Vulnerability of the Suncoast Connector Toll Road Study Area to Future Storms and Sea Level Rise

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Abstract

The Multi-use Corridors of Regional Economic Significance Program (M-CORES) authorizes the design and construction of three new toll road corridors through portions of Florida, including the proposed Suncoast Connector. This paper assesses the potential vulnerability of the Suncoast Connector study area and specifically the U.S. 19/U.S. 27/U.S. 98 corridor to coastal hazards including storms and sea level rise. The results of this analysis indicate that the study area and existing U.S. 19/U.S. 27/U.S. 98 corridor are not only currently at risk from flooding and coastal storms, but that sea level rise and climate change will significantly exacerbate these risks in the future. Findings include that at least 30 percent of the study area is already at risk from a Category 5 storm surge, with sea level rise projected to increase that risk even further. This region also provides one of the best opportunities for coastal biodiversity to functionally respond to increasing sea level rise, but a new major highway corridor along with the additional development that it facilitates will complicate biodiversity conservation and resiliency efforts. With these concerns in mind, it is critical to ensure that investment in new infrastructure, if pursued within the study area, is strategic and located in areas least vulnerable to impacts and repeat loss and least likely to conflict with efforts for facilitating the adaptation of regional natural systems to sea level rise and other related impacts.

Vulnerability of the Suncoast Connector Toll Road Study Area to Future Storms and Sea Level Rise

In May 2019 the Multi-use Corridors of Regional Economic Significance Program (M-CORES) was approved by Governor Ron DeSantis. The Program authorizes the design and construction of three new toll road corridors through portions of Florida, including the proposed Suncoast Connector, extending from Citrus County to Jefferson County. The purpose of this paper is to assess the potential vulnerability of the Suncoast Connector study area and specifically the U.S. 19/U.S. 27/U.S. 98 corridor to coastal hazards - including storms and sea level rise.

As made clear by the impacts from the "No-Name Storm" in 1993, Hurricane Hermine in 2016, and Hurricane Michael in 2018, the Gulf Coast is already vulnerable to coastal storms and hurricanes. Climate change, including sea level rise and the impacts from warmer temperatures on tropical cyclones will only increase the likely hazards along this coastline from flooding, erosion, and related changes such as saltwater intrusion. With these concerns in mind, it is critical to assess potential vulnerability based on the best available data as a means of ensuring that investment in new infrastructure is strategic, and is located in areas where new infrastructure and the additional development that it facilitates are least vulnerable to impacts and repeat loss.

The following sections provide a brief summary and map of the Suncoast Connector study area, information about historic sea level changes and impacts from storms within the study area, future potential vulnerability from storms and sea level rise, existing high priority ecological corridors, the relationship between new infrastructure and urbanization, and a short summary of conclusions and recommendations to maximize resiliency in the region and reduce future vulnerability. Note that this is not an exhaustive study and is based on the best readily available existing data and research. Data and maps included in this paper are not intended for use in detailed planning purposes, and all statistics are intended to be estimates.

The Multi-use Corridors of Regional Economic Significance Program (M-CORES)

The Florida Legislature created the Multi-use Corridors of Regional Economic Significance Program (M-CORES) in 2019 (Laws of Florida Chapter 2019-43 [Ch. 2019-43], 2019). The Legislature describes the purpose and objectives of the M-CORES program as follows:

> "The purpose of the program is to revitalize rural communities, encourage job creation, and provide regional connectivity while leveraging technology, enhancing quality of life and public safety, and protecting the environment and natural resources. The objective of the program is to advance the construction of regional corridors that are intended to accommodate multiple modes of transportation and multiple types of infrastructure." (Ch. 2019-43, 2019, p. 3)

To pursue these outcomes, the Legislature identifies three corridors for the construction of tolled facilities to be a part of the Florida turnpike system (Ch. 2019-43, 2019, pp. 3-4). The three corridors are the Southwest-Central Florida Connector, the Suncoast Connector, and the Northern Turnpike Connector (Ch. 2019-43, 2019, p. 3).

The Suncoast Connector Corridor Study Area

The study area for the Suncoast Connector corridor incorporates eight predominantly rural counties: Citrus, Levy, Dixie, Gilchrist, Lafayette, Taylor, Madison, and Jefferson. Primary existing transportation corridors include Interstate 10, U.S. 19/U.S. 27/U.S. 98, and a number of other state and local roads. Development consists primarily of small towns with populations under 10,000, with significant areas of coastal wetlands, timberland, conservation, springs, and historic cultural attractions. Coastal topography is characterized by low coastal to inland gradients, amplifying the extent of coastal flooding impacts. As part of this paper, the vulnerability of the U.S. 19/U.S. 27/U.S. 98 corridor is being evaluated in particular as a means of determining potential impacts to the primary existing north/south road corridor within the study area. The total length of this corridor within the study area is approximately 175 miles. It consists of 4 lanes along the majority of its length and is classified as an evacuation corridor.

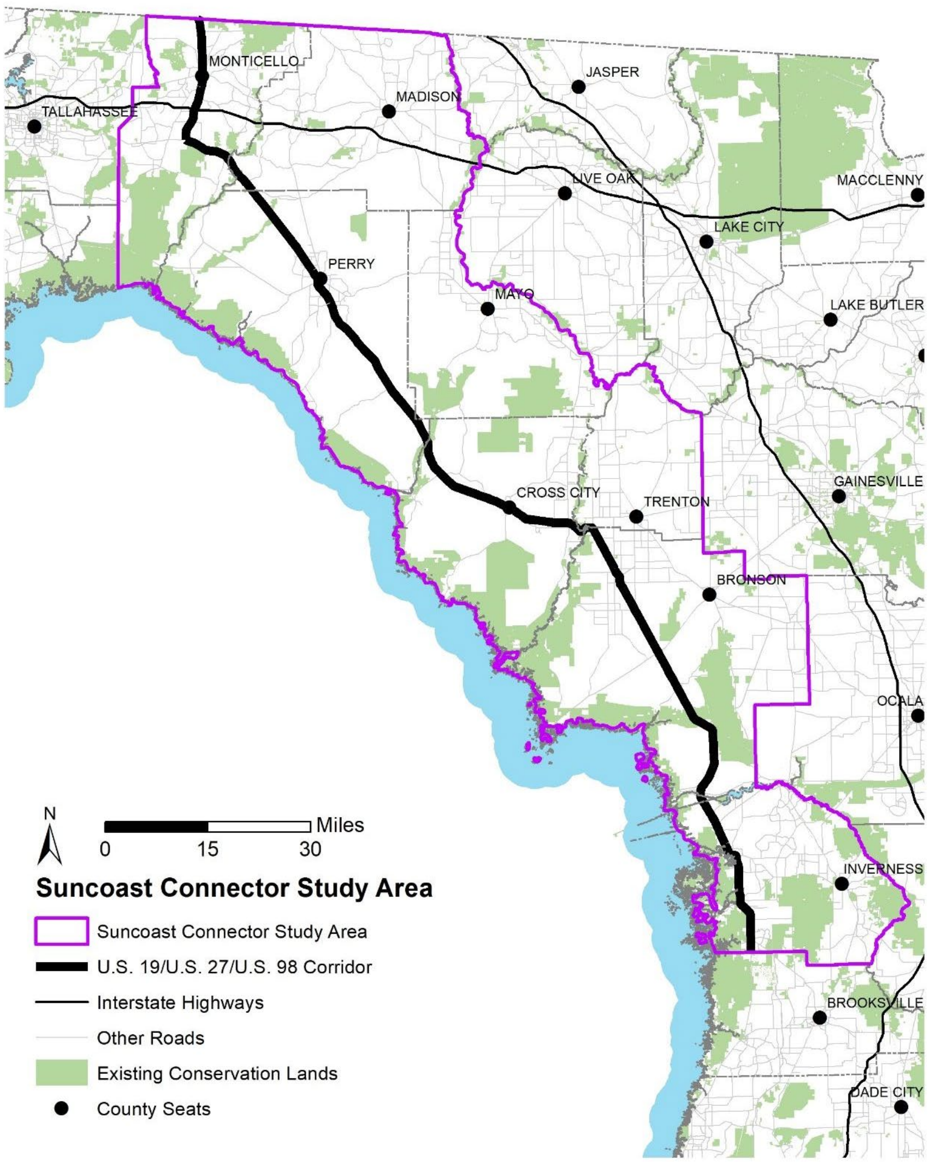

Figure 1. Suncoast Connector Study Area

Vulnerability to Sea Level Rise and Storms

Historic and Current Vulnerability to Storms and Flooding

Historic Impacts from Storms

Florida's Gulf Coast, including the eight counties in the Suncoast Connector study area, are vulnerable to the impacts of coastal storms and hurricanes. During recorded history, tropical storms and hurricanes have crisscrossed the Suncoast Connector study area (Figures 2 and 3). Along with the storm winds comes storm surge, which is a temporary rise in sea level associated with a storm (NOS, 2019). The storm surge combines with astronomical tides to form *storm tides* that can inundate coastal areas (NOS, 2019). Table 1 shows a partial listing of the storm tides expressed in feet above Mean Higher High Water (MHHW) that have been recorded at the National Ocean Service (NOS) tide gauge on Cedar Key since 1950.

The bathymetry, topography, and coastline shape make the Suncoast Connector study area particularly vulnerable to inundation from storm tides. Peak storm surge increases over low-sloping sea floors, such as those found along Florida's Gulf Coast (Irish et al., 2008 & Li et al., 2013). Similarly, the low-lying topography allows water to move inland. Higher storm surge is also more likely to impact areas of the coast that bow inward because winds can funnel the water into those areas (UCAR, 2020). This makes the area near the curve of Florida's Big Bend more vulnerable to storm surge when winds are blowing from the south/southwest.

In recent years, Hurricane Hermine, which made landfall near St. Marks in 2016 as a Category 1 hurricane, caused significant damage in the Big Bend region. Along the coasts of Jefferson, Taylor, Dixie, and Levy Counties, inundation above ground level reached 4-7 feet. Near Steinhatchee, the Steinhatchee River crested nearly 4 feet above flood stage. Rain and freshwater flooding also damaged structures in Citrus County (Berg, 2017). Figures 4-5 show high water marks within the study area for both Hurricane Hermine, as well as the 2018 Hurricane Michael.

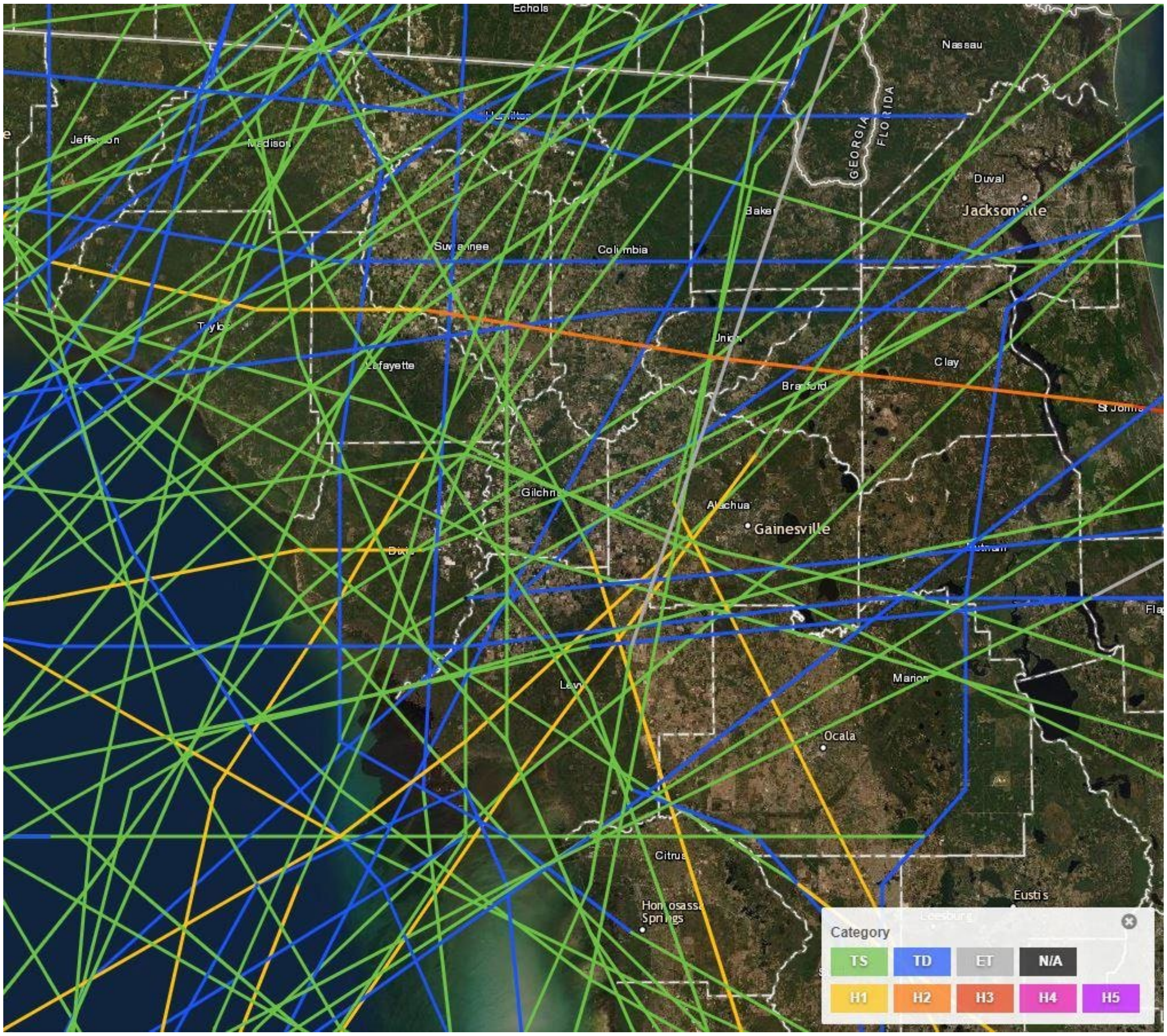

Figure 2. Historical tracks of tropical storms and tropical depressions from 1853 to present (Source: Office for Coastal Management, NOAA).

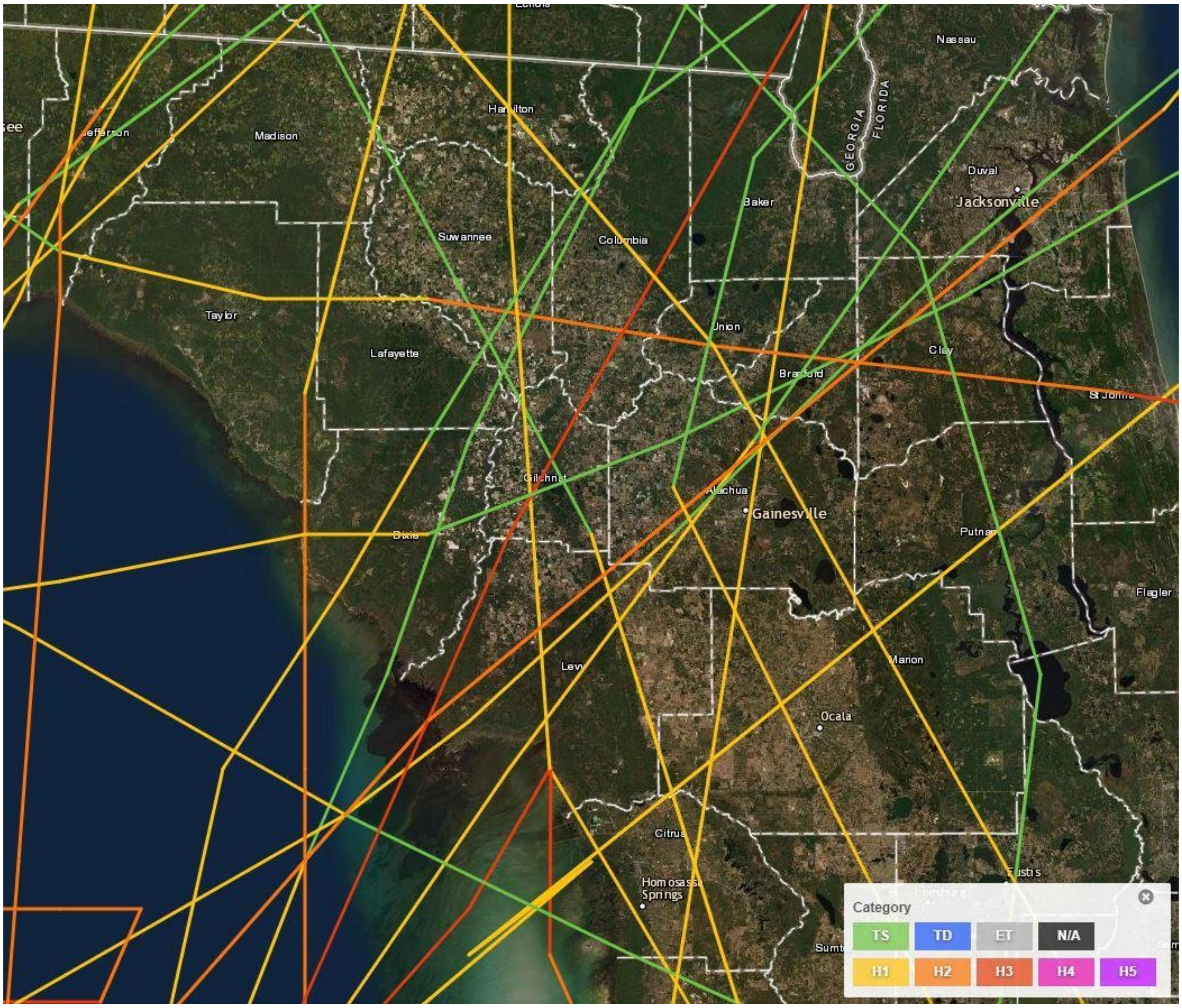

Figure 3. Historical hurricane tracks from 1852 to present. (Source: Office for Coastal Management, NOAA).

Table 1. A partial list of major storm tide events recorded at Cedar Key. Data from NOAA.

Storm Tide Event	**Date**	**Storm Tide at Cedar Key (MHHW feet)**
Hurricane Easy	5 September 1950	2.01
Hurricane Alma	9 June 1966	4.00
Hurricane Agnes	19 June 1972	4.15
Hurricane Eloise	23 September 1975	1.76
Extra-Tropical Event	23 April 1983	2.85
Hurricane Elena	31 August 1985	5.41
Hurricane Juan	1 November 1985	3.11
Hurricane Kate	21 November 1985	1.43
Extra-Tropical Event (No-Name Storm)	13 March 1993	4.96
Hurricane Allison	5 June 1995	3.66
Hurricane Opal	5 October 1995	3.40
Tropical Storm Josephine	8 October 1996	5.15
Hurricane Earl	3 September 1998	3.50
Extra-Tropical Event	24 July 2001	2.88
Tropical Storm Bonnie	12 August 2004	1.29
Hurricane Frances	6 September 2004	2.69
Hurricane Ivan	15 September 2004	2.47
Hurricane Dennis	10 July 2005	3.94
Tropical Storm Debby	25 June 2012	4.44
Tropical Storm Colin	6 June 2016	3.59
Hurricane Hermine	2 September 2016	5.91
Hurricane Michael	10 October 2018	4.09

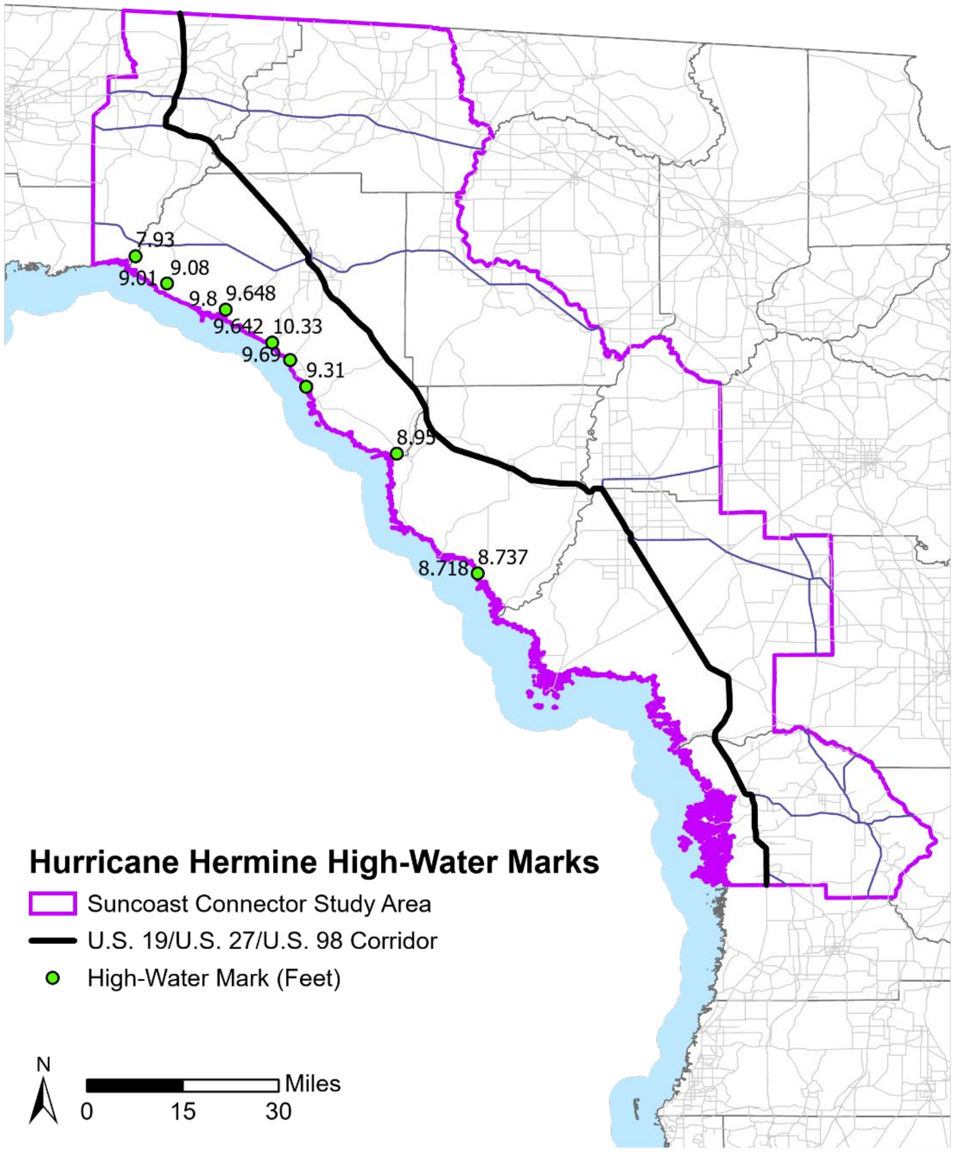

Figure 4. High-water marks from Hurricane Hermine (2016). (Source: USGS).

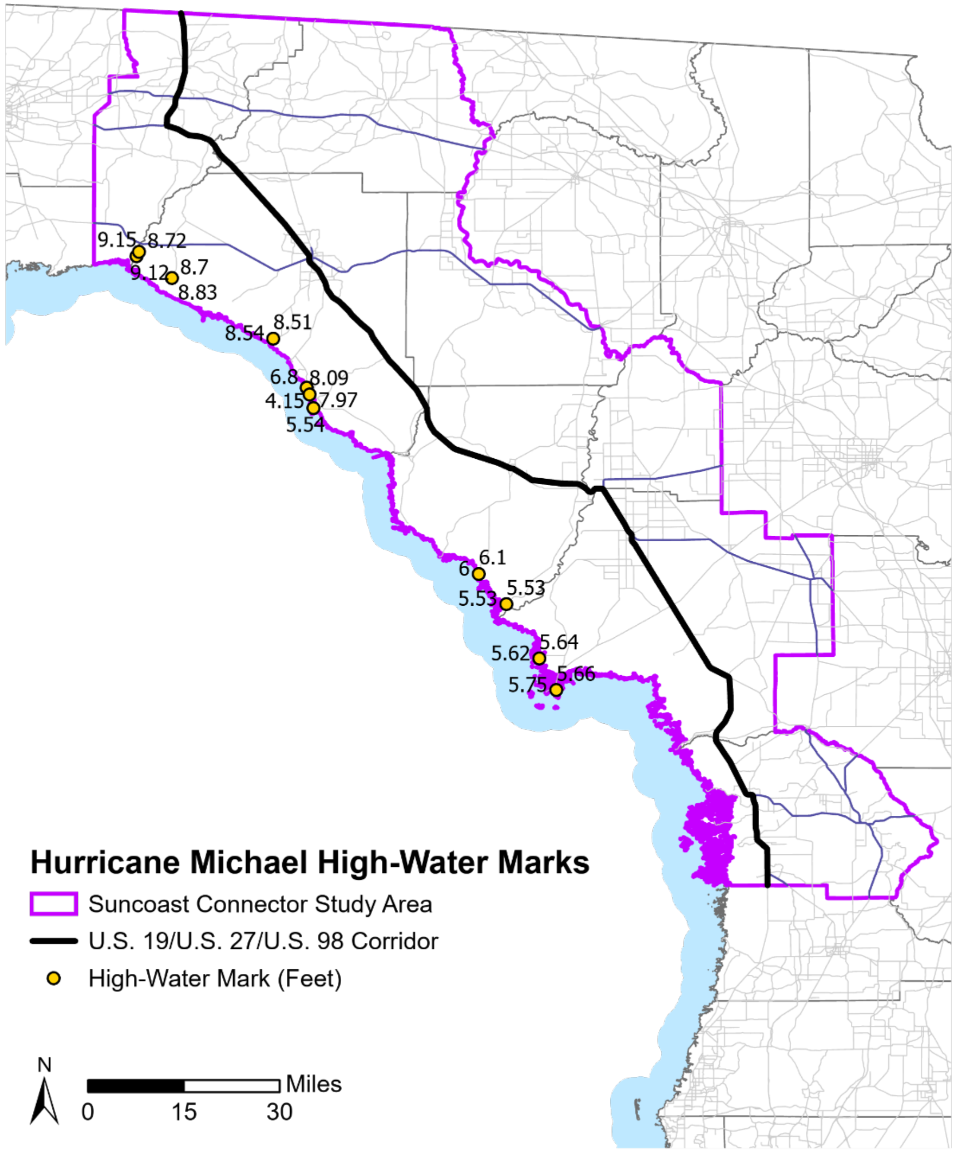

Figure 5. High-water marks from Hurricane Michael (2018). (Source: USGS).

Current Vulnerability to Flooding and Storm Surge

The vulnerability of the Suncoast Connector study area and existing major road corridors to future storm surge based on *current* sea levels is shown as follows. Figures 6-7 show the percentage of existing road corridors within the 100 and 500 year floodplains and the Category 5 storm surge zone. Digital Flood Insurance Rate Map (DFIRM) data was used to identify 100 and 500 year floodplains, defined as the areas that would be inundated by a flood event having either a one percent or 0.2 percent chance of being equaled or exceeded in any given year (FEMA, 2019). Storm surge data was obtained from the Florida Division of Emergency Management and identifies areas inundated by tropical storm surge, as well as storm surge from hurricane Categories 1-5, which are classified according to the Saffir-Simpson

Hurricane Wind Scale (Table 2). Data quantifying roadway impacts was obtained from the University of Florida GeoPlan Center Sea Level Scenario Sketch Planning Tool (https://sls.geoplan.ufl.edu/), an application developed with funding from the Florida Department of Transportation (FDOT) to assist with identifying transportation infrastructure vulnerable to current and future flood risks, and using the Florida Department of Transportation Roads Characteristics Inventory (RCI) database. Percentage impacts are identified for specific segments of roadway within the study area. Roadways that are highlighted and shown as having a percentage of their length impacted are not necessarily impacted throughout the entire highlighted segment.

Table 3 shows the total miles of the U.S. 19/U.S. 27/U.S. 98 corridor within the 100 year floodplain, 500 year floodplain, and Category 1-5 storm surge zones, as well as the percentage and total acres of the study area within floodplain and storm surge zones.

Table 2. Saffir-Simpson Hurricane Wind Scale (n.d.a). Data from NOAA.

Hurricane Category	**Sustained Wind Speeds**
Category 1	74-95 mph
Category 2	96-110 mph
Category 3	111-129 mph
Category 4	130-156 mph
Category 5	157+ mph

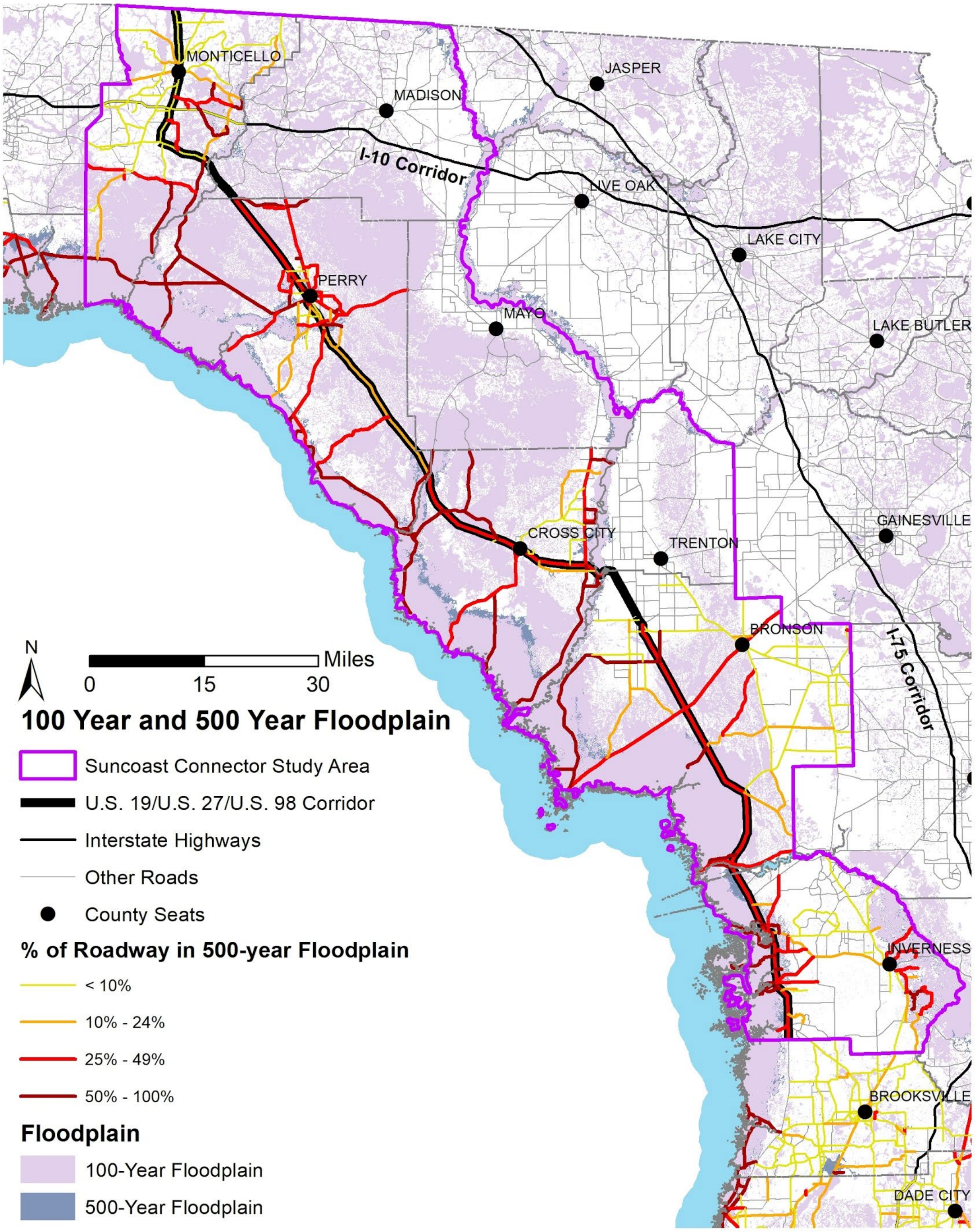

Figure 6. Roadways and portions of the study area within the floodplain.

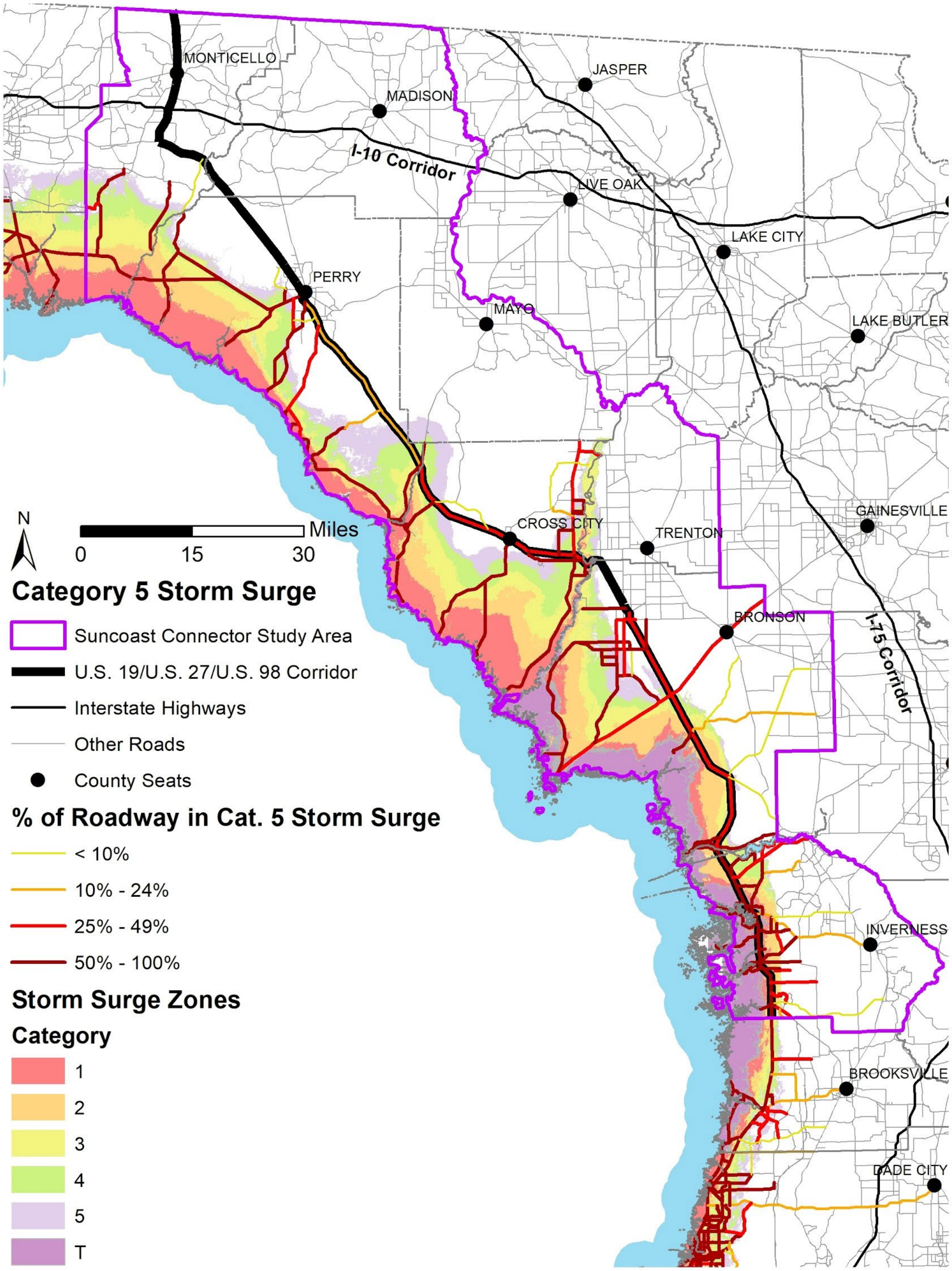

Figure 7. Percentage of roadways impacted by a Category 5 storm surge.

Table 3. Miles, percent and acres of the U.S. 19/U.S. 27/U.S. 98 Corridor and Suncoast Connector Study Area within the 100 and 500 year floodplain and storm surge zones. All statistics are estimates. Roadway statistics were obtained using the Sea Level Scenario Sketch Planning Tool and using the Florida Dept of Transportation Roads Characteristics Inventory (RCI) database.

	Miles of the U.S. 19/U.S. 27/U.S. 98 Corridor	Percent of the U.S. 19/U.S. 27/U.S. 98 Corridor	Total Miles of Roadway Impacts within Study Area	Percent of the Suncoast Connector Study Area	Acres of the Suncoast Connector Study Area
Floodplain					
100 Year	37	21%	334	54%	1,974,176
500 Year	44	25%	286	56%	2,047,648
Storm Surge Zones					
Category 1	10	6%	70	10%	365,886
Category 2	28	16%	163	16%	588,624
Category 3	38	22%	273	21%	766,671
Category 4	49	28%	407	26%	949,662
Category 5	59	34%	498	30%	1,107,011

Future Sea Level Rise and Storm Vulnerability

Historic Sea Level Changes

The State of Florida has a long history of dynamic sea level changes that have affected the coastline and upland areas. Modern-day Florida is the emergent portion of a plateau known as the Florida Platform (Donoghue, 2011; Hine et al., 2017). Peninsular Florida lies toward the eastern side of the plateau, and the submerged western portion of the plateau forms the continental shelf in the Gulf of Mexico (Hine & Locker, 2011). This shelf ranges in width from 25 km to 250 km, and much of the shelf is relatively shallow at depths less than 100 m (Hine & Locker, 2011; Skarke, 2018). Beyond the continental shelf, the sea floor drops approximately 3,000 m (Skarke, 2018). Since the Florida Platform is a plateau, changes in sea level have markedly transformed the coastline of Florida throughout time. Geologic studies show that during periods of high sea levels, most of the Florida Platform was submerged (Hine et al., 2017). During cooler periods, large portions of the plateau emerged (Hine et al., 2017). For example, during the last glacial event sea levels in the Gulf were approximately 100 to 120 m lower than current levels (Donoghue, 2011; Hine et al., 2017). As a result, Florida's coastline was more than 100 km west of today's coastline (Donoghue, 2011). As the glaciers melted, sea levels rose at a variable rate that at times approached 40mm per year until the sea level in the Gulf reached its near-present-day level approximately 6,000 years ago (Donoghue, 2011).

Sea level changes in the recent past have been measured by tide gauges that measure the height of the water relative to a vertical point on land. These measurements, which capture the movement of the water relative to the vertical movement of the land, are known as relative sea level trends (RSL)(Rovere et al., 2016). The only tide gauge in the study area is located at Cedar Key. The RSL trend at Cedar Key is

2.13 mm/yr based on monthly mean sea level data from 1914 to 2018, which is the equivalent of a 0.70 feet change in 100 years (Figure 8)(NOAA, n.d.).

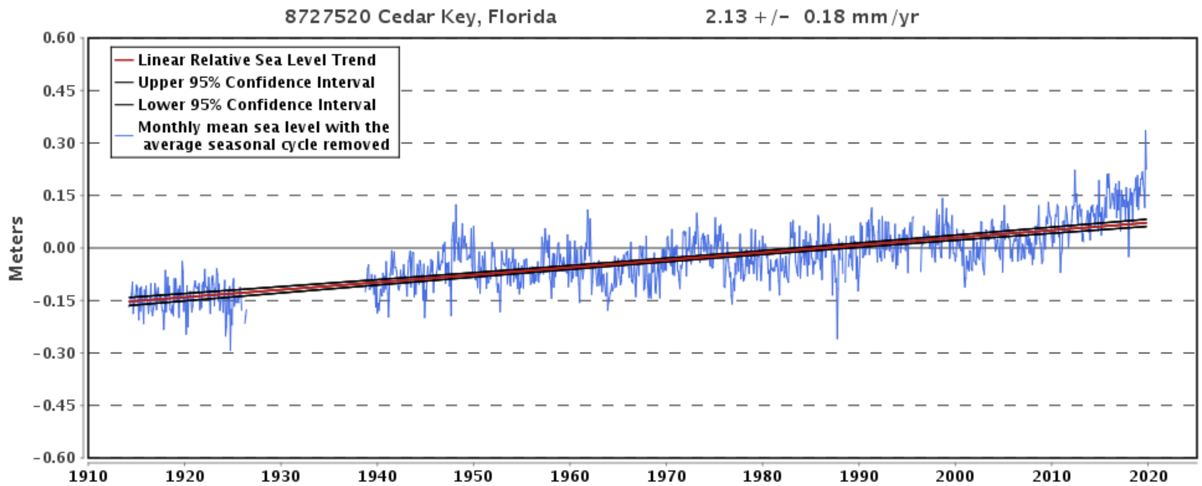

Figure 8. Relative sea level trend, Cedar Key, Florida. (Source: NOAA).

Since 1992, satellite altimeters have been utilized to record global sea levels, which are the average elevations of the Earth's oceans (Center for Satellite Application & Research, 2015; NOAA, 2019). According to these measurements, the global ocean mean sea level trend is 2.9mm/yr. However, the mean sea level trend in the Gulf of Mexico is 3.8mm/yr.

Future Sea Level Rise Scenarios

The scientific community projects that sea level will continue to rise. However, projections vary because many processes affect sea level, especially at the local level, and scientists utilize different methods to construct projections (Mitchum et al., 2017). Three of the more commonly accepted projections come from the Intergovernmental Panel on Climate Change (IPCC), the U.S. Army Corps of Engineers (USACE), and the National Oceanic and Atmospheric Administration (NOAA) Coastal Services.

The IPCC, an international organization established by the United Nations and the World Meteorological Organization for the purpose of assessing climate change science, utilizes scenarios to project global mean sea level rise (IPCC, n.d.; IPCC, 2014). The Representative Concentration Pathways (RCP) scenarios consider "different 21st century pathways of GHC emissions and atmospheric concentrations, air pollutant emissions and land use" (IPCC, 2014, 7). The RCP2.6 scenario assumes strong emissions mitigation (IPCC, 2014). RCP8.5 utilizes high GHC emissions, while RCP4.0 and RCP6.5 use intermediate levels (IPCC, 2014).

The U.S. Army Corps of Engineers (USACE) utilizes three different future scenarios to develop their projections. The USACE Low Curve is a linear extrapolation of the historic rate of global sea level rise (USACE, n.d.). The USACE Intermediate Curve adds the local rate of vertical land movement to the modified NRC Curve I with consideration of the recent IPCC projections and modified NRC projections (USACE, n.d.). The USACE High Curve adds the local rate of vertical land movement to the modified NRC III curve with consideration of the recent IPCC projections and modified NRC projections (USACE, n.d.).

NOAA has six sea level rise scenarios: Low, Intermediate, Low Intermediate, Intermediate High, High, and Extreme. The Low scenario is based on the current rate of sea level rise (Sweet et al., 2017). The Intermediate through High scenarios are the same as the scenarios developed by the Department of Defense Working Group. For an explanation of how the scenarios were calculated, see the April 2016 report *Regional Sea Level Rise Scenarios for Coastal Risk Management* {https://www.usfsp.edu/icar/files/2015/08/CARSWG-SLR-FINAL-April-2016.pdf). NOAA recently added an Extreme scenario, which takes into consideration more recent modeling on ice loss from Greenland and Antarctica (Lindsey, 2019).

The Southeast Florida Regional Climate Compact has also developed Regionally Unified Sea Level Rise (SLR) Projections for Southeast Florida, which it updates at least every five years (Southeast Florida Regional Climate Compact, 2020). The Compact released its 2019 projections in December (Figure 9) (Southeast Florida Regional Climate Compact, 2020). In the updated projections, the Compact extended the planning horizon to account for long-lasting infrastructure, and the sea level rise curves are slightly higher (Southeast Florida Regional Climate Compact, 2020). When planning long-range projects that 1) have a long design life, 2) are not easily removable, or 3) are interdependent with other infrastructure or services, the Compact utilizes the NOAA High projection curve (Sea Level Rise Work Group, 2015).

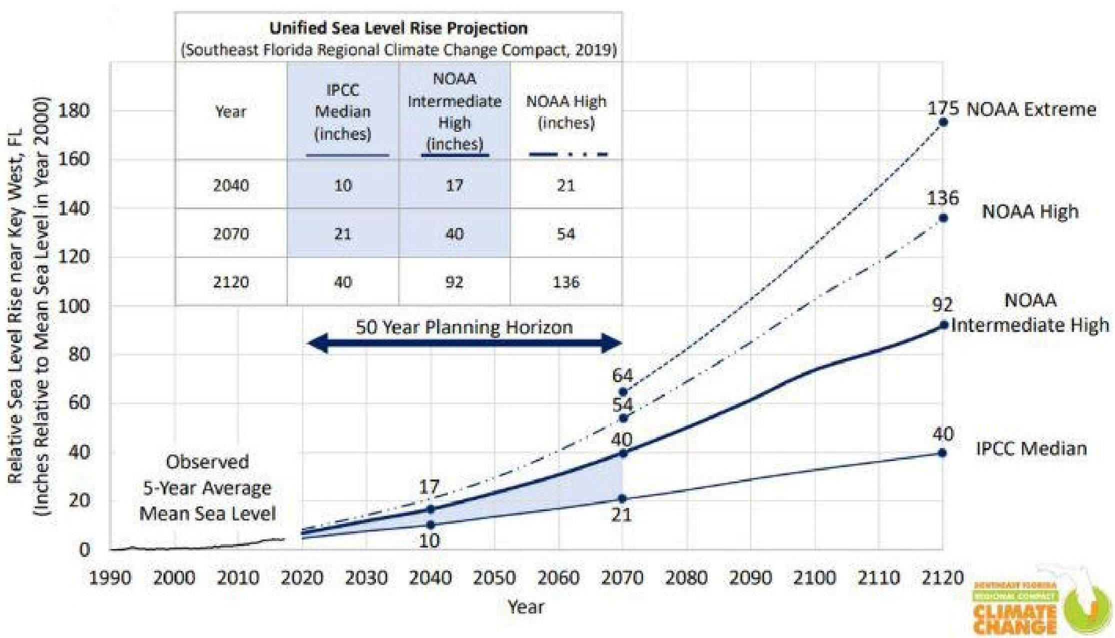

Figure 9. Unified sea level rise projections for Southeast Florida. (Source: Southeast Florida Regional Compact).

The following section describes the vulnerability of the Suncoast Connector study area and specifically the U.S. 19/U.S. 27/U.S. 98 corridor to future sea level rise using data from the University of Florida GeoPlan Center Sea Level Scenario Sketch Planning Tool. Sea level rise scenarios are derived from the U.S. Army Corps of Engineers (USACE) and National Oceanic and Atmospheric Administration (NOAA)/National Climate Assessment projections. Scenarios are based on a 5-meter horizontal resolution LiDAR-based digital elevation model (DEM), are tidally and hydrologically adjusted to show mean higher high water (MHHW) and remove isolated inundated areas not connected to a major waterway, and are adjusted for relative sea level rise within the study area (for more information see https://sls.geoplan.ufl.edu/)

Figure 10 shows the portions of the study area potentially impacted by future sea level rise by 2100 under a NOAA High (6.7 feet), NOAA Intermediate High (4 feet), and NOAA Intermediate Low/USACE Intermediate scenario (1.7 feet), and the percentage of existing road corridors impacted by the NOAA High scenario. Table 4 shows the total miles of the U.S. 19/U.S. 27/U.S. 98 corridor impacted by each scenario, as well as the percentage and total acres of the study area. Although the percentage and miles of roadway directly inundated by these scenarios appear to be less than the potential impacts from current storm surge and floodplain vulnerability, it is important to note that sea level rise will also exacerbate storm surge and other flooding, impact underground infrastructure, affect erosion and sedimentation patterns, and impact surrounding ecosystems and land uses through flooding and salinity changes. These changes are more difficult to model but should not be discounted.

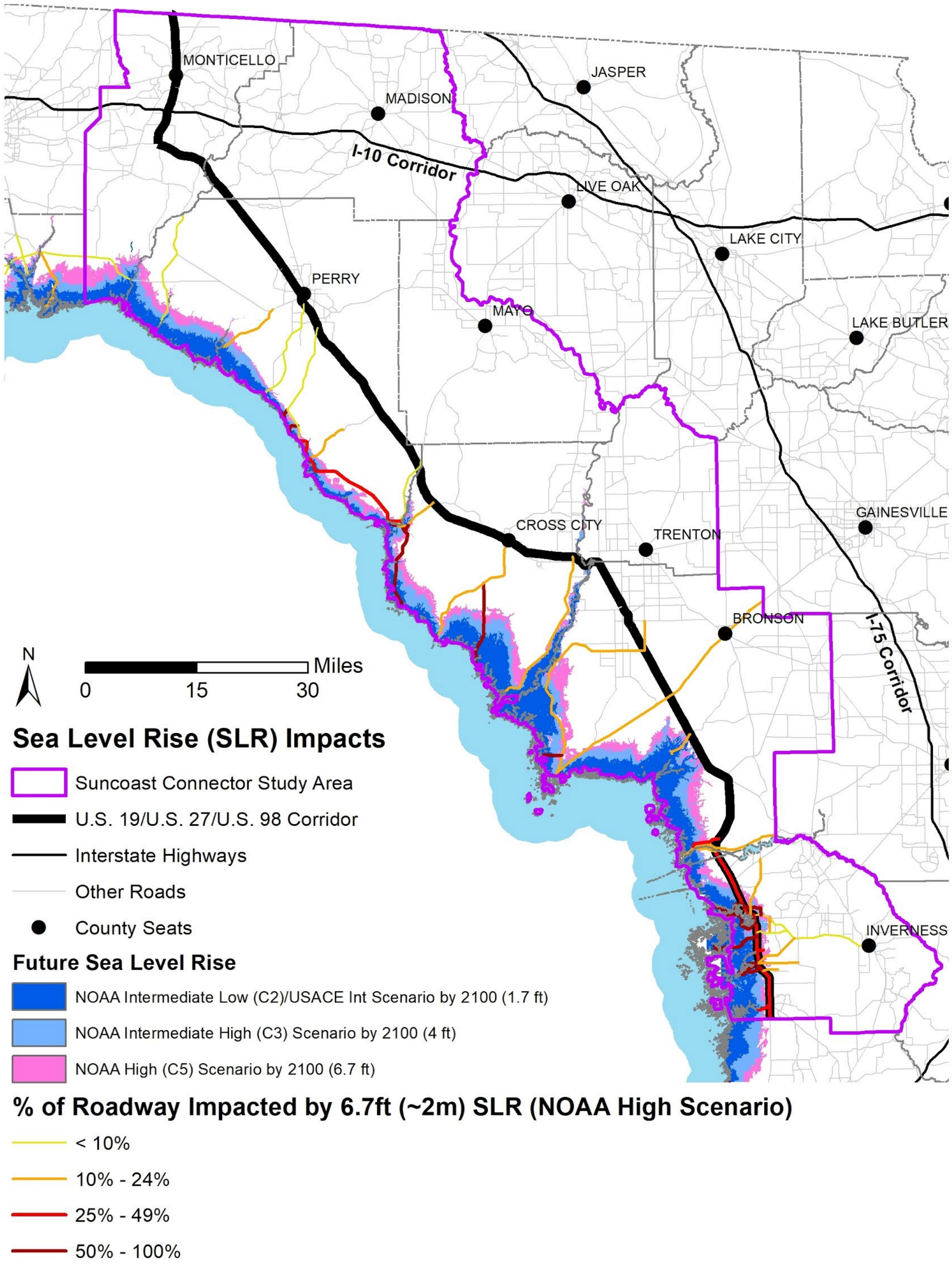

Figure 10. Impacts to roadways and the study area from sea level rise based on a NOAA High (C5) scenario of approximately 6.7 ft (~2m) by 2100

Table 4. Miles, percent and acres of the U.S. 19/U.S. 27/U.S. 98 Corridor and Suncoast Connector Study Area impacted by sea level rise. All statistics are estimates. Roadway statistics were obtained using the Sea Level Scenario Sketch Planning Tool and using the Florida Dept of Transportation Roads Characteristics Inventory (RCI) database.

	Miles of the U.S. 19/U.S. 27/U.S. 98 Corridor	**Percent of the U.S. 19/U.S. 27/U.S. 98 Corridor**	**Total Miles of Roadway Impacts within the Study Area**	**Percent of the Suncoast Connector Study Area**	**Acres of the Suncoast Connector Study Area**
Sea Level Rise Scenario for 2100					
NOAA Intermediate Low (C2)/USACE Intermediate Scenario (1.7ft)	N/A	N/A	2	4%	163,277
NOAA Intermediate High (C3) Scenario (4ft)	1	0.5%	41	7%	261,071
NOAA High (C5) Scenario (6.7ft)	7	4%	99	10%	361,148

Future Vulnerability from Combined Sea Level Rise and Storm Surge

Historic storms are not necessarily good indicators of future storms. Higher sea levels added to storm surges will impact areas further inland than previous storms (Lindsey, 2019), while also increasing the frequency of high-tide flooding. Studies indicate that hurricane intensity will also increase, and that the increase in intensity will add to the surge height (Balaguru et al., 2016; Knutson et al., 2013). Some studies project a decrease in storm frequency, but an increase in intense (Category 4 & 5 hurricanes) storms and amount of precipitation (see Knutson et al., 2013 for example).

Vulnerability to a combination of storm surge and future sea level rise was assessed using two different methods. The first method utilized probabilistic storm surge data, while the second method interpolated worst-case scenario data. The first assessment was developed by University of Florida emeritus faculty member Dr. Paul Zwick using the Hazus software application provided by FEMA (see https://www.fema.gov/hazus). Hazus works in conjunction with GIS to identify areas vulnerable to floods, hurricanes, tsunamis, and earthquakes (FEMA, n.d.). Zwick utilized the flood model for three storm surge scenarios. The first scenario analyzed the storm surge impacts of a 100-year probabilistic storm. The second and third scenario analyzed storm surge impacts of a 100-year probabilistic storm with the addition of 0.5 meter (1.64 ft) and 1 meter (3.28 ft) of sea level rise respectively. It should be noted that these are only very general estimates of potential impacts and that actual combined sea level rise and storm surge impacts could vary significantly based on storm and sea level characteristics.

Figure 11 shows the results of these analyses within the study area. These sea level rise scenarios are similar (though not the same) as the NOAA Intermediate Low and NOAA Intermediate High sea level scenarios shown in Figure 10, but due to available data are not exactly the same. These are therefore conservative assessments of potential impacts, and actual impacts could be greater with sea level rise of more than 1 meter. Table 5 identifies the miles of the U.S. 19/U.S. 27/U.S. 98 corridor, all roadways within the study area, and percentage/acres of the study area impacted by each scenario.

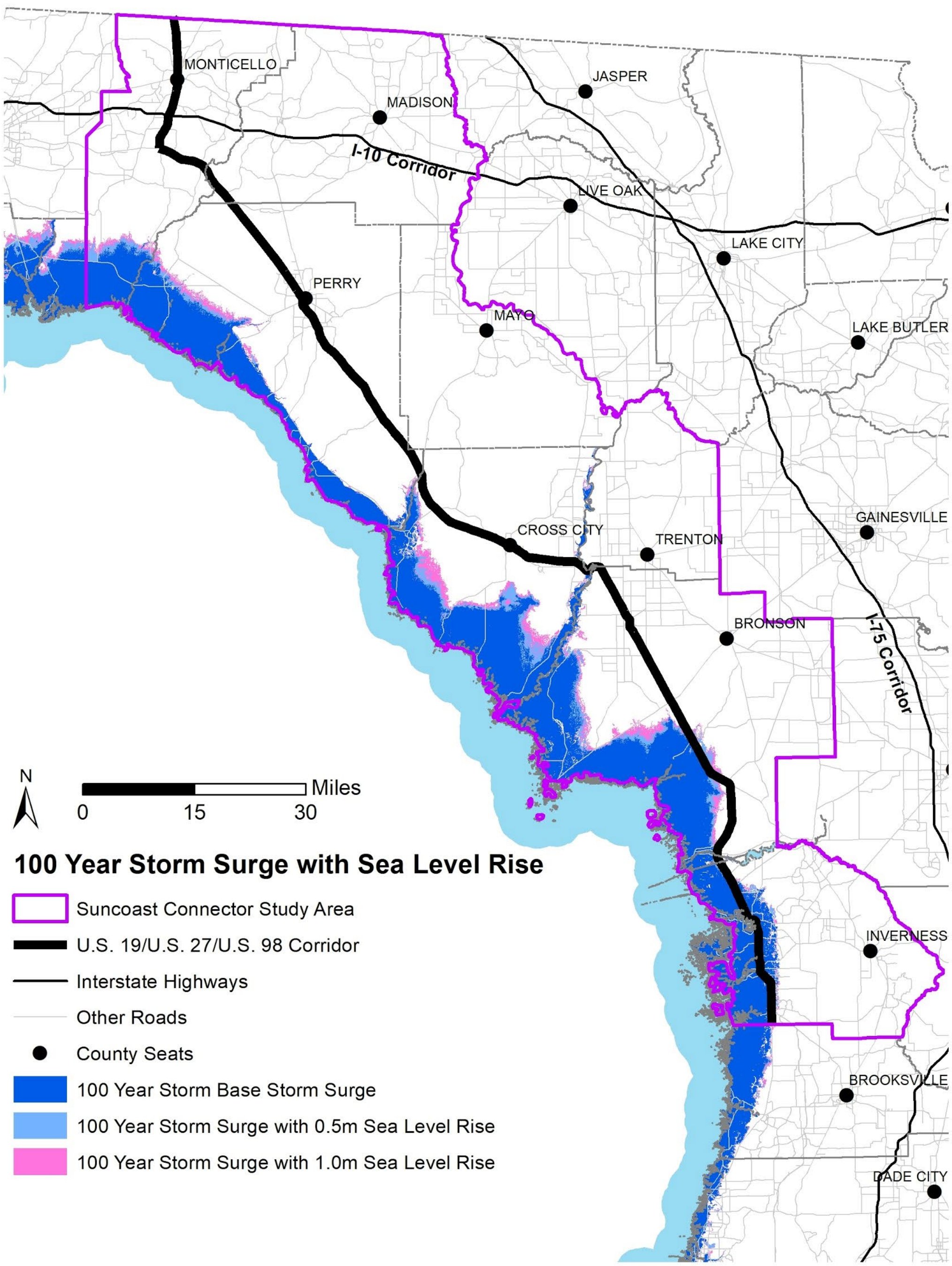

Figure 11. Impacts within the study area from a combination of 100 year storm surge and sea level rise.

Table 5. Miles, percent and acres of the U.S. 19/U.S. 27/U.S. 98 Corridor and Suncoast Connector Study Area impacted by storm surge and sea level rise combined. All statistics are estimates. Roadway statistics were derived from the Florida Dept of Transportation Roads Characteristics Inventory (RCI) database.

	Miles of the U.S. 19/U.S. 27/U.S. 98 Corridor	**Percent of the U.S. 19/U.S. 27/U.S. 98 Corridor**	**Total Miles of Roadway Impacts within the Study Area**	**Percent of the Suncoast Connector Study Area**	**Acres of the Suncoast Connector Study Area**
Storm Surge and Sea Level Scenario					
Base 100 year storm surge	35	20%	205	14%	517,486
100 year storm surge with a 0.5 meter sea level rise	39	22%	228	16%	572,429
100 year storm surge with a 1 meter sea level rise	48	27%	255	17%	623,233

The second assessment utilized a composite approach (versus a probabilistic approach) to identify the extent of potential worst-case storm tide flooding. This methodology interpolated the Maximums of Maximum Envelopes of Water (MOMs) for a Category 5 hurricane at high tide combined with 0.5m and 1m of sea level rise. To generate the underlying MOMs used in this assessment, the National Weather Service (NWS) runs thousands of hypothetical hurricanes (NOAA, n.d.b). These MOMs are a compilation of the worst-case storm tide generated by the hypothetical hurricanes in the SLOSH model for each location (NOAA, n.d.c). To determine the combined impacts of storm tide and sea level rise, 0.5m and 1m of sea level rise were added to the MOM outputs of the storm tide of a Category 5 hurricane at high tide. The extent of potential inundation was then interpolated using spatial analysis tools in ESRI's ArcGIS. This method of interpolation is outlined in the NOAA publication *Mapping Coastal Inundation Primer* (https://coast.noaa.gov/data/digitalcoast/pdf/coastal-inundation-guidebook.pdf).

Given that this is a composite approach, the area and roadways that could be impacted by storm tide inundation are greater than that projected by a probabilistic approach (Table 6). While a single storm or flood event is highly unlikely to inundate the percentage of roads and acres shown below, this assessment shows the percentage of roads and acres that could potentially be inundated by storm or flood events over time.

All models have limitations and can only provide a general estimate of the potential impacts of storm tide and sea level rise. One limitation of this assessment was the bounds of the MOM data which is generated for particular basins and focused on coastal areas. Additionally, since MOMs capture the worst-case storm tide at each location, no *single* hurricane or flood event is likely to generate the extent of regional flooding shown in the MOMs. As a result of these and other limitations, the actual combined impacts of storm tide and sea level rise could vary significantly.

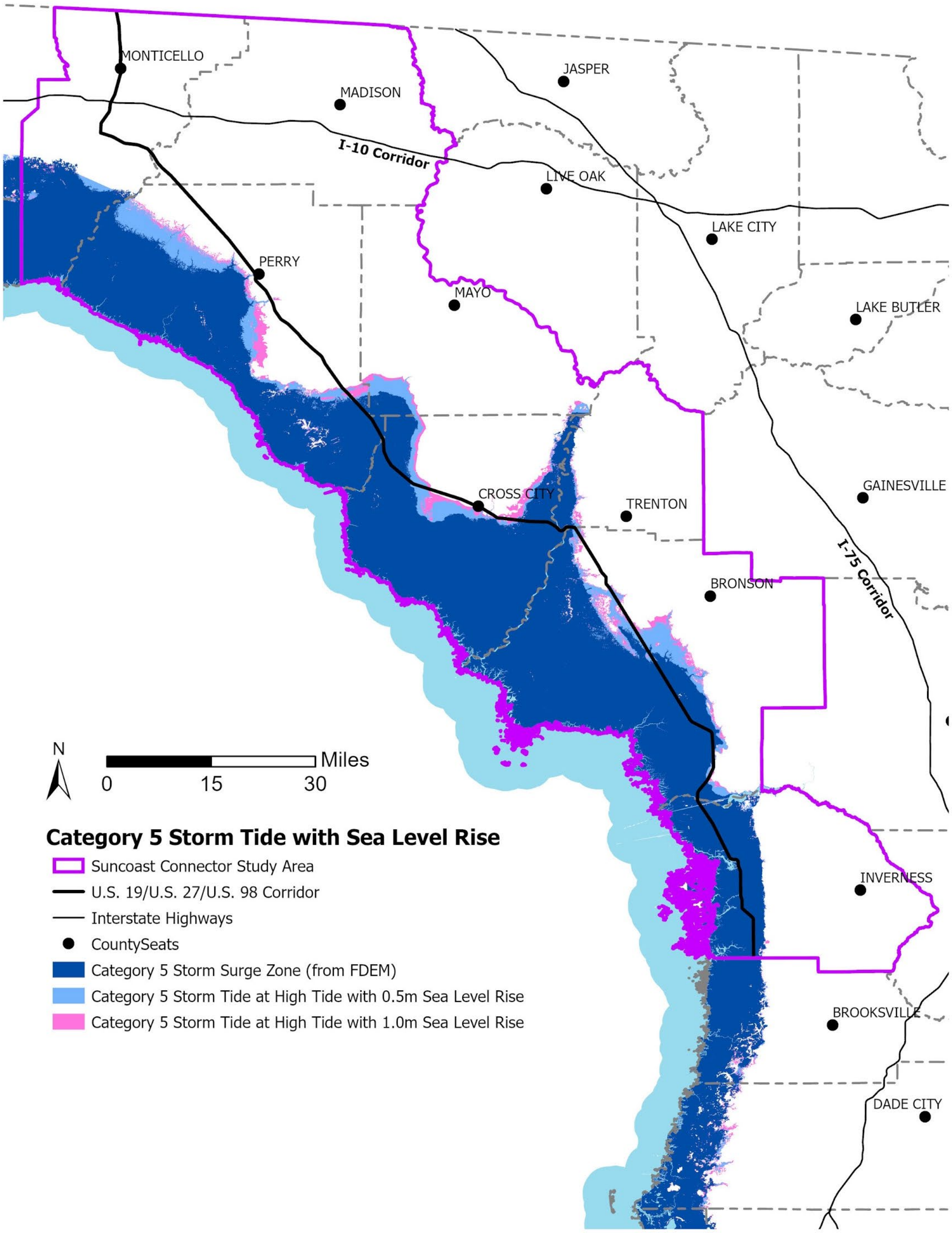

Figure 12. Impacts within the study area from a combination of Category 5 storm tide and sea level rise.

Table 6. Miles, percent and acres of the U.S. 19/U.S. 27/U.S. 98 Corridor and Suncoast Connector Study Area impacted by Category 5 hurricane storm tide and sea level rise combined. All statistics are estimates. Roadway statistics were derived from the Florida Dept of Transportation Roads Characteristics Inventory (RCI) database. Category 5 base storm surge zone data was obtained from the Florida Division of Emergency Management (FDEM).

	Miles of the U.S. 19/U.S. 27/U.S. 98 Corridor	**Percent of the U.S. 19/U.S. 27/U.S. 98 Corridor**	**Total Miles of Roadway Impacts within the Study Area**	**Percent of the Suncoast Connector Study Area**	**Acres of the Suncoast Connector Study Area**
Storm Tide and Sea Level Scenario					
Category 5 Base Storm Surge Zone (from FDEM)	59	34%	498	30%	1,107,011
Category 5 hurricane storm tide at high tide with 0.5m sea level rise	73	42%	691	34%	1,269,842
Category 5 hurricane storm tide at high tide with 1m sea level rise	82	47%	746	36%	1,321,377

Ecological Connectivity

The Suncoast Connector study area contains a variety of significant hydrologic and ecological resources, and extensive undeveloped landscapes and ecosystems, including a major critical linkage within the Florida Ecological Greenways Network (FEGN), which is also part of the Florida Wildlife Corridor (http://floridawildlifecorridor.org/). Within these landscapes are significant natural communities and a variety of focal plant and animal species important at both state and federal levels. Much of the undeveloped landscapes in the study area have been protected via a complex of coastal conservation lands, but there are still important gaps along the coast and further inland. These areas, as well as agricultural and other land uses would be impacted by new infrastructure and related (sub)urbanization resulting from the M-CORES program.

The Florida Ecological Greenways Network (FEGN) is a statewide dataset that identifies and prioritizes a functionally connected statewide ecological network of public and private conservation lands. The FEGN guides the Florida Office of Greenways and Trails (OGT) ecological greenway conservation efforts, and promotes public awareness of the need for and benefits of a statewide ecological greenways network. It is also the primary data layer used to inform Florida Forever and other state and regional land acquisition programs regarding the most important ecological corridors and intact landscapes across the state.

Importantly, there are a number of published studies that describe changes in coastal forests in the Big Bend region already occurring in response to sea level rise (see Williams et al. 1999 for example). In the most recent 2016 update of the FEGN, high priority landscapes important for maintaining coastal to inland connectivity in the face of rising sea levels were identified. Landscapes within the Suncoast Connector study area are some of the best remaining opportunities for facilitating inland retreat of coastal ecosystems and focal species, as well as maintaining a functionally connected north-south ecological corridor.

Figures 13 shows Florida Ecological Greenways Network (FEGN) priorities within the study area based on the most recent 2016 FEGN update. Figure 14 shows important coastal to inland connectivity priorities that should be maintained to facilitate ecosystem and species migration up to a 3 meter sea level rise in areas of high landscape integrity (i.e. undeveloped, semi-natural, or natural landscapes). The 3 meter threshold is an arbitrary decision criteria used to guide more near term coastal inundation and land cover change due to sea level rise. But we also know that sea level rise is likely to surpass this 3 meter threshold in the next several centuries (if not sooner). The implication is that if we are going to maintain one of Florida's only remaining large and functionally connected coastal landscapes to ensure functional coastal retreat opportunities for native species, building a new highway in this regional landscape with primary and secondary impacts including more development is not compatible with the goal of protecting functional ecological connectivity in this region.

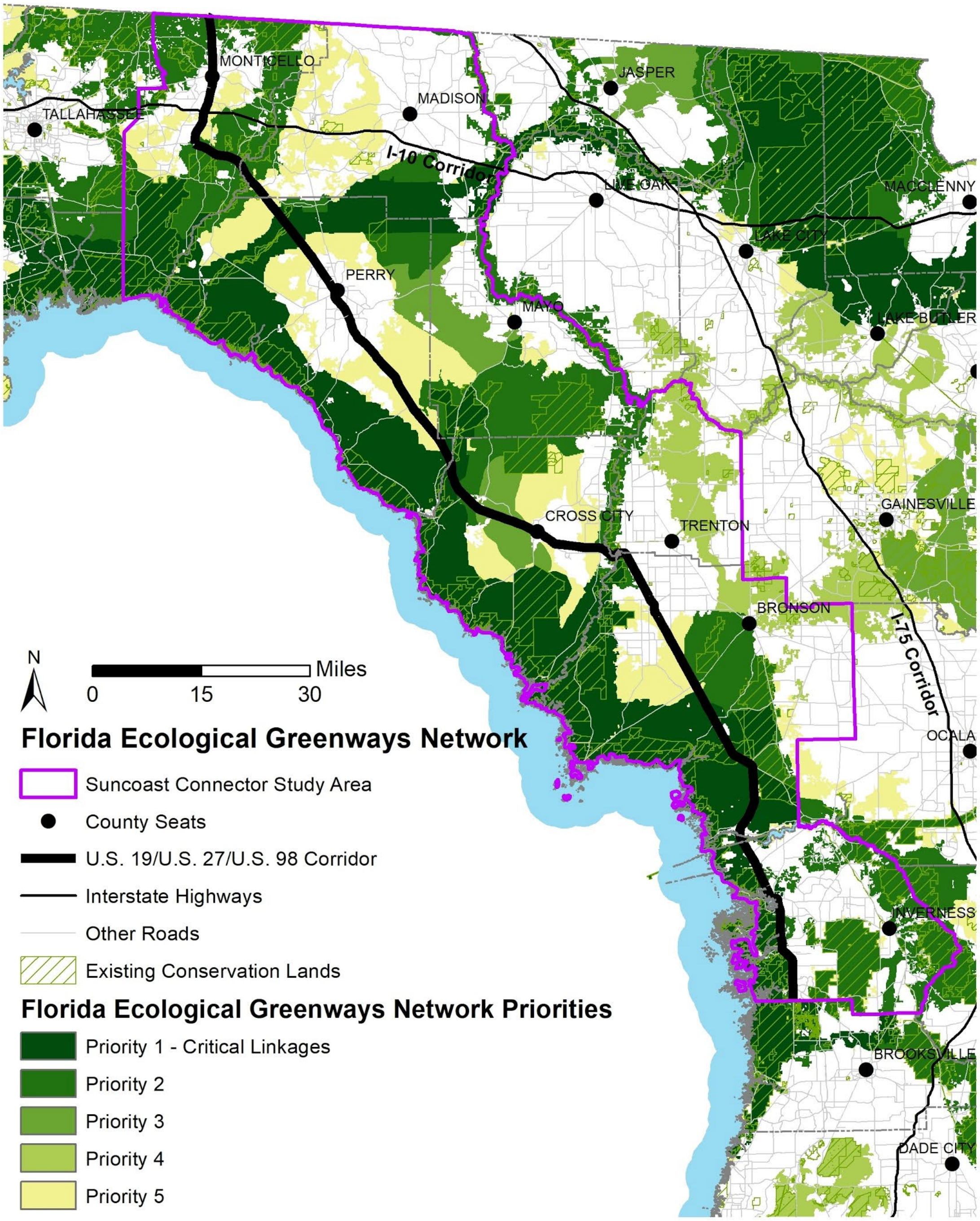

Figure 13. Florida Ecological Greenways Network (FEGN) Priorities within the Suncoast Connector study area.

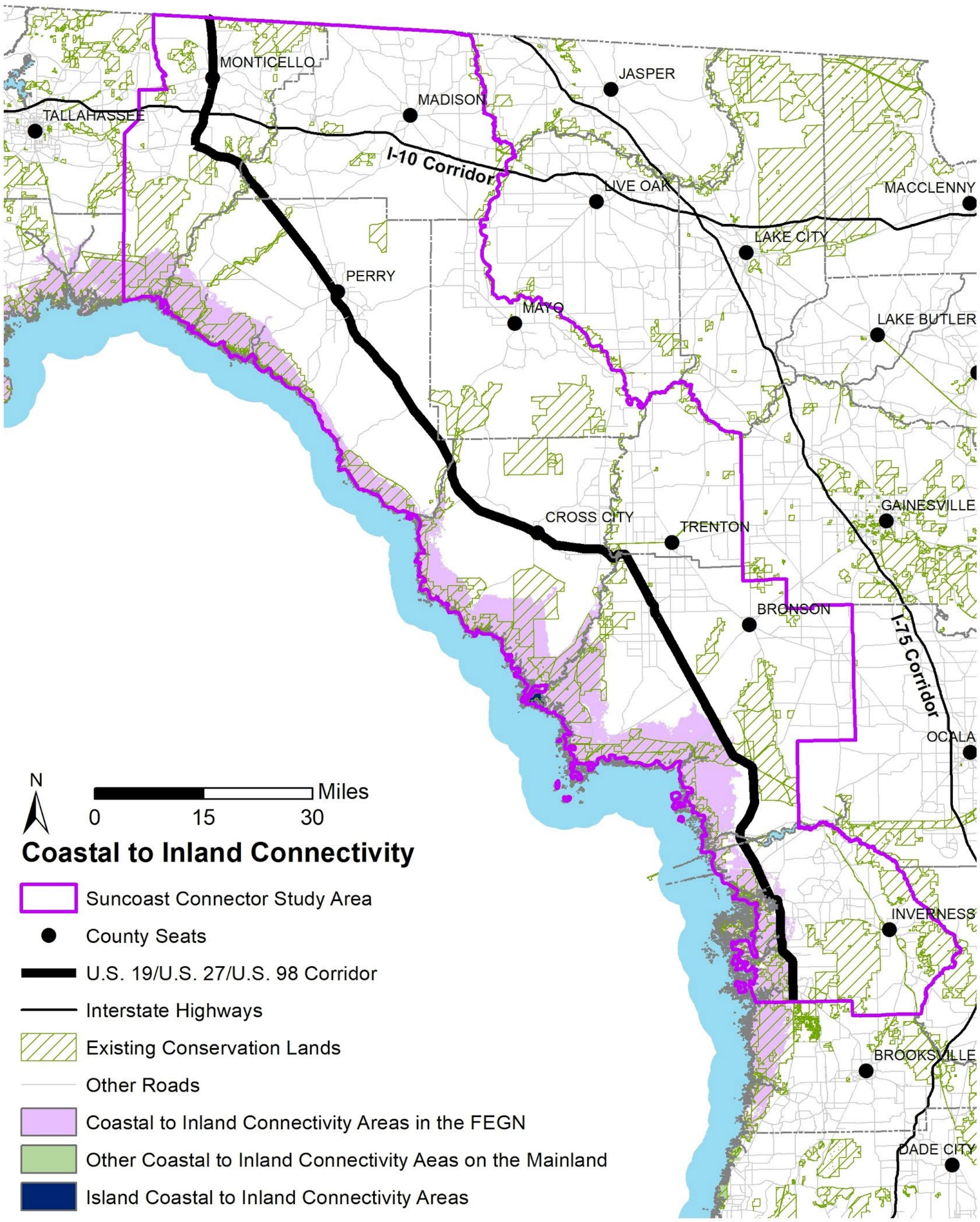

Figure 14. Coastal to inland ecological connectivity priorities within the Suncoast Connector study area.

The Connection between Transportation Infrastructure and Urbanization

Land requires public services to be suitable for urban development. To use land intensely, services like potable water, sewer, transportation, and other utilities must be available. The presence or absence of public services, therefore, can determine whether private real estate developers urbanize certain land.

This reality has led researchers to investigate induced growth, the concept that providing public services to land can spur the development of that land. In particular Robert Cervero—a professor of city and regional planning and the University of California at Berkeley—and Robert Noland—of the Department of Civil and Environmental Engineering at the Imperial College of Science, Technology, and Medicine, London—have studied the relationships between expressway development and induced growth.

Both researchers found that induced growth exists (Noland, 2001; Cervero, 2003).

Cervero explains the concept this way, “people and firms locate to explore the accessibility benefits created when freeways are upgraded.” (2003, p. 146). Noland similarly says, “land use patterns adjust to the newly available capacity and the resulting spatial allocation of activities. If speeds are higher, many residences and businesses will tend to relocate over time often resulting in longer distance trips.” (Noland, 2001, p. 51).

While this conclusion—that people locate homes and businesses on accessible land—seems too self-evident to be worth mentioning, policy-makers sometimes focus only on existing traffic when planning expressway development. That myopic view excludes acknowledging the land use patterns new road construction will inevitably cause.

Conclusions and Recommendations

The Suncoast Connector study area contains significant ecological, cultural, and agricultural assets, including sensitive ecosystems and hydrologic resources, critical ecological corridors, productive silviculture operations, and a number of culturally rich small towns and communities.

There is a clear link between the provision of new infrastructure and the expansion of intensive land uses. A new major highway and infrastructure corridor as proposed in SB 7068 along with the new development it facilitates will complicate resiliency efforts within the region and forever change the character of existing communities and landscapes. The resulting conversion of existing agricultural and silvicultural land uses to development will alter production within the region as well as the state and impact related benefits including water recharge, filtration, and habitat for focal species. Fragmentation of critical ecological corridors by development will significantly impact conservation planning, reduce functional connectivity and the ability for ecosystems to respond to sea level rise, and degrade or potentially eliminate habitat for some focal species. In addition, increased development within the study area will have impacts on water quality and supply, resulting in impacts to riverine and coastal ecosystems, as well as water dependent industries such as those in the Cedar Key region. This includes potential reduction in freshwater flows as a result of increased demand, which will change salinity levels and further increase the impact of sea level rise by reducing the ability of coastal ecosystems to resist and adapt to change.

The data in this paper shows that the study area and existing road corridor are currently at risk from flooding and that this risk will only increase in the future. Direct risks from sea level rise and storm surge, particularly to the existing U.S. 19/U.S. 27/U.S. 98 corridor, are highest in the southern portion of the study area in the vicinity of Homosassa, Crystal River, and Yankeetown, but continue along the coast throughout the study area. Over 50% of the study area where the existing U.S. 19/U.S. 27/U.S. 98 corridor is located and where a new toll road might be built is in the current 100 or 500 year floodplain, and at least 30% is vulnerable to storm surge from a Category 5 hurricane at current sea levels. Based on the existing vulnerability of the U.S. 19/U.S. 27/U.S. 98 corridor, which is also a hurricane evacuation route, plans to retrofit the existing corridor or add a new road corridor near it would need to address that vulnerability in order to maintain suitability for hurricane evacuation.

To minimize future additional risk to infrastructure and communities, it will be essential to avoid actions that increase the amount of vulnerable infrastructure and development in this region. While it is recognized that a certain degree of investment is necessary to maintain both a vibrant economy and existing levels of service, expansion of infrastructure within the Suncoast Connector study area as proposed in SB 7068 will only increase the amount and cost of development and assets at risk from existing and expanding coastal hazards. This will result in higher costs for mitigation and recovery from storm events, as well as increased costs for future adaptation to long term hazards such as sea level rise.

To minimize negative impacts within the study area, new infrastructure must be strategically located to direct growth in ways that considers both near term impacts on existing communities, agriculture, and natural resources, and reduces future vulnerability to storms and sea level rise. However the probability of significant and irreversible change in the study area, coupled with a high degree of vulnerability to existing and future coastal hazards suggests that this region has low suitability for supporting the kind of new highway and infrastructure corridor proposed in the M-CORES project.

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