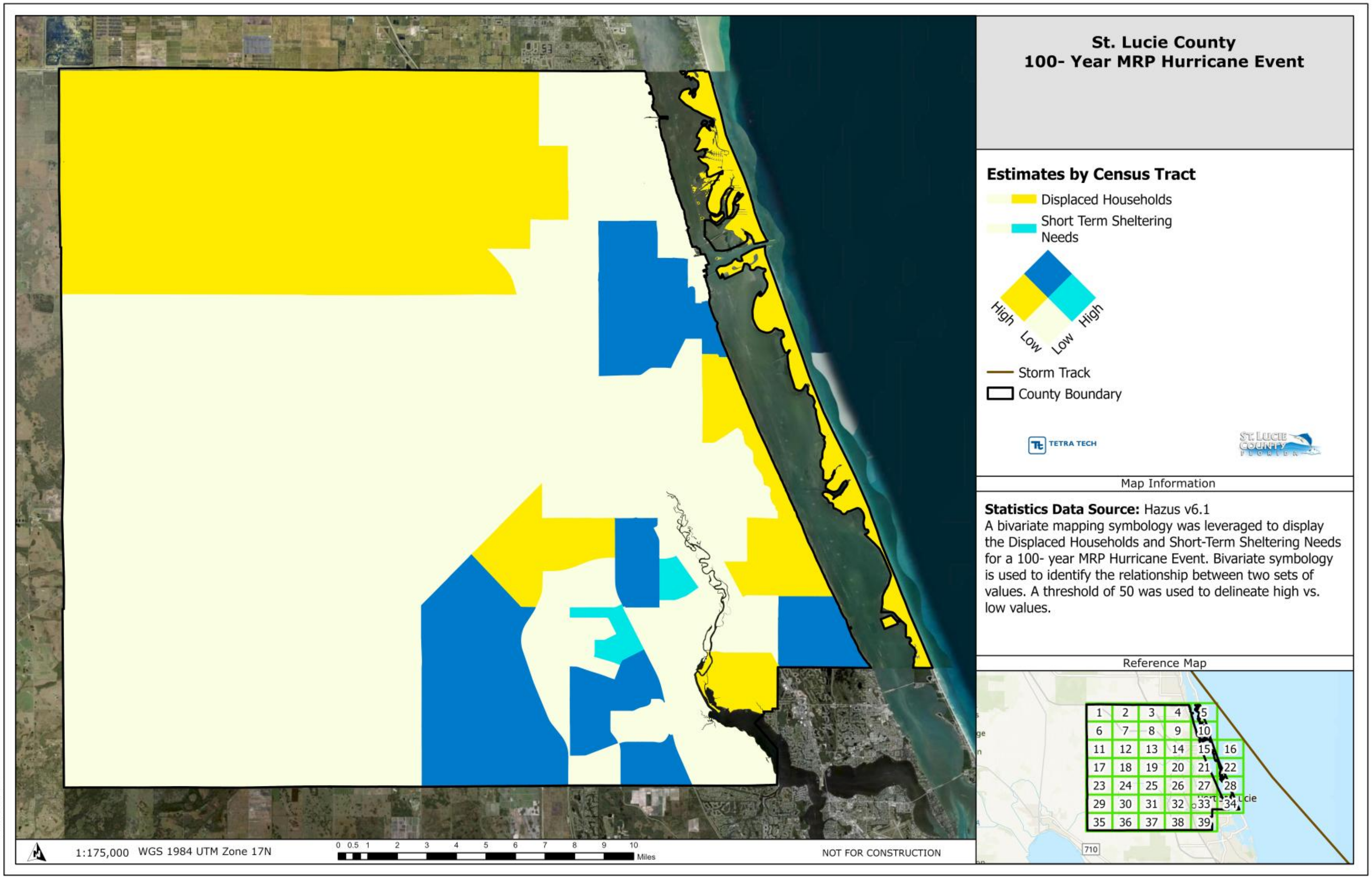


Figure 6-31. St. Lucie County Population Sensitivity to 100-Year Mean Return Period Hurricane

Table 6-16. Population Sensitivity to 100-Year Mean Return Period Hurricane

Jurisdiction	Total Population	Displaced Population	% of Total	Population Requiring Short Term Shelter	Percent of Total
Fort Pierce (C)	48,094	600	1.2%	612	1.3%
Port St. Lucie (C)	220,453	1,432	0.6%	1,433	0.7%
St. Lucie Village (T)	818	2	0.2%	2	0.2%
Unincorporated St. Lucie County	76,872	1,158	1.5%	712	0.9%
St. Lucie County (Total)	**346,237**	**3,192**	**0.9%**	**2,759**	**0.8%**

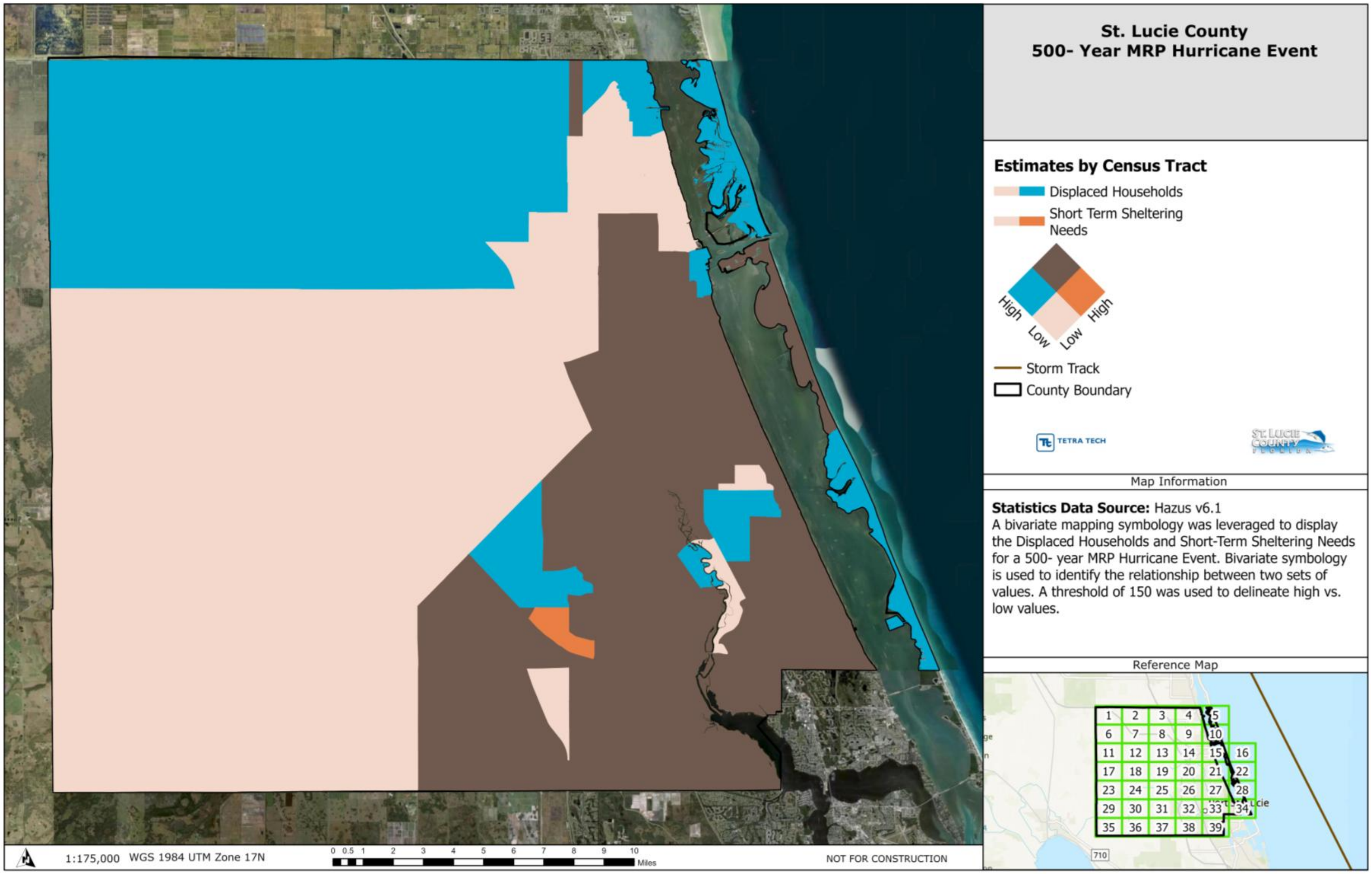


Figure 6-32. St. Lucie County Population Sensitivity to 500-Year Mean Return Period Hurricane

Table 6-17. Population Sensitivity to 500-Year Mean Return Period Hurricane

Jurisdiction	Total Population	Displaced Population	Percent of Total	Population Requiring Short Term Shelter	Percent of Total
Fort Pierce (C)	48,094	3,879	8.1%	4,046	8.4%
Port St. Lucie (C)	220,453	9,244	4.2%	9,206	4.2%
St. Lucie Village (T)	818	15	1.8%	12	1.5%
Unincorporated St. Lucie County	76,872	6,625	8.6%	4,358	5.7%
St. Lucie County (Total)	**346,237**	**19,763**	**5.7%**	**17,622**	**5.1%**

6.2.7 Wildfire

Most of Florida's natural systems are adapted to periodic wildfires and even dependent on them to maintain a balanced and sustainable ecosystem. However, in urbanized areas, naturally occurring wildfires are suppressed to protect life and property. Without management strategies, this results in the build-up of dead or decaying vegetation that provides fuel when a fire occurs and can lead to rapid acceleration and increased danger to surrounding areas.

Wildfire Hazard data from the University of Wisconsin-Madison's SILVIS Lab categorizes wildfire risk into two types: intermix and interface. Interface areas are where housing exists near large, contiguous wildlands, while intermix areas are where housing and smaller natural areas are intermingled. The most recent dataset from 2020 was used in this analysis. These wildfire hazard boundaries were overlaid on updated asset layers, including population data and critical facilities. Any asset points, lines or blocks that intersected the wildfire boundaries were totaled to estimate building replacement cost values and populations vulnerable to wildfire risk.

Wildfires can be caused by humans or occur naturally. Often, weather conditions determine how much a wildfire grows; dry conditions, high temperatures, and wind can cause a wildfire to grow quickly. Additionally, topography is important because it affects the movement of air over the ground surface, and the slope and shape of terrain can change the rate of speed at which fire travels. The Florida Forest Service records fire events by cause through a reporting system. In Florida, a total of 7,184 occurred between 2018 and 2022 burning 304,493 acres. About half of the acres were burned due to wildfires started by lightning. The 2023 Florida State Hazard Mitigation Plan states that the Wildland Urban Interface (WUI) areas of the state have increased and evaluates wildfire risk in the state as high. WUI areas are vulnerable to wildfires and can cause significant property damage (Florida Enhanced State Hazard Mitigation Plan 2023).

Wildfires have the potential for the following impacts within communities (SLC Department of Public Safety Division of Emergency Management 2021):

- Lives and property loss
- Electric power outage
- Surface and air transportation disruption
- Telecommunications system outage

- Disruption of community services
- Human health and safety
- Economic disruption
- Agricultural/fisheries damage
- Loss of livestock
- Damage to critical environmental resources
- Damage to identified historical resources

6.2.7.1 Wildfire Exposure Analysis

To evaluate exposure to wildfire, the assessment uses the WUI data from the University of Madison-Wisconsin to identify vulnerable areas with certain topographies and vegetation, as well as historical incidents of wildfires.

Wildfires are of particular concern in the WUI because they bring humans—the primary cause for wildfire ignition in the United States—into greater contact with flammable wildlands. The WUI grows nationwide by approximately 2 million acres each year as communities continue to expand, often due to the pressures of high housing costs in more densely populated areas.

The wildfire assessment categorized exposure into two categories: intermix and interface. As indicated previously, a wildfire interface is an area where human development meets or mixes with relatively large undeveloped natural environments such as forests, grasslands, or shrublands. This zone is a transition between unoccupied land and developed land. Interface areas are defined as having more than one house per 40 acres, less than 50 percent vegetation, and are within 1.5 miles of an area over 1,235 acres that is more than 75 percent vegetated (Stewart, et al. 2006).

The wildfire intermix is a geographical area where structures and wildlands intermingle, with no clear boundary between the two. In an intermix area, homes and other structures are scattered throughout a wildland area. These structures are often surrounded by trees and vegetation and are only accessible by narrow roads. This makes it difficult to reach these areas if a fire occurs. Intermix areas have more than one house per 40 acres and have more than 50 percent vegetation (Stewart, et al. 2006).

Using the WUI data, assets were overlaid with the wildfire hazard data. Assets that intersected the interface and intermix hazard area are considered exposed. The analysis determined the extent (in miles) of shoreline, the extent (in acreage) of critical asset areas, count of critical assets, count of populations, and land area affected by the wildfire hazard.

The Florida Wildfire Risk Map shown in **Figure 6-33** shows burn probability data. Burn probability is the annual probability of wildfire burning in a specific location. The map was generated using a geospatial Fire Simulation (FSim) system developed by the U.S. Forest Service, Missoula Fire Sciences Laboratory. The FSim includes modules for weather, wildfire occurrence, fire growth, and fire suppression. The map shows wildfires are likely to occur across most of the state, with a 5 to 10 probability ranking, except for portions of the Panhandle and other intermittent areas across the state (Florida Division of Emergency Management 2023).

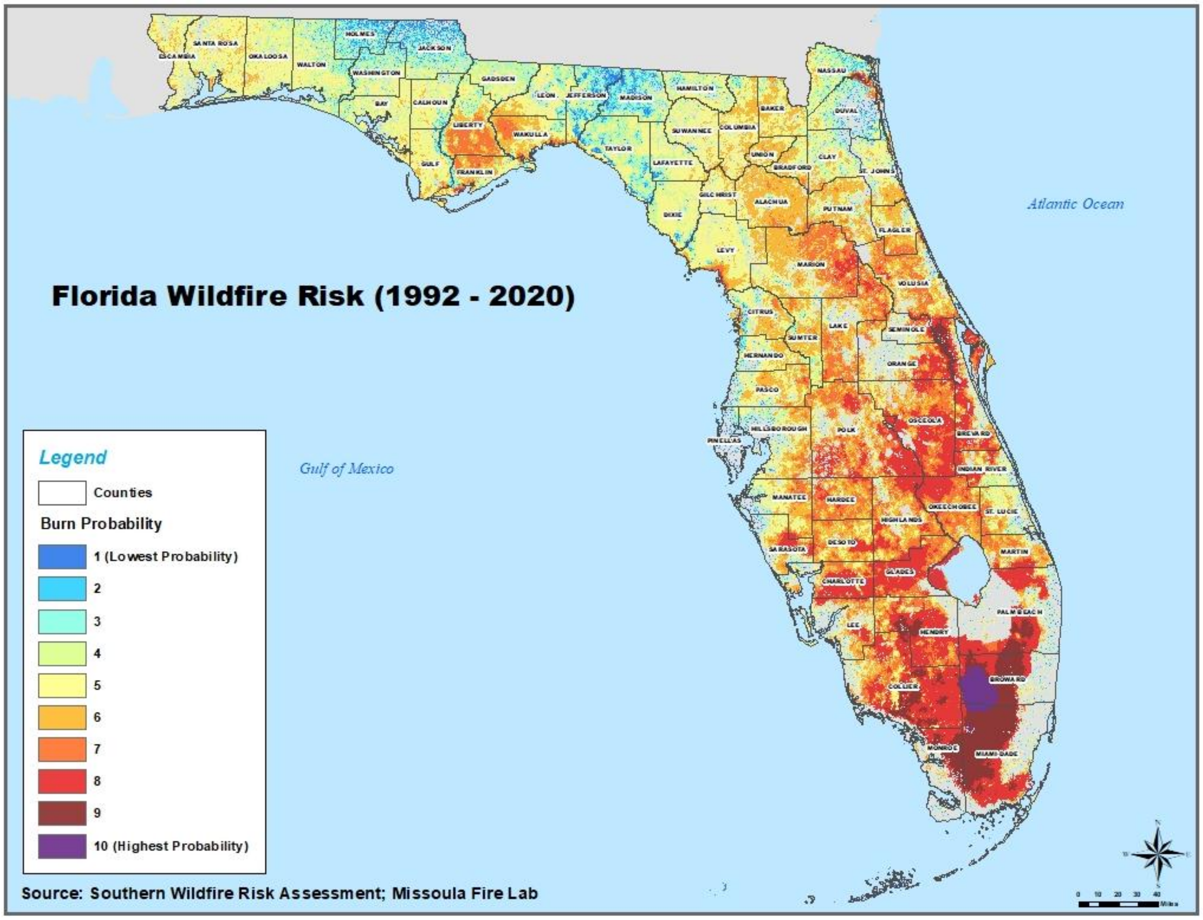


Figure 6-33. Florida Wildfire Risk Map

Land, Assets and Population Exposure

Land Exposure

Wildfire exposure is assessed using both WUI interface and intermix areas. **Figure 6-34** shows the WUI interface and intermix areas in St. Lucie County.

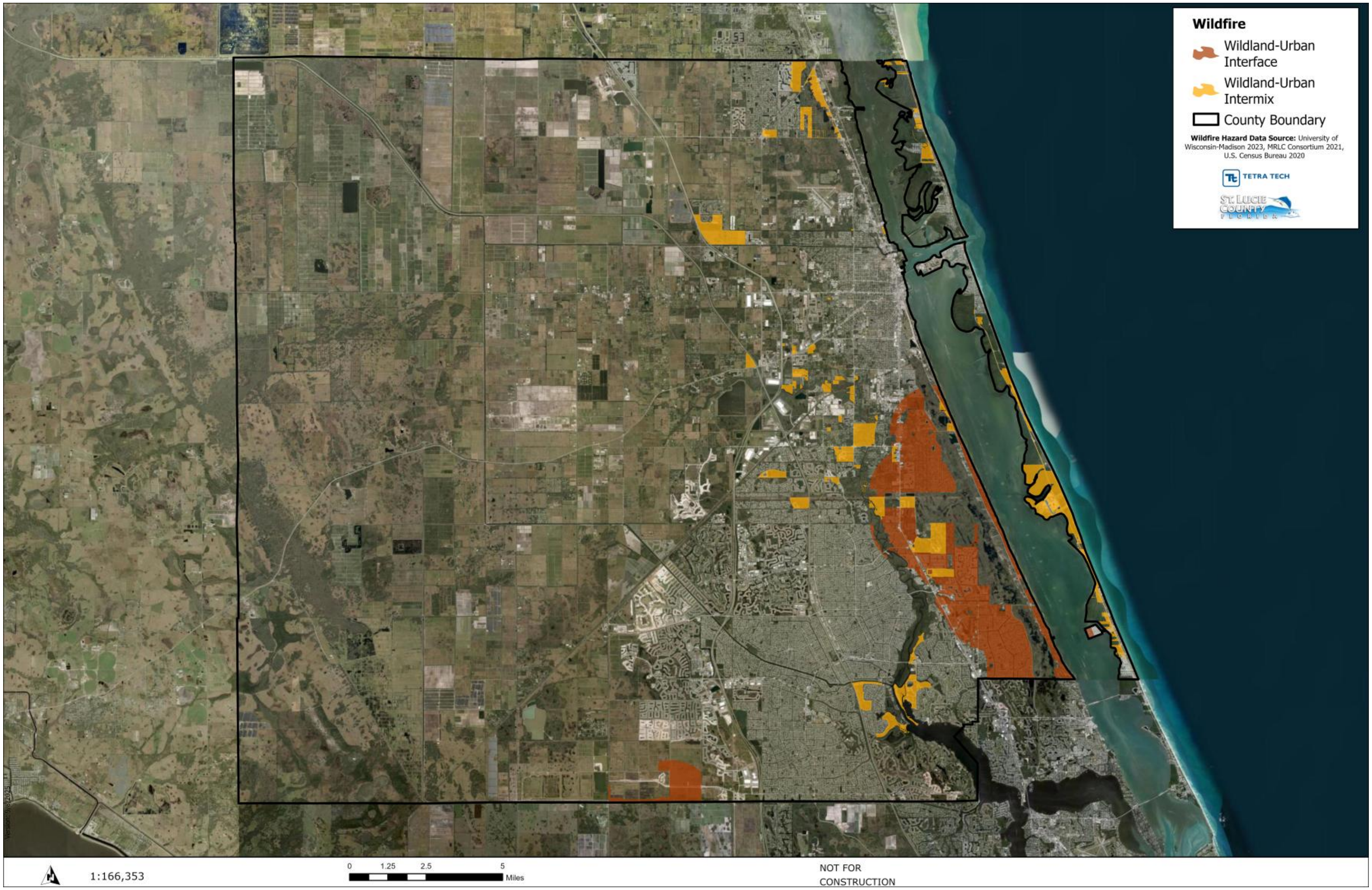


Figure 6-34. St. Lucie County Wildfire Hazard Area

As shown in **Table 6-18**, approximately 17,700 acres countywide are considered exposed to wildfire, representing almost 5 percent of the total land area. Of those total acres, 11,270 or 3.1 percent are categorized as wildfire interface, while 6,563 or 1.8 percent are categorized as wildfire intermix.

Table 6-18. Land Area in Wildfire Hazard Areas

Jurisdiction	Total Land Area (Acres)	Land Area Exposure in Acres			
		Interface	% of Total	Intermix	% of Total
Fort Pierce (C)	15,663.3	802.4	5.1%	230.1	1.5%
Port St. Lucie (C)	75,850.8	4,589.7	6.1%	1,132.0	1.5%
St. Lucie Village (T)	524.0	0.0	0.0%	13.9	2.7%
Unincorporated St. Lucie County	274,265.0	5,878.9	2.1%	5,186.9	1.9%
St. Lucie County (Total)	**366,303.2**	**11,270.9**	**3.1%**	**6,563.0**	**1.8%**

Asset Exposure

As shown in **Table 6-19**, nearly 23 percent of critical assets are exposed to wildfires countywide, with Critical Infrastructure assets making up the largest group facing wildfire exposure.

Table 6-19. Summary of Assets Exposed to Wildfire

Jurisdiction	Number of Assets					Percent of Total Exposed
	Total Critical Assets Evaluated	Critical Community and Emergency Facilities	Critical Infrastructure	Natural, Cultural, and Historic Resources	Transportation Assets	
Fort Pierce (C)	18,654	12	451	1	1	8.1%
Port St. Lucie (C)	805	46	36	17	2	43.40%
St. Lucie Village (T)	445	0	6	0	0	1.4%
Unincorporated St. Lucie County	7,307	35	484	83	8	41.30%
St. Lucie County (Total)	**27,211**	**93**	**977**	**101**	**11**	**23%**

Table 6-20. Assets Exposed to Wildfire by Jurisdiction and Asset Category

Jurisdiction	Critical Asset Category	Total Critical Assets Evaluated	Number of Critical Assets Exposed to the Wildland-Urban Interface (WUI) Hazard Area			
			Interface	% of Total	Inter-mix	% of Total
Fort Pierce (C)	Critical Community and Emergency Facilities	714	11	1.5%	1	0.1%
	Critical Infrastructure	17,152	335	2.0%	116	0.7%
	Natural, Cultural, and Historic Resources	761	0	0.0%	1	0.1%
	Transportation and Evacuation Routes	27	0	0.0%	1	3.7%
Port St. Lucie (C)	Critical Community and Emergency Facilities	343	45	13.1%	1	0.3%
	Critical Infrastructure	275	32	11.6%	4	1.5%
	Natural, Cultural, and Historic Resources	124	10	8.1%	7	5.6%
	Transportation and Evacuation Routes	63	1	1.6%	1	1.6%
St. Lucie Village (T)	Critical Community and Emergency Facilities	5	0	0.0%	0	0.0%
	Critical Infrastructure	435	0	0.0%	6	1.4%
	Natural, Cultural, and Historic Resources	4	0	0.0%	0	0.0%
	Transportation and Evacuation Routes	1	0	0.0%	0	0.0%
Unincorporated St. Lucie County	Critical Community and Emergency Facilities	283	21	7.4%	14	4.9%
	Critical Infrastructure	5,595	170	3.0%	314	5.6%
	Natural, Cultural, and Historic Resources	1,373	9	0.7%	74	5.4%
	Transportation and Evacuation Routes	56	1	1.8%	7	12.5%
St. Lucie County (Total)	**Critical Community and Emergency Facilities**	**1,345**	**77**	**5.7%**	**16**	**1.2%**
	Critical Infrastructure	**23,457**	**537**	**2.3%**	**440**	**1.9%**
	Natural, Cultural, and Historic Resources	**2,262**	**19**	**0.8%**	**82**	**3.6%**
	Transportation and Evacuation Routes	**147**	**2**	**1.4%**	**9**	**6.1%**

As shown in **Table 6-21**, a small portion of countywide evaluated road miles, for transportation systems and critical asset systems (systems like transmission lines, that cannot be identified as a single site), are exposed to the wildfire hazard areas; 4.8 percent of critical infrastructure asset miles (334 miles) and 6.3 percent transportation asset miles (479 miles).

Table 6-21. Total Miles Exposed to the Wildfire Hazard Area

Jurisdiction	Critical Asset Category	Total Miles Evaluated	Total Miles of Critical Assets (Linear) Exposed to the Wildland-Urban Interface (WUI) Hazard Area			
			Interface	% of Total	Inter-mix	% of Total
Fort Pierce (C)	Critical Infrastructure	53.9	0.97	1.8%	0.65	1.2%
	Transportation and Evacuation Routes	52.6	0.94	1.8%	0.70	1.3%
Port St. Lucie (C)	Critical Infrastructure	99.4	1.80	1.8%	2.90	2.9%
	Transportation and Evacuation Routes	133.7	1.56	1.2%	1.03	0.8%

Jurisdiction	Critical Asset Category	Total Miles Evaluated	Total Miles of Critical Assets (Linear) Exposed to the Wildland-Urban Interface (WUI) Hazard Area			
			Interface	% of Total	Inter-mix	% of Total
St. Lucie Village (T)	Critical Infrastructure	2.2	0.00	0.0%	0.00	0.0%
	Transportation and Evacuation Routes	2.1	0.00	0.0%	0.00	0.0%
Unincorporated St. Lucie County	Critical Infrastructure	169.3	4.02	2.4%	5.38	3.2%
	Transportation and Evacuation Routes	271.1	6.72	2.5%	18.05	6.7%
St. Lucie County (Total)	**Critical Infrastructure**	**324.8**	**6.79**	**2.1%**	**8.93**	**2.7%**
	Transportation and Evacuation Routes	**459.4**	**9.22**	**2.0%**	**19.78**	**4.3%**

Population Exposure

The population in the wildfire interface and intermix areas described above are presented in **Table 6-22**. Ten percent of countywide residents are exposed to wildfire, equating to about 34,700 people.

Table 6-22. Population Exposure in Wildfire Areas

Jurisdiction	Total Population	Population Exposure to the Hazard Area			
		Interface	% of Total	Intermix	% of Total
Fort Pierce (C)	48,094	1,183	2.5%	505	1.1%
Port St. Lucie (C)	220,453	12,858	5.8%	2,073	0.9%
St. Lucie Village (T)	818	0	0.0%	32	3.9%
Unincorporated St. Lucie County	76,872	11,193	14.6%	6,872	8.9%
St. Lucie County (Total)	**346,237**	**25,234**	**7.3%**	**9,482**	**2.7%**

Wildfires can cause significant property damage, as well as result in lingering environmental health issues. As discussed previously, asset exposure and sensitivity to wildfire is as much a function of location as it is structure type. The materials and structural integrity of older homes that pre-date enhanced building codes can be significantly more vulnerable to wildfires, as well as mobile homes no matter their age.

The impacts from smoke entering and lingering in the air can become an increased threat to certain populations. Elderly people, children, disabled individuals, and those living with respiratory and chronic illnesses are particularly vulnerable to wildfire hazards. Children breathe more air than adults in proportion to their body size, making them more susceptible to smoke inhalation.

6.2.7.2 Wildfire Sensitivity Analysis

Wildfire risk has been increasing in recent years across the United States. NOAA's Billion-Dollar Weather and Climate Disasters report shows that there was $79.8 billion in costs associated with wildfires between 2018 and 2021, as compared to $8.5 million between 2012 and 2016.

The 2023 Florida State Hazard Mitigation Plan estimates nearly $4.4 million in expected annual loss for St. Lucie County due to wildfires. Total expected annual loss is a combination of exposure, frequency, and historical loss ratio, and depicts the average economic loss in dollars from each natural hazard by census tract and county. Expected annual loss is computed for each hazard type and only quantifies loss for relevant consequence types (i.e., buildings, population or agriculture).

The 'fuel' that drives wildfires is primary dry or decaying vegetation that builds up over time. Local land managers use various strategies to consistently reduce fuel build-up in our rural and urban environments, thereby reducing the risk of catastrophic fires to occur. This includes clearing wide corridors to act as fire breaks, mechanically chopping flammable materials, and using prescribed fires, which are controlled burns under optimal conditions that eliminate the fuel load.

Reduced moisture of living vegetation, soils, and decomposing organic matter during drought or extreme heat events is associated with increased incidence of wildfires. Changes over time in vegetation types could change the mixture and flammability – either favorably or unfavorably – for fuel build-up. As these transitions occur, wildfire occurrences and severity could increase with the introduction of more flammable vegetation types or decrease with the introduction of more fire-resistant species. Florida has weather patterns that lead to both dry and wet periods each year. Future conditions may cause one or the other, or both types of conditions to increase in occurrence and magnitude.

The First Street Foundation's 5th National Risk Assessment: Fueling the Flames Report models risk to fire and threat to properties (First Street Foundation 2022). The Wildfire Model integrates information on fuels, wildfire weather, and ignition. The wildfire weather data looks at factors like surface wind, air temperature, relative humidity, and precipitation. This report shows Florida's current 6 percent of properties at risk from wildfires could jump to 12 percent by 2052 (First Street Foundation 2022). This is partially because Florida is expected to have an increased number of hot days, but also because development is increasingly encroaching into undeveloped land.

7.0 NATURAL, CULTURAL, AND HISTORIC RESOURCES

7.1 Natural Resources

The Sea Level Affecting Marshes Model (SLAMM) is a freely available, spatially explicit land cover change model that simulates coastal habitat transformation due to sea level rise (SLAMM 2022). The model integrates multiple datasets and processes, including elevation and slope, tidal datum shifts, erosion and accretion, storm tide over wash, and existing land cover. SLAMM produces spatially explicit projections of land cover changes over user-defined time steps and SLR scenarios. It is widely used for long-term conservation planning, including imperiled species conservation (Evans & Bergh, 2016; Benedict et al., 2018), flood risk assessments (Hauer et al., 2015), coastal resilience, and planning (Clough et al., 2016; Mazor et al., 2021).

The full St. Lucie County 2025 SLAMM analysis, entitled "Long-Term Resilience in St. Lucie County, FL: A Conservation Planning Approach," is presented in Part II of this report. It provides a comprehensive evaluation of the countywide vulnerability to sea level rise and outlines strategic pathways for long-term resilience.

SLAMM version 6.7 was implemented with locally calibrated parameters to accurately represent local conditions. The model uses a 10-meter-by-10-meter cell-based approach, where each cell represents elevation, habitat type, and key attributes. The fate of each cell is determined by SLR-driven processes that includes inundation of low-lying areas, shoreline erosion, habitat conversion, soil saturation from rising water tables, and sediment and organic matter accretion.

As a rapidly growing coastal region, SLC is particularly vulnerable to the impacts of SLR, extreme weather, and increased flooding, especially on its ecosystems. St. Lucie County's coastal ecosystems provide critical services, including storm protection, carbon storage, wildlife habitat, and recreational opportunities. Emerging concerns in resilience are focused on development in flood-prone areas that increase regional flood exposure, reduce the footprint of natural lands, and lead to a condition known as coastal squeeze, where developed waterfront land prevents the migration of wetlands in response to SLR (Clearview Geographic LLC 2025).

Recent record rainfall from Hurricanes Irma (2017) and Milton (2024) has further highlighted these concerns, emphasizing the need for integrated stormwater management, wetland conservation, and sustainable land-use planning (Clearview Geographic LLC 2025).

SLAMM is a computer-based model that simulates how coastal wetlands and shorelines respond to rising sea levels. It predicts how habitats such as mangroves, marshes, and beaches may migrate, transform, or disappear as sea levels rise. SLAMM considers key processes like inundation, erosion, accretion, and habitat conversion, making it a valuable tool for climate adaptation planning and coastal resilience strategies. The SLAMM analysis for the SLC region explored opportunities to enhance resilience through open space conservation and green stormwater infrastructure. Science-based planning and proactive management will be increasingly important for the region as it seeks to protect its environment, economy, and quality of life. The findings from this SLAMM analysis will help local decision-makers develop strategies that will minimize ecosystem loss and maximize natural flood protection (Clearview Geographic LLC 2025).

Using high-resolution elevation data, wetland inventories, and NOAA's SLR projections, the study modeled ecological changes for years 2040, 2070 and 2100 under two scenarios: Intermediate Low (NIL) and Intermediate High (NIH). The results show that under the NIH scenario, St. Lucie County could lose up to 94 percent of its mangrove habitat (over 64,000 acres) and nearly 49 percent of regularly-flooded marshes, while estuarine open water could expand by nearly 400 percent. In contrast, the NIL scenario projects far less dramatic changes, including a slight increase in mangrove area and more moderate wetland losses (Clearview Geographic LLC 2025).

While protection strategies (such as safeguarding all dry land or only developed dry areas) are effective at preserving infrastructure, they offer limited benefits for natural systems. In fact, the "Protect All Dry Land" strategy may exacerbate habitat loss due to 'coastal squeeze', where wetlands are trapped between rising seas and hardened infrastructure, unable to migrate inland. A "Protect Developed Dry Land" strategy, offers a more balanced approach, preserving infrastructure while supporting some ecological adaptation (Clearview Geographic LLC 2025).

To guide future action, a phased adaptation strategy is recommended in the report. In the short term, priorities should include monitoring habitat changes, protecting critical wetland areas, and updating land use codes, with longer term strategies considering increased land acquisition, floodplain restoration, and infrastructure retrofits.

Figure 7-1 presents a spatial analysis of high-priority parcels in SLC identified for potential conservation action. The map integrates outputs from the SLAMM model with the Florida Natural Areas Inventory's Critical Lands and Waters Identification Project (CLIP) data to highlight parcels that are ecologically valuable, and have the potential to support flood mitigation, biodiversity long-term resilience. Specifically, it displays 581 parcels, each 10 acres or larger, that meet multiple criteria: they contain natural land cover types (e.g., wetlands, upland forests), overlap with Priority 1 or 2 CLIP conservation areas, and are adjacent to or near existing protected lands. These parcels are primarily located in the western portion of the County, where SLAMM projections indicate less direct inundation risk, but nonetheless critical for preserving freshwater ecosystems, groundwater recharge zones, and habitat connectivity. The figure underscores the importance of proactive land acquisition and conservation easements in areas that can serve as refugia or migration corridors for ecosystems threatened by SLR and development pressure.

Ultimately, the SLAMM report provides a robust foundation for recognizing increased hazard risk potential and integrating adaptation and mitigation strategies into land use planning, conservation initiatives, and infrastructure investment. It underscores that local actions—particularly those that preserve and restore natural systems—can significantly enhance St. Lucie County's ability to adapt to a changing conditions.

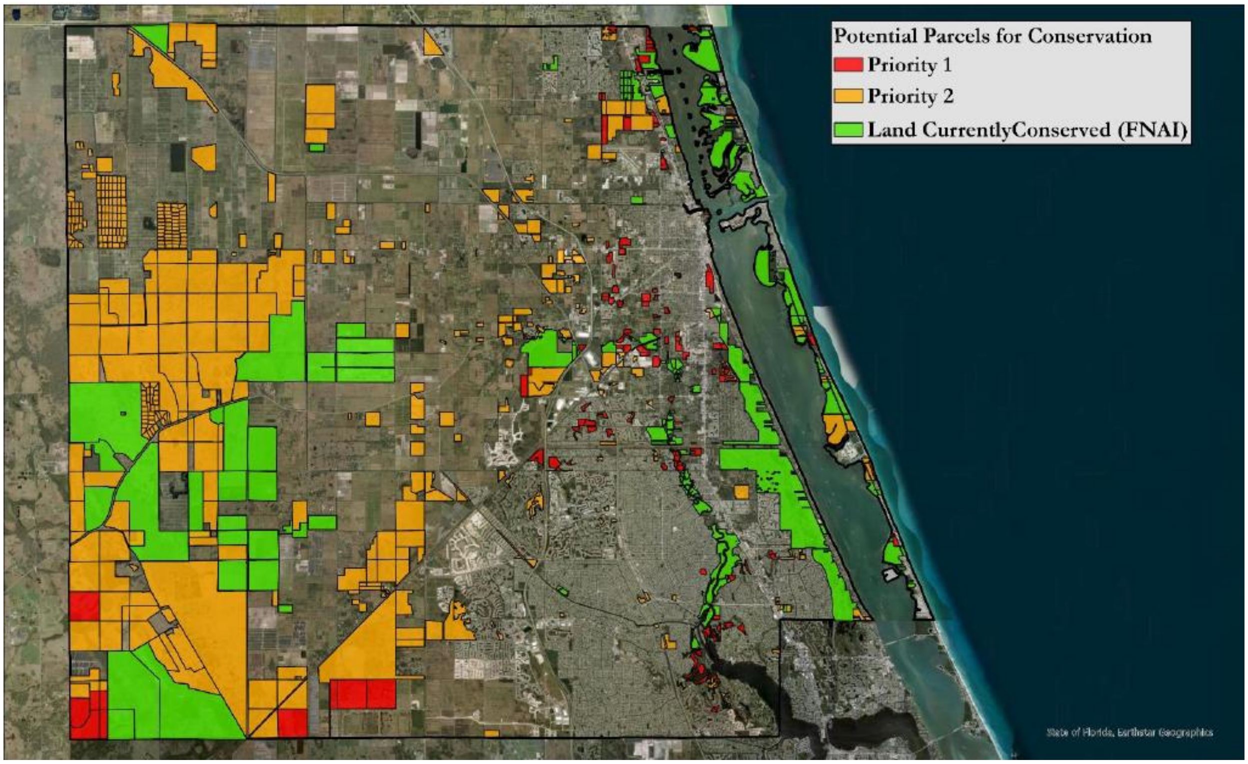


Figure 7-1. Potential Conservation Land Parcels in St. Lucie County

7.2 Cultural and Historic Resources

St. Lucie County is rich in cultural and historical assets that reflect its diverse heritage and community. These cultural and historical assets play a vital role in preserving the community's heritage, fostering a sense of identity, and promoting tourism. These assets include museums, historical landmarks, cultural centers, and heritage sites.

A number of historical resources are at risk due to flood hazards and pose substantial challenges for continued protection and preservation. As reflected in **Figure 7-2**, within SLC, there are 66 previously recorded historic buildings or structures (April 2024), and 59 previously recorded archaeological sites on city-, county-, or state-owned or managed parcels (Parsons et al. 2025).

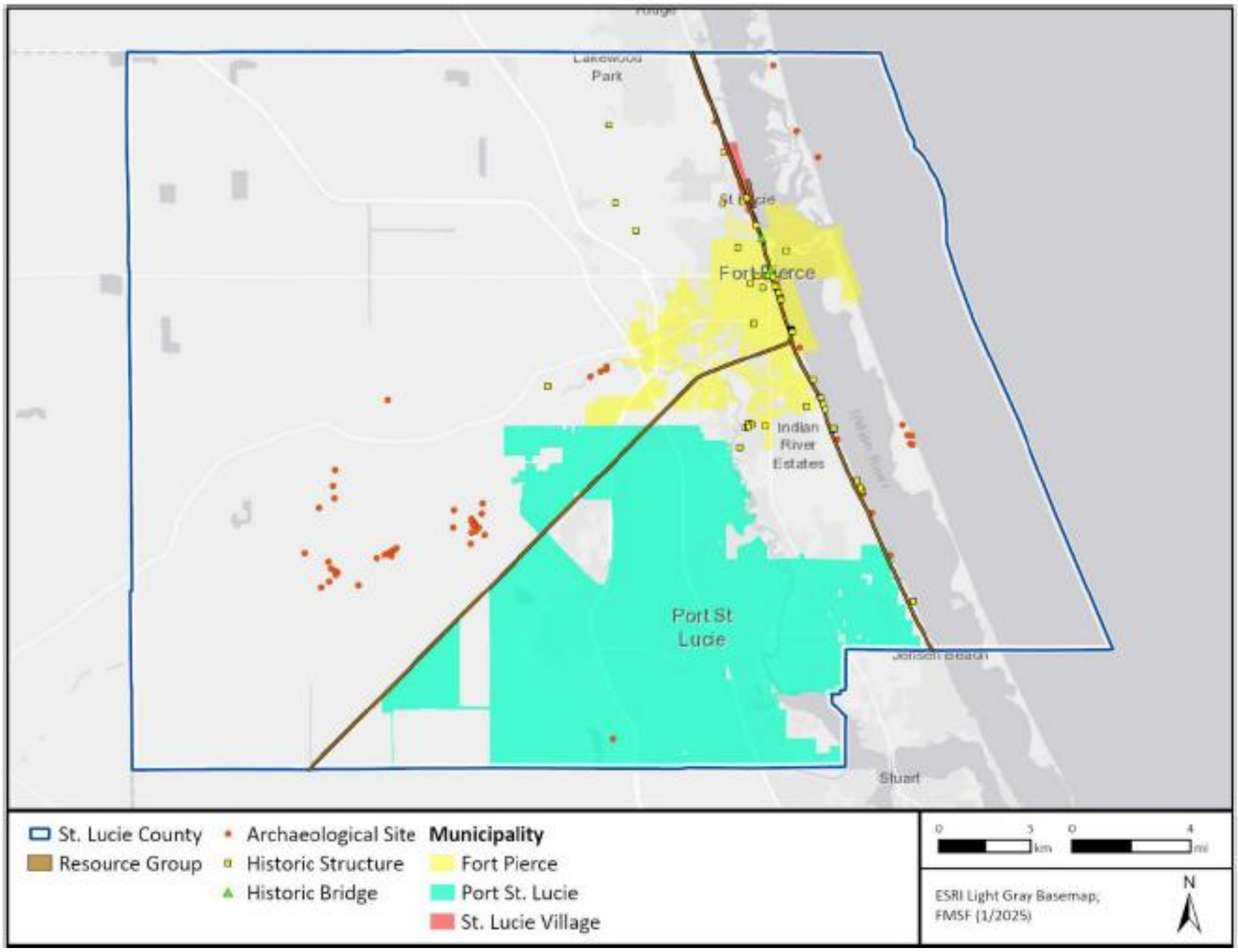


Figure 7-2. Overview of Historic Buildings, Structures, and Archeological Sites within St. Lucie County

Of the 66 historic resources analyzed, 62 are currently vulnerable to 24-hour 100-year rainfall events, while all face risks from heavy rainfall events. The Florida East Coast Railroad – Lake Harbor Branch is projected to have the most severe potential flood value (11.24 inches) along with Moore's Creek Bridge (9.91 inches). Of the 59 archeological sites analyzed, 42 are currently vulnerable to 24-hour 100-year rainfall events (ranging from 0.38 to 9.5 inches). Field Site #3 (a prehistoric habitation site) is projected with the most severe potential flood value (9.5 inches) along with Williams Midden (8.28 inches) (Parsons et al. 2025).

By 2040, the number of historic resources impacted by the 100-year rainfall event is projected to remain at 62, with the number of archeological sites impacted increases from 42 to 48. The projected impacts to historic resources under 2040 conditions range from less than 1.0 inch to 12.81 inches. Sites with significant potential flooding impacts include Indian Garden, Indian River Drive Site #9, Williams Midden, Blind Creek II, and Indian River Drive Site #8 (Parsons et al. 2025).

By 2070, projected impacts to historic resources range from less than 1.0 inch to 12.84 inches. Historic resources with significant potential flooding impacts include the Captain Hammond House, N U.S. Highway 1, Dixie Highway, and Red Barn Produce. Similarly, by 2070, the number of archeological sites impacted by the 100-year rainfall event is projected to increase to 52 sites (Parsons et al. 2025).

Historic buildings in SLC and the municipalities have diverse foundation types, including poured concrete footers, concrete block foundations, brick piers, raised concrete slabs, and at-grade concrete slabs. This variety results in different first-floor elevations, affecting each building's vulnerability and adaptation strategies. Architectural surveys and research can identify prominent building types and development patterns to estimate impacts and inform adaptive strategies. Public input is crucial for determining which historic resources the community prioritizes for protection.

Identifying general building types can aid in developing adaptation strategies, as well as design regulations for future construction, following guidelines from the National Park Service.

Flooding and inundation risks reduce opportunities to document and interpret archaeological information. SLC and the municipalities have various archaeological site types, including Native American precontact sites, Spanish and early American historic sites, multicomponent sites, and submerged sites like historic shipwrecks listed in the National Register of Historic Places. While not all sites can undergo intensive investigations, prioritizing at-risk sites for documentation involves professional judgment and systematic criteria, considering factors like rarity, integrity, threat severity, archaeological potential, and access. Unlike historic buildings, archaeological sites cannot be moved without destruction, limiting mitigation options.

This analysis highlights the growing vulnerability of SLC and the municipalities' historic and cultural resources. Proactively protecting these cultural and historic assets is essential for preserving SLC's cultural and historical fabric. Prioritizing adaptive measures, such as flood mitigation infrastructure, elevation, and other preservation techniques, will help ensure that these irreplaceable sites remain intact for future generations.

PART 2

St. Lucie County

Resilience Vulnerability Assessment

Phase II – Other Hazards (RVA-OH)

August 2025

This Report was developed through research by Clearview Geographic LLC, and supported by the CBDG-MIT Program

TETRA TECH

PART 2: A CONSERVATION APPROACH TO LONG-TERM RESILIENCE

8.0 INTRODUCTION

St. Lucie County's natural and semi-natural interior landscape is characterized by a mosaic of forests, grasslands and wetlands. Located at the intersection of the subtropical and tropical zones, the county contains a unique mix of flora and fauna, contributing to its relatively high local biodiversity. The county contains large areas of protected conservation areas and privately held undeveloped lands that provide important ecosystem services, including provisioning of water quality protection, groundwater recharge and floodwater storage. Each of these natural communities plays a vital role in the region's environmental resilience.

In addition, St. Lucie County's coastal landscape is a rich tapestry of 18 interconnected habitats, ranging from beaches and mangroves to freshwater wetlands and upland systems. Oceanfront habitats form the county's first line of defense against storms and rising seas. Beach systems and coastal scrub naturally buffer inland areas from wave and wind energy while mangroves, salt marshes and tidal flats create stable shoreline anchors.

Coastal areas of eastern St. Lucie County are known to be susceptible to major flood hazards associated with coastal erosion, storm surge, long-term sea level rise, and extreme precipitation. Due to the very low gradient of the St. Lucie River and its connection to tidal influence, some areas of central St. Lucie County are vulnerable to impacts from long-term sea level rise and rainfall. Many populated areas throughout St. Lucie County, not located near a water body, are also known to be susceptible to flooding associated with localized extreme rainfall and stormwater runoff.

Conservation, preservation, and restoration of undeveloped open space is widely regarded as one of the most efficacious and cost-effective flood risk mitigation strategies, especially when considering the uncertainties of future flood-related hazards. Open space conservation is known to reduce flood risk at multiple scales that range from stormwater catch basins draining less than an acre of land, up to regional watershed drainages covering hundreds of square miles or more. The many other co-benefits of open space – including biodiversity preservation, water quality protection, food and fiber production, carbon capture and storage, recreational enjoyment, and quality of life – provide further impetus for increased utilization of land conservation as a primary tool in comprehensive flood management, resilience, and mitigation programs.

The Sea Level Rise Affecting Marshes Model (SLAMM) is a data-driven initiative designed to assess how coastal ecosystems will respond to rising sea levels. By utilizing county-wide high-resolution elevation data, wetland inventories, and advanced habitat modeling, this study provides key insights into the migration of coastal habitats, potential ecosystem shifts, and long-term resilience strategies.

This study explores opportunities to enhance resilience through open space conservation and green stormwater infrastructure. The analysis examines:

Ecosystem Vulnerabilities – Identifying which coastal habitats face the greatest risk from sea level rise.

Projected Changes Over Time – Understanding when and how ecological transitions may occur.

Protection and Adaptation Strategies – Evaluating conservation and mitigation efforts to enhance resilience.

This SLAMM Analysis of St. Lucie County's coastal ecosystems reveals a complex interplay of vulnerability and resilience. While rising seas and changing local weather patterns pose significant risks, many of the county's natural systems retain the potential to adapt—if given adequate space and support.

As a rapidly growing coastal county, St. Lucie is particularly vulnerable to the impacts of sea level rise, extreme weather, and increased flooding. Recent record rainfall from Hurricanes Irma (2017) and Milton (2024) has further highlighted these risks, emphasizing the need for integrated stormwater management, wetland conservation, and sustainable land-use planning (e.g. Low Impact Development strategies).

Results from this analysis, under moderate to high sea level rise projection scenarios, show the potential for extensive wetland change within the coastal areas of St. Lucie County and conversion of freshwater ecosystems into estuarine conditions within the St. Lucie River, by the year 2070. However, projected trend-based land cover change patterns associated with expected population growth, show much more extensive impacts than even the highest modeled rate of sea level rise on freshwater wetlands and other natural ecosystems across St. Lucie County.

Without proactive measures, the county faces significant risks, including:

- Increased infrastructure damage due to flooding and extreme weather events.
- Loss of critical natural resources that provide storm protection, water filtration, and habitat preservation.
- Economic disruptions affecting property values, tourism, agriculture, and local businesses.
- Greater financial strain on county budgets due to disaster response and recovery expenses.

As St. Lucie County continues to grow and develop, strategic protection and maintenance of priority green space areas will be required in order to maintain these ecosystem services. This will take a complex, multi-layered strategy involving conservation policy, fee simple land acquisition, conservation easements, forestry and agricultural land use incentives, and low impact development approaches.

The key to enhancing long-term resilience lies in:

- Decisive action in the present
- Flexibility to adapt strategies as conditions evolve
- A resilient future requires sustained commitment and collaboration from all sectors. The investment in protecting and enhancing natural infrastructure today will help ensure St. Lucie County remains a vibrant, resilient community for generations to come.

8.1 Project Overview

This document presents a comprehensive analysis of the Sea Level Affecting Marshes Model (SLAMM) outputs for St. Lucie County, Florida. The study evaluates projected changes in coastal habitats under various sea level rise (SLR) scenarios, protection strategies, and planning horizons. The findings indicate significant habitat transitions over time, with the extent and timing of changes varying based on the SLR scenario and chosen protection strategy.

What is SLAMM? The Sea Level Affecting Marshes Model (SLAMM) is a computer-based model that simulates how coastal wetlands and shorelines respond to rising sea levels. It predicts how habitats such as mangroves, marshes, and beaches may migrate, transform, or disappear as sea levels rise. SLAMM considers key processes like inundation, erosion, accretion, and habitat conversion, making it a valuable tool for adaptation planning and coastal resilience strategies (**Figure 8-1**).

Figure 8-1. Warren Pinnacle Consulting, Inc's Website, more details are available for SLAMM at: https://www.warrenpinnacle.com/

8.1.1 Study Area

St. Lucie County (**Figure 8-2**), located on Florida's east coast, contains diverse coastal ecosystems including mangroves, swamps, marshes, and developed areas. The county has approximately 21 miles of Atlantic Ocean coastline and significant estuarine shoreline along the Indian River Lagoon. These ecosystems provide important ecological services, including:

- Habitat for wildlife, including threatened and endangered species
- Storm protection and flood mitigation
- Carbon sequestration and storage
- Water quality improvement
- Recreational opportunities and tourism

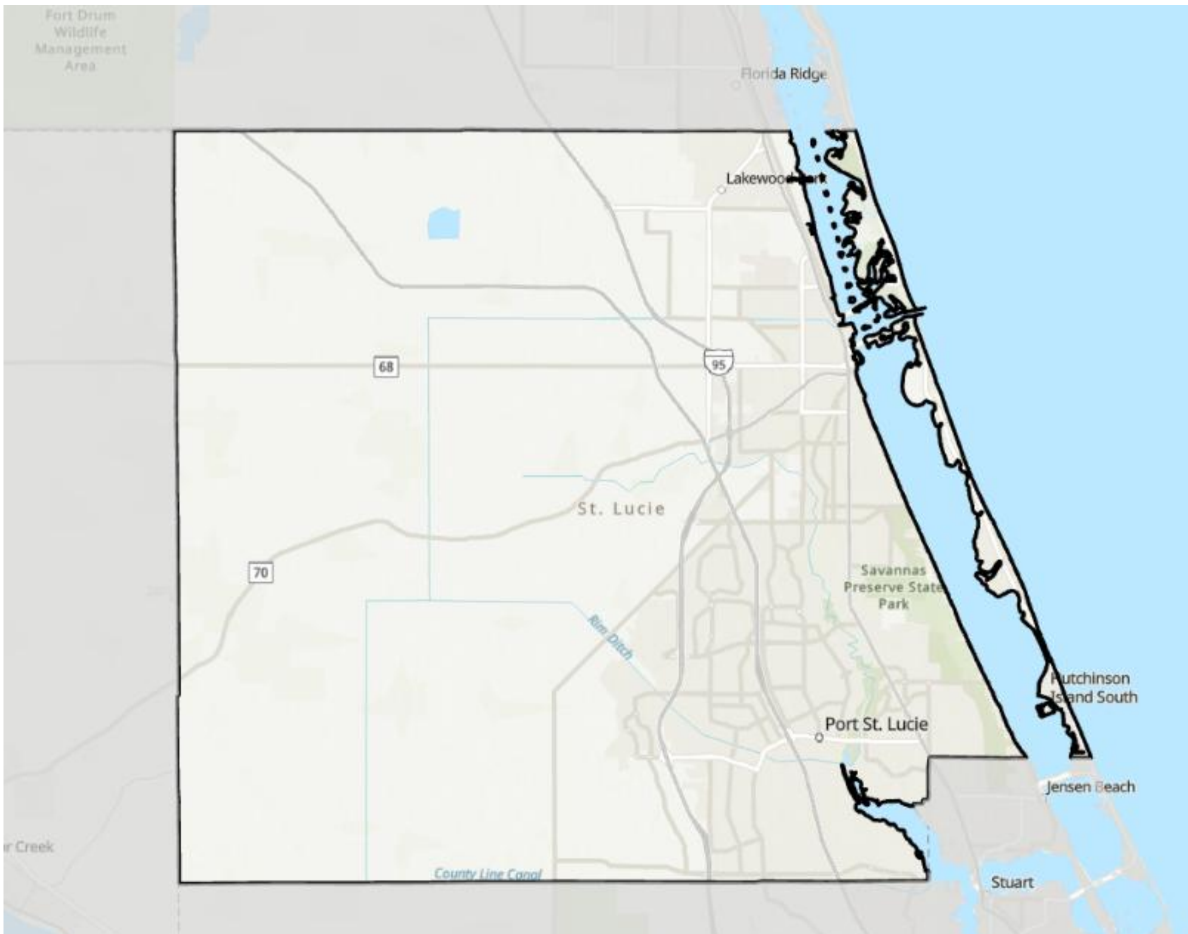


Figure 8-2. Overview of St. Lucie County

Sea level rise poses a significant threat to these coastal ecosystems and developed areas, potentially causing habitat transitions, loss of ecosystem services, and impacts to infrastructure. While it is not clear if sea-level rise is already contributing to increasing flood risk along the St. Lucie River in St. Lucie County, high rates of sea-level rise would be expected to increase water levels within the St.

Lucie River – and cause increased flood risk in low-lying riverine areas – across western and southern St. Lucie County over the next several decades.

St. Lucie County is a geographically moderate-sized and populous coastal county in southeastern Florida (**Figure 8-3**). With a total area of approximately 688 square miles, including 572 square miles of land area and 116 square miles of open water, St. Lucie County is not among the largest by area out of Florida's 67 counties. The 2020 U.S. Census Bureau's population count for St. Lucie County is approximately 373,586, making it the 20th largest by population within Florida.

St. Lucie County currently contains a total of three incorporated cities and towns: Port St. Lucie, Fort Pierce, and St. Lucie Village. The county seat is Fort Pierce.

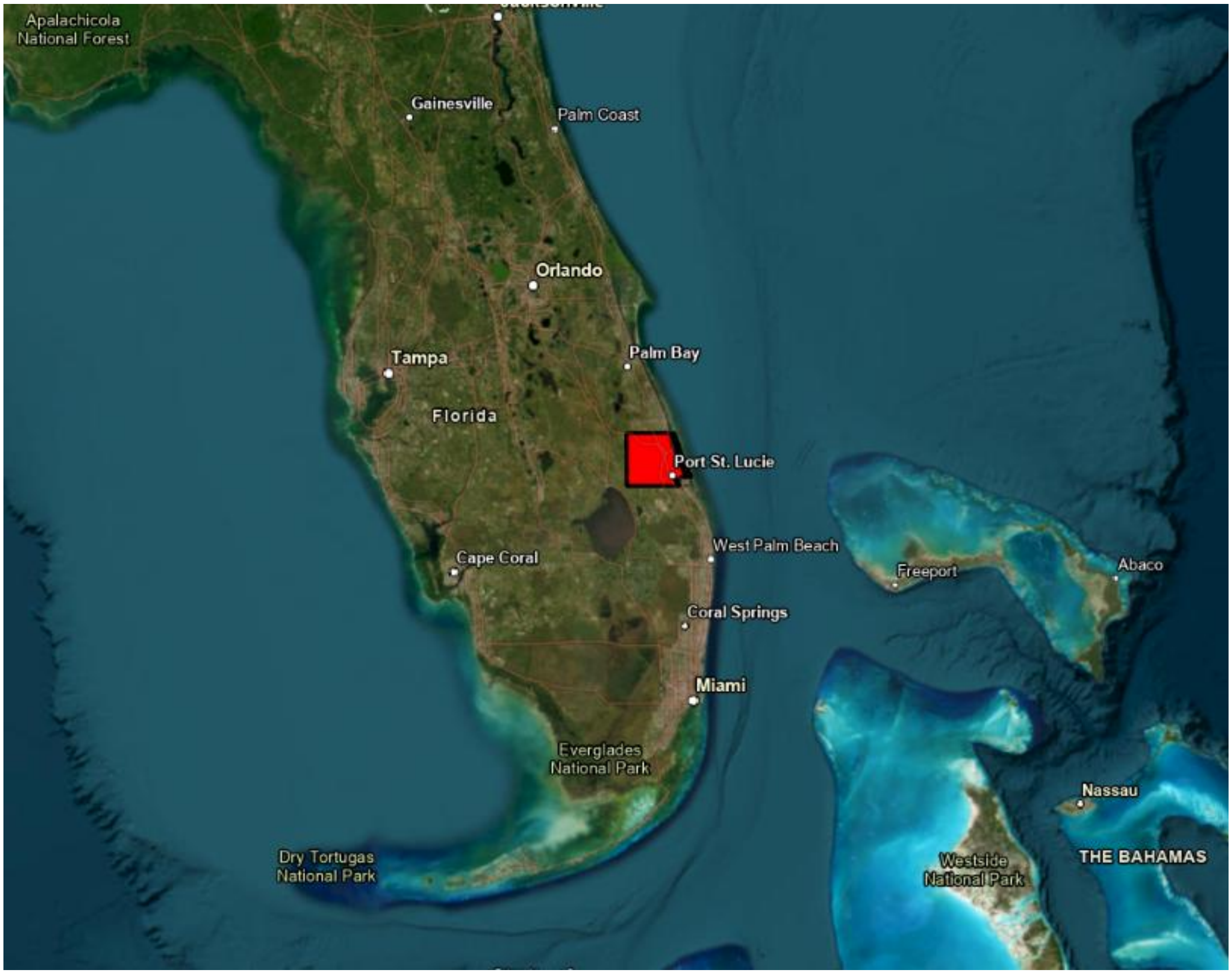


Figure 8-3. Regional overview, locating St Lucie County for context within the peninsula of Florida

Eastern St. Lucie County is bordered by the Atlantic Ocean and includes significant inland estuarine waters within the Indian River Lagoon and North Fork St. Lucie River. Indian River County borders St. Lucie County to the north, Martin County to the south, and Okeechobee County to the west.

The National Weather Service reports the average annual precipitation for Port St. Lucie as approximately 53.5 inches per year. Summer months of June-September tend to bring the highest precipitation totals due to the regular occurrence of convective thunderstorms and periodic impacts from tropical cyclones. The driest months usually occur in December-February. Frontal storms generally provide the most significant precipitation to St. Lucie County during non-summer months.

8.1.1.1 Flood Risk Hazards

Coastal areas of eastern St. Lucie County are known to be susceptible to major flood hazards associated with coastal erosion, storm surge, long-term sea level rise, and extreme precipitation. Central and western St. Lucie County contains large expanses of low-lying areas, particularly near the St. Lucie River and ancillary water bodies, that experience riverine flooding – also known as "fluvial" flooding – in the aftermath of large regional precipitation events. Due to the very low gradient of the St. Lucie River, some areas of central and western St. Lucie County may additionally be vulnerable to impacts from long-term sea level rise. Many populated areas throughout St. Lucie County not located near a water body are also known to be susceptible to flooding associated with localized extreme rainfall and stormwater runoff, or what is often referred to as "pluvial" flooding (**Figure 8-4**).

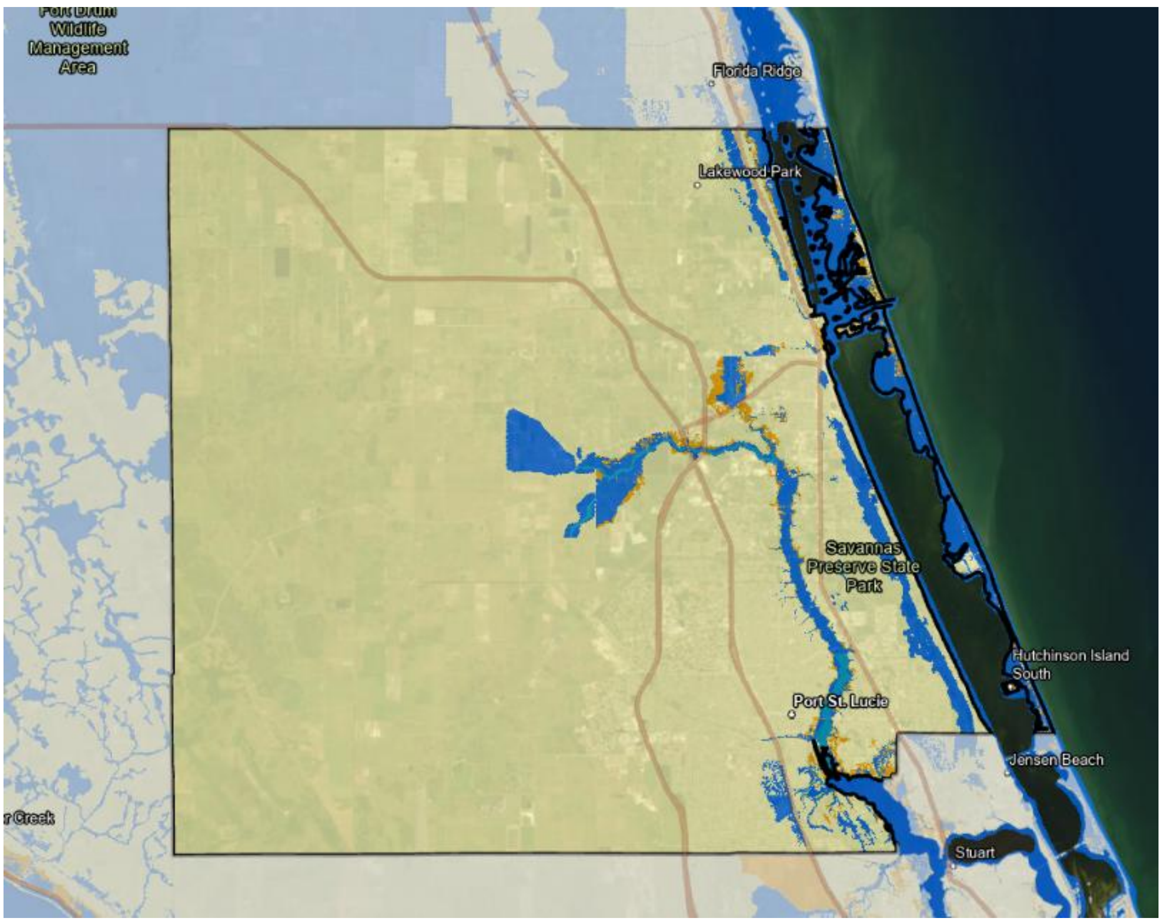


Figure 8-4. St Lucie Flood 100-yr and 500-yr flood hazard areas

Although large rainfall events that bring the potential for flooding can occur anytime of the year in St. Lucie County, the area's most severe flooding events have generally been associated with storm surge as a result of landfalling tropical cyclones (i.e., hurricanes, tropical storms, or tropical depressions) in late summer to early fall. Some of the named tropical cyclones that have produced major flooding in portions of St. Lucie County over the past three decades include Tropical Storm Gordon (November 1994), Hurricane Frances (September 2004), Hurricane Jeanne (September 2004), Tropical Storm Fay (August 2008), Tropical Storm Debby (2012), Hurricane Dorian (2019), Tropical Storm Eta (2020), Hurricane Ian (2022), Hurricane Nicole (2022), and Hurricane Milton (2024). Unfortunately, research indicates a trend toward larger, wetter tropical cyclones, within the North Atlantic Ocean basin that impacts Florida and, more generally, across the world (Marsooli et al. 2019; Guzman and Jiang 2021; Reed et al. 2022).

In 2022, St. Lucie County was significantly impacted by both Hurricane Ian and Hurricane Nicole over an approximately six-week period. On September 28, Hurricane Ian made landfall as a large and powerful Category 4 storm on Florida’s Gulf coast near Ft. Myers, where its winds and storm surge caused catastrophic levels of damage. Although Ian’s winds weakened substantially as it crossed the state before impacting St. Lucie County, many coastal and inland properties – including properties not contained within an officially designated FEMA flood zone – sustained some degree of flood damage. Wind speeds in St. Lucie County reached up to 59 mph in Fort Pierce, and rainfall totals varied, with some areas receiving up to 12 inches of rain.

Most of Ian’s flooding in St. Lucie County was caused by torrential rainfall, which in some locations along its path totaled up to 20 inches over the duration of the storm (~24 hours). The sheer volume of precipitation overwhelmed natural and human-engineered drainage systems, resulting in large amounts of pluvial flooding that severely impacted many streets, homes, businesses, and other structures as the storm moved through the area. Numerous lakes, ponds, streams, and wetlands also reached record levels in the days and weeks after Ian passed, as floodwaters slowly made their way through natural drainages. For example, several gauges along the St. Lucie River, the primary drainage basin for most of St. Lucie County, crested at the highest stages ever recorded approximately 1-2 weeks following Ian.

Several weeks later, numerous beachfront properties in St. Lucie County were further impacted by additional storm surge and shoreline erosion associated with Hurricane Nicole, a large Category 1 storm that made landfall on the Atlantic Coast near Vero Beach on November 10, 2022. Despite being less intense than Ian, Nicole still had a notable impact on St. Lucie County, causing coastal flooding and beach erosion due to the storm surge, localized flooding from heavy rains, and moderate wind damage to structures and vegetation. Wind speeds in St. Lucie County during Nicole reached up to 44 MPH near Treasure Coast International Airport, and rainfall totals in the county were around 2.61 inches.

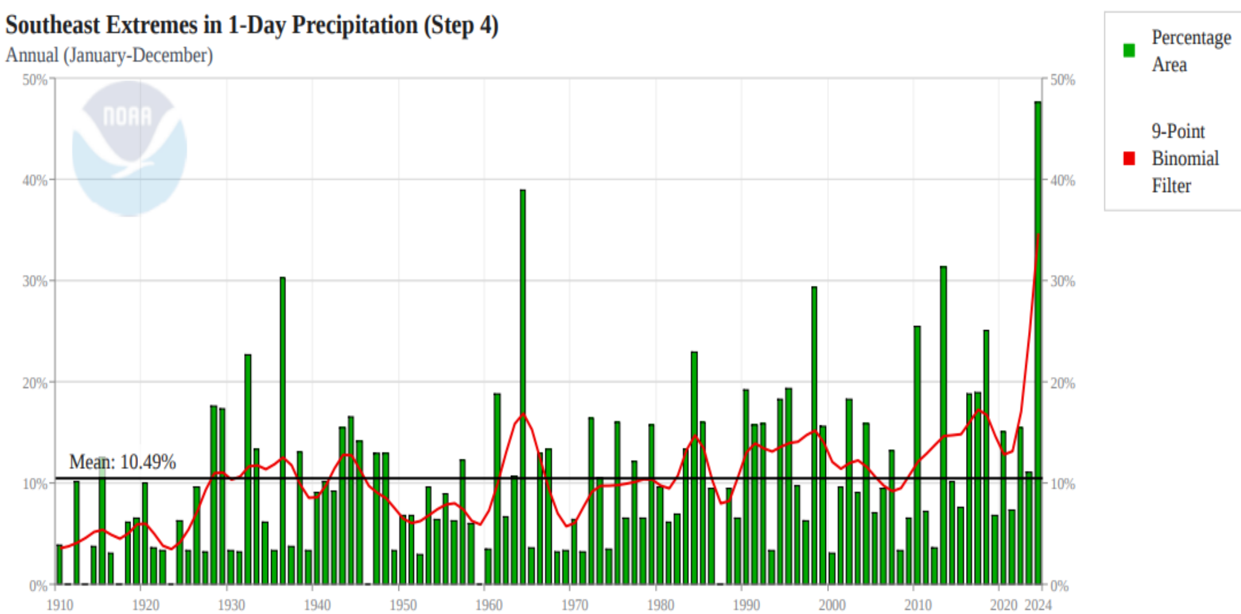
By contrast, damages from Nicole were mostly associated with severe waterfront erosion, which occurred as the large, slow-moving storm brought multiple days of large waves and storm surge to shoreline areas that had already been damaged by Ian several weeks earlier. Large areas of the urbanized shoreline in St. Lucie County, particularly the area’s Atlantic beaches that had recently been impacted by Ian, suffered devastating damages from the additional coastal flooding and erosion brought by Nicole.

Together, the impacts from both hurricanes combined to increase damages in SLC, and individually highlighted the vulnerability of coastal communities like St. Lucie County to severe weather events.

8.1.1.2 Increasing Flood Risks

Concern about the potential for increased flooding risk in St. Lucie County comes from at least three major factors. First, historical and ongoing population growth is associated with substantial land use change, increasing amounts of impervious cover, and the loss of natural functioning in wetland and floodplain areas (Volk et al. 2017). Such land use change factors are known to increase the risks of pluvial flood magnitude and extent within urban, suburban, and peri-urban areas (Blum et al. 2020; Li et al. 2022). Second, ongoing sea level rise is a source of compounding flood risks within the coastal zone, as increasingly higher sea levels directly correspond to higher storm surge potential and reduced ability of existing stormwater conveyance systems to remove rainfall-driven water from the built environment. Third, data suggest that eastern Florida may already be undergoing a trend toward a more frequent occurrence of more extreme precipitation events as compared to historical baselines (Obeysekera et al. 2021) (**Figure 8-5**). Taken together, these factors bring the likelihood of higher flood damage risks for built areas that are already designated as flood-prone, while also potentially creating novel flood exposure hazards within areas historically thought to have minimal flood risk (Sohn et al. 2020; Panos et al. 2021).

St Lucie Flood 100-yr and 500-yr flood hazard areas; majority of St Lucie County mapped in X or minimal flood hazard area.



Data source: NOAA (National Oceanic and Atmospheric Administration). (2024). Southeast Climate Extremes Index. Retrieved May 6, 2025, from www.ncei.noaa.gov/access/monitoring/cei

Figure 8-5. Increases in freshwater rates via rainfall in southeast Florida, one component of increasing hydrologic flood risk.

Even with the advent and enforcement of modern stormwater management standards since the 1980s, the much higher footprint of developed lands in eastern Florida has likely increased the region's overall exposure to flooding (Feng et al. 2021). The large-scale flooding associated with recent hurricanes has raised substantial public discussion and concern about the potential role of development in exacerbating flood risks. In addition, the large rainfall totals associated with recent storms appear to be a direct function of increasingly warmer ocean and atmospheric temperatures. For example, a detailed meteorological attribution study of Hurricane Ian suggests that the modern increase in average global temperatures and associated climatic alterations increased the storm's overall rainfall total in Florida by about 18 percent (Reed and Wehner 2023). Given the increased developed area throughout the St. Lucie River watershed and the record rain events associated with Hurricane Irma and Hurricane Milton, it is perhaps unsurprising that record water levels were observed in some areas of St. Lucie County during the aftermath of these storms.

Sea level along the U.S. coastline is expected to rise, on average, 10 - 12 inches in the next 30 years, which will be as much as the rise measured over the last 100 years (1920 - 2020). Sea level rise will vary regionally along U.S. coasts because of changes in both land and ocean height. On average, rise in the next three decades is anticipated to be: 10-14 inches along the U.S. east coast---https://sealevel.globalchange.gov/.

It is also quite clear that rising sea levels have already increased flood risks in coastal St. Lucie County. For example, the height and extent of the storm surges associated with Irma, Nicole, and Milton were enhanced by the 0.12 inches (+/- 0.009 inches) per year of sea level rise that has occurred over the past 93 years (NOAA Tides and Currents, 2025). Legacy coastal stormwater drainage systems that discharge into tidal water bodies also have inherently less capacity to convey water due to increased infiltration from the rising sea. During Irma and Milton, the combination of storm surge, sea level rise, and extreme rainfall resulted in the complete failure of some legacy stormwater systems in St. Lucie County and associated municipalities. As sea level rise continues to accelerate, associated flood risks from storm surge and failure of coastal stormwater drainage systems can be expected to increase. Legacy coastal stormwater drainage systems that discharge into tidal water bodies also have inherently less capacity to convey water due to increased infiltration from the rising sea. During Irma and Milton, the combination of storm surge, sea level rise, and extreme rainfall resulted in the complete failure of some legacy stormwater systems in St. Lucie County and associated municipalities. As sea level rise continues to accelerate, associated flood risks from storm surge and failure of coastal stormwater drainage systems can be expected to increase.

8.1.1.3 Open Space Conservation and Flood Resilience

Planning for flood risk mitigation and resilience in the context of an uncertain future is an incredibly challenging task. Upgrades of existing infrastructure systems are highly expensive and often face significant funding and permitting barriers. In addition, the complexity of forecasting future precipitation patterns and the diverse range of potential impacts from sea level rise makes it difficult to know if engineered systems are likely to be inadequate (thus prone to catastrophic failure) or, conversely, substantially overbuilt (thus costing much more than needed) in support of long-term flood resilience. Despite these uncertainties, there is a compelling need for society to locate and implement thoughtful interventions that can be reasonably expected to provide resilience against even the most unpredictable current and future flood risks (Axelsson et al. 2021).

Conservation, preservation, and restoration of undeveloped open space is widely regarded as one of the most efficacious and cost-effective flood risk mitigation strategies, especially when considering the uncertainties of future flood-related hazards (Farrugia et al. 2013; Kousky et al. 2013; Mukherjee and Takara 2018). Open space conservation is known to reduce flood risk at multiple scales that range from stormwater catch basins draining less than an acre of land (Liao et al. 2017), up to regional watershed drainages covering hundreds of square miles or more (Lourenco et al. 2020). The many other co-benefits of open space – including biodiversity preservation, water quality protection, food and fiber production, carbon sequestration, and recreational enjoyment – provide further impetus for increased utilization of land conservation as a primary tool in comprehensive flood management, resilience, and mitigation programs (Rosenzweig et al. 2018; Axelsson et al. 2021). **Figure 8-6** provides a general idea of where St. Lucie possesses the most open space.

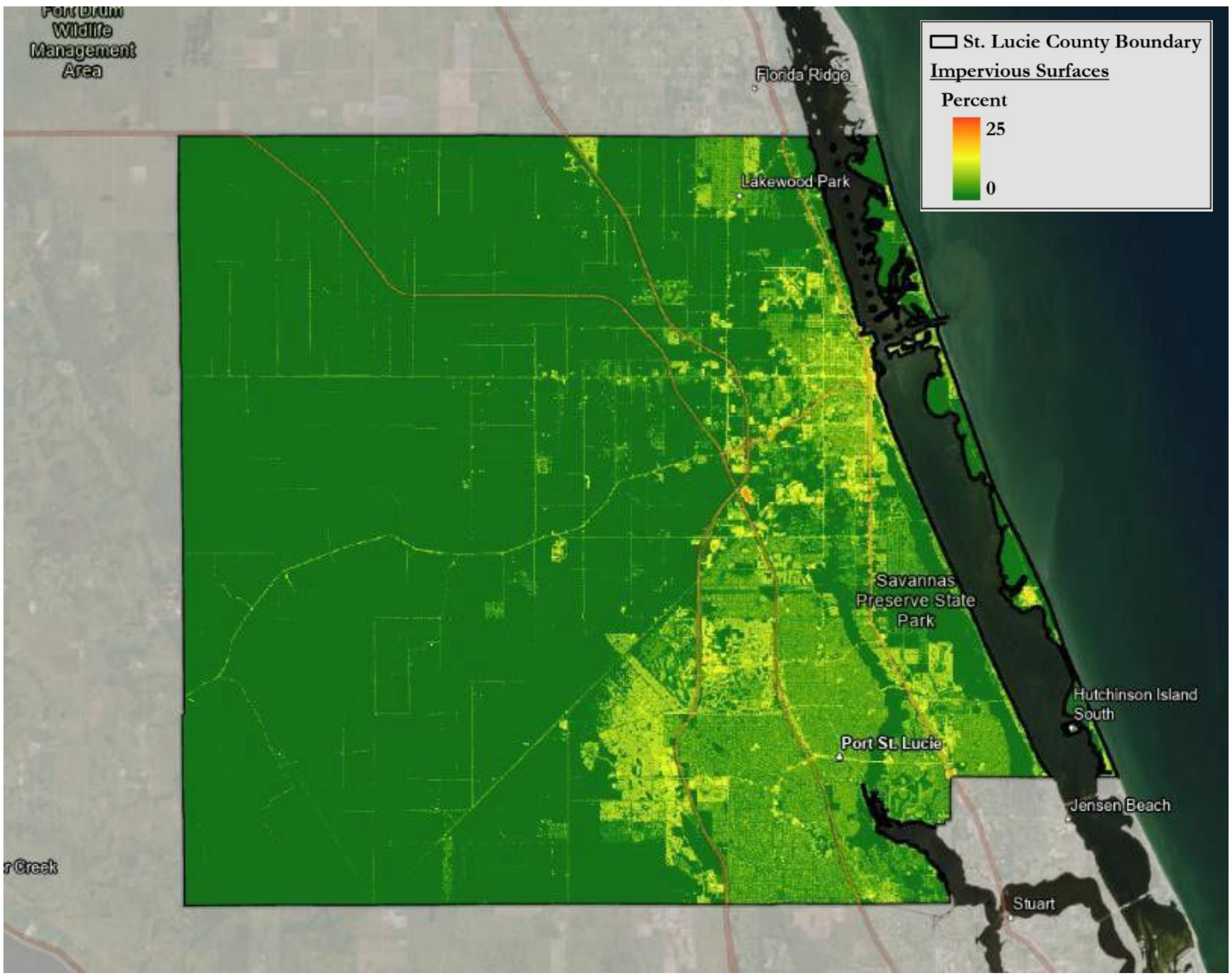


Figure 8-6. Open space within St Lucie County, considering areas with less than 25 percent impervious surface coverage

8.1.2 Current Climate Trends & Recent Storm Context

Analysis of localized climate data reveals significant changes affecting coastal habitats:

- Average annual temperature increase: 1.2°C over past 30 years
- Precipitation pattern shifts: 15 percent increase in extreme rainfall events
- Storm intensity: 23 percent increase in Category 3+ hurricane frequency

8.1.2.1 Recent Storm Impacts

Recent major storms have demonstrated the vulnerability of the circled region (an 80-mile radius around St. Lucie County) to sea level rise and extreme weather events: to sea level rise and extreme weather events:

Hurricane Ian (2022) (**Figure 8-7**):

- Peak storm surge: 8.5 feet above MHHW - Rainfall: 20+ inches in 24 hours
- Erosion: 45-foot dune recession in vulnerable areas
- Environmental impacts: 35 percent loss of sea turtle nesting habitat; significant mangrove defoliation; extensive marsh sediment redistribution

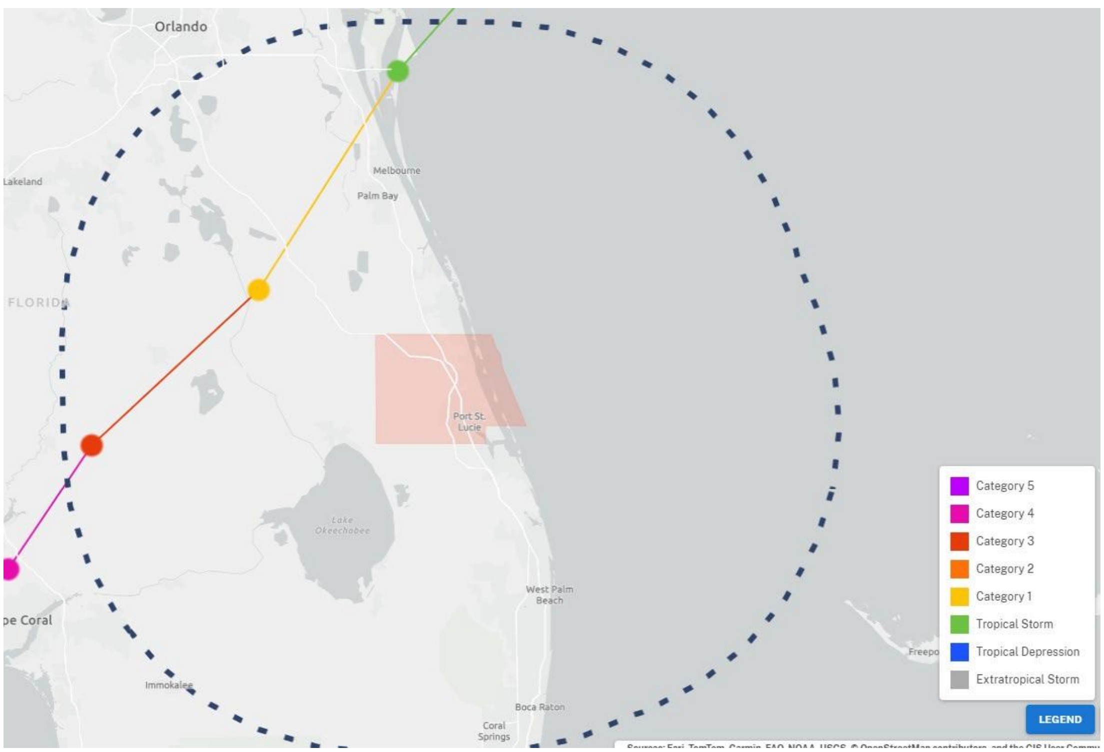


Figure 8-7. Hurricane Ian Storm Track

Hurricane Milton (2024) (**Figure 8-8**):

- Peak storm surge: 6.2 feet above MHHW
- Rainfall: 15 inches in 36 hours
- Combined surge and rainfall created compound flooding effects
- Environmental impacts: - 28 percent temporary loss of wading bird foraging habitat; significant freshwater wetland salinity intrusion; accelerated barrier island over wash

Figure 8-8. Hurricane Milton Storm Track

8.1.2.2 Notes on Compound Flooding

Historical data reveals an increase in compound flooding events since 1990. Primary mechanisms typically include:

- Storm surge + extreme rainfall
- King tides + moderate rainfall
- Groundwater emergence + tidal flooding

It is likely that surge event duration and frequency will continue to increase now and into the future, indicating a growing threat to coastal ecosystems and infrastructure

8.1.2.3 Risk Adverse Tidal Assessment

Analysis of sea level trends for St. Lucie County utilized data from the Virginia Key NOAA tide gauge (Station 8723214), which provides a relevant reference point for coastal water level projections in the region. Historical measurements from Virginia Key show a relative sea level trend of 0.125 inches/year with a 95 percent confidence interval of +/- 0.009 inches/yr, based on monthly mean sea level data from 1931 to 2024 (**Figure 8-9**). This rate is equivalent to approximately 1.05 feet of sea level rise over a 100-year period. To isolate the long-term trend, the observed data excludes regular seasonal fluctuations from coastal ocean temperatures, salinity, wind, atmospheric pressure, and ocean currents.

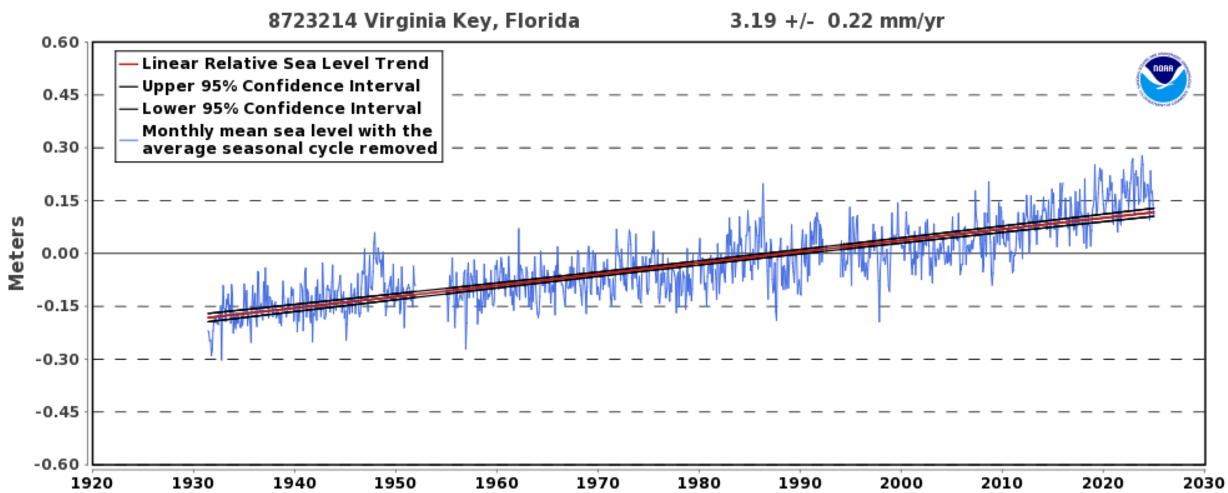


Figure 8-9. Relative sea level trend at Gauge 8723214 Virginia Key, Florida

To provide a perspective of how sea level rise trends have been increasing in more recent years an analysis of the observed high and low tides was conducted for the timeframes 1950 to 2024, 1970 to 2024, and 1990 to 2024. Because the Virginia Key tide gauge only possesses observed high and low tide records from 1994 to 2024 the analysis was conducted on the Key West NOAA tide gauge, which possesses observed tide record from 1913 to 2024. In order to account for any variation between the sea level trends at the Virginia Key tide gauge and Key West tide gauge a comparison of observed high and low tide levels from 1994 to 2024 was conducted, this showed that the Virginia Key tide gauge sea level trend is approximately 0.023 inches higher then the Key West tide gauge sea level trend, therefore the value of 0.023 was added to the sea level rise trends taken from the Key West tide gauge to make the trends relative to the Virginia Key tide gauge sea level trend. Based on this analysis indicates that sea level rise is on an upward trend see **Table 8-1**.

Table 8-1. Historic Sea Level Trends

Year	Sea Level Rise Trend (inches per year)
1950 - 2024	0.146
1970 - 2024	0.169
1990 - 2024	0.225

The St. Lucie SLAMM assessment incorporated projections from the Virginia Key tide gauge, which serves as an established reference point for sea level rise planning in the region. This gauge provides sea level projections under multiple NOAA scenarios, allowing for risk-based planning approaches that consider both lower and higher potential sea level rise trajectories. Based on the Virginia Key tide gauge data used in the St. Lucie Vulnerability Assessment, the projected tidal elevations for key planning horizons and the difference between NOAA Intermediate Low (NIL) and NOAA Intermediate High (NIH) scenarios are (**Table 8-2**).

Table 8-2. NIL and NIH Sea Level Rise Scenarios (in feet)

Year	NIL	NIH	Difference
Present Day	0.42	0.72	0.3
2040	0.78	1.5	0.72
2070	1.34	3.37	2.03
2100	1.87	6.1	4.23

These projections demonstrate a pattern of increasing divergence between time. In the near term, the difference between scenarios is relatively modest (a 0.72 ft difference by 2040), but this gap widens substantially for longer planning horizons. By 2070, the difference increases to 2.03 ft (3.37 ft - 1.34 ft), and by 2100, the scenarios diverge by 4.23 ft (6.10 ft – 1.87 ft).

The significant difference between the Intermediate-Low and Intermediate-High scenarios by 2100 highlights the increased uncertainty inherent in longer-term sea level rise projections. This pattern of scenario divergence suggests that while near-term planning horizons through 2040 face relatively constrained uncertainty, longer-term planning should account for a much wider range of potential outcomes.

The Intermediate-High projection of 6.10 ft by 2100 represents a risk-adverse planning scenario that may be appropriate for critical infrastructure and long-term coastal resilience initiatives where the consequences of underestimating sea level rise could be significant. The Intermediate-Low projection of 1.87 ft by 2100 may be more suitable for shorter-term planning or less vulnerable assets.

These Virginia Key tide gauge projections provide St. Lucie County with scientifically grounded reference points for sea level rise planning across various time horizons and risk tolerances, supporting adaptive management approaches that can be adjusted as new data and projections become available over time.

However, because the observed tide levels at the Virginia Key tide gauge only go back as late as 1994 and later tidal records from the Miami and Haulover gauges are no longer available, in order to calculate tidal trends later than 1994 the Key West tide gauge was utilized as it possesses observed tidal records between 1913 and present day. Therefore, to strengthen this record with a longer historical perspective, observations from the Key West tide gauge—spanning 1913 to the present—were incorporated. This enabled the calculation of sea level rise trends over multiple eras (1950–2024, 1970–2024, and 1990–2024), highlighting how the pace of sea level rise has accelerated in more recent decades compared to earlier periods. A direct comparison of overlapping records from Virginia Key (1994–2024) and Key West confirmed that the Virginia Key trend is approximately 0.023 inches higher.

This adjustment was applied to align the historic Key West trends with the Virginia Key record, ensuring consistency and producing a continuous, historically informed dataset for local planning.

8.2 Methodology

This project had two primary objectives:

- Model potential future land cover and ecosystem changes in St. Lucie County due to sea level rise using the Sea Level Affecting Marshes Model (SLAMM).
- Overlay SLAMM results with future land use maps to protect and conserve valuable ecosystems.

8.2.1 SLAMM Model Overview

The Sea Level Affecting Marshes Model (SLAMM) is a freely available, spatially explicit land cover change model that simulates coastal habitat transformation due to sea level rise (SLR) (Warren Pinnacle Inc., 2016). The model integrates multiple datasets and processes, including:

- Elevation & slope
- Tidal datum shifts
- Erosion & accretion
- Storm tide over wash (in version 6.6)
- Existing land cover

SLAMM produces spatially explicit projections of land cover changes over user-defined time steps and SLR scenarios. It is widely used for long-term conservation planning, including:

- Imperiled species conservation (Evans & Bergh, 2016; Benedict et al., 2018)
- Flood risk assessments (Hauer et al., 2015)
- Coastal resilience planning (Clough et al., 2016; Mazor et al., 2021)

For St. Lucie County, SLAMM version 6.7 was implemented with locally calibrated parameters to accurately represent local conditions. The model uses a 10m x 10m cell-based approach, where each cell represents elevation, habitat type, and key attributes. The fate of each cell is determined by SLR-driven processes, including:

- Inundation of low-lying areas
- Shoreline erosion
- Habitat conversion
- Soil saturation from rising water tables
- Sediment & organic matter accretion.

8.2.2 Input Data Sources

The St. Lucie County SLAMM implementation utilized the input data shown in **Table 8-3**.

Table 8-3. Input Data for the SLAMM model

Input Data Type	Source	Resolution	Format	Description
Digital Elevation Model (DEM)	2022 & 2018 USGS LiDAR survey	32.8ft	ASCII grid (.asc)	High-resolution elevation data critical for determining inundation patterns
Land Cover Classification	USFWS National Wetlands Inventory (NWI) & SFWMD Land Use Land Cover	32.8ft	ASCII grid (.asc)	Baseline habitat distribution derived from NWI data
Dikes / Levees	NWI Attribute Table	32.8ft	ASCII grid (.asc)	Locations of existing flood protection infrastructure
Impervious Surfaces	National Land Cover Database	32.8ft	ASCII grid (.asc)	Areas with impervious cover (buildings, roads, etc.)
Slope	Derived from DEM	32.8ft	ASCII grid (.asc)	Calculated slope values used in erosion calculations

8.2.2.1 Natural Systems Analysis

Coastal Defense Systems: The county's oceanfront habitats form its first line of defense against storms and rising seas. Beach systems and coastal scrub provide critical nesting habitat for a multitude of wildlife species while naturally buffering inland areas from wave energy. Mangroves, scrub habitat, salt marshes, and tidal flats create stable shoreline anchors and support diverse marine life (**Figure 8-10**). These systems are highly vulnerability to erosion and storms but demonstrate moderate capacity to adapt through natural processes when given sufficient space and sediment supply.

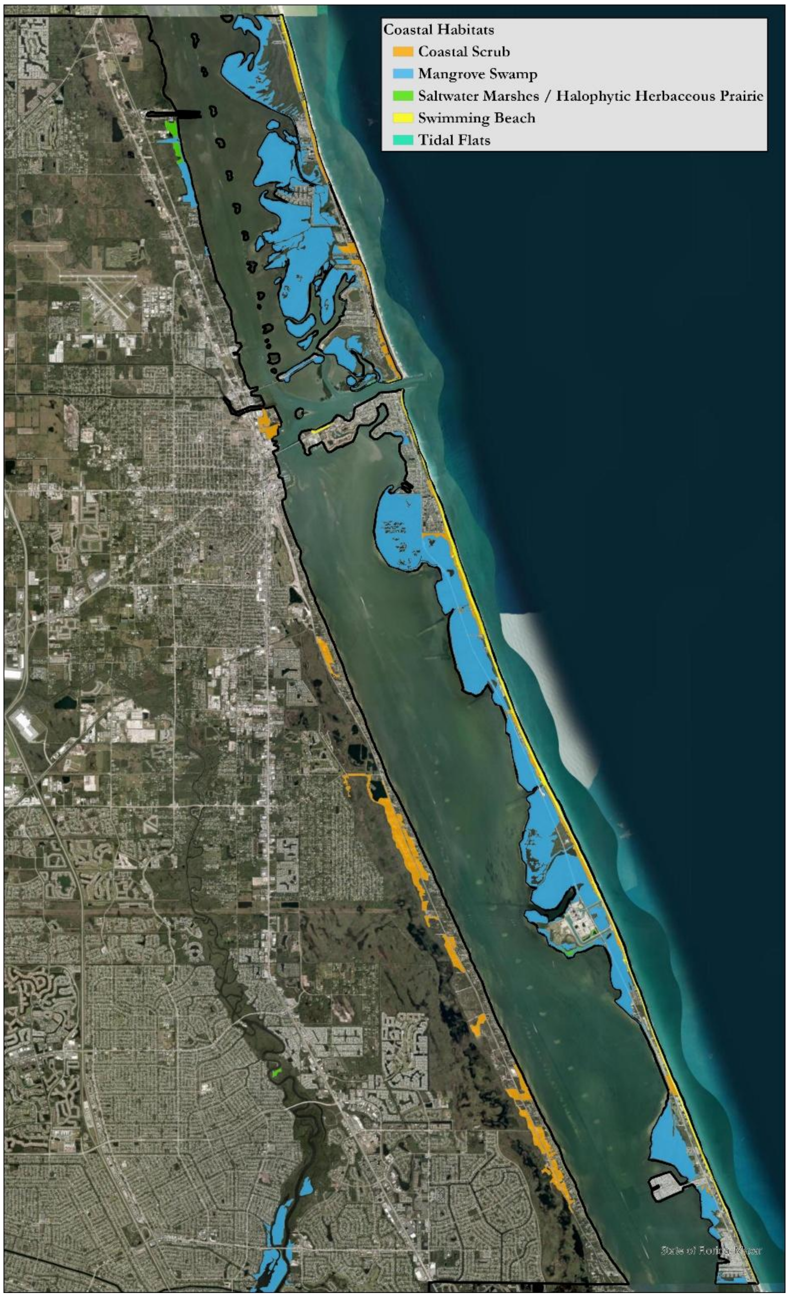


Figure 8-10. Coastal Defenses Systems of St. Lucie

Wetland Complexes: The heart of St. Lucie County's natural infrastructure lies in its extensive wetland networks. Mangrove forests excel at stabilizing shorelines while providing essential nursery habitat for fisheries. The marsh system, comprising transitional, regular, and irregular flooding zones creates a dynamic buffer that naturally adapts to changing water levels (**Figure 8-11**). These wetlands show promising adaptation potential through vertical accretion and inland migration, though they face challenges from coastal squeeze against developed areas (**Figure 8-12**).

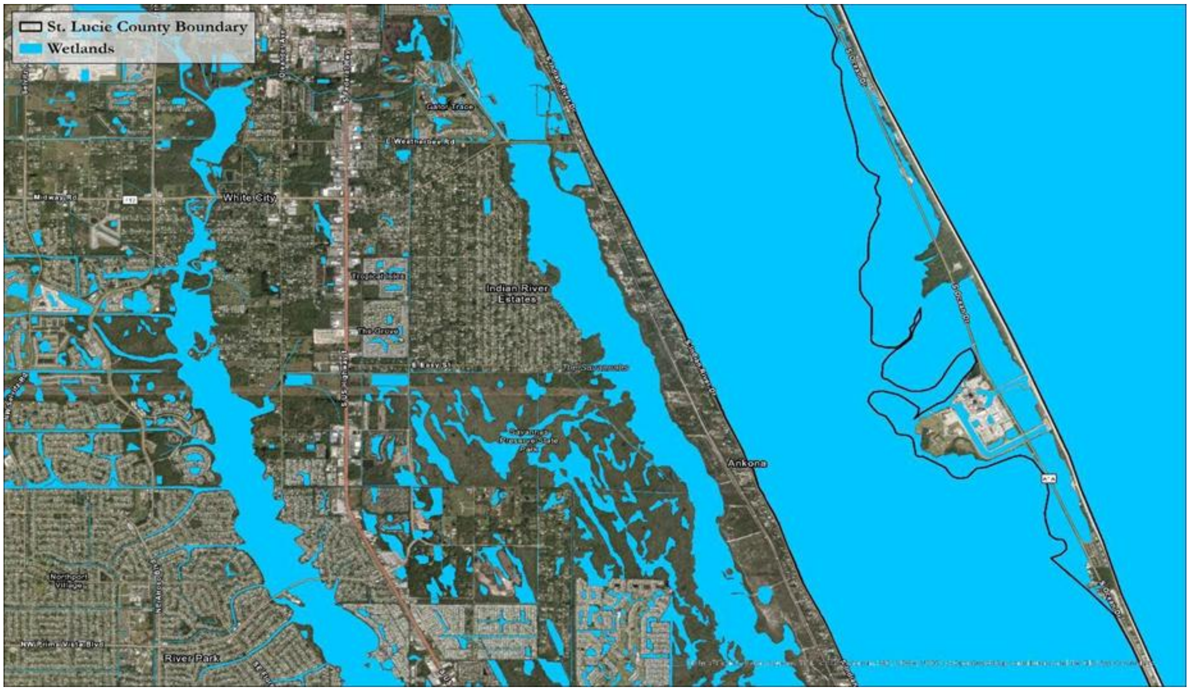


Figure 8-11. Map detailing a complex system of coastal wetlands (blue areas within the map above) vulnerable to "coastal squeeze" and other stressors.

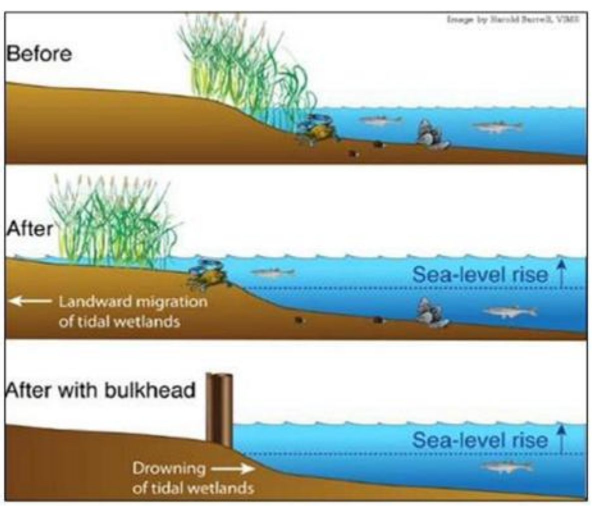


Figure 8-12. Visualization of Coastal Squeeze Freshwater Resources

Interior wetland systems, including swamps and cypress stands (Categories 3 and 4), represent some of the county's most vulnerable yet valuable habitats (**Figure 8-13**). These freshwater-dependent ecosystems face increasing stress from saltwater intrusion and changing rainfall patterns. Their preservation is crucial for maintaining water quality and natural flood protection for inland communities.

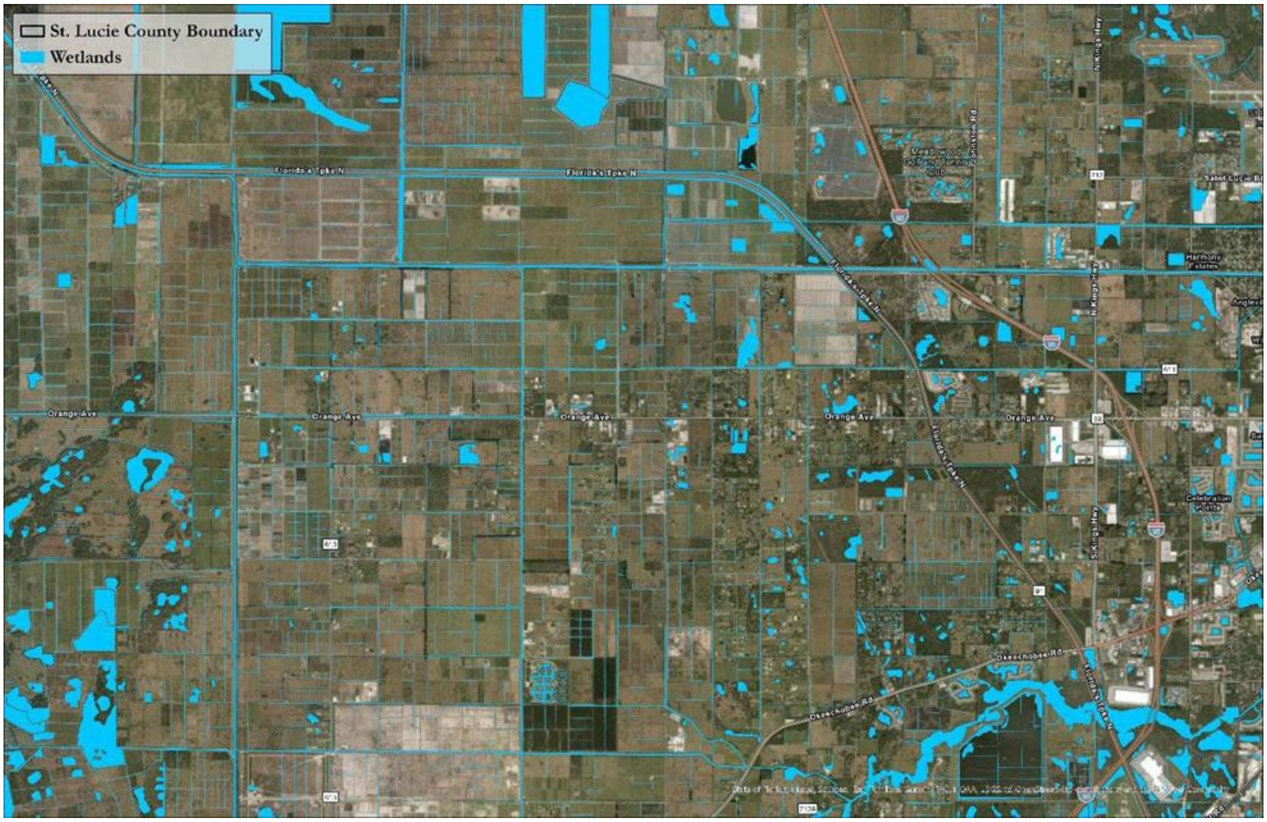


Figure 8-13. Map of some Northeastern Portions of the Freshwater Wetland Resources in the Interior of the County

Development Interface: The transition between natural and built environments presents both challenges and opportunities. Currently developed areas must be protected while allowing space for habitat migration through remaining undeveloped lands and inland shores. **Figure 8-14** and **Figure 8-15** highlight some of the areas in St. Lucie County where urbanization has encroached upon freshwater wetlands. This interface zone offers prime opportunities for implementing nature-based solutions that benefit both human and natural communities.

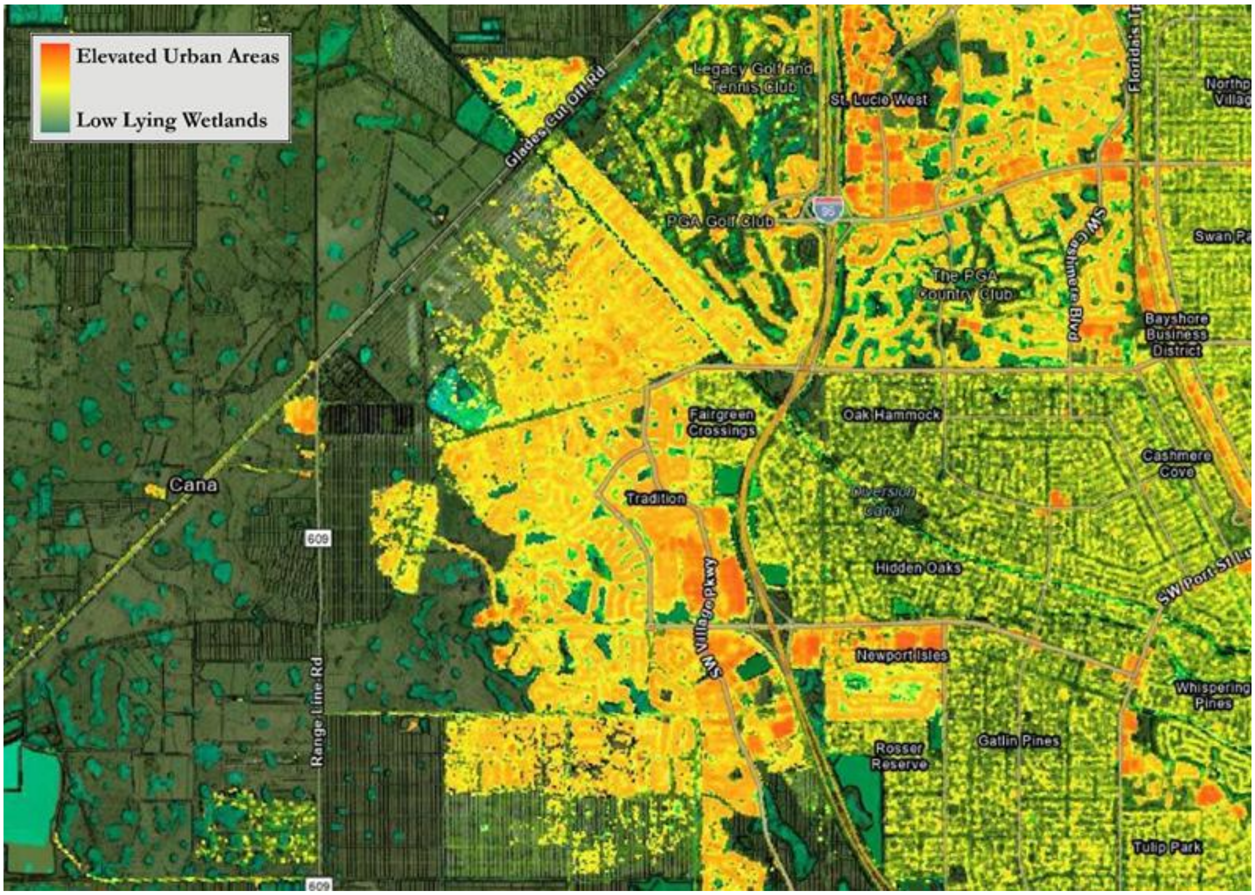


Figure 8-14. Map depicting freshwater wetland systems, within highlighted urbanized areas

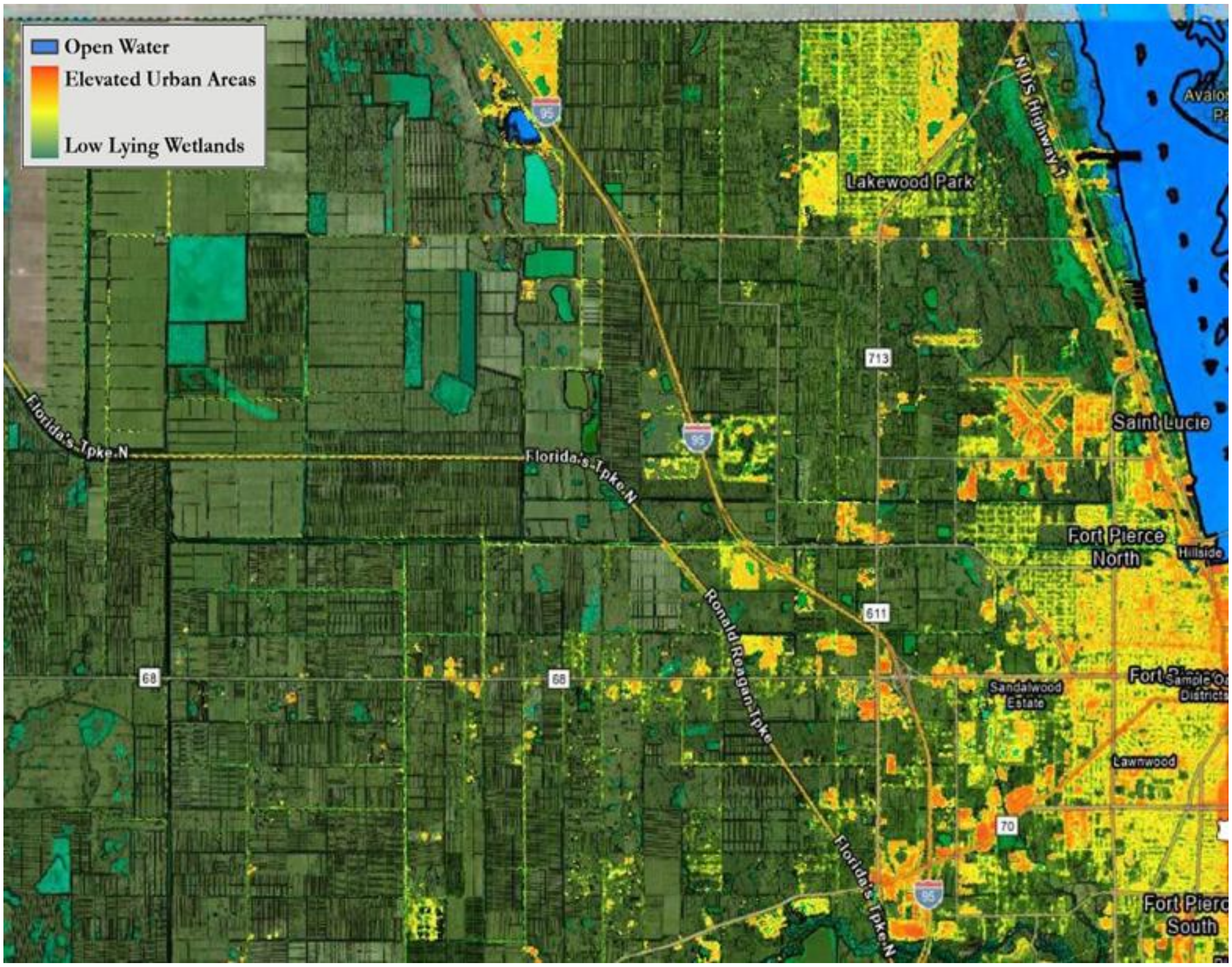


Figure 8-15. Map depicting portions of coastal St Lucie County with wetland and impervious surface overlays to highlight areas with high migration potential

8.2.2.2 Physiographic Subdistricts

Becoming a more flood resilient community is a complex and ongoing endeavor. A first step involves better understanding of current and future risk factors within the natural and human environments. The underlying geology of the natural environment is critically important for understanding how the natural environment functions, helping to explain patterns of human development, and clarifying key risks, challenges, and opportunities from a geophysical perspective (**Figure 8-16**).

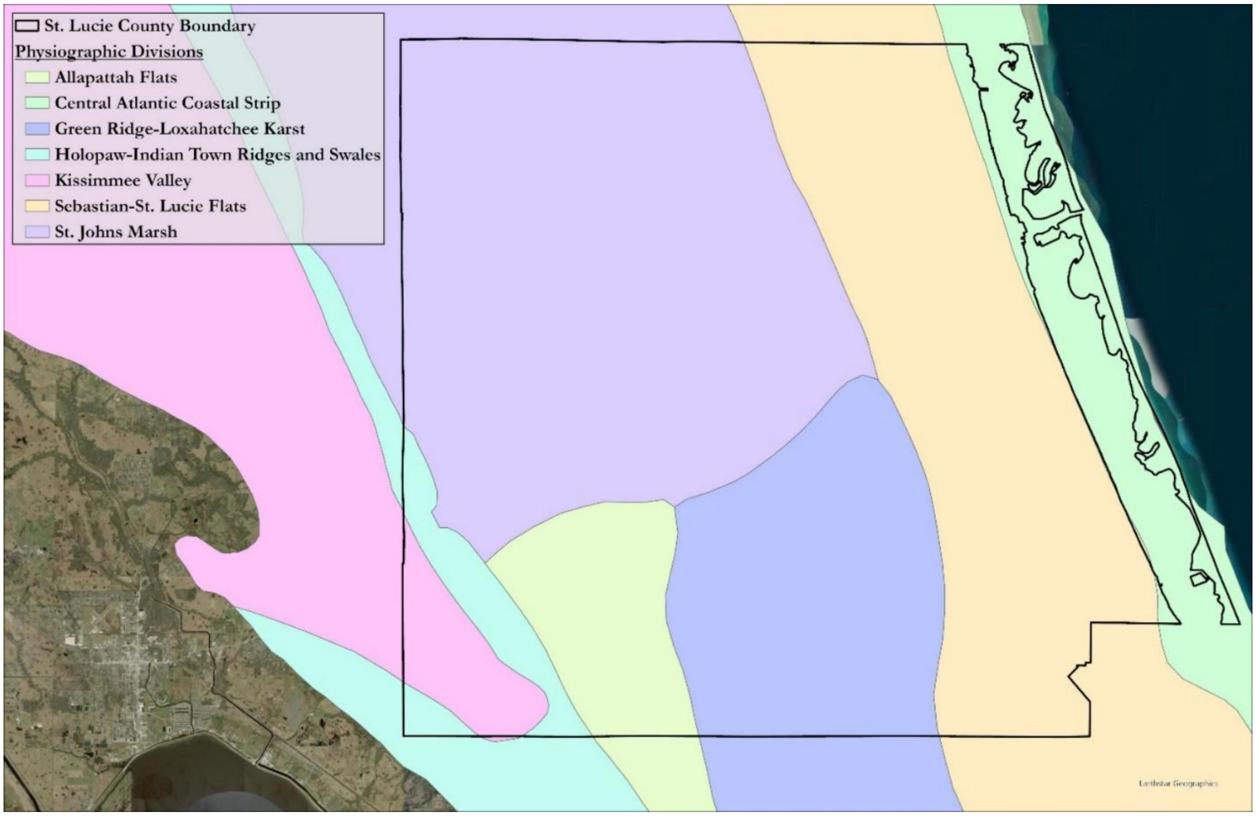


Figure 8-16. Physiographic Subdistricts of St. Lucie County

Understanding flood risk requires knowledge of natural geology and hydrological conditions, as outlined in **Table 8-4**.

Table 8-4. Description of the physiographic subdistricts

Subdistrict	Key Features	Primary Flood Risks
Central Atlantic Coastal Strip	Atlantic beaches & estuaries	Storm surge, coastal erosion, SLR, pluvial flooding
St. Johns Marsh	Inland marshes with peat deposits	Slow drainage, prolonged flood retention
Green Ridge Loxahatchee Karst	Limestone bedrock with sinkholes	Sinkhole-induced flooding, underground drainage failures
Allapattah Flats & Kissimmee Valley	Wetlands & floodplains	Hurricane-driven overflows, high urbanization pressure

The easternmost parts of St. Lucie County fall within the Central Atlantic Coastal Strip physiographic subdistrict (**Figure 8-16**), encompassing barrier islands and coastal lowlands adjacent to the Atlantic Ocean. The geology is dominated by sandy soils mixed with shell materials overlying limestone bedrock. These sandy soils are typically well-drained, allowing rainwater to percolate rapidly. However, because the water table is shallow near the coast and the soils rest on porous limestone, rising sea levels and storm surge events can elevate the water table or cause coastal upwelling. This reduces the soil's capacity to absorb rainfall, leading to prolonged pluvial flooding even where soils would otherwise drain well. The loose sandy soils also increase vulnerability to erosion from wave energy and wind. Dune and mangrove restoration helps stabilize these soils, buffer wave energy, and maintain natural drainage capacity.

The Sebastian-St. Lucie Flats physiographic subdistrict lies just inland, adjacent to the Intracoastal Waterway. This area features flat terrain and poorly drained, fine-textured soils that naturally retain water. Urbanization has further altered drainage patterns by replacing natural ground cover with impervious surfaces (asphalt, concrete) and fill material. These modifications reduce infiltration, diminish soil water storage, and increase surface runoff during storms. The geology and modified soils contribute to flood risks from intense rainfall (pluvial flooding), storm surge, and long-term inundation due to sea level rise. The interaction of poorly drained soils, low relief, and human alterations means this area is especially prone to compound flooding events.

The central portion of St. Lucie County includes the St. Johns Marsh and Green Ridge Loxahatchee Karst subdistricts. The St. Johns Marsh is underlain by fibrous peat deposits that have high water-holding capacity but become quickly saturated, limiting infiltration during heavy rainfall. The underlying flat limestone plain and minimal river gradient cause slow water movement, prolonging flood conditions. Here, geology shapes a landscape where water lingers, and drainage is inherently sluggish.

The Green Ridge Loxahatchee Karst area is defined by limestone bedrock prone to dissolution, forming sinkholes, springs, and underground conduits. This karst system typically allows rapid infiltration, with stormwater draining into the subsurface. However, if sinkholes clog or conduits become overloaded, drainage is impeded, and surface flooding can result. The complex, uneven underground drainage creates unpredictable flood patterns, sometimes causing flash flooding far from the rainfall source. In this subdistrict, the geology creates both rapid drainage routes and hidden flood risks when those pathways fail.

The southwestern parts of the county, including the Allapattah Flats, Kissimmee Valley, and Holopaw-Indian Town Ridges and Swales, consist of low-lying floodplains, wetlands, and sandy to loamy soils. In the Allapattah Flats, extensive fibrous peats and flat topography limit drainage, causing water to pool during heavy rains. In the Kissimmee Valley, the broad floodplain and low slope of the Kissimmee River mean water spreads out during floods, and past channelization has altered how floodwaters disperse, often reducing natural drainage capacity and increasing flood intensity downstream. The Holopaw-Indian Town Ridges and Swales feature sandy, poorly drained soils where water rapidly saturates the soil profile, accumulating in low areas. Here, geology interacts with drainage by limiting infiltration rates and slowing runoff, making these areas highly flood-prone without extensive natural or engineered drainage solutions.

8.2.2.3 Florida Natural Areas Inventory Data

FNAI data is often used to inform development of implementation strategies that strive to meet a diverse array of conservation objectives. Six layers have direct relevance to conservation planning as it relates to flood hazard mitigation:

- Natural Floodplain Function,
- Functional Wetlands,
- Surface Water Protection,
- Groundwater Recharge,
- Forests Lands to Maintain Recharge, and
- Fragile Coastal Resources.

The other five layers focus more directly on protection of imperiled species and plant communities; open space and natural lands connectivity; and maintenance of rural economies and livelihoods:

- Strategic Habitat Conservation Areas,
- Rare Habitat Conservation Priorities,
- Florida Ecological Greenway Network,
- Underrepresented Ecosystems, and
- Sustainable Forestry.

Future studies should build upon the Florida Natural Areas Inventory (FNAI) data by integrating it with outputs from the Sea Level Affecting Marshes Model (SLAMM) assessment to develop a parcel-level ranking system. This will provide a data-driven approach to identifying, prioritizing, and evaluating specific areas for conservation, flood hazard mitigation, and long-term resilience planning.

Overview of FNAI Layers in the Following Pages

1. Natural Floodplain Function – Examines the ecological condition of 100-year floodplains, identifying areas with minimal human disturbance that provide critical flood storage and water quality benefits.
2. Functional Wetlands – Maps existing wetland ecosystems, emphasizing their role in stormwater retention, aquifer recharge, and biodiversity conservation.
3. Surface Water Protection – Highlights areas essential for maintaining clean and reliable water supplies, including riparian buffers, reservoirs, and key watersheds.
4. Groundwater Recharge – Identifies zones that contribute significantly to aquifer replenishment, which is vital for drinking water supplies and ecosystem health.
5. Forested Lands to Maintain Recharge – Focuses on forested areas that enhance infiltration and groundwater recharge, mitigating runoff and erosion.
6. Fragile Coastal Resources – Includes barrier islands, dunes, and estuarine habitats that buffer storm surges, sea level rise, and coastal erosion.

In addition to the flood and water-related layers, the following pages also provide preliminary overviews of datasets that focus on habitat conservation, ecosystem connectivity, and sustainable land management:

1. Strategic Habitat Conservation Areas – Prioritizes lands critical for the long-term viability of native species, based on habitat quality and fragmentation risks.
2. Rare Habitat Conservation Priorities – Identifies imperiled and underrepresented ecosystems, ensuring targeted conservation efforts.
3. Florida Ecological Greenway Network – Maps corridors that connect protected lands, maintaining wildlife movement and ecological resilience.
4. Underrepresented Ecosystems – Highlights natural communities lacking sufficient protection, guiding efforts to expand preservation initiatives.
5. Sustainable Forestry – Focuses on working forests that balance ecological health and economic viability, promoting carbon sequestration, water quality protection, and biodiversity.

These preliminary assessments help establish a baseline understanding of each dataset within the context of the SLAMM assessment. They are intended to:

- Facilitate stakeholder engagement by providing accessible explanations of why these layers matter in the context of county planning.
- Guide future research efforts by identifying gaps or opportunities for further data refinement.
- Lay some groundwork for the parcel-level ranking system, ensuring that land-use and conservation decisions are based on robust environmental data.

By reviewing these layers in detail, decision-makers can begin aligning conservation priorities with broader county goals, ensuring that natural resources, flood resilience, and land-use planning efforts are effectively integrated into future policy and investment strategies.

The conservation priorities for natural floodplain function involve ranking the ecological condition of identified 100-year floodplains (**Figure 8-17**). This ranking is based on the "naturalness" of the plant community and the intensity of existing land use. Higher prioritization is given to floodplain areas that are more natural, meaning they have less human disturbance and more intact plant communities. As depicted above, nearly all of the barrier island within St. Lucie County is highly prioritized.

By focusing on these more natural floodplain areas, conservation efforts can better preserve the ecological functions that floodplains provide, such as water filtration, flood mitigation, and habitat for wildlife. Protecting these areas helps maintain the health and resilience of ecosystems, ensuring that they continue to provide essential services and support biodiversity. This approach is crucial for effective floodplain management and long-term environmental sustainability.

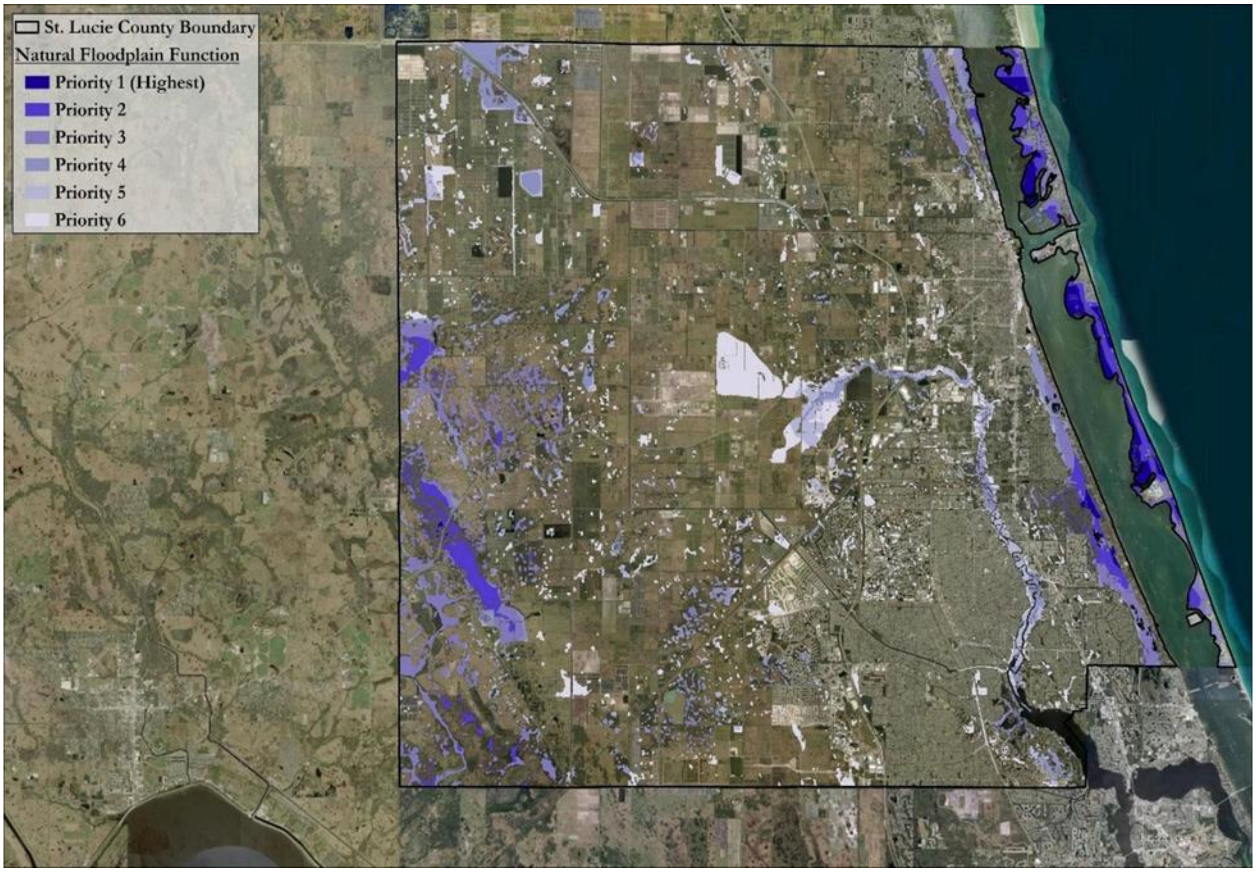


Figure 8-17. FNAI Natural Floodplain Function

The conservation priorities for priorities for functional wetlands involve identifying and ranking wetlands based on an assessment of their vegetative and hydrologic integrity. Wetlands that are in a more natural state, with intact plant communities and minimal human disturbance and intact plant communities, are given higher prioritization. This approach ensures that conservation efforts focus on preserving wetlands that maintain their ecological functions, such as water filtration, flood control, and habitat provision for diverse species. By prioritizing these more natural wetlands, conservation planners can enhance the resilience and health of wetland ecosystems, ensuring they continue to provide essential services and support biodiversity. Protecting functional wetlands is crucial for maintaining the overall ecological balance and sustainability of the environment and reducing flood risk in both urban and rural areas of the county. Within St. Lucie County, the highest priority functional wetlands are mainly located along the coastal areas, followed by large swaths of intact wetlands in the west, as shown in **Figure 8-18**.

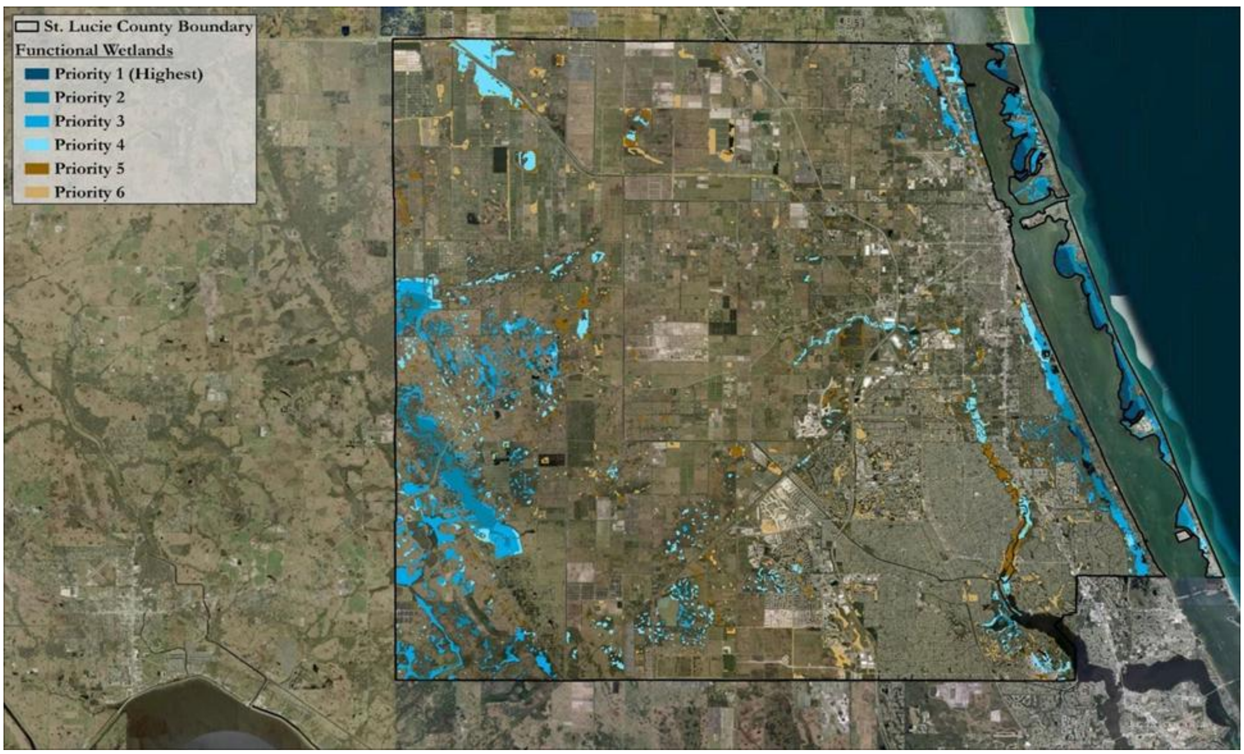


Figure 8-18. FNAI Functional Wetlands

The conservation priorities for surface water protection involve ranking the landscape based on proximity and other factors that impact water quality in critical areas. The surface waters through this land conservation strategy in SLC include: Outstanding Florida Waters, National Scenic Waters, National Estuaries, shellfish harvesting areas, seagrass beds, water supply areas, and waters important for imperiled fish. By prioritizing landscapes that have a significant influence on these water bodies, conservation efforts can be more effectively directed to maintain and improve water quality. Protecting these vital water resources ensures the health of aquatic ecosystems, supports biodiversity, and provides clean water for human use. This approach is essential for safeguarding the ecological integrity of Florida's water bodies and ensuring their sustainability for future generations. The image above indicates that the areas of St. Lucie County with the highest priority of surface water protection are located along the Indian River Lagoon, with most of the western areas listed as medium priority (**Figure 8-19**).

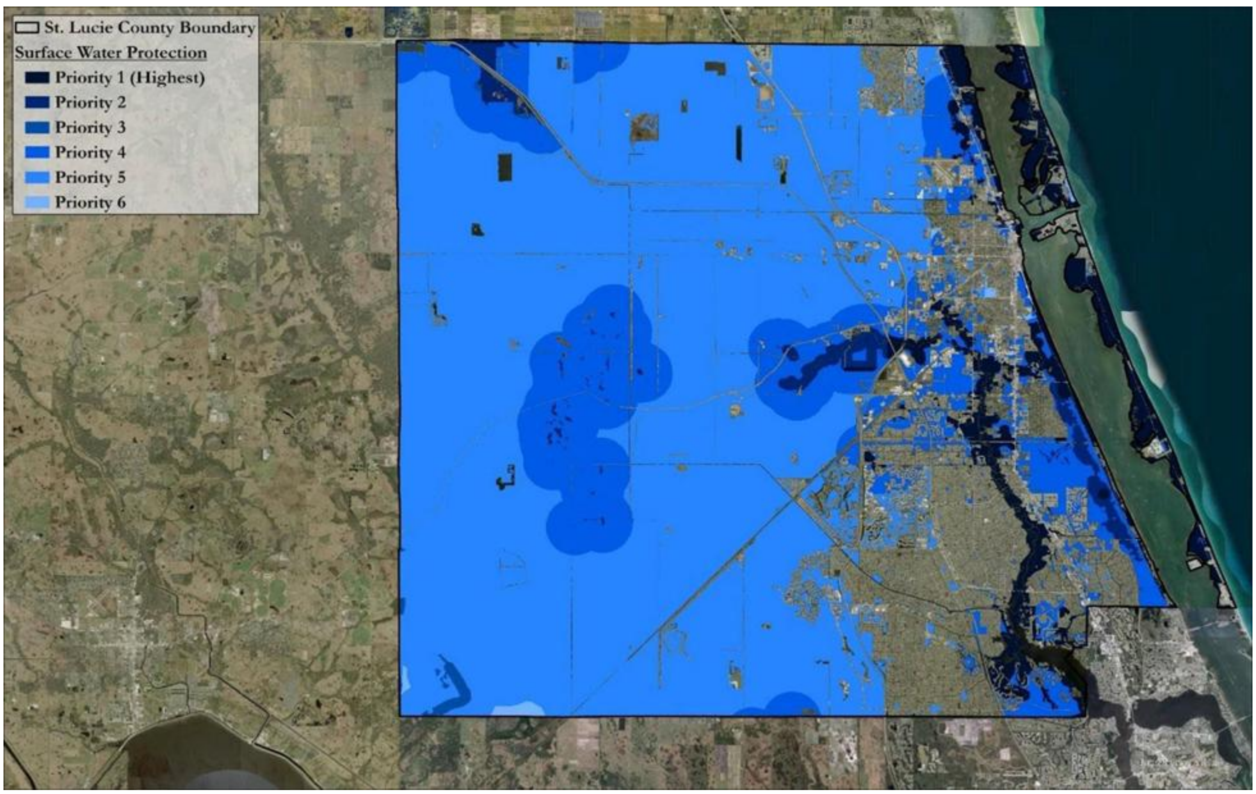


Figure 8-19. FNAI Surface Water Protection

The conservation priorities for groundwater recharge involve ranking the importance of areas based on their impact on the quality and quantity of groundwater recharge. This ranking considers several factors, including proximity to public water supply wells, the thickness of the aquifer confining unit, and the presence of swallets or topographical sinks. By prioritizing areas that significantly influence groundwater recharge, conservation efforts can ensure the protection and sustainability of vital water resources. This approach helps maintain the availability of clean groundwater for public use, supports the health aquifers, and preserves the overall integrity of the hydrologic cycle. Protecting key groundwater recharge areas is essential for long-term water security and environmental sustainability. Areas with the highest priorities are scattered throughout the inland portion of the county (**Figure 8-20**).

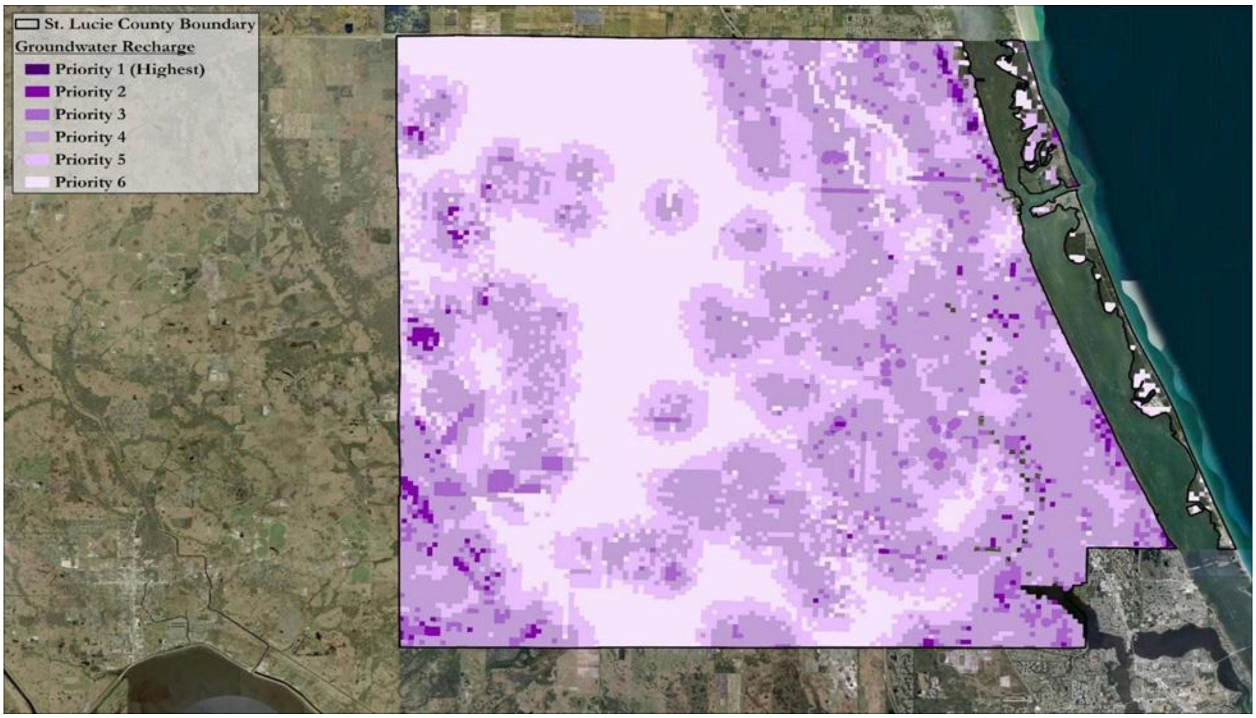


Figure 8-20. FNAI Groundwater Recharge

The conservation priorities for forest lands to maintain recharge function involve identifying areas of existing forestland that also serve as high groundwater recharge zones. By focusing on these dual-function areas, conservation efforts can ensure that forest lands continue to support both ecological health and water resource sustainability. Protecting these forested recharge areas helps maintain the natural processes that allow groundwater to be replenished, ensuring a reliable supply of clean water. This approach is crucial for preserving the integrity of both forest ecosystems and groundwater resources, providing long-term environmental and community benefits. Prioritizing forest lands that contribute significantly to groundwater recharge is essential for maintaining the balance between land use and water conservation. These areas are few and scattered within St. Lucie County, as shown in **Figure 8-21**.

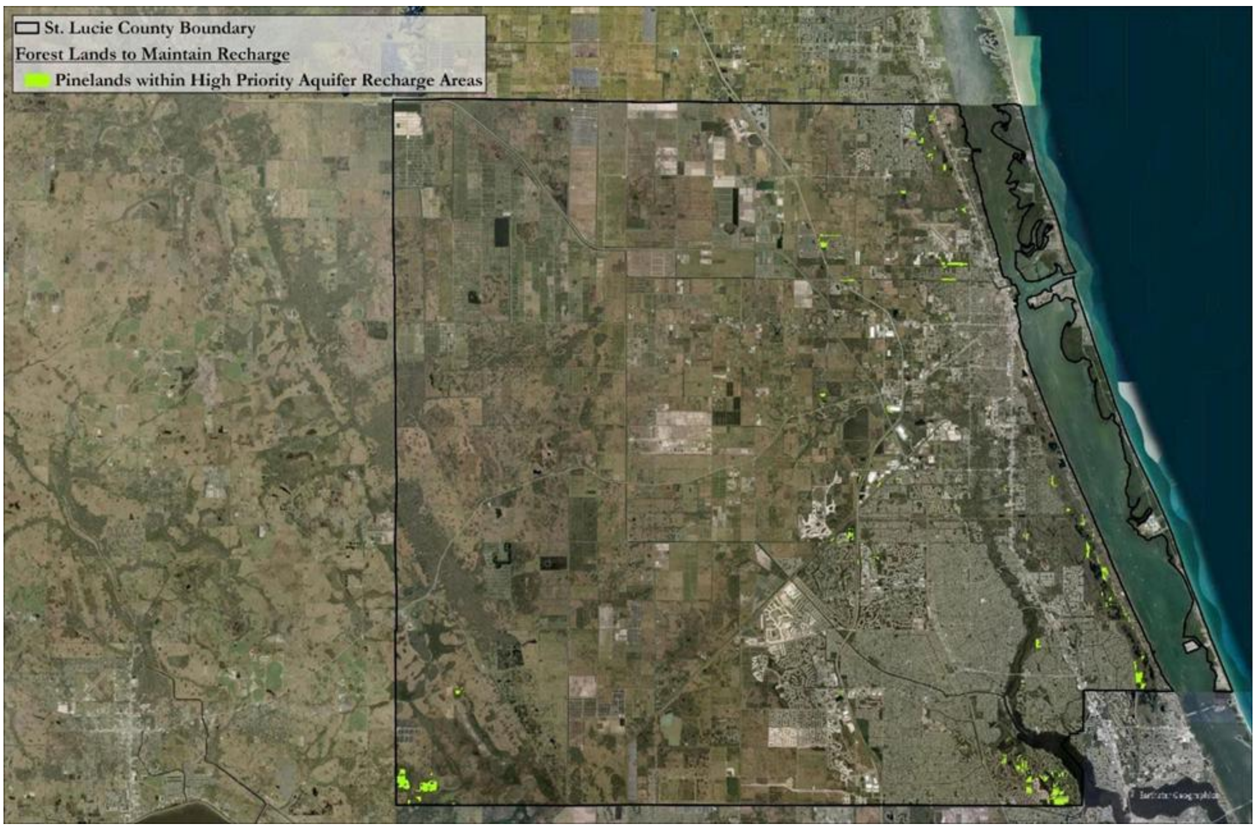


Figure 8-21. FNAI Forest Lands to Maintain Recharge Function

The conservation priorities for fragile coastal resources focus on natural communities located within one mile of the coast that are most vulnerable to development or disturbance. By identifying and prioritizing these areas, conservation efforts can be directed towards protecting coastal ecosystems that are at the highest risk. These fragile coastal resources are essential for maintaining biodiversity, providing habitat for various species, and supporting the overall health of coastal environments. Protecting these areas helps to mitigate the impacts of development and human activities, ensuring that coastal ecosystems remain resilient and continue to provide vital ecological services. This approach is crucial for preserving the natural beauty and ecological integrity of coastal regions, safeguarding them for future generations. While there are some fragile coastal uplands in the northernmost region, the majority of the barrier island within St. Lucie is classified as a fragile coastal wetland (**Figure 8-22**).

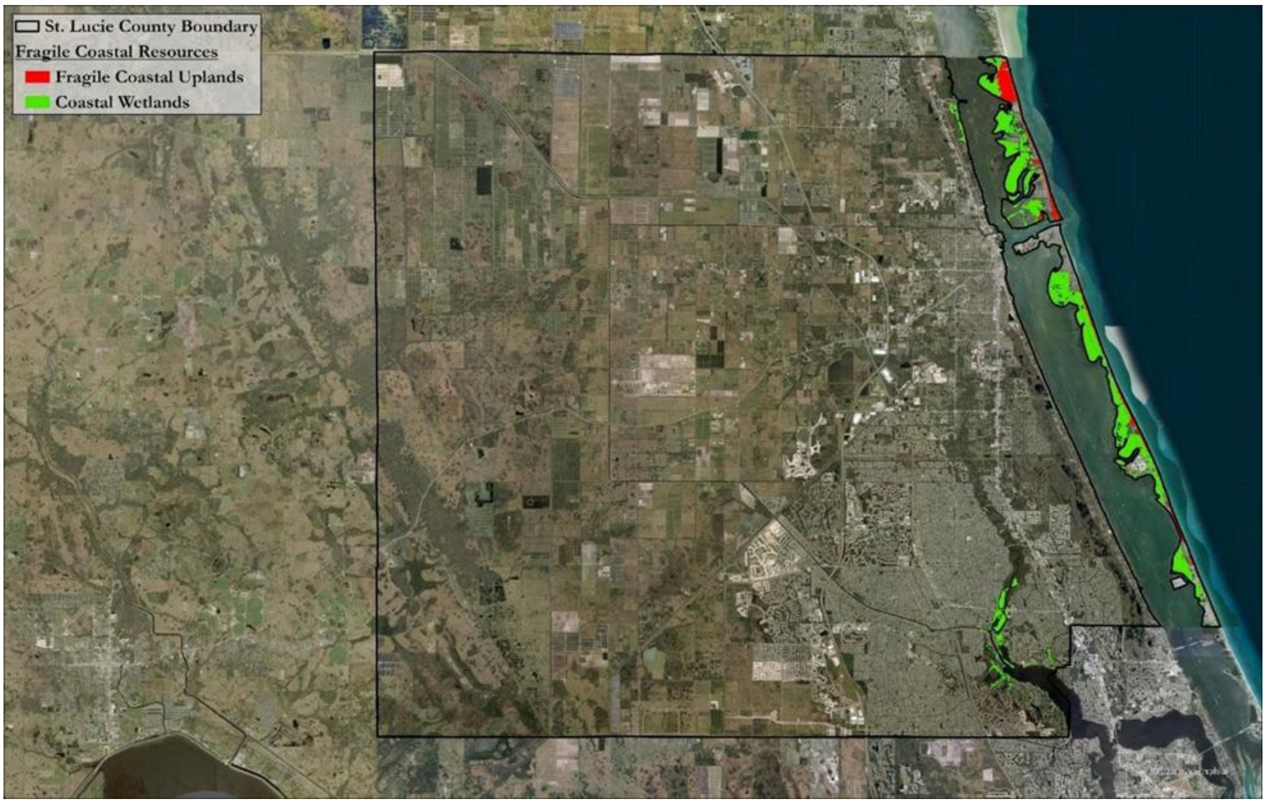


Figure 8-22. FNAI Fragile Coastal Resources

The Florida Fish and Wildlife Conservation Commission (FWC) has identified areas across Florida that serve as potential habitats for the long-term maintenance of 62 focal vertebrate species. These species are not adequately protected by existing conservation lands. The prioritization of these areas is based on the quality of the habitat and the rarity of the focal species. Higher quality habitats and those supporting rarer species are given higher priority for conservation efforts. Identifying high-priority habitats allows conservation planners to target their efforts more effectively. Resources can be allocated to areas that will have the most significant impact on preserving biodiversity. This is useful in developing adaptive management strategies that can respond to changing environmental conditions, which is particularly important in the face of sea level rise. High priority habitat conservation areas within St. Lucie County, depicted in **Figure 8-23**, are concentrated along the Indian River Lagoon, St. Lucie River, and within the expansive agricultural areas of the county's southwestern corner region.

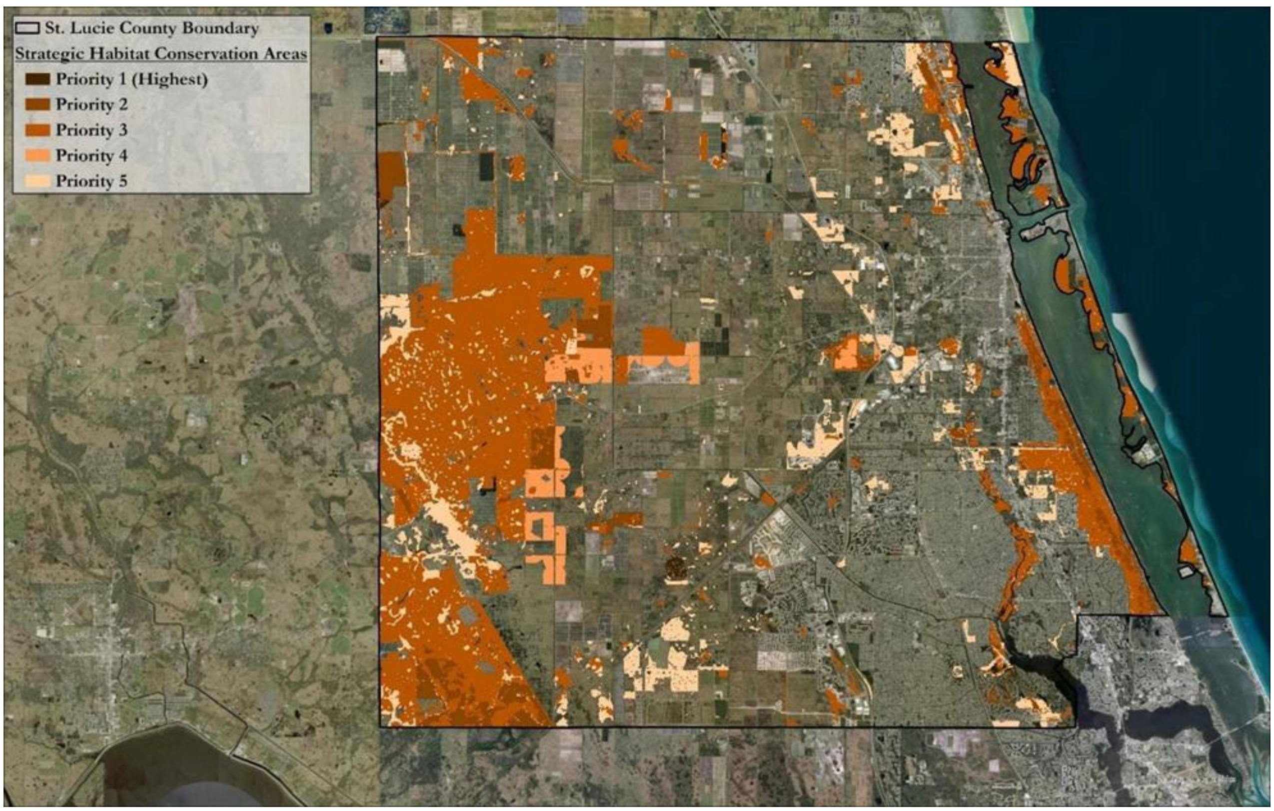


Figure 8-23. FNAI Strategic Habitat Conservation Area

The conservation priorities for rare species habitats focus on occurrence-based habitats for 281 species that require conservation efforts. These species include a diverse array of plants, invertebrates, and vertebrates. The prioritization of these habitats is determined by the rarity and diversity of the species they support. This approach ensures that conservation efforts are directed towards the most critical areas, where the preservation of unique and diverse species can have the most significant impact. By focusing on habitats that support a high diversity of rare species, conservation planners can maximize the effectiveness of their efforts, ensuring that these vulnerable species have the best chance of survival in the long term. This strategy is essential for maintaining biodiversity and ecological balance, as it targets the protection of species that are most at risk of extirpation or extinction. **Figure 8-24** highlights high priority habitats, most of which are concentrated along the coast.

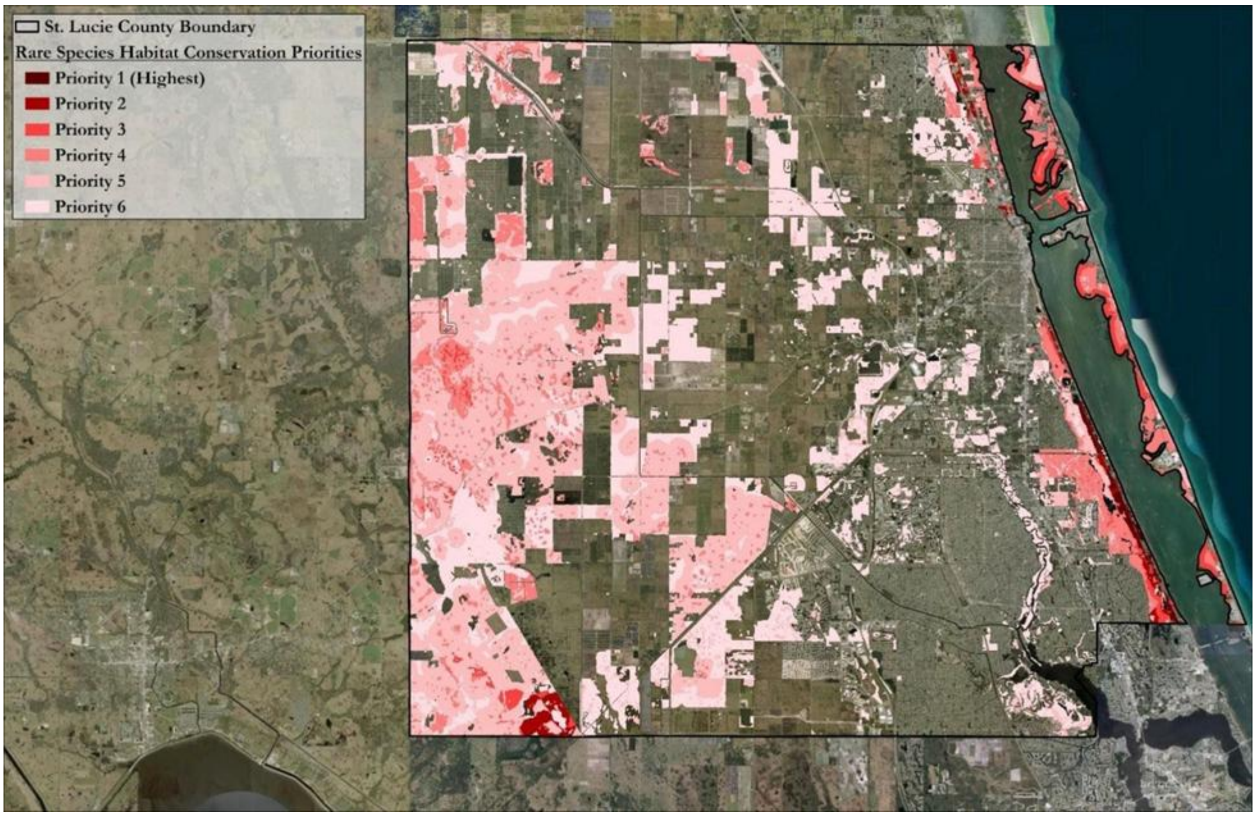


Figure 8-24. FNAI Rare Species Habitat Conservation Priorities

The Florida Ecological Greenway Network prioritizes the representation of landscape hubs, linkages, and corridors to enhance ecological connectivity. This network focuses on creating and maintaining connections that facilitate the movement of wide-ranging species, ensuring they can traverse between existing reserves and riparian areas. By prioritizing links that promote connectivity, the network supports the ecological health and genetic diversity of species populations. This strategic approach helps to mitigate habitat fragmentation, allowing species to access essential resources, migrate in response to environmental changes, and maintain viable populations. The emphasis on connectivity within the Florida Ecological Greenway Network is crucial for the long-term conservation of biodiversity and the resilience of ecosystem services, such as water storage and resource protection, flood attenuation and water quality enhancement across the state. As depicted in **Figure 8-25**, most of the western portion of the county is encompassed by the Florida Ecological Greenway Network and listed as the second highest priority.

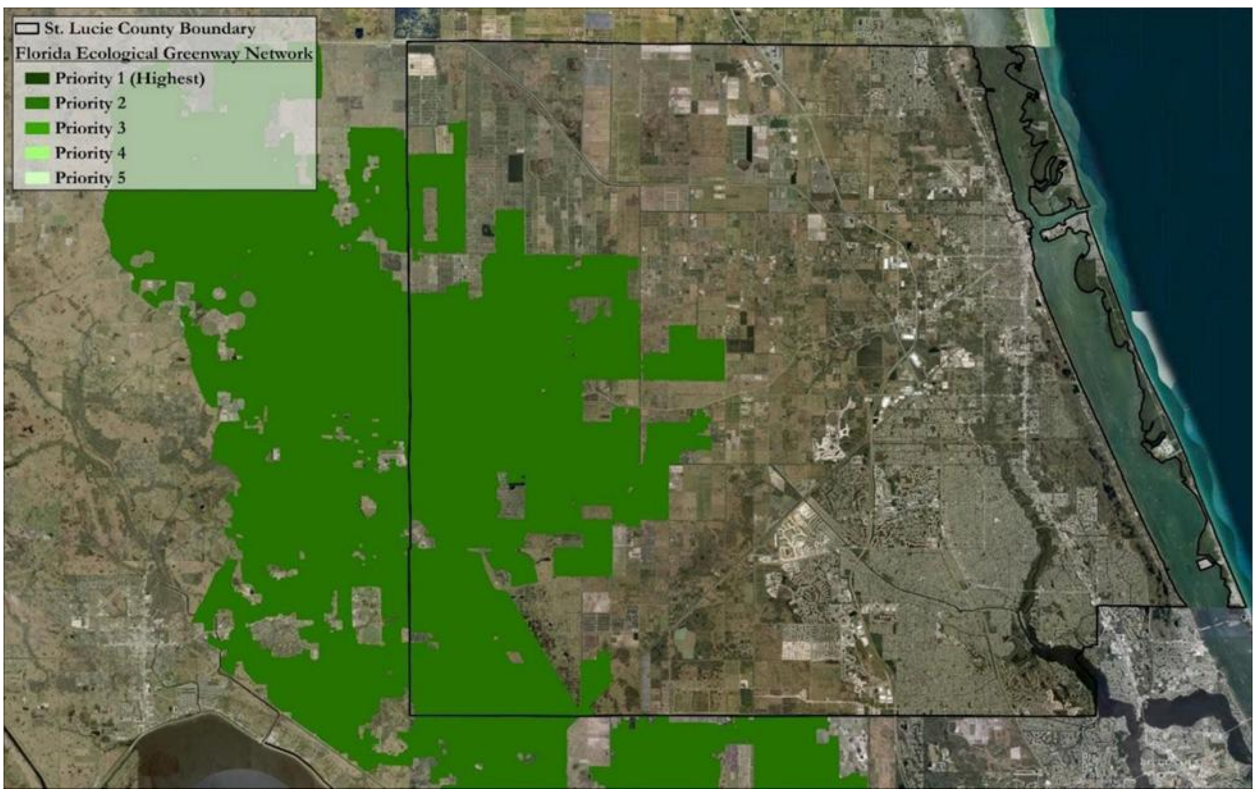


Figure 8-25. FNAI Florida Ecological Greenway Network

The conservation priorities for underrepresented natural communities focus on identifying and protecting those that lack adequate representation within existing conservation lands. These natural communities are prioritized based on their global rarity, ensuring that the most unique and vulnerable ecosystems receive the attention they need. By targeting these underrepresented areas, conservation efforts can address gaps in the current network of protected lands, safeguarding a broader range of biodiversity. This approach helps to preserve the ecological integrity and resilience of these rare natural communities, ensuring their survival for future generations. Prioritizing rare natural communities is essential for maintaining the overall health and diversity of the environment, as it ensures that even the most uncommon ecosystems are given the protection they deserve. The majority of under- represented natural communities in St. Lucie County are pine flatwoods, followed by scrub and scrubby flatwoods (**Figure 8-26**).

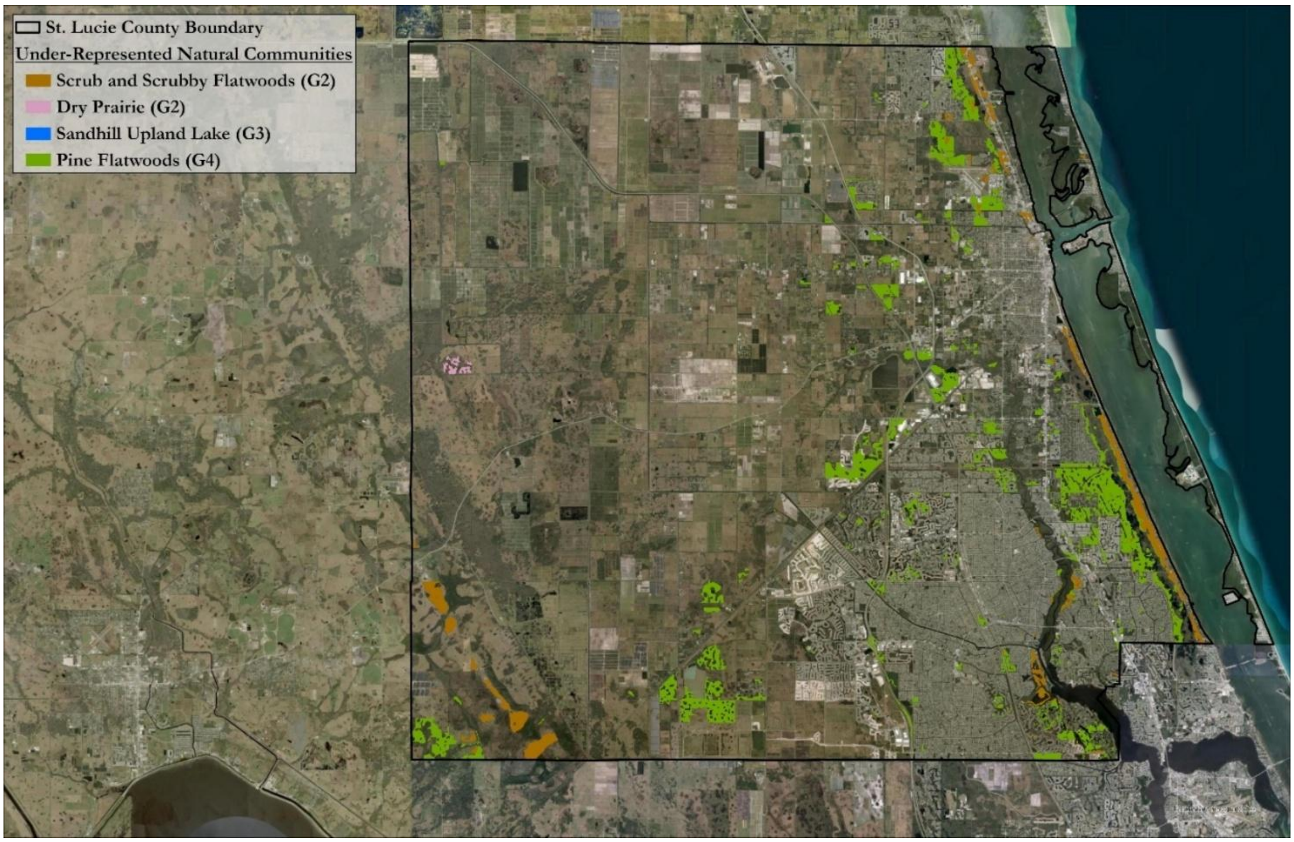


Figure 8-26. FNAI Under-Represented Natural Communities

The conservation priorities for sustainable forestry involve identifying areas that are potentially suitable for pine-based forestry. Higher prioritization is given to larger tracts of land, more mesic (moderately moist) sites, and locations within 50 miles of a mill. By focusing on these criteria, conservation efforts can support the development of sustainable forestry practices that maximize productivity while minimizing environmental impact. Prioritizing larger tracts ensures that forestry operations can be more efficient and economically viable. Mesic sites are preferred because they provide optimal growing conditions for pine species. Proximity to a mill promotes sustainable forestry operations. This approach helps balance the economic benefits of forestry with the need to protect and manage natural resources responsibly. Suitable areas within the county, most of which have a low priority, are concentrated to the east (**Figure 8-27**).

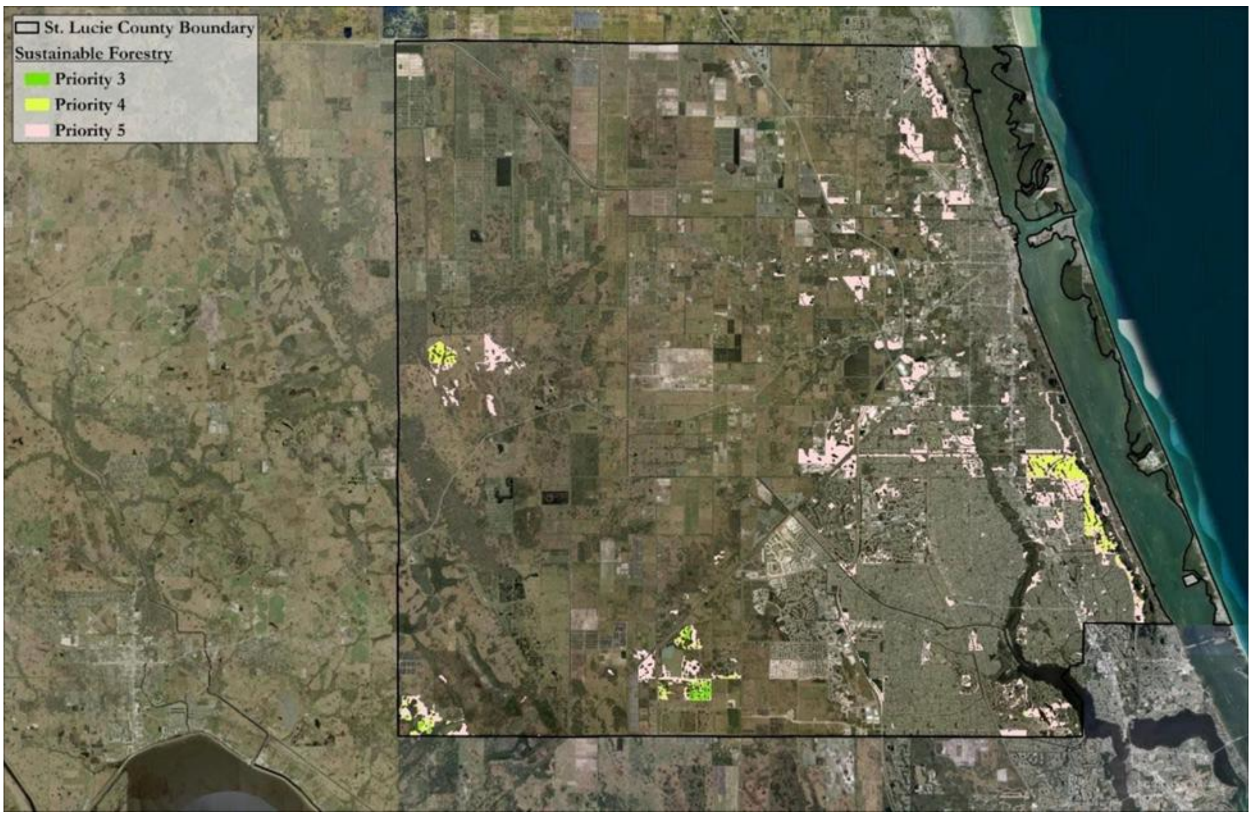


Figure 8-27. FNAI Sustainable Forestry

The FNAI CLIP layer utilizes the natural data resources described above to identify critical lands and waters that support flood storage, groundwater recharge, and biodiversity; and protect surface waters; and supply essential landscapes and waterways to different wildlife species. The utilization of this data can support local government initiatives to identify high quality natural ecosystems for conservation (**Figure 8-28**).

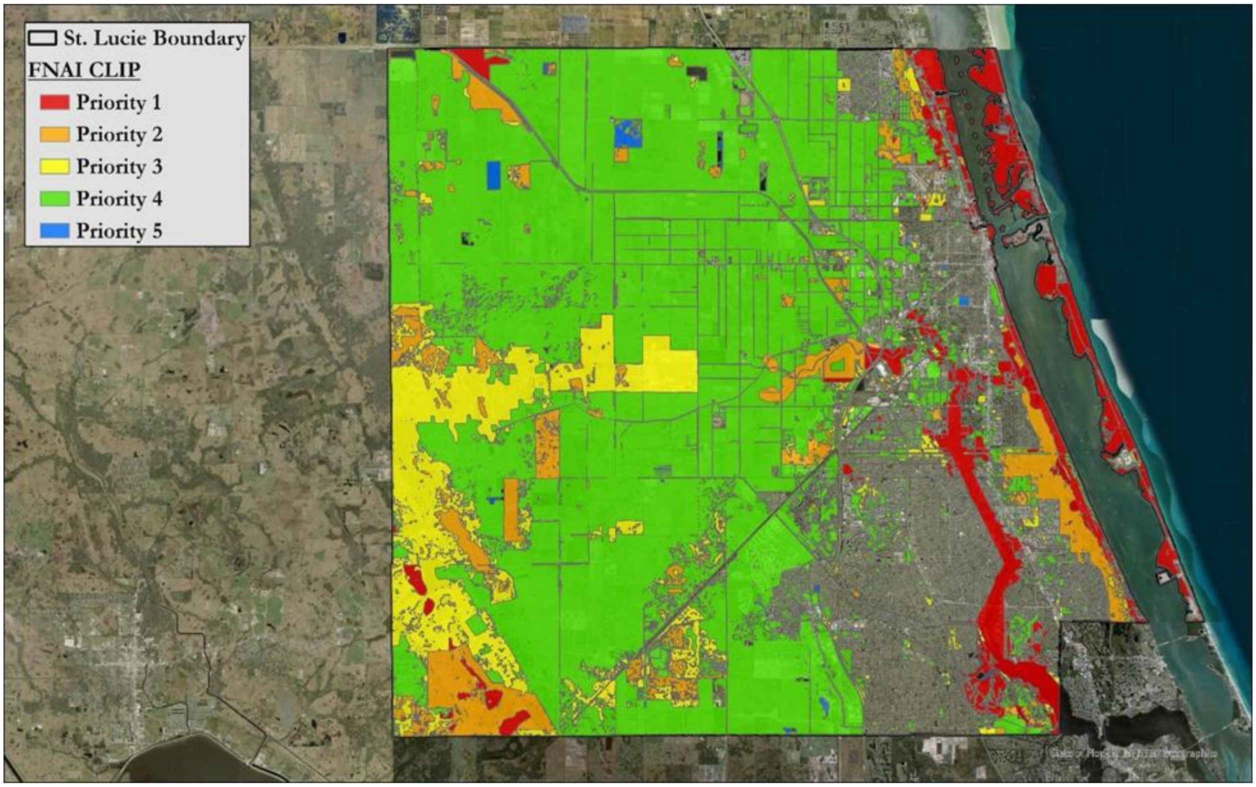


Figure 8-28. FNAI Critical Lands and Waters Identification Project (CLIP)

8.2.2.4 Habitat Profiles

The SLAMM model uses a detailed 26-category land classification system to represent coastal and wetland ecosystems, each responding differently to sea level rise. **Figure 8-29** highlights some key categories occurring within St Lucie County.

Figure 8-29. Color Coded Legend of baseline SLAMM Habitats

Upland Categories:

- Developed Dry Land: Urban/developed areas above Mean Tide Level (MTL), including infrastructure and built environment.
- Undeveloped Dry Land: Natural areas above MTL, potential for wetland migration

Freshwater Wetlands:

- Swamp: Non-tidal forested wetlands.
- Cypress Swamp: Specialized freshwater forested wetlands dominated by cypress trees.
- Inland-Fresh Marsh: Non-tidal herbaceous wetlands.
- Tidal-Fresh Marsh: Fresh marshes influenced by tidal action but minimal salinity

Transitional and Salt Marshes:

- Transitional Salt Marsh: Intermediate zone between fresh and salt marshes.
- Regularly-Flooded Marsh: Salt marsh flooded daily by tides.
- Irregularly-Flooded Marsh: Salt marsh flooded only during spring tides or storms

Coastal Wetlands and Shores:

- Mangrove: Saltwater-tolerant forest ecosystems.
- Estuarine Beach and Ocean Beach: Different types of shoreline environments.
- Tidal Flat and Ocean Flat: Low-lying areas regularly exposed at low tide.
- Rocky Intertidal: Rocky shores influenced by tides

Water Bodies :

- Inland Open Water: Freshwater bodies.
- Riverine Tidal: Rivers influenced by tides.
- Estuarine Open Water: Brackish water bodies.
- Tidal Creek: Small tidal channels.
- Open Ocean: Marine environment

Additional Categories:

- Inland Shore: Non-tidal shorelines.
- Tidal Swamp: Forested wetlands with tidal influence.
- Flooded Developed Dry Land: Developed areas inundated by sea level rise.
- Flooded Forest: Forested areas inundated by sea level rise.

This classification system enables computational modeling of how different habitats respond to sea level rise, considering factors such as elevation, tidal range, salinity, and accretion rates. Each category has unique threshold elevations and transition rules that determine how it changes under different sea level rise scenarios.

St. Lucie County's coastal landscape is characterized by a rich tapestry of 18 interconnected habitats, ranging from beaches and mangroves to freshwater wetlands and upland systems. Each of these natural communities plays a vital role in the region's environmental resilience, while facing unique challenges from sea level rise and prolonged flooding implications.

8.2.2.5 Land Cover and Native Ecological Communities

St. Lucie County's natural and semi-natural landscape is characterized by a highly diverse mosaic of forests, grasslands, and wetlands. One of the drivers of the diversity of landscapes and associated species is the location of the county at a transition point between the humid subtropical climate zone of the southeastern United States and a more tropical climate zone characteristic of southern Florida. Accordingly, the flora and fauna of St. Lucie County contain a mix of species between the two zones, contributing to relatively high local biodiversity.

Land cover and land use data from the South Florida Water Management District provides an in-depth snapshot of current land cover in St. Lucie County (**Figure 8-30**; **Table 8-5**). As a coastal county, St. Lucie County contains extensive areas of marine water, wetlands, lakes, and other water features, which together account for 13 percent of total area in the county. Over

15 percent of these water features are comprised of marine and estuarine waters – including the nearshore Atlantic Ocean – that are highly valued for their support of outdoor recreation, tourism, and productive fishery economies. The county's estuarine wetlands, including salt marshes and mangrove swamps, play an especially important role in regulating nearshore water quality, supporting fisheries, and helping to protect inland areas from storm surges.

Similarly, the county's extensive freshwater wetland communities are critical for regulating water quality in lakes and streams, serving as storage for floodwaters, and providing important nursery habitat for many native birds, amphibians, fish, and other wildlife.

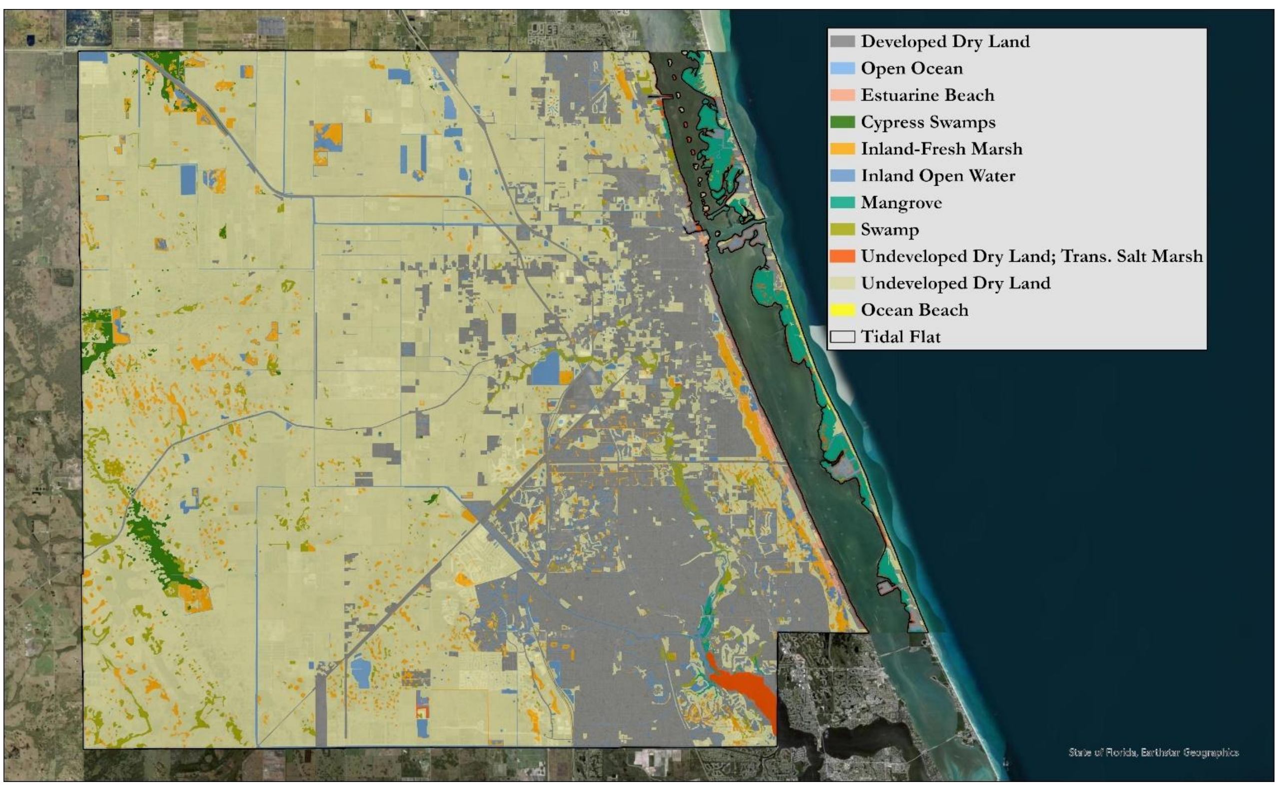


Figure 8-30. SFWMD Land Use Classifications color coded to match SLAMM legend

Table 8-5. Land cover types by area

Land Cover Type	Area (Acres)
Low Density Urban	12,030.71
Medium Density Urban	39,757.33
High Density Urban	6,925.97
Transportation	5,787.15
Industrial/Commercial	15,168.88
Barren/Open Land	6,353.53
Agriculture	206,408.51
Recreational	4,516.36
Upland Non-Forested	8,283.88
Upland Forest	17,133.29
Mangroves	5,098.29
Wetlands/Sloughs (Excluding Mangroves)	30,184.05
Reservoirs	6,756.92
Lakes	689.05
Streams/Waterways	3,468.7
Bays/Estuaries	2,186.52
Ocean	21.02
Total	**370,770.16**

8.2.2.6 Existing Conservation Lands

To facilitate stakeholder engagement in future projects, the names, management entity, and land areas of the fifteen largest protected land units in St. Lucie County are shown in **Table 8-6** below. Conservation lands within St. Lucie are highlighted in green in **Figure 8-31**.

Table 8-6. St Lucie Conservation Lands by Size and Manager

Property	Manager	Area (Acres)
Savannas Preserve State Park	FL Dept. of Environmental Protection, Div. of Recreation and Parks	6,408.00
C-23/C-24 South Reservoir	South Florida Water Management District	4,853.37
Cow Creek Ranch Agricultural and Conservation Easement #2	FL Dept. of Agriculture and Consumer Services	3,488.23
Bluefield Ranch	St. Lucie County	3,278.77
Ru-Mar Conservation Easement	FL Dept. of Environmental Protection, Div. of State Lands	3,153.45
McCarty Ranch Preserve	City of Port St. Lucie	3,107.00
C-23/C-24 Stormwater Treatment Area	South Florida Water Management District	2,757.12
C-23/C-24 North Reservoir	South Florida Water Management District	2,609.21
Bluefield Ranch Mitigation Bank	Bluefield Ranch Mitigation Bank	2,494.65
Cypress Creek Complex	South Florida Water Management District	1,233.17

Property	Manager	Area (Acres)
Ten Mile Creek	South Florida Water Management District	959.89
Cypress Creek	St. Lucie County	783.75
St. Lucie Pinelands	St. Lucie County	750.84
Fort Pierce Inlet State Park	FL Dept. of Environmental Protection, Div. of Recreation and Parks	701.20
Avalon State Park	FL Dept. of Environmental Protection, Div. of Recreation and Parks	657.24
Walpole Ranch Agricultural and Conservation Easement	FL Dept. of Agriculture and Consumer Services	599.16

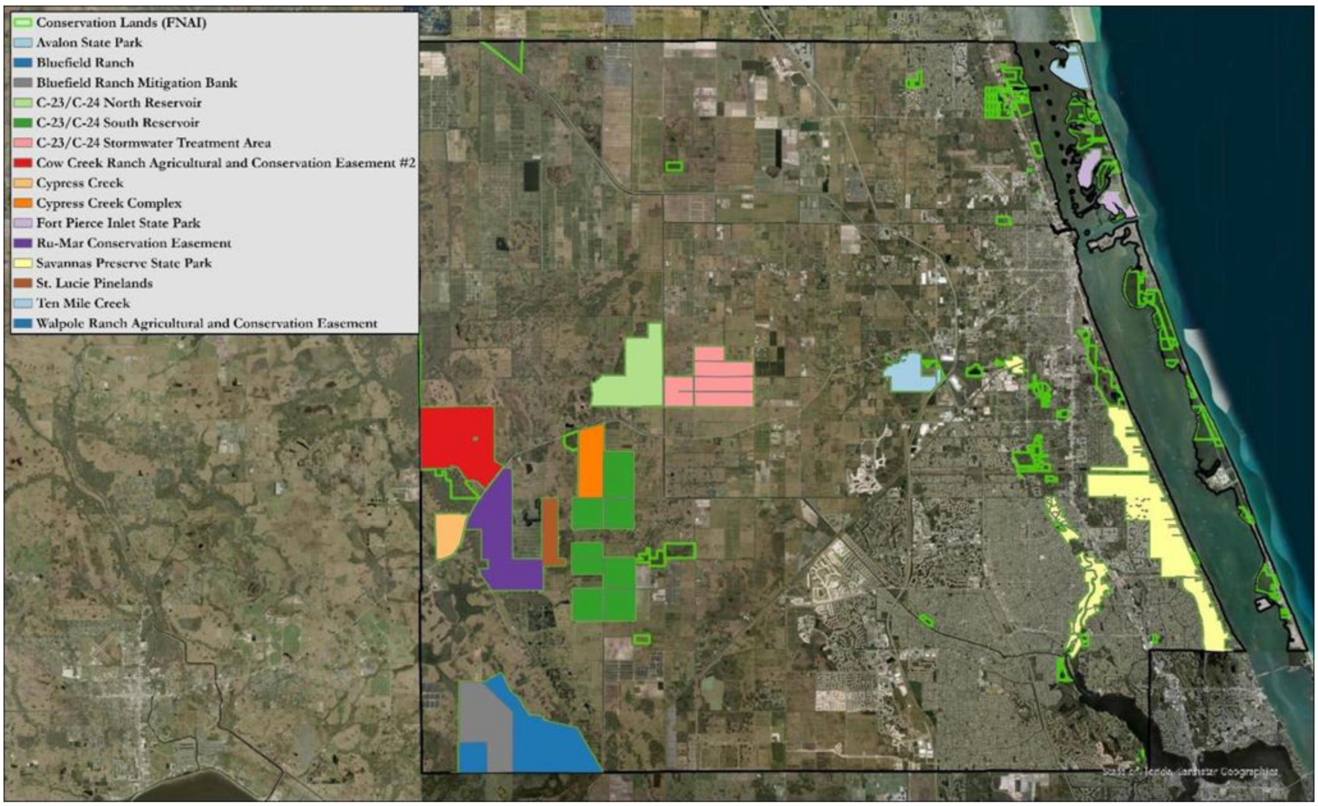


Figure 8-31. Map of Existing Conservation Lands within the St. Lucie County

8.3 Model Parameters

The model was configured using locally calibrated parameters, ensuring accuracy in simulating SLR effects (**Table 8-7**). Future assessments should work on verifying or validating these values:

Table 8-7. Table of SLAMM Input Parameters

Parameter	Value	Description	Importance
NWI Photo Date	2022	Date of NWI data used for initial conditions	Establishes baseline year
DEM Date	2018	Date of majority elevation data	Ensures consistency with NWI data
Direction Offshore	East	Primary direction toward open ocean	Used in fetch calculations
Historic Trend	0.13 inches/year	Historic rate of sea level rise	Used to adjust initial conditions
MTL-NAVD88	-0.34 m	Correction between Mean Tide Level and NAVD88 datum	Critical for accurate elevation referencing
GT Great Diurnal Tide Range	2.20 ft	Tide range for the study area	Determines habitat elevation ranges
Salt Elevation	1.12 ft	Elevation above MTL for salt boundary	Defines boundary between fresh and salt influence
Marsh Erosion	3.28 ft/year	Horizontal erosion rate for marshes	Affects shoreline retreat rates
Swamp Erosion	1.64 ft/year	Horizontal erosion rate for swamps	Lower than marsh due to greater root stabilization
Tidal Flat Erosion	4.92 ft/year	Horizontal erosion rate for tidal flats	Higher due to lack of vegetation
Mangrove Erosion	3.28 ft/year	Horizontal erosion rate for mangroves	Based on field measurements
Regularly Flooded Marsh Accretion	0.16 inches/year	Vertical accretion rate	Critical for determining marsh response to SLR
Irregularly Flooded Marsh Accretion	0.12 inches/year	Vertical accretion rate	Lower than regularly flooded due to less sediment input
Tidal Fresh Marsh Accretion	0.14 inches/year	Vertical accretion rate	Intermediate value based on local conditions
Beach Sedimentation Rate	0.02 inches/year	Vertical accretion rate for beaches	Conservative estimate for natural beaches
Mangrove Accretion	0.18 inches/year	Vertical accretion rate for mangroves	Higher than marshes due to root structures

These parameters were carefully selected based on scientific literature, local measurements, and expert knowledge to ensure the model accurately represents the processes affecting coastal habitats in St. Lucie County.

Accretion rates represent how quickly wetlands can build up vertically by trapping sediment and organic matter. If a wetland can build up faster than sea level is rising, it may survive. If sea level rises faster than the wetland can build up, it may convert to open water. The values above show that mangroves (0.18 inches/year) can build up faster than marshes (0.12-0.16 inches/year), which may affect their relative vulnerability to sea level rise.

8.4 Scenarios and Runs

8.4.1 Sea Level Rise Scenarios

Two sea level rise scenarios from NOAA were selected to represent a range of possible futures:

- **NOAA Intermediate Low (NIL)**: A lower sea level rise trajectory
  - 2040 = 0.78 ft
  - 2070 = 1.34 ft
  - 2100 = 1.87 ft
- **NOAA Intermediate High (NIH)**: A higher sea level rise trajectory
  - 2040 = 1.5 ft
  - 2070 = 3.37 ft
  - 2100 = 6.1 ft

These scenarios were selected to represent a plausible range of sea level rise based on current scientific understanding, without exploring the most extreme scenarios. The historic rate of sea level rise in this region has been about 0.09 inches/year. If this rate continued unchanged, sea level would rise only about 0.61 ft (7.3 inches) by 2100. Both scenarios used in this analysis project significantly faster rates of sea level rise, which is evident in **Figure 8-32**.

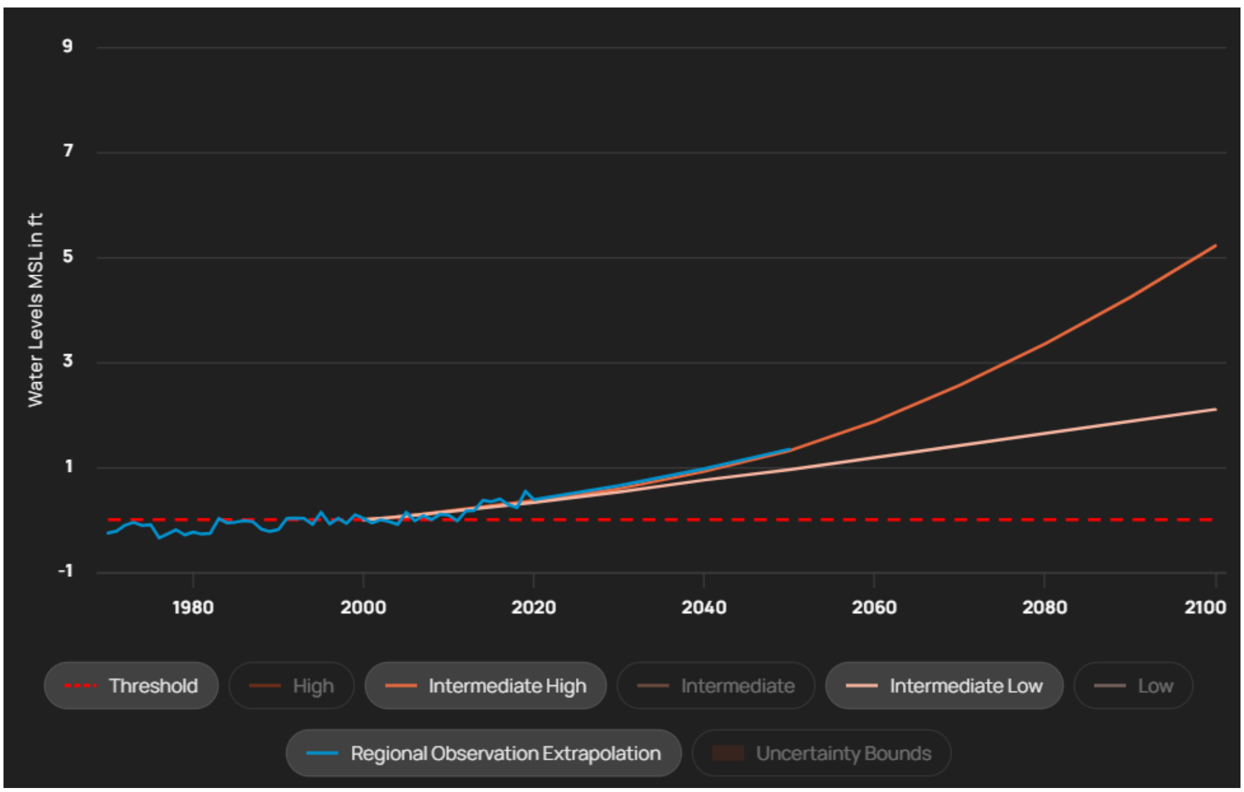


Figure 8-32. Sea level rise relative to NOAA Intermediate High and Intermediate Low

8.4.2 Protection Scenarios

Three protection scenarios were modeled to evaluate different management approaches:

- **No Protection**: Natural migration of all habitats with no human intervention
  - Serves as a baseline for comparison; wetlands move inland where possible
  - Represents a "do nothing" approach, natural habitat migration
- **Protect All Dry Land**: Protection of all developed and undeveloped dry land
  - Represents a comprehensive protection approach; Limits habitat migration, increases coastal squeeze
  - Would require significant infrastructure investment; Hard barriers around all land
- **Protect Developed Dry Land**: Protection of only developed dry land areas
  - Represents a more targeted protection approach; reduces infrastructure risk, but allows wetland transition
  - Focuses on protecting infrastructure and developed areas; barriers for urban areas only

When sea levels rise, coastal habitats naturally try to migrate inland. However, if there are barriers like seawalls or elevated roads (as in the protection scenarios), these habitats can become "squeezed" between the rising water and fixed barrier. This can lead to habitat loss if there's nowhere for these ecosystems to go.

8.4.3 Planning Horizons

Results were analyzed for four time periods to support planning at different time scales:

- **Initial conditions (2020):** Baseline conditions – Midway point DEM and NWI dates
- **Near-term (2040)**: 20-year planning horizon
- **Mid-term (2070)**: 50-year planning horizon
- **Long-term (2100)**: 80-year planning horizon

Different planning horizons are relevant for different types of decisions. Near-term projections (2040) are most relevant for current planning cycles and immediate adaptation decisions. Mid-term projections (2070) align with the lifespan of major infrastructure and buildings. Long-term projections (2100) are important for understanding the legacy of current decisions and long-range planning.

8.5 Analysis Methods

The St. Lucie County SLAMM (Sea Level Rise Affecting Marshes Model) Analysis Project employed a structured approach to quantify habitat changes, assess carbon sequestration potential, and compare the effectiveness of various adaptation strategies. The following analytical methods were used:

1. Habitat Area Calculation
   - The total area (hectares) of each habitat type was summed by year and scenario to track changes over time.
   - This method enabled a direct comparison of habitat areas across different sea level rise scenarios and time periods.

2. Percentage Change Calculation
   - Changes in habitat extent were assessed relative to baseline conditions using the following formula:

$$\text{Percentage Change} = \left(\frac{\text{Current} - \text{Baseline}}{\text{Baseline}}\right) \times 100$$

   For example, to calculate the change in mangrove habitats:

$$\left(\frac{5{,}000\ acres\ -\ 10{,}000\ acres}{10{,}000\ acres}\right) \times 100 = -50\%$$

   - This metric provides a standardized way to measure the rate and magnitude of habitat transitions.

3. Cross-Scenario Comparison
   - A comprehensive comparison was conducted across all modeled scenarios and protection strategies to assess the relative effectiveness of these three different adaptation approaches.

These methods provide a quantifiable and comparative framework to support data-driven decision-making for coastal resilience planning in St. Lucie County.

9.0 MODEL STRUCTURE AND CONTENT

Results from the SLAMM runs show progressive and increasing inundation of low-lying developed lands and undeveloped uplands, particularly within coastal areas of St. Lucie County, from 2040 through 2100. Inspection of the full SLAMM land cover categories and projected changes by scenario reveals the need for some important interpretive caveats.

The SLAMM algorithm appears to be systematically – and could certainly mistakenly – be selecting for marshes, rather than mangroves within habitat transition modules, as the dominant saltwater wetland for areas newly inundated by sea level rise in St. Lucie County. This suggests that the interpretation of SLAMM land cover change results should likely focus on broader, aggregated categories (e.g., saltwater wetlands, which includes mangroves, marshes, and other intertidal areas), rather than place high levels of confidence in the accuracy of specific wetland types provided by the raw model outputs.

Another key caveat is that the extension of SLAMM into the non-tidal portions of the St. Lucie River should be viewed as both exploratory and experimental. While it is intuitive that significant upstream transgression of saltwater can be expected with large increments of sea level rise, the current model does not incorporate more complex dynamics between non-stationary groundwater (e.g., rising regional water table) and surface head pressure from fresh headwater areas that could, for example, be expected to favor creation of new freshwater wetlands in areas that are currently uplands. Moreover, the extent of saltwater transgression into the upper St. Lucie River seems conservative under the sea level rise scenarios.

A final caveat is that the SLAMM results are obviously dependent on the accuracy of data input files, model parameters, and sea level rise projection scenarios, while also being subject to the technical limitations of the model itself. The results can be informative about general trends and planning at the landscape scale but should not in any way be used as a standalone tool for site-level design, engineering, or ecosystem management decisions.

9.1 Primary Results

Six scenario-specific model runs were conducted, each representing different sea level rise projections and protection strategies (**Table 9-1**). These results offered a quantitative foundation for assessing habitat changes, ecosystem resilience, and adaptation measures.

Total Study Area:
3,263,184 hectares (approximately 8,063,503 acres)

Years Simulated:
2020, 2040, 2070, 2100

Sea Level Rise Scenarios:
NOAA Intermediate Low ("NIL") and NOAA Intermediate High ("NIH")

Protection Strategies:
None, Protect All Dry Land, Protect Developed Dry Land

Each scenario provides insight into how different protection strategies influence habitat transformation over time, guiding coastal planning, resilience efforts, and conservation priorities.

Table 9-1. Description of modeling results output provided by the SLAMM model

Parameter	Description	Values	Purpose
Scenario	Sea level rise scenario	"NIL", "NIH" (See SLR – eustatic below)	Specifies which SLR curve was used
Year	Simulation year	2020, 2040, 2070, 2100	Indicates the time period
Protection	Protection strategy	"Protect None", "Protect All Dry", "Protect Developed Dry"	Specifies the protection approach
GIS Num	Numeric identifier for habitat type	1-25 (see SLAMM technical documentation)	Internal SLAMM code for habitat types
Acres	Area in acres	276153.9146, -9999.0 (for null/void)	The primary data value being tracked
SLAMMText	Habitat type name	"Developed Dry Land", "Mangrove", etc.	Habitat description
SLR (eustatic)	Sea level rise value in meters	"NOAA et al 2017"	The amount of sea level rise for that year

The model provides over 30 outputs, which are grouped into six categories below. Understanding these habitat types is essential for interpreting the model results.

9.1.1 Dry Land Habitats

- **Developed Dry Land**: Urban and built-up areas above the reach of tides
- **Undeveloped Dry Land**: Natural upland areas above the reach of tides
- **Flooded Developed Dry Land**: Developed areas that have been inundated

9.1.2 Wetland Habitats

- **Swamp**: Freshwater forested wetland
- **Cypress Swamp**: Wetland dominated by cypress trees
- **Tidal Swamp**: Forested wetland influenced by tides
- **Mangrove**: Salt-tolerant tropical trees growing in intertidal zones
- **Inland-Fresh Marsh**: Non-tidal freshwater herbaceous wetland
- **Tidal-Fresh Marsh**: Tidally influenced freshwater herbaceous wetland
- **Trans. Salt Marsh**: Transitional zone between salt marsh and upland
- **Regularly-Flooded Marsh**: Salt marsh flooded by most high tides
- **Irreg.-Flooded Marsh**: Salt marsh flooded only by spring or storm tides
- **Saltmarsh**: General category for salt marshes

9.1.3 Water Habitats

- **Estuarine Open Water**: Open water in estuaries
- **Open Water**: General category for open water
- **Inland Open Water**: Freshwater lakes and ponds
- **Open Ocean**: Marine waters beyond the shoreline
- **Tidal Creek**: Small tidal channels within marshes
- **Riverine Tidal**: Rivers influenced by tides

9.1.4 Beach and Flat Habitats

- **Estuarine Beach**: Beaches along estuarine shorelines
- **Ocean Beach**: Beaches along ocean shorelines
- **Tidal Flat**: Unvegetated intertidal areas
- **Ocean Flat**: Unvegetated areas in shallow ocean waters
- **Rocky Intertidal**: Rocky areas in the intertidal zone

9.1.5 Other Categories

- **Transitional**: Areas transitioning between habitat types
- **Inland Shore**: Shorelines of inland water bodies
- **Freshwater Tidal**: Areas with freshwater that are tidally influenced
- **Freshwater Non-Tidal**: Areas with freshwater not influenced by tides
- **Aggregated Non Tidal**: Combined category for non-tidal areas
- **Low Tidal**: Areas in the lower intertidal zone

Note: Submerged Aquatic Vegetation SAV (sq.km) underwater plants are not included in this analysis

These habitat types represent the full range of coastal ecosystems found in St. Lucie County and are the basis for tracking changes due to sea level rise. As sea level rises, habitats typically transition in a predictable sequence. For example, upland areas may become freshwater wetlands, freshwater wetlands may become brackish or salt marshes, salt marshes may become mangroves (in tropical areas like Florida), and mangroves may eventually become open water if they cannot keep pace with sea level rise. The SLAMM model results offer a framework for understanding habitat vulnerability and potential adaptation pathways in St. Lucie County. By comparing scenarios, stakeholders can assess the trade-offs between land protection strategies, ecosystem resilience, and long-term sustainability. These insights will directly inform coastal management, wetland conservation, and adaptation efforts for the region.

10.0 SEA LEVEL RISE PROJECTIONS

This section examines the projected sea level rise (SLR) trajectories for St. Lucie County based on two NOAA-defined scenarios: NOAA Intermediate Low (NIL) and NOAA Intermediate High (NIH). These projections help guide long-term resilience planning, habitat conservation, and climate adaptation strategies.

10.1 NOAA Intermediate Low (NIL)

The NOAA Intermediate Low (NIL) scenario, assumes:

- Decreased rate of sea level rise.
- Slower ocean thermal expansion.
- Moderate ice sheet loss from Antarctica and Greenland.

10.1.1 Description

This scenario represents a more optimistic future with substantial mitigation efforts.

10.1.2 SLR Values

The rate of sea level rise is more consistent over time than in the Intermediate High scenario, with the rate increasing from 0.20 inches/year in the 2020-2040 period to 0.22 inches/year in the 2040-2070 period, then maintaining a similar rate of 0.22 inches /year in the 2070-2100 period (**Table 10-1**).

Table 10-1. NOAA 2017 Intermediate Low Sea Level Rise values for the St Lucie County SLAMM model

Year	SLR (eustatic) (m)	Inches	Feet	Cumulative Change
2020	0.00	0.0	0.0	Baseline
2040	0.10	3.9	0.3	+0.33ft in 20 years
2070	0.27	10.6	0.9	+0.56ft in next 30 years
2100	0.44	17.3	1.4	+0.56ft in final 30 years

10.1.3 Key Characteristics

The Intermediate Low scenario leads to several distinctive outcomes:

- More gradual habitat transitions
  - Slower conversion of wetlands to open water
  - Less extensive loss of beaches and tidal flats
  - More limited inland migration of salt-influenced habitats
- Less expansion of estuarine open water
  - Moderate increase in water area in the Indian River Lagoon
  - Less conversion of mangroves and marshes to open water
  - Fewer changes in water quality and fisheries
- More preservation of mangroves and marshes

- Slight increase 0.2 percent or approximately 153 acres of mangroves by 2100
- 32.0 percent loss or approximately 133 acres of regularly-flooded marsh by 2100
- Greater retention of habitat for wildlife

- Lower atmospheric carbon emissions
  - Less release of stored carbon as wetlands are preserved
  - Greater future carbon sequestration capacity
  - Reduced feedback from temperature increases

10.2 NOAA Intermediate High (NIH)

The NOAA Intermediate (NIH) scenario represents a higher sea level rise trajectory, assuming:

- Continued thermal expansion of ocean waters.
- Accelerated ice sheet loss from Antarctica and Greenland.
- Moderate net atmospheric greenhouse gases due to limited emissions reduction (aligned with RCP 4.5).

10.2.1 Description

This scenario represents a plausible future if current trends continue with some mitigation efforts.

10.2.2 SLR Values

The rate of sea level rise accelerates over time, with the rate increasing from 0.45 inches/year in the 2020-2040 period to 0.75 inches/year in the 2040-2070 period, then slightly increasing to 1.09 inches/year in the 2070-2100 period (**Table 10-2**).

Table 10-2. NOAA 2017 Intermediate High Sea Level Rise values for the St Lucie County SLAMM model

Year	SLR (eustatic) (m)	Inches	Feet	Cumulative Change
2020	0.00	0.0	0.0	Baseline
2040	0.23	9.1	0.8	+0.75ft in 20 years
2070	0.80	31.5	2.6	+1.88ft in next 30 years
2100	1.63	64.2	5.3	+2.72ft in final 30 years

10.2.3 Key Characteristics

The Intermediate High scenario leads to several distinctive outcomes:

- More rapid and severe habitat transitions
  - Faster conversion of wetlands to open water
  - More extensive loss of beaches and tidal flats
  - Greater inland migration of salt-influenced habitats
- Greater expansion of estuarine open water
  - Significant increase in water area in the Indian River Lagoon

  - Conversion of mangroves and marshes to open water
  - Potential changes in water quality and fisheries
- More significant loss of mangroves and marshes
  - Up to 94.3 percent loss or approximately 65,061.4 acres of mangroves by 2100
  - Up to 48.8 percent loss or approximately 197.44 acres of regularly-flooded marsh by 2100
  - Substantial reduction in habitat for wildlife
- Atmospheric carbon emissions
  - Coastal wetlands that are allowed to migrate have been found to sequester 5 to 9 times more carbon than coastal wetlands unaffected by sea level rise (Rogers et al, March 7, 2019)
  - Wetlands that are unable to migrate and become drowned rapidly release stored carbon
  - Lost wetlands result in reduced future carbon sequestration capacity
  - Potential feedback from increased temperatures

11.0 PROTECTION SCENARIOS

While many strategies exist for protecting natural and built environments, this assessment compares three protection scenarios: No Protection (no protective/management action taken), Protect All Dry Land, and Protect Developed Dry Land.

11.1 No Protection

11.1.1 Description

The No Protection scenario assumes no human intervention to mitigate the impacts of sea level rise, allowing natural processes such as inundation, erosion, and habitat migration to occur unimpeded. This serves as a baseline scenario for assessing the extent of environmental changes in the absence of adaptive measures.

Key assumptions under this scenario:

- No new coastal defenses such as dikes, levees, or seawalls are constructed.
- Existing infrastructure remains unchanged and is not elevated or modified.
- Coastal and inland habitats transition naturally based on sea level rise projections.
- Both developed and undeveloped areas are affected by rising water levels and coastal changes.

This scenario is useful for identifying the most vulnerable regions and serves as a benchmark against which other protection strategies can be compared. In certain areas with low development density and high ecological value, a No Protection approach may be considered a viable option.

11.1.2 Key Characteristics

The No Protection scenario results in several significant environmental outcomes:

- **Maximum dry land loss:** Both developed and undeveloped lands are susceptible to inundation.
- **Greatest transition to open water:** Coastal wetlands experience extensive conversion to estuarine waters.
- **Rapid habitat changes:** The highest rates of habitat transformation and migration occur.
- **Provides a comparative baseline:** Highlights the full extent of sea level rise impacts and helps assess the effectiveness of intervention strategies.

While this scenario represents a "do-nothing" approach, it reflects an intentional decision to allow natural landscape shifts in response to environmental changes.

11.1.3 NOAA Intermediate Low (NIL) - No Protection

11.1.3.1 Habitat Changes by Year

Table 11-1. NOAA Intermediate Low Habitat Change by Year with Percentage change from Baseline – No Protection

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682, 390.09	682,383.18	682,316.95	682,236.64	-153.42	-0.02%
Undeveloped Dry Land	2,397,649.68	2,397,631.89	2,397,529.10	2,397,377.62	-272.16	-0.01%
Swamp	189,752.13	189,735.92	189,630.72	189,493.31	-258.81	-0.14%
Cypress Swamp	152,206.85	152,206.38	152,203.09	152,194.05	-12.80	-0.01%
Mangrove	68,999.62	69,165.83	68,951.04	69,109.98	110.36	0.16%
Inland-Fresh Marsh	164,953.95	164,953.68	164,950.07	164,948.32	-5.63	0.00%
Regularly-Flooded Marsh	404.56	367.49	314.64	271.77	-132.79	-32.82
Estuarine Open Water	19,749.05	24,474.81	25,673.74	26,325.63	6,576.67	33.30%

11.1.3.2 Spatial Distribution of Changes

Table 11-1 reveals several important patterns under the NIL 'No Protection' scenario:

1. **Coastal Areas**: Moderate changes in low-lying coastal areas
2. **Inland Areas**: Minimal changes in inland areas
3. **Wetland Areas**: Gradual transition of wetlands to open water

11.1.4 NOAA Intermediate High (NIH) - No Protection

This scenario combines the higher sea level rise trajectory with no protection measures, representing a "do nothing" approach under more severe sea level rise conditions.

11.1.4.1 Habitat Changes by Year

Table 11-2. NOAA Intermediate High Habitat Change by Year with Percentage change from Baseline – No Protection

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682,390.09	682,350.56	681,525.96	677,792.46	-4,597.73	-0.67%
Undeveloped Dry Land	2,397,649.68	2,397,575.80	2,395,907.59	2,391,294.39	-6,355.37	-0.27%
Swamp	189,752.13	189,552.17	187,083.86	178,941.98	-10,810.15	-5.70%
Cypress Swamp	152,206.85	152,197.68	151,936.12	151,028.70	-1,178.15	-0.77%
Mangrove	68,999.62	59,098.32	26,295.93	3,938.26	-65,061.26	-94.29%
Inland-Fresh Marsh	164,953.95	164,948.25	164,875.99	164,724.86	-229.09	-0.14%

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Regularly-Flooded Marsh	404.56	290.79	65.95	207.17	-197.39	-48.79%
Estuarine Open Water	19,749.05	35,460.93	74,283.72	98,406.33	78,657.28	398.28%

11.1.4.2 Spatial Distribution of Changes

Table 11-2 reveals several important patterns:

1. **Minimal dry land impacts**: Despite the higher sea level rise scenario, dry land losses remain below 1 percent, approximately 10,900 acres, indicating that most developed and undeveloped areas are above the projected inundation levels.

2. **Severe mangrove loss**: Mangroves show a dramatic decline of over 94 percent, approximately 64,250 acres, with losses accelerating over time. This represents a significant loss of critical coastal habitat.

3. **Loss of regularly-flooded marsh**: With a decline of nearly 48 percent, approximately 195 acres, regularly-flooded marshes are significantly reduced by 2100.

4. **Dramatic expansion of estuarine open water**: A 398 percent increase, approximately 77,000 acres, in estuarine open water represents a fundamental transformation of coastal areas, with significant implications for ecosystems and human use.

5. **Significant increase in atmospheric carbon emissions**: The GHG values become increasingly negative over time, indicating substantial carbon emissions as wetlands are lost.

Based on the percentage loss by 2100 under the NOAA Intermediate High (NIH) sea level rise scenarios with no protection measures, the most vulnerable habitats are: (1) Mangroves (-94.29 percent or –65,061.26 acres), (2) Regularly-Flooded Marsh (-48.79 percent or -197.39 acres), (3) Swamp (-5.70 percent or –10,810.15 acres), and (4) Dry Land (-0.94 percent or -10,953.10 acres). This vulnerability ranking highlights the disproportionate impact of sea level rise on coastal wetland ecosystems and sandy shorelines, which face extensive habitat conversion and loss under the higher sea level rise trajectory. The extreme vulnerability of mangroves and beach habitats underscores the urgent need for targeted conservation and adaptation strategies to preserve these critical coastal ecosystems.

11.2 Protect All Dry Land

11.2.1 Description

The Protect All Dry Land scenario assumes full protection of all developed and undeveloped dry land areas against sea level rise. This approach prioritizes land preservation through engineered infrastructure such as levees, seawalls, and drainage systems. While it prevents the loss of land, it does not include measures to protect wetlands, marshes, or intertidal zones, leading to significant ecological consequences.

Under this scenario:

- Urban, residential, commercial, and industrial areas are fully protected.
- Undeveloped upland areas are also safeguarded against inundation.
- Protection is assumed to be 100 percent effective, with no infrastructure failures.
- Wetlands, marshes, and coastal ecosystems remain unprotected and are subject to sea level rise.

This scenario represents an aggressive protection strategy that maintains human infrastructure but alters natural coastal processes.

11.2.2 Key Characteristics

The Protect All Dry Land scenario leads to several distinctive outcomes:

- Preservation of all dry land: Ensures no loss of developed or undeveloped dry land.
- Significant wetland losses: Coastal squeeze prevents wetland migration, leading to habitat loss.
- Altered hydrology: Infrastructure changes drainage and sediment flow patterns.
- Accelerated wetland conversion: Wetlands convert to open water more quickly due to restricted inland migration.
- Potential for increased erosion: Protection structures may exacerbate erosion at their edges.

11.2.3 NOAA Intermediate Low (NIL) - Protect All Dry Land

11.2.3.1 Habitat Changes by Year

Table 11-3. NOAA Intermediate Low Habitat Change by Year with Percentage change from Baseline – Protect All Dry Lands

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682,391.14	682,391.14	682,391.14	682,391.14	0.00	0.00
Undeveloped Dry Land	2,397,653.38	2.397,579.42	2,395,911.31	2,391,298.27	-6,355.2	-0.27
Swamp	189,752.42	189,552.46	187,083.8	178,941.75	-10,810.66	-5.70
Cypress Swamp	152,207.08	152,197.91	151,936.35	151,028.93	-1,178.14	-0.77
Mangrove	68,999.72	59,098.41	26,296.23	3,938.39	-65,061.33	-94.29
Inland-Fresh Marsh	164,954.2	164,948.5	164,876.19	164,725.01	-229.19	-0.14
Regularly-Flooded Marsh	404.56	290.79	65.95	207.17	-197.38	-48.79
Estuarine Open Water	19,749.08	35,460.98	74,283.83	98,406.6	78,657.52	398.28

11.2.3.2 Spatial Distribution of Changes

Table 11-3 reveals several important patterns:

1. **Protected Areas**: No change in developed and undeveloped dry land
2. **Wetland Areas**: Gradual transition of wetlands to open water
3. **Transition Zones**: Sharp boundaries between protected and unprotected areas

11.2.4 NOAA Intermediate High (NIH) - Protect All Dry Land

This scenario combines the higher sea level rise trajectory with comprehensive protection of all dry land, representing an aggressive protection approach under more severe sea level rise conditions.

11.2.4.1 Habitat Changes by Year

Table 11-4. NOAA Intermediate Habitat Change by Year with Percentage change from Baseline – Protect All Dry Lands

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682,391.14	682,391.17	682,396.17	682,391.17	0.00	0.00
Undeveloped Dry Land	2,397,653.38	2,397,647.5	2,397,504.0	2,397,132.95	-520.52	-0.02
Swamp	189,752.42	189,555.27	187,112.46	178,999.28	-10,753.13	-5.67
Cypress Swamp	152,207.08	152,198.40	151,955.69	151,051.24	-1,155.83	-0.76
Mangrove	68,999.72	59,030.83	24,749.39	2,727.96	-66,271.76	-96.05
Inland-Fresh Marsh	164,954.20	164,948.50	164,876.66	164,727.34	-226.86	-0.14
Regularly-Flooded Marsh	404.56 ¯	290.79	65.95	198.40	-206.16	-50.96
Estuarine Open Water	19,749.08	35,460.98	74,283.68	97,972.02	78,222.93	396.08

11.2.4.2 Spatial Distribution of Changes

Table 11-4 Error! Reference source not found. reveals several important patterns:

1. **Complete protection of developed dry land**: As expected, there is no loss of developed dry land under this scenario.
2. **Near-complete protection of undeveloped dry land**: Undeveloped dry land shows only a minimal loss of 0.01%, 26.31 acres, representing a significant improvement over the No Protection scenario.
3. **Similar wetland losses**: Despite the protection of dry land, wetland losses are similar to or slightly worse than the No Protection scenario, indicating that protection does not benefit wetlands.
4. **Slightly worse mangrove loss**: Mangroves show a slightly higher loss rate (56.77 percent) compared to the No Protection scenario (54.57 percent), suggesting that protecting dry land may actually increase pressure on mangroves.
5. **Similar water expansion**: The expansion of estuarine open water is nearly identical to the No Protection scenario, indicating that protection of dry land does not significantly affect this process.

The slightly worse outcomes for mangroves under the Protect All Dry Land scenario demonstrate the "coastal squeeze" effect. When sea levels rise, wetlands would naturally migrate inland. Protection of structures prevents this migration, resulting in greater wetland loss than would occur under natural conditions.

11.3 Protect Developed Dry Land

11.3.1 Description

The Protect Developed Dry Land scenario prioritizes human infrastructure by safeguarding only developed areas (urban, residential, commercial, and industrial). Unlike the Protect All Dry Land scenario, this strategy allows undeveloped areas to undergo natural processes, permitting some wetland migration.

Under this scenario:

- All developed areas are protected.
- Undeveloped uplands remain unprotected.
- Wetlands and other coastal habitats continue to evolve naturally.
- Infrastructure investments are more targeted, reducing overall protection costs.

This approach represents a compromise between full protection and unmanaged retreat.

11.3.2 Key Characteristics

The Protect Developed Dry Land scenario leads to several distinctive outcomes:

- Full protection of human infrastructure: Ensures no loss of developed areas.
- Allows natural adaptation of undeveloped areas: Supports some wetland migration.
- Less extreme coastal squeeze: Wetlands adjacent to undeveloped land have room to migrate.
- Moderate habitat loss: Coastal habitats still face sea level rise impacts.

The Protect Developed Dry Land scenario represents a compromise between full protection and no protection. It prioritizes protection of human infrastructure while allowing natural processes to occur in undeveloped areas. This approach may be more feasible from both economic and ecological perspectives.

11.3.3 NOAA Intermediate Low (NIL) - Protect Developed Dry Land

11.3.3.1 Habitat Changes by Year

Table 11-5. NOAA Intermediate Low Habitat Change by Year with Percentage change from Baseline – Protect Developed Dry Lands

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682,390.09	682,390.09	682,390.09	682,390.09	0.00	0.00
Undeveloped Dry Land	2,397,649.68	2,397,631.89	2,397,529.10	970,185.80	-110.14	-0.01
Swamp	76,790.08	76,783.52	76,740.95	76,685.34	-104.74	-0.14
Cypress Swamp	61,596.02	61,595.83	61,594.50	61,590.84	-5.18	-0.01
Mangrove	27923.20	27,990.46	27,903.54	27,967.86	44.66	0.16
Inland-Fresh Marsh	66,754.60	66,754.49	66,753.03	66,752.32	-2.28	0.00

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Regularly-Flooded Marsh	163.72	148.72	127.33	109.98	-53.74	-32.82
Estuarine Open Water	7,992.17	9,904.62	10,389.81	10,653.66	2,661.49	33.30

11.3.3.2 Spatial Distribution of Changes

The spatial distribution of changes under the NIL Protect Developed Dry Land scenario shows (**Table 11-5**):

1. **Protected Areas**: No change in developed dry land
2. **Unprotected Areas**: Gradual transition of wetlands to open water
3. **Transition Zones**: Sharp boundaries between protected and unprotected areas

11.3.4 NOAA Intermediate High (NIH) - Protect Developed Dry Land

This scenario combines the higher sea level rise trajectory with targeted protection of only developed dry land, representing a more balanced protection approach under more severe sea level rise conditions.

11.3.4.1 Habitat Changes by Year

Table 11-6 shows the projected habitat areas and changes over time under this scenario:

Table 11-6. NOAA Intermediate Habitat Change by Year with Percentage change from Baseline – Protect Developed Dry Lands

Habitat Type	2020 (acres)	2040 (acres)	2070 (acres)	2100 (acres)	Change 2020-2100 (acres)	Change 2020-2100 (%)
Developed Dry Land	682,391	682,391.14	682,391.14	682,391.14	0.00	0.00
Undeveloped Dry Land	2,397,653	2.397,579	2,395,9111	2,391,298.27	-6,355.2	-0.27
Swamp	189,752	189,552.46	187,083.8	178,941.75	-10,810.66	-5.70
Cypress Swamp	152,207	152,197.91	151,936.35	151,028.93	-1,178.14	-0.77
Mangrove	68,999	59,098.41	26,296.23	3,938.39	-65,061.33	-94.29
Inland-Fresh Marsh	164,954.2	164,948.5	164,876.19	164,725.01	-229.19	-0.14
Regularly-Flooded Marsh	404.56	290.79	65.95	207.17	-197.38	-48.79
Estuarine Open Water	19,749.08	35,460.98	74,283.83	98,406.6	78,657.52	398.28

11.3.4.2 Spatial Distribution of Change

Table 11-6 reveals several important patterns:

1. **Complete protection of developed dry land**: As expected, there is no loss of developed dry land under this scenario.

2. **Same undeveloped dry land loss as No Protection**: Undeveloped dry land shows the same loss as under No Protection, indicating that this strategy does not protect undeveloped areas.
3. **Same wetland losses as No Protection**: Wetland losses are identical to the No Protection scenario, suggesting that protecting only developed dry land does not affect wetland dynamics.
4. **Same water expansion as No Protection**: The expansion of estuarine open water is identical to the No Protection scenario.
5. **Slightly better carbon emissions than Protect All Dry Land**: Carbon emissions are slightly lower than under Protect All Dry Land, suggesting that allowing natural processes in undeveloped areas may have slight carbon benefits.

The data shows that protection strategies are highly effective for preserving developed dry land but have minimal or even slightly negative effects on wetland preservation. This suggests that protection strategies should be carefully targeted and combined with wetland conservation measures to achieve comprehensive resilience.

11.4 Protection Strategy Parameter Comparison

The results of the SLAMM analysis indicate that the 3 different protection strategies are highly effective for preserving developed dry land but have minimal or even slightly negative effects on wetland preservation. This suggests that protection strategies should be carefully targeted and combined with wetland conservation measures to achieve comprehensive resilience.

The spatial distribution of changes suggests that adaptation and conservation efforts should prioritize the Indian River Lagoon and North Fork St. Lucie River areas, where the most significant changes are projected to occur. These areas may require more immediate and intensive management interventions such as:

- Replacing seawalls and ripraps where possible with natural shorelines to allow mangroves and salt marshes to migrate inland as sea levels rise.
- Increase land acquisition and restoration efforts for undeveloped parcels along the Indian River Lagoon and North Fork St. Lucie to maintain and expand existing mangrove and salt marsh habitats.
- Consider large-scale restoration projects such as the creation of barrier islands and tidal flats to increase area of mangroves and salt marshes in the Indian River Lagoon, while also facilitating habitat migration.

12.0 PLANNING HORIZONS

12.1 Initial Conditions (2020)

12.1.1 Description

The initial conditions represent the baseline land cover at the start of the simulation. For St. Lucie County, the baseline year is 2020, which corresponds to the most recent comprehensive land cover data available (**Figure 12-1** and **Figure 12-2**).

The initial conditions serve several important purposes:

- Provide a starting point for all model simulations
- Establish a baseline for measuring changes
- Document the current distribution of habitats
- Serve as a reference for validation

Understanding the initial distribution of habitats is essential for interpreting the projected changes and identifying the most vulnerable areas.

12.1.2 Spatial Distribution

The spatial distribution of habitats in the initial conditions shows several important patterns:

1. Coastal Zone:
    - Narrow band of beaches along the Atlantic coast
    - Mangroves concentrated in protected coastal areas
    - Regularly-flooded marsh in limited areas adjacent to mangroves
2. Estuarine Zone:
    - Estuarine open water in the Indian River Lagoon
    - Mangroves along the estuarine shoreline
    - Transitional areas between estuarine and freshwater systems
3. Inland Zone:
    - Swamps and cypress swamps in low-lying inland areas
    - Inland-fresh marsh in scattered wetland complexes
    - Developed and undeveloped dry land in higher elevation areas

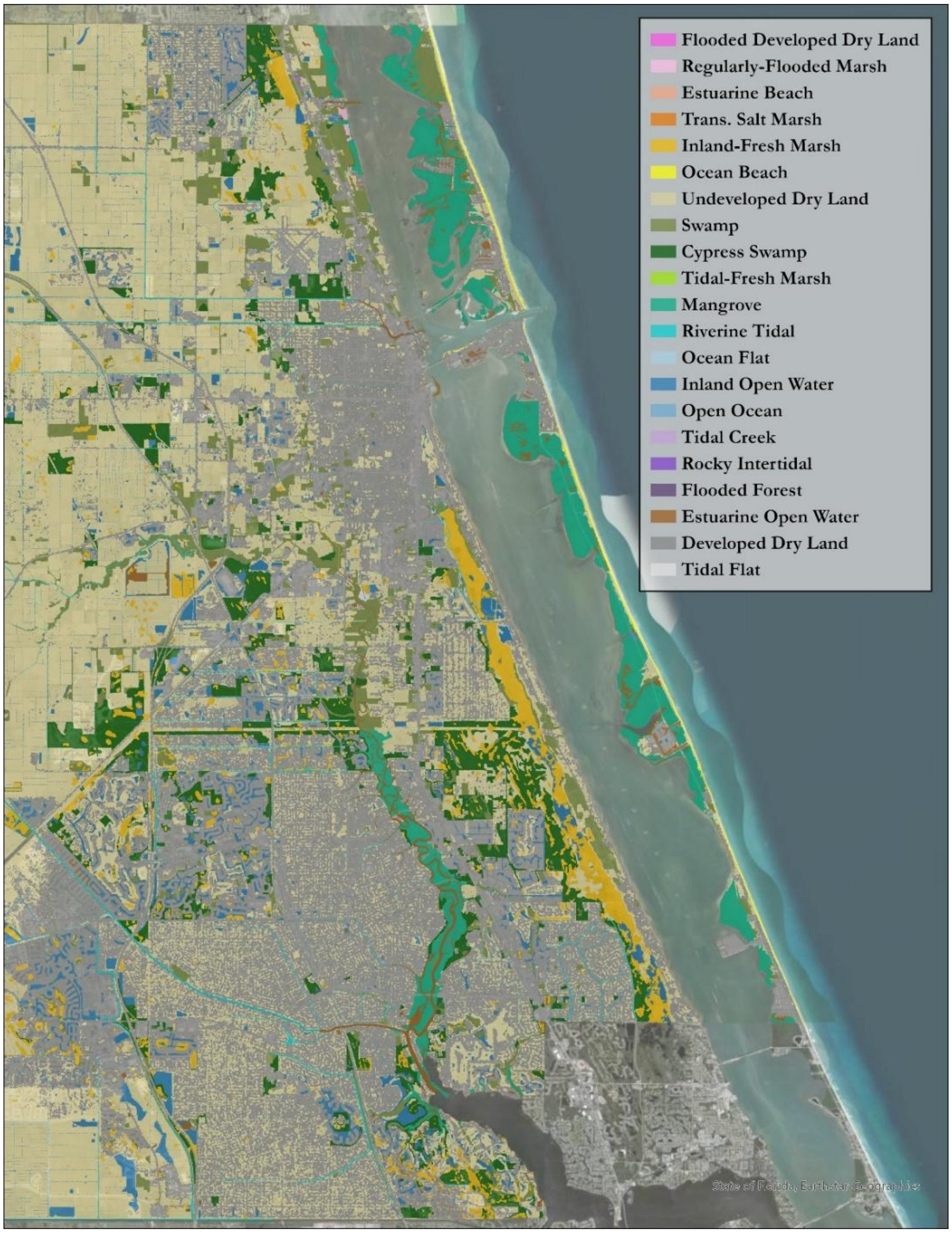


Figure 12-1. Map of SLAMM's initial input condition adjusted to fit SLR curve for baseline NOAA Intermediate Low

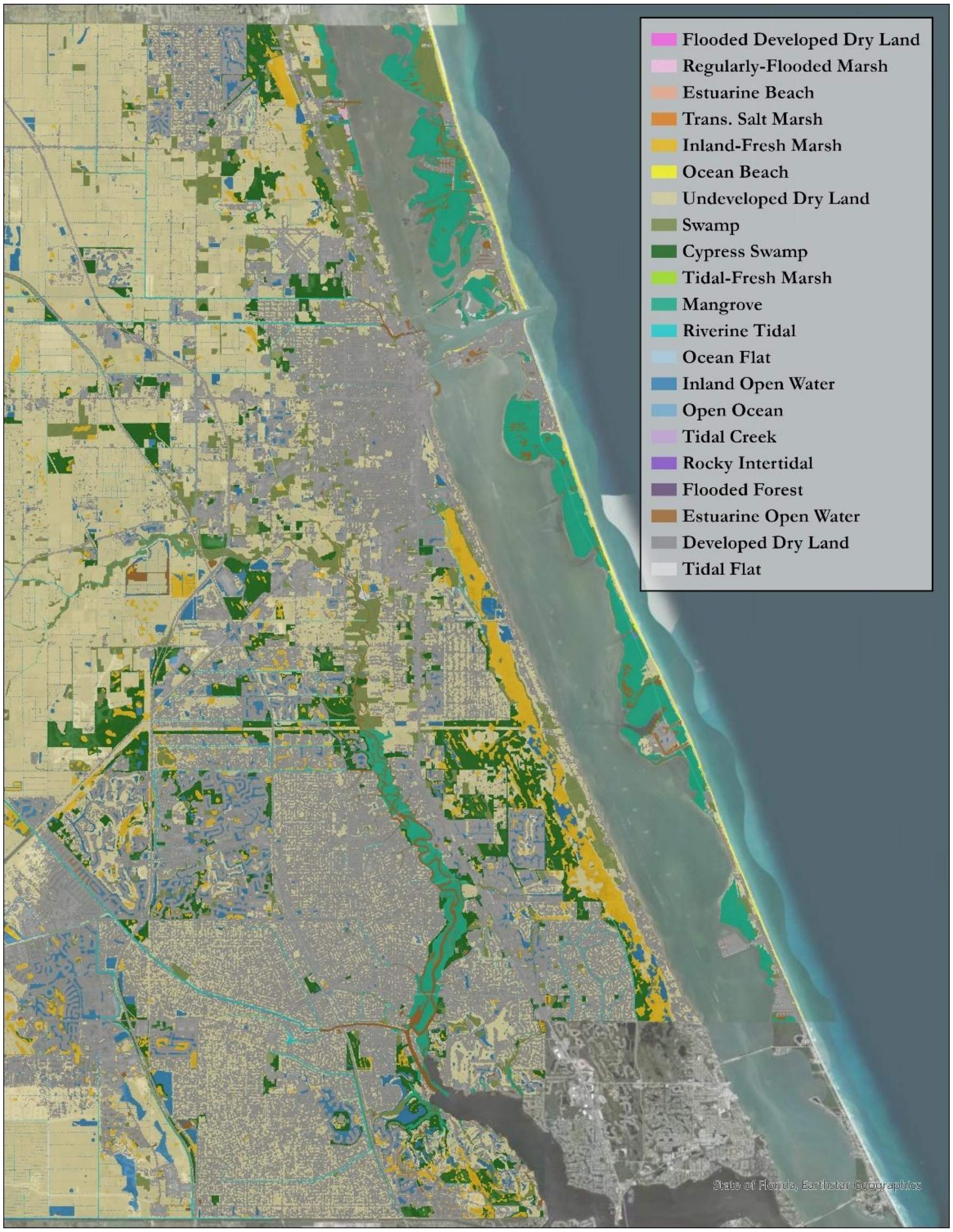


Figure 12-2. Map of SLAMM's initial input condition adjusted to fit SLR curve for baseline NOAA Intermediate High

12.1.3 Habitat Distribution

Table 12-1 shows the distribution of key habitat types in the 2020 conditions:

Table 12-1. Distribution of initial condition habitat types

Habitat Type	Area (acres)	Percentage of Total
Developed Dry Land	682,391.17	10.3%
Undeveloped Dry Land	2,397,653.48	36.2%
Swamp	189,752.42	2.9%
Cypress Swamp	152207.08	2.3%
Mangrove	68,999.72	1.0%
Inland-Fresh Marsh	164954.20	2.5%
Regularly-Flooded Marsh	404.56	0.01%
Estuarine Open Water	19,749.08	0.3%
Open Ocean	158,092.80	5.9%
Other	1,038,421.56	38.7%
Total	2,684,184.00	100.0%

This distribution shows that St. Lucie County is dominated by dry land (46.5 percent or 3,080,045.18 acres combined developed and undeveloped), with significant areas of swamp, cypress swamp, and inland-fresh marsh. Mangroves and regularly-flooded marsh occupy relatively small areas but provide important ecosystem services.

12.2 Near-term (2040)

The near-term planning horizon (2040) represents conditions approximately 20 years from the baseline.

12.2.1 Description

This timeframe is relevant for immediate planning and adaptation strategies, including:

- Current comprehensive planning cycles
- Infrastructure planning and investment
- Near-term conservation priorities
- Adaptation planning for existing development

This planning horizon is most relevant for current decision-makers and represents changes that may occur within their tenure or professional careers.

12.2.2 SLR Values

The sea level rise values for 2040 vary by scenario:

- NOAA Intermediate Low (NIL): 3.9 inches
    - This represents a rate of 0.20 inches/year from 2020
    - Approximately 2.2 times the historic rate of 0.09 inches/year

- NOAA Intermediate High (NIH): 9.1 inches
  - This represents a rate of 0.45 inches/year from 2020
  - Approximately 5.0 times the historic rate of 0.09 inches/year

These values represent a significant acceleration from historic rates but are within the range of current observations in some locations.

The 2040 timeframe aligns with typical comprehensive planning cycles (15-20 years) and infrastructure planning horizons. Decisions made today about infrastructure investments, land use planning, and conservation priorities will be directly affected by the sea level rise projected for this period.

12.2.3 Projected Changes

By 2040, the model projects relatively minor changes in habitat distribution under both sea level rise scenarios (**Table 12-2**, **Figure 12-3**, and **Figure 12-4**):

Table 12-2. Relative differences between projected NIL and NIH conditions in 2040 - No Protection

Habitat Type	NIL No Protection Change (%)	NIH No Protection Change (%)	Difference
Developed Dry Land	-0.01%	-0.02%	0.01%
Undeveloped Dry Land	-0.01%	-0.01%	0.00%
Swamp	-0.05%	-0.03%	-0.02%
Cypress Swamp	0.00%	0.00%	0.00%
Mangrove	+0.24%	-14.35%	14.59%
Inland-Fresh Marsh	0.00%	0.00%	0.00%
Regularly- Flooded Marsh	-9.16%	-28.12%	18.96%
Estuarine Open Water	+23.93%	+79.55%	56.62%

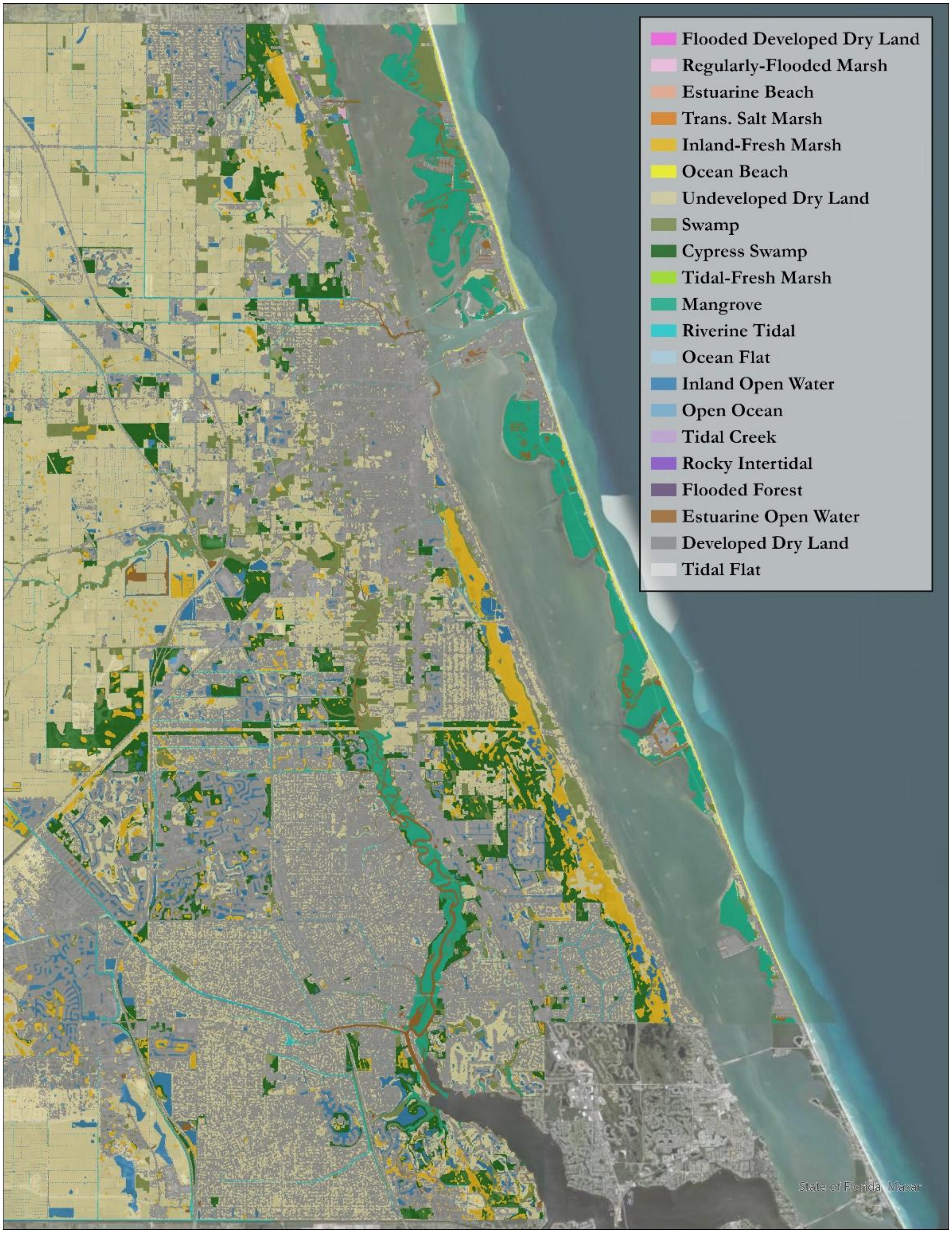


Figure 12-3. St Lucie County 2040 SLAMM habitat change results – NOAA Intermediate Low

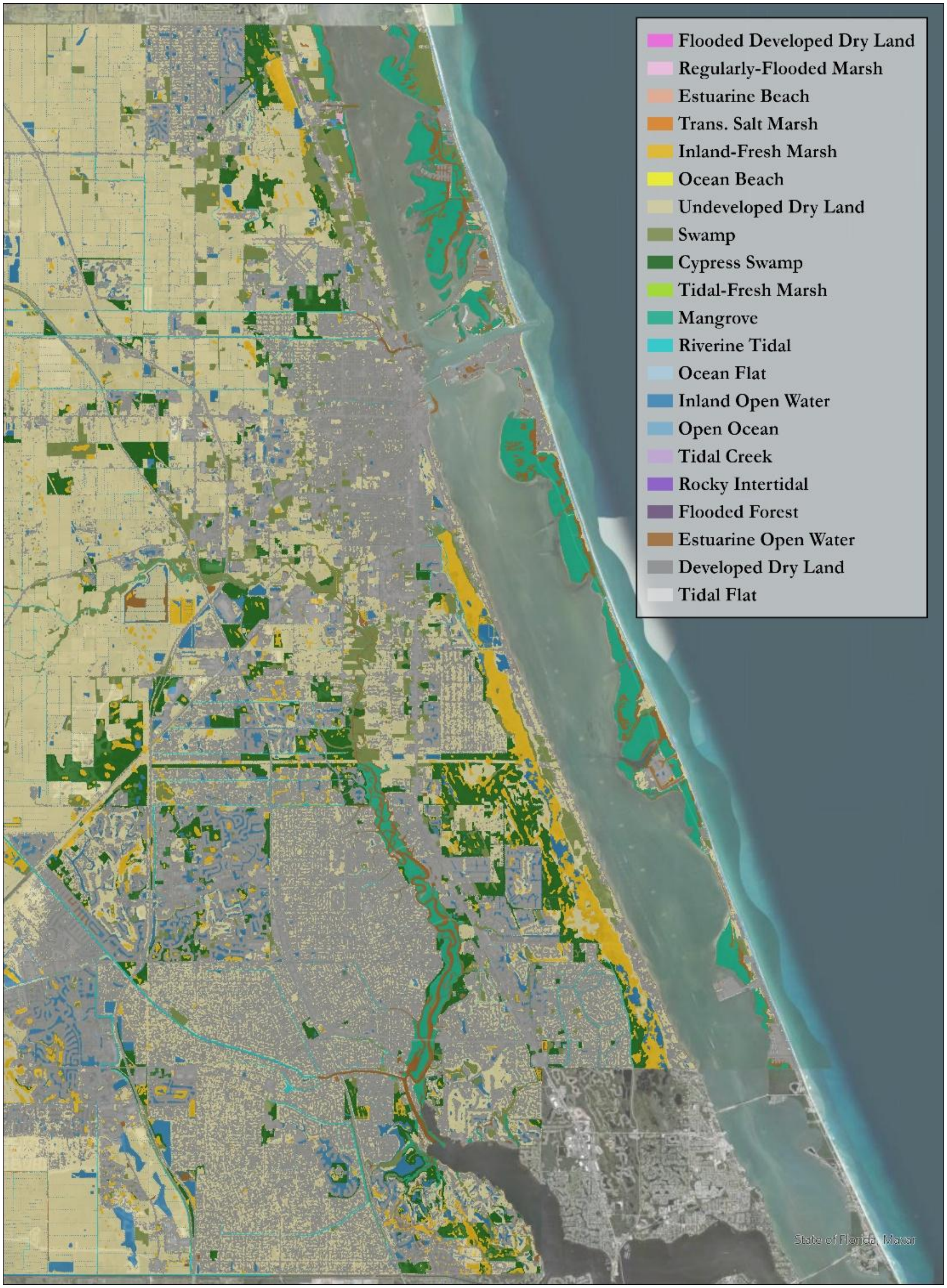


Figure 12-4. St. Lucie County 2040 SLAMM habitat change results - NOAA Intermediate High

These changes show that by 2040:

- Dry land shows minimal impacts under both scenarios
- Mangroves show slight increase under NIL (24%) but moderate loss (14.4%) under NIH
- Regularly- flooded marsh shows moderate loss under NIL (9.16%) and significant loss (28.1%) under NIH
- Estuarine open water shows significant increase under both scenarios, with a much larger increase under NIH.

The relatively minor changes by 2040 suggest that there is time to implement monitoring, planning, and conservation measures before more significant impacts occur. However, the differences between scenarios highlight the importance of monitoring actual sea level rise trends to determine which trajectory is unfolding.

12.2.4 Key Characteristics

The near-term (2040) planning horizon under both scenarios (NIL and NIH) shows several distinctive patterns:

- Minor to moderate habitat changes
  - Initial signs of habitat transitions
  - Beginning of wetland losses
  - Early expansion of estuarine open water
- Beginning of wetland transitions
  - Slight mangrove increase under NIL scenario
  - 14.4% mangrove loss under NIH Scenario
  - 28.1% regularly-flooded marsh loss under NIH Scenario
- Limited dry land impacts
  - Minimal loss of developed and undeveloped dry land
  - Impacts primarily limited to lowest-lying areas
  - Protection strategies highly effective
- Initial carbon emission increases
  - Beginning of release of carbon into atmosphere from wetland loss
  - Similar level of emissions across scenarios and protection strategies

12.2.5 Protection Strategy Effectiveness

By 2040, protection strategies show minimal differences in outcomes compared to the No Protection scenario, as shown in **Table 12-3**.

Table 12-3. Relative differences between projected NIL and NIH conditions in 2040 - Protection Strategy Comparisons

Habitat Type	NIL Protect All Dry Land	NIL Protect Developed Dry Land	NIH Protect All Dry Land	NIH Protect Developed Dry Land
Developed Dry Land	0.00%	0.00%	0.00%	0.00%
Undeveloped Dry Land	0.00%	-0.01%	0.00%	-0.01%
Mangrove	+0.22%	+0.24%	-14.45%	-14.35%
Regularly-Flooded Marsh	-9.16%	-9.16%	-28.12%	-28.12%
Estuarine Open Water	+23.93%	+23.93%	+79.55%	+79.55%

These results show that by 2040:

- Protection strategies effectively preserve dry land, though impacts are minimal even under No Protection
- Protection strategies have negligible effect on wetland habitats
- The differences between protection strategies are minimal at this timeframe

The minimal differences between protection strategies by 2040 suggest that near-term management decisions should focus on monitoring, planning, and conservation rather than major protection infrastructure. This provides time to develop and implement more targeted adaptation strategies based on observed trends.

12.3 Mid-term (2070)

12.3.1 Description

The mid-term planning horizon represents conditions approximately 50 years from the baseline. This timeframe is relevant for infrastructure planning and long-term adaptation strategies, including:

- Long-term infrastructure planning
- Building and facility lifespans
- Mortgage and financing timeframes
- Generational planning

This planning horizon is relevant for long-term investments and represents changes that may occur within the lifetime of current young adults (**Figure 12-5** and **Figure 12-6**).

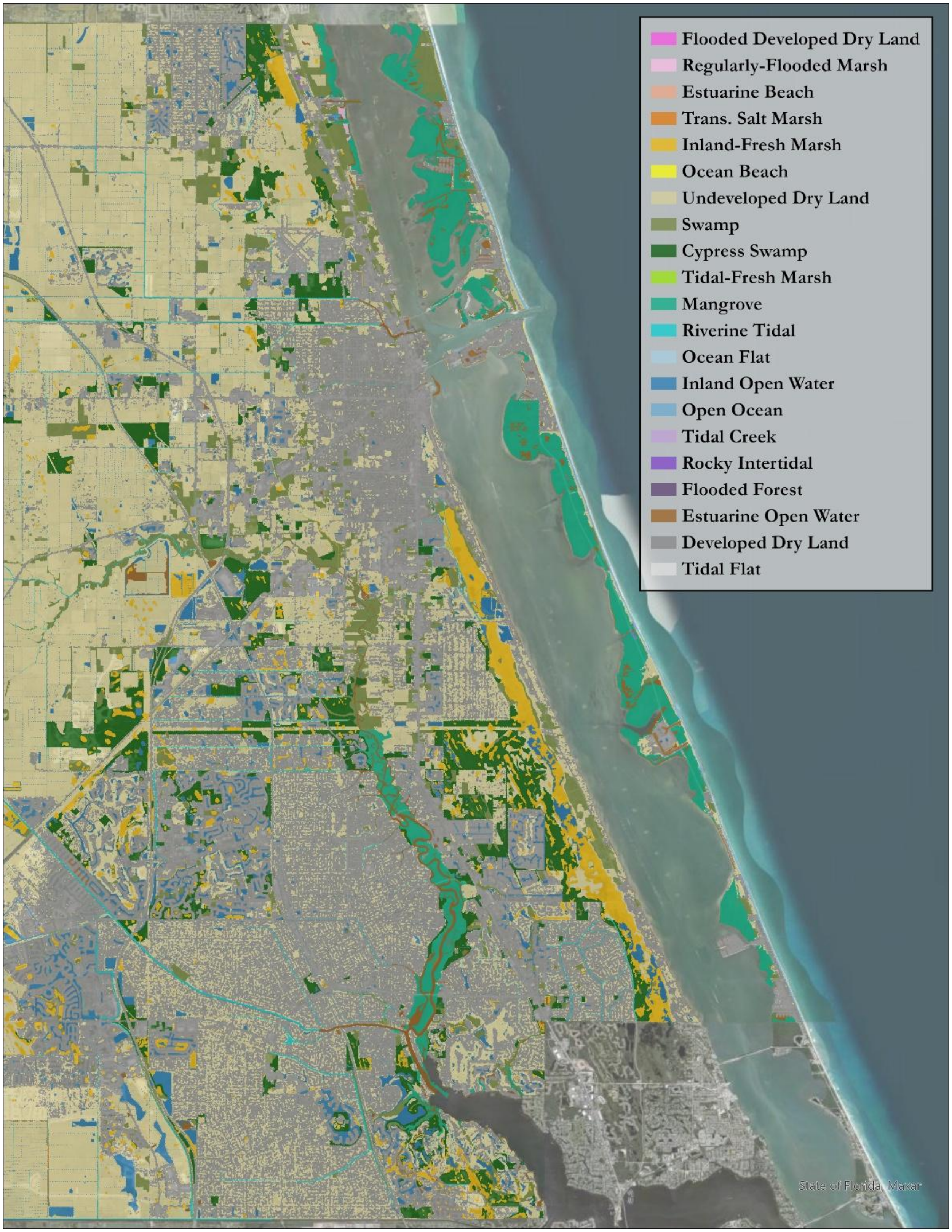


Figure 12-5. St. Lucie County 2070 SLAMM habitat change results – NOAA Intermediate Low

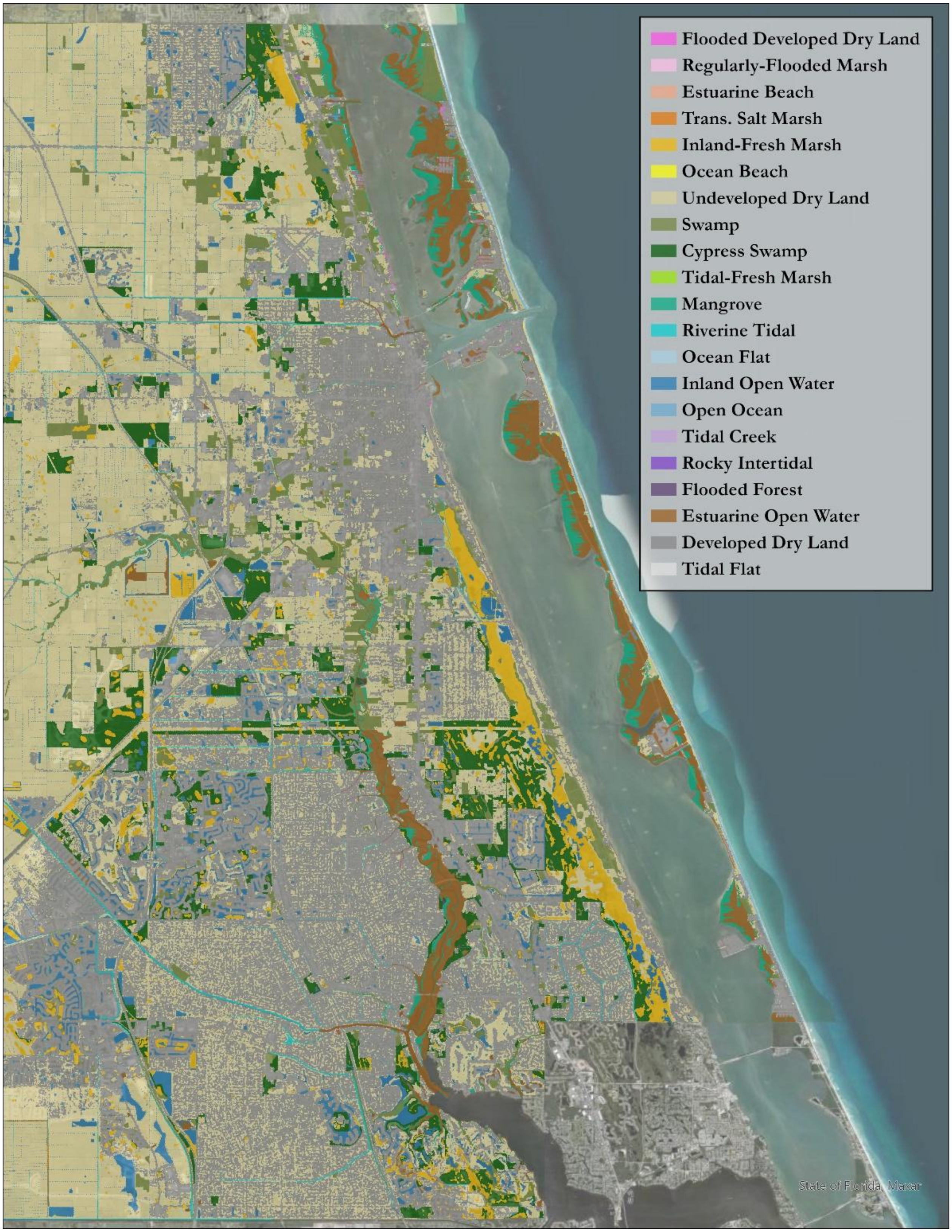


Figure 12-6. St. Lucie County 2070 SLAMM habitat change results – NOAA Intermediate High

12.3.2 SLR Values

The sea level rise values for 2070 vary significantly by scenario:

- NOAA Intermediate Low (NIL): 10.6 inches
  - This represents a rate of 0.09 inches/year from 2040
  - Approximately 2.5 times the historic rate of 0.09 inches/year
- NOAA Intermediate High (NIH): 31.5 inches
  - This represents a rate of 0.75 inches/year from 2040
  - Approximately 8.2 times the historic rate of 2.32 mm/year

These values represent a substantial difference between scenarios, with the NIH Scenario showing nearly twice the sea level rise of the NIL scenario.

Many infrastructure investments made today (roads, bridges, water/sewer systems, buildings) have design lifespans of 50+ years, meaning they will still be in service in 2070. The sea level rise projected for this period should be considered in current infrastructure design and investment decisions.

12.3.3 Projected Changes

By 2070, the model projects more significant changes in habitat distribution, with substantial differences between sea level rise scenarios (**Table 12-4**).

Table 12-4. Relative differences between projected NIL and NIH conditions in 2070 - No Protection

Habitat Type	NIL No Protection Change (%)	NIH No Protection Change (%)	Difference
Developed Dry Land	-0.02%	-0.13%	0.11%
Undeveloped Dry Land	-0.01%	-0.07%	0.06%
Swamp	-0.06%	-1.40%	1.34%
Cypress Swamp	0.00%	-0.18%	0.18%
Mangrove	-0.07%	-61.89%	61.82%
Inland-Fresh Marsh	0.00%	-0.05%	0.05%
Regularly-Flooded Marsh	-22.23%	-83.70%	61.47%
Estuarine Open Water	+30.00%	+276.14%	246.14%

These changes show that by 2070:

- Mangroves show minimal loss under NIL (0.07%) but severe loss (61.89%) under NIH
- Regularly-flooded marsh shows moderate loss under NIL (22.23%) and severe loss (83.7%) under NIH
- Estuarine open water shows moderate increase under NIL (30%) and dramatic increase (276.1%) under NIH.

The dramatic differences between scenarios by 2070 highlight the importance of the sea level rise trajectory in determining mid-term outcomes. Under the NIH Scenario, significant adaptation measures would be needed by this time, while under the NIL scenario, impacts remain relatively moderate and are almost identical to NIH 2040 projections.

12.3.4 Key Characteristics

The mid-term (2070) planning horizon shows several distinctive patterns:

- Moderate to significant habitat changes
  - Accelerating habitat transitions
  - Moderate wetland losses under NIL scenario
  - Significant wetland losses under NIH Scenario
- Accelerating wetland transitions
  - 22.23% regularly-flooded marsh loss under NIL scenario
  - 0.07% mangrove loss under NIL scenario
  - 61.82% mangrove loss under NIH Scenario
  - 83.70% regularly-flooded marsh loss under NIH Scenario
- Beginning of dry land impacts
  - Minor loss of developed and undeveloped dry land
  - Impacts expanding beyond lowest-lying areas
  - Protection strategies still highly effective
- Significant carbon emission increases
  - Substantial carbon emissions from wetland loss

By 2070, the two sea level rise scenarios show dramatically different outcomes, particularly for vulnerable habitats like mangroves and regularly-flooded marshes. The NIH Scenario shows losses by 2070 that are similar to or greater than what the NIL scenario shows by 2100, highlighting the importance of both the magnitude and timing of sea level rise.

12.3.5 Protection Strategy Effectiveness

By 2070, protection strategies show more noticeable differences in outcomes compared to the No Protection scenario (**Table 12-5**):

Table 12-5. Relative differences between projected NIL and NIH conditions in 2070 - Protection Strategy Comparison

Habitat Type	NIL Protect All Dry Land	NIL Protect Developed Dry Land	NIH Protect All Dry Land	NIH Protect Developed Dry Land
Developed Dry Land	0.00%	0.00%	0.00%	0.00%
Undeveloped Dry Land	0.00%	-0.01%	-0.01%	-0.07%
Mangrove	-0.14%	-0.07%	-64.12%	-61.89%
Regularly-Flooded Marsh	-22.23%	-22.22%	-83.70%	-83.70%
Estuarine Open Water	+30.00%	+30.00%	+276.14%	+276.14%

These results show that by 2070:

- Protection strategies effectively preserve dry land, though impacts remain relatively minor even under No Protection
- Protection strategies have minimal effect on wetland habitats, with Protect All Dry Land showing slightly worse outcomes for mangroves due to coastal squeeze
- The differences between protection strategies remain relatively minor at this timeframe

By 2070, the sea level rise scenario becomes the dominant factor determining outcomes, with protection strategies having relatively minor effects.

12.4 Long-term (2100)

12.4.1 Description

The long-term planning horizon (2100) represents conditions approximately 80 years from the baseline. This timeframe is relevant for long-range planning and understanding the full potential impacts of sea level rise, including:

- Long-term community visioning
- Major infrastructure investments
- Intergenerational equity considerations
- Understanding potential end-of-century conditions

This planning horizon is relevant for understanding the legacy of current decisions and represents changes that may occur within the lifetime of children born today.

12.4.2 SLR Values

The sea level rise values for 2100 vary dramatically by scenario (**Figure 12-7** and **Figure 12-8**):

- NOAA Intermediate Low (NIL): 17.3 inches
  - This represents a rate of 0.22 inches/year from 2070
  - Approximately 2.5 times the historic rate of 0.09 inches/year
- NOAA Intermediate High (NIH): 64.2 inches
  - This represents a rate of 1.09 inches/year from 2070
  - Approximately 11.9 times the historic rate of 0.09 inches/year

These values represent a substantial difference between scenarios, with the NIH Scenario showing 73% more sea level rise than the NIL scenario.

The 2100 timeframe represents conditions that will be experienced by future generations. Decisions made today about protection strategies and land use will determine the coastal conditions inherited by these future generations, raising important questions about intergenerational equity and responsibility.

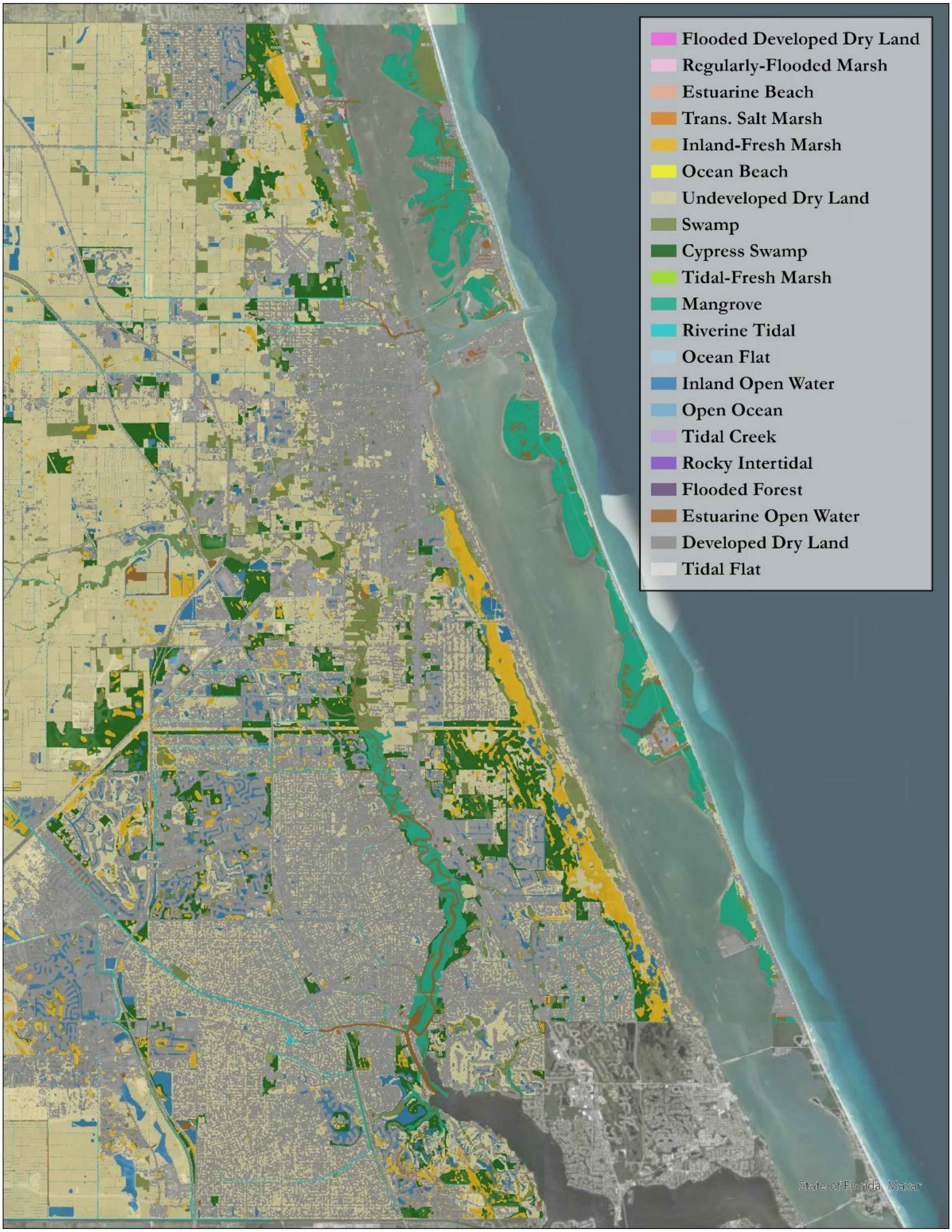


Figure 12-7. St. Lucie County 2100 SLAMM habitat change results - NOAA Intermediate Low

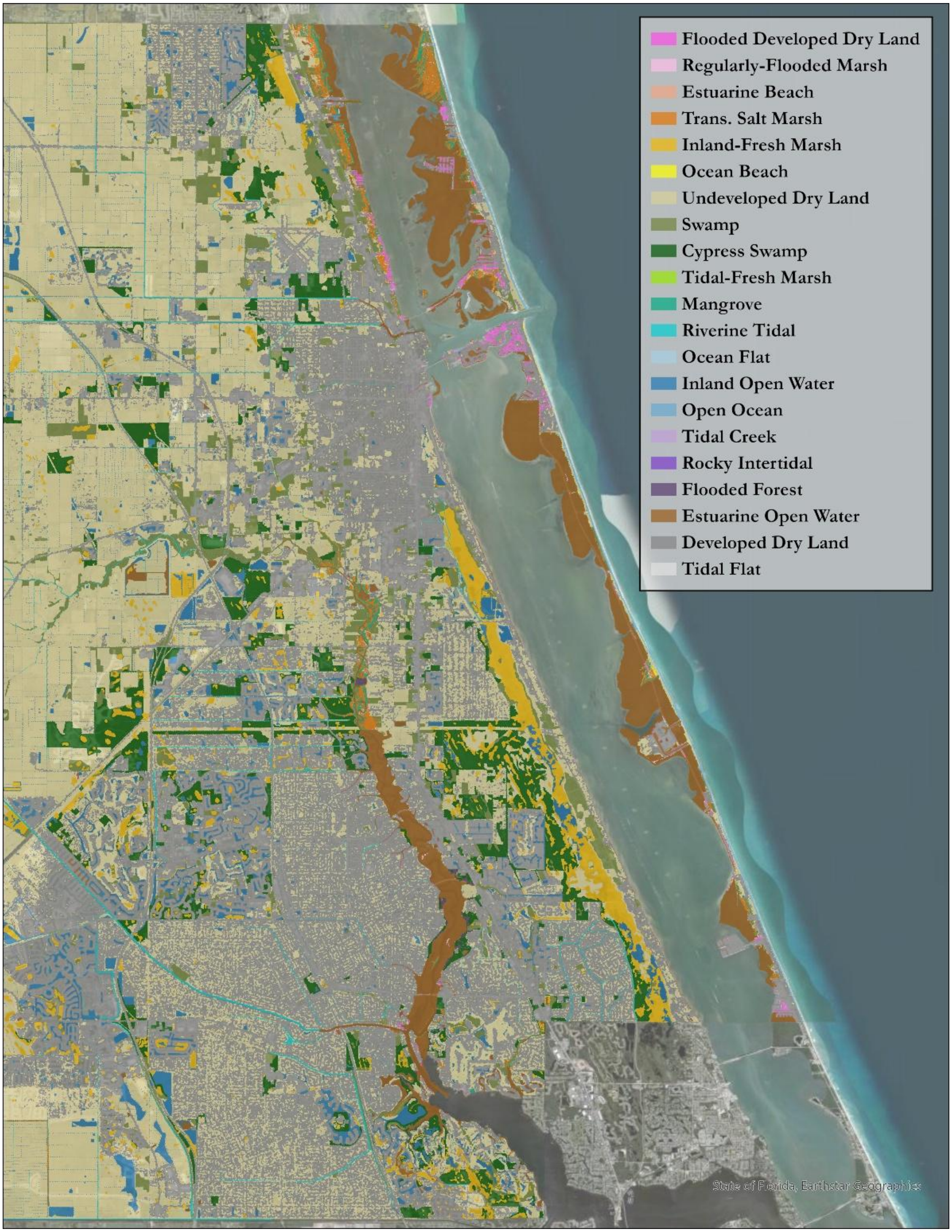


Figure 12-8. St. Lucie County 2100 SLAMM habitat changes results -NOAA Intermediate High

12.4.3 Projected Changes

By 2100, the model projects major changes in habitat distribution, with dramatic differences between sea level rise scenarios (**Table 12-6**).

Table 12-6. Relative differences between projected NIL and NIH conditions in 2100 – No Protection

Habitat Type	NIL No Protection Change (%)	NIH No Protection Change (%)	Difference
Developed Dry Land	-0.04%	-0.67%	0.63%
Undeveloped Dry Land	-0.02%	-0.27%	0.25%
Swamp	-0.27%	-5.70%	5.43%
Cypress Swamp	-0.01%	-0.77%	0.76%
Mangrove	0.20%	-94.29%	94.49%
Inland-Fresh Marsh	0.00%	-0.14%	0.14%
Regularly-Flooded Marsh	-32.80%	-48.79%	15.99%
Estuarine Open Water	+33.30%	+398.28%	364.98%

These changes show that by 2100:

- Dry land shows minimal impacts under NIL (0.02% to 0.04%) and more significant losses under NIH (0.27% to 0.67%).
- Mangroves show slight increase under NIL (0.20%) but catastrophic loss (94.3%) under NIH.
- Regularly-flooded marsh shows significant loss under both scenarios (NIL: 32.8% / NIH: 48.8%).
- Estuarine open water shows moderate increase under NIL (33.3%) and dramatic increase (398.3%) under NIH.

The extreme differences between scenarios by 2100 highlight the critical importance of the sea level rise trajectory in determining long-term outcomes. The NIH Scenario would require transformative adaptation approaches, while the NIL scenario would still require significant adaptation but may be manageable with more conventional approaches.

12.4.4 Key Characteristics

The long-term (2100) planning horizon shows several distinctive patterns:

- Major habitat changes
  - Extensive habitat transitions
  - Moderate wetland losses under NIL scenario
  - Severe wetland losses under NIH Scenario
- Significant wetland losses
  - 32.8% regularly-flooded marsh loss under NIL scenario
  - Slight mangrove gain under NIL
  - 94.3% mangrove loss under NIH Scenario
  - 48.8% regularly-flooded marsh loss under NIH scenario

- Moderate dry land impacts (depending on protection)
  - Noticeable loss of developed and undeveloped dry land under No Protection
  - Minimal impacts under protection scenarios
  - Protection strategies remain effective but with increasing challenges
- Maximum net carbon emission increases
  - Maximum atmospheric carbon released due to wetland loss
  - Greater under NIH Scenario

The progression from near-term (2040) to long-term (2100) shows an acceleration of impacts, with relatively minor changes by 2040, moderate to significant changes by 2070, and major changes by 2100. This progression highlights the importance of both immediate adaptation actions and long-term planning to address the full range of potential impacts.

12.4.5 Protection Strategy Effectiveness

By 2100, protection strategies show more noticeable differences in outcomes compared to the No Protection scenario (**Table 12-7**).

Table 12-7. Relative differences between projected NIL and NIH conditions 2100 - Protection Strategy Comparison

Habitat Type	NIL No Protection	NIL Protect All Dry Land	NIL Protect Developed Dry Land	NIH No Protection	NIH Protect All Dry Land	NIH Protect Developed Dry Land
Developed Dry Land	-0.04%	0.00%	0.00%	-0.67%	0.00%	0.00%
Undeveloped Dry Land	-0.02%	0.00%	-0.02%	-0.27%	-0.01%	-0.27%
Mangrove	+0.20%	-0.20%	+0.20%	-94.29%	-96.05%	-94.29%
Regularly-Flooded Marsh	-32.80%	-32.80%	-32.80%	-48.79%	-50.96%	-48.79%
Estuarine Open Water	+33.30%	+33.30%	+33.30%	+398.28%	+396.08%	+398.28%

These results show that by 2100:

- Protection strategies effectively preserve dry land, though impacts remain relatively minor even under No Protection
- Protection strategies have minimal effect on wetland habitats, with Protect All Dry Land showing worse outcomes for mangroves due to coastal squeeze
- The differences between protection strategies remain relatively minor compared to the differences between sea level rise scenarios

By 2100, the sea level rise scenario is clearly the dominant factor determining outcomes, with protection strategies having relatively minor effects. Local adaptation strategies should focus on accommodating habitat migration and managing the transition to new ecosystem configurations.

13.0 CROSS-SCENARIO COMPARISONS

13.1 Impact of Sea Level Rise Scenario

13.1.1 Habitat Loss Comparison

Table 13-1 compares habitat losses between the NIL and NIH scenarios under No Protection scenario.

Table 13-1. Generalized rate of habitat loss without protection within modeling

Habitat Type	NIH No Protection (%)	NIL No Protection (%)	Difference (%)
Developed Dry Land	-0.67%	-0.04%	0.63%
Undeveloped Dry Land	-0.27%	-0.02%	0.25%
Swamp	-5.70%	-0.27%	5.43%
Cypress Swamp	-0.77%	-0.01%	0.76%
Mangrove	-94.29%	+0.20%	94.49%
Regularly-Flooded Marsh	-48.79%	-32.80%	15.99%
Estuarine Open Water	398.28%	33.30%	364.98%

The NIH Scenario causes significantly more habitat conversion than the NIL scenario, with the most dramatic differences in mangroves (94.49% more loss) and estuarine open water (364.98% more increase). On average, the NIH Scenario causes approximately 5-6 times more habitat conversion than the NIL scenario. The dramatic differences between scenarios highlight the importance of sea level rise trajectory in determining habitat outcomes. The 1.19m difference in sea level rise by 2100 (1.63m vs. 0.44m) results in approximately 10-12 times more habitat conversion. This suggests that global emissions reductions that result in lower sea level rise could significantly reduce habitat impacts.

13.1.2 Timing of Impacts

Table 13-2 shows the timing of mangrove loss under both scenarios.

Table 13-2. Rate and time line of significant mangrove losses

Year	NIL Scenario Mangrove Loss (%)	NIH Scenario Mangrove Loss (%)
2040	+0.24%	-14.35%
2070	-0.07%	-61.89%
2100	+0.20%	-94.29%

Under the NIL scenario, major impacts are delayed until 2100, while under the NIH Scenario, significant impacts occur by 2070. This difference in timing has important implications for adaptation planning, as it affects the urgency of adaptation measures. The timing differences between scenarios have important implications for adaptation planning. Under the NIL scenario, there would be more time to implement adaptation measures than under the NIH Scenario, where significant adaptation measures would be needed by 2070. This highlights the importance of monitoring sea level rise trends and adjusting adaptation timelines accordingly.

13.2 Impact of Protection Strategy

13.2.1 Developed Dry Land Preservation

Table 13-3 compares the preservation of developed dry land across the three protection strategies.

Table 13-3. Preservation rates of developed dry lands across protection strategies

Protection Strategy	NIL Scenario (acres)	NIH Scenario (acres)	Preservation (%)
No Protection	682,237.74	677,793.43	99.33% / 99.96%
Protect All Dry Land	682,391.17	682,391.17	100.00% / 100.00%
Protect Developed Dry Land	682,391.17	682,391.17	100.00% / 100.00%

All protection strategies effectively preserve developed dry land, with 100% preservation under both protection strategies and minimal loss (less than 0.7%) under No Protection. This suggests that protection strategies may not be necessary for preserving developed dry land in St. Lucie County, as most developed areas are already above projected inundation levels.

The high preservation rates for developed dry land even under the No Protection scenario (99.96% under NIL scenario; 99.33% under NIH Scenario) suggest that most developed areas in St. Lucie County are already above projected inundation levels. This raises questions about the necessity and cost-effectiveness of extensive protection measures, especially given their minimal or slightly negative effects on wetland preservation.

13.2.2 Undeveloped Dry Land Preservation

Table 13-4 compares the preservation of undeveloped dry land across all three protection strategies.

Table 13-4. Preservation rates of undeveloped dry lands across protection strategies

Protection Strategy	NIL Scenario (acres)	NIH Scenario (acres)	Preservation (%)
No Protection	2,397,381.32	2,391,298.1	99.73% / 99.98%
Protect All Dry Land	2,397,627.93	2,397,132.95	99.98% / 100.00%
Protect Developed Dry Land	2,397,381.32	2,391,299.78	99.73% / 99.98%

Protection strategies have minimal effect on undeveloped dry land preservation, with all strategies preserving at least 99.73% (2,397,381.32 acres) of the initial area. This suggests that protection strategies may not be necessary for preserving undeveloped dry land in St. Lucie County, as most undeveloped areas are already above projected inundation levels.

The high preservation rates for both developed and undeveloped dry land across all protection strategies suggest that St. Lucie County has relatively high topography compared to other coastal areas. This topographic context is important for interpreting the results and considering their applicability to other regions, which may have different topographic profiles and therefore different vulnerability patterns.

13.2.3 Wetland Preservation

Table 13-5 compares the preservation of mangroves across all three protection strategies.

Table 13-5. Preservation rates of mangrove habitats across protection strategies

Protection Strategy	NIL Scenario Mangrove (acres)	NIH Scenario Mangrove (acres)	Preservation (%)
No Protection	69,110.08	3,938.26	5.41% / 100.20%
Protect All Dry Land	68,875.8	2,727.96	3.95% / 99.82%
Protect Developed Dry Land	69,110.08	3,938.39	5.71% / 100.20%

Protection strategies have minimal effect on wetland preservation, with similar loss rates across all strategies. In fact, the Protect All Dry Land strategy shows slightly worse outcomes for mangroves than the No Protection strategy, suggesting that comprehensive protection may have unintended negative consequences for wetlands.

The slightly worse outcomes for mangroves under the Protect All Dry Land strategy compared to the No Protection strategy provide evidence for the "coastal squeeze" effect. When sea levels rise and protection structures prevent wetlands from migrating inland, they can become trapped between rising water and fixed barriers, resulting in greater wetland loss than would occur under natural conditions.

14.0 SLAMM STUDY CONCLUSION AND RECOMMENDATIONS

Like many communities in Florida, St. Lucie County faces significant challenges from a rapidly growing population, loss of green space, and increasing flood risks. Recent record rainfall events from Hurricanes Ian (2022) and Milton (2024) have highlighted vulnerabilities to flooding throughout much of St. Lucie County. This has prompted calls for more integrated stormwater management, wetlands protection, and low-impact development practices, all of which provide opportunities to build greater resilience.

The modeling results and analyses developed in this report are intended to help St. Lucie County better understand some of the challenges it faces, while at the same time helping the community and decision-makers identify key opportunities for moving forward toward a more resilient future.

14.1 Sea Level Rise and Land Cover Change

Results from the Sea Level Affecting Marshes Model (SLAMM) under moderate to high sea-level rise projection scenarios show the potential for extensive wetland change within the coastal areas of St. Lucie County and conversion of freshwater ecosystems within the St. Lucie River into estuarine conditions through the year 2070. However, projected trend-based land cover change patterns associated with expected population growth, as previously modeled by University of Florida researchers (Carr and Zwick 2016), show much more extensive impacts than even the highest modeled rate of sea level rise on freshwater wetlands and other natural ecosystems across St. Lucie County through 2070.

Sea-level rise is already a clear factor in increasing the compound flood risks from storm surges and extreme rainfall events in coastal St. Lucie County. While it is not clear if sea-level rise is already contributing to increasing flood risk along the St. Lucie River in St. Lucie County, high rates of sea-level rise would be expected to increase water levels within the St. Lucie River, causing increased flood risk in low-lying riverine areas across western and southern St. Lucie County over the next several decades.

14.2 Florida Natural Areas Inventory

St. Lucie County contains large areas of protected conservation areas and privately held undeveloped lands that provide important ecosystem services, including provisioning of critical wildlife habitat, water quality protection, groundwater recharge, and floodwater storage. As St. Lucie County continues to grow and develop, strategic protection and maintenance of priority green space areas will be required in order to maintain these ecosystem services. A complex, multi-layered approach involving fee simple land acquisitions, conservation easements, regulatory conservation, forestry and agricultural land use incentives, and low impact development approaches would almost certainly be required to meet aggressive land conversation targets.

Utilizing the results of the SLAMM projections along with the FNAI CLIP, SFWMD landcover, and Florida conservation lands data, the project team developed a preliminary assessment of parcels within St. Lucie County that may have the potential to maintain ecological biodiversity, preserve essential wetland and terrestrial ecosystems, and support in flood storage, groundwater recharge, and surface water protection. This assessment specifically reviewed parcels that contained priority 1 and 2 critical lands and waters identified by FNAI; had a natural ecosystem land cover classification such as wetland, upland forests; and non- forested uplands, and were connected to or in relative proximity to already conserved land areas. The result of this method identified 581 potential conservation parcels that were 10 acres or greater in size. The coastal portion of St. Lucie County already possesses a significant area of conserved land, however, based on SLAMM projections coastal ecosystems such as mangroves and tidal marshes, which are essential habitats and provide natural protection from storm surge, are at significant risk of being lost as a result coastal squeeze. The western portion St. Lucie County possesses the greater area of land that is unaffected by future habitat change based on the SLAMM projections, therefore conservation in these areas may be essential in order to maintain freshwater ecosystems within St. Lucie County (**Figure 14-1**).

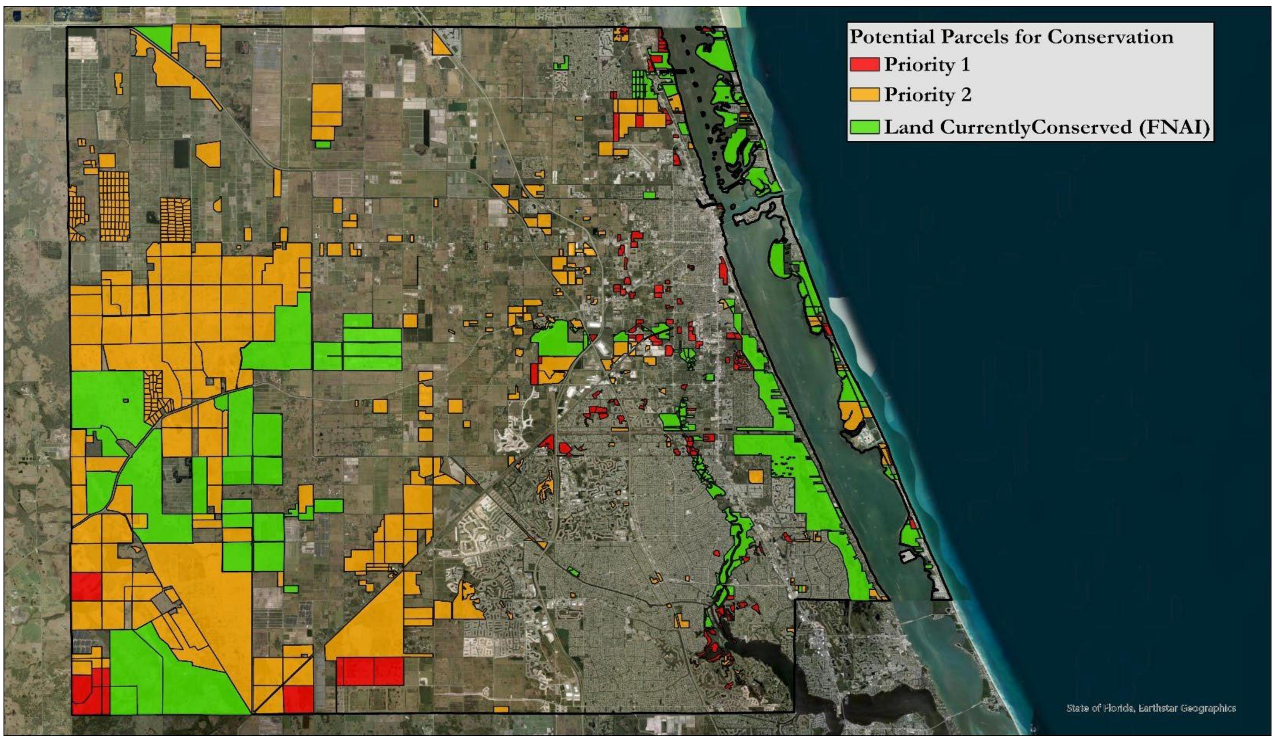


Figure 14-1. Potential Conservation Lands Based on FNAI CLIP Data

The analysis of St. Lucie County's coastal ecosystems reveals a complex interplay of vulnerability and resilience. While rising seas and changing climate patterns pose significant risks, many of the county's natural systems retain the potential to adapt, if given adequate space and support.

The key to enhancing long-term resilience lies in:

1. Decisive action in the present
2. Flexibility to adapt strategies as conditions evolve

A Note about Recommendations:

The following pages provide recommendations for short-term, medium-term and long-term planning strategies. Recommendations should be considered 'as practicable' and independently evaluated to ensure compliance with state and federal law, as applicable, at the time of implementation.

14.3 Short-term (2040) Priorities

The next 20 years represent a critical window for monitoring, planning, and conservation to establish a strong foundation for long-term adaptation. The short-term priorities lay the foundation for long-term adaptation. In this timeframe, monitoring and research are critical for understanding local environmental processes and establishing baseline conditions. Planning and conservation efforts should prioritize no-regrets actions - strategies that provide benefits under all scenarios, regardless of future conditions.

14.3.1 Monitoring

- Establish baseline monitoring for key habitats for continued observation, i.e. wetlands and mangroves:
  - Mangrove loss starts under NIL (+0.24), while NIH (-14.35%) sees a slight increase.
  - Regularly-flooded marsh declines more significantly under NIH (-9.16%) compared to NIL (-8.1%)
- Develop early warning indicators for habitat transitions, such as tidal gauges and elevation benchmarks in estuarine transition zones:
  - Estuarine open water begins to expand (+23.9% under NIL, +79.5% under NIH).
- Monitor accretion rates in wetland areas by installing surface elevation tables.
- Track changes in water quality and salinity.
- Implement storm impact monitoring to assess compound flooding effects.
- Implement policy overlays and integrate SLAMM data in permitting where practicable:
  - Establish "SLAMM-informed" setback zones for new development in flood- prone areas.
  - Limit impervious surface expansions in habitat transition zones.
  - Prioritize permitting incentives for low-impact development (LID).
  - Require site-scale SLAMM overlays in environmental impact assessments.

14.3.2 Planning

- Develop long-term adaptation strategies.
- Identify critical areas for protection.
- Incorporate sea level rise projections into land use planning.
- Update building codes and infrastructure standards.
- Integrate compound flooding risk into emergency management plans.

14.3.3 Conservation

- Protect critical mangrove and marsh habitats.
- Enhance sediment delivery to wetlands.
- Restore degraded wetlands.
- Create buffer zones around vulnerable habitats.

- Implement species-specific conservation strategies for vulnerable mangroves and threatened or endangered species.

14.3.4 Research

- Improve understanding of habitat migration patterns.
- Study accretion rates and sediment dynamics.
- Develop better carbon sequestration estimates.
- Evaluate effectiveness of adaptation strategies.
- Research compound flooding mechanisms and mitigation approaches.

14.4 Medium-term (2070) Priorities

The next 50 years will require active adaptation, restoration, and infrastructure improvements to manage the accelerating impacts of sea level rise and land use change. The timing of medium-term priorities will depend on the sea level rise scenario that unfolds. Under the NIH Scenario, these actions should be implemented sooner (by 2050-2060) to address accelerating impacts. In contrast, the NIL scenario allows for a more gradual approach. Continuous monitoring of actual sea level rise trends will be essential to determine the optimal implementation timeline.

14.4.1 Key Findings and Supporting Actions

- Under the NIL Scenario 0.07% of mangroves were lost while in the NIH Scenario 61.89% of mangroves were lost.
- Under the NIL Scenario 22.23% of regularly-flooded marsh was lost while in the NIH Scenario 83.70% of regularly-flooded marsh was lost.
- Estuarine open water increases significantly under the NIH Scenario (+276.14%) compared to the NIL Scenario (+30.00%).
- Notable conversion of freshwater systems and saltwater intrusion into swamp begins.

14.4.2 Strategic Land Acquisition for Migration

- Acquire key undeveloped upland parcels in marsh and mangrove transition zones.
- Focus acquisitions on the North Fork St. Lucie River and Indian River Lagoon Corridors.

14.4.3 Advance Restoration of Floodplain and Marsh Systems

- Reconnect historic floodplains through culvert and berm removal.
- Begin trial restorations of brackish transition zones to improve resilience.

14.4.4 Scale Up Use of Conservation Easements

- Prioritize landowner outreach in medium-priority SLAMM vulnerability areas.
- Partner with agricultural interests in southwestern St. Lucie to preserve recharge zones.

14.4.5 Upgrade Stormwater Infrastructure for Dual Threats

- Begin design of hybrid gray-green systems considering compound flooding risks.
- Retrofit systems in low-gradient inland areas where flooding and saltwater intrusion may overlap.

14.4.6 Reform Comprehensive Planning Policy

- Amend comprehensive plans to include long term SLAMM and FNAI data layers.
- Require 2070 scenario overlays in all infrastructure funding requests.

14.5 Long-term (2100) Priorities

The long-term priorities emphasize transformative approaches to address the significant changes projected by 2100, under both scenarios. These strategies require a fundamental shift from preserving current conditions to actively managing change and emerging ecosystems. To ensure a smooth transition, early planning should begin in the short- and medium-terms.

14.5.1 Key Findings and Supporting Actions

- Under NIL scenario an increase in mangroves 0.02% while under the NIH scenario 94.3% mangrove loss, NIL 32.80% marsh loss and NIH 48.8% marsh loss.
- Under NIL scenario a 33.00% increase in estuarine open water and under NIH scenario a significant increase in estuarine open water, 398.28%.
- Major carbon released into atmospheric due to wetland loss (33.1 million kg CO_2e).
- Undeveloped lands face minimal inundation, but ecological transformation is substantial.

14.5.2 Develop Managed Retreat Framework

- Plan for the potential relocation or retreat from low-lying coastal developments, recognizing both flood exposure and the shifting boundaries of sensitive ecosystems as sea level rise progresses.
- Identify trigger points for asset relocation based on SLAMM projections, incorporating not just flood risk thresholds (e.g., frequency of inundation) but also ecological indicators such as the migration of critical habitats (e.g., wetlands, mangroves) and movement wildlife species into new areas.
- Consider that as areas become increasingly inundated or "swampy", certain sensitive built assets (e.g., infrastructure, cultural sites) may face greater risk and merit proactive relocation - while at the same time, these emerging wetland areas may provide important habitat for species adapting to new conditions.

14.5.3 Strengthen Support for Wetland Conservation with Resilience Co-Benefits

- Prioritize the protection and restoration of wetlands that provide multiple benefits, including flood attenuation, habitat for wildlife, and long-term carbon storage potential.

- Explore voluntary and incentive-based programs that recognize the hazard mitigation value of wetland preservation, while keeping the focus on flood resilience and ecosystem health as primary drivers for action.

14.5.4 Create Coastal Habitat Transition Reserve Network

- Designate and maintain upland buffers for wetland migration via acquisition and zoning.
- Focus on the "coastal squeeze" particularly adjacent to areas that are highly developed and migration space is limited.

14.5.5 Enhance Freshwater System Resilience

- Implement major hydrologic modifications to maintain freshwater inputs in high- priority systems.
- Introduce salinity barriers or adaptive culverts in estuarine-freshwater interfaces.

14.5.6 Invest in Adaptive Infrastructure for End-of-Century Conditions

- Support floating infrastructure, elevated development design standards, and tidal- resistant roads in high-risk areas.

14.6 Framework for Taking Action

This report offers both analysis and a practical framework for action. Through continuous monitoring and adaptive management, St. Lucie County can ensure that both its natural and human communities thrive in the face of future projected hazards.

In creating a conservation approach for resilience, three areas of focus are important throughout the process:

Policy and Planning:

- Conduct a Future Land Use Review to identify areas at highest risk and assess opportunities for conservation, redevelopment, and infrastructure adaptation.
- Strengthen policy and land development codes as practicable to incorporate adaptation and resilience measures that benefit the community as a whole.
- Update and align local, state, and federal policies to streamline funding and regulatory approvals.

Strategic Collaboration and Resource Allocation:

- Foster cross-sector partnerships among government agencies, private landowners, conservation groups, and local businesses to align resources and initiatives.
- Expand participation in state and federal grant programs that support conservation and adaptation efforts.
- Develop public-private funding models for resilient infrastructure and green spaces that benefit both environmental sustainability and economic growth.

Implementation of Nature-Based and Infrastructure Solutions:

- Invest in nature-based solutions, such as wetland restoration / augmentation, enhanced green stormwater infrastructure, and living shorelines, to enhance flood protection and ecosystem health.
- Enhance resilient infrastructure, including elevated roadways, enhanced stormwater management systems, and flood-resistant public buildings.
- Develop long-term monitoring and adaptation strategies to track environmental changes and adjust policies accordingly.

14.6.1 A Three Phase Approach to Tackling Priorities

Phase 1 - First Five Years: Building a Strong Foundation

The first phase focuses on immediate actions that establish a solid base for long-term resilience:

1. Prioritize Green Infrastructure – Use nature-based approaches as the first line of defense against flooding and climate impacts.
2. Enhance Habitat Connectivity – Protect and link natural lands to support wildlife migration and ecosystem adaptation.

Key Actions:

- Strengthen what works – Protect the county's healthiest mangrove and marsh systems.
- Test new approaches – Launch pilot living shoreline projects in vulnerable areas.
- Secure future options – Identify and protect key habitat migration corridors.
- Learn and adapt – Implement robust monitoring programs to track ecosystem responses.

Phase 2 – The Next Decade: Scaling Solutions

With a strong foundation in place, the next phase expands and enhances resilience measures:

- Heal and restore – Revitalize degraded wetlands to improve flood protection.
- Work with nature – Integrate natural solutions into existing infrastructure.
- Plan ahead – Develop flexible easement programs for at-risk areas.
- Think regionally – Coordinate with neighboring communities on sediment and shoreline management.

Phase 3 - Long-Term Vision: Transformative Resilience

To ensure lasting resilience, long-term planning must prioritize adaptability and innovation:

- Support natural adaptation – Help ecosystems migrate as environmental conditions shift.
- Reimagine infrastructure – Design built environments to work with, rather than against, natural processes.
- Preserve vital ecosystem services – Maintain clean water, storm protection, and biodiversity benefits.
- Build partnerships – Strengthen cross-jurisdictional collaboration to enhance regional resilience.

The data and technology available today provide unprecedented insights into how coastal systems respond to change. However, information alone is not enough; we must act on it.

This report offers both analysis and a practical framework for action. Through continuous monitoring and adaptive management, St. Lucie County can ensure that both its natural and human communities thrive in the face of future projected hazards.

Immediate Policy and Planning Adjustments

- Conduct a Future Land Use Review to identify areas at highest risk and assess opportunities for conservation, redevelopment, and infrastructure adaptation.
- Strengthen zoning and development regulations to incorporate climate adaptation and resilience measures.
- Update and align local, state, and federal policies to streamline funding and regulatory approvals.

Strategic Collaboration and Resource Allocation

- Foster cross-sector partnerships among government agencies, private landowners, conservation groups, and local businesses to align resources and initiatives.
- Expand participation in state and federal grant programs that support conservation and climate adaptation efforts.
- Develop public-private funding models for resilient infrastructure and green spaces that benefit both environmental sustainability and economic growth.

Implementation of Nature-Based and Infrastructure Solutions

- Invest in nature-based solutions, such as wetland restoration, green stormwater infrastructure, and living shorelines, to enhance flood protection and ecosystem health.
- Enhance climate-resilient infrastructure, including elevated roadways, stormwater management systems, and flood-resistant public buildings.
- Develop long-term monitoring and adaptation strategies to track environmental changes and adjust policies accordingly.

The cost of inaction far exceeds the investment needed for resilience. Without proactive measures, the county faces significant risks, including:

- Increased infrastructure damage due to flooding and extreme weather events.
- Loss of critical natural resources that provide storm protection, water filtration, and habitat preservation.
- Economic disruptions affecting property values, tourism, agriculture, and local businesses.
- Greater financial strain on county budgets due to disaster response and recovery expenses.

By taking thoughtful steps now, St. Lucie County can safeguard its communities, ecosystems, and economy for future generations. A resilient future requires sustained commitment and collaboration from all sectors. The investment in protecting and enhancing natural infrastructure today will help ensure St. Lucie County remains a vibrant, climate-resilient community for generations to come.

14.7 Recommendations for Future Assessments

Further studies could strengthen decision-making and resilience planning in St. Lucie County, including:

1. **Submerged Aquatic Vegetation Analysis (SAV) –** St. Lucie County's estuarine and coastal systems contain extensive SAV resources that provide essential ecosystem services. A dedicated SAV assessment would be implemented into the SLAMM analysis to provide valuable insights for restoration planning and coastal resource management.

2. **Future Land Use Review –** To build a comprehensive and data-driven approach to land conservation and resilience in St. Lucie County, a Future Land Use Review will provide St Lucie County with a powerful tool for prioritizing conservation efforts, optimizing land use planning, and achieving balanced environmental and economic goals.

3. **Storm Impact Analysis** – Evaluate the effects of Hurricane Ian (2022), Hurricane Milton (2024) and similar storms specifically on coastal habitats.

4. **Compound Flooding Analysis** – Assess risks where storm surge combines with heavy rainfall with both hydraulic and hydrologic considerations.

5. **Mangrove Migration Modeling** - Incorporate existing knowledge of species-specific mangrove responses to water levels (red mangroves preferring inundation, black mangroves requiring less water for pneumatophore exposure, and white mangroves favoring salt-tolerant upland positions) to create more detailed spatial projections of mangrove community composition changes under sea level rise scenarios which is conceptually captured within the results of this assessment. This would enhance habitat management planning by identifying areas where specific species interventions might be most effective.

6. **Enhanced Tide Gauge Analysis** – Utilize detailed tide gauge data from Virigina Key and other nearby tide and water level gauges.

7. **Expanded Management Recommendations** – Provide refined adaptation strategies based on risk and timeframe.

8. **Improved Visualizations** – Enhance graphical representations of key findings.

9. **Technical Appendix Expansion** – Include more details on data processing, methodology, and model limitations.

10. **Additional References** – Expand the literature base supporting analysis and recommendations.

14.7.1 Modeling Submerged Aquatic Vegetation Analysis

The SAV module of the SLAMM model was not included in this assessment due to scope constraints and data limitations. However, given the importance of submerged aquatic vegetation to water quality, habitat stability, and coastal resilience, we strongly recommend incorporating this module in future analyses. This will provide critical insights into the impact of sea level rise on SAV and support conservation and restoration efforts across St. Lucie County's estuarine ecosystems.

To model SAV distribution, the module requires spatial datasets that define current SAV locations and surrounding water conditions. These include data such as:

- Existing SAV Distribution – High-resolution GIS layers (e.g., NOAA Coastal Change Analysis Program (C-CAP), Florida Fish and Wildlife Conservation Commission (FWC), or Florida Natural Areas Inventory (FNAI)).
- Bathymetric Data – Elevation of the seafloor and nearshore bathymetry (e.g., NOAA Coastal Bathymetry, USGS Digital Elevation Models (DEMs)).
- Light Availability (PAR – Photosynthetically Active Radiation) – Determines SAV growth potential (NASA MODIS, NOAA Coastal Monitoring).
- Turbidity & Water Quality – Suspended sediment and nutrient levels affecting light penetration (USGS, Florida DEP, local water quality monitoring programs).
- Salinity Gradients – Changes in freshwater inputs and estuarine conditions (USGS streamflow data, NOAA estuarine salinity datasets).
- Wave Energy & Erosion – Determines SAV stability and potential loss areas (NOAA WaveWatch III, local hydrodynamic models).

By integrating these additional analyses, St. Lucie County can better prepare for long-term environmental changes, improve resilience, and prioritize conservation efforts that protect both natural ecosystems and human communities.

SAV persistence depends on the ability of different species to tolerate changing conditions, including variations in sediment type, water quality (e.g., turbidity, nutrient levels, dissolved oxygen), salinity, light availability, and depth. Some of the data that can enhance SAV assessments include:

- Sediment Type & Stability – Sandy vs. muddy substrates influence SAV rooting and resilience (USGS Coastal Sediment Surveys, NOAA Seafloor Mapping).
- Species-Specific Growth Tolerances – Each SAV species has different tolerance thresholds for depth, salinity, and light availability (local seagrass monitoring studies, NOAA Seagrass Watch).
- Coastal Land Use & Human Impact Data – Urbanization, shoreline hardening, and boat traffic impact SAV survival (Florida DEP Coastal Land Cover Data, USGS National Land Cover Database).

The SAV module in SLAMM requires an integrated approach, combining spatial, environmental, hydrodynamic, and datasets where available to simulate how submerged aquatic vegetation responds to sea level rise. By incorporating high-resolution GIS layers, water quality data, and ecosystem monitoring records, this module provides a detailed projection of SAV vulnerability and guides conservation and restoration planning for coastal resilience. The SAV module of the SLAMM model was not included in this assessment due to scope constraints and data limitations. However, given the importance of submerged aquatic vegetation to water quality, habitat stability, and coastal resilience, we strongly recommend incorporating this module in future analyses. This will provide critical insights into the impact of sea level rise on SAV and support conservation and restoration efforts across St. Lucie County's estuarine ecosystems.

To model SAV distribution, the module requires spatial datasets that define current SAV locations and surrounding water conditions. These include data such as:

- Existing SAV Distribution – High-resolution GIS layers (e.g., NOAA Coastal Change Analysis Program (C-CAP), Florida Fish and Wildlife Conservation Commission (FWC), or Florida Natural Areas Inventory (FNAI)).
- Bathymetric Data – Elevation of the seafloor and nearshore bathymetry (e.g., NOAA Coastal Bathymetry, USGS Digital Elevation Models (DEMs)).
- Light Availability (PAR – Photosynthetically Active Radiation) – Determines SAV growth potential (NASA MODIS, NOAA Coastal Monitoring).
- Turbidity & Water Quality – Suspended sediment and nutrient levels affecting light penetration (USGS, Florida DEP, local water quality monitoring programs).
- Salinity Gradients – Changes in freshwater inputs and estuarine conditions (USGS streamflow data, NOAA estuarine salinity datasets).
- Wave Energy & Erosion – Determines SAV stability and potential loss areas (NOAA WaveWatch III, local hydrodynamic models).

By integrating these additional analyses, St. Lucie County can better prepare for long-term environmental changes, improve resilience, and prioritize conservation efforts that protect both natural ecosystems and human communities.

SAV persistence depends on the ability of different species to tolerate changing conditions, including variations in sediment type, water quality (e.g., turbidity, nutrient levels, dissolved oxygen), salinity, light availability, and depth. Some of the data that can enhance SAV assessments include:

- Sediment Type & Stability – Sandy vs. muddy substrates influence SAV rooting and resilience (USGS Coastal Sediment Surveys, NOAA Seafloor Mapping).
- Species-Specific Growth Tolerances – Each SAV species has different tolerance thresholds for depth, salinity, and light availability (local seagrass monitoring studies, NOAA Seagrass Watch).
- Coastal Land Use & Human Impact Data – Urbanization, shoreline hardening, and boat traffic impact SAV survival (Florida DEP Coastal Land Cover Data, USGS National Land Cover Database).

The SAV module in SLAMM requires an integrated approach, combining spatial, environmental, hydrodynamic, and datasets where available to simulate how submerged aquatic vegetation responds to sea level rise. By incorporating high-resolution GIS layers, water quality data, and ecosystem monitoring records, this module provides a detailed projection of SAV vulnerability and guides conservation and restoration planning for coastal resilience.

14.7.2 Future Land Use Review

Key goals of a Future Land Use Review include:

- Identify vulnerable areas most at risk to hazard projections such as sea level rise, flooding, and habitat loss, in conjunction with asset vulnerability assessments to maximize capital improvement program investments.
- Prioritize conservation and protection efforts for lands that provide critical ecosystem services, natural flood mitigation, and serve nearby critical and regionally significant assets
- Determine areas suitable for resilient development and infrastructure upgrades utilizing SLAMM modeling, asset vulnerability assessment results, future land use analyses and other types of data with conservation prioritization tools like the Marxan Model (https://marxansolutions.org/what-is-marxan).
- Align land use planning with state and federal funding opportunities to maximize financial and environmental benefits.

Through proactive planning, strategic investment, and community engagement, St. Lucie County can transform challenges into opportunities, ensuring a sustainable and resilient future for all residents. The following information provides an overview of the Future Land Use (**Figure 14-2**) within St Lucie County for preliminary targeting of areas that may benefit from strategic conservation focused land acquisition programs.

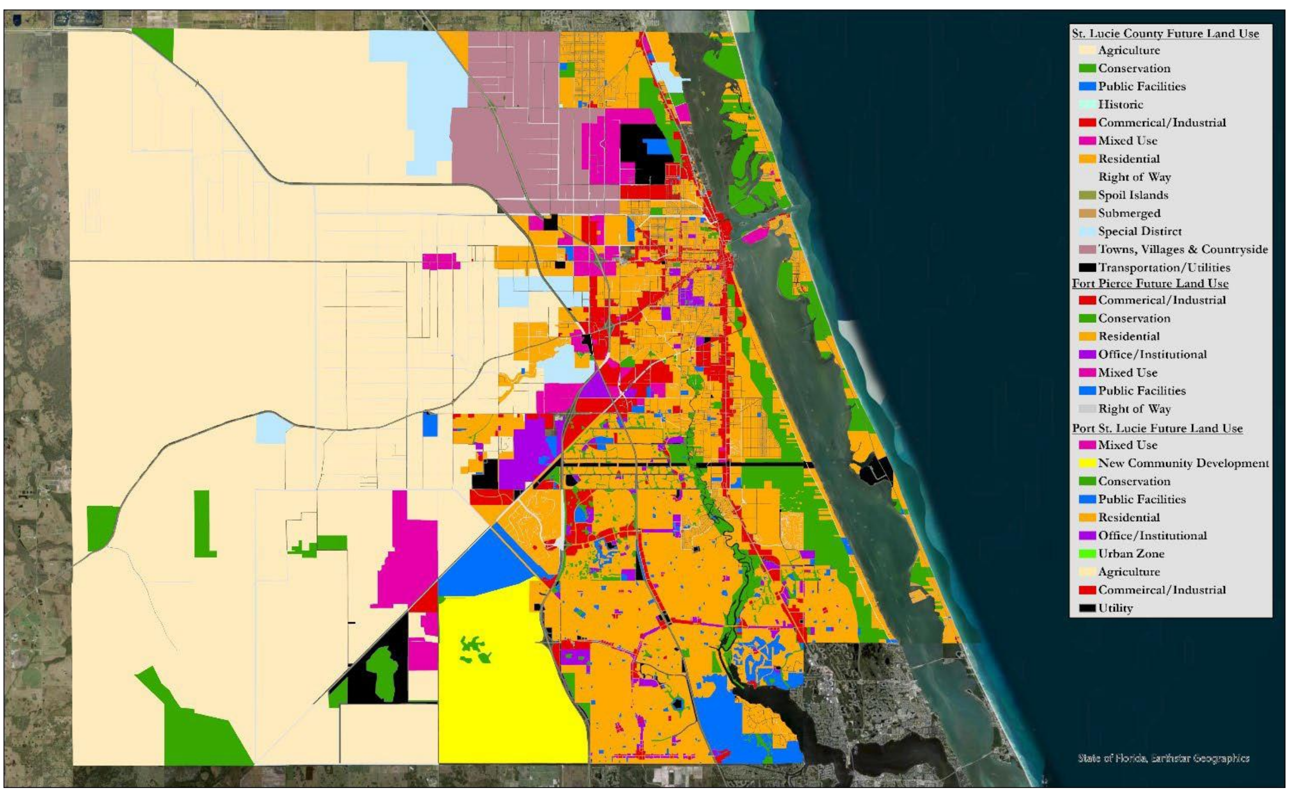


Figure 14-2. Future Land Use of St Lucie County

To build a comprehensive and data-driven approach to land conservation and resilience in St. Lucie County, incorporating Marxan into a Future Land Use Review can provide St Lucie County with a powerful tool for prioritizing conservation efforts, optimizing land use planning, and achieving balanced environmental and economic goals.

Originally designed for marine spatial planning, Marxan has evolved into one of the most widely used systematic conservation planning tools across the globe. It enables decision- makers to:

- Identify optimal conservation areas while balancing cost-effectiveness and land-use priorities.
- Consider multiple land use scenarios and trade-offs between development, conservation, and infrastructure planning.
- Address ecological connectivity, ensuring that protected areas support biodiversity and ecosystem services over time.
- Incorporate uncertainty and risk factors, helping planners adapt to flood-related hazards and other environmental stressors.

Marxan's flexibility makes it a powerful tool for guiding St. Lucie County's conservation planning efforts, ensuring resilient landscapes that can withstand natural hazard events while supporting economic sustainability. Marxan can be used to support St. Lucie County's Future Land Use Review by:

1. Identifying High-Priority Conservation Lands:
    - Using Marxan's spatial optimization algorithms, planners can identify critical areas for land conservation based on biodiversity, flood mitigation, and ecosystem services.
    - The model helps target undeveloped lands that provide natural flood protection, ensuring coastal resilience.
    - Conservation priorities can be aligned with funding opportunities, including state and federal land acquisition programs.
2. Optimizing Development and Infrastructure Planning:
    - Marxan can analyze how urban expansion, transportation corridors, and utility infrastructure interact with natural systems.
    - It helps balance land use demands, ensuring that development does not compromise ecosystem functions.
    - The tool can assess alternative land-use scenarios to support smart growth strategies.
3. Enhancing Connectivity Between Natural Areas:
    - Maintaining ecological corridors is crucial for wildlife movement, water flow, and landscape resilience.
    - Marxan can identify key linkages between protected areas, helping avoid fragmentation of natural habitats.
4. Incorporating Community and Stakeholder Input:

    - The model enables scenario planning, allowing stakeholders to visualize trade-offs between conservation and development.
    - By integrating local knowledge with scientific modeling, planners can ensure that conservation decisions reflect community priorities.

By incorporating Marxan into St. Lucie County's Future Land Use Review, decision-makers can take a science-based approach to conservation and growth management.

- Resilience can be strengthened by prioritizing high-value conservation lands and coastal adaptation measures.
- Sustainable growth can be achieved through balanced land-use planning.
- Cost-effective solutions can be identified, ensuring that investments in conservation yield long-term economic and environmental benefits.

15.0 TECHNICAL APPENDIX

15.1 Project Workflow

The Sea Level Affecting Marshes Model (SLAMM) analysis for St. Lucie County followed a structured workflow to ensure transparency, reproducibility, and accuracy. The key steps are outlined below:

1. Data Preparation

- Convert input datasets to ASCII grid format for compatibility with SLAMM.
- Ensure all spatial data maintains consistent projection and resolution to prevent misalignment.
- Conduct quality control checks on input datasets to validate completeness and accuracy.

2. Model Configuration

- Define model parameters, including tidal ranges, sedimentation rates, and other parameterized factors.
- Configure sea level rise (SLR) scenarios, incorporating projections from NOAA and other sources.
- Establish protection scenarios, differentiating between natural adaptation, managed retreat, and engineered interventions.

3. Model Execution

- Run SLAMM for each SLR scenario and protection strategy to simulate long-term marsh and wetland changes.
- Generate output CSV files containing habitat transition results and projected landscape shifts.
- Perform output validation, comparing results against historical trends and ground-truthing data where available.

4. Data Analysis

- Extract key metrics from SLAMM output CSV files for further processing.
- Calculate habitat changes, including net loss/gain percentages for each wetland type.
- Generate summary tables and visualizations to illustrate projected ecosystem transitions.

5. Reporting

- Compile results into comprehensive reports detailing findings and implications.
- Develop scenario-specific summaries to highlight the expected outcomes under different SLR trajectories.
- Provide management recommendations based on modeled results, emphasizing adaptation strategies for local decision-makers.

15.2 Data Limitations

While rigorous quality control measures were applied, certain limitations inherent to the input data and modeling approach should be acknowledged:

1. Land Cover Classification: Potential classification errors in the input datasets may affect habitat change projections.
2. Temporal Resolution: The analysis is limited to discrete time steps (2020, 2040, 2070, and 2100), which may not capture dynamic, year-to-year variations.
3. Protection Scenarios: The representation of protection strategies is simplified and does not account for future policy changes or evolving adaptation measures.

To ensure data reliability, multiple quality control and assurance validation methods were applied, including:

- In-depth staff review to identify and correct potential issues.
- Comparisons with historical data to validate classification accuracy.
- Model calibration to refine assumptions where possible.

Any issues identified during the modeling process were addressed before finalizing the results in this report.

15.3 Modeling & Analysis Limitations

In addition to data constraints, several modeling limitations should be considered when interpreting results:

1. Land Cover Classification: Errors in land cover classification can impact habitat transition projections.
2. Temporal Resolution: The model operates on specific years (2020, 2040, 2070, 2100), limiting its ability to capture continuous change.
3. Protection Scenarios: The model assumes simplified protection strategies that do not fully account for future engineering innovations or policy changes.
4. Species-Specific Data: The analysis lacks species-specific responses to sea level rise, limiting biodiversity impact assessments.
5. Elevation Data Accuracy: The model relies on 10-meter cell size elevation data, which is appropriate for large-scale planning but may require higher-resolution data for site-specific applications.
6. Accretion Assumptions: The model applies constant accretion rates, which may not fully reflect local field conditions or recent sedimentation trends.
7. Habitat Grouping: Certain habitat types are simplified into broader categories, potentially masking localized ecological responses.
8. Spatial Analysis: The analysis focuses on large-scale trends, with limited fine-scale spatial analysis in this report.

9. Uncertainty Analysis: The report does not include a full uncertainty analysis, meaning that error margins around projections are not explicitly quantified.
10. Submerged Aquatic Vegetation (SAV): The SAV module was not run, so potential impacts on submerged habitats are not assessed.
11. Simplified Processes: Some complex ecological and hydrodynamic interactions are simplified to align with model constraints.
12. Spatial Resolution: The 10m resolution may omit small-scale features and microhabitats, limiting the detection of finer ecological changes.

These limitations should be carefully considered when applying the results of this analysis. While the findings provide valuable insights into potential sea level rise impacts, they should be viewed as projections based on current data and assumptions, rather than precise predictions. To address these limitations, an adaptive management approach is recommended—allowing policies and decisions to evolve as new data and improved methodologies become available. Future studies incorporating higher-resolution data, improved uncertainty analyses, and site-specific validations will enhance the accuracy and applicability of SLAMM-based projections.

16.0 RVA-OH RECOMMENDATIONS

The overarching objectives of this RVA revolve around the comprehensive acquisition of data and the evaluation of threats posed by hazards. The results of this analysis will inform the formulation of the St. Lucie Regional Resilience Plan (RRP). The RVA is based on an analysis that revealed potential County and municipal susceptibilities to the adverse impacts of hazards. The hazards considered include coastal erosion, drought, extreme heat, inland flooding, storm surge, wind, wildfire and sea level rise (see Part II: SLAMM Analysis). Present day and future hazard scenarios were layered on maps containing County and municipal assets to determine each asset's relative risk. This was followed by identifying specific characteristics of the assets and the predicted impacts to determine vulnerability levels to the hazards.

The following items, organized by hazard, are offered for consideration to enhance the overall understanding of hazard-related risks and inform future planning efforts for the County and municipalities. In each case it should be noted that steps taken to facilitate private and commercial resilience activities will benefit the local government socially and economically.

Part I: Multi-Hazard Vulnerability Assessment Recommendations

All Hazards

- Create an updated user-defined general building stock and critical facilities dataset using up-to-date parcels, footprints, elevations, and values from the RSMeans Data (cost data software) inventory.
- Use updated and current demographic data.
- Using assessor data, include updated occupancy class attributes in general building stock and critical facilities.
- Develop construction ready plans for priority adaptation projects and ensure they are incorporated into the Local Mitigation Strategy to maximize access to mitigation funding.
- Update the essential employee list for emergency preparation and response activities and conduct preparedness training for government employees to maximize the workforce available to respond to and prepare for both pre- and post-disaster.
- Ensure that an employee team of the appropriate size and composition is trained and up to date on disaster response expense tracking to maintain eligibility for reimbursements.
- Develop an on-line library of disaster preparedness and recovery resources that is broadly advertised and available to the public, underscoring that each one of us plays a part in community resilience.

Coastal Erosion

- Ensure that dynamic shoreline management planning continues.
- Prioritize nature-based solutions (e.g., dune restoration, living shorelines) over hard infrastructure where feasible.

- Link engineered beach designs to MSL or other relative datum and not a fixed elevation such as NAVD to incorporate sea level changes into beach construction templates.
- Investigate the use of structures (groins) to reduce and/or control erosion rates.
- Expand coastal monitoring programs to track erosion hotspots and sediment transport patterns, especially in areas identified as medium-high risk by FDEP.
- Establish rolling easements or conservation buffers in erosion-prone areas to allow for natural shoreline migration and reduce long-term infrastructure exposure.
- Continue coordination with FDEP and local municipalities to prioritize beach nourishment projects in areas with critical infrastructure or evacuation routes that may be at risk by 2070.
- Continue to collect localized coastal erosion data for St. Lucie County beaches and use it to model future erosion rates. Data for the northern mile of the County's Fort Pierce project was not available within the USGS datasets used in this RVA, and local data is essential to fill this gap and support targeted planning and mitigation.

Drought

- Incorporate drought early warning into existing hazard mitigation plans by tracking the weekly updates on the US Drought Monitor website and longer term forecasts on the National Drought Mitigation Center website. Identify clear triggers for remedial actions and communicate those actions to the public.
- Determine percentage of water use by sector to identify key target customers for water reduction strategies and to prioritize water use categories, e.g. essential, socially and economically important, non-essential.
- Develop a countywide adaptive water management strategy that includes drought contingency planning, water reuse, and aquifer recharge initiatives.
- Promote drought-tolerant landscaping and agricultural practices through incentives and technical assistance, especially in high-risk agricultural zones.
- Expand public education campaigns on water conservation and drought preparedness, targeting both residential and commercial users
- Incentivize the use of low-flow appliances such as showers, faucets, toilets, washing machines, and promote water catchment devices like rain barrels and cisterns for irrigation.
- Integrate drought risk into land use planning by discouraging high-water-demand development in areas with limited water supply resilience.

Extreme Heat

- Track extreme temperature data for injuries, deaths, shelter needs, agricultural losses, and other impacts to determine distributions of most at-risk areas.
- Use and explore future land development data from the County and municipalities through a qualitative analysis.
- Use best available hazard data as it becomes available.

- Establish a Heat Resilience Task Force to coordinate cross-sectoral responses, including public health, emergency management, and urban planning.
- Prioritize tree canopy expansion and green infrastructure in urban heat islands, especially in Fort Pierce and Port St. Lucie where exposure is highest.
- Ensure that critical public services are equipped to function during power outages that may accompany extreme heat events – including public buildings that may be needed as cooling centers.
- Retrofit public housing and critical facilities with energy-efficient cooling systems and passive design features to reduce heat stress, possibly using renewable energy sources that would be available during power outages.
- Expand parks, increase tree coverage, install splash pads and pools to provide cooling options for the public.
- Develop a countywide extreme heat early warning system and cooling center network, with targeted siting and outreach. Monitor the Heat Risk tool developed by NWS and CDC for heat impact forecasting up to a week in advance.
- Ensure facilities are well weatherized to avoid leaky building envelopes and keep HVAC systems maintained.
- Investigate energy efficiency improvements and renewable energy sources as strategies to reduce stress on the power grid during peak energy demand driven by extreme heat events.

Inland Flooding

- Maintain and update a general building stock inventory dataset with critical facility attributes regarding first floor elevation and foundation type (pier, slab on grade, etc.) to enhance loss estimates via a Hazus loss analysis.
- As more current FEMA floodplain data becomes available (i.e., Digital Flood Insurance Rate Maps), update the exposure analysis and generate a detailed flood depth grid that can be integrated into the current Hazus version.
- Conduct a Hazus loss analysis to better understand economic and social impacts from flooding in specific areas.
- Conduct a repetitive loss area analysis and layer those results with the vulnerability analysis. Consider a property acquisition program or flood-proofing subsidies for the highest repetitive losses areas.
- Review building codes periodically to identify updates in building standards that may be required to address hazards as they change and/or intensify.
- Conduct large scale public education to better inform residents of the flood risk to their neighborhood and on flood damage reduction strategies they can implement such as installing flood vents, waterproofing exterior walls, sealing foundations, flood barriers, elevating electric panels and HVAC systems. Consider an incentive program for these activities.
- Continue to expand and update urban flood areas to further inform mitigation.

- Upgrade stormwater infrastructure using future rainfall projections (e.g., 100-year, 24-hour events under 2070 conditions) to reduce system overload or system failure.
- Restore and protect inland wetlands and floodplains to enhance natural flood storage and reduce downstream impacts.
- Incorporate flood risk into zoning and building codes, especially in areas with high socio-economic vulnerability and aging infrastructure exists.
- Develop a green infrastructure master plan to integrate bioswales, rain gardens, and permeable surfaces into urban redevelopment projects.
- Encourage residents in low-lying areas to participate in structure elevation programs as they become available.
- Provide education opportunities on the benefits of well-designed landscaping as it relates to floodwater management.
- Provide public access to GIS maps that identify flooded areas in real time to reduce traffic congestion in these areas and allow recovery actions to progress unimpeded.

Storm Surge

- Maintain and update a general building stock inventory dataset with critical facility attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates via a Hazus loss analysis.
- Update evacuation planning and sheltering strategies based on SLOSH Category 5 exposure, particularly for St. Lucie Village and Fort Pierce.
- Elevate or floodproof critical infrastructure in high-exposure zones, including emergency services, utilities, and transportation corridors.
- Implement coastal setback policies and discourage new development in areas projected to be inundated under Category 5 scenarios.
- Coordinate with FEMA and FDEM to develop and align local mitigation projects with NFIP and CRS program incentives.

Wind

- Perform additional Hazus modeling scenarios, such as the 1,000 MRP.
- A custom general building stock inventory could be developed and include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
- Establish a pre-storm preparedness protocol for inspecting infrastructure and securing or moving equipment.
- Strengthen building codes and enforcement for wind-resistant construction, especially for mobile homes and coastal high-rises.
- Ensure that a debris management plan includes pre-staging, rapid clearance, and recycling strategies to reduce post-storm recovery time and minimize impact to landfill.

- Retrofit critical facilities with wind-hardened features (e.g., impact-resistant windows, reinforced roofs) to maintain continuity of operations.
- Expand public education on wind hazard preparedness, including exterior preparation/securing loose objects, safe sheltering practices and insurance literacy.

Wildfire

- Maintain and update a general building stock inventory dataset with critical facility attributes regarding first floor elevation and foundation type (pier, slab on grade, etc.) to enhance loss estimates via a Hazus loss analysis.
- Implement a Wildland-Urban Interface (WUI) mitigation strategy that includes defensible space standards, fuel reduction, and fire-adapted landscaping.
- Enhance wildfire detection and response capacity through improved GIS mapping, remote sensing, and interagency coordination.
- Convene a wildfire preparedness stakeholder committee to create a community fire-emergency response plan and to assist with communicating the plan, along with types and timing of wildfire warnings.
- Target prevention-based outreach and support to vulnerable populations in high-risk zones, including manufactured housing communities and low-income residents.
- Integrate wildfire risk into comprehensive planning and development review processes, especially in expanding suburban areas.

Part II: SLAMM Analysis Recommendations

Short Term (2040)

- Establish baseline monitoring for wetlands and mangroves.
- Develop early warning indicators for habitat transitions.
- Integrate SLAMM data into permitting and land use decisions.
- Protect and restore critical habitats (mangroves, marshes).
- Promote low-impact development and conservation incentives.
- Conduct research on habitat migration, sediment dynamics, and compound flooding.

Medium Term (2070)

- Acquire upland parcels in marsh/mangrove transition zones.
- Restore floodplain and brackish transition zones.
- Expand use of conservation easements, especially in vulnerable areas.
- Upgrade stormwater infrastructure to address compound flooding.
- Amend comprehensive plans to include SLAMM and FNAI data layers.

Long Term (2100)

- Develop a managed retreat framework for vulnerable assets.
- Strengthen wetland conservation for flood and carbon benefits.
- Create a coastal habitat transition reserve network.
- Enhance freshwater system resilience through hydrologic modifications.
- Invest in adaptive infrastructure (e.g., floating roads, elevated buildings).

Recommendations for Future Assessments

- Conduct submerged aquatic vegetation (SAV) analysis.
- Perform compound flooding and storm impact assessments.
- Model mangrove migration and enhance tide gauge analysis.
- Expand technical documentation and visualizations.
- Use Marxan modeling for strategic land conservation planning.

17.0 REFERENCES

These references provide additional context and information on sea level rise projections, coastal adaptation planning, and the SLAMM analysis. They are recommended for readers interested in exploring these topics in more depth.

These sources were selected to support the technical foundation of this report and to provide additional guidance for decision-makers and researchers interested in climate adaptation and resilience planning.

Benedict, L., C. Glazer, C. Bergh, S. Traxler, B. Stys, and J. Evans. 2018. Florida Keys Case Study on Incorporating Climate Change into Conservation Planning and Actions for Threatened and Endangered Species. Tallahassee: Florida Fish and Wildlife Conservation Commission.

Bernard, C.R., and A. Proano. 2022. "Too Hot to Handle: Curbing Mobile Home Heat Deaths in a Warming Climate." *Washington Journal of Social and Environmental Justice.*

Blum, A., P.J. Ferraro, S.A. Archfield, and K.R. Ryberg. 2020. Causal effect of impervious cover on annual flood magnitude for the United States. Geophysical Letters 47:e2019GL086480.

Carstens, J, C. Uejio, and A. Wing. 2022. Understanding Past, Present, and Future Tropical Cyclone Activity. Florida State University.

Center for Climate and Energy Solutions. 2023. Hurricanes and Climate Change. https://www.c2es.org/content/hurricanes-and-climate-change/.

Centers for Disease Control and Prevention. 2022. Natural Disasters and Severe Weather: Extreme Heat. June 17 . Available online at: https://www.cdc.gov/disasters/extremeheat/index.html.

Clearview Geographic LLC. 2025. Long-Term Resilience in St. Lucie County, Florida: A Conservation Planning Approach.

Clough, J. A. Polaczyk, and M. Propato. 2016. Modeling the potential effects of sea-level rise on the coast of New York: Integrating mechanistic accretion and stochastic uncertainty. Environmental Modelling & Software 84:349-362.

ECFRPC and TCRPC. 2016. Indian River Lagoon Economic Valuation Report. https://files.tcrpc.org/portfolio%20of%20work/Economic%20Development/IRL%20Valuation/FinalReportIRL08_26_2016.pdf.

EPA (U.S. Environmental Protection Agency). 2016. Climate Change and Extreme Heat What You Can Do to Prepare. EPA 430-R-16-061: CDC.

EPA. 2023. Heat Island Effect. July 20. https://www.epa.gov/heatislands#:~:text=Heat%20Islands%20and%20Equity%20%E2%80%93%20Updated!,-Explore%20the%20reasons&text=Heat%20islands%20are%20urbanized%20areas,as%20forests%20and%20water%20bodies.

Evans, J.M. and C. Bergh. 2016. Sea Level Rise Vulnerability Assessment for Monroe County, Florida: Technical Appendix in Support of the GreenKeys! Sustainability and Climate Action Plan.

FDEP. 2023. Critically Eroded Beaches Reports 2023. Florida Department of Environmental Protection. https://floridadep.gov/sites/default/files/FDEP_Critically%20Eroded%20Beaches_07-2023_0.pdf.

FDOT. 2019. "Florida Population Growth; A Technical Memorandum from FDOT Forecasting and Trends Office".

FEMA (Federal Emergency Management Agency). 2025. "National Risk Index".

FEMA. 2017. Flood Insurance Study, St. Lucie County, Florida and Incorporated Areas. Flood Insurance Study Number 12111CV005B.

FEMA. 2009. *Protecting Manufactured Homes from Floods and Other Hazards (FEMA P-85, Second Edition).* Federal Emergency Management Agency.

First Street Foundation. 2022. 5th National Risk Assessment: Fueling the Flames.

Florida Bureau of Economic and Business Research. 2024. Population. Available online at: https://bebr.ufl.edu/.

Florida Department of Environmental Protection. (2021). Florida Adaptation Planning Guidebook.

Florida Division of Emergency Management. 2023. *2023 Enhanced State Hazard Mitigation Plan.* Available online at: https://flshmp-floridadisaster.hub.arcgis.com/.

Florida Gulf Coast University. n.d. *Wind.* Available online at: https://www.fgcu.edu/emergencymanagement/hurricanepreparedness/wind.

Florida State University. n.d.a. Florida Climate Center: Drought. Available online at: https://climatecenter.fsu.edu/topics/drought.

Florida State University. n.d.b. Florida Climate Center: Hurricanes. https://climatecenter.fsu.edu/topics/hurricanes.

Harris, Alex, and Nicholas Rivero. 2022. "What we know — and don't — about how climate change impacts hurricanes like Ian." *NPR*, October 7.

Hauer, M.E., J.M. Evans, and C.R. Alexander. 2015. Sea-level rise and sub-county population projections in coastal Georgia. Population and Environment 37:44-62.

IPCC. (2021). Sixth Assessment Report. Intergovernmental Panel on Climate Change.

Kirwan, M.L., & Megonigal, J.P. (2013). Tidal wetland stability in the face of human impacts and sea-level rise.

Liao, K.H., S. Deng, and P.Y. Tan. 2017. Blue-green infrastructure: new frontier for sustainable urban stormwater management. Greening Cities, pp.203-226. Singapore: Springer.

Liu, J.C., A. Wilson, L.J. Mickley, K. Ebisu, M.P. Sulprizio, Y. Wang, R.D. Peng, X. Yue, F. Dominici, M.L. 2017. Who Among the Elderly Is Most Vulnerable to Exposure to and Health Risks of Fine

Particulate Matter From Wildfire Smoke? Available online at: https://pmc.ncbi.nlm.nih.gov/articles/PMC5860049/.

Mazor, T., R.K. Runting, M.I. Saunders, D. Huang, D.A. Friess, N.T.H. Nguyen, R.J. Lowe, J.P. Gilmour, P.A. Todd, and C.E. Lovelock. 2021. Future-proofing conservation priorities for sea level rise in coastal urban ecosystems. Biological Conservation 260:109190.

Moftakhari, H.R., et al. (2017). Compounding effects of sea level rise and fluvial flooding. Proceedings of the National Academy of Sciences.

National Drought Mitigation Center. 2025. US Drought Monitor.

National Hurricane Center. n.d. Sea, Lake, and Overland Surges from Hurricanes (SLOSH). National Oceanic and Atmospheric Administration. Available online at: https://www.nhc.noaa.gov/surge/slosh.php.

National Low Income Housing Coalition and Public and Affordable Housing Research Corporation (NLIHC & PAHRC). 2021. Taking Stock: National Hazards and Federally Assisted Housing. Available online at: https://preservationdatabase.org/wp-content/uploads/2021/06/Taking-Stock.pdf.

NOAA (National Oceanic and Atmospheric Administration). 2023a. NOAA Atlas 14 Precipitation Frequency Estimates in GIS Compatible Format. Retrieved from Precipitation Frequency Data Server. Available online at: https://hdsc.nws.noaa.gov/pfds/pfds_gis.html.

NOAA Tides and Currents. 2025. Sea Level Rise Technical Report. National Oceanic and Atmospheric Administration.

NOAA. 2021. Landmark Nationwide Losses Avoided Study Finds That Building Codes Save

NOAA. 2022. Sea Level Rise Technical Report. National Oceanic and Atmospheric Administration.

NOAA. 2022. *NOAA State Climate Summaries: Florida.* National Oceanic and Atmospheric Administration. Available online at: https://statesummaries.ncics.org/chapter/fl/.

NOAA. 2025a. "Storm Events Database."

NOAA. 2025b. "U.S. Climate Resilience Toolkit Climate Explorer Version 3.1."

NOAA. 2025c. National Hurricane Center. Historical Hurricane Tracks.

NOAA. 2025d. National Weather Service. Atlas 14 Point Precipitation Frequency Estimates: FL. Volume 9 Version 2. Available online at: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=fl.

NOAA. 2025e. National Integrated Drought Information Systems.

Obeysekera, J., M. Sukop, T. Troxler, and A. John. 2021. Updating the Statewide Extreme Rainfall Projections. Sea Level Solutions Center, Institute of Environment, Florida International University. Available online at: https://environment.fiu.edu/what-westudy/projects/fbc_fiu_finalreport.pdf.

Panos, C.L., J.M. Wolfand, and T.S. Houge. 2021. Assessing resilience of a dual drainage urban system to redevelopment and climate change. Journal of Hydrology 596:126101.

Parsons, T., A. Theriot, J. Normandy, and R. Shears. 2025. St. Lucie County Sea Level Rise and Vulnerability Assessment for Historic Resources.

Pen State. 2022. Humans can't endure temperatures and humidities as high as previously thought. Available online at: https://www.psu.edu/news/research/story/humans-cant-endure-temperatures-and-humidities-high-previously-thought.

Pierce, G., C.J. Gabbe, and A. Rosser. 2022. "Households Living in Manufactured Housing Face Outsized Exposure to Heat and Wildfire Hazards: Evidence from California." Natural Hazards Review. Available online at: https://doi.org/10.1061/(ASCE)NH.1527-6996.0000540.

Powell, E. 2022. 2021 Florida Weather and Climate Summary. Florida Climate Center.

Runkle, J., K.E. Kunkel, S.M. Champion, R. Frankson, B.C. Stewart, W. Sweet, and S. Rayne. 2022. NOAA National Center for Environmental Information State Climate Summaries 2022: Florida. Available online at: https://statesummaries.ncics.org/chapter/fl/.

Sea Level Affecting Marshes Model (SLAMM). 2022. Sea Level Affecting Marshes Model Documentation. Warren Pinnacle Consulting, Inc.

South Florida Water Management District. 2022. Technical Memorandum: Adoption of Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida.

Skinner, A. 2025. "Florida Sees Worst Drought In 24 Years." *Newsweek*, May 8.

SLAMM. (2022). Sea Level Affecting Marshes Model Documentation. Warren Pinnacle Consulting, Inc.

SLC Department of Public Safety Division of Emergency Management. 2021. "St. Lucie County Unified Local Mitigation Strategy." St. Lucie County Unified Local Mitigation Strategy. Available online at: https://www.stlucieco.gov/home/showdocument?id=8252.

SLC Planning & Development Services. 2021. Planning and Development Services. Available online at: https://www.stlucieco.gov/departments-and-services/planning-and-development-services.

Sohn, W., J.H. Kim, M.H. Li, R.D. Brown, and F.H. Jaber. 2020. How does increasing impervious surfaces affect urban flooding in response to climate variability? Ecological Indicators 118:106774.

St. Lucie County. (2022). St. Lucie County Comprehensive Plan.

Tetra Tech (Tetra Tech, Inc.). 2021. St. Lucie County Vulnerability Assessment. Prepared for the Florida Department of Environmental Protection. August.

Thompson Earth Systems Institute. 2022. Tell Me About Sinkholes in Florida. Available online at: https://www.floridamuseum.ufl.edu/earth-systems/blog/tell-me-about-sinkholes-in-florida/.

U.S. Census Bureau. 2023. QuickFacts: St. Lucie County, Florida.

U.S. Climate Resilience Toolkit. 2021. Coastal Erosion. April 1. Available online at: https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion.

USACE (U.S. Army Corps of Engineers). 2023. Herbert Hoover Dike Rehabilitation Project Update. Jacksonville District Website. Available online at: https://www.saj.usace.army.mil/HHD/.

USGS (U.S. Geological Survey). 2021. Digital Shoreline Analysis System (DSAS) version 5.1.

Volk, M.I., T.S. Hoctor, B.B. Nettles, R. Hilsenbeck, F.E. Putz, and J. Oetting. 2017. Florida land use and land cover change in the past 100 years. In Florida's Climate: Changes, Variations, and Impacts, pp.51-82. Available online at: https://floridaclimateinstitute.org/docs/climatebook/Ch02-Volk.pdf.

Wdowinski, S., et al. (2020). Increasing flooding hazard in coastal communities due to rising sea level: Case study of Miami Beach, Florida. Ocean & Coastal Management

Young, V. 2023. Florida, the seas are rising and time is short. The Invading Sea: Florida and the Climate Crisis. May 23.

Zinnert, J.C., et al. (2019). Connectivity in coastal systems: barrier island vegetation influences upland migration in a changing climate. Global Change Biology.