Hazard Identification and Risk Assessment

2022

version 2

Promulgation Document

The *Hazard Identification and Risk Assessment* establishes the community profile and hazard analysis for Lee County and its political subdivisions. The document provides extensive information useful to those responsible for executing public safety responsibilities, as well as to the public and visitors to the county. It integrates the efforts of public, private, and nonprofit sectors to ensure the protection and preservation of life, property, and the environment. The plan applies to all individuals, organizations, and groups involved in such operations within the county's boundaries.

This document forms the foundation for emergency management in Lee County and its political subdivisions. It provides the basis for the jurisdictions' *Joint Local Mitigation Strategy* and the *Lee County Comprehensive Emergency Management Plan*. Strategies, programs, plans, policies, and procedures undertaken by the emergency management program derive their justification and direction from the identification, assessment, and prioritization of the jurisdictions' hazards and the potential outcome of those hazards. Input from each jurisdiction and critical stakeholders in the document's development and maintenance ensures it is integrated across organizational boundaries and helps unify efforts to achieve the best outcomes in times of emergency.

This iteration of the document supersedes the hazard identification and risk assessment of natural hazards previously contained in the *Joint Unified Local Mitigation Strategy*. Forthcoming updates to this document in mid-2022 will address human-caused hazards.

Sandra Tapfumaneyi
Lee County
Department of Public Safety – Emergency Management

Record of Changes

Version	Change	Reference	Date
2022.01	Document drafted	NA	2021-01-19
2022.02	Added section to address changes in risk and vulnerability	Ch. 3, p. 36	2022-03-14
	Updated table for repetitive loss properties to reflect property type	Flood hazard profile, p. 87	2022-03-14
	Updated map of planning area	Ch. 2, p. 6	2022-03-16

Record of Distribution

Agency/Organization	Version	Medium	Date
City of Bonita Springs	2022.01	Digital	
City of Cape Coral	2022.01	Digital	
City of Fort Myers	2022.01	Digital	
City of Fort Myers Beach	2022.01	Digital	
City of Sanibel	2022.01	Digital	
DAC Membership	2022.01	Digital	
Lee County Administration	2022.01	Digital	
Lee County Dept. of Public Safety Website	2022.01	Digital	
Village of Estero	2022.01	Digital	

Table of Contents

Promulgation Document i
Record of Changes ii
Record of Distribution iii
Table of Contents iv
List of Tables vi
List of Figures viii
Chapter 1 Introduction 1
Purpose 1
Scope 1
Assumptions 2
Constraints 3
HIRA Process 3
Chapter 2 Community Profile 5
Lee County 5
People 6
Economy 19
Natural Environment 23
Built Environment 27
Cultural Resources 34
Chapter 3 Community Hazards and Risks 35
Nature of Hazards and Risks 35
Changes in Risk and Vulnerability 36
History of Hazardous Incidents 37
Hazards Assessed 40
Ranking Methodology 41
Chapter 4 Natural Hazards 43
Animal/Plant Disease Outbreaks 43

Coastal Erosion 48
Drought 54
Epidemic/Pandemic Diseases 60
Excessive Heat 66
Extreme Cold 71
Flood 76
Freeze 96
Severe Weather 99
Tornado 107
Tropical Cyclone 113
Wildfire 121
Chapter 5 Human-Caused Hazards 128
Chapter 6 Hazard Prioritization 129
Hazard Summary 129
Prioritization Scheme 131

List of Tables

Table 1 Lee County and Municipal Populations (2010-2020) 7
Table 2 BEBR Population Projections by Age Group 8
Table 3 Population Density by Subdivision 9
Table 4 Region 6 Ages 0-17 10
Table 5 Region 6 Ages 65+ 10
Table 6 Top Employers in Lee County (2019) 20
Table 7 Percentage of Occupied Housing Units with Vehicles Available 28
Table 8 Total Buildings and Property Value 28
Table 9 List of Utilities in Lee County 31
Table 10 Land in Farms by Use 32
Table 11 Farm Statistics for Lee County (2017) 33
Table 12 Lee County Top Crops by Acres (2017) 33
Table 13 Lee County Livestock Inventory (2017) 33
Table 14 History of Major Disaster Declarations for Lee County 38
Table 15 NCEI Hazard Events for Lee County (as of November 2021) 39
Table 16 List of Hazards Assessed 40
Table 17 List of Hazards Not Assessed 41
Table 18 Hazard Assessment Schedule 42
Table 19 Exotic Pests Damage Estimate 47
Table 20 Critical Facilities within 1000ft of Eroded Beaches 50
Table 21 Buildings at Risk of Loss due to Coastal Erosion 52
Table 22 Drought Severity Classifications 55
Table 23 Weeks by Drought Severity in Lee County (2000-2021) 57
Table 24 Max Monthly Temperatures (2000-2020) 67
Table 25 Min Monthly Temperatures (2000-2020) 73
Table 26 Precipitation Mean, Max, and Min by Month 80
Table 27 Flood-Related Federal Disaster Declarations for Lee County 83
Table 28 Notable Historic Flooding Events 83
Table 29 Lee County NFIP Participation 85
Table 30 Lee County NFIP Policies and Claims (Since 1978) 86
Table 31 Lee County CRS Participation 87
Table 32 Lee County Repetitive Loss Properties 87
Table 33 Total Exposure in Floodplain (TEIF) 100-Year Summary by Jurisdiction 92
Table 34 Critical Facilities in 500 Year Floodplain (TEIF) 93

Table 35 Storm Surge Impact by Hurricane Category 93
Table 36 Critical Fruit Temperature (Tc) for Citrus Fruit 96
Table 37 Enhanced Fujita Scale 107
Table 38 Number of Tornado Events in Lee County (1950-2021) 108
Table 39 Saffir-Simpson Hurricane Wind Scale 114
Table 40 NOAA NCEI Storm Events Database (Tropical Cyclones) 115
Table 41 Presidential Declared Emergencies & Disasters for Hurricanes Since 1960 .116
Table 42 Recent Tropical Cyclones 116
Table 43 Lee County Hazards Ranking by Composite Score 130

List of Figures

Figure 1 HIRA as a Foundation 1
Figure 2 Threat and Hazard Definitions 2
Figure 3 HIRA Process 4
Figure 4 Lee County, Florida 5
Figure 5 Lee County and its Subdivisions 6
Figure 6 Percent Population Change from 2010 to 2020 7
Figure 7 Population Projections 2010-2045 8
Figure 8 Population Density by Census Tract 9
Figure 9 Mean Age by Census Tract (2020 US Census) 11
Figure 10 Nonwhite Population as Percent of Total Population (Florida Counties) 12
Figure 11 Ethnic Composition by Census Tract (Hispanic or Latino) 12
Figure 12 Mobile Home Parks 13
Figure 13 Lee County Visitations 5-Year Trend 14
Figure 14 Percentage of Population with a Hearing Disability 15
Figure 15 Percentage of Population with a Disability 16
Figure 16 Civilian Non-Institutionalized Population with a Disability 16
Figure 17 Estimated Number of Persons Experiencing Homelessness in Lee County 17
Figure 18 Percentage of Households Where English is not the First Language 18
Figure 19 Institutionalized Population by Census Tract 18
Figure 20 Number of Business by Industry 19
Figure 21 Mean Household Income by Census Tract (2020 US Census) 21
Figure 22 Per Capita Income by Year (2010-2019) 22
Figure 23 Per Capita Income by Census Tract (2020 US Census) 23
Figure 24 Lee County Topography 24
Figure 25 Drainage Systems in Lee County 25
Figure 26 Parks, Preserves, and Recreational Areas in Lee County 26
Figure 27 Conservation Areas 26
Figure 28 Estimated Values of Owner-Occupied Homes (ACS 5-Year Estimate 2019) 27
Figure 29 Lee County Major Roads 29
Figure 30 Airports, Seaports, Railways, and Waterways 30
Figure 31 Existing Land Use in Lee County 31
Figure 32 Lee County Future Land Use Map 32
Figure 33 Lee County Historic Properties 34
Figure 34 Hazards, Communities, and Risks 35

Figure 35 Number of Disasters by Month since 1953 (Lee County) 37
Figure 36 Critically Eroded Beaches in Lee County 51
Figure 37 Droughts in Lee County since 2000 56
Figure 38 National Weather Service Heat Index 66
Figure 39 Weather Related Fatalities (US, 2020) 68
Figure 40 Wind Chill Advisory and Warning Criteria 71
Figure 41 Wind Chill Chart 72
Figure 42 Understanding Storm Tide (source: NOAA) 77
Figure 43 Storm Surge vs. Storm Tide (source: National Hurricane Center) 78
Figure 44 Flood Insurance Rate Map - Unincorporated Lee County 79
Figure 45 Lee County Storm Surge Zones 81
Figure 46 Coastal High Hazard Area and Coastal Building Zone 82
Figure 47 Repetitive Loss Areas in Planning Area 88
Figure 48 Total Exposure in 100-Year Floodplain (TEIF) 91
Figure 49 Total Exposure in 500-Year Floodplain (TEIF) 92
Figure 50 Life Cycle of a Thunderstorm (source: NOAA) 99
Figure 51 Charge Distribution in Storm Clouds (source: NOAA) 101
Figure 52 Ultimate Design Wind Speeds - Risk Category I Buildings 102
Figure 53 Ultimate Design Wind Speeds - Risk Category II Buildings 102
Figure 54 Ultimate Design Wind Speeds - Risk Category III Buildings 103
Figure 55 Ultimate Design Wind Speeds - Risk Category IV Buildings 103
Figure 56 U.S. Lightning Fatalities, 2010-2012 (source: NOAA) 105
Figure 57 Damage in Lee County from an EF1 Tornado 110
Figure 58 Influence of El Niño and La Niña on the Frequency of Tornadoes 112
Figure 59 Hurricane Category 2 Winds: Probability of Occurrence by Return Period 119
Figure 60 Hurricane Category 5 Winds: Probability of Occurrence by Return Period 120
Figure 61 Wildland-Urban Interface Fire near RSW Airport (April 3, 2020) 122
Figure 62 Lee County Wildland-Urban Interface 124
Figure 63 Lee County Wildland-Urban Interface Risk Index 124
Figure 64 Lee County Hazard Prioritization 131

Chapter 1 Introduction

The introduction to this hazard identification and risk assessment (HIRA) states the purpose of the document and its scope. It establishes the goals and objectives to be met by the HIRA process and this document. The introduction provides readers with the assumptions used by planners throughout the HIRA process and the constraints that had to be considered. The chapter concludes with a summary of the HIRA process.

Purpose

The purpose of this document is to define the planning area, to compile and present the area's community profile, and to identify and assess threats and hazards that could significantly affect the area's population of residents and visitors and the built and natural environments. By doing so, this document establishes the foundation for the programs and systems that need to be in place to prevent or mitigate threats and hazards, prepare for their onset, respond to their consequences, and to aid the community in returning to normal after times of significant disruption (see Figure 1 below). A comprehensive, high-quality HIRA not only guides and directs strategic and tactical decisions and priorities, but places all actions taken to save lives, protect property, and safeguard the environment in their proper context for the community.

Figure 1 HIRA as a Foundation

Scope

The HIRA is constrained to the unincorporated areas of Lee County and the following political subdivisions:

- City of Bonita Springs
- City of Cape Coral
- City of Fort Myers
- City of Sanibel
- Town of Fort Myers Beach
- Village of Estero

Threats and hazards addressed in this document encompass those which occur naturally and those brought upon the community by failures in human technology and systems or the intentional actions of bad actors. “Daily” emergencies that are handled by existing services or that do not result in significant disruption of the community, such as temporary power outages, are not included in the scope of this document.

Figure 2 Threat and Hazard Definitions

Assumptions

Whereas “facts are verified pieces of information … assumptions consist of information accepted by planners as being true in the absence of facts.”[1] Assumptions enable planners to create an adaptable framework while assessing hypothetical situations and possibilities. Planners and those responsible for using this document make necessary adjustments as facts become available and replace assumptions.

The number of assumptions underlying the HIRA are too many to enumerate in this document. Furthermore, there is limited benefit to listing every possible assumption made or used. This document provides a summary of fundamental assumptions underlying the HIRA process, which are listed below.

- Complex social, economic, political, and environmental systems can be understood well enough to assess their risks and vulnerabilities to threats and hazards;

- Available data on the community and its threats and hazards is current and accurate;
- Available methods for assessing and analyzing threats and hazards, including their effects on populations and environments, are accurate and sufficient to conduct effective analyses;
- The lack of historical precedence for a threat or hazard does not preclude that threat or hazard from occurring in the future;
- The likelihood or risk of some threats or hazards are so small that the cost of addressing them is relatively too high to justify doing so.

Constraints

The HIRA is constrained by numerous factors. These constraints place limitations on the HIRA process, as well as on the HIRA's outcome and utility. Planners identify and account for constraints to facilitate the most effective and accurate analyses possible, given the circumstances or conditions in which they are performed. Efforts are made continually to minimize or eliminate constraints throughout the HIRA process. Changes in characteristics of factors affecting the process are incorporated into the analysis through regular maintenance and updates of this document.

Some factors that limit or complicate this HIRA are:

- Limited access to current data or information;
- Limited currency to data or information in some cases;
- Delays in release of US Census data;
- Social, economic, and political disruptions from COVID-19;
- Complex social, economic, political, and environmental systems interact with each other in overly complex ways, making comprehensive analysis extraordinarily difficult;
- The HIRA is a snapshot of a continually evolving and changing planning area;
- Limited resources (including time, political will, and so forth) necessitates prioritization in assessing and addressing threats and hazards.

HIRA Process

The threat and hazard identification and risk assessment process consists of multiple phases (see Figure 3 below). The process is cyclical; planners continually monitor and assess the planning area (see Scope above) to determine what changes are occurring in

the community and adjusting analyses accordingly. Following the onset of one or more hazards in the planning area or in a place similar to the area, planners gather and incorporate lessons learned into the process.

The cycle begins with planners building a community profile, which summarizes certain characteristics of the planning area, such as population demographics, economic indicators, protected lands, and cultural resources. Following the community profile, planners identify all possible threats and hazards that could affect the planning area. By comparing the community profile against identified threats and hazards, planners identify vulnerabilities and areas of risk. The outcome of this comparison is then used to develop prevention, mitigation, preparedness, response, and recovery strategies and plans. Planners and others then maintain the process through any threats or hazards that occur, as well as through general monitoring and upkeep of the community.

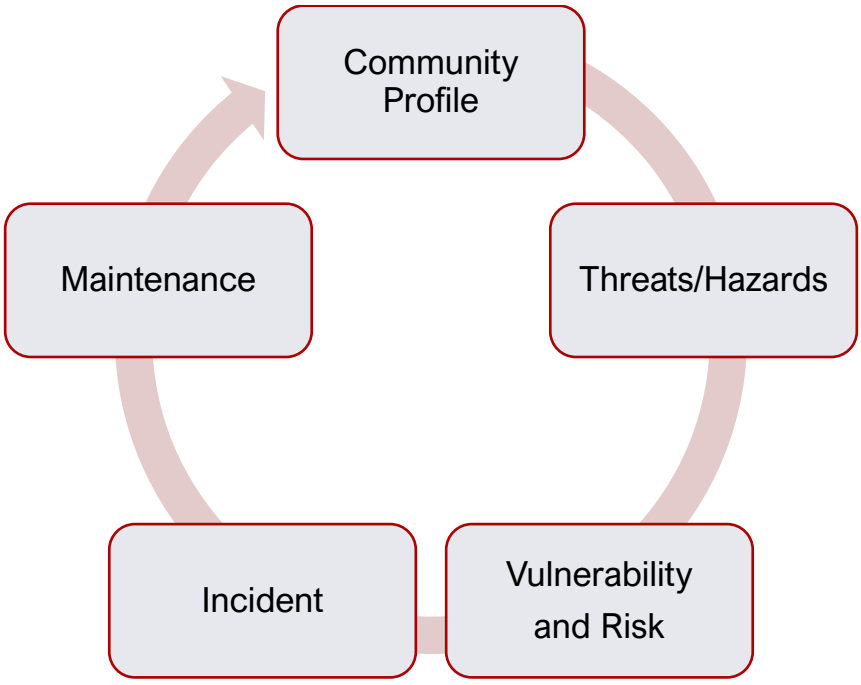

Figure 3 HIRA Process

This document addresses the planning area's community profile (see Chapter 2), threats and hazards (see Chapter 3 and Chapter 5), and hazard prioritization (see Chapter 6). Chapter 5 is a placeholder for human-caused hazards, which will be assessed in mid-2022 as part of the update to the *Lee County Comprehensive Emergency Management Plan*.

Chapter 2 Community Profile

The Community Profile describes demographic and economic aspects of Lee County and its political subdivisions. The profile also addresses the county's natural and built environments and cultural resources. Taken together, these aspects demonstrate the collection of systems that can be affected by or contribute to the onset of one or more hazards. In this way, the community profile helps to identify risks and vulnerabilities and assets that contribute to resiliency.

Lee County

Lee County is located in the south-west region of the State of Florida, abutting the Gulf of Mexico. The jurisdiction is adjacent to two other coastal counties (Charlotte and Collier) and two inland counties (Glades and Hendry); see Figure 4 below. In addition to its unincorporated territory, the county encloses four cities, one town, and a village (see Figure 5 below). Lee County covers approximately 785 square miles of land (12.5% of which is salt-water wetland) and 428 square miles of water[2].

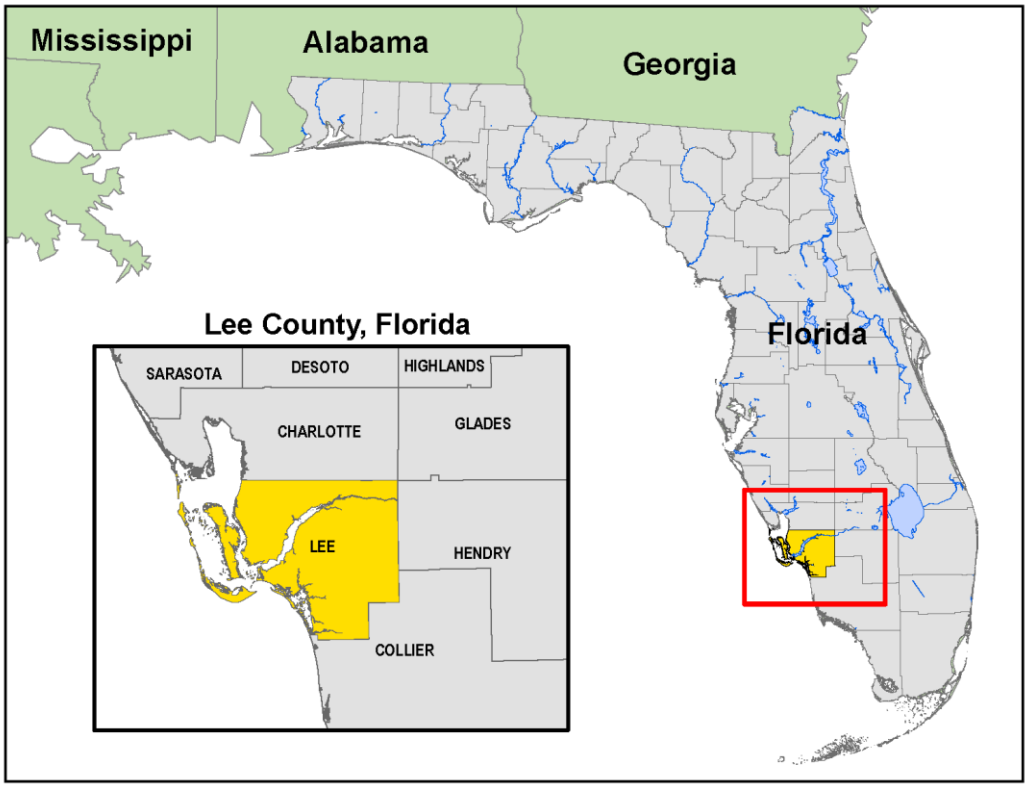

Figure 4 Lee County, Florida

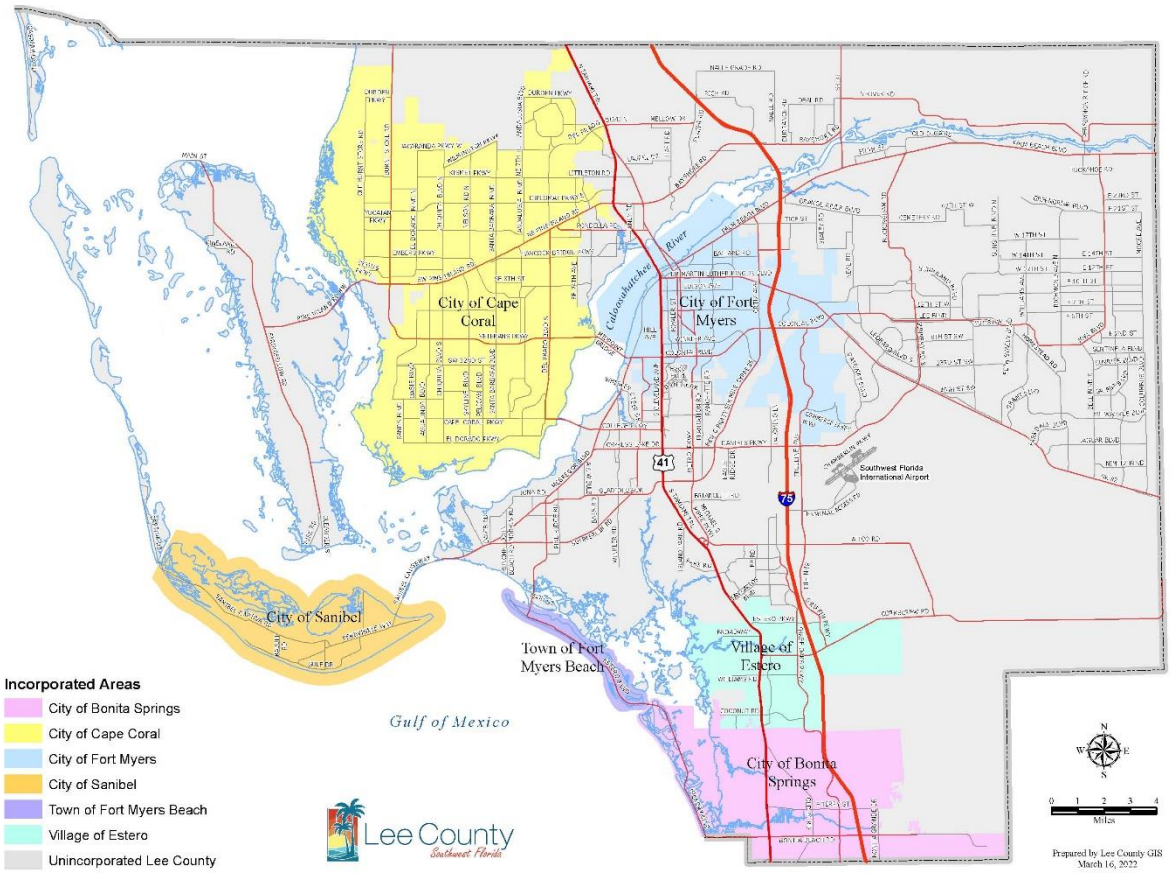

Figure 5 Lee County and its Subdivisions

People

Demographic information accounts for the people who reside in Lee County and its municipalities. Areas of focus for this portion of the community profile are dictated largely by state requirements. The information presented here summarizes community characteristics such as total population and growth trends, population distributions, and community geographic locations. Demographic information yields important insights into community systems, networks, vulnerabilities, resiliencies, and so forth.

Total Population and Growth Trends

Per estimates from the 2020 US Census, over 750,000 people reside in Lee County. The largest concentration of residents occurs in the unincorporated portions of the county. The City of Cape Coral is the largest municipality in the county, with over 187,000 residents. The cities of Fort Myers Beach and Sanibel have the smallest populations in the county with less than 7,000 residents each. See Table 1 below.

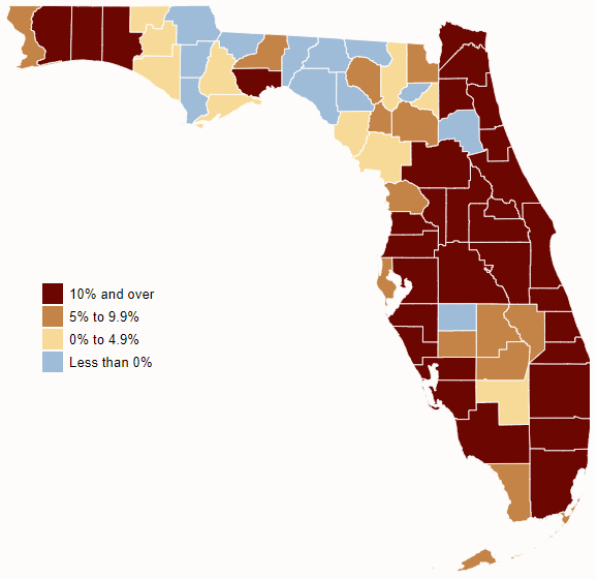

Figure 6 Percent Population Change from 2010 to 2020

According to the 2020 US Census estimate, Lee County is the eighth largest county in the State of Florida. Compared with 2010 US Census numbers, Lee County had the 10th highest growth in population in the state over the last decade, adding over 131,000 residents (21% increase). Lee County is the largest county in Region 6 by over 300,000 people. While Region 6 added nearly 375,000 people in the last decade, the largest contributor was Lee County, which made up 35% of that growth.

In the last ten years, the county's overall population has grown steadily. Most of the growth occurred in the cities of Bonita Springs, Cape Coral, and Fort Myers, in addition to the growth that occurred in the unincorporated areas of the county. Since 2010, the City of Bonita Springs has grown by 27%, while the City of Cape Coral grew by 21%. The largest relative growth occurred in the City of Fort Myers, which increased its population size by nearly 50%. Conversely, Fort Myers Beach and Sanibel experienced decreased populations over the last decade. See Table 1 below.

Table 1 Lee County and Municipal Populations (2010-2020)[3]

County Subdivision	2010 Census	2020 Census	Change	% Change
Bonita Springs	43,857	53,644	9,787	22%
Cape Coral	154,305	194,016	39,711	26%
Estero	NA	36,939	NA	NA
Fort Myers	62,298	86,395	24,097	39%
Fort Myers Beach	6,277	5,582	-695	-11%
Sanibel	6,469	6,382	-87	-1%
Unincorporated	345,548	377,864	32,316	9%
Total	**618,754**	**760,822**	**142,068**	**23%**

Population projections show continued growth in Lee County over the next two and a half decades (see Figure 7 below). This is in line with projections showing significant increases in population across the entire State of Florida during that same time period[4]. According to these projections, Lee County's population will increase to about 900,000 by 2030 and over 1,000,000 by 2040. Concurrent to this continued growth will be changes in the

community's social, natural, and artificial environments, as well as shifts in economic factors and outcomes.

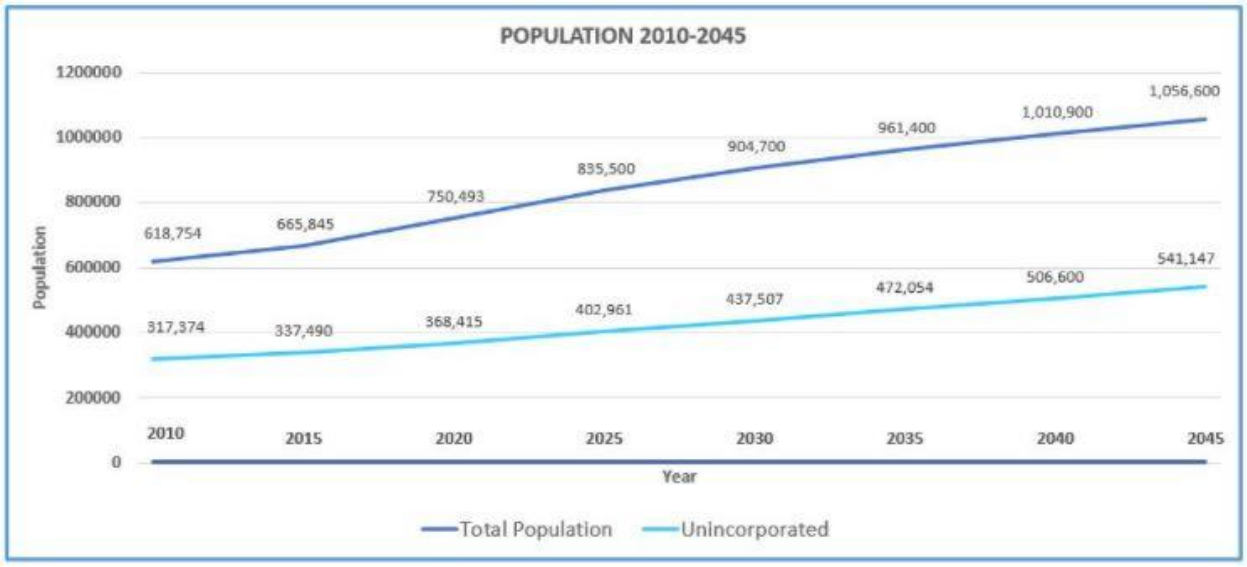

Figure 7 Population Projections 2010-2045

According to BEBR projections, population increases over the next two decades will be consistent across most age groups. Compared with other age groups, however, the proportion of the population aged 65-years-old or older will become larger (see Table 2).

Table 2 BEBR Population Projections by Age Group[5]

Age	2010	2020	2030	2040
0-4	32,866	38,586	46,718	50,965
5-17	88,003	100,851	116,768	133,780
18-24	47,476	56,220	64,266	70,888
25-54	218,111	250,137	296,071	338,455
55-64	87,192	109,263	108,079	116,998
65+	145,106	194,571	259,306	295,982

Population Density and Distribution

Fort Myers and Fort Myers Beach have the highest density in the county, while Sanibel and the unincorporated county areas have the lowest. See Table 3 below. Figure 8 shows population density by census tract, which demonstrates the largest concentrations of residents in the Cape Coral and Fort Myers areas.

Table 3 Population Density by Subdivision

County Subdivision	Area (sq mi)	Density (sq mi)
Bonita Springs	38.40	1,397
Cape Coral	119.39	1,625
Estero	24.35	1,517
Fort Myers	39.84	2,169
Fort Myers Beach	2.78	2,169
Sanibel	16.18	394
Unincorporated	544.06	695

For this table, area in square miles only includes land

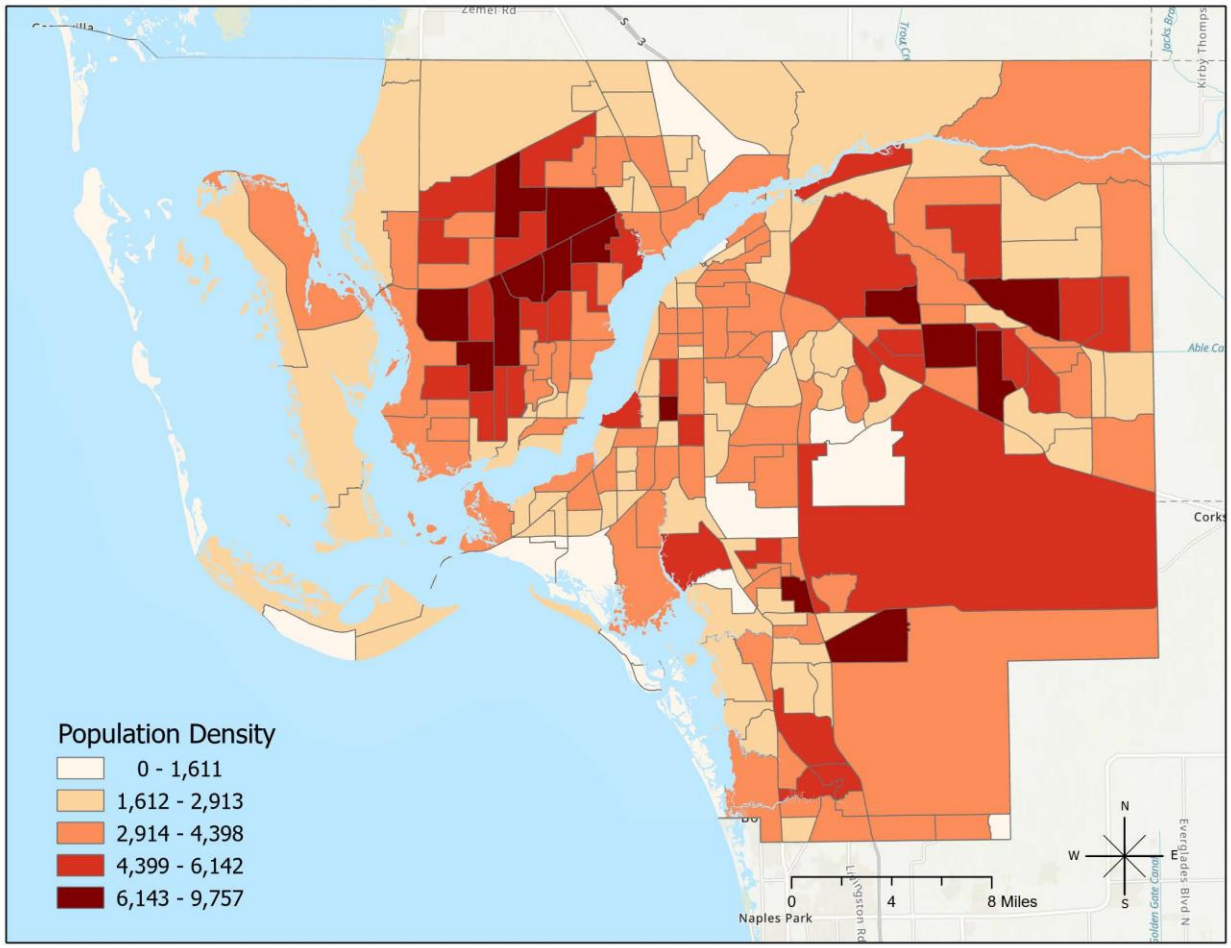

Figure 8 Population Density by Census Tract

In 2019, the median age for residents was 48 years-old, per the ACS 5-Year Estimate. This is contrast to the State of Florida's median age, which was 42 years-old. The national median age during that same period was 38 years-old.[6]

Most recent census data reports that approximately 5% of the county's population is under the age of 5-years-old and approximately 17% of the population is under the age of 18-years-old. This is comparable to the state's (20%) and the nation's proportion (22%). It is also comparable to regional neighbors (see Table 4 below). Nearly 30% of the county's population is aged 65-years-old or older. Comparatively, 20% of the state's population and approximately 17% of the county's population are aged 65-years-old or older.[7] As demonstrated in Table 2 above, the proportion of 65-years-old and older will continue to grow over the next two decades.

Table 4 Region 6 Ages 0-17

County	2020 Pop.	Age >18	% >18
Hendry	40,034	11,119	28%
DeSoto	35,848	7,738	22%
Manatee	394,332	76,356	19%
Lee	749,628	139,437	19%
Collier	379,905	69,410	18%
Glades	13,453	2,336	17%
Highlands	104,840	18,056	17%
Sarasota	426,322	62,572	15%
Charlotte	179,349	23,384	13%

While Lee County has the largest number of residents aged 65-years-old and older, proportionally, that number is smaller than several of the county's regional neighbors (see Table 5).

Table 5 Region 6 Ages 65+

County	2020 Pop.	Age 65+	% 65+
Sarasota	426,322	170,155	40%
Charlotte	179,349	67,653	38%
Highlands	104,840	36,069	34%
Manatee	394,332	125,802	32%
Collier	379,905	109,167	29%
Lee	749,628	194,571	26%
Glades	13,453	3,375	25%
DeSoto	35,848	6,932	19%
Hendry	40,034	5,617	14%

Figure 9 below shows the mean age of the county's resident population distributed across US Census tracts. Generally, the older portion of the county's resident population is congregated in the southern half of the jurisdiction and in the county's islands.

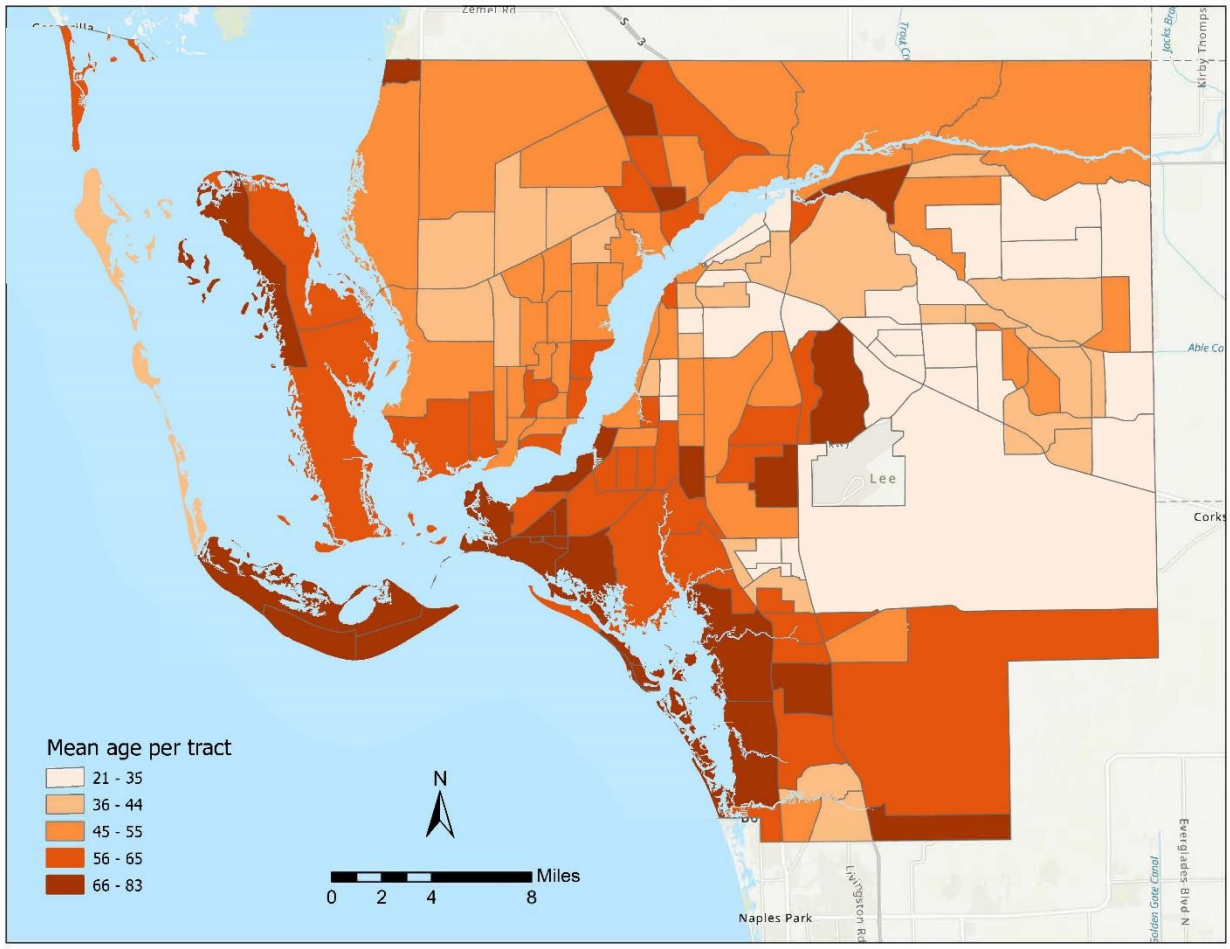

Figure 9 Mean Age by Census Tract (2020 US Census)

Lee County's resident population is split nearly even between male (49%) and female (51%). This is consistent with the State of Florida and the nation.[8]

The majority of Lee County's resident population is white (~87%); 66% are White alone, not Hispanic or Latino. Nearly 10% of the population is Black or African American and 22% of the population is Hispanic or Latino.[9] Comparatively, Lee County's racial and ethnic composition is similar to much of the State of Florida (Figure 10 below). BEBR's projections for the next two decades show a steady growth across racial and ethnic groups. Per the projections, the largest growth will occur within the Hispanic and Latino group, increasing from 181,178 in 2020 to 304,637 in 2040.[10] Figure 11 below illustrates the geographic distribution of the county's resident Hispanic or Latino population.

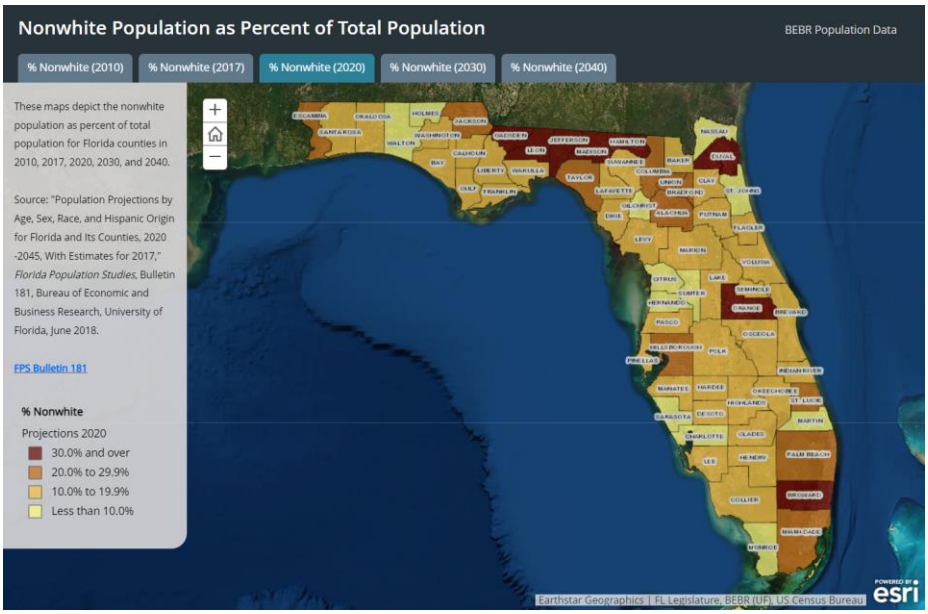

Figure 10 Nonwhite Population as Percent of Total Population (Florida Counties)

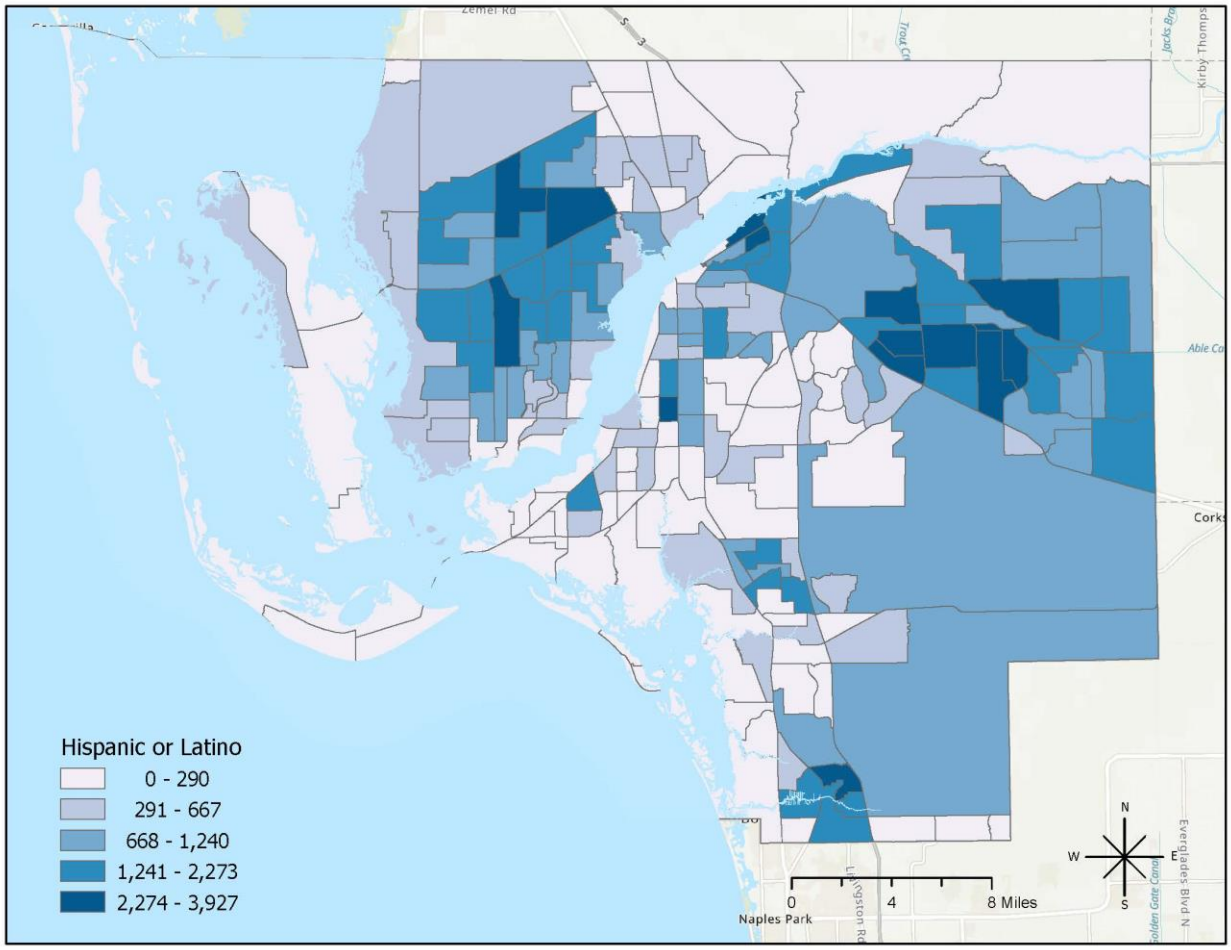

Figure 11 Ethnic Composition by Census Tract (Hispanic or Latino)

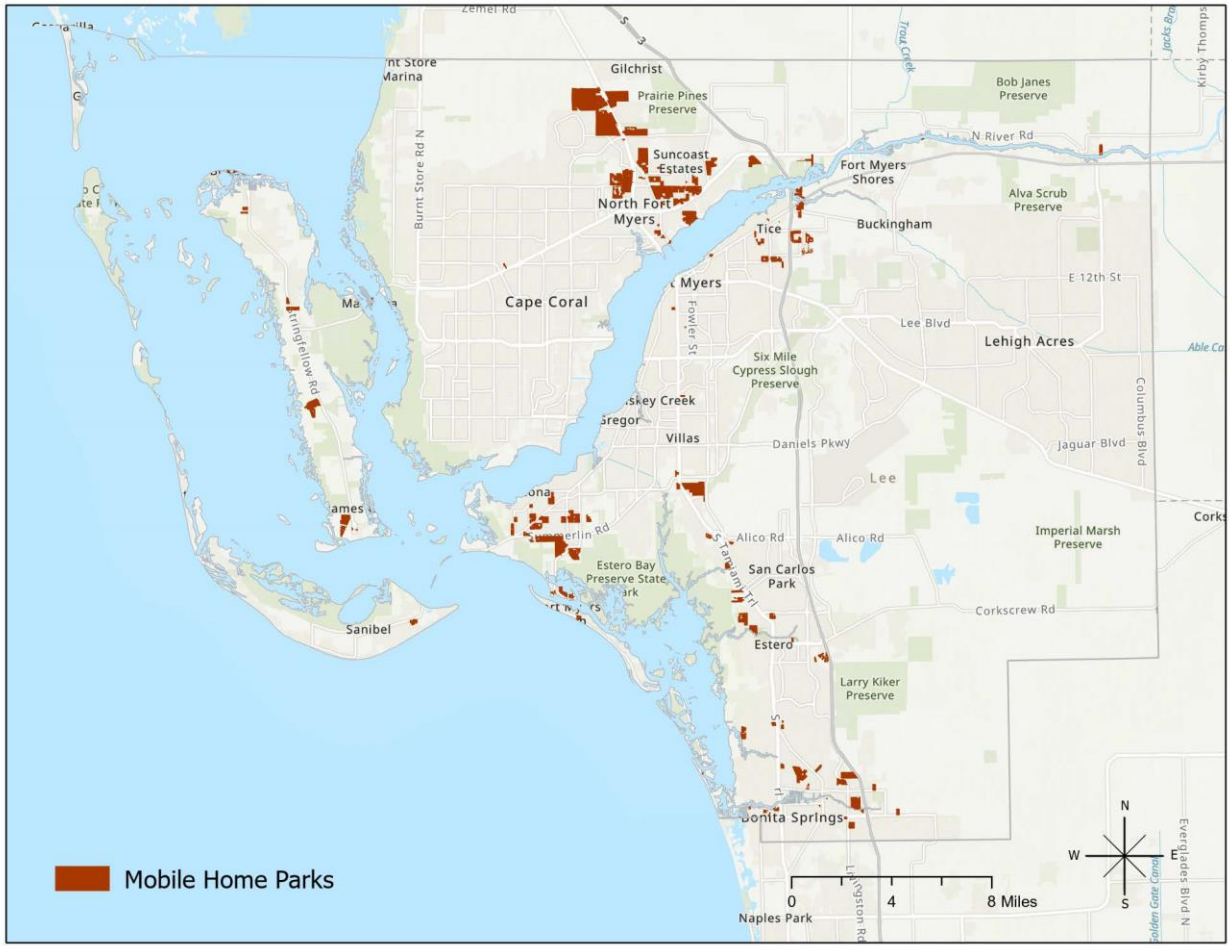

Figure 12 Mobile Home Parks

Mobile Home Population

Lee County has nearly 40,500 mobile homes and non-transient RVs. An estimated 60,000 people reside in these locations, with a seasonal population of about 15,000.[11] These mobile homes and non-transient RVs are mostly located in dedicated communities and parks. The largest congregation of mobile home parks occurs in the North Fort Myers and Cape Coral area, although parks are located throughout the western half of the county (see Figure 12 above).7

Tourist Population

Lee County hosts a large annual tourist population. Primary attractions for the area include the beaches, water recreation, and spring training for Major League Baseball. Consequently, the county sees seasonal tourism largely during the spring and summer.

Beaches in Fort Myers and Sanibel attracted nearly 3.4 million visitors in 2020. Figure 13 below depicts the last five-year trend for tourist visitations to beaches in the county.

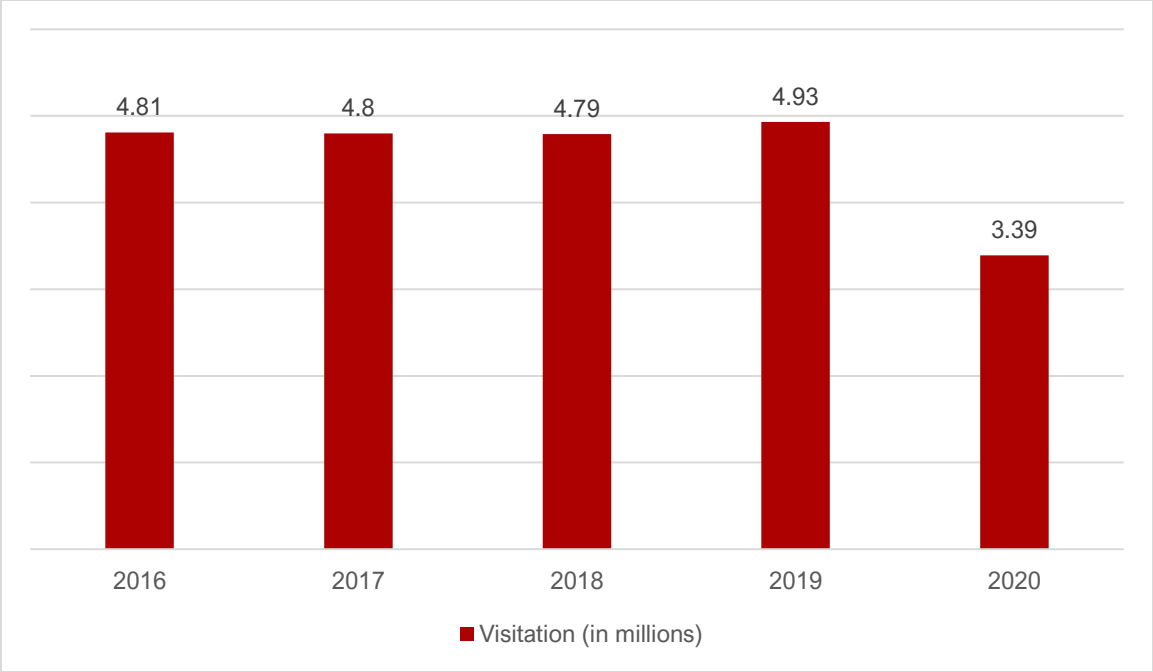

Figure 13 Lee County Visitations 5-Year Trend

Recent events with the global pandemic resulted in significant decreases in visits over the last one-to-two years.

Special Needs Population

The county's special needs population includes those individuals and families who have unique service needs, including veterans, the elderly, persons with disabilities, persons with HIV/AIDS, persons with special medical needs, farmworkers, and persons experiencing homelessness. Unique services include (but are not limited to) aging assistance, independent living, substance abuse prevention and treatment, mental health services, temporary housing, financial assistance, and special medical care.[12]

In 2019, approximately 20% of county residents aged 65-years-old or older lived alone[13]. Single elderly residents often need assistance with in-home healthcare, meal delivery, and daily task services. They also often live on fixed incomes, limiting access to some services. Indeed, in 2017 at least 19,000 single elderly residents had annual incomes below the financial requirements of their mortgage or rent. Moreover, some elderly residents experience physical, mental, or emotional problems necessitating residence in assisted living facilities or procuring services assisting them with aging in place.[14]

In 2017, about 8% of Lee County's population below the age of 65 years had a disability[15]. In the same year, about 2% of the population between 18-64 years old had vision or

hearing difficulty, compared with about 4% with vision difficulty and nearly 14% with hearing difficulty among those age 65 years old or more. Figure 14 below illustrates the distribution of hearing disabilities throughout the county. Among Lee County's population in 2017 aged 65 or older, about 13% were probable Alzheimer's cases.[16] Figure 15 below illustrates the prevalence of disabilities in the county between 2015 and 2019. As the county's population grows, so does the number of residents with a disability (see Figure 16 below)[17].

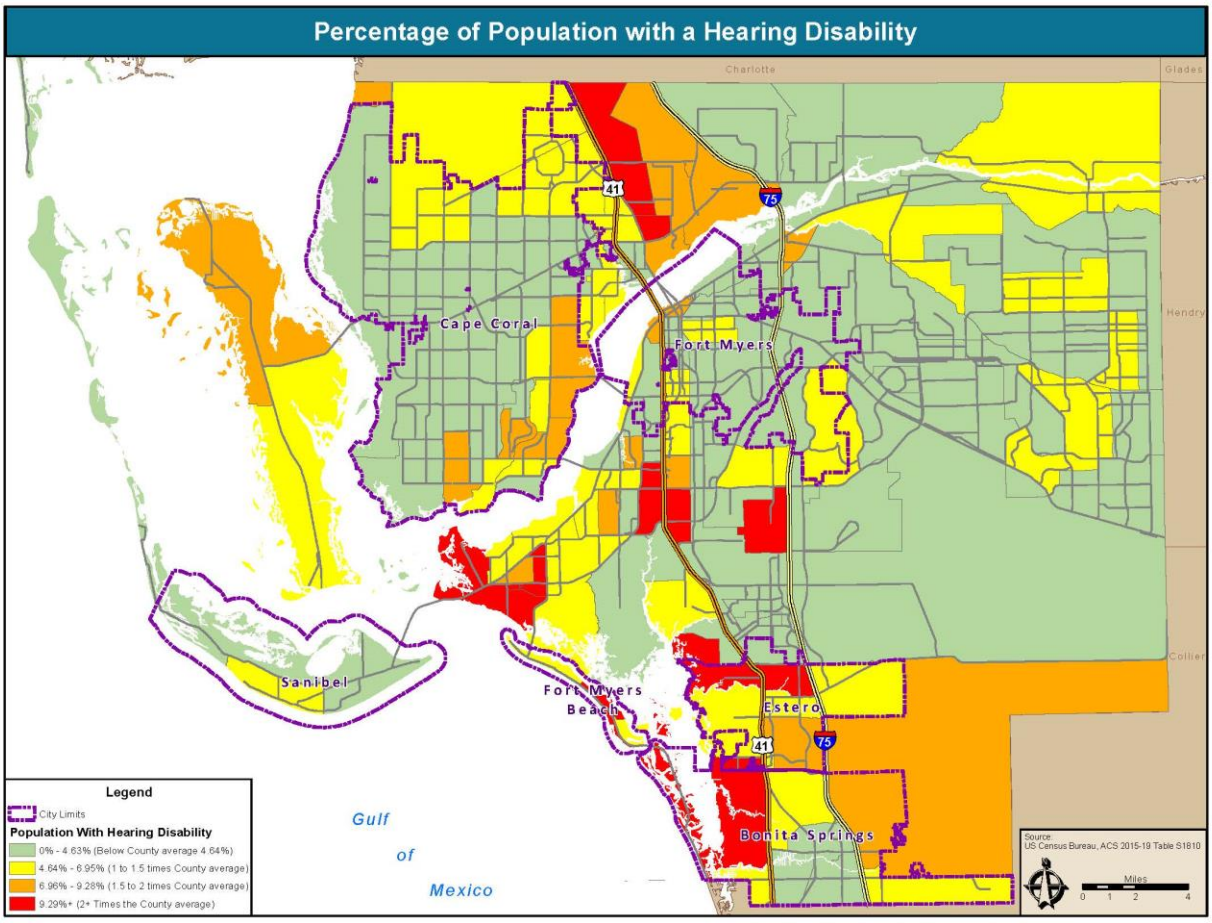

Figure 14 Percentage of Population with a Hearing Disability

In 2016, about 10% of people surveyed in Lee County used special equipment because of one or more health problems[18]. With the growth in population, particularly among those aged 65-years-old or older, the number of people requiring special medical equipment continues to increase as well. As of 2020, there were approximately 2,600 people on the county's Special Needs Registry. This represents a steady increase over the last several years of the registry's existence.

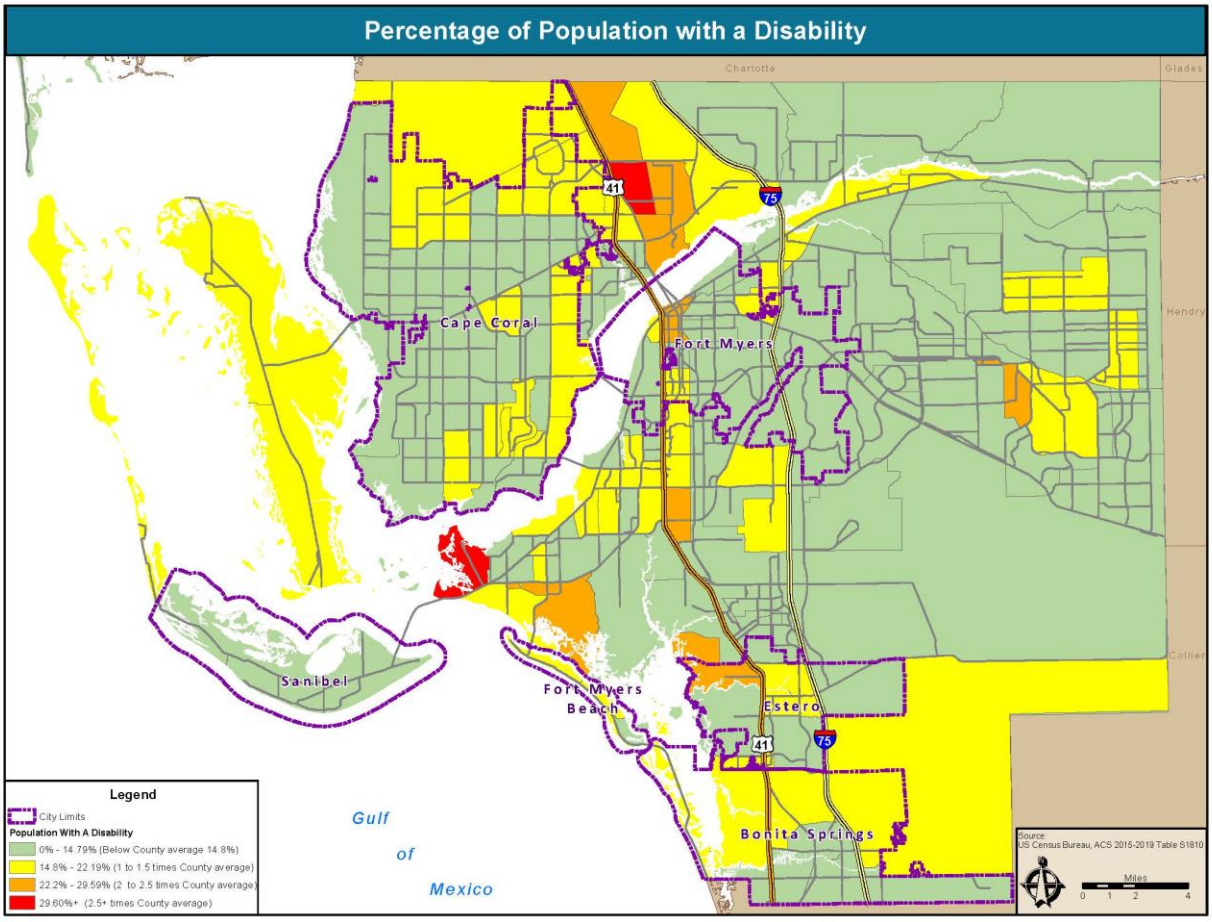

Figure 15 Percentage of Population with a Disability

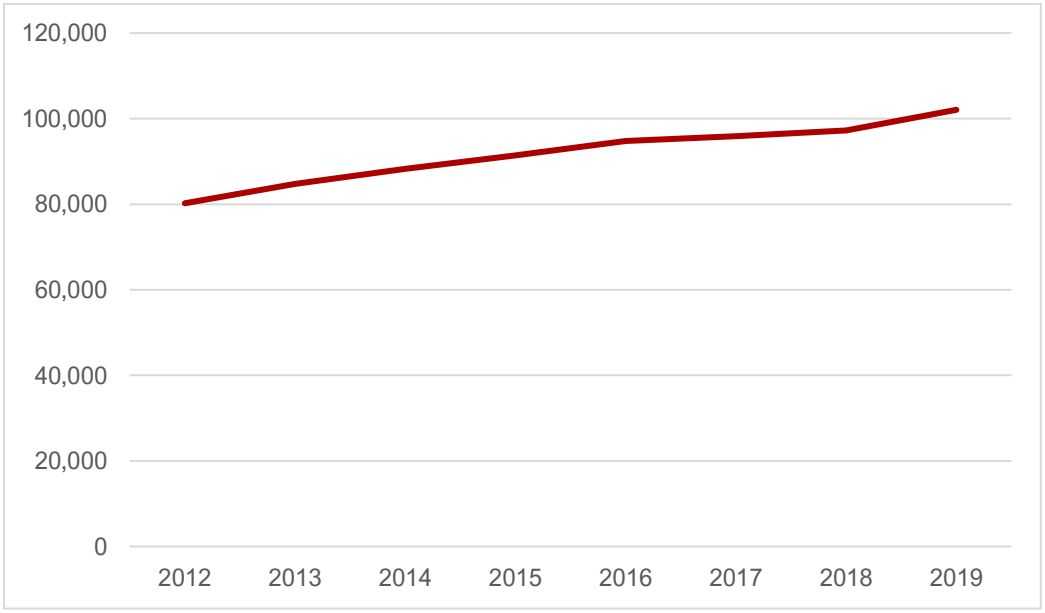

Figure 16 Civilian Non-Institutionalized Population with a Disability

In 2020, estimated 444 persons experienced homelessness in Lee County[19]. This represents a decrease from 2019, which had an estimated 630 persons experiencing homelessness. Even so, this number fluctuates quite frequently, as shown in Figure 17 below.

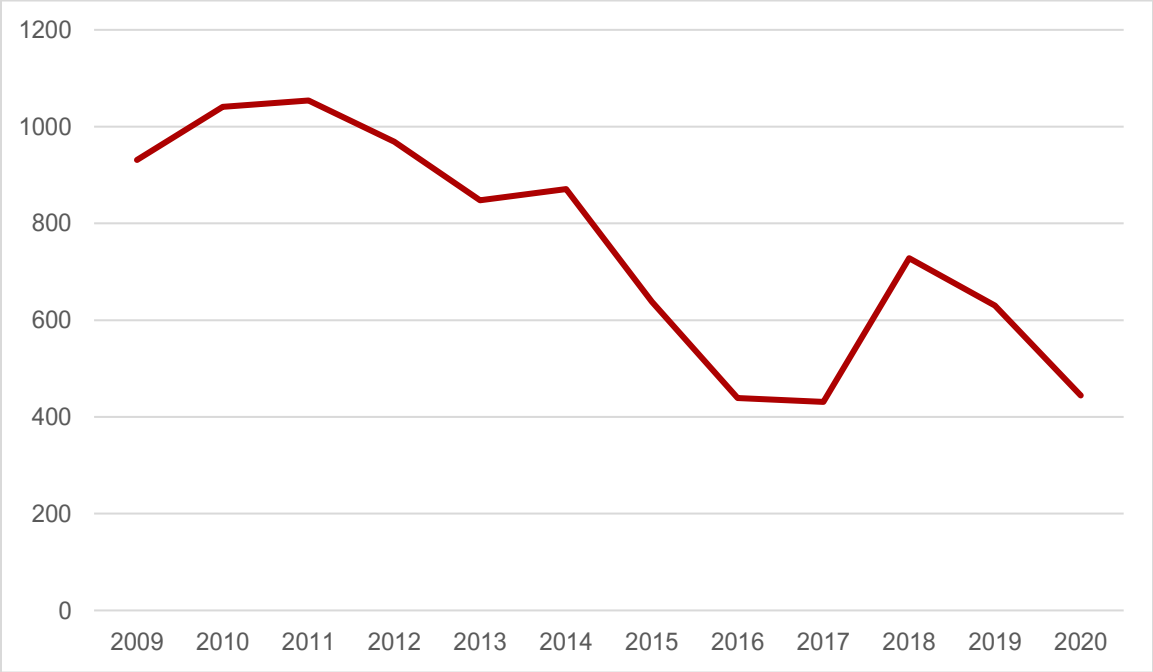

Figure 17 Estimated Number of Persons Experiencing Homelessness in Lee County

Non-English-Speaking Population

Various languages are spoken by members of Lee County's population. English constitutes the primary spoken language (~80% of the population), followed by Spanish (~15% of the population). A small portion of the population speaks French Creole (~1%), while smaller segments speak other languages, such as German, Portuguese, French, and so forth.[20] Nearly a quarter of Lee County's households speak a language other than English at home[21]. Figure 18 below illustrates the prevalence of non-English speaking populations in the county.

Institutionalized Population

Lee County has a relatively small institutionalized population[22]. The Sheriff's Office operates a downtown jail (with 457 beds), a core facility (with 1,216 beds), and a community program unit (with 336 beds). In 2019, the county had an average daily inmate population of approximately 1,700[23]. There are approximately 20 nursing home facilities operating in Lee County. Figure 19 visualizes the county's institutionalized population.

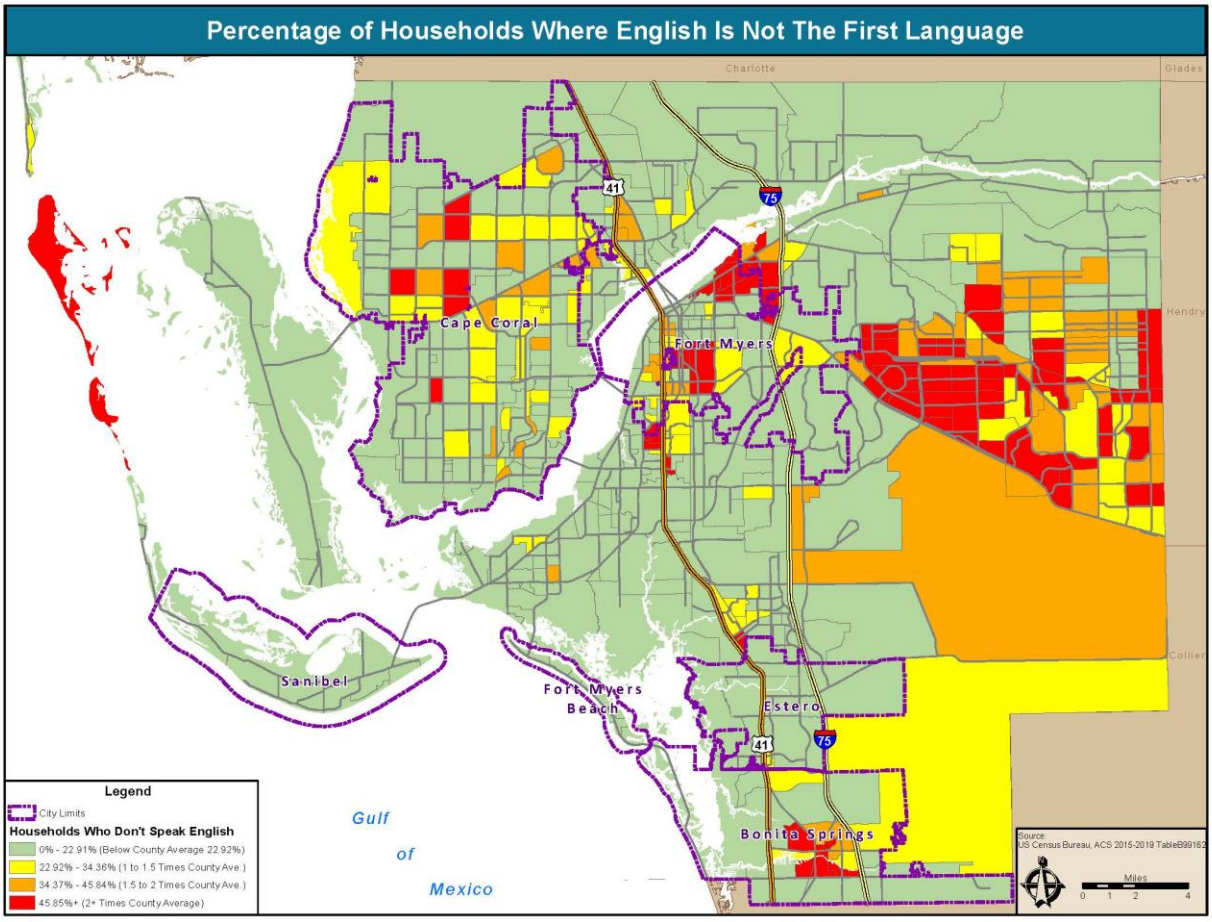

Figure 18 Percentage of Households Where English is not the First Language

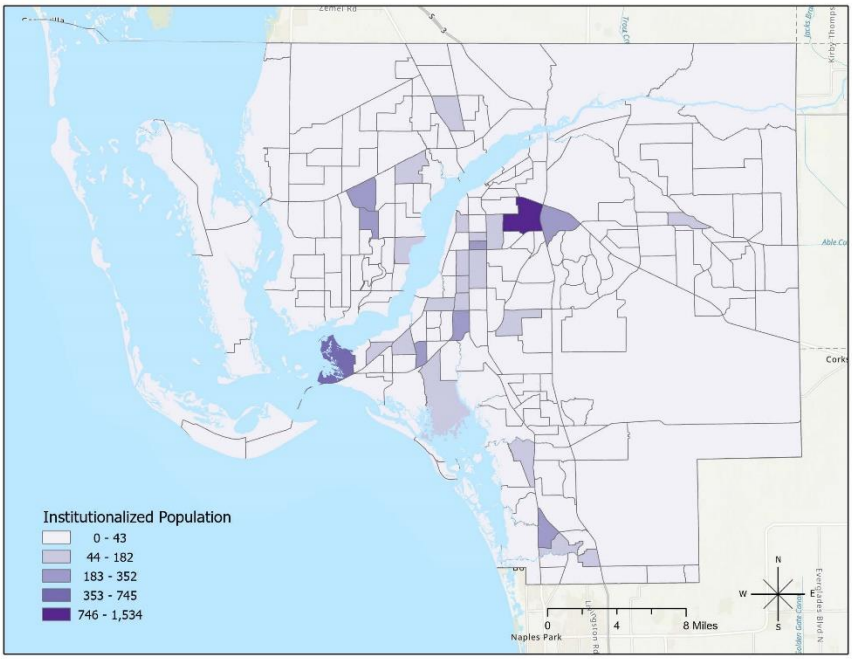

Figure 19 Institutionalized Population by Census Tract

Economy

Lee County's economy contributes nearly 3% to the State of Florida's overall Real Gross Domestic Product (RGDP)[24]. In 2019, Lee County's economy yielded over $28 billion in RGDP (in chained 2012 dollars)[25]. Comparatively, Lee County economy is the eighth largest in the State of Florida. Between 2015 and 2019, the county's economy grew by 16 percent.

From 2015-2020, jobs in the southwest Florida region increased from approximately 489,000 to nearly 530,000. This growth of approximately 8% was larger than the national growth rate of about 1.5% during the same period. There are approximately 33,500 businesses in Lee County. The majority of these businesses operate within the services, retail trade, and construction industries. Utilities, communication, and government make up the fewest number of businesses.[26] See Figure 20 below.

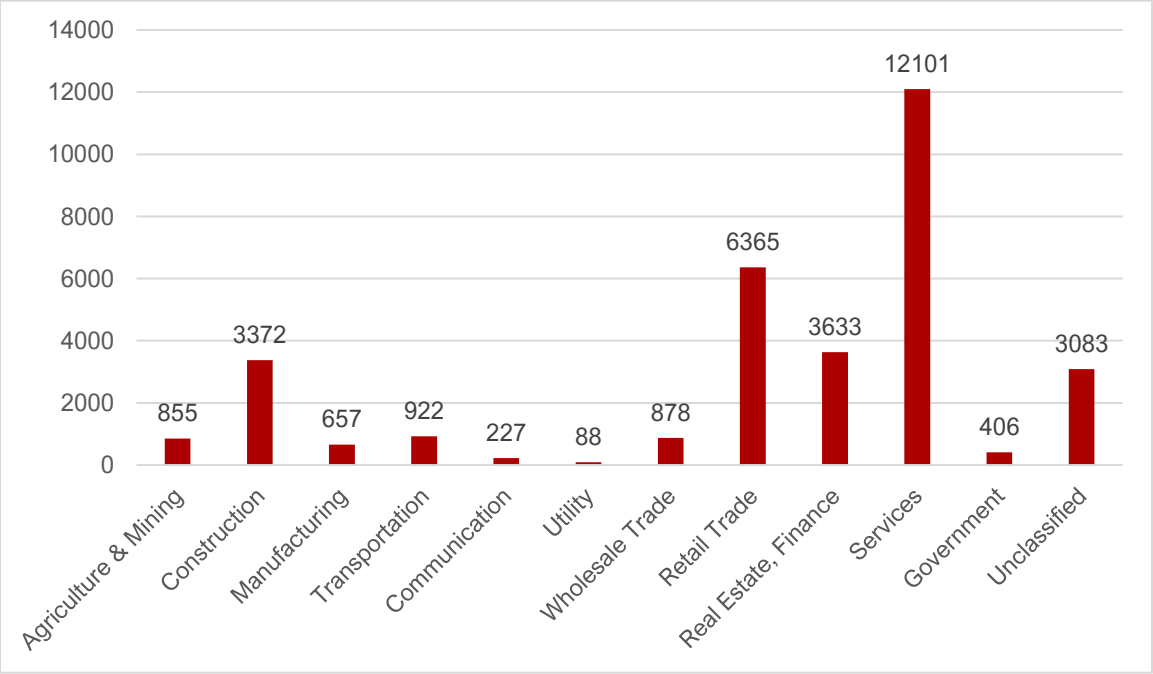

Figure 20 Number of Business by Industry

Unemployment in Lee County has remained relatively steady over the last five years. In 2016, the county experienced an average 4.7% unemployment rate. This rate decreased to 4.1%, 3.5%, and 3.3% in 2017, 2018, and 2019 respectively. The onset of COVID-19 in 2019 and through 2020 resulted in an increase in the unemployment rate to 7.3% in 2020. As of August, 2021, the county's unemployment rate has dropped to 4.7%.[27]

Healthcare services make up nearly 14% of Lee County's economy. The healthcare industry employed nearly 45,000 in 2018 and produced $5.2 billion[28]. Lee Health constitutes the largest employer in the sector and within the county (see Table 6 below). The education sector makes up nearly 8% of the economy and employees approximately 25,000 people. The Lee County School Board is the second largest employer in the county. Construction is the third largest sector in the county (employees nearly 45,000 people) and accounts for nearly 13% of the county's economy. Farms in Lee County hired employed approximately 1,500 people[29].

Approximately 95% of businesses in Lee County employ fewer than 50 people[30].

Table 6 Top Employers in Lee County (2019)[31]

Rank	Company Name	Employment
1	Lee Health	13,595
2	Lee County School District	12,936
3	Lee County Board of County Commissioners	9,038
4	Publix Super Market	8,728
5	NCH Healthcare System	7,017

In addition to the sectors previously mentioned, tourism is a major contributor to the economic health of Lee County and its political subdivisions. Between 2013 and 2017, approximately three million visitors entered Lee County per year, about 30% of whom were from outside the United States. During that same period, visitor expenditures in Lee County exceeded $14.75B, an average of nearly $3B per year.[32] In 2018, nearly five million people visited Lee County, which resulted in $3.1B of direct visitor spending. This spending supported approximately 60,000 jobs in the county. Consequently, 1 out of every 5 jobs in the county is tied to tourism.[33]

In 2020, visitors to the beaches of Fort Myers and Sanibel put more than $2.5 billion into the local economy and generated over $4.2 billion in total economic impacts. Prior to 2020, annual visitor spending was growing steadily; however, following the onset of COVID-19, the number of visitations decreased drastically in 2020, along with associated expenditures. Recently, the number of visitations and the amount of spending tied to tourism has begun to increase.[34]

Residents in Lee County and its political subdivisions use a variety of means of traveling to and from their places of employment. In 2019, the majority of the county's workforce made use of personal vehicles or carpools (~240,000 and ~30,000 respectively).

Approximately 2,000 people relied on public transportation and another 3,500 or so walked. About 19,000 worked from home. The mean travel time to work in the county in 2017 was about 30 minutes.[35]

Household Income

From 2015-2019 the median household income in Lee County was just under $58,000[36]. Median family income during that period was just under $70,000. The largest concentrations of high mean household income occur in the southern portions of the county, compared with concentrations of low mean household income around the Fort Myers area (see Figure 21 below). The mean household income during this same period was about $82,500. This represents a steady increase over the last several years.[37]

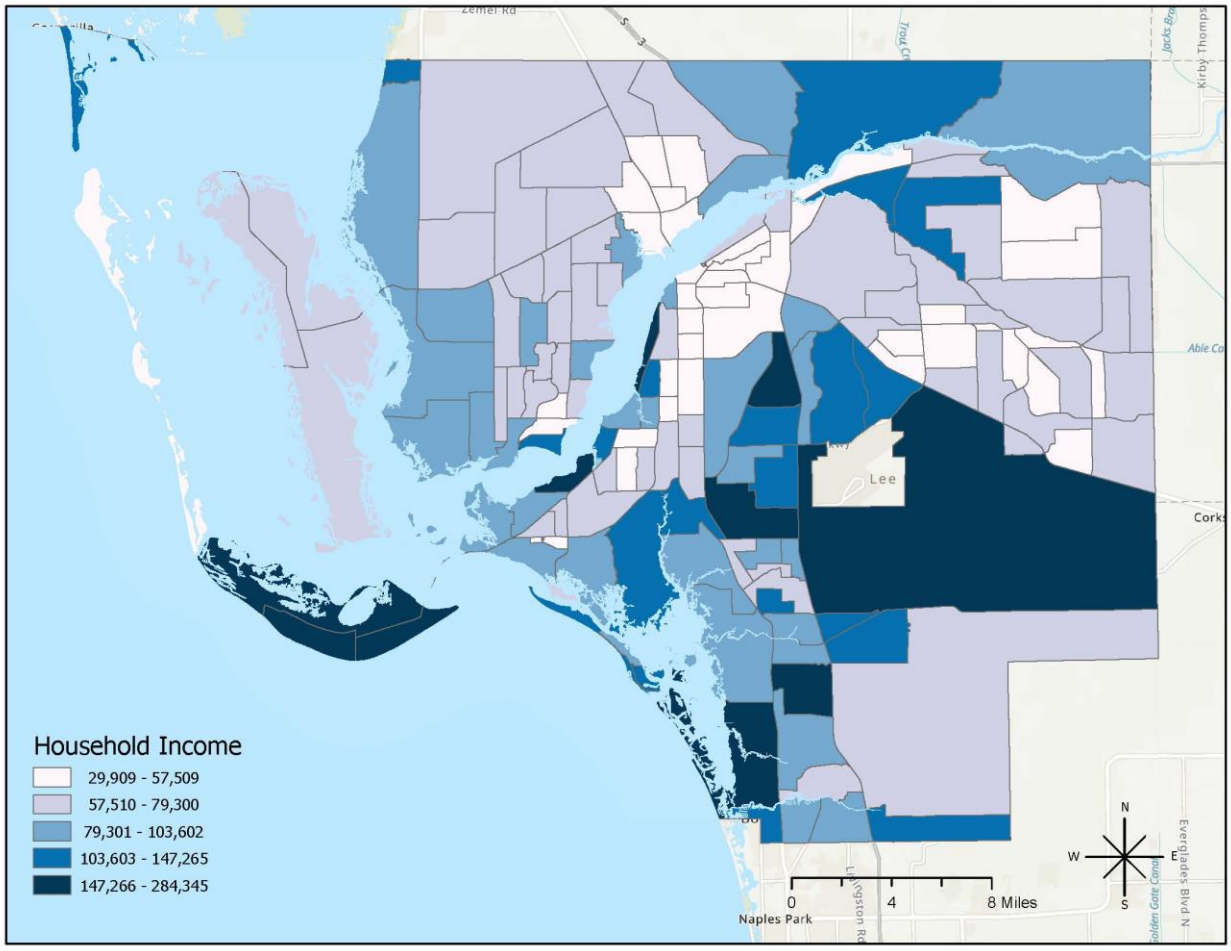

Figure 21 Mean Household Income by Census Tract (2020 US Census)

Over the last decade, per capita income in the county has steadily increased, rising from approximately $39,000 in 2010 to approximately $52,000 in 2019 (see Figure 22 below).[38]

Unsurprisingly, the distribution of per capita income in the county (see Figure 23 below) closely reflects the distribution of mean household income.

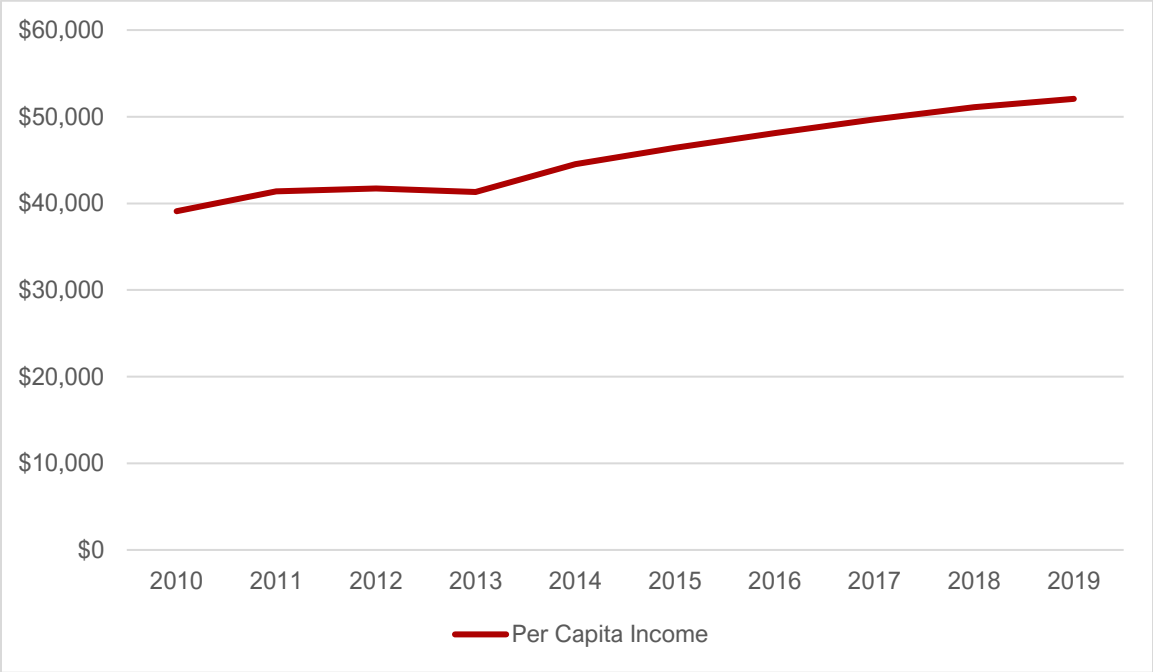

Figure 22 Per Capita Income by Year (2010-2019)

According to the American Community Survey 5-Year Estimate, approximately 175,000 households in Lee County earned an income through employment. In comparison, over 131,000 households earned income through social security, over 77,000 through supplemental Social Security, and nearly 4,500 through cash assistance. Over 25,000 households received Food Stamp /SNAP benefits. (According to the Florida Access and Functional Needs Profile, nearly 12% of households in Lee County received cash public assistance or food stamps[39].)

Lee County's median household income was slightly higher than the State of Florida average, and its percentage of persons in poverty was slightly lower. Compared with the national average, Lee County's median household income was less, but so was its percentage of persons in poverty.[40] During the 5-Year Estimate, 13% of county residents were below the poverty level; 22% of residents under 18 and 8% of residents 65-years-old and older were below the poverty level.

The American Community Survey also reports that nearly 635,000 residents in the county have health insurance. Nearly two-thirds of those are insured through private health

coverage. Nearly 98,000 residents in the county do not have health insurance. Almost 13,000 children in the county are not covered by health insurance.

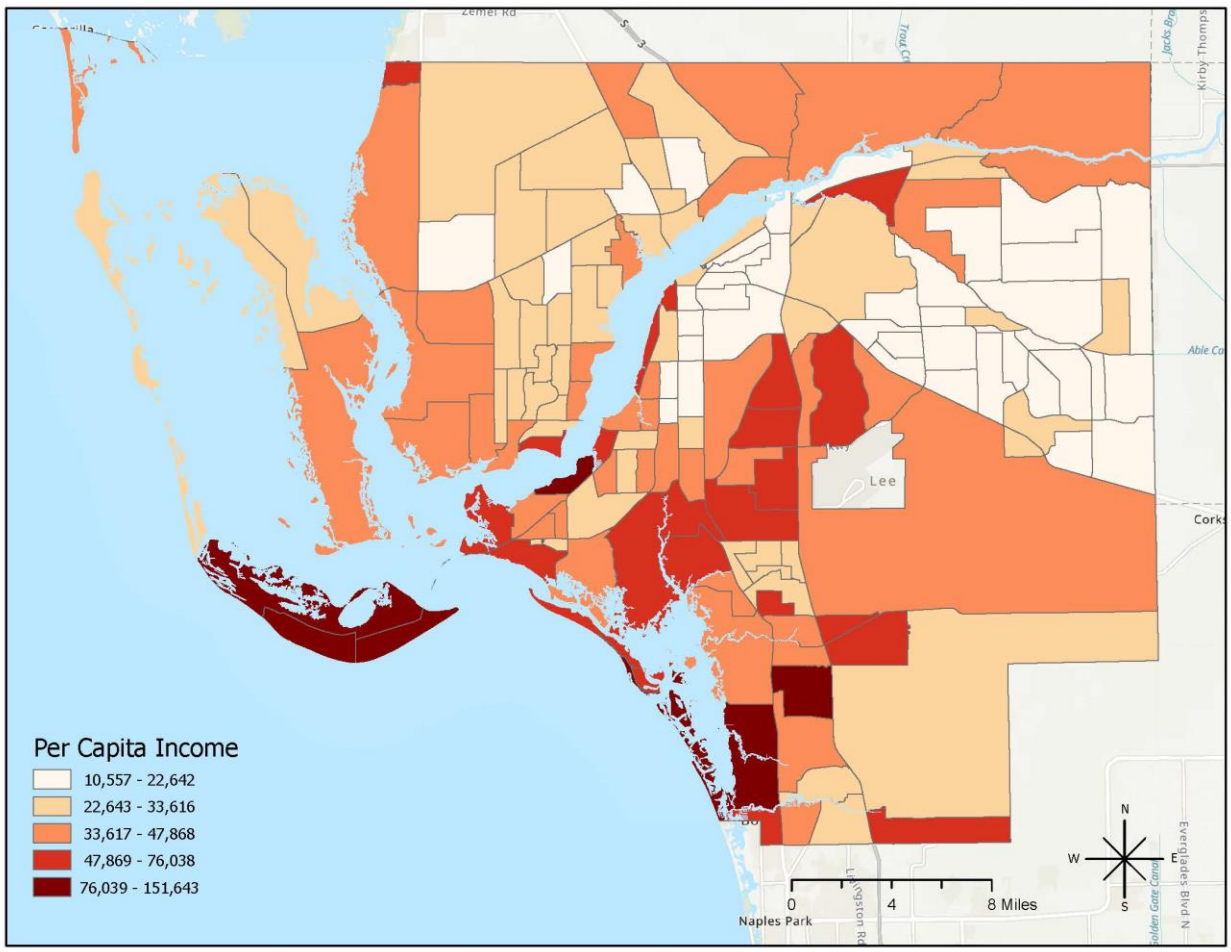

Figure 23 Per Capita Income by Census Tract (2020 US Census)

Natural Environment

Area topography for Lee County is generally flat and low. Land elevation ranges from sea level in the west to about 30-35 feet above mean sea level in the east. Figure 24 below visualizes the county's topography. Approximately 351 islands, forming about 80 square miles, help make up the county's coastline[41].

The Caloosahatchee River, which empties into San Carlos Bay, and other rivers and creeks that empty into Estero Bay make up the county's two major drainage areas. Rivers and creeks, such as Sanibel, Estero, and Imperial Rivers, empty into the Gulf of Mexico. Major creeks in the area include the Mullock, Spring, Hendry, Whiskey, Yellow Fever, Hancock, Daughtrey, Powell, Popash, Jug, Stroud, Otter, Telegraph, Billy, Hickey,

Bedman, and Cypress. The City of Cape Coral's boundaries enclose nearly 400 miles of canals. Figure 25 below visualizes the county's rivers and drainage systems.

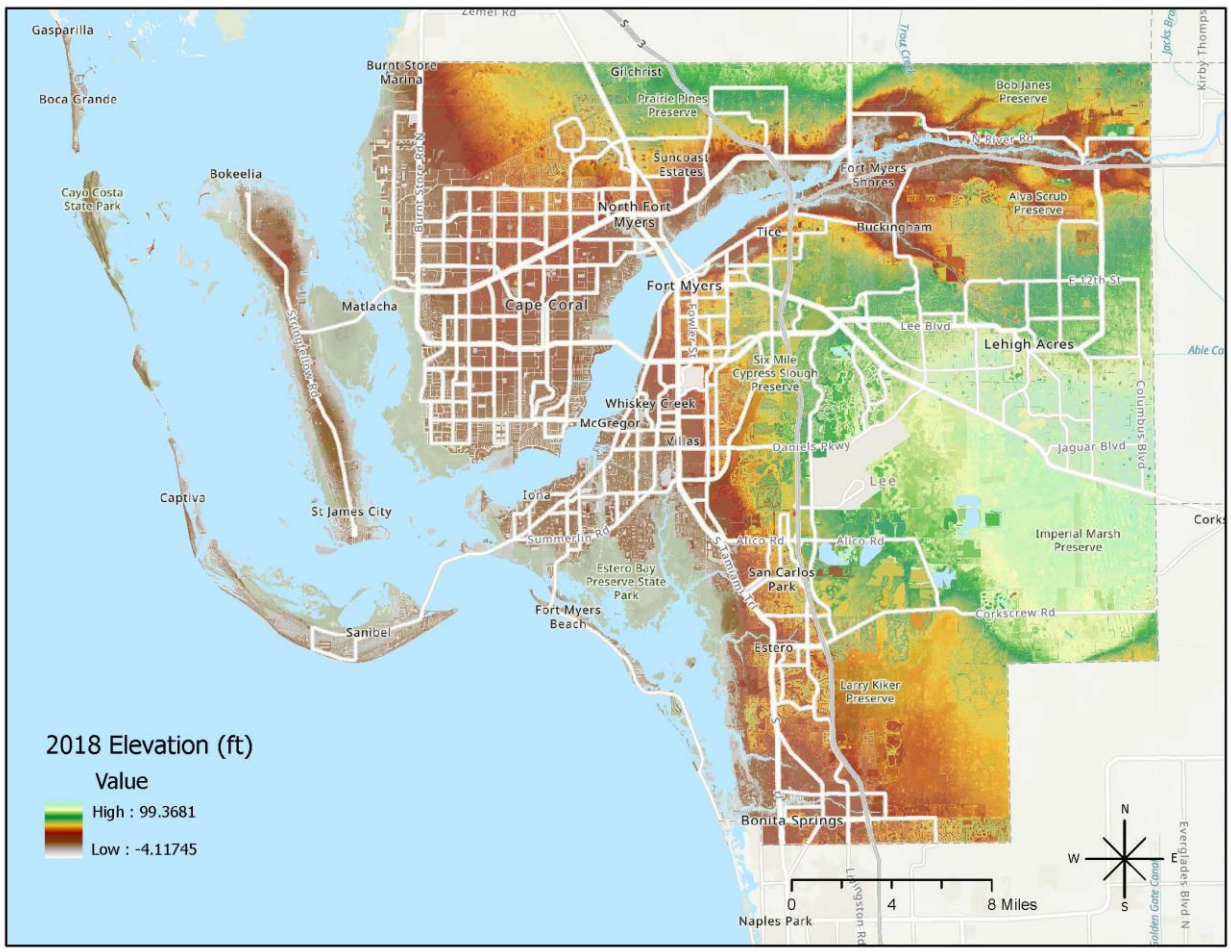

Figure 24 Lee County Topography

Lee County is home to a large variety of plant and animal life. This includes southern bald eagles, sea turtles, gopher tortoises, wood storks, fox squirrels, and eastern indigo snakes. Protected plan species include the joewood, beautiful paw-paw, Curtis milkweed, and Florida coontie. The *Lee County Land Development Code* provides an extensive list of protected animal and plant species in the county (see Appendix H).[42]

Mangroves also form an important part of the county's natural environment. These plants provide protection and stabilization of low-lying coastal lands and ensuring continuations of vital food chains. Mangroves provide protection against storm winds, waves, and floods and support ecosystems important to marine species, such as snook, snapper, tarpon, jack, sheepshead, red drum, oysters, and shrimp. Mangroves also protect the coastline against erosion.

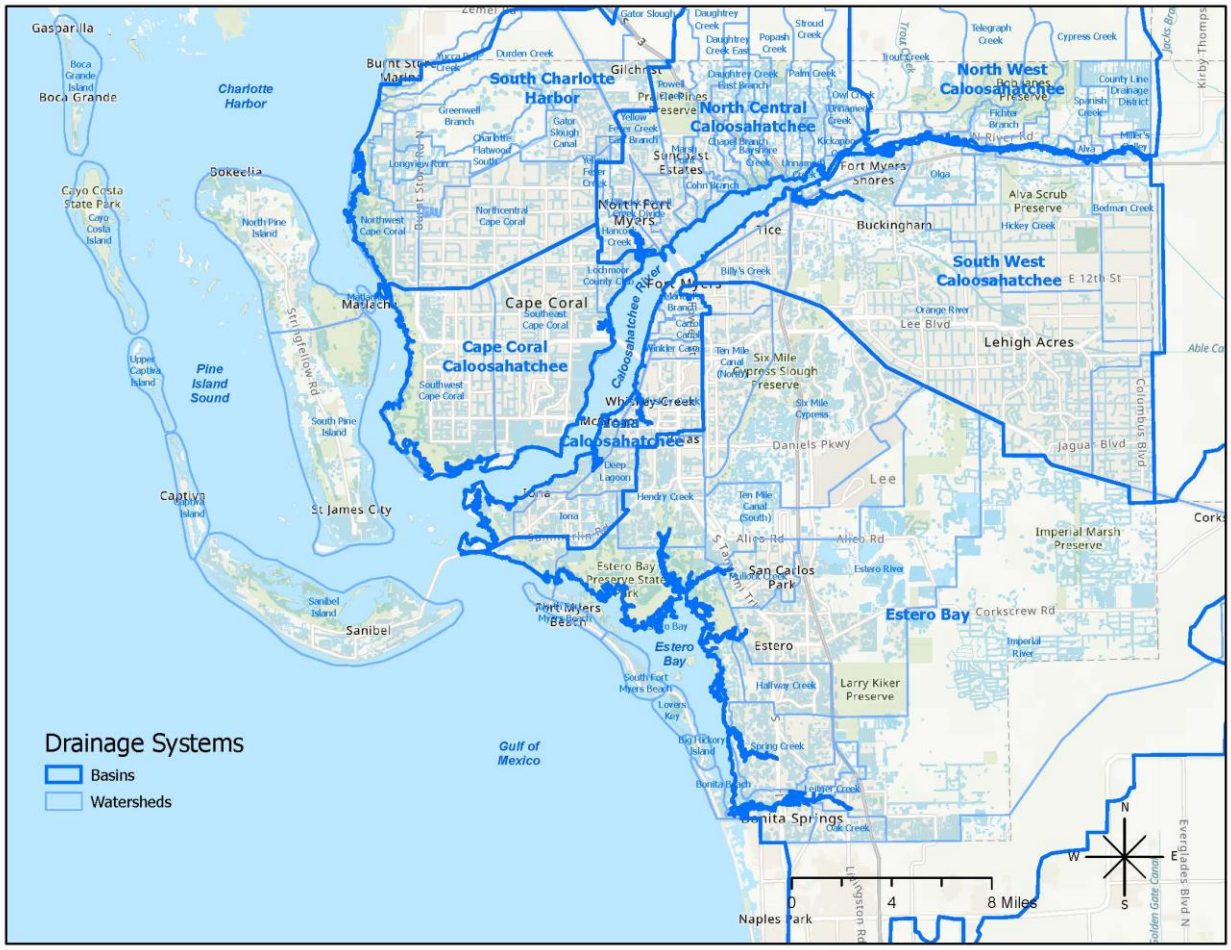

Figure 25 Drainage Systems in Lee County

The county's climate and topography combine to create several environmentally sensitive areas. The *Lee Plan* addresses multiple environmental spaces, such as wetlands, estuaries, mangroves, natural water system features, critical habitat for listed wildlife species, undeveloped barrier islands, beach and dune systems, aquatic preserves, wildlife refuges, undeveloped tidal creeks and inlets, critical wildlife habitats, benthic communities, and marine grass beds. Overall, Lee County maintains 63 environmental and wildlife preserves, in addition to a number of parks and recreational areas (see Figure 26 and Figure 27 below).

Lee County operates the Conservation 20/20 program to protect natural areas through land acquisition and stewardship initiatives. The program has acquired 149 properties since its initiation in 1996. Currently, the program manages 51 preserves totaling 31,343 acres.

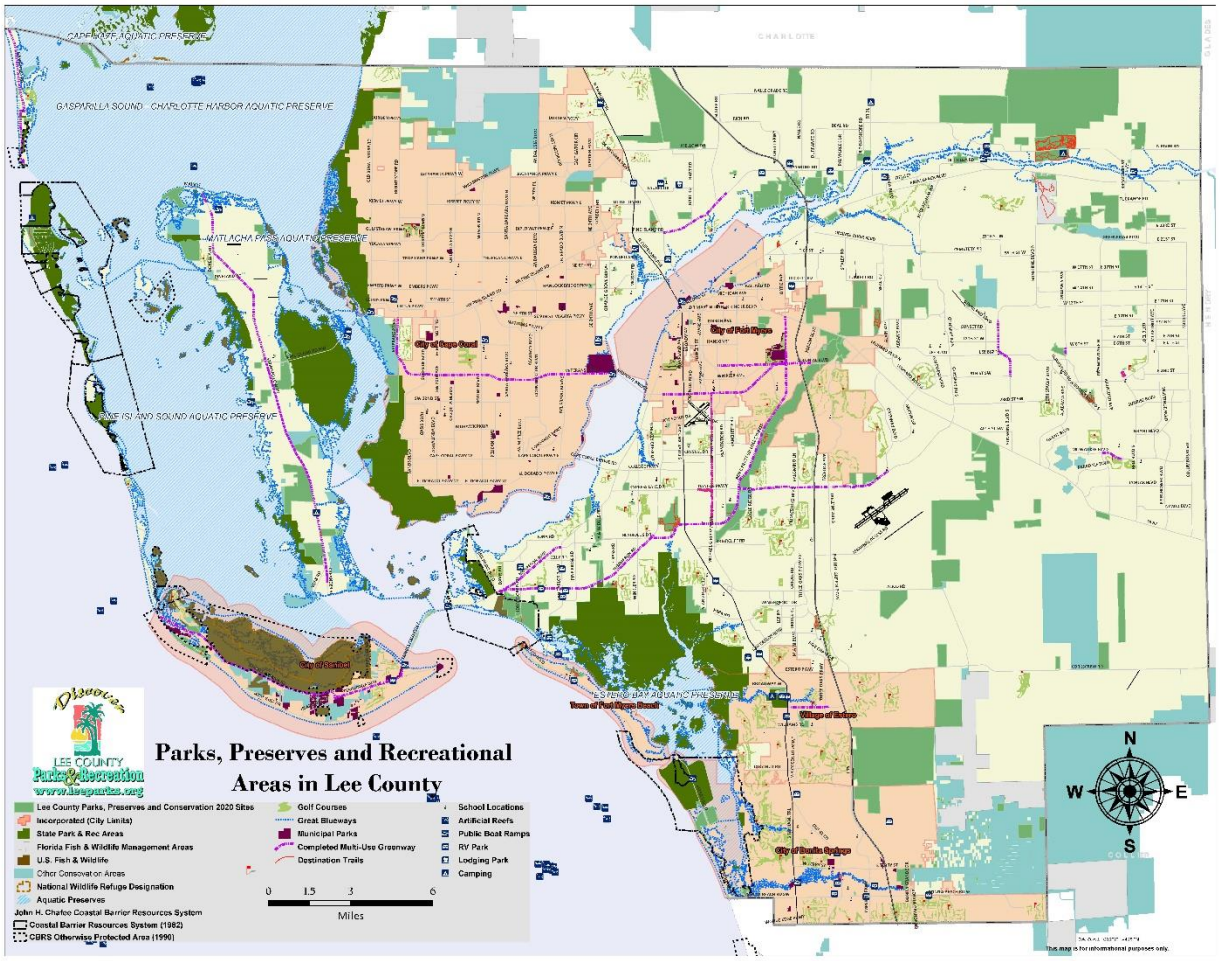

Figure 26 Parks, Preserves, and Recreational Areas in Lee County

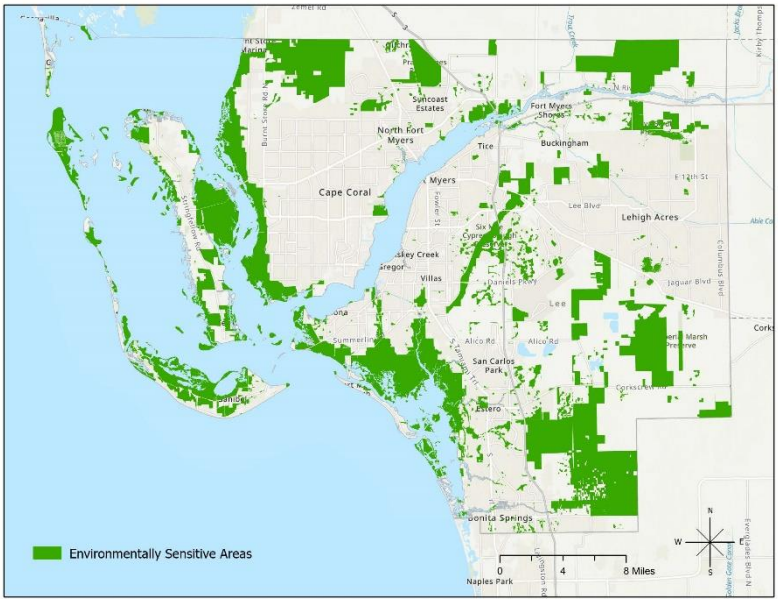

Figure 27 Conservation Areas

Built Environment

According to the American Community Survey 5-Year Estimate, Lee County has nearly 395,000 housing units. Seventy-percent of that inventory consists of occupied housing. Fifty-five percent of the inventory consists of single unit, detached housing, while 11% of the inventory consists of housing made of 20 or more units. About one-fifth of housing in the county was constructed between 1980 and 1989. Thirty-percent of housing was constructed between 2000 and 2009. Nearly 40% of houses in the county were built after the year 2000.

About 72% of houses in the county are owner-occupied and about 28% are renter-occupied. The average household size for owner-occupied residences is 2.5. For renter-occupied residences, the average household size is about 3. Nearly 60% of residents moved into the county or its political subdivisions in 2010 or thereafter. One out of ten residents have lived in the county or its political subdivisions since 2017. This mirrors very closely with the composition of residents in the State of Florida, where 55% of residents have lived in the state since 2010.

The median value for owner-occupied homes in Lee County is $224,800, compared with the median value for the State of Florida, which is $215,300. This represents an increase in the median value for the county and its political subdivisions over the last several years.

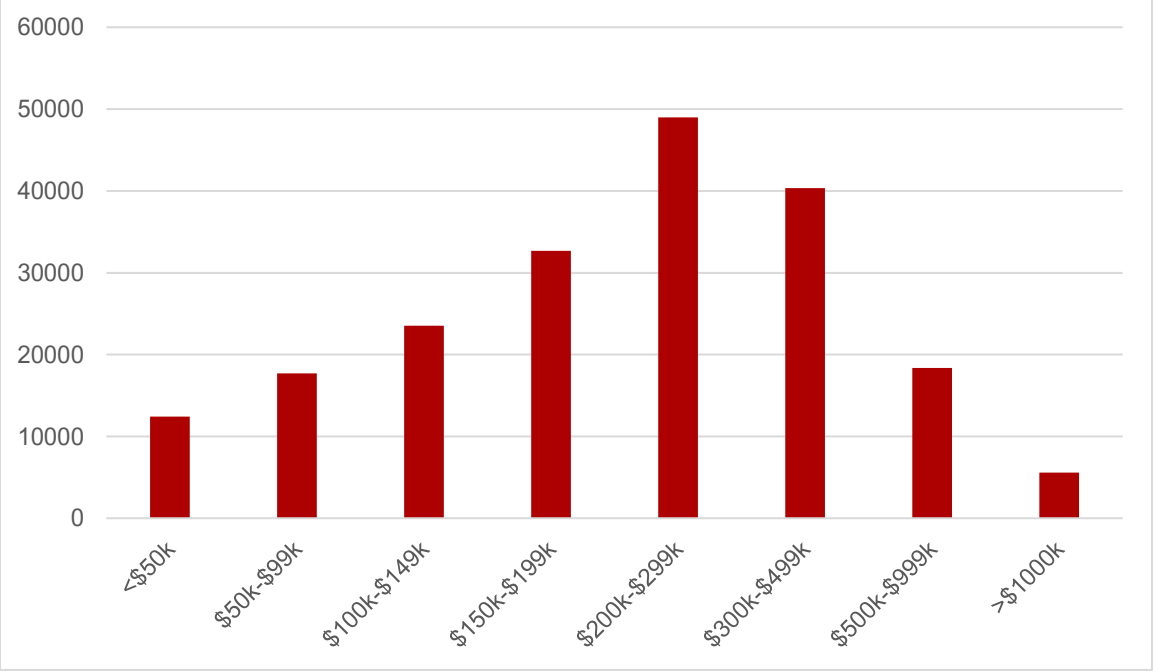

Figure 28 Estimated Values of Owner-Occupied Homes (ACS 5-Year Estimate 2019)

Table 7 Percentage of Occupied Housing Units with Vehicles Available[43]

Vehicles available	2015	2016	2017	2018	2019
0	5.1%	5.1%	4.9%	5.0%	6.3%
1	45.6%	44.3%	43.6%	43.0%	39.7%
2	38.3%	39.0%	39.0%	38.9%	38.4%
3+	11.0%	11.7%	12.5%	13.1%	15.6%

There are over 320,000 buildings in Lee County and it political subdivisions. Half of these are located in the unincorporated portions of the county; a quarter are in the City of Cape Coral. The Town of Fort Myers Beach and the Village of Estero have smallest building inventories of the participating jurisdictions. All the same, their property has greater relative value. Overall, Lee County and its political subdivisions comprise over $83 billion in property values. See Table 8 below.

Table 8 Total Buildings and Property Value

Jurisdiction	Total Buildings	% Total Buildings	Property Values	% Total Property Value
Bonita Springs	26,375	8%	$10,811,897,279	13%
Cape Coral	82,884	26%	$16,337,442,249	20%
Estero	16,739	5%	$6,436,764,722	8%
Fort Myers	27,441	9%	$8,435,515,114	10%
Fort Myers Beach	3,403	1%	$2,796,940,251	3%
Sanibel	5,254	2%	$3,660,251,306	4%
Unincorporated	159,453	50%	$34,596,578,713	42%
Total	**321,549**	**100%**	**$83,075,389,634**	**100%**

Interstate-75, U.S. Route 41, and Florida State Road 82 comprise the county's major vehicular thoroughfares. Figure 29 below depicts these routes, as well as other major roadways for Lee County and its political subdivisions. As Table 7 above demonstrates, the availability of vehicles to occupied housing units has remained fairly consistent over the last five years. (Although, there was a slight increase in the number of units without vehicles available in 2019.) The vast majority of residents in the county have access to at least one vehicle (about 94%). Aside from personal vehicles, a multitude of transportation options are used by residents, including public buses, taxis, share ride services, and so forth.

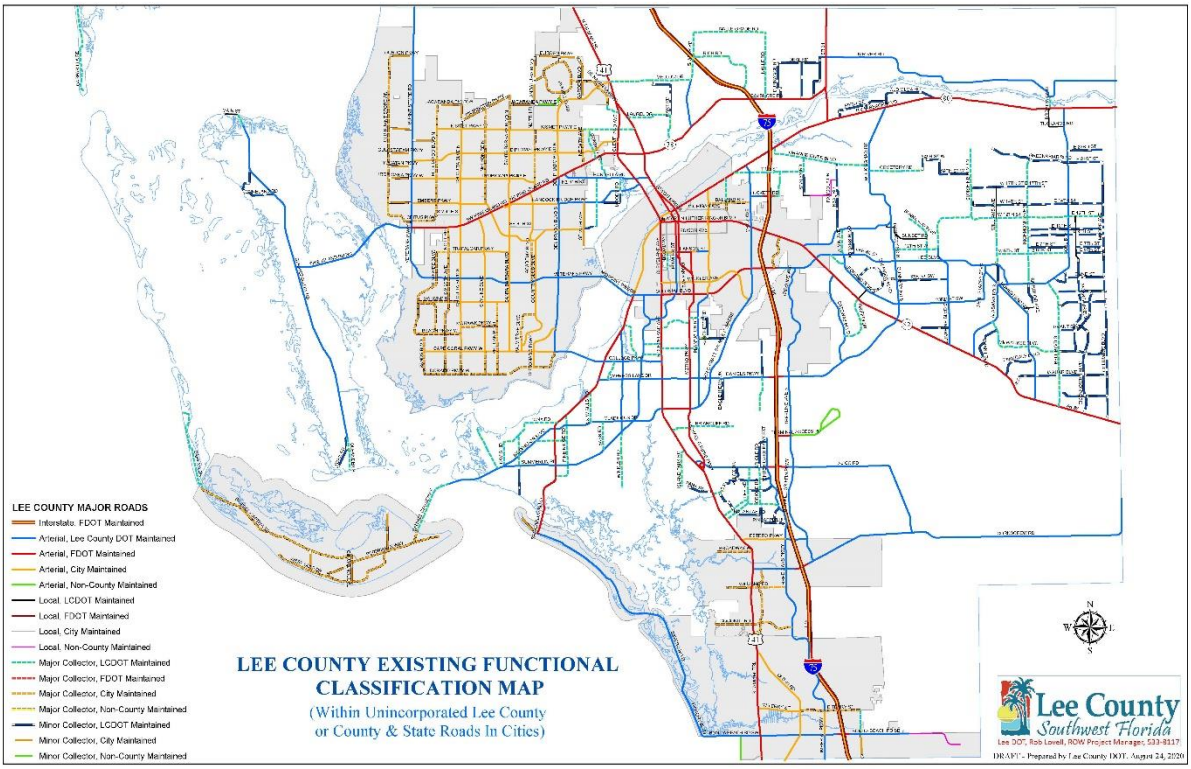

Figure 29 Lee County Major Roads

The prevalence of large water features, such as the Caloosahatchee River, the bays, and the barrier islands necessitates the construction and use of bridges to facilitate movement throughout the county. Major bridges include structures such as the Cape Coral Bridge, the Midpoint Bridge, the Cleveland Avenue Bridge, the Edison Bridge, and the I-75 overpass. Other important routes over water features include Pine Island Road, the Sanibel Causeway, and the Boca Grande Causeway. Some barrier islands are not connected to the mainland via roads or bridges and must be accessed by boat.

Figure 30 below further illustrates Lee County's transportation infrastructure. In addition to its roadways, the county's infrastructure includes railways, seaports, and airports. Southwest Florida International Airport (RSW) is the largest airport in the county. TSA reports show that RSW is 17th in the nation for passenger traffic. RSW covers 13,555 acres of land and is the third largest airport in the country in terms of land size. The county's second airport is Page Field, which covers 670 acres and consists of two asphalt runways. The Seminole Gulf Railway connects the Southwest Florida region with 118 miles of track. It hauls newsprints, building materials, gas, plastics, stone, steel, and other commodities.[44]

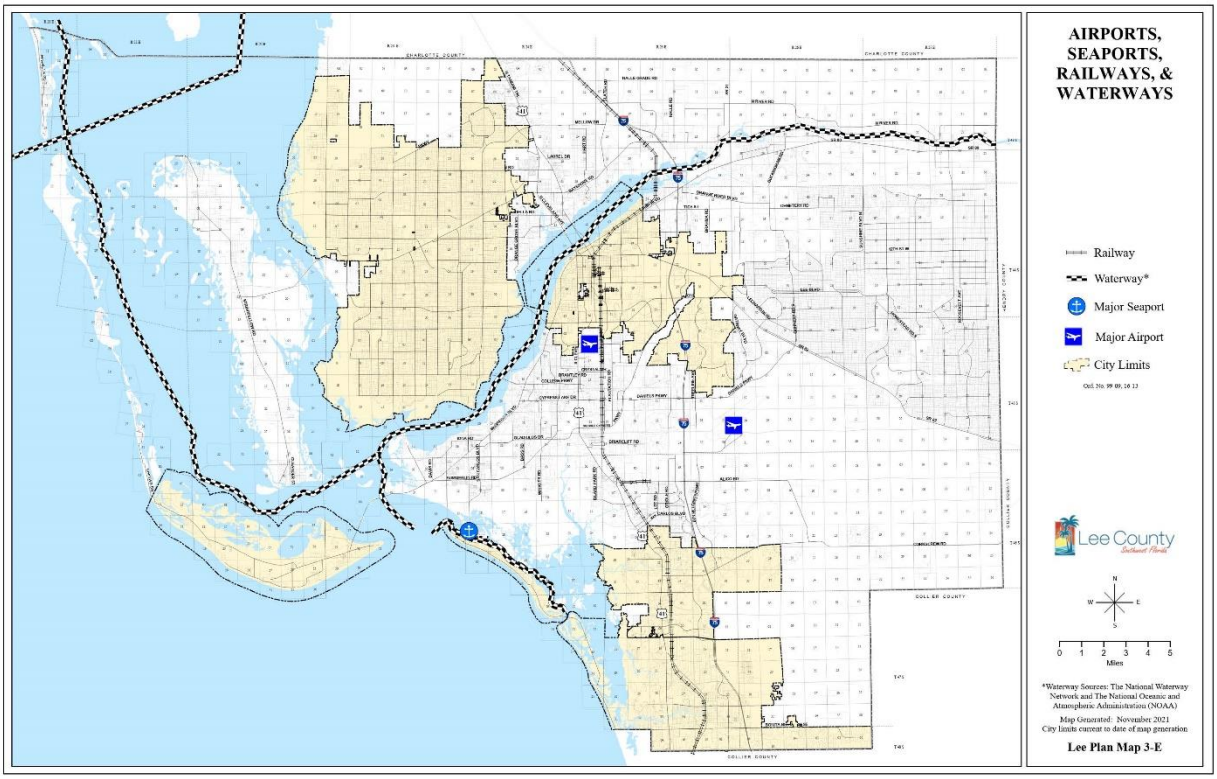

Figure 30 Airports, Seaports, Railways, and Waterways

There are multiple utility companies operating in Lee County. Table 9 enumerates some of these utilities and the locations for their primary offices. Florida Power & Light (FPL) and the Lee County Electric Cooperative constitute the two major providers for power in the county. Lee County Utilities provides water and wastewater services to over 254,000 customers.

Lee County Emergency Management maintains a list of critical facilities in the county. Critical facilities consist of infrastructure that is essential to supporting the community (such as utilities), ensuring its safety (such as law enforcement stations), and provisioning basic public health (such as hospitals). This list is included here by reference only; the list is not meant for public distribution.

Lands use in Lee County is spread across numerous functions, such as residential, commercial, agricultural, and so forth. Figure 31 below shows the spatial distribution of land use in the county. As expected, wetlands dominate the county's coastlines. The City of Cape Coral is largely residential and agricultural land use is congregated primarily along the northern and western edges of the county. Commercial land use falls largely along primary routes of transportation.

Table 9 List of Utilities in Lee County

Utility	Location
Bonita Springs Utilities Inc	Bonita Springs
City of Fort Myers Utilities	Fort Myers
East County Water Control District	Lehigh Acres
Florida Governmental Utility Authority	North Fort Myers, Lehigh Acres
Florida Power & Light Co	Fort Myers
Gasparilla Island Water Association	Boca Grande
Greater Pine Island Water Association	Bokeelia
Island Water Association	Sanibel
Lee County Electric Cooperative	North Fort Myers
Lee County Utilities	Fort Myers
North Fort Myers Utility Inc	North Fort Myers
Town of Fort Myers Beach Utilities	Fort Myers Beach

The *Lee Plan* addresses land use in more detail. The *Lee Plan* gives particular attention to future trends in development and land use. Figure 32 below is a reproduction of the Future Land Use Map for the county, which is part of the *Lee Plan*[45].

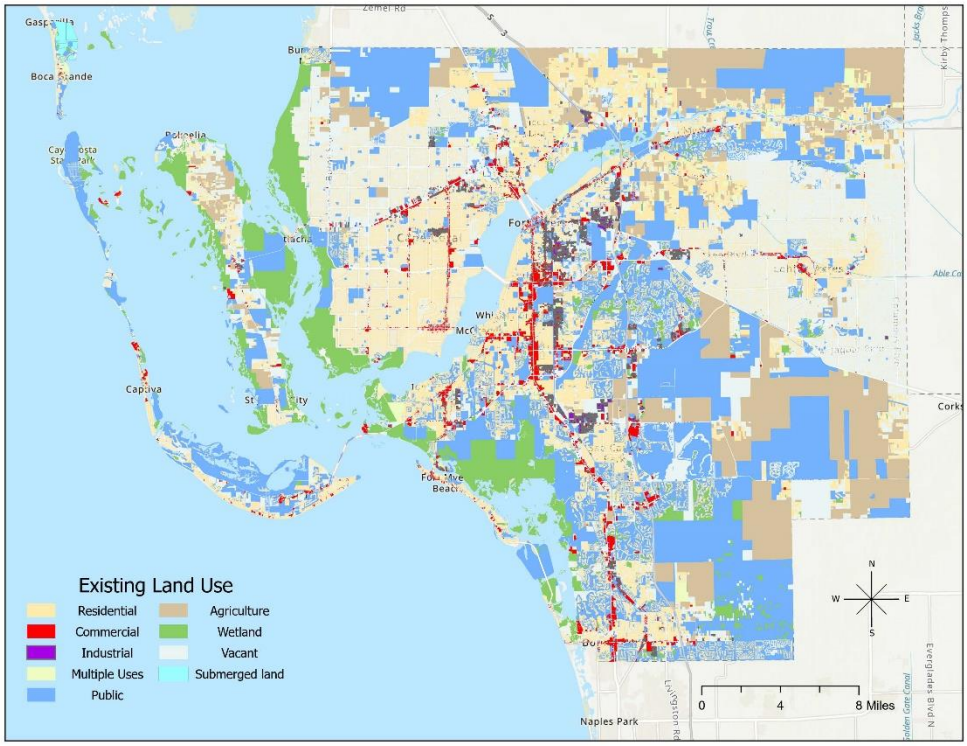

Figure 31 Existing Land Use in Lee County

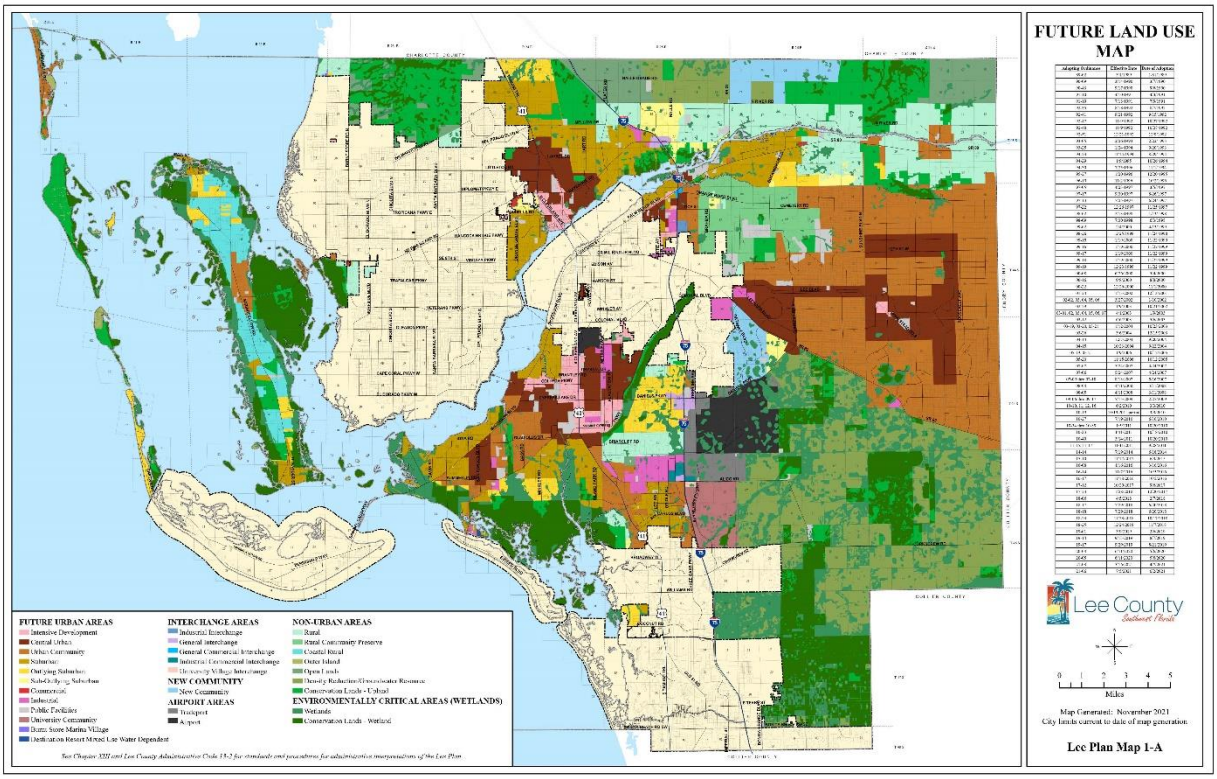

Figure 32 Lee County Future Land Use Map

In 2017 (the most recent date for available data)[46], Lee County had 800 farms. Together, these farms covered over 87,000 acres. The average size was 109 acres, while the median was 10. Compared with many other regions in the state, Lee County's agricultural foot print is small.[47] Table 10 below breakdowns the proportion of farmland in the county by type of use.

Table 10 Land in Farms by Use

Type of Use	Percentage
Cropland	25%
Pastureland	47%
Woodland	20%
Other	8%

There are 800 farms operating in Lee County and its political subdivisions. Average value for these farms is approximately $1.3 million dollars. Machinery and equipment in the county make up an inventory valued at over $42 million dollars. The average farm in the county sales about $130,000 in agricultural product. Table 11 below summarizes this data.

Table 11 Farm Statistics for Lee County (2017)[48]

Category	Value
Number of Farms	800
Estimated market value of land and buildings: Average per farm	$1,3330,329
Estimated market value of all machinery and equipment	$42,590,000
Market value of agricultural products sold	$104,359,000
Average per farm	$130,449
Net cash farm income of operation	$11,129,000
Average per farm	$13,911

Vegetables make up the largest crop by acres in the county, followed by oranges. Other top crops in the county by acreage include potatoes, forage, and tomatoes. See Table 12 below. Cattle make up the largest number of livestock in the county, followed by layers. Goats and chickens also contribute large numbers to the overall livestock inventory. See Table 13 below.

Table 12 Lee County Top Crops by Acres (2017)[49]

Crop	Acres
Vegetables harvested, all	7,014
Oranges, all	4,260
Potatoes	Not disclosed
Forage (hay/haylage)	2,636
Tomatoes in the open	Not disclosed

Table 13 Lee County Livestock Inventory (2017)[50]

Livestock	Inventory
Broilers and other meat-type chickens	1,190
Cattle and calves	10,839
Goats	2,096
Hogs and pigs	307
Horses and ponies	955
Layers	5,923
Pullets	388
Sheep and lambs	336
Turkeys	126

Cultural Resources

Lee County has thirteen historic districts, listed below. These districts have multiple historic sites and historical values.[51] Figure 33 below shows the locations of historic properties across the county.

Historic Districts	
Boca Grande	Captiva Chapel by the Sea
Boca Grande Lighthouse	Koreshan State Historic Park
Bokeelia	Matlacha
Buck Key	Mound Key
Buckingham Army Airfield	Pineland
Burgess Island	Tween Waters
Calusa Island and Barancas Avenue	

Within Lee County and its political subdivisions, there is a multitude of museums, galleries, theaters, centers, and so forth. For example, Fort Myers Beach has Mound House, which is on the National Historic Registrar. Together, these establishments and locations provide a collection of scientific, historical, cultural, and artistic expressions of the numerous cultures that are a part of the county, its make-up, and its history.

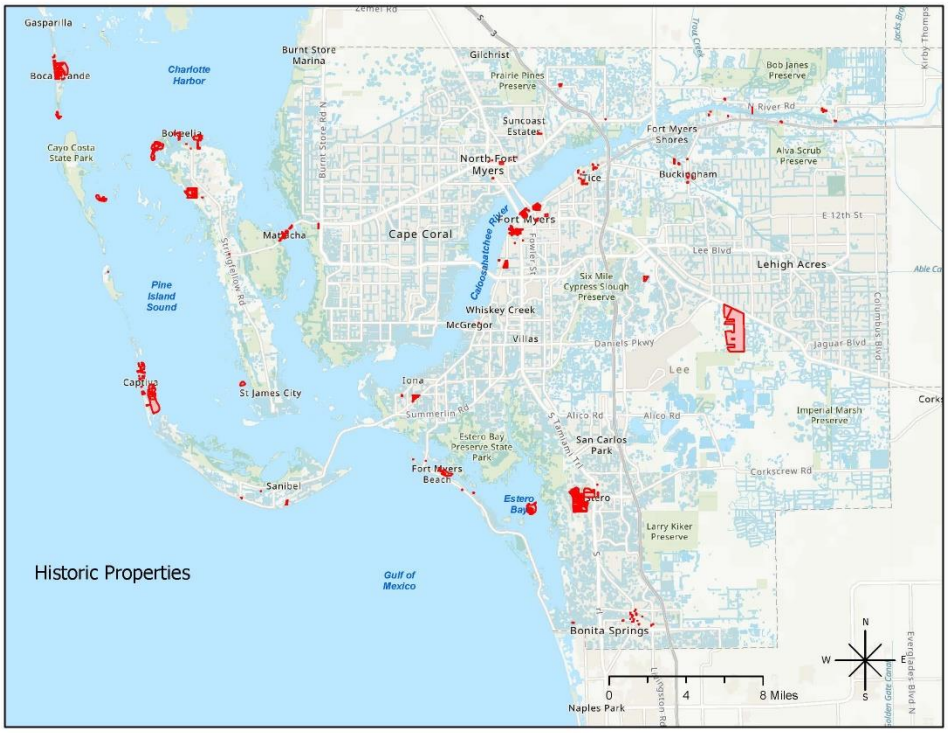

Figure 33 Lee County Historic Properties

Chapter 3 Community Hazards and Risks

This chapter establishes the framework for the hazard identification and risks assessment (HIRA) used by Lee County and its political subdivisions. First, the chapter defines terms and contexts for the framework. Second, the chapter summarizes the onset of hazards in the past that have resulted in major declarations. Third, the chapter identifies which hazards will be included and excluded from the assessment and the rationale for such. Fourth, the chapter describes the methodology used to assess and rank community hazards.

Nature of Hazards and Risks

Hazards are events, either caused by natural forces or by human activity, that carry the potential for significant disruptions to natural and human systems. Ultimately, hazards threaten the safety and stability of communities. Unlike "everyday" emergencies that are typically resolved with standard systems, such as emergency services, law enforcement, and so forth, the consequences of hazards are of such size and/or breadth that special coordination and additional resources are necessary to effectively save lives and protect property. In this manner, the hazards examined by the HIRA are inherently larger in scale and depth than "normal" instances of instability.

Hazards are defined in hereby their type, location, extent, previous occurrences, and the likelihood of occurring in the future. When compared against the community's population, the built and natural environment, and the economy, planners are able to determine the community's risk.

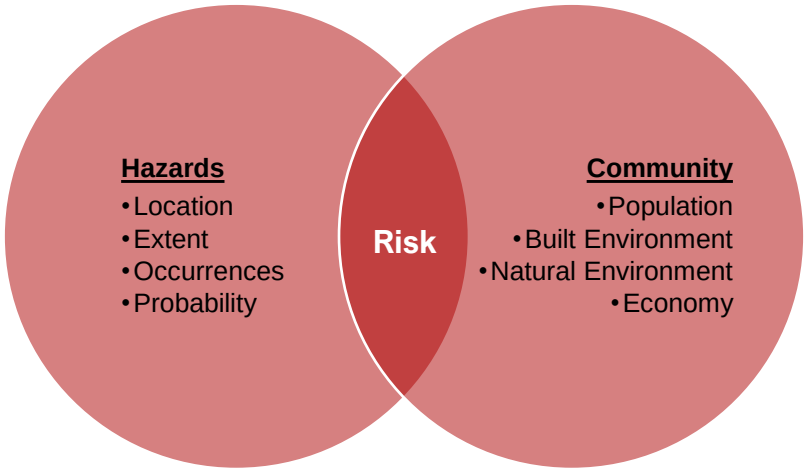

Figure 34 Hazards, Communities, and Risks

Changes in Risk and Vulnerability

Over the last ten years, changes in the demographics, economy, and built and natural environments of Lee County and its municipalities have naturally resulted in changes to risk and vulnerability from hazards. Since 2010, the area's population has increased by 23%, placing more people potentially in harm's way and concurrently placing more demand on government and non-government services before, during, and after a hazardous event occurs. Some of the increase occurred in areas prone to flooding, including storm surge, like in areas around Bonita Springs, Fort Myers, and Estero; meanwhile, population decreases in areas around Sanibel and Fort Myers Beach decrease some of that risk and vulnerability. Decreases in the number of persons experiencing homelessness in the county and its political subdivisions means a slight reduction of risk and vulnerability among that group to hazardous incidents.

The increase in population over the last ten years has included additional individuals and families with special medical needs, such as energy-dependence medical care, or with financial constraints (e.g., fixed-income senior citizens), or both. The median age for the county and its political subdivisions has increased slightly, which generally has resulted in an increase of vulnerability among the population. Based on Figure 9 on page 11, older members of the population are congregate in flood prone areas, such as Sanibel, Bonita, Fort Myers Beach, and the area around Iona and McGregor.

Recent tourism decreases from the COVID-19 pandemic resulted in fewer individuals and families unfamiliar with the area and its resources and a reduction in those who may seek government and non-government services before, during, and after a hazards incident. However, it is likely tourism will return to near- or at-pre-pandemic levels within the next year or so.

Economic growth in the region provides greater access to employment and financial resource before, during, and after a hazardous incident occurs. Resilience in the community improves with economic health and lower unemployment. Lee County and its political subdivisions have economies dominated by the service industry, however, so that disruptions in that area could have larger economic and resiliency consequences than disruptions in other parts of the economy.

With population growth, the built environment has expanded significantly as well, placing more infrastructure at risk of a hazardous incident. The expansion of the built environment has inevitably affected the natural environment, decreasing its ability to absorb

disruptions. As additional infrastructure in placed along coastal areas, the risk and vulnerability of erosion will grow, as the ability of fauna and waterways to absorb flooding will shrink.

History of Hazardous Incidents

Like all places, Lee County has a history experiencing hazardous incidents. Given the area's climate and geography, the county and its political subdivisions are susceptible to a multitude of natural hazards that occur with some degree of regularity. Since 1953, Lee County has experienced 32 disasters since 1953. These disasters have consisted of[52]:

14 hurricanes	6 fires
5 freezes	3 severe storms
2 biological	2 coastal storms

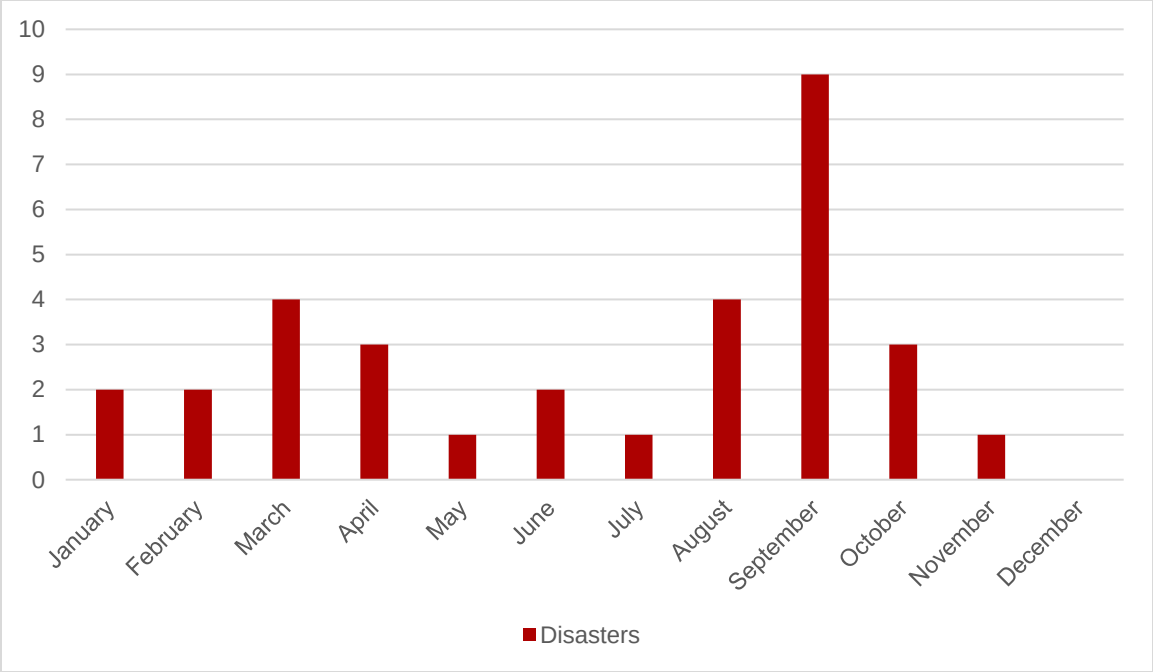

Figure 35 Number of Disasters by Month since 1953 (Lee County)[53]

Historically, these disasters have occurred mostly in the fall months, primarily because of the propensity for severe weather in the southeastern United States during that time of the year. Figure 35 above demonstrates the distribution of disasters in Lee County since 1953 over the 12-month calendar year.

Major Disaster Declarations

Not every onset of a hazard is significant. Some pass by with little to no impact while others inflict damage and disruptions on the county and its political subdivisions. Since 1965, there have been 19 major disaster declarations for Lee County. Twelve of the declarations were for severe weather-related incidents (i.e., hurricanes, coastal storms, and severe storms). Five of the declarations were for freezes and one was for fire. The most recent declaration occurred in 2020 for COVID-19.

Table 14 History of Major Disaster Declarations for Lee County[54]

Number	Type	Year	IH	IA	PA	HM
209	Hurricane	1965	-	X	X	X
252	Hurricane	1968	-	X	X	X
304	Freezing	1971	-	X	X	X
337	Coastal Storm	1972	-	X	X	X
526	Freezing	1977	-	X	-	-
732	Freezing	1985	-	X	-	-
851	Freezing	1989	-	X	-	-
1069	Hurricane	1995	-	X	X	X
1223	Fire	1998	-	X	X	-
1359	Freezing	2000	-	X	-	X
1393	Coastal Storm	2001	-	-	X	X
1539	Hurricane	2004	X	X	X	X
1545	Hurricane	2004	X	X	X	X
1551	Hurricane	2004	X	X	X	X
1561	Hurricane	2004	X	X	X	X
1609	Severe Storm(s)	2008	X	X	X	X
4068	Severe Storm(s)	2012	X	X	X	X
4337	Hurricane	2017	X	X	X	X
4486	Biological	2020	X	-	X	X

NCEI Storm Events Data

The National Weather Service (NWS) publishes the National Centers for Environmental Information (NCEI) Storm Events Database. As of the analysis performed for this HIRA, the database ranges from January 1950 to July 2021. Records for the majority of weather events were reported starting in 1996, as defined in the NWS Directive 10-1605. The exception is tornado events that were recorded from 1950-1954. Thunderstorm wind and

hail events haven't been recorded since 1955. The database contains information on storms and weather phenomena that have caused the following:

- loss of life;
- injuries;
- significant property damage; and/or
- disruption to commerce.

The data collection methods for the NCEI Database have varied significantly over time. The records kept prior to 1993 were extracted from a manually typed Storm Data Publication. From 1993 to the present, the Storm Data Publication was built from the digital records of the database. It should be noted that property and crop damage should be considered a broad estimate. The NWS makes a best guess using all available data.

There have been 616 incidents recorded for Lee County by the NCEI database since 1955. Table 15 below summarizes these incidents.

Table 15 NCEI Hazard Events for Lee County (as of November 2021)[55]

Type	Total	Injuries	Deaths	Property Dmg Est	Crop Dmg Est
Flood	36	0	0	$503m	$0
Heat	3	0	3	$0	$0
Heavy Rain	15	0	0	$0	$0
Severe Weather	391	29	14	$21.9m	$3.6k
Tornado	143	34	1	$33.4m	$0
Tropical Cyclone	10	0	1	$326m	$11m
Wildfire	15	0	0	$103m	$0
Total	**606**	**63**	**93**	**$2,176.5m**	**$33.4m**

It should be noted that the database does not account for all hazardous incidents. Flooding includes riverine floods, flash floods, coastal flooding, and storm surge. Tropical cyclone includes tropical storms and hurricanes. Severe weather consists of thunderstorms, lightning, and hail. Tornados include not only tornadoes of F0 or greater, but also dust devils, waterspouts, and funnel clouds. It should also be noted that the database takes the available total damage estimate from the event and, if multiple jurisdictions are involved, evenly spreads the damage across them.

Hazards Assessed

Community leaders and planners compare hazard risks to each other to prioritize efforts to manage their prevention and mitigation. Prioritization is imperative when allocating limited resources to managing hazards. Care is taken during the HIRA process to weigh various factors, such as the likelihood of occurrence, the potential for injury or loss of life, and economic impacts, so that proper attention is given to those hazards that carry the most overall risk. The methodology for ranking is discussed in the Ranking Methodology section below. In this version of the *Hazard Identification and Risk Assessment*, only natural hazards are included. Human-caused hazards are current in the process of being assessed. This document will be updated in mind-2022 to include the results of that assessment.

The process of assessing hazards is time-intensive. The interaction of hazards—often times driven by complex natural or human-led forces—with sophisticated natural and human systems requires extensive research and historical perspective. So it is that planners are not capable of assessing every possible hazard. The likelihood of some hazards is either non-existent (e.g., volcanoes) or so small (e.g., tsunamis) that there is no practical benefit to assessing them. Other hazards, such as aircraft crashes, carry such potential for loss of life that despite their low likelihood, they must be assessed. Based on such factors and considerations, planners determined which hazards would be included in the HIRA. Table 16 and Table 17 below delineate the planners' decision.

Table 16 List of Hazards Assessed

Natural Hazards		Human-Caused Hazards
Animal/Plant Disease Outbreak	Flood	Aircraft Crash
Coastal Erosion	Freeze	Cyberattack
Drought	Severe Weather	Hazardous Materials Release
Epidemic/Pandemic Disease	Tornado	Mass Casualty/Mass Fatality
Excessive Cold	Tropical Cyclone	
Excessive Heat	Wildfire	

Table 17 List of Hazards Not Assessed

Earthquake/Seismic Event	Sinkhole/Subsidence	Tsunami	Volcano
Dam/Levee Failure	Major Pipeline Failure	Major Power Failure	Major Transportation Route/Bridge Failure
Radiological Release	Urban/Major Structure Fire	Civil Disturbance	Mass Migration
Special Events			

In this version of the *Hazard Identification and Risk Assessment*, only natural hazards are included. Human-caused hazards are currently in the process of being assessed. This document will be updated in mid-2022 to include the results of that assessment.

Ranking Methodology

To compare different hazards, this hazard identification and risk assessment uses a standardized methodology that allows for flexibility and subject matter expertise. The method used prioritizes hazard risk based on a blend of quantitative and qualitative factors. Assessed data was pulled from a multitude of sources for each relevant hazard. Many of the hazards assessed in the following chapters do not have quantifiable probability or impact data, necessitating reliance in some instances on consensus among subject matter experts.

When assessing hazards and risks, planners considered the following factors for comparison between hazards:

- Probability or likelihood of the hazard occurring;
- Direct injuries or deaths from the hazard's onset;
- Financial impact of the hazard; and
- Warning time available to detect the hazard's onset before its occurrence.

For each of these factors, planners assigned a rank of (1) low, (2) medium, or (3) high. These scores were then weighted according to the schedule provided in Table 18 below. Once weighted, the final scores were sorted in descending manner (i.e. largest to smallest).

Table 18 Hazard Assessment Schedule

Score	Probability	Direct Deaths and Injuries	Impact	Warning Time
Weighting	1.25	1.0	1.25	0.5
1	Somewhat Likely – infrequent occurrence	None recorded	<$50,000	3+ days
2	Likely – frequency occurrence	Any injuries recorded, no deaths	$50,000-$150,000	1-2 days
3	Highly likely – common events	Any deaths recorded	>$150,000	<1 days

Chapter 4 Natural Hazards

Natural hazards are sources of harm or difficulty created by a meteorological, environmental, or geological event[56]. While human activity may affect the likelihood or extent of natural hazards, they are events inherently outside human control. The intersection of natural hazards with one another and with built and social systems can create cascading effects, such as naturally occurring diseases spreading from animals to humans, which in turn can create instances of social instability. For the purpose of this assessment, interaction between hazards is not considered, although their narrative may at times touch upon them.

Animal/Plant Disease Outbreaks

Lee County and its political subdivisions are located within a tropical climate. As outlined in the Natural Environment section of the Community Profile, the region hosts numerous species of plants and animals. Some of these plants and animals are endangered or susceptible to environmental or population disruptions. The region also consists of agricultural land and operations that are important contributors to employment and economic activity. This combination of natural and agricultural resources places the county at risk of experiencing animal and plant disease outbreaks, as well as intrusion from invasive species.

Medfly, citrus, canker, and melaleuca are examples of invasive species that have had significant impact on Florida residents, growers, and the environment. Medfly is a devastating pest of more than 200 varieties of fruits, nuts, and vegetables. Citrus canker, a serious disease of most citrus plants, causes lesions on leaves, stems, and fruit, as well as premature fruit dropping. In Florida, not only is there an abundance of commercial citrus crops to serve as hosts, but there is a multitude of backyard citrus that can contribute to the spread of the illness, as well. Melaleuca and other noxious weeds threaten to crowd out native Florida vegetation and deplete essential natural resources, including unique ecosystems, such as the Everglades.

Lee County has an identified list of 21 invasive plants in the area[57]. Invasive plant life could lead to significant ecosystem disruptions with serious consequences for local animal and plant life. The county defines plants as either naturalized or exotic, as demonstrated in the bullets below[58]:

- Exotic – a species introduced to Florida, purposefully or accidentally, from its native range outside of Florida
- Native – a species whose natural range included Florida at the time of European contact (1500 AD)
- Naturalized Exotic – an exotic that sustains itself outside of cultivation and its native range (it is still exotic; it has not "become" native)
- Invasive Exotic – a naturalized exotic that is expanding its range into natural areas and disrupting naturally occurring native plant communities. These plants don't encounter the natural enemies in the U.S. that controlled their growth in their home range.

Other risks to plant life in the county include the eastern lubber grasshopper[59], the emerald ash borer[60], exotic fruit flies[61], the giant African land snail (which also poses a risk to humans by carrying pathogens that can cause meningitis)[62], the horntail snail (with the same risk to humans as the giant snail)[63], and different kinds of mites[64,65]. Vegetation in the region is also at risk of experiencing wilt diseases[66].

Risks to animal life in the county include the avian influenza[67], bovine spongiform encephalopathy[68], eastern equine encephalitis[69], equine infectious anemia[70], equine piroplasmosis[71], rabies[72], strangles[73], and the West Nile virus[74]. The Florida Fish and Wildlife Conservation Commission (FWC) also monitors disease in wildlife populations, including those that reside in Lee County[75]. Concurrently, the Florida Department of Agriculture and Consumer Services (FDACS) maintains a statewide surveillance program to detect and monitor the onset and spread of plant and animal diseases[76]. FDACS maintains a list of reportable animal diseases in the State of Florida, such as anthrax, chronic wasting disease, foot and mouth disease, and so forth[77].

There is also a conjunction of risks posed to the county and its public subdivisions by the intersection between animal and human infections. For example, infections, such as rabies, can be transmitted from animals to humans. The recent occurrence of COVID-19 has been demonstrated to be transmittable from humans to domestic and wildlife animals.

Location and Extent

The most vulnerable locations in Lee County and its political subdivisions for animal/plant disease outbreaks are those centered on undeveloped areas, such as the wetlands, and agricultural lands (see Figure 31). As addressed in the Community Profile, these

agricultural lands are located primarily in the county's unincorporated areas. Residential agriculture, such as citrus trees in yards, are susceptible to plant disease spread, as well.

Previous Occurrence(s)

Citrus canker was discovered in Manatee County in 1986. It was declared eradicated by 1994. Three years later, the plant disease was found again on Florida's west coast. From August 2002 to January 2006, FDACS destroyed about 660,000 citrus trees, some of which were in Lee County, to prevent an outbreak of citrus canker. Many trees on private property were forcibly destroyed in an attempt to control this contagious disease during that period.[78]

Part of FDACS' operations include the Cooperative Agricultural Pest Survey (CAPS). This is a combined state and federal effort to surveil, detect, and monitor plant diseases, insects, weeds, nematodes, and other invertebrate organisms[79]. CAPS distributes quarterly reports, which are available on the agency's website[80].

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Except in those instances where an outbreak is capable of being transmitted to humans, the impact to the public from this hazard will mostly likely not result in any injuries or fatalities.

Responders

Except in those instances where an outbreak is capable of being transmitted to humans, the impact to responders from this hazard will most likely not result in any injuries or fatalities.

Continuity of Operations and Delivery of Services

Except in those instances where an outbreak is capable of being transmitted to humans, the impact to the continuing operations of the county and its political subdivisions and to the delivery of services to the public will most likely be negligible.

Built Environment

Property, facilities, and infrastructure will experience minimal impact from the onset of this hazard. If loss of property occurs, it will be highly localized to specific farms or similar locations.

Natural Environment

There is not an available estimate for what impact an outbreak of animal or plant disease would have on the natural environment in Lee County. It can be assumed that given the sensitivity of many of the species residing in the area, that a severe outbreak of disease can affect plant and animal populations in the Lee County in deleterious ways. Such disruptions could result in "downstream" consequences in the ecosystem where precipitous decreases in population among animal or plant life can affect the food chain or other aspects of environmental stability. Invasive animal and plant species that experience a notable spread could have similar consequences for the county's natural environment.

Economy

In Lee County, there are 4,282 species of ferns and plant seeds. Of these, 1,412 are considered to be exotic. Within that exotic population, 11% are considered to be invasive, amounting to about 156 species. Thus, invasive species constitute 3.6% of the total number of species in the county. These are considered to be the greatest threat to the natural species, with urban sprawl being the second greatest.

Using GIS data, planners analyzed land uses and considered the impact estimate for exotic plants to the natural environment. The following areas were considered "Natural Areas" for the purposes of the analysis:

- Conservation Lands Upland
- Conservation Lands Wetland
- Density Reduction/Groundwater Resource
- Open Lands
- Outer Islands
- Rural Community Preserve
- Wetlands

According to Census 2020 block values, the natural areas were given property based on the proportion of area within each tract. These were then summed to quantify the value

of the natural areas. Because 3.65% of species are considered invasive, that was used to quantify the potential annual impact that the pest species may have. The estimates of this analysis are listed in Table 19 below.

Table 19 Exotic Pests Damage Estimate

Parameter	Values
Natural Areas Land Value	$7,619,326
Total Seed Species	4,282
Percent Not Natural	33%
Total Exotic Species	1,412
Percent Pest	11%
Total Exotic Pests	156
Percent Pest of Total	3.64%
Natural Area Value Affected by Pest Species	$278,000

Significant disease outbreaks in Lee County could affect tens to hundreds of farms, resulting in the loss of hundreds of thousands of dollars to millions[81,82]. Impacts of that magnitude have not occurred in the county in the past, however.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

The prevalence of plant and animal diseases, as well as invasive plant and animal species, makes it likely an outbreak will occur any given year.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Likely	<$50k	None	3+ days	5

Coastal Erosion

Coastal erosion "is the process by which local sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast."[83] Whereas coastal erosion occurs across most beaches as a natural process, *critical coastal erosion* is:

> A segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. Critically eroded shorelines may also include peripheral segments or gaps between identified critically eroded areas which, although they may be stable or slightly erosional now, their inclusion is necessary for continuity of management of the coastal system or for the design integrity of adjacent beach management projects.[84]

It is important to note that for an erosion problem to be labeled "critical" there must exist a threat to or loss of one of four specific interests:

- Upland development
- Recreation
- Wildlife habitat
- Important cultural resources

Erosion rates and potential impacts are highly localized. Many areas have significant historical or contemporary erosion conditions, yet the erosion processes do not currently threaten public or private interests. Some areas experience in the United States experience 25 feet per year, while others experience 50 feet or more. Single events, such as storms, can remove significant amounts of beach land. While this may not be an issue for undeveloped areas, areas with significant cultural or economic ties to the beach, this could be catastrophic.[85]

Location and Extent

Lee County has approximately 47 miles of Gulf beaches. These coastal areas stretch along the western edges of the county facing the Gulf of Mexico and all along the barrier islands. Regular wave action, tropical weather, and development place all of these beaches at risk of coastal erosion. Major coast erosion could exacerbate the location and extent of other hazards, such as tropical cyclones and coast flooding.

Previous Occurrence(s)

Coastal erosion is a continual process that occurs naturally. Severe weather events and human activity contribute to the speed of erosion, however. For example, North Captiva Island and Captiva Island were once a continuous stretch of beach. In 1921, a hurricane passed through the area and in the process eroded the beach so significantly that the beach separated into two parts. This area came to be known as Redfish Pass.[86] Similarly, North Captiva Island experienced a breach in one of its beaches as a consequence of Hurricane Charley in 2004[87]. Overall, Hurricane Charley added 1.1 miles of critically eroded beaches to Lee County[88].

A mild tropical storm in 2006 eroded portions of a small beach and inlet segments at Boca Grande. A series of tropical storms in 2007 (Andrea, Barry, and Noel) affected Florida's beaches, including erosion to a segment of North Captiva Island and critical erosion to 0.8 miles of beach on Big Hickory Island. In 2012, Hurricane Sandy affected 0.8 miles of beach on southern Estero Island and Tropical Storm Debby forced the closure of Lighthouse Road by the Sanibel Police Department because of coastal erosion.[89]

As of 2021, Lee County has 11 critically eroded beaches (22.4 miles), four non-critically eroded beaches (5.3 miles), three critically eroded inlet shoreline areas (0.6 miles), and two non-critically eroded inlet shoreline areas (0.4 miles). A full description of the beaches and their states of erosion are reported in the *Florida Department of Environmental Protection, Critically Eroded Beaches in Florida* report, dated July 2021[90]. See Figure 36 on p. 51 for a visual representation.

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

There are no recorded deaths or injuries due to coastal erosion. Individuals, families, businesses, and government agencies could be displaced by coastal erosion.

Responders

First responder facilities and non-mobile equipment located in areas prone to coastal erosion could be affected by single events (e.g., tropical storms or hurricanes). However, the vast majority of such facilities and equipment are not at risk of being damaged or loss to coast erosion. Furthermore, the relatively large inventory available for responders (facility- and equipment-wise) means that in instances of such loss, the disruption would not be significant. See Table 20 below for the number of such facilities at risk.

Table 20 Critical Facilities within 1000ft of Eroded Beaches

Locality	Building Type	Building Count
Town of Fort Myers Beach	Emergency Medical Service	1
	Fire Station	1
	Gas Station	1
	Government Building	1
	Hazardous Materials Site	1
	School	1
	Supermarket	1
Unincorporated Lee County	Government Building	1
	Sewage Treatment Facility	3

Continuity of Operations and Delivery of Services

With the exception of loss of access to facilities due to erosion, the onset of this hazard is unlikely to disrupt the continuity of government operations or the delivery of government services. The relatively limited extent of the hazard (i.e., less than 50 miles of beaches in total) means that any such disruptions would be localized and compensated for relying on existing infrastructure and systems. See Table 20 above for the number of such facilities at risk.

Built Environment

Buildings and other physical infrastructure located on or near beaches are at risk of being significantly affected by coastal erosion. In the United States, coastal erosion is responsible for causing $500 million per year in coastal property loss. A study performed following Hurricanes Katrina and Rita found that along the Gulf Coast, the loss of one hectare of land (100 meters x 100 meters) corresponded to an average increase of $33,000 in damage from a given storm[91].

Lee County, FL	
Location	Classification
R007-R026.7	Critically Eroded Beach
Boca Grande N Shore	Critically Eroded Inlet
R027-R033	Non-critically Eroded Beach
R046 - R052	Non-critically Eroded Beach
R060 - R065	Non-critically Eroded Beach
R066 + East 1000 Ft	Critically Eroded Inlet
R066 - R071	Critically Eroded Beach
R071 - R078	Non-critically Eroded Beach
R079 - R082.3	Critically Eroded Beach
R083 - R084	Critically Eroded Inlet
R084 - R109	Critically Eroded Beach
R109 - R118	Critically Eroded Beach
R129 - R133	Critically Eroded Beach
R175.4 - R200	Critically Eroded Beach
R203 - R207	Critically Eroded Beach
R211-R213	Non-critically Eroded Inlet
R214-R222	Critically Eroded Beach
R222	Non-critically Eroded Inlet
R222.7-R225.9	Critically Eroded Beach
R226-R230	Critically Eroded Beach

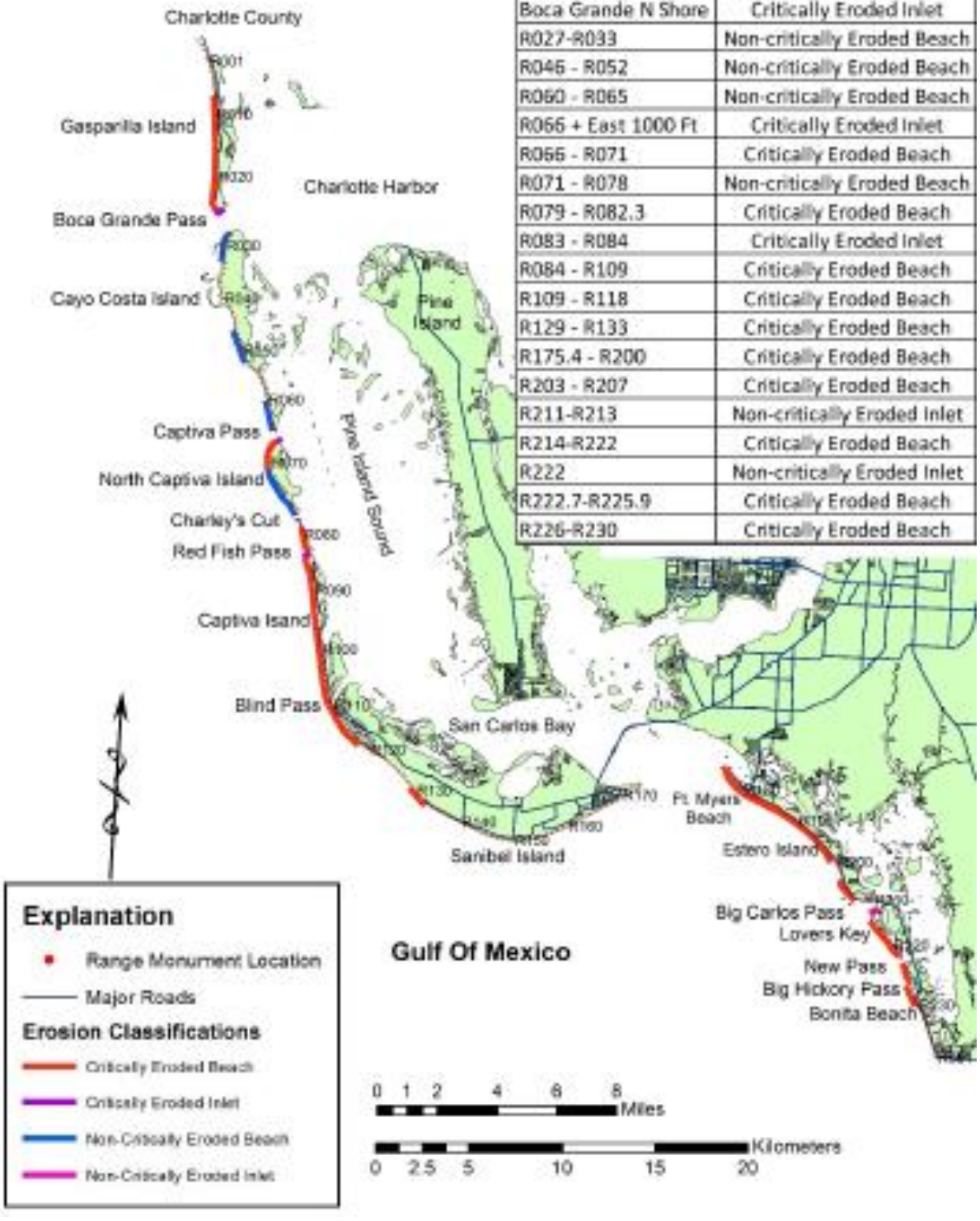

Figure 36 Critically Eroded Beaches in Lee County

According to a study performed at the behest of the Federal Emergency Management Agency in 2000, over the next 60 years erosion may claim 1 out of 4 houses within 500 feet of the US shoreline[92]. The 60-year Coastal Erosion Hazard area represents the land expected to be lost to coastal erosion during that period. The aforementioned study established this zone as land within 500 feet from the coastline. Any structure located within 500 feet is considered to be vulnerable. See Table 21 on p. 52 for a list of structures and values by political subdivision.

Table 21 Buildings at Risk of Loss due to Coastal Erosion

Jurisdiction	Buildings	Est. Value	Ave. Value
Boca Grande	653	$451,013,637	$690,679
Bonita Springs	419	$836,648,283	$1,996,774
Captiva	542	$521,903,751	$962,922
Cayo Costa	10	$946,075	$94,608
Fort Myers Beach	1,790	$1,809,587,993	$1,010,943
Sanibel	1,331	$2,320,750,705	$1,743,616
Upper Captiva	238	$75,879,489	$318,821
Total	4,983	$6,016,731,933	$6,818,363

Natural Environment

Coastal erosion can lead to loss of habitat for some species of plants and animals. This may have systemic, cascading consequences for the ecosystem as a whole. Loss of habitat in these instances can also lead to increased risks for contamination. Coastal erosion can also reduce the ability of a given coastline to absorb coastal flooding from severe weather and tropical cyclones.

Economy

The onset of this hazard is unlikely to impact the jurisdictions' economy.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

Coastal erosion is a continuous natural process that does not cease. The likelihood of exacerbating events, such as tropical storms and hurricanes, are also likely given the location and climate of Lee County.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Very Likely	<$50k	None	3+ days	6.5

Drought

A drought is a period of moisture deficiency affecting crops, a prolonged period with less than normal precipitation, and/or an extended amount of time with decreased precipitation and streamflow. It is a period of drier-than-normal conditions that result in water-related problems. Because precipitation is uneven across the country and across months and seasons, drought conditions are based upon local historical data. Because of the localized nature of drought conditions and changing seasonal patterns, it is sometimes difficult to determine that a drought is beginning until trend data accumulates sufficiently for comparison and analysis.[93]

According to the National Oceanic and Atmospheric Administration (NOAA), there are four types of droughts[94]:

1. Meteorological – dry weather patterns dominate a given area
2. Hydrological – low water supply becomes evident, especially in streams, reservoirs, and groundwater levels (usually trending over several months)
3. Agricultural – when crops become affected by limited availability of water
4. Socioeconomic – affects supply and demand of commodities linked to a drought

Location and Extent

Drought in Southwest Florida is most likely to occur in late winter. As Figure 25 on p. 25 illustrates, rivers, streams, drainage basins, canals, and other types of waterways are present throughout the county. Lee County is a tropical climate, which requires regular access to relatively large quantities of water. Meteorological and hydrological droughts are therefore capable of occurring anywhere in the county. Figure 31 on p. 31 shows where agricultural land use occurs in the county; droughts associated with agriculture are capable of occurring in those areas. The figure also shows areas of human habitation, commerce, and industry, which in turns shows those areas that are capable of being affected by socioeconomic droughts.

Drought durations are situationally dependent and could last weeks or months. In Lee County, some severe droughts have extended for more than a year, while others with less severity have lasted for only a week or two. Historical episodes of drought and their extent are address in more detail in the Previous Occurrence(s) portion of the profile below.

The National Weather Service (NWS) classifies drought severity according to the schedule shown below:

Table 22 Drought Severity Classifications[95]

			Ranges			
Cat.	**Description**	**Possible Impacts**	**Palmer**	**CPC**	**USGS**	**SPI**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less

Palmer Drought Index
CPC Soil Moisture Model (Percentiles)
USGS Weekly Streamflow (Percentiles)
Standardized Precipitation Index (SPI)

Another measure of drought severity is the Keetch-Bryam Drought Index (KBDI), which monitors fire danger and severity using maximum daily temperature and daily, antecedent, and annual precipitation.

Previous Occurrence(s)

Lee County averages 55.5 inches of precipitation every year[96]. In the county's region, most precipitation occurs during the summer months, but the state's hydrography is such that much of that is lost through evaporation. Consequently, the area is prone to weather extremes, such as floods and droughts.[97]

At the time, 2000 was the driest year on record for the southwest region of Florida. The period from November 1999 through May 2001 was the driest recorded sequence of dry-wet-dry seasons. The drought began in 1998. The U.S. Drought Monitor characterized the southwest region of the state as experiencing the most severe level of drought by March 2000.[98] Decreased water levels in Lake Okeechobee and the surrounding area resulted in saltwater intrusion into potable water, necessitating corrective and protective actions to manage chloride levels in the affected water plant[99].

Another significant period of drought occurred in 2007. This drought began in March 2006 and lasted until August 2008. The most severe drought conditions during this period for Florida occurred in the northern and southern regions of the state (including Lee County). Portions of the state experienced well failures; some jurisdictions in the state experienced large seasonal unemployment from reductions in tourism and outdoor recreation. Livestock and crop reductions occurred during this time as well.[100] This drought affected the entire Southeastern United States and resulted in some jurisdictions in other states to import water.

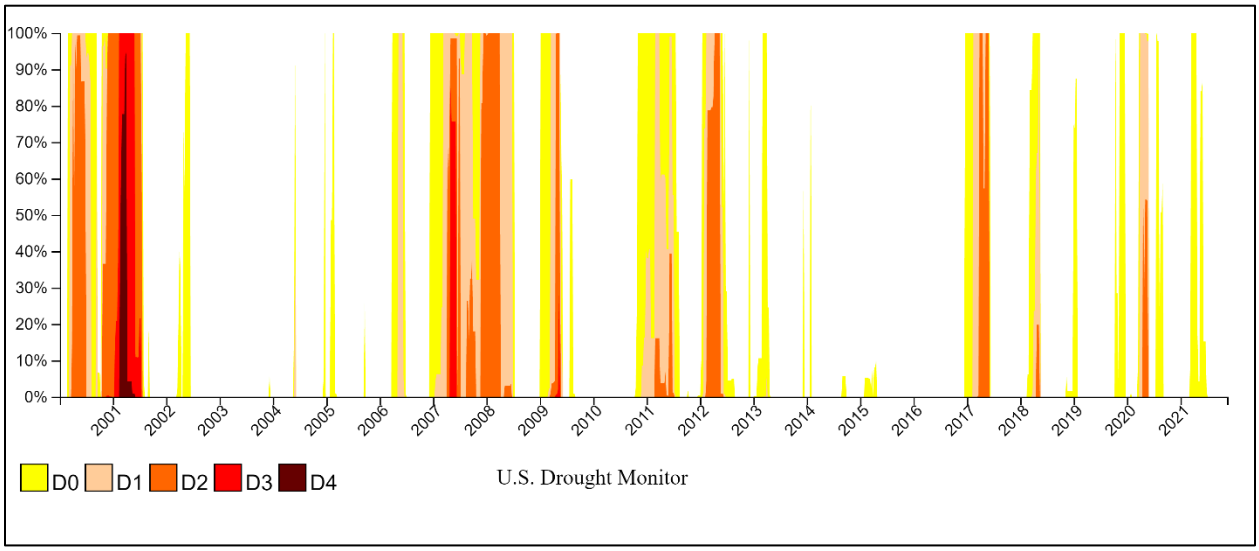

Figure 37 Droughts in Lee County since 2000[101]

Lee County has experienced many instances of drought, of varying degrees of severity, with some level frequency (see Figure 37 above). Between 2000 and November of 2021, the year with the greatest number of weeks with drought conditions was 2007 (52 weeks total), followed closely by 2000 (44 weeks total). On average, Lee County experiences almost 20 weeks of drought conditions per year. Since 2000, the county has experienced

at least one week of drought conditions every year. Over the period 2000-2021, the county experienced the following severities of drought, by number of weeks:

Table 23 Weeks by Drought Severity in Lee County (2000-2021)

D0	D1	D2	D3	D4
50	29	26	26	15

(Different levels of severity can exist concurrently to one another in the same week.)

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Socioeconomic droughts will affect the ability of the public to procure goods and services tied to water-use, such as water utilities, landscape maintenance, and so forth. In Southwest Florida, 90% of residential and commercial water use is drawn from groundwater sources. The rest of the water drawn comes from surface water sources. Above-ground and underground sources of water in the area are highly dependent on precipitation for replenishment.[102] The highest demand for water occurs during the region's dry season[103]. While disruptions are a very real possibility due to water shortages, there are no recorded instances of injuries or deaths occurring in Lee County as a result of drought.

Responders

Drought conditions will not affect responders, per the scope of this assessment.

Continuity of Operations and Delivery of Services

Extended drought conditions could affect the water supply necessary to execute emergency services, such as fire suppression. Such conditions could also affect the delivery of utilities, such as providing potable water and disposing of waste. Overall continuity of operations will not be affected by drought conditions.

Built Environment

Agriculture will most likely experience the greatest impact. Demand for irrigation increases during the region's dry season[104]. Significant drought in the past has led to water rationing and water use controls being implemented by the county. There are no recorded financial losses to the built environment resulting from drought.

Natural Environment

According to NOAA, droughts can affect natural environments in a number of ways: "When a drought occurs, the existing pressures on the ecosystem's natural water supplies are amplified. If the ecosystem's water needs aren't considered in water allocation decisions, then this already vulnerable ecosystem may be pushed beyond the threshold at which it can recover. The ecosystem will begin to function differently, leading to a loss in the critical services it once provided humans—such as purifying water and air, preventing erosion, and providing recreation opportunities."[105]

Lee County's tropical climate relies upon the prevalence of water to sustain certain elements of its various ecosystems. Prolonged drought conditions can threaten to unbalance such ecosystems. Loss of plant life in some areas may lead to increased risk of flooding in those areas. Drought conditions may also pose a risk for deleterious consequences to wildlife.

The cost of droughts to ecosystems have not been discussed at much length, historically[106]. This is changing at the moment; even so, there are no available records quantifying the consequences of drought on the natural environment in Lee County.

Economy

Drought conditions may affect the production and cultivation of agricultural resources, could increase supply cost for commercial and industrial production, and could decrease the tourism through diminished natural lands and resources (e.g., fishing). Of these, agriculture is the most likely to experience negative economic outcomes, given the sector's intimate reliance on water sources.

Primary economic loss in the agricultural sector will occur with crop failure and loss of pastures. These impacts have a tendency to equate to financial costs to consumers through increased prices. Related impacts could include decreased labor demand, decreased demand for product processing services, and decreased demand for production inputs, such as fertilizer. Similarly, drought may lead to the increase or expansion of pests and plant or animal diseases.[107]

While agricultural losses themselves could equate to millions to tens-of-millions of dollars in Lee County, there are no available records for economic losses in Lee County due to previously experienced drought conditions.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

Lee County has experienced some degree of drought conditions every year, since at least 2000. Increased temperatures and changes in the climate are likely to sustain this trend, if not exacerbate it. Therefore, it is highly likely that every year, Lee County will have drought conditions, although the length and severity of the conditions may be limited.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Highly Likely	$<50k	None	3+ days	4.25

Epidemic/Pandemic Diseases

Every community experiences some level of disease within its population. A disease that is commonplace to some degree in a community is referred to as endemic. The Centers for Disease Control and Prevention (CDC) describe an endemic as a disease that:

> In the absence of intervention and assuming that the level is not high enough to deplete the pool of susceptible persons, the disease may continue to occur at this level indefinitely. Thus, the baseline level is often regarded as the expected level of the disease.[108]

Sudden deviations in the common prevalence of a given disease, in particular an increase in the number of cases experienced in a community, potentially raises the profile of the disease from endemic to epidemic.

- **Epidemic**: an increase, often sudden, in the number of cases of a disease above what is normally expected in a given population area.
- **Pandemic**: an epidemic that has over several countries or continents, usually affecting a large number of people.

Epidemics may result from changes in an existing disease that makes it more virulent, the introduction of a new disease, an enhanced mode of transmission, a change in the susceptibility in the population, and/or increased exposure. Multiple epidemics may coexist simultaneously (for example, see the CDC's current outbreak list[109] or the World Health Organization's outbreaks and emergencies list[110]).

The baseline presence of a disease in the community in large part determines its classification as being endemic or an epidemic. For example, the relatively low occurrences of rabies mean a small increase would necessitate epidemiological investigation and classification, versus the common cold.

Other terms relevant to the description of epidemic and pandemics include the following:

- **Sporadic:** refers to a disease that occurs infrequently and irregularly
- **Hyperendemic:** refers to persistent, high levels of disease occurrence
- **Outbreak:** carries the same definitions of epidemic, but is often used for a more limited geographic area
- **Cluster:** refers to an aggregation of cases grouped in place and time that are suspected to be greater than the number expected, even though the expected number may not be known

Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites, or fungi. Zoonotic diseases are those infectious diseases that can be transmitted between human and animal populations.

Location and Extent

Epidemics and pandemics can occur anywhere within Lee County and its political subdivisions, as clearly demonstrated by the recent onset of COVID-19. The scenarios in which this can occur are myriad, as are the types of infections that could become an epidemic (e.g., Ebola, SARS, COVID, etc.). The extent to which such onsets may occur is also highly dependent on the type of disease involved and the factors at play during that time. COVID-19, for example, has shown to be prevalent across all demographic categories of the population; however, current data shows that the likelihood of experiencing severe to life-threatening consequences are centralized around particular demographic groups.

Previous Occurrence(s)

Outbreaks, epidemics, and pandemics have been present throughout human history. Relatively recent occurrences include the Spanish Flu, which killed 500,000,000 people worldwide, the Asian Flu, which killed between 1,000,000 and 4,000,000 people worldwide, and the Hong Kong Flu, which killed about 700,000 people worldwide. More recently, in 2009 the United States and other areas of the world experienced a pandemic with H1N1, which resulted in far fewer deaths than the ones mentioned previously. In part, because of the relatively low number of deaths from H1N1, some portions of the public questioned whether health and government officials exaggerated warnings and claims about the disease. While Lee County and its political subdivisions experienced impacts from H1N1, they were relatively localized and did not constitute a significant outbreak.

In December 2019, the World Health Organization (WHO) identified a new coronavirus, SARS-CoV-2 (COVID-19), in China. COVID-19 eventually spread around the world to the United States. On March 6, Lee County experienced its first two confirmed cases of COVID-19. On March 11, the WHO declared the disease to be a pandemic. The President of the United States approved Florida's Disaster Declaration on March 25, 2020.

The onset of COVID-19 resulted in economic and government closures across the country, including in Lee County and its political subdivisions. Supply issues developed with regards to medical and personal protective equipment (e.g., respirators, masks, and gowns), and with the overall supply chain in general. Hospitals in some areas became

overwhelmed. Public confidence in the governance of the country, the state, and local areas decreased, as did public confidence in the media and other institutions.

Currently, the State of Florida has experienced three waves of infections in the community (July, 2020; January, 2021, and August, 2021). Overall, there have been over 126,000 cases of COVID-19 identified in Lee County. Of these, 1,840 resulted in death.[111] Many more cases resulted in long-term health consequences for survivors. The impacts of COVID-19 are still occurring and still being assessed as of the update to this hazard identification and risk assessment.

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Of all the factors considered as part of the hazard identification and risk assessment, the public is most at risk of experiencing deleterious consequences from the onset of an epidemic or pandemic. As demonstrated with COVID-19, the public is can be expected that a significant number of people may become infected with the disease, become hospitalized, or suffer death. Even in instances of recovery, a notable number of survivors may continue to experience physical and mental health issues long after their immediate illness passes.

Disruptions to government operations and services and limited or lack of access to commodities, healthcare facilities, social services, financial services, and so forth will only act to exacerbate any physical or mental consequences of the illness. In the example of COVID-19, suspension of non-essential medical procedures prolonged care for those ailments. Some individuals who did not experience illness from the disease still experienced mental distress or trauma from the disease's prevalence in the community and the consequences brought about by it.

Community disruptions also occurred in some areas with protests against public health measures and mandates, such as continued closures of businesses. Concurrently, other social and demographic issues became subjects for protest during the distresses of COVID-19, leading to additional community disruptions.

Responders

Responders will experience many of the same consequences as the general public in terms of propensity for infection and illness, death, and injury. Depending on the virility of the disease and its ability to transmit and spread, this can reduce the ability of the county and its political subdivisions to staff emergency services and provide response and recovery services. The nature of the responders' role almost necessarily means they will be at higher risk of exposure to the disease than members of the general public.

Continuity of Operations and Delivery of Services

The onset of an epidemic or pandemic in Lee County has the notable potential to disrupt continuity of operations and delivery of services by the area's jurisdictions. The initial onset of COVID-19 results in wholesale government closures to slow the spread of the illness. This resulted in the suspension of some operations and services; other operations and services were rearranged in their formats, such as working from home and conducting transactions over the internet. The prolonged nature of COVID-19 has also resulted in reformatting several aspects of government operations and services in the long-term.

Built Environment

The built environment is not subject to direct damage or impact from infectious diseases.

Natural Environment

With the exception of zoonotic diseases, the onset of infectious diseases does not affect the natural environment. Some diseases are capable of spreading from the human population to the wildlife population. A study conducted by the U.S. Department of Agriculture found COVID-19 among deer populations in the United States. (The study did not determine if the illness was transmitted to the deer from humans or if it was contracted in some other fashion.)[112]

Economy

Infections, as well as the need to control the spread of infection, directly affect the economy's wellbeing. Sectors may lose access to their workforce (either through illness, lockdown, or personal concern of individual workers). Decreased economic activity in general could lead to "downstream" losses from reduced demand. Infections or the threat of infections could also affect the distribution of goods and services, such as reduced availability of truck drivers.

The prevalence of illness could also affect the willingness or ability of tourists to visit the area. Whereas this did not appear to be the case for H1N1, government lockdowns and public health concerns lead to enormous decreases in tourism in Lee County, which in turn had significant economic effects[113].

A COVID-19 economic survey in 2020 showed the 61% of respondents had experienced substantial decreases in sales. Survey results also showed that 65% of respondents had laid off 1/5 of their workforce, with 21% of small firms (fewer than 25 employees) having laid off 80% of the employees.[114]

The full economic consequences of COVID-19 are still unknown and being assessed.

Public Confidence

The onset of an epidemic or pandemic in Lee County is likely to affect the public's confidence in the governance of the county and its political subdivisions. As the outcome of H1N1 demonstrated, some members of the public questioned the necessity and efficacy of the messaging put forth and the actions taken by public and government officials. COVID-19 has shown noteworthy social divisions over messaging and actions by the government, by public health officials, by the media, and by other institutions, with groups either in support of or opposed to one or more aspects of response to and recovery from the disease. Divisions have occurred over business closures, eviction moratoria, mask mandates, vaccine mandates, social distancing guidelines, and so forth. These divisions have led to some measure of protests. The divisions have also been apparent between different jurisdictions and different levels of government. During the initial stages of the roll-out for the COVID-19 vaccine, limitations on the supply of the vaccine and other factors led to notable public backlash to county governance; once the supply of vaccine stabilized and either met or exceeded demand, the backlash diminished significantly.

Probability

COVID-19 remains a continuing, ongoing hazard for Lee County, its political subdivisions, and the rest of the United States. For the foreseeable future, this infectious disease will continue to exact costs on the public, responders, the government, the built and natural environments, the economy, and the public's confidence. With new strains of the illnesses continuing to develop and to be identified, the likelihood for additional waves of infections remains very high. The propensity for the spread of other infectious diseases remains at

the very least where it was at the last time the hazard identification and risk assessment took place.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Very Likely	>$150k	Deaths	3+ days	11.00

Excessive Heat

Excessive heat is a phenomenon involving temperatures over 100°F for a period of several days. The National Weather Service (NWS) posts notices and advisories to the public when forecasts show the possibility of excessive heat events. These consist of the following[115]:

- Excessive Heat Warning – issued within 12 hours of an onset when the maximum heat index temperatures are expected to be 105°F or higher for at least 2 days and nighttime temperatures will not drop below 75°F. (These criteria vary across the country.)
- Excessive Heat Watch – issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours.
- Heat Advisory – issued within 12 hours of an onset when the maximum heat index temperatures are expected to be 100°F or higher for at least 2 days and nighttime temperatures will not drop below 75°F. (These criteria vary across the country.)
- Excessive Heat Outlook – issued when the potential exists for an event in the next 3-7 days.

The National Weather Service (NWS) manages a Heat Index, which is also known as the Apparent Temperature, that provides a subjective measure of the amount of water in the air compared with the amount of water that air can hold at the current temperature (see Figure 38 below).

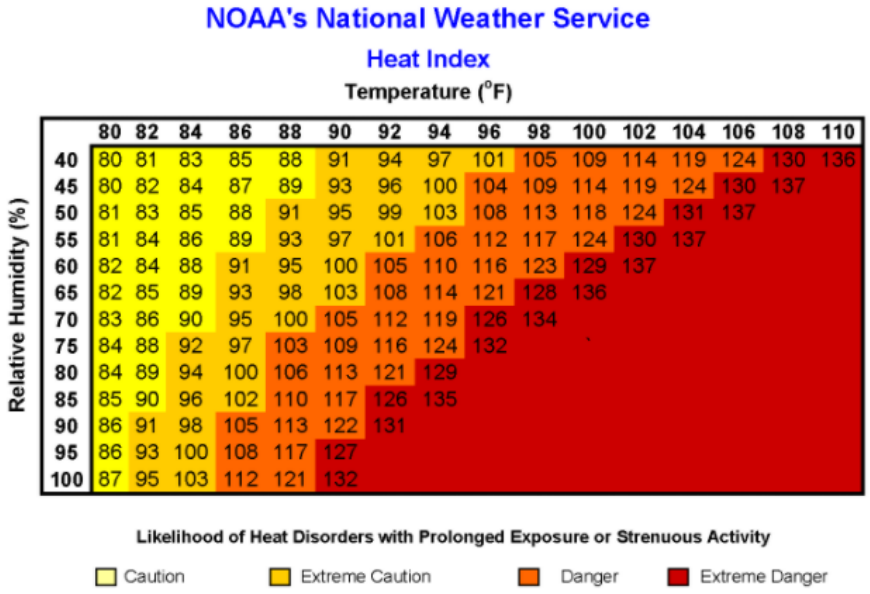

Figure 38 National Weather Service Heat Index

Location and Extent

All of Lee County and its political subdivisions are susceptible to excessive heat incidents. Even so, heat-related injuries and deaths are more likely to occur in urbanized environments. Population density, urban heat, and building construction can add to and exacerbate heat events. Heat combined with humidity can lead to heat-related illnesses.

Previous Occurrence(s)

Over the last two decades, maximum temperature observations for Lee County have not exceeded 98°F (see Table 24 below). Several instances of excessive heat have occurred in the State of Florida over the last several years, which are discussed in the impacts section below.

Prior to 2000, the National Center for Environmental Information Storm Events Database records three instances of excessive heat occurring in Fort Myers and North Fort Myers in 1998, which resulted in three deaths.

Table 24 Max Monthly Temperatures (2000-2020)[116]

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
2000	83	84	88	89	94	96	95	94	92	90	86	86	96
2001	85	88	88	90	96	96	96	95	92	90	86	85	96
2002	86	85	90	92	96	95	95	93	93	91	89	82	96
2003	83	85	88	90	94	94	94	93	93	90	89	83	94
2004	83	84	85	90	94	96	95	94	93	91	90	85	96
2005	86	83	87	88	92	91	95	96	94	91	86	83	96
2006	85	83	86	91	96	96	94	95	94	92	87	86	96
2007	85	86	88	94	92	98	96	96	95	94	88	86	98
2008	84	85	88	89	97	96	94	95	94	90	89	86	97
2009	83	85	87	91	96	97	96	95	94	95	89	86	97
2010	85	81	85	88	94	98	96	96	94	92	88	80	98
2011	81	86	89	93	97	96	96	96	95	89	87	86	97
2012	86	89	90	92	95	95	97	97	94	92	84	86	97
2013	88	86	84	94	94	94	94	94	93	90	87	87	94
2014	83	88	87	92	95	97	96	97	96	91	86	85	97
2015	86	86	90	93	95	96	96	96	94	90	92	87	96
2016	83	84	87	90	93	95	96	96	94	93	86	91	96
2017	87	90	90	96	97	95	96	96	95	92	88	85	97
2018	83	89	88	92	93	95	94	95	94	92	90	86	95
2019	85	89	87	91	94	98	95	96	95	94	91	88	98
2020	88	89	94	95	95	96	96	96	96	92	88	83	96

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

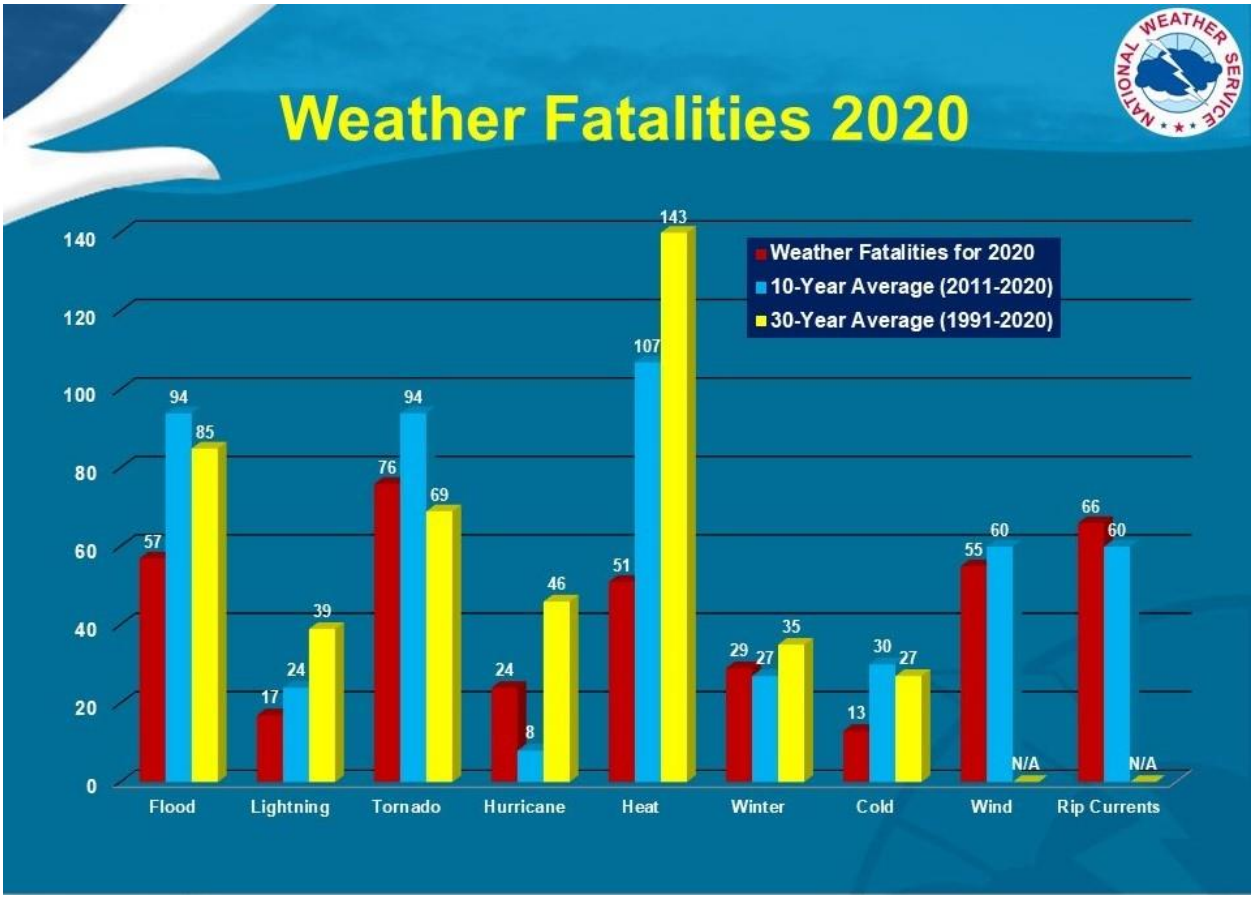

Figure 39 Weather Related Fatalities (US, 2020)

Public

Florida's tropical climate, with a combination of heat and humidity, creates an environment prone to annual temperatures that are harmful to humans. Extreme heat can lead to heat-related illnesses, such as heat exhaustion, heat stroke, cardiovascular-related issues, mental health and behavioral disorders, respiratory health, and so forth.[117] (See the referenced State of Florida Department of Health document for more in-depth information related to heat-related illnesses.) The most vulnerable members of the public to instances of excessive heat include children, the elderly, persons experiencing homelessness, and individuals with mobility restrictions.

When considering weather-related events, heat is most responsible for deaths and injuries in the United States (more so than floods, tornadoes, or hurricanes). Figure 39 above visualizes this comparison in the year 2020, across a 10-year average, and across a 30-year average. Between 2016 and 2020, excessive heat resulted in 158 deaths and 288 injuries across Florida.

Responders

Instances of excessive heat place responders at risk of heat-related illnesses and other deleterious effects. As part of response operations, Lee County and its political subdivisions develop safety action plans and protocols to protect against over exposure to the elements and address means for mitigating the effects of such through appropriate aid.

Continuity of Operations and Delivery of Services

With the exception of specific actions taken by jurisdictions and their respective departments related to protective measures for employees and some equipment/facilities, there is likely to be no impact to the continuity of operations or delivery of services resulting from excessive heat conditions.

Built Environment

There are no recorded data for impacts to the built environment in Lee County or its political subdivisions related to excessive heat. Considering that the impacts from excessive heat primarily relate to their effect on human health, it is unlikely that notable damage or other impacts would occur as a consequence of this hazard.

Natural Environment

There are no recorded data for impacts to the natural environment in Lee County or its political subdivisions related to excessive heat. Aside from ancillary consequences to instances of this hazard—such as drought—it is unlikely that notable damage or other impacts would occur as a consequence of this hazard.

Economy

The onset of this hazard may have limited impacts on economic activity; even so, there are no recorded economic losses in Lee County related to excessive heat conditions.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

Considering the paucity of instances of excessive heat in Lee County over the last twenty years, planners consider the probability of experiencing an instance in the future as somewhat likely.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Somewhat Likely	>$50k	Deaths	3+ days	4.75

Extreme Cold

The definition of extreme cold varies across different regions of the country and is based in part on the relative frequency of low temperatures in a given location. Areas that do not often experience low temperatures have broader thresholds for extreme cold than areas that are subject to low temperatures on a consistent basis for longer periods of time.[118] Figure 40 below visualizes criteria used for south Florida.

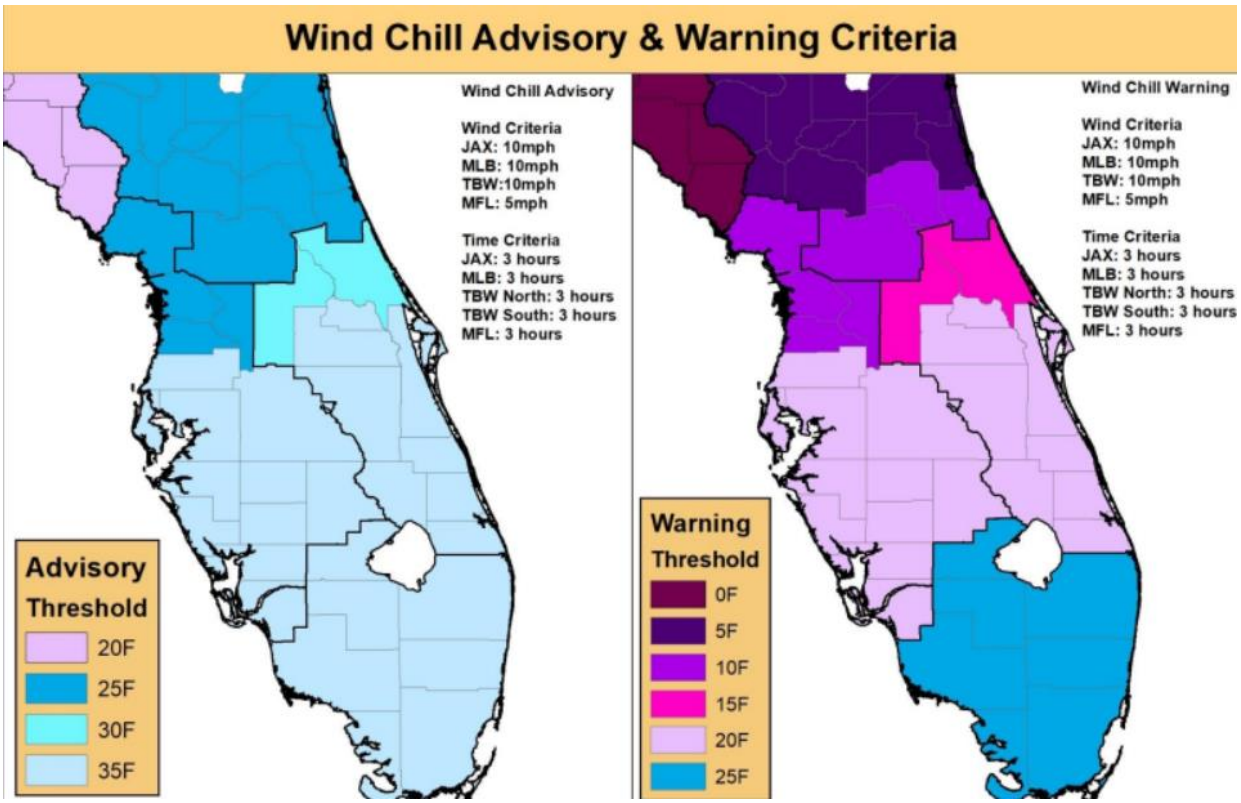

Figure 40 Wind Chill Advisory and Warning Criteria

Cold air combined with brisk wind creates conditions favorable to wind chill values. Wind chill is often described as the “feels like” temperature associated with cold. Wind chill is based on the rate of heat loss from exposed skin by combined effect of wind and cold. As the wind increases, heat is carried away from the body at an accelerated rate, driving down the body temperature. Wind chill affects all animal life[119], but does not affect inanimate objects that cannot cool below the actual air temperature[120]. Figure 41 below shows the Wind Chill Chart used by the National Weather Service (NWS).

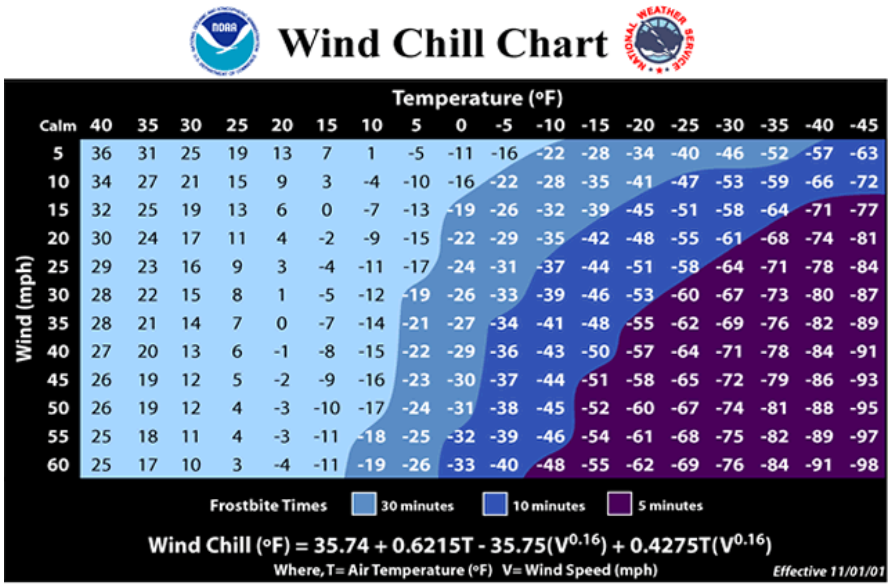

Figure 41 Wind Chill Chart

The NWS posts notices and advisories to the public when forecasts show the possibility of extreme cold events. These consist of the following[121]:

- Wind Chill Warning – issued when dangerously cold wind chill values are expected or occurring.
- Wind Chill Watch – issued when dangerously cold wind chill values are *possible*.
- Wind Chill Advisory – issued when there are seasonably cold wind chill values but not extremely cold values are expected or occurring.

Location and Extent

All of Lee County and its political subdivisions are susceptible to extreme cold incidents. Even so, cold-related injuries and deaths are more likely to occur in communities with limited access to warm shelter, such as transient populations and people experiencing homelessness.

Previous Occurrence(s)

Lee County has experienced a small number of freezes in the past, which were accompanied by extreme cold (see Table 14 on p. 38), although these occurred in the 1970s and 1980s. Since 1901, there have been 60 days in Lee County where temperatures were 32°F or below[122]. There were only 10 days been 2000 and 2010, and no days between 2010 and 2020. Table 25 below shows the minimum temperatures per month for the last two decades in Lee County.

Table 25 Min Monthly Temperatures (2000-2020)[123]

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MIN
2000	37	41	54	48	58	68	71	70	70	54	42	33	33
2001	30	40	46	49	59	68	70	71	68	52	57	43	30
2002	36	38	43	59	63	71	70	71	72	60	43	39	36
2003	36	44	50	44	69	71	72	72	71	63	46	40	36
2004	40	41	46	50	61	70	71	73	71	57	53	383	38
2005	36	43	49	51	58	68	72	73	71	53	51	43	36
2006	39	35	45	56	58	71	72	72	67	50	45	48	35
2007	38	38	45	49	60	68	73	72	72	67	49	44	38
2008	32	44	46	51	60	67	71	74	68	47	42	41	32
2009	33	34	41	51	63	70	70	73	72	50	46	42	33
2010	31	41	41	53	69	71	72	72	72	57	49	33	31
2011	35	45	46	57	63	68	70	74	73	56	53	47	35
2012	34	40	48	53	67	70	74	74	73	53	49	39	34
2013	45	38	39	59	59	70	71	71	71	60	42	50	38
2014	37	45	48	56	61	70	72	71	72	58	47	46	37
2015	46	35	50	60	61	69	72	72	71	66	55	51	35
2016	41	43	47	53	57	71	72	73	73	56	47	45	41
2017	40	49	45	56	57	71	72	74	69	51	58	43	40
2018	33	52	46	57	64	71	70	72	72	54	45	44	33
2019	41	48	45	56	66	70	71	73	70	72	53	48	41
2020	37	46	46	58	60	70	71	72	67	69	57	43	37

On average, December and January are the coldest months and therefore the most likely to produce extreme cold conditions. All the same, cold temperatures are possible in February, March, and November.

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Exposure to extreme cold can lead to frostbite in a matter of minutes, as well as hypothermia. Instances of extreme cold can lead to ancillary consequences, such as improper use of sources of heat or power (such as propane, gas, generators, etc.). Although Florida is generally a warmer climate than other areas in the United States,

extreme cold does pose a risk to residents and visitors. A harsh winter in 1989-1990 resulted in 26 deaths (from hypothermia) in Florida.

There are no recorded injuries or deaths in Lee County attributable to extreme cold.

Responders

The onset of this hazard is unlikely to significant impact on responders.

Continuity of Operations and Delivery of Services

The onset of this hazard is unlikely to impact the continuation of government operations and delivery of services.

Built Environment

The onset of this hazard is unlikely to impact the built environment.

Natural Environment

Low temperatures can affect animal and plant life, just as it does the human population. Extreme cold events could lead to injury or death among flora and fauna communities. Low temperatures leading to freezes could potentially have a significant impact on plants in the wild, just as it would on crops.

Economy

Extreme cold events in Lee County are unlikely to cause notable negative consequences to the economy, except in those instances where livestock are affected. All the same, there are no recorded economic losses in Lee County attributable to extreme cold events.

Freezes have the potential to affect crops, which is addressed in the Freeze hazard profile below.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

The low frequency with which extreme cold events happen in Lee County, combined with the paucity of such events over the last ten years, renders this hazard as somewhat likely to occur in the future.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Somewhat Likely	>$50k	None	3+ days	4.00

Flood

The National Flood Insurance Program (NFIP) defines a flood as[124]:

> A general and temporary condition of partial or complete inundation of 2 or more acres of normally dry land area of 2 or more properties … from:
>
> - Overflow of inland or tidal waters; or
> - Unusual and rapid accumulation of runoff of surface waters from any source; or
> - Mudflow; or
> - Collapse or subsidence of land along the shore or a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above.

Floods can occur from a multitude of causes, including heavy rainfall, ocean waves coming on shore (i.e., storm surge), or dams or levees breaking. Geography plays an important role in shaping flooding events, such as the propensity of rivers to overflow regularly in floodplains. The built environment also helps to develop and shape floods, such as the creation of impermeable surfaces, rooftops funneling rainwater to the ground, and so forth.[125]

Severe weather is a primary driver for flooding. Weather events, such as tropical cyclones, result in significant amounts of precipitation dropping in a region in a relatively short period of time. Tropical cyclones also push water onto shorelines, resulting in coastal flooding.[126] Rainfall outside of a given region can also contribute to flooding conditions in that region through the collection and delivery of the water by drainage basins.

Levees and dams are located throughout Florida; the failure of these can contribute to or cause flooding events to occur. These types of events typically happen with little to no warning and most often occur by water overtopping the structure, excessive seepage through the surrounding ground, or a structural failure.[127]

The NWS produces products to alert the public with regards to potential or ongoing flooding events. These products include the following[128]:

- **Flash Flood Warning:** issued when a flash flood is imminent or occurring
- **Flood Warning:** issued when the hazardous weather event is imminent or already happening. A Flood Warning is issued when flooding is imminent or occurring.

- **Flood Watch:** issued when conditions are favorable for a specific hazardous weather event to occur. A Flood Watch is issued when conditions are favorable for flooding. It does not mean flooding will occur, but it is possible.
- **Flood Advisory:** issued when a specific weather event that is forecast to occur may become a nuisance. A Flood Advisory is issued when flooding is not expected to be bad enough to issue a warning.

Common types of flooding in Florida include flash flooding, river flooding, and storm surge. The National Weather Service (NWS) defines two of these types accordingly[129]:

- **Flash flood:** a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (i.e., intense rainfall, dam failure, ice jam).
- **River Flooding:** a rise in water levels that result in a river overflowing its banks or the edges of its main channel and inundate areas that are normally dry.

Both types of flooding are possible in Florida, though given Lee County's geography and hydrography, river flooding is the most likely of the two.

The National Ocean Service defines storm surge as "the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide"[130] Figure 42 visualizes this definition. However, *storm surge* should not be confused with *storm tide*. Storm tide is "water level rise due to the combination of storm surge and the astronomical tide"[131] Figure 43 below illustrates this difference in definitions.

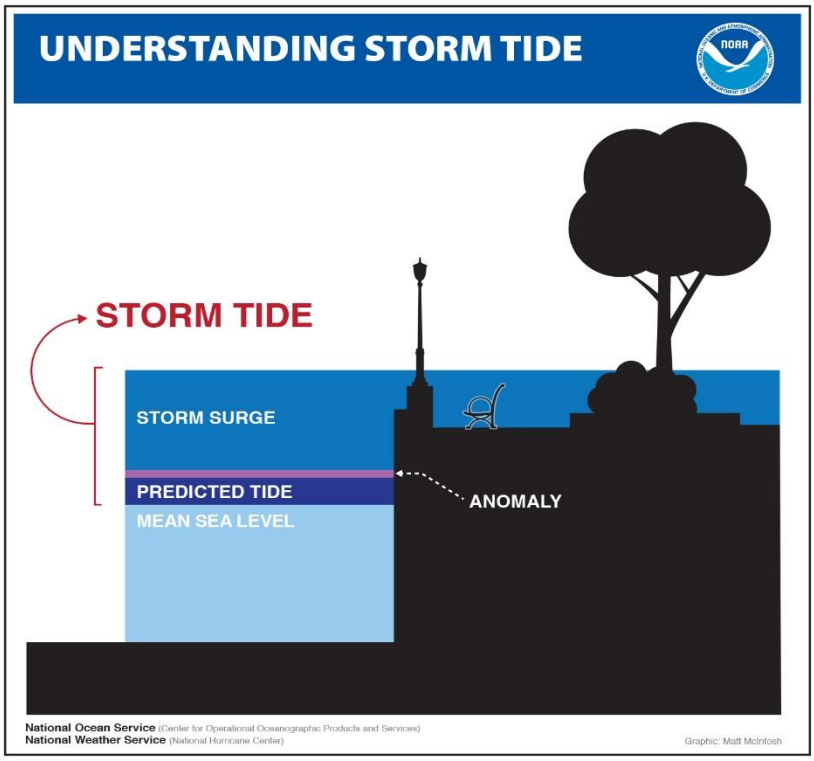

Figure 42 Understanding Storm Tide (source: NOAA)

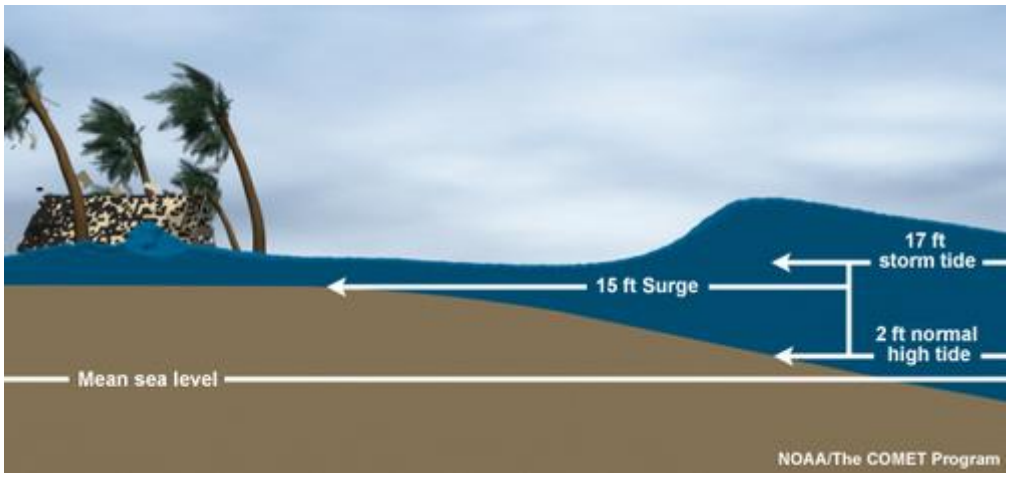

Figure 43 Storm Surge vs. Storm Tide (source: National Hurricane Center)

Storm surge is produced by water being pushed toward the shoreline by the force of winds moving cyclonically around a given storm. The interaction of ocean water with the width and slope of the shoreline, in addition wind speed, angle of approach, air pressure, and so forth help to define specific characteristics of any given instance of storm surge.[132] All the same, storm surge is only one factor of several that contributes to water levels rising along the coast during tropical cyclones. Other factors include tides, wave runup and setup, and freshwater input (e.g., rainfall).[133]

Storm surge inundation is a measure of storm surge as height above ground level. Inundation is measured a network of 175 long-term, continuously operating water level stations throughout the U.S. NOAA uses these stations to produce predictive products and data for storm surge estimates.[134]

Location and Extent

As discussed in the Natural Environment section of Chapter 2, Lee County's topography is generally low and flat with extensive areas of drainage (e.g., streams and rivers) and shoreline. Thirty-five percent of the county's developed area is located at or below 10 feet. According to a Flood Insurance Study conducted by the Federal Emergency Management Agency (FEMA):

> Flooding in the coastal regions of [Lee County] results primarily from hurricanes and tropical storms. Not all storms which pass close to the study areas produce extremely high storm surges ... with the condition of high winds directed onshore, the storms surges produced can inundate the coastal islands and flood the coastal areas behind them for some distance inland. Wave action which accompanies wind-generated

storms can cause flooding, erosion, and structural damage, particularly on the offshore islands. The Caloosahatchee River is a broad estuary and, under certain conditions, storm surges generated at its mouth can intrude far upstream. The rainfall which usually accompanies hurricanes and tropical storms can aggravate the flood situation, particularly in areas where the secondary drainage system is poorly developed. Freshwater flooding was considered in the coastal zone, but it is not as significant as flooding caused by storm surge in terms of damaging effects. Inland freshwater flooding is significant in regions near streams and rivers. Because of the flatness of the terrain, most inland areas are characterized by shallow flooding during heavy rainfalls.[135]

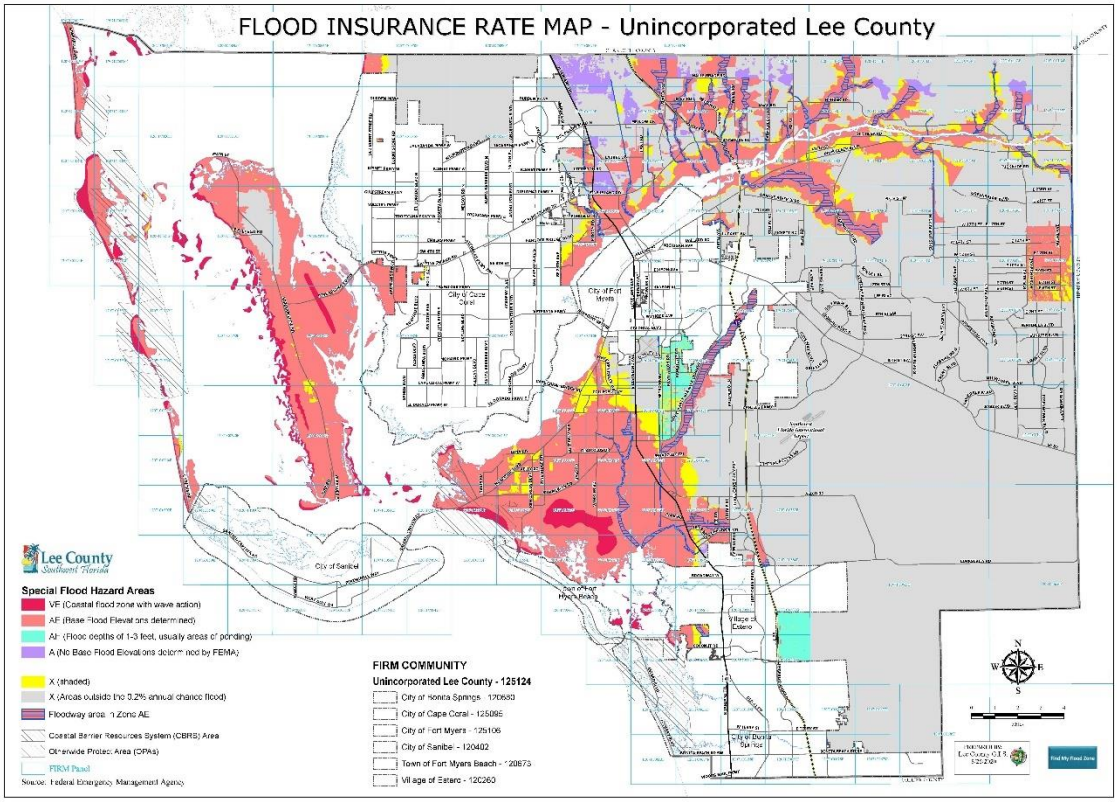

Figure 44 Flood Insurance Rate Map - Unincorporated Lee County

FEMA provides Flood Insurance Rate Maps (FIRMs), which identify flood hazard areas in US communities. FIRMs center on Special Flood Hazard Areas (SFHA), which are defined as “the area that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year”[136]. This is known more colloquially as 100-year flood areas. SFHAs have a labeling schematic, which is detailed on FEMA’s website, linked the previous endnote citation, as well as Lee County’s Department of Public Safety website[137].

FIRMs also consider moderate flood hazards, which are those "areas between the limits of the base flood and the 0.2% annual chance (or 500-year) flood"[138].

(The term "100-year floodplain" has been applied as a colloquialism to incorrectly assert that floods occur in a given area once every 100 years. This old adage is false. As described in the preceding paragraph, the term means that a given area has a 1% chance of experiencing a flood every year. This means that flooding could occur much more frequently than the improper adage asserts. Thus, it is possible for a 100-year floodplain to experience consecutive years of flooding.)

It is estimated that 35% of the land in the planning area (i.e., Lee County and its political subdivisions) are located within the 100-year floodplain. Figure 44 above illustrates the location and extent of the currently mapped flood zones in Lee County based on the most recent effective FEMA Flood Insurance Study.

On average, the most amount of precipitation in Lee County occurs annually between June and September. Table 26 below provides precipitation data for Lee County by month concerning the mean, maximum, and minimum amounts by inches.

Table 26 Precipitation Mean, Max, and Min by Month

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Mean	1.9	1.6	1.7	2.1	3.4	9.8	9.2	11.2	9.1	3.0	1.6	2.0
Max	13.0	3.4	7.2	4.1	12.8	18.4	14.4	17.0	17.2	10.7	5.7	5.7
Min	-	-	0.0	0.0	0.0	4.5	2.4	6.8	2.9	0.5	-	0.1

Storm surge is most typically associated with strong tropical cyclones, which historically occur annually between June and November. (All the same, it is possible for tropical cyclones to develop outside of that historical norm.) Coastal flooding is also possible near strong cold fronts during the region's dry season[139].

Storm surge can occur anywhere along Lee County's coastline. Low-lying marsh areas and the region's barrier islands are the most likely to experience flooding of this type. Depending on various factors, storm surge flooding can reach some distance beyond the coastline. Figure 45 below shows the extent of storm surge flooding based on the various categories of tropical cyclone (i.e., hurricane) that could affect Lee County. Worst cast scenarios for Category 1 storms could push water over large portions of the barrier islands and inundate marsh lands and developments along the coast and up the riverbank of the Caloosahatchee. Comparatively, worst case scenarios for Category 5 hurricanes could potentially push storm surge into the mid-to-eastern portions of the county.

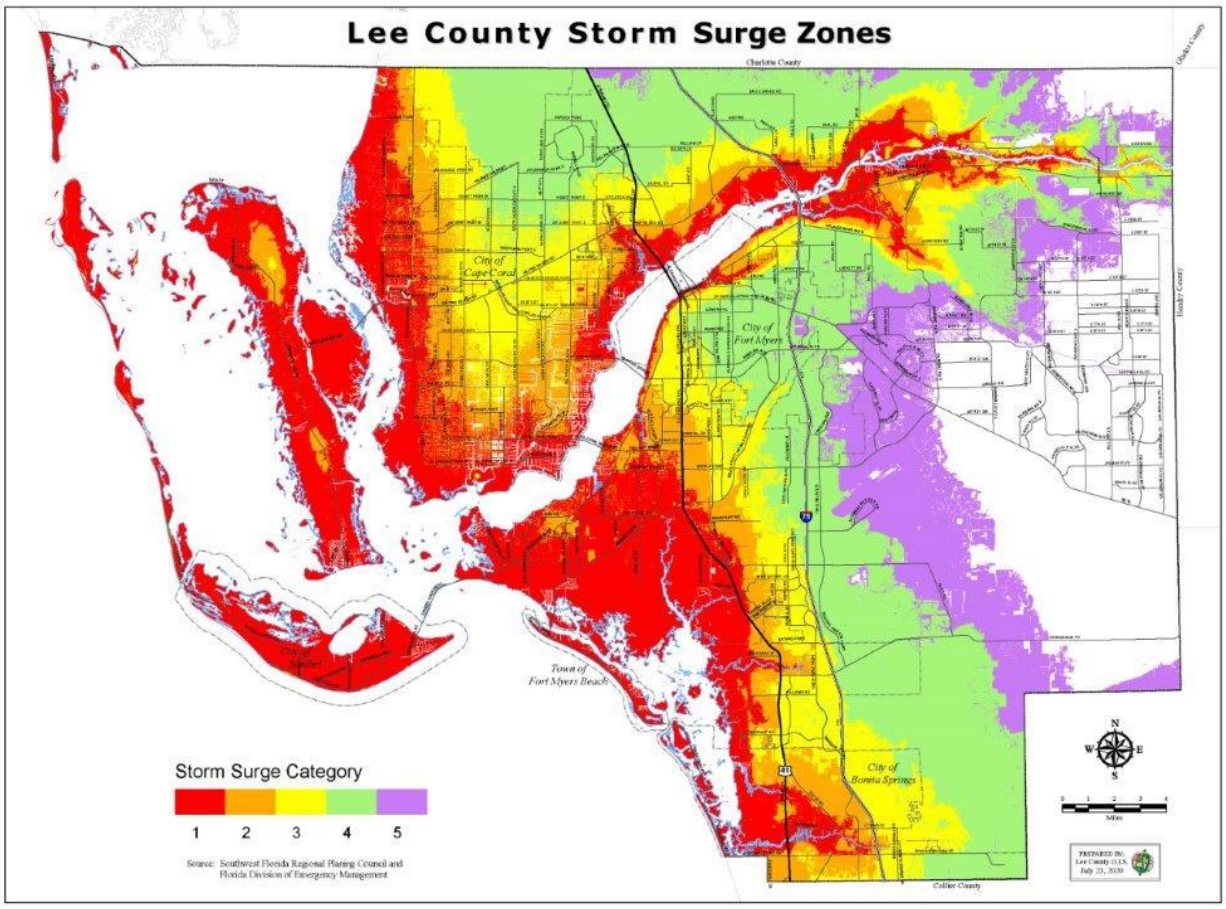

Figure 45 Lee County Storm Surge Zones

According to the NWS:

> Storm Surge is a particular problem directly along the coast. Entire coastlines can be altered by the sheer magnitude of the water battering the shores. Storm surge can also travel several miles inland causing additional flooding and destruction … the inland flood threat is often under emphasized during a tropical event. Typically, greater rainfall amounts and flooding are associated with tropical cyclones that have a slow forward speed or stall over an area. Any remnants of a tropical system can cause flooding if conditions are right. Both river flooding and flash flooding are common with tropical cyclones.[140]

It is possible for Lee County to experience storm surge of over 20 feet in some areas. Those portions of the county and its political subdivisions that are most vulnerable or at risk of storm surge are referred to as coastal high hazard areas. These are Special Flood Hazard Areas along the coast with additional hazards due to wave and wind action[141].

Figure 46 below shows the coastal high hazard areas of the county and its political subdivisions.

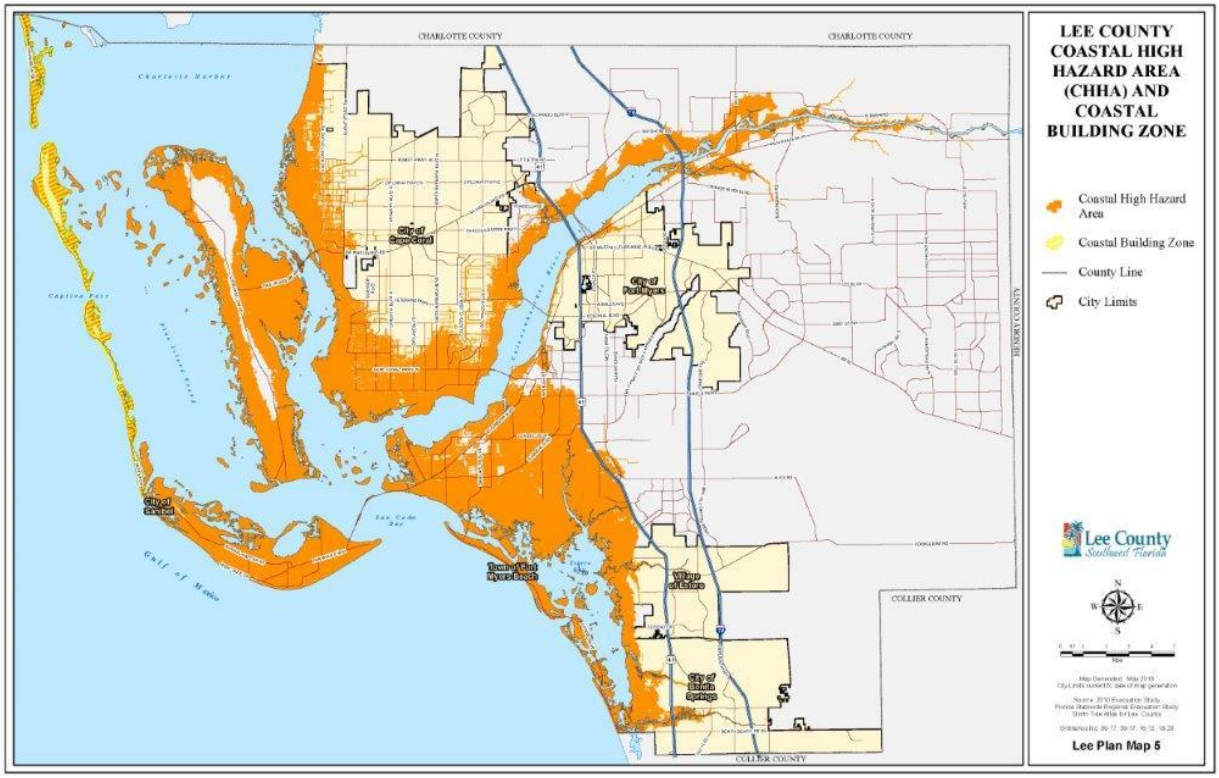

Figure 46 Coastal High Hazard Area and Coastal Building Zone

Previous Occurrence(s)

According to the NWS, approximately 75% of all Presidential disaster declarations in the United States are associated with flooding events[142]. Since 1953, there have been 36 flooding events in Lee County. Ten of these instances were flash floods, one was coastal flooding, and one was storm surge/tide. The rest of the events were related to other causes, such as rainfall, river overflow, and so forth.

In 2017, significant rainfall prior to Hurricane Irma resulted in saturation of the ground in many parts of Lee County. So much so, that additional rainfall associated with the oncoming hurricane caused significant flooding to occur in Bonita Springs, amounting to approximately half-a-billion dollars in damages. Table 27 below lists other events that have occurred in Lee County with concurrent flooding. Flooding in these instances were consequences of severe tropical weather, such as hurricanes and tropical storms, involving heavy amounts of rainfall and coastal flooding through storm surge. Table 28 below summarizes some notable flooding events in Lee County.

Table 27 Flood-Related Federal Disaster Declarations for Lee County

Disaster #	Declaration Date	Event Title
4337	09-27-2017	Hurricane Irma
1609	10-24-2005	Hurricane Wilma
1561	09-26-2004	Hurricane Jeanne
1551	09-16-2004	Hurricane Ivan
1545	09-04-2004	Hurricane Frances
1539	08-13-2004	Tropical Storm Bonnie and Hurricane Charley
1393	09-28-2001	Tropical Storm Gabrielle
1069	10-04-1995	Hurricane Opal
337	06-23-1972	Tropical Storm Agnes
252	11-07-1968	Hurricane Gladys
209	09-14-1965	Hurricane Betsy

Table 28 Notable Historic Flooding Events

Location	Date	Type	Prop Dmg	Description
Bonita Springs and Estero	08-20-2008	Sheet Flow	$250,000 (roads) and $250,000 (homes)	Six to 14 inches associated with Tropical Storm Fay caused extensive sheet flow flooding from the Imperial River that runs through Bonita Springs. Flood damage was reported to numerous roads and homes with 500 residents, including the population of an RV park, evacuated to a shelter.
Bonita Springs	06-24-2003	Heavy Rainfall	$20,000	A RV Park in East Bonita Springs was evacuated as the area was inundated with four feet of water after heavy rains.
Ft. Myers Beach and Lehigh Acres	10-04-2000	Heavy Rainfall	$200,000	Eight to 10 inches of rain fell in less than six hours, flooding roadways and low-lying areas from Lehigh Acres southwest to Fort Myers Beach. A few homes and several vehicles incurred water damage at low-lying roads and intersections.
Countywide	09-17-2000	Heavy Rainfall	$250,000	Six to eight inches of rain associated with Hurricane Gordon fell in less than 18 hours. Several homes in low-lying and poor drainage areas and several vehicles were damaged, mainly at flooded intersections and low-lying roadways.

Location	Date	Type	Prop Dmg	Description
Bonita Springs	09-21-1999	Heavy Rainfall	$200,000	Four to seven inches of rain fell over the previously saturated soil of southern Lee County and flooded homes and businesses in low-lying areas along the U.S. Highway 41 corridor from Estero south to Bonita Springs.
North Ft. Myers	07-01-1999	Heavy Rainfall	$150,000	Four to six inches of rain fell in less than three hours causing urban and small stream flooding along and east of I-75 from Port Charlotte in Charlotte County south to Lehigh Acres in Lee County. Four piglets drowned in North Fort Myers.
Cape Coral and Ft. Myers	09-27-1997	Flash Flooding	$200,000	Six to 10 inches of rain flooded roads, homes and businesses when rivers and streams overtopped.
Cape Coral	06-18-1999	Flash Flooding and Heavy Rainfall	$500,000	Six to eight inches of rain fell in less than three hours, flooded roadways, damaged carpets in nearly 50 homes and caused structural damage to an additional nine homes.

Historical Summary of Insured Flood Losses

The National Flood Insurance Program (NFIP) is federal program that enables property owners in participating communities to purchase insurance for flood losses. For a community to participate in the NFIP they must adopt floodplain management regulations that reduce future flood damages. This insurance is designed to provide an alternative to disaster assistance to reduce the high costs associated with repairing damage to buildings and their contents caused by floods (FEMA).

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

Communities that participate in the NFIP are required to adopt and enforce the minimum federal NFIP floodplain management regulations. These regulations apply to all types of floodplain development and ensure that development activities will not cause an increase in future flood damages. To ensure that new construction is reasonably safe from flooding,

the finished floor elevation must meet or be higher than the Base Flood Elevation (BFE) established by FEMA Flood Insurance Rate Maps and a community's Flood Insurance Study (FIS). These maps identify areas that have a 1%-annual chance of flooding as well as those areas with a 0.2%-annual chance of flooding. If there is a federally insured loan on the structure, like most mortgages, there is a mandatory requirement to purchase a flood insurance policy. The City of Bonita Springs, The City of Cape Coral, The City of Fort Myers, The Town of Fort Myers Beach, The City of Sanibel and unincorporated Lee County all participate in the National Flood insurance program and Community Rating System, which offers discounts on NFIP policies. In February 2015, the newly incorporated Village of Estero received its NFIP Identification Number and began the formal process of joining the NFIP and CRS.

Table 29 below contains a summary of National Flood Insurance Program participation in Lee County and its incorporated communities. Participating communities in Lee County coordinate as a group to share information and best practices to remain in compliance with NFIP requirements. Jurisdictions meet on a regular basis as part of a Community Rating System (CRS) Users Group and also participate in the county's Multijurisdictional Program for Public Information.

Table 29 Lee County NFIP Participation

Community	Status	Initial FHBM Identified	Initial FIRM Identified	Current Effective Date
Bonita Springs	Participating	N/A	09-19-1984	12-07-2018
Cape Coral	Participating	03-30-1973	08-17-1981	08-28-2008
Estero	Participating	N/A	09-19-1984	12-07-2018
Fort Myers Beach	Participating	N/A	07-20-1998	12-07-2018
Fort Myers	Participating	10-30-1970	11-15-1984	12-07-2018
Sanibel	Participating	07-23-1976	04-16-1979	08-28-2008
Lee Unincorporated	Participating	09-03-1971	09-19-1984	12-07-2018

Of the 132,050 flood insurance policies in force within the county, 74,989 are within the unincorporated county. As of January 2017, 9,274 NFIP claims with $75.7 million in total payments had been filed for properties within the county since 1978. Table 30 below summarizes the NFIP policy and claim statistics for the county with Florida totals for comparison. These losses include both inland (freshwater) and storm surge flooding events. It should be emphasized that these numbers include only those losses to

structures that were insured through the NFIP policies, and for losses in which claims were sought and received. It is likely that additional flood losses in Lee County were either uninsured, denied claims payment, or not reported.

Table 30 Lee County NFIP Policies and Claims (Since 1978)

Community	# of Policies	Ttl Coverage	Ttl Premium	Ttl Claims	Ttl Paid
Bonita Springs	8,041	$1,964,456,300	$4,886,585	13	**$118,396**
Cape Coral	31,669	$8,151,551,000	$22,214,070	765	**$808,984**
Estero	N/A	N/A	N/A	N/A	**N/A**
Fort Myers Beach	3,739	$793,052,900	$3,829,118	345	**$6,341,842**
Fort Myers	5,510	$1,446,614,000	$3,026,404	243	**$1,526,847**
Sanibel	8,102	$1,901,426,700	$9,505,725	1342	**$7,464,158**
Lee Unincorporated	74,989	$17,217,613,500	$50,183,807	6,566	**$59,486,559**
Total	**132,050**	**$31,474,714,400**	**$93,645,709**	**9,274**	**$75,746,786**

Community Rating System (CRS)

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Thus, flood insurance premium rates are discounted to reflect the reduced flood risks. There are 10 CRS classes: Class 1 requires the most credit points and gives the largest flood insurance premium reduction; Class 10 receives no premium reduction. These discounts are applied per each CRS community and apply to all flood insurance policyholders. For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community would receive a 45% premium discount, while a Class 9 community would receive a 5% discount.[143]

All communities in Lee County and the unincorporated area of Lee County, participate in the CRS program. Table 31 below provides an overview of each community's class rating the date they entered the program. Participation in this program allows residents within the SFHA to receive a discount on their flood insurance premiums for policies purchased under the NFIP. Residents within the non-SFHA also receive a discount on their policies.

Table 31 Lee County CRS Participation

Community	Class Rating	Effective Date	SFHA Insurance Discount	Non-SFHA Insurance Discount
Bonita Springs	5	05-01-2017	25%	10%
Cape Coral	5	05-01-2010	25%	10%
Estero	6	10-01-2017	20%	10%
Fort Myers Beach	7	10-01-1999	15%	5%
Fort Myers	7	10-01-1999	15%	5%
Sanibel	5	10-01-1996	25%	10%
Lee Unincorporated	5	10-01-2007	25%	10%

FEMA Repetitive Loss Flood Claims

A repetitive loss (RL) property is defined as a facility or structure that has experienced two or more insurance claims of $1,000 or more in any given 10-year period since 1978, under the National Flood Insurance Program. A RL property may or may not be currently insured by the NFIP. Currently there are over 122,000 RL properties nationwide.

Based on information provided by all jurisdictions in Lee County, as of March 2017 there are 579 repetitive loss properties in the county and its political subdivisions. Fort Myers Beach has the greatest share of such properties. The unincorporated portions of Lee County has the next greatest share. Table 32 below provides a summary of these properties. Figure 47 below illustrates areas of repetitive loss.

Table 32 Lee County Repetitive Loss Properties

Community	Residential	Commercial	Other
Bonita Springs	60	0	2
Cape Coral	4	0	0
Estero	1	0	0
Fort Myers Beach	164	40	0
Fort Myers	7	1	0
Sanibel	55	1	4
Lee Unincorporated	223	6	3
Total	**514**	**48**	**9**

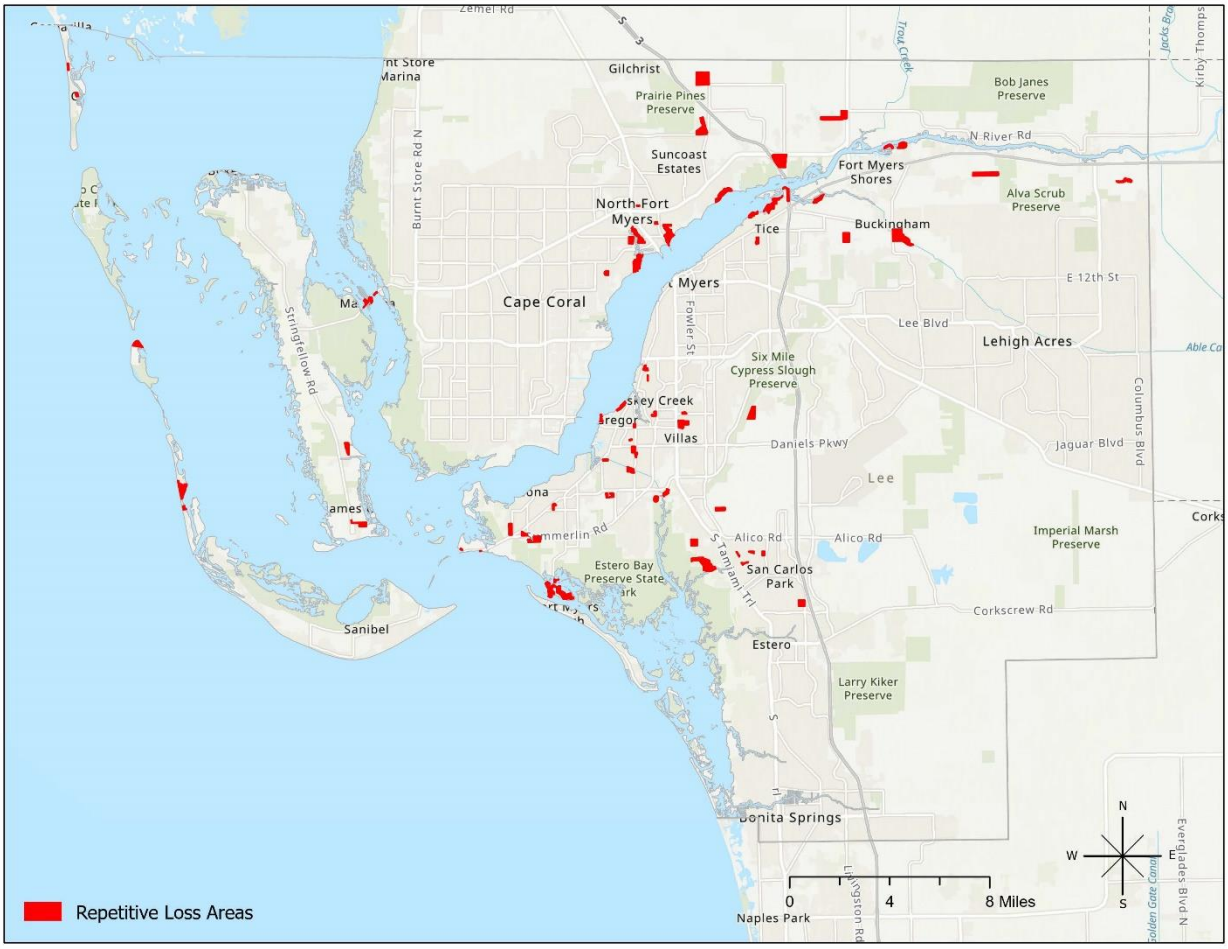

Figure 47 Repetitive Loss Areas in Planning Area

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Flooding carries incredible risks for the public. According to the National Hurricane Center, between 1963 and 2012, 90% of deaths associated with tropical cyclones were caused by storm surge and another 27% were caused by rain. Between 2016 and 2018, water continued to be the leading cause of death from tropical cyclones, though the majority of such instances were from inland flooding and not storm surge.[144]

Beyond injury and death, flooding also poses health risks associated with increased pest population, intrusion into potable water sources, disturbance and distribution of pollution sources (e.g., storm drains, chemicals stored in flooded-out structures, etc.), and disturbance of potential harmful wildlife. Flooding, especially with regards to storm surge, is also likely to result in evacuations of the public. Evacuations create significant disruptions in the lives of people, particular those with vulnerabilities and/or limited mobility, create and exacerbate stress, and can in their own right create safety risks.

Lee County and its political subdivisions do not have any recorded injuries or deaths related to flooding. All the same, a significant portion of the population resides in areas that could experience significant flooding; moreover, the county's storm surge zones cover most of the area's geography. Indeed, during Hurricane Irma, the county evacuated 300,000 residents. Even though the county has not yet experienced recorded injuries or deaths related to flooding, the risk and probability remain high.

Responders

Flooding events create dangerous operational environments for responders that necessitate appropriate protective actions during response and recovery. Flooding may also impact the ability of responders to execute life safety actions, such as evacuations and search and rescue, by creating obstacles through standing or moving water and the creation and movement of debris. Damage to utilities, such as power lines, also create dangerous operational conditions.

There are nearly 400 critical facilities located in areas that could experience flooding. About a quarter of these facilities are related to emergency response and medical care. Although it is highly unlikely a large number of these would be affected at the same time, damage to these facilities could affect, at least in the short-term, the ability of responders to carry out response operations.

Continuity of Operations and Delivery of Services

Of the nearly 400 critical facilities located in areas that could experience flooding, about 75% of them relate in some fashion to the conduct of government business and the delivery of services. Damage to these facilities would result in temporary disruptions to the continuation of operations and services; the extent and degree of such situations would be determined on the size of the facility, the building inventory of the jurisdiction, and types of services being provided, among a host of other factors. Depending on the

level of damage experienced, continuation or restoration of operations and services may require jurisdictions to relocate to other areas of the region.

Built Environment

Floods affect multiple facets of the built environment, including transportation and mobility systems, as well as residential and commercial property. Coastal flooding can contribute to coastal erosion, which as addressed in the description of impacts from Coastal Erosion (starting on p. 49), can contribute to negative consequences for the built environment near the coastline. Historical flood damages from tropical storms and hurricanes include damage to structure foundations and walls, content damage, loss of utilities, infrastructure damage to roads, and beach erosion. Damages from storm water runoff events include wall damage due to "wicking," as well as damages to contents, foundations, water distribution systems. Water contamination is also a possible consequence of flooding.

According to the NFIP, just one inch of water can cause $25,000 of damage to a home[145]. Previous flooding events have ranged in damages to the built environment ranging from very minor (approximately $0 recorded) to moderate (approximately $20,000) to very substantial (approximately $500 million)[146]. On average, flooding events in Lee County and its political subdivisions have incurred about $120,000 in damages per instance[*]. Public costs from flooding include debris clearance; equipment, material, and labor expenses related to emergency response; and building or facility damages (e.g., county parks, utilities, communications, etc.).

FEMA's RiskMAP Program endeavored to produce flood risk analyses to estimate the potential losses from flooding across the Lower 48 states. This effort occurred circa 2009/2010 and produced a product known as the 2010 AAL Study Results. The 2010 AAL Study and its associated results were intended to be a mechanism for FEMA - as well as local stakeholders - to assist in the prioritization of flood mitigation activities across the lower 48 states. Further information on the 2010 AAL Results and its use in RiskMAP Risk Assessments can be viewed in Guidance for Flood Risk Analysis and Mapping (May 2014). Notably, there were some problem areas in which the Hazus software was unable to produce valid results for the 2010 AAL Study in certain coastal areas. Lack of estimated flood damages limited the ability to assess potential damage across the entirety of the regional geography. An analysis was performed to estimate the Total Exposure in the

[*] The $500m damages in 2017 was 1,000 times more than the next largest instance of flooding; by definition, it was a unique event. Therefore, the average mentioned here is calculated by excluding the lowest and highest damages ($0 and $500m) to account the extreme nature of the 2017 event.

Floodplain of the building stock in Lee County, Florida. The subsequent sections describe the methodology and vulnerability assessment as part of this analysis.

Total Exposure in Floodplain (TEIF) Methodology

Lee County building footprints polygons were converted to centroids and those points were intersected with the FEMA effective 100-year and 500-year floodplain data. To create a resolution that summarizes the results affectively, 1000 foot grids were created and the building footprint points were intersected with the grids and the estimated building values were summarized within each grid. For displaying purposes, the grid values were divided into five categories: Very Low, Low, Medium, High, and Very High. Where values were 1.5 or less standard deviations below the mean, they were classified as Very Low, between 1.5 and 0.5 below the mean were Low, between 0.5 below and 0.5 above the mean were medium, between 0.5 and 1.5 above the mean were high, and those 1.5 or above the mean were very high.

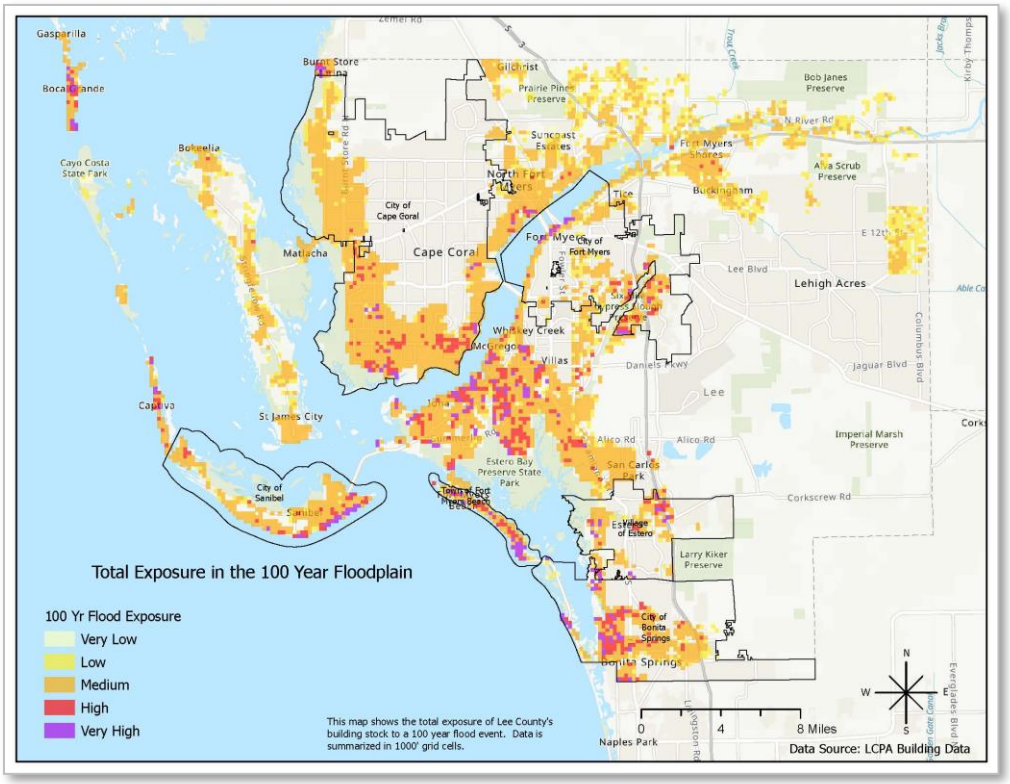

Figure 48 Total Exposure in 100-Year Floodplain (TEIF)

TEIF Vulnerability Analysis and Assessment

The results of the analysis identified many areas within each jurisdiction that may be at risk to flood. The unincorporated areas of Lee County are considered most at risk,

accounting for 44 percent of the total exposure in the county. The City of Cape Coral is the second most at risk jurisdiction with over $7 billion worth of building stock exposed to the 100-year floodplain, or 22.1% of the total exposure in the county. See Figure 48 above.

Table 33 Total Exposure in Floodplain (TEIF) 100-Year Summary by Jurisdiction

Jurisdiction	TEIF Value in Floodplain	% of Lee County
Bonita Springs	$3,952,617,597	11.4%
Cape Coral	$7,683,998,224	22.1%
Estero	$1,491,511,719	4.3%
Fort Myers	$2,274,899,393	6.5%
Fort Myers Beach	$1,363,310,920	3.9%
Sanibel	$2,614,094,496	7.5%
Lee Unincorporated	$15,440,955,161	44.3%
Total	$	100%

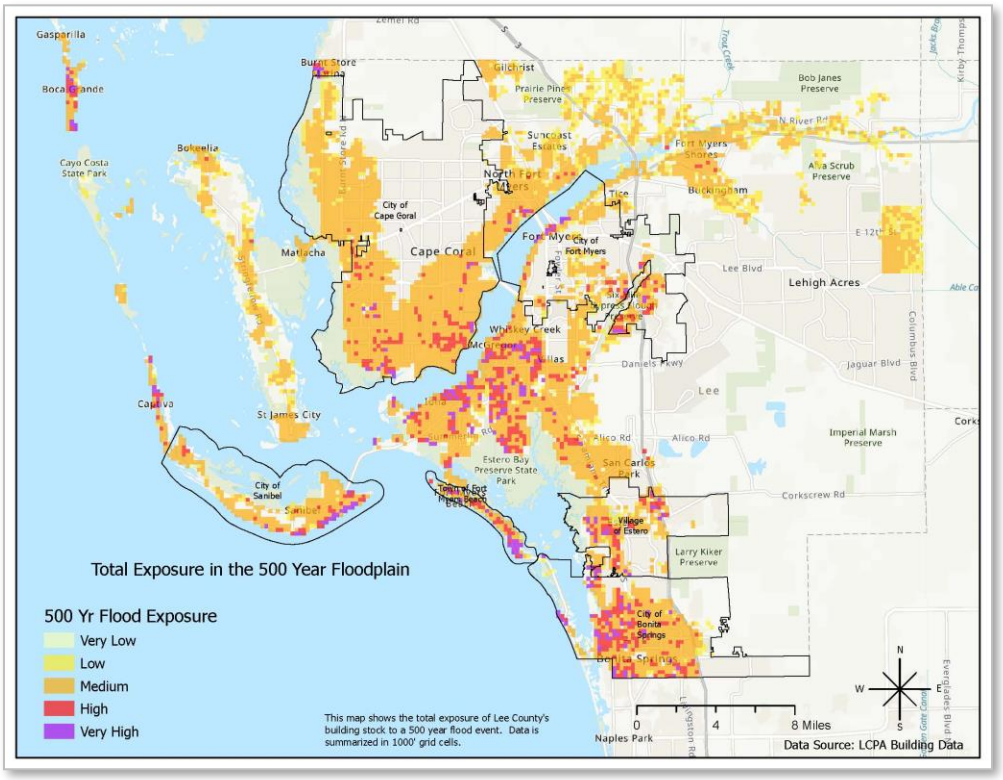

Figure 49 Total Exposure in 500-Year Floodplain (TEIF)

Table 33 above summarizes the results of the TEIF analysis in Lee County by jurisdiction. Figure 49 above visualizes the results for 500-year floodplains. Both Figure 48 and Figure 49 use 1000 foot square grids to demonstrate the greater at risk areas within the county. Table 34 below details the number of critical facilities in each of the categories shown in Figure 49.

Table 34 Critical Facilities in 500 Year Floodplain (TEIF)

Jurisdiction	Very High	High	Medium	Low	Very Low	Not in TEIF	Total
Bonita Springs	3	8	32	3	1	48	95
Cape Coral	7	16	53	6	1	149	232
Estero	4	3	17	2	0	32	58
Fort Myers	13	2	47	6	3	168	239
Fort Myers Beach	5	4	10	0	0	0	19
Sanibel	0	4	24	5	0	1	34
Lee Incorporated	4	3	17	2	0	32	58
Total	**63**	**65**	**394**	**55**	**16**	**795**	**1,388**

Table 35 below summarizes the number of buildings that may be impacted by storm surge associated with tropical cyclones. The categories shown in the table correlate with the Saffir-Simpson Hurricane Wind Scale (cross reference Table 39 on p. 114).

Table 35 Storm Surge Impact by Hurricane Category

Jurisdiction	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Total
Bonita Springs	7,036	9,020	5,344	4,802	9	26,211
Cape Coral	10,207	31,392	26,687	12,934	2	81,222
Fort Myers	1,172	2,524	6,229	12,882	4,433	27,240
Sanibel	5,101	67	0	0	0	5,168
Fort Myers Beach	3,343	1	0	0	0	3,344
Lee Unincorporated	42,673	26,630	20,810	21,553	14,279	125,945
Estero	1,558	3,210	7,542	4,358	71	16,739
Total	**71,090**	**72,844**	**66,612**	**56,529**	**18,794**	**285,869**

Natural Environment

Flooding is a natural occurrence in most portions of Florida. The marshes, estuaries, and other natural drainage systems in Lee County and its political subdivisions have developed naturally to accommodate these occurrences. While flooding may result in localized disturbances to some wildlife populations, the environmental impact of flooding may not be overly negative. However, salt water intrusion into areas not accustomed to it could result in negative consequences to that areas flora and fauna and the ecosystem surrounding them. It is also possible that flooding can lead to drowning, the spread of plant and/or animal diseases, habitat destruction, and other negative outcomes for the natural environment. Negative consequences are likely to occur in the natural environment from flooding if toxins or pollutants are disturbed and distributed through an area by the event. Finally, flooding can contribute to sedimentation and erosion, the outcome of which may be good or bad depending on the area and circumstances.

Economy

Damage and disruptions to the built environment carry economic costs. Commercial areas can experience damage to property, loss of utilities and other services, decreased access to transportation networks and supply lines, reduced labor pools, and a host of other outcomes. Large-scale flooding events, such as those caused by significant storm surge, could result in increased costs during the recovery phase. Flooding in agricultural areas could result in the loss of livestock and/or crops, as well as loss in equipment and facilities.

Public Confidence

Generally, flooding in Lee County and its political subdivisions has not demonstrated to produce strong or notable consequences for the public's confidence in the jurisdictions' governance. Truly, instances do produce localized concern over flood-related issues, but not to the point of eroding confidence to an identifiable level. Nevertheless, catastrophic flooding, such as what occurred during Hurricane Katrina, could result in serious erosion of public confidence.

Probability

Since 1996, flooding events occur about 1.5 times on average every year. The region's climate, including the propensity for severe weather events, means that conditions conducive to flooding existing on a regular basis.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Highly Likely	$50k-$150k	Injuries*	Less than 24 hours	9.75
Although there are no recorded instances of injury or death in Lee County related to flooding events, the potential for loss of life remains significantly high. For this reason, planners decided to assign “Injuries” to account for this potential in the composite score.				

Freeze

A freeze occurs when the surface temperature of the air over a large area remains below 32°F (0°C). In addition to the hazard low temperatures pose to anima life, low temperatures associated with freezes pose risks for plant life as well. One risk is frost, which develops during clear nights that are calm when temperatures approach the mid-30s Fahrenheit. Plant species have varying degrees of tolerance for cold weather.[147]

The National Weather Service distributes the following notices and advisories related to freeze events[148]:

- Hard Freeze Warning – issued when temperatures are expected to drop below 28°F for an extended period of time, killing most types of commercial crops and residential plants.
- Freeze Warning – issued when temperatures are forecasted to go below 32°F for an extended period of time. This temperature threshold kills some types of commercial crops and residential plants.
- Freeze Watch – issued when there is a potential for significant, widespread freezing temperatures within the next 24-36 hours. These are issued in the autumn until the end of the growing season and in the spring at the start of the growing season.
- Frost Advisory – issued when areas of frost are expected or occurring, posing a threat to sensitive vegetation.

Table 36 Critical Fruit Temperature (Tc) for Citrus Fruit

Citrus Species	Critical Temperature (°C)
Green oranges	-1.9 to -1.4
Half ripe oranges, grapefruit, and mandarins	-2.2 to -1.7
Ripe oranges, grapefruit, and mandarins	-2.8 to -2.2
Button lemons	-1.4 to -0.8
Tree ripe lemons	-1.4 to -0.8
Green lemons (diameter >12mm)	-1.9 to -1.4
Lemon buds and blossoms	-2.8

Location and Extent

Domesticated and wild vegetation occurs throughout the entirety of Lee County. In addition to crops cultivated by the agricultural industry, there are extensive conservation areas in the county that host numerous types of wild plants. Numerous homes maintain

private gardens and citrus trees have been planted in a large number of yards (see Table 36 above for citrus critical temperatures). As freezes by definition are not localized events, the entirety of the county and its political subdivisions are at risk of experiencing a freeze and a single event could affect the entire area at once.

Previous Occurrence(s)

Lee County has experienced four freezes in the past that resulted in major disaster declarations (see Table 14 on p. 38). These occurred in 1971, 1977, 1985, and 1989. Overall, there have been 60 days in Lee County where temperatures were 32°F or below, since 1901[149]. There were only 10 days been 2000 and 2010, and no days between 2010 and 2020. Table 25 on p. 73 shows the minimum temperatures per month for the last two decades in Lee County.

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Freeze events will not have consequences on the public beyond those caused by extreme cold situations, as described in the Extreme Cold hazard profile.

Responders

The onset of this hazard is unlikely to impact responders.

Continuity of Operations and Delivery of Services

The onset of this hazard is unlikely to impact the continuation of government operations and the delivery of services.

Built Environment

The onset of this hazard is unlikely to impact the built environment.

Natural Environment

Freeze events could result in damage to wild plant life, similar to how damages would occur in crops and residential agriculture.

Economy

The primary economic consequences of a freeze will center on crop production and the goods and services networks surrounding it. According to the United States Department of Agriculture survey, in 2017 there were 800 farms operating in Lee County covering just over 87,000 acres of land—the vast majority of farms (653) consist of 1 to 49 acres. Of the 800 farms, 272 had harvested cropland, which accounted for 25% of total farm acreage in the county (see Table 10 on p. 32). At the time of the survey, the market value of crops in Lee County was approximately $98,000,000. On average, farms in the county sold about $130,000 in agricultural products (including livestock and so forth). About 650 farms had sales that totaled less than $25,000. Three-hundred and sixty nine farms had sells that totaled less than $2,500.[150] As Table 12 on p. 33 shows, there is variety in the types of crops cultivated and harvested in the county, each type with its own tolerance for temperature variations. Thus, not every freeze event will affect all crops equally.

The county's previous experience with freeze events shows that there is potential for notable economic impact should such an event occur in the future.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

The low frequency with which freeze events happen in Lee County renders this hazard as somewhat likely to occur in the future.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Somewhat Likely	>$150k	None	3+ days	6.50

Severe Weather

Severe weather consists of thunderstorm winds, lightning, and hail. A thunderstorm is, simplistically, a rain shower with lightning and thunder. Thunderstorms become severe weather events when they are accompanied by[151]:

- One or more inches of hail, or
- Wind gusts in excess of 50 knots (57.5 mph), or
- A tornado†

Thunderstorms form with moisture, rising unstable air, and lifting mechanisms (i.e., phenomena that moves the air, like heating from the sun). Heat transference in the air as it rises leads to convection, where water vapor begins to cool. This process results in the formation of clouds that release moisture when sufficiently cooled. Figure 50 below shows illustrates each stage of a thunderstorm.[152]

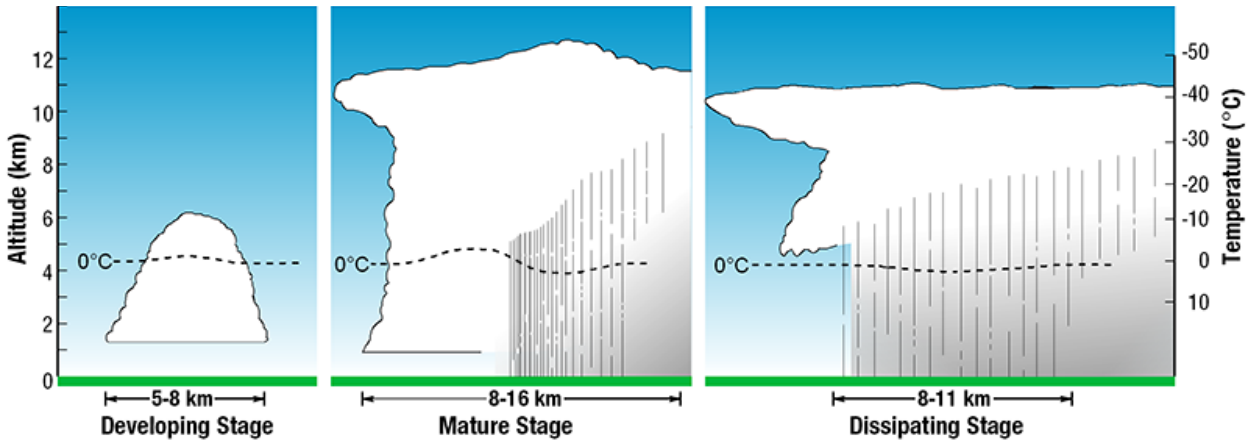

Figure 50 Life Cycle of a Thunderstorm (source: NOAA)

There are multiple types of thunderstorms, including[153]:

- Multi-cell storms – "garden-variety" storm, with individual cells lasting between 30-60 minutes, and the whole storm lasting possibly for many hours. These may produce hail, strong winds, brief tornadoes, and/or flooding.
- Squall line storms – a group of storm arranged in a line, often accompanied by "squalls" of high wind and heavy rain. These tend to pass by quickly and are less prone to produce tornadoes than supercells. These storms can be hundreds of miles long, but are typically 10-20 miles wide.

† Tornadoes are addressed as their own hazard in this hazard identification and risk assessment.

- Supercell – a long-lived storm (greater than one hour), highly organized, and tilted and rotating. Most large and violent tornadoes come from these storms.
- Derecho – widespread, long-lived wind storms associated with rapidly moving showers or thunderstorms. These storms are capable of producing wind damage similar to tornadoes, the difference being that the winds from these storms tend to be unidirectional, instead of rotational. Damage from this type is sometimes referred to as straight-line wind damage. To qualify as a derecho, the wind damage swath must extend more than 240 miles and include wind gusts of at least 58 mph along most of its length.

Other types of thunderstorms include bow echos, Mesoscale convective systems, Mesoscale convective complexes, and Mesoscale convective vortexes.

When precipitation begins to fall out of a developing thunderstorm, it creates a downward draft. The downward draft and rain-cooled air spreads out along the ground, which creates a wind gust front. Winds that exceed 50-60 mph are considered to be damaging winds. Types of wind include—but are not limited to—the following[154]:

- Straight-line wind – damaging wind that is unidirectional rather than rotational.
- Downdraft – a small-scale column of air that rapidly sinks toward the ground; this is the general term for all localized strong winds that are caused by strong downdrafts within a thunderstorm.
- Macroburst – an outward burst of strong winds at or near the surface with horizontal dimensions larger than 2.5 miles, occurring when a downdraft reaches the surface.
- Microburst – a small concentrated downburst that produces an outward burs of strong winds at or near the surface, less than 2.5 miles across, short-lives (5-10 minutes), with maximum speeds sometimes exceeding 100mph. Microbursts can be wet or dry.

During convection, exchanges of electrical charges between cooled particles can result in lightning. Air insulates positive and negative charges during the early stages of a thunderstorm's lifecycle, but during convection exchanges of electrical charges between cooling particles begin to break the insulation down. Lightning is the rapid discharge of electricity released when the charges are large enough to overcome the strength of the air's insulation. This exchange and discharge of electrical energy can occur within

thunderstorm clouds (i.e., intra-cloud lightning), as well as between thunderstorm clouds and the ground (i.e., cloud-to-ground lightning).[155]

Lightning can occur not only with thunderstorms, but also volcanic eruptions, extremely intense forest fires, heavy snowstorms, and large hurricanes. Figure 51 below provides a diagram of how charges are distributed in storm clouds.

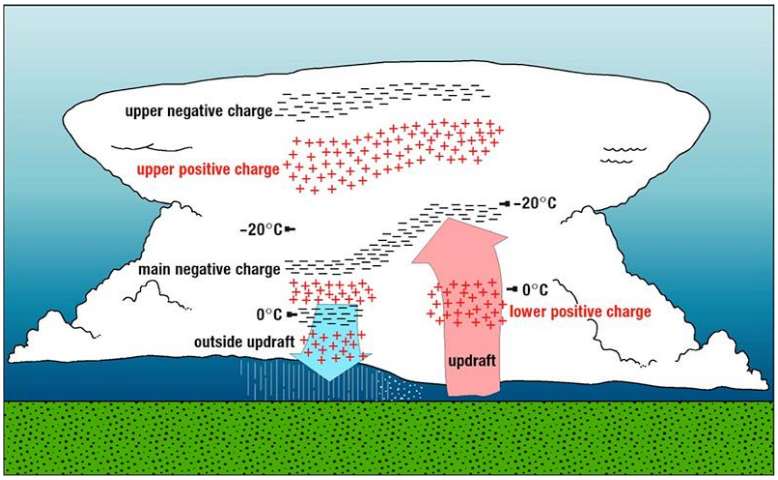

Figure 51 Charge Distribution in Storm Clouds (source: NOAA)

Hail is a type of participation made of solid ice. It forms inside the updrafts of thunderstorms when rain is carried into extremely cold portions of the atmosphere. Hail proceeds to the surface when the updraft is no longer able to suspend the hailstones—the stones become too large and/or the draft weakens. Depending on the size of the hailstones and the strength of the storm's wind, hail can fall straight down, at an angle, or sideways in relation to the storm. Most hailstorms consist of hailstones of different sizes.[156]

Location and Extent

Severe weather is most likely to occur during the region's wet months and can occur anywhere within Lee County. Depending on the size of the storm and its path, portions of the county or the entire county may experience severe weather conditions at the same time. Thunderstorms along the Gulf Coast occur most often during the afternoon[157]. In addition to the risk of flooding associated with rainfall, strong winds can inflict significant damage on people and the built and natural environment. Lightning from thunderstorms poses risks of injury or death to people and can damage structures, utilities, and possibly spark wildfires. Hail can inflict injury or death on people, damage structures, and damage or destroy crops. Figure 52, Figure 53, Figure 54, and Figure 55 below show risk areas for high wind speeds in Lee County and its political subdivisions.

Figure 52 Ultimate Design Wind Speeds - Risk Category I Buildings

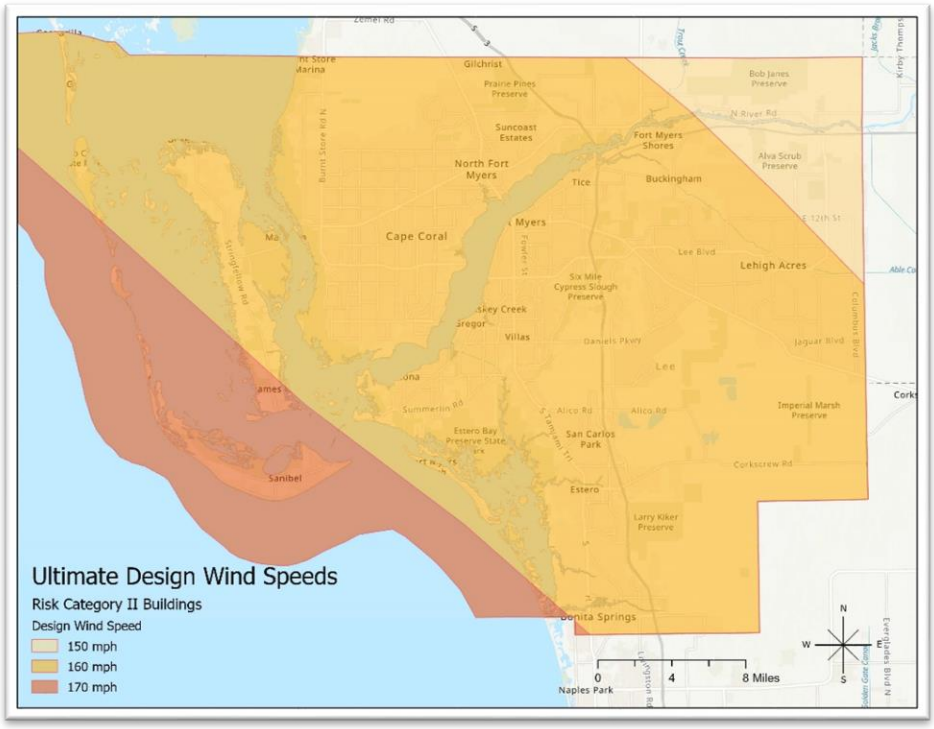

Figure 53 Ultimate Design Wind Speeds - Risk Category II Buildings

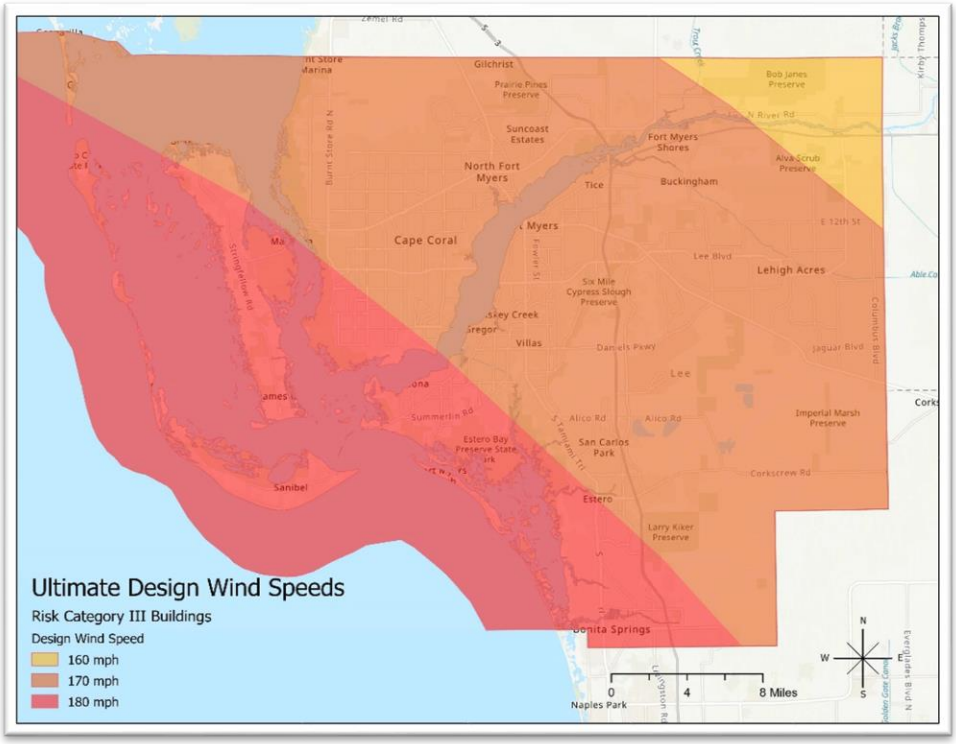

Figure 54 Ultimate Design Wind Speeds - Risk Category III Buildings

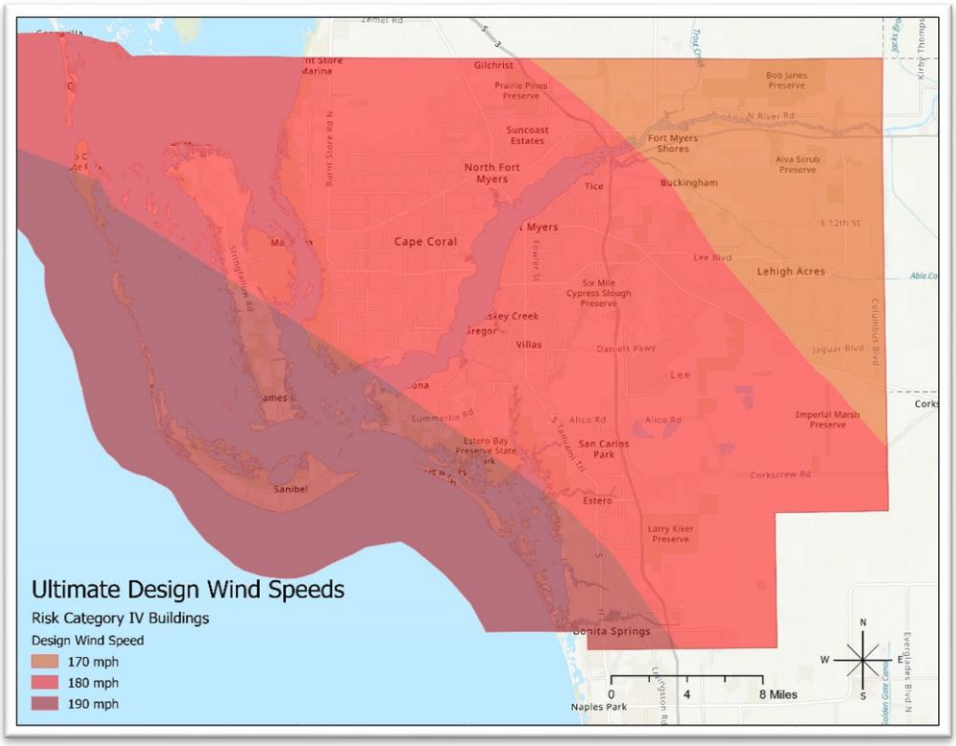

Figure 55 Ultimate Design Wind Speeds - Risk Category IV Buildings

Previous Occurrence(s)

The Storm Events Database records 391 severe weather events for Lee County between 1957 and 2021[158]. (It must be noted and stress that this number counts the same storm system multiple times if it occurred in more than one of the county's political subdivisions; in other words, the database does not record 391 distinct, mutually exclusive events.) Of these 223 were related to wind, 114 to hail, and 54 to lightning. Wind speeds for the events ranged from 0-75 knots (about 86 mph), with an average of 33 knots (about 38 mph). Hail events ranged from 0.75-2.00 inches, with an average of about 1 inch.

Table 14 on p. 38 shows that Lee County has had two major disaster declarations (in 2008 and 2012) related to severe weather.

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Severe weather poses significant risk to the public in terms of wind damage, harm from lightning strikes, and the potential for flooding associated with heavy or extensive rainfall. As of September 2021, lightning has killed 10 people in the United States—three of the fatalities occurred in Florida. Since 2010, lightning has killed 285 people. (See Figure 56 below.) Since 1996, 3 people in Lee County have been killed by lightning and another 3 injured. According to the Storm Events Database, damaging winds have injured 11 people in Lee County since 1959. No injuries or deaths related to hail have been recorded for the county.

As previously mentioned, severe weather can contribute to flooding events, which pose additional risks to the public. Strong winds can lead to coastal flooding while heavy rainfall can lead to increased water levels in rivers, collection of water in low or flat lying areas, pool in areas with low permeability (like urbanized areas), saturate the ground contributing to flooding over time, and so forth.

Responders

Similar to the risks posed to the public, severe weather increases risks to responders with strong wind that makes movement difficult and dangerous and lightning conditions that create potentially unsafe environments. Rainfall associated with severe weather can also pose additional risks to responders, as addressed in the Flood hazard profile.

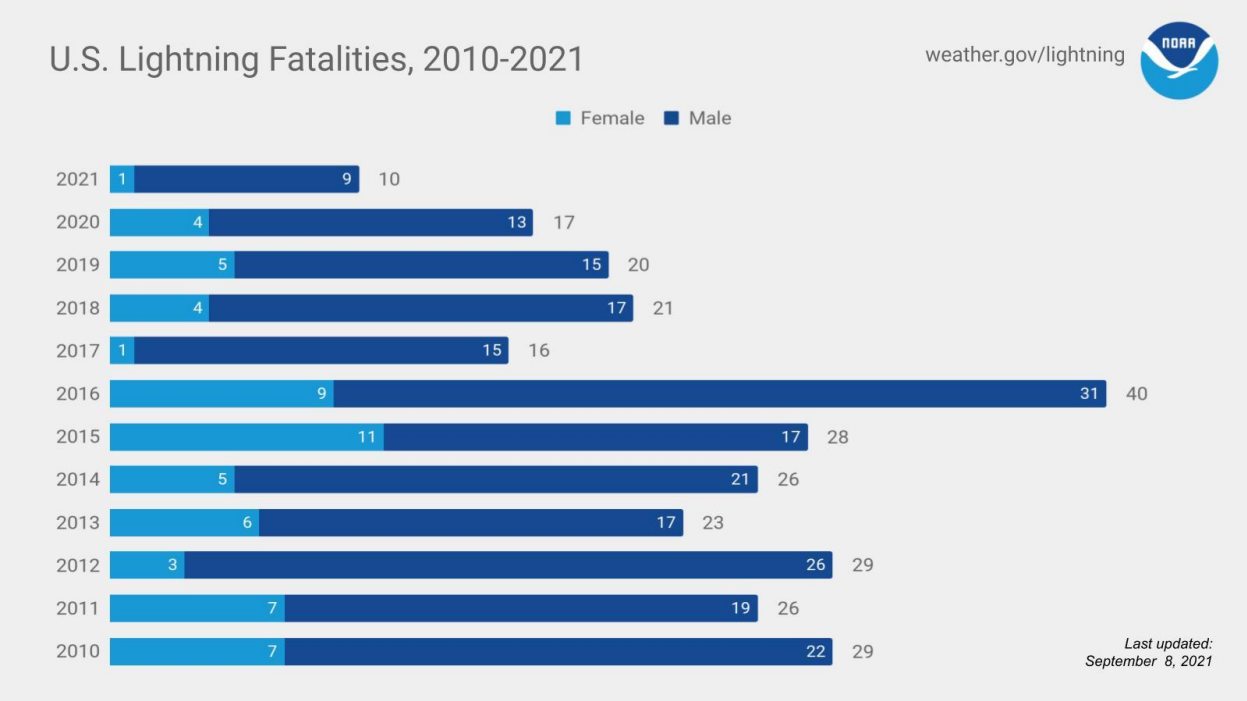

Figure 56 U.S. Lightning Fatalities, 2010-2012 (source: NOAA)

Continuity of Operations and Delivery of Services

The onset of this hazard is unlikely to impact the continuation of government operations and delivery of services.

Built Environment

Strong winds that are a part of severe weather events can cause significant damage to the built environment. Strong enough winds can move debris in dangerous and harmful ways, essentially using elements of the built and natural environment to create projectiles that can damage or destroy property and buildings. Winds can topple power lines, severing utilities and creating electrocution risks for the public and responders. Winds also pose risks to suspended structures and to vehicles moving on roads. Rainfall from severe weather can also damage the built environment through flooding. Lightning can damage or destroy electrical components, start fires, or harm buildings in other ways.

Recorded damages to the built environment in Lee County and its political subdivision from previous severe weather events (between 1993 and 2021) total nearly $22,000,000. On average, severe weather events have caused nearly $72,000 of damage per event (just over half of recorded severe weather events had no noted damage).

Natural Environment

The area's natural environment is adapted to handle many aspects of severe weather events. All the same, damage can still occur to areas from excessive or prolonged rainfall, lightning strikes could result in wildfire, and strong bursts of wind can damage foliage.

The United States Department of Agriculture published a report in August 2020 on a study performed to identify and assess the consequences of weather events on the natural environment. The content is included here by reference.[159] (See the endnote for the report's citation and location.)

Economy

Damage to people and the built environment could have associated economic consequences. Debris could disrupt transportation systems, limit access to economic centers, or disrupt supply lines. Areas of the economy not directly affected by severe weather events are likely to continue operating with minimal to no disruptions following a severe weather event.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

Lee County's climate is such that the area is prone to significant weather events on an annual basis. It is very likely that in any given year, the county will experience one, if not multiple, severe weather events.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Very Likely	$50k-$150	Deaths	3+ days	9.75

Tornado

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The path width of a tornado is generally less than half of a mile, but the path length can vary from a few hundred yards to dozens of miles. A tornado moves at speeds from 30 to 125 mph, but can generate winds exceeding 300 mph.

Table 37 Enhanced Fujita Scale

Enhanced F-Scale	Wind Speeds (mph)	Typical Damage	Prop.
EF0	65-85	**Light Damage.** Some damage to chimneys, TV antennas, roof shingles, trees, and windows	29%
EF1	86-110	**Moderate Damage.** Automobiles overturned, carports destroyed, trees uprooted	40%
EF2	111-135	**Considerable** Damage. Roofs blown off homes, sheds and outbuildings demolished, mobile homes overturned	24%
EF3	136-165	**Severe Damage.** Exterior walls and roofs blown off homes. Metal buildings collapsed or severely damaged. Forests and farmland flattened.	6%
EF4	166-200	**Devastating Damage.** Few walls, if any, standing in well-built homes. Large steel and concrete missiles thrown far distances.	2%
EF5	>200	**Incredible Damage.** Homes leveled with all debris removed. Schools, motels, and other larger structures have considerable damage with exterior walls and roofs gone. Top stories demolished.	<1%

Tremendous destruction can occur in paths over a mile wide and 50 miles long with winds reaching 300 mph. In the United States, tornadoes have been classified on the Fujita Scale, assigning numeric scores from 0-5 (or higher) based on the severity of observed damages. The traditional Fujita scale, introduced in 1971, was used to rate the intensity of tornadoes thereafter, and was also applied to previously documented tornadoes. Starting in February of 2007, an “enhanced” Fujita scale was implemented, with somewhat lower wind speeds at the higher F-numbers, and more thoroughly-refined structural damage indicator definitions. Table 37 above shows the following values for the

enhanced Fujita scale: tornado intensity scales, wind speeds, typical damages, and proportion of all tornadoes nationwide.

Location and Extent

Tornado season typically is March through August; however, a tornado can occur in any month. All of Lee County and its political subdivisions are susceptible to tornadic events. Tornadoes impacting urban and heavily populated areas would cause the most damage and risk to life and property.

Lee County may experience tornadoes ranging from EF0, minimum severity and upward to EF4. See Table 37 above for the expected severity for each value of the scale. Vulnerability to tornadoes is dependent on the geographic extent and magnitude of the event. Damages from lower intensity tornadoes (EF0) can range from chimney damage to uprooted shallow trees. A significant tornado (EF2) would cause considerable damage to roofs on frame houses, complete destruction of mobile homes and large trees and utility lines snapping. Mobile homes are at risk of damage from tornados and other related high wind events. A devastating tornado (EF4) would result in well-constructed houses being leveled, weak foundations blown to a distance and cars thrown.

Previous Occurrence(s)

There have been 112 tornadoes recorded in Lee County since 1950. Additionally, there have been 19 waterspouts recorded in the county (the first record is for 1996 and the last record is for 2001).[160] Table 38 below tabulates the number of tornado events recorded by magnitude. According to the database, Lee County has not experienced a tornado above (E)F2. Most recently, Lee County experienced an EF1 tornado in December 2021. The event resulted in damage to residential and commercial property and a single injury.

Table 38 Number of Tornado Events in Lee County (1950-2021)

F-Scale	Events
F0	66
F1	19
F2	11

EF-Scale	Events
EF0	10
EF1	5
EF2	1

No magnitude recorded: 2

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the

natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

The high-speed winds of tornadoes pose serious risks to people. Tornadoes sweep up debris and inflict damage on the built environment. People caught in the path of a tornado can become seriously injured or killed. Structures with relatively limited structural strength or foundations (e.g., mobile homes and RVs) are especially susceptible to damage from tornadoes, as are the tenants of those structures. Since 1950, one person in Lee County has been killed by a tornado event another 34 injured.[161] An EF1 tornado in 2021 resulted in one injury to a resident who had to seek medical care at a hospital.

Responders

Tornadoes may impact responder facilities, infrastructure, equipment, and roadways. This can limit their ability to communicate, navigate, and fulfill their job responsibilities. Damage to responders' personal properties can also impact their abilities to report to work. However, based on Lee County historical data, tornadoes that impact Lee County (EF0-EF2) would not cause a serious impediment to responders.

Continuity of Operations and Delivery of Services

Tornadoes may impact county critical facilities and infrastructure. Should this occur, Lee County will transition to remote work where applicable. When necessary, Lee County departments will deliver required services as outlined in their continuity of operations plans until there is a permanent solution. Mutual aid agreements and memorandums of understanding between local, regional, and state partners may be enacted until full functionality is restored.

Built Environment

Buildings must be designed to withstand both external and internal wind pressures on the structural framing and exterior elements. The level to which these structures are designed, as expected, directly correlates with its ability to resist damages due to high winds. The community's building code dictates the design wind speed to which a structure must be designed; Lee County has adopted the International Building Code. For some building types, the structures constructed subsequent to the adoption of the building code are the most likely to be the most resistant to damages from wind.

Figure 57 Damage in Lee County from an EF1 Tornado

The damages resulting from tornadoes are affected by the condition of the exposed structures, their design and construction, and the quality of the building materials. The current building code requires structures to be built to withstand a 90 mph (in a 3 second wind burst) wind events. However, structures within the county were built prior to the adoption of the current building code and current standards. As such older homes, certain construction materials, mobile homes, and poorly designed homes are very vulnerable to tornadoes. If homes are destroyed by tornadoes this would impact residents by requiring them to rebuild to current standards or relocate. Destruction of commercial buildings and infrastructure would cause employees to search for employment elsewhere, resulting in relocating to other areas outside of Lee County.

Thirty-two of the recorded tornadoes in Lee County resulted in no reported damages. The most severe instance of a tornado in the county resulted in $5,000,000 damages. This amount is somewhat unique—75% of tornadoes recorded resulted in $155,000 damages or less, 50% recorded $20,000 or less. As a consequence, the average damage per event

($289,000) is skewed.[‡] In total, the county has experienced approximately $33,333,650 in damages from tornadoes.

Only one of the 19 recorded waterspouts in the Storm Events Database, which occurred in 1997, resulted in noted damages. Property damage for the event was estimated to be $50,000. The EF1 tornado in 2021 resulted in significant damage to residential and commercial property. (Estimates for the cost of damages are not yet available.) Homes experienced damage to roofs and structures, vehicles were totaled by debris, and individuals lost power for a day or more (see Figure 57 above). The tornado produced an extensive amount of plant debris on private property, which necessitated homeowners to arrange the collection and placement of the debris on public easements for removal.

Natural Environment

Lee County's natural environment can be damaged by a tornado depending on where in the county the tornado touches down. Tornadoes can rip up mangroves that create habitats for native wildlife and protection from coastal erosion. They can also destroy trees and conservation areas.

Economy

Tornadoes can cause damages to historical sites, down town areas, beaches, parks, and lodging which can impact tourism, housing, and local businesses in Lee County. Lee County could also incur increased unemployment should a large employer become impacted by a tornadic event.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

Based on the historical record, tornadoes are fairly common occurrence in Lee County. From 1950 to 2021, the county experienced on average about 1.5 tornadoes per year.

Global weather patterns affect probability of tornadoes; for example, El Niño and La Niña either increase or decrease the likelihood of tornadoes, depending on which is influencing predominately at a given time. See Figure 58 below.

[‡] For this reason, the final assessment considers the third quartile ($155,000) to be a better approximate of the expected average of damages for future tornado events in Lee County.

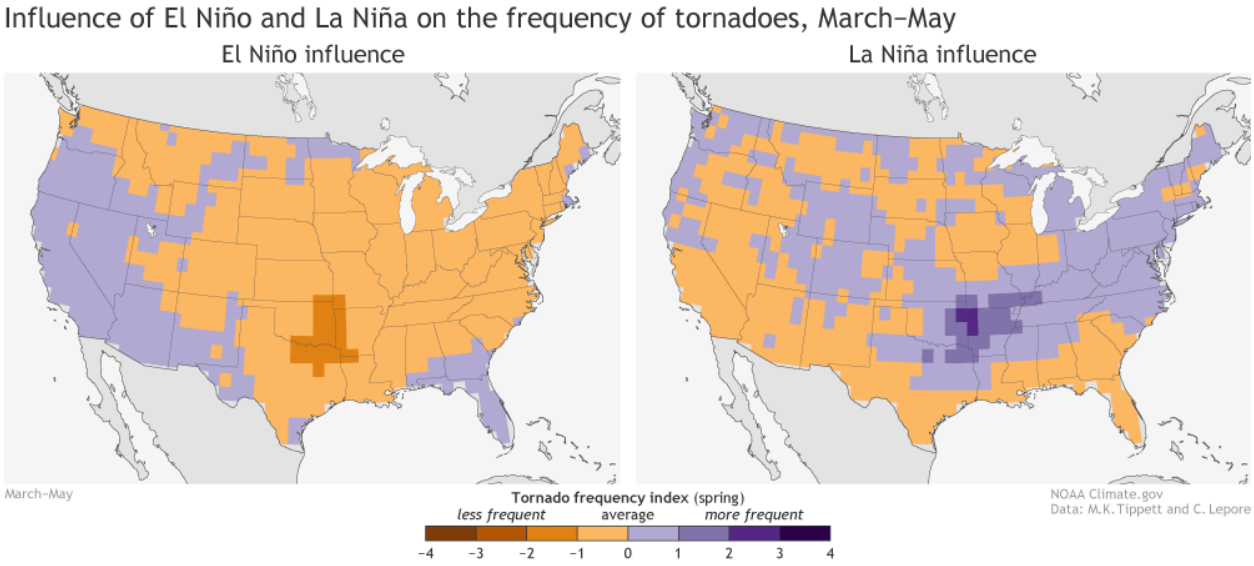

Figure 58 Influence of El Niño and La Niña on the Frequency of Tornadoes

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Very Likely	>$150k	Deaths	Less than 24 hours	12.00

Tropical Cyclone

A tropical cyclone is defined as a warm-core non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organized deep convection, and a closed surface wind circulation about a well-defined center. Tropical cyclones act as a "safety-valve" that limits the build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole ward latitudes.

As a tropical cyclone develops over warm water, pressure drops (measured in millibars or inches of Mercury) in the center of the storm. As the pressure drops, the system becomes better organized and the winds begin to rotate around the low pressure, pulling in the warm and moist ocean air. It is this cycle that causes the wind (and rain) associated with a tropical cyclone. If all the conditions are right (warm ocean water and favorable high-altitude winds), the system could build to a point where it has winds in excess of 156 miles per hour and could become catastrophic if it makes landfall in populated areas.

The Saffir-Simpson Hurricane Wind Scale, the standard describing an event's disaster potential, uses wind speed, central pressure, and damage potential to create storm classifications. The Scale consists of 1 to 5 categorizations based on the hurricane's intensity at the indicated time and provides examples of the type of damage and impacts in the United States associated with winds of the indicated intensity. In general, damage rises by about a factor of four for every category increase. Table 39 below shows the Saffir-Simpson Hurricane Wind Scale that is used to classify tropical storms and hurricanes based on the potential wind damage.

The hurricane season is defined as June 1 through November 30. The earliest observed hurricane formation occurred on March 7, 1908, while the latest observed formation was on December 31, 1954, which persisted as a hurricane until January 5, 1955. The earliest hurricane to strike the United States during this date range was Alma which struck northwest Florida on June 9, 1966, while the latest hurricane to strike the U. S. during a hurricane season was Kate late on November 30, 1925, near Tampa, Florida.

Other hydro-meteorological hazards associated with hurricanes include the following: storm surge flooding; windstorms due to extremely strong winds; riverine flooding caused by heavy rains; and tornadoes. These hazards are not exclusively associated with tropical cyclones and therefore will not be described in this hazard profile. For more information, refer to the section for each hazard.

Table 39 Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74-95 mph 64-82 kt	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, and vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph 83-95 kt	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 ***(major)***	111-129 mph 96-112 kt	Devastating damage will occur: Well-built framed homes may incur major damage or 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.
4 ***(major)***	130-156 mph 113-136 kt	Catastrophic damage will 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, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 ***(major)***	157+ mph 137+ kt	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Location and Extent

The entire state of Florida is at risk of the damaging effects of hurricane and tropical storm wind damage. Forty percent of all U.S. hurricanes and major hurricanes have been in Florida. Typically, hurricanes have winds extending out 300 miles although they can vary considerably in size. Since there is no point in Florida wider than 70 miles from the Gulf of Mexico to the Atlantic Ocean, damaging hurricane winds can be felt throughout the state.

As a coastal county, Lee County is especially vulnerable to hurricane force winds when hurricanes make landfall on the Gulf side of the state. Land that is near the coastline is more vulnerable to the high winds associated with tropical cyclones but all buildings within the county are susceptible to wind damage from tropical cyclones.

Previous Occurrence(s)

From 1842 to 2020, Southwest Florida experienced 53 tropical cyclones of hurricane intensity, and another 32 tropical storms and tropical depressions occurring in the same area. Southwest Florida experiences a tropical cyclone on average every two years.

Table 40 NOAA NCEI Storm Events Database (Tropical Cyclones)

Location	Date	Type	Deaths	Injuries	PropertyD	CropD
COASTAL LEE (ZONE)	09/01/2016	Tropical Storm	0	0	$0.00K	$0.00K
INLAND LEE (ZONE)	09/01/2016	Tropical Storm	0	0	$0.00K	$0.00K
INLAND LEE (ZONE)	10/06/2016	Tropical Storm	0	0	$0.00K	$0.00K
COASTAL LEE (ZONE)	10/06/2016	Tropical Storm	0	0	$0.00K	$0.00K
INLAND LEE (ZONE)	09/10/2017	Hurricane	0	0	$163.14M	$9.60M
COASTAL LEE (ZONE)	09/10/2017	Hurricane	1	0	$163.14M	$0.00K
INLAND LEE (ZONE)	11/09/2020	Tropical Storm	0	0	$0.00K	$0.00K
INLAND LEE (ZONE)	11/11/2020	Tropical Storm	0	0	$0.00K	$0.00K
COASTAL LEE (ZONE)	11/11/2020	Tropical Storm	0	0	$100.00K	$0.00K
INLAND LEE (ZONE)	07/06/2021	Tropical Storm	0	0	$0.00K	$0.00K
Totals:			1	0	$326.380M	$9.600M

According to the NOAA NCEI Storm Events Database (see Table 40 above), 11 hurricane and tropical storm events occurred in Lee County between 1996 and 2020. There was 1 death and zero injuries reported because of these storms. Property damages totaled $326.4 million and crop damages totaled $11 million. However, of the 49 Presidential Declared Emergencies and Disasters issued for Hurricanes since 1960, Lee County has been identified in 13 of them (4 Emergency Declarations and 9 Major Disaster Declarations). See Table 41 below.

Table 41 Presidential Declared Emergencies & Disasters for Hurricanes Since 1960

Tropical Cyclone	Year	Presidential Declaration
Donna	1960	DR-106-FL
Betsy	1965	DR-209-FL
Gladys	1968	DR-252-FL
Irene	1999	EM-3150-FL
Charley	2004	DR-1539-FL
Francis	2004	DR-1545-FL
Ivan	2004	DR-1551-FL
Jeanne	2004	DR-1561-FL
Katrina Evacuation	2005	EM-3220-FL
Wilma	2005	DR-1609-FL
Irma	2017	EM-3385-FL
Irma	2017	DR-4337-FL
Dorian	2019	EM-3419-FL

Hurricane Irma in 2017 and is the last storm to make landfall in Lee County. The following is a brief description of recent hurricane and tropical storm events that have directly or indirectly threatened and/or impacted Lee County.[162]

Table 42 Recent Tropical Cyclones

Tropical Cyclone	Date	Impacts
Hurricane Sally	09-12-2020	Minimal
TS Gordon	09-03-2018	Minimal
Hurricane Irma	09-10-2017	Major
TS Emily	07-31-2017	Minimal

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Tropical cyclones carry incredible risks for the public. According to the National Hurricane Center, between 1963 and 2012, 90% of deaths associated with tropical cyclones were caused by storm surge and another 27% were caused by rain. Winds from a hurricane can destroy buildings and manufactured homes. Signs, roofing material, and other items left outside can become flying missiles during hurricanes.

Beyond injury and death, tropical cyclones also pose health risks associated with increased pest population, damage, and distribution of pollution sources (e.g., storm drains, chemicals stored in damaged structures, etc.), and disturbance of potential harmful wildlife. Tropical cyclones, especially with regards to storm surge, is also likely to result in evacuation of segments of the public. Evacuations create significant disruptions in the lives of people, especially those with vulnerabilities and/or limited mobility, which creates and exacerbates stress, and can create safety risks. No evacuation is risk free.

Lee County and its political subdivisions do have recorded injuries and deaths related to tropical cyclones. Indeed, during Hurricane Irma, the county evacuated 300,000 residents. Even though the county has experienced less than 1,000 recorded injuries or deaths related to tropical cyclones, the risk and probability remain high.

Responders

Tropical cyclone events create dangerous operational environments for responders that necessitate appropriate protective actions during response and recovery. Tropical cyclones may also impact the ability of responders to execute life safety actions, such as evacuations and search and rescue, by creating obstacles through the creation and movement of debris. Damage to utilities, such as power lines, also create dangerous operational conditions.

There are nearly 400 critical facilities located in areas that could experience wind damages. About a quarter of these facilities are related to emergency response and medical care. Although it is highly unlikely many these would be affected at the same time,

damage to these facilities could affect, at least in the short-term, the ability of responders to carry out response operations.

Continuity of Operations and Delivery of Services

Of the nearly 400 critical facilities located in areas that could experience tropical cyclone winds, about 75% of them relate in some fashion to the conduct of government business and the delivery of services. Damage to these facilities would result in temporary disruptions to the continuation of operations and services; the extent and degree of such situations would be determined on the size of the facility, the building inventory of the jurisdiction, and types of services being provided, among a host of other factors. Depending on the level of damage experienced, continuation or restoration of operations and services may require jurisdictions to relocate to other areas of the region.

Built Environment

Hurricane force winds can easily destroy poorly constructed buildings and mobile homes. Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, water, and underground utility lines (from uprooted trees), and fallen poles cause considerable disruption.

High-rise buildings are also vulnerable to hurricane force winds, particularly at the higher levels since wind speed tends to increase with height. Recent research suggests you should stay below the tenth floor but still above any floors at risk for flooding. It is not uncommon for high-rise buildings to suffer a great deal of damage due to windows being blown out. Consequently, the areas around these buildings can be very dangerous.

Natural Environment

While tropical cyclones may result in localized disturbances to some wildlife populations, the environmental impact of damages may not be overly negative, and many habitats can be restored as part of recovery and mitigation projects. However, the damages caused by tropical cyclones may lead to the spread of plant and/or animal diseases, habitat destruction, and other negative outcomes for the natural environment. Negative consequences are likely to occur in the natural environment from tropical cyclones if toxins or pollutants are disturbed and distributed through an area by the event.

Economy

It can be estimated that Lee County will experience at least 0.71 events every year. Damages from these events can be expected in the magnitude of $127,000,000 or more

for property and $602,000 or more for crop damages for any given tropical cyclone. Damage and disruptions to the built environment carry economic costs. Commercial areas can experience damage to property, loss of utilities and other services, decreased access to transportation networks and supply lines, reduced labor pools, and a host of other outcomes.

Public Confidence

Generally, in Lee County and its political subdivisions has not demonstrated or produced strong or notable consequences for the public's confidence in the jurisdictions' governance. In all tropical cyclone events there are instances that do produce localized concern over tropical cyclone-related issues, but not to the point of eroding confidence to an identifiable level. Nevertheless, catastrophic flooding, such as what occurred during Hurricane Katrina, could result in serious erosion of public confidence.

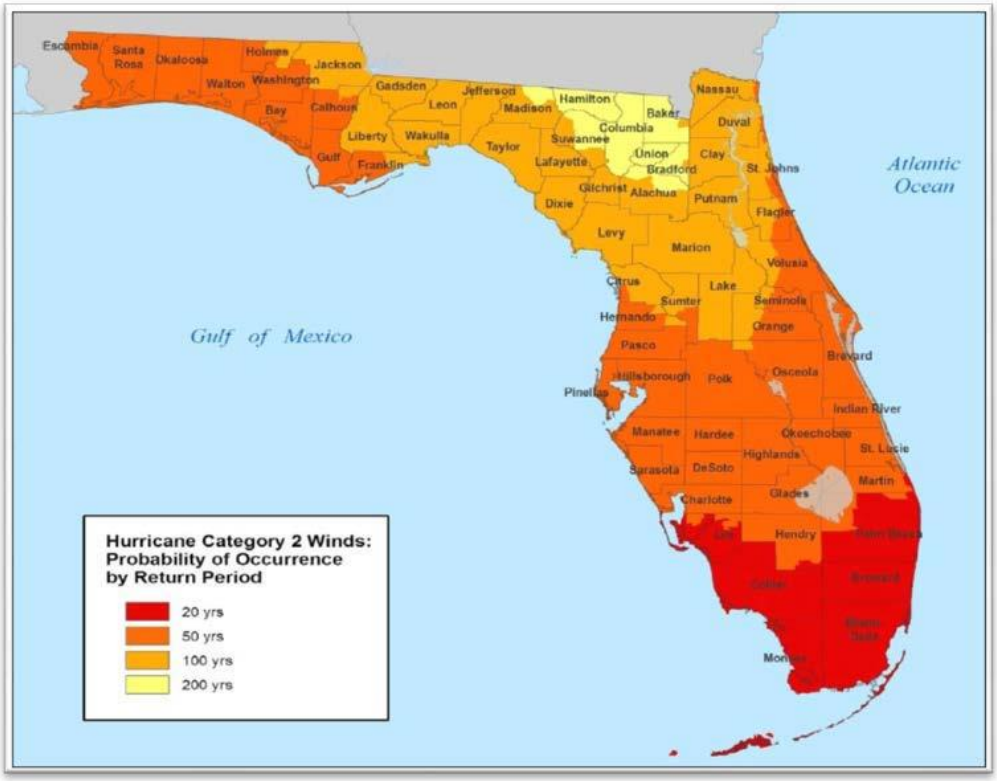

Figure 59 Hurricane Category 2 Winds: Probability of Occurrence by Return Period

Probability

Figure 59 above shows the probability of a Category 2 hurricane in Florida, with the extents for the 20, 50, 100 and 300-year return periods. The majority of Lee County is located within the 20-year return period or 20% annual occurrence, with the northern tip

within the 50-year return period. From Figure 60 below, the western half of Lee County is within the 500-year return period for a Category 5 hurricane. Based on historic data from the NCEI Storm Events Database and NOAA Historical Hurricane Tracks, the probability of a land falling hurricane in Lee County for a given year is 1 every 2-3 years. For tropical storms, the probability is 1 every 1-2 years. This does not mean that it is not possible for hurricanes and tropical storms to appear more frequently in Lee County.

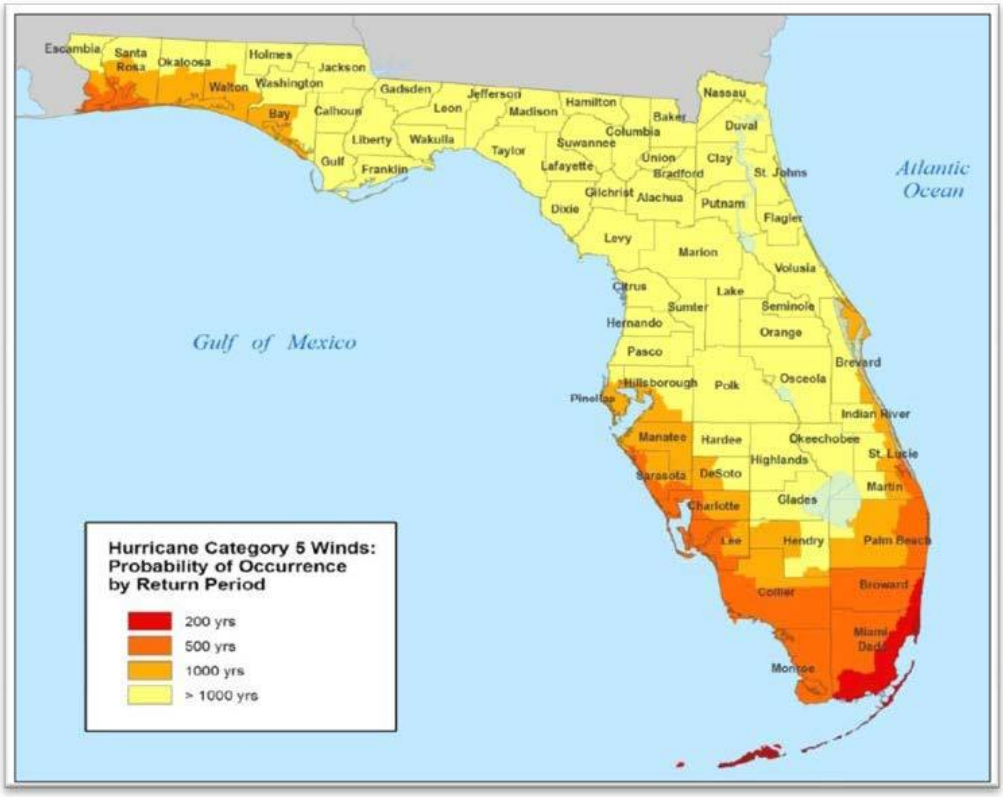

Figure 60 Hurricane Category 5 Winds: Probability of Occurrence by Return Period

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Very Likely	>$150k	Deaths	3+ days	11.00

Wildfire

Wildfires are unplanned fires that burn in natural and rural areas. Sometimes these fires have the potential to expand into built and urbanized areas. They can start naturally or by intentional or unintentional human intervention. These fires burn vegetation in and above the soil. In some instances, ground fires can smolder for some time before conditions become amenable to a larger blaze.[163,164]

Wildfires can be categorized the in the following manner[165]:

- Ground fires – plant roots and other organic material below the soil surface ignite, which can then grow into surface fires.
- Surface fires – burn dead or dry vegetation lying or growing just above the ground.
- Crown fires – burn through the tree canopy, where the influence of wind is greater and vegetation is interconnected.

Two leading causes for wildfires are lightning and humans. Wildfires associated with lightning strikes are usually started by "hot lightning bolts," which have less voltage than "cold lightning bolts" but much longer duration[166]. Between 2001 and 2020, lightning strikes resulted in nearly 191,000 fires nationwide, resulting in over 1.8 million acres of land burning[167]. Humans cause fires through myriad of ways, such as defective or damaged infrastructure (such as power lines), unattended campfires, burning debris, equipment use or malfunctions, and arson. Between 2001 and 2020, humans caused over 1.2 million fires (over six times more than lightning), resulting in over 58 million acres of land burning[168].

Drought conditions contribute significantly to conditions conducive to wildfires and can greatly enlarge the area and spread of fires as they move and develop. Warm winters and hot, dry summers are similar contributors. Pest infestations and disease may also aid in building and sustaining wildfires by affecting the health of flora and "fuel loading" a given area.

Not all wildfires are considered inherently bad or dangerous. Wildfires have many ecological benefits, some of which are necessary to the continued health of flora and fauna in a given area. Determinations are made about the necessity to eliminate a wildfire when it poses a threat or potential threat to people or property. Wildfires that pose no such threat and are not likely to destabilize relevant ecosystems may be permitted to continue unabated.[169]

Figure 61 Wildland-Urban Interface Fire near RSW Airport (April 3, 2020)

In the US, more wildfires occur in the eastern and central portions of the country, but wildfires in the western portions tend to be larger and burn more acreage. While fires are fairly common—there are tens of thousands of wildfires in the US every year—a few wildfires manage to grow into large events.[170] According to the U.S. National Park Service, between 2-3% of all fires in the country account for more than 95% of the total area burned annually[171]. Large wildfires are capable of inflicting significant destruction and harm to people and property. And while there are many ecological benefits to wildfires, the natural environment can experienced negative outcomes from these fires as well.

Wildfires pose the greatest danger to people and property around the wildland urban interface (WUI). The Federal Emergency Management Agency defines the WUI as the "zone of transition between unoccupied land and human development. It is the line, area or zone where structure and other human development meet or intermingle with undeveloped wildland or vegetative fuels."[172] The U.S. Department of Agriculture provides a more defined and technical definition and analysis of the WUI in *The 2010 Wildland-Urban Interface of the Conterminous United States*[173]. Generally, the WUI can be areas where the edge of a community transitions to forest land (i.e., boundary); structures that are scattered and interspersed among wildland areas, like individual farms or vacation homes (i.e. intermix); or areas where structures surround wildland, like neighborhood preserves (i.e. island/occluded)[174].

Figure 61 above provides an example of the WUI and how fire interplays with such an area and other exacerbating factors. Closures from COVID-19 resulted in vehicles being

parked very close to one another in a lot near an undeveloped forested area. The lot was covered in grass that had received little precipitation because of the dry season. Heat from a vehicle's exhaust ignited the dry grass, which spread to the nearby woodlands (also dry, because of the season) and began to threaten other nearby structures.

The U.S. Fire Administration reports that[175]:

- More than 46 million residences in 70,000 communities in the United States are at risk of WUI fires;
- Between 2002 and 2016, an average of over 3,000 structures per year were lost to WUI fires in the US;
- The WUI continues to grow by approximately 2 million acres per year; and
- Florida ranks #3 with the greatest number of houses in the WUI.

According to the Department of Agricultural report cited above, at the time of the report, Florida had the largest number of seasonal homes in the WUI[176].

Location and Extent

Forested lands and areas in or around the WUI are most at risk of experiencing a wildfire. Figure 32 on p. 32 shows future land use for Lee County. Among the uses noted are non-urban areas and environmentally critical areas (wetlands). Primarily, non-urban areas surround marsh and other large drainage areas, as well as the comparatively less-developed northern and south-eastern portions of the county. Figure 62 below shows the WUI for Lee County. Figure 63 below shows the WUI Risk Index for the county.

The extent of damage from wildfires is dependent on the location and duration of the fire, among other factors. Wildfires that remain primarily or entirely in non-developed areas are, on the whole, less extreme than those that interact with built environment. The fire shown in Figure 61 above was relatively small in the number of acres burned, but it inflicted over $100,000,000 in property damages. The juxtaposition between humans, the built environment, and the natural environment creates situations where otherwise "insignificant" wildfires can result in catastrophic outcomes.

Previous Occurrence(s)

The Storm Events Database records 15 occurrences of wildfire in Lee County between 1999 and 2021[177]. Four of the events occurred in 1999; seven of the instances occurred in 2000. In 2006, a wildfire caused in Lehigh Acres burned nearly 2,000 acres over a three-day period, destroyed 16 homes, and damaged another 25, in addition to damages

to other types of personal property. In 2008, a lightning strike in Cape Coral resulted in a wildfire burned a 5-mile-long, 1-mile-wide path in the WUI that resulted in evacuations.

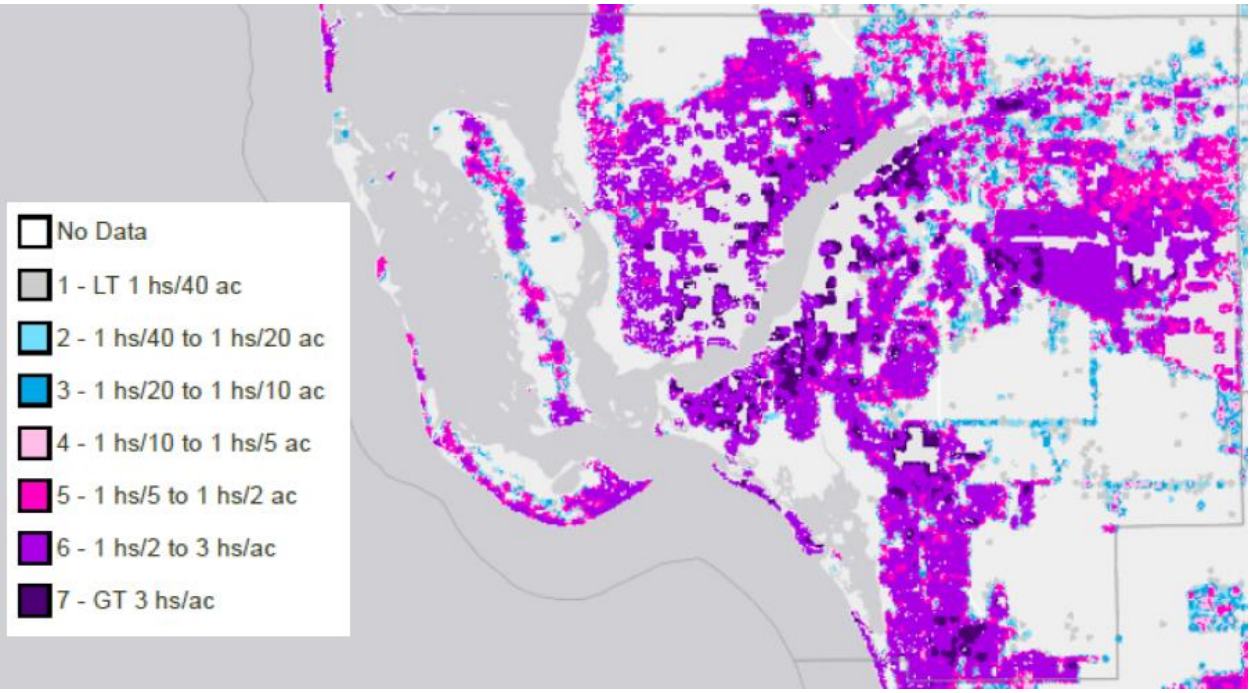

Figure 62 Lee County Wildland-Urban Interface[178]

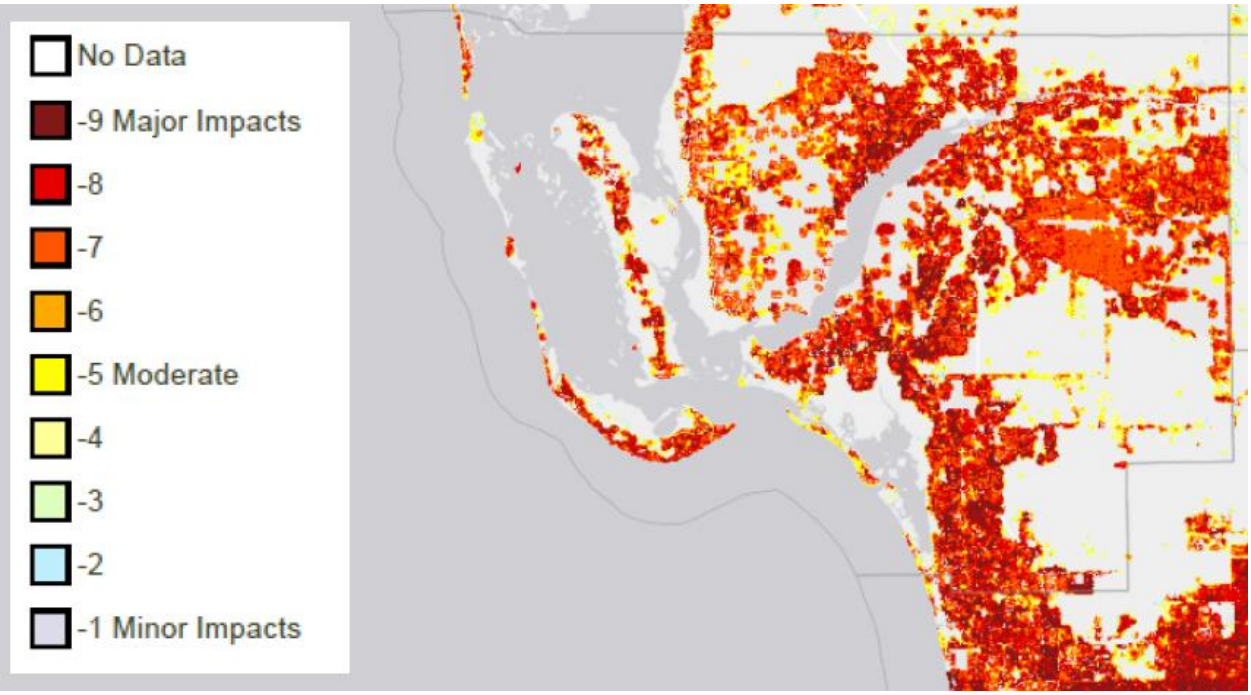

Figure 63 Lee County Wildland-Urban Interface Risk Index

Impacts

The assessment for this hazard considered impacts to the public, responders, continuity of government operations, delivery of government services, the built environment, the natural environment, the economy, and the public's confidence in the jurisdictions' governance (i.e., Lee County and its political subdivisions). These considerations are discussed below.

Public

Wildfires are dangerous affairs that can result in injuries and deaths. These events can occur with little warning, and when paired with good fuel and sufficient wind, can move with incredible speed. Homes built in or around the WUI can become engulfed by a fire quickly so that a lack of warning to or hesitancy to evacuate on the part of the public can lead to seriously negative outcomes. Aside from mortal danger, the public can also be affected through loss of property and community, which in turn become sources of stress. It is estimated that about 455,000 residents in Lee County live within the WUI[179].

There are no recorded injuries or deaths in Lee County or its political subdivisions associated with wildfires.

Responders

Wildfires create additional dangers for responders by adding the unpredictability of fire to the operational environment. Heat produced by wildfires adds to the risk of dehydration, heat stroke, and other complications to risks already inherent in emergency response. Wildfires can have lengthy duration, which produces mental and physical stresses on responders, as well as stress on equipment.

Continuity of Operations and Delivery of Services

The onset of this hazard is unlikely to impact the continuation of government operations and the delivery of services.

Built Environment

Wildfire can inflict serious damage to the built environment. Structures can be reduced to rubble and ashes, utilities rendered inoperable, and roads can become impassable due to smoke and other hindrances. Personal property, such as vehicles, household inventories, and so forth can be destroyed. Residences can be burned down or damaged to the point of inhabitability. Commercial and industrial buildings can be damaged or

destroyed, and agriculture can experience impacts though the loss of land, equipment, crops, livestock, or structures.

Previously instances of wildfire in Lee County have caused over $103 million in property damage. It must be noted that $100 million of that damage was inflicted by a single fire in 2020 that destroyed nearly 4,000 rental cars. That event caused 57 times more damage than the next most damaging fire, which occurred in 2017 and resulted in $1.8 million. Not considering the 2020 fire, wildfires have caused no average $216,000 in damages.

Natural Environment

Wildfires have many ecological benefits. These benefits include[180]:

- Insect pest control
- Removal of exotic or nonnative species
- Addition of nutrients for vegetation
- Removal of undergrowth
- Encouraged growth for fire-dependent species

In this manner, wildfires are integral parts of nature. They help to sustain ecosystems and generally improve the health of forests. Some parts of nature have developed to where wildfires are an essential and necessary part of the lifecycle.

All the same, wildfires can harm animal populations and loss of vegetation can cause water absorption issues in the soil. The removal of vegetation also diminishes nature's ability to filter water passing over and through the soil.[181]

Economy

Aside from damage to the built environment, economic consequences to the community from wildfires will likely be localized and relatively short-term. Some disruptions to economic may occur during and shortly after a wildfire incident, but is unlikely to spread to noteworthy levels or over larger areas of the county or its political subdivisions. For example, the most damaging wildfire in Lee County's history, mentioned in more detail above, did not affect the overall economy to a significant degree. Fires that required evacuations and damaged or destroyed structures in the past also have not created significant economic impacts, beyond damages to the built environment. This could be different if a wildfire were to afflict damage on the agricultural sector, but there are no recorded instances like that in Lee County from which to draw inferences or predictions.

Public Confidence

The onset of this hazard is unlikely to impact the public's confidence in the jurisdictions' governance.

Probability

The probability of wildfire in Lee County and its political subdivisions is largely dependent on weather conditions. All of the recorded instances of wildfire in Lee County occurred during the area's dry season. In the last two decades, there have been 15 recorded instances of wildfire, so that during this period, on average the county experienced an event every one-a-half years. (Note that 75% of the recorded wildfires occurred in 1999 and 2000.) With temperature changes occurring and the WUI growing due to an expanding population and commercial base, it is possible for these events to become more common. But for the time being, wildfires in Lee County and its political subdivisions remain somewhat likely.

Risk and Vulnerability

Probability	Impact	Injury/Death	Warning Time	Composite Score
Somewhat Likely	>$150k	None	Less than 24 hours	7.50

Chapter 5 Human-Caused Hazards

This chapter is scheduled to be completed and distributed in mid-2022. This is a placeholder for that content for the time being.

Chapter 6 Hazard Prioritization

This chapter summarizes the results from the hazard assessments provided in Chapter 4 and Chapter 5. As part of the summarization, the chapter provides the composite score for all of the hazards for comparison to one another. Once the assessments are summarized, the chapter prioritizes identified hazards as either high, medium, or low.

Hazard Summary

Lee County and its political subdivisions are susceptible to a range of natural hazards, most of which are tied to weather patterns associate with the region's climate. While a history of weather-induced emergencies and disasters has left behind injuries and deaths and large amounts of financial damage, the onset of COVID-19 has carried with it significant consequences across myriad elements of society. This has made epidemics and pandemics one of the highest concerns for the future, in relation to the jurisdictions' identified hazards.

Table 43 below lists all of the identified and assessed hazards for Lee County and its political subdivisions. The scores for each factor, which were established and described in the Ranking Methodology section of Chapter 3, are shown as well. The composite score for each hazard is provided and the table is ranked in descending order. Hazards with the same score are shown in alphabetical order.

Per the composite scores, the top three natural hazards for Lee County and its political subdivision are tornadoes, epidemics and pandemics, and tropical cyclones. Although COVID-19 has carried substantially larger impacts overall in comparison to tornadoes, it ranks below the latter because of the dangerously low warning time available for the public with the onset of tornadoes. Tropical cyclones remain high on the list, because of the county's proximity to the Gulf and Atlantic.

Excessive Heat, Freeze, Animal/Plat Disease Outbreak, and Extreme Cold rank at the bottom of the summary list because of their relatively low probability, lack of financial impact, and ample warning time. All the same, it must be noted that the comparatively rankings for any of the hazards, particular those near the table's end, does not indicate a lack of threat or risk. Indeed, nearly every hazard identified and assessed has the potential for inflicting injury or death on people, disrupting the built and natural environment, and causing other significant, negative consequences. While the county and its political subdivision compute these scores to assist in prioritizing allocation of scarce resources,

systems are in place and efforts are continuously being made to monitor and address each hazard identified and assessed in this document.

Table 43 Lee County Hazards Ranking by Composite Score

Hazard	Probability	Impact	Injury/ Death	Warning Time	Score
Tornado	Highly Likely	>$150k	Deaths	Less than 24 hours	12.00
Epidemic/ Pandemic	Highly Likely	>$150k	Deaths	3+ days	11.00
Tropical Cyclone	Highly Likely	>$150k	Deaths	3+ days	11.00
Flood	Highly Likely	$50k-$150k	Injuries*	Less than 24 hours	9.75
Severe Weather	Highly Likely	$50k-$150k	Deaths	3+ days	9.75
Wildfire	Somewhat Likely	>$150k	None	Less than 24 hours	7.50
Coastal Erosion	Highly Likely	<$50k	None	3+ days	6.50
Drought	Highly Likely	<$50k	None	3+ days	6.50
Excessive Heat	Somewhat Likely	<$50k	Deaths	3+ days	6.00
Freeze	Somewhat Likely	<$50k	None	3+ days	5.25
Animal/Plant Disease Outbreak	Somewhat Likely	<$50k	None	3+ days	4.00
Extreme Cold	Somewhat Likely	<$50k	None	3+ days	4.00
Aircraft Crash	TBD	TBD	TBD	TBD	TBD
Cyberattack	TBD	TBD	TBD	TBD	TBD
Hazardous Materials Release	TBD	TBD	TBD	TBD	TBD
Mass Casualty/ Mass Fatality	TBD	TBD	TBD	TBD	TBD

Prioritization Scheme

To best save lives, protect property, and preserve the environment, it is essential the county and its political subdivision prioritize the allocation of scarce resources. The purpose of developing a scoring methodology and calculating composite scores is to assist government officials, emergency managers, and emergency management program stakeholders to determine a prioritization scheme. Ultimately, the process of prioritization is subjective, as there is no established, objective means for determining where the breakpoints are for what makes a hazard "high" priority versus "medium" priority. At the end of the day, interactive discussions between decision-makers, expert opinion, the public, and best judgment are the only available means to make these decisions. Figure 64 below shows the natural hazards ranked according from high, medium, to low.

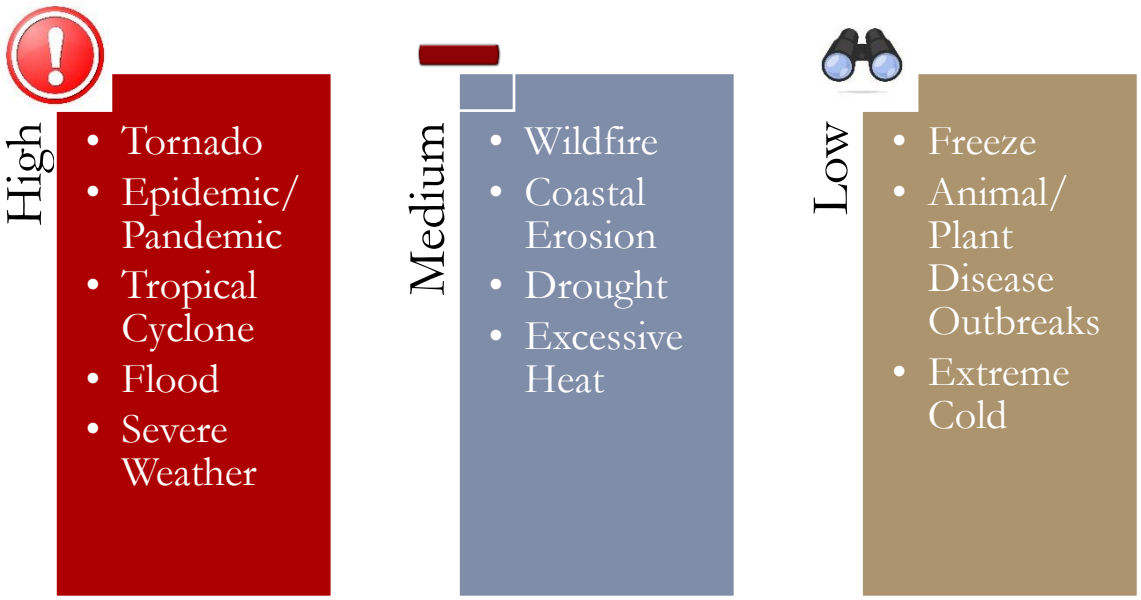

Figure 64 Lee County Hazard Prioritization

Sources and endnotes for all of the *Hazard Identification and Risk Assessment*.

[1] FEMA (2010). *Developing and Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide (CPG) 101*, p. 4-10
[2] United States Census Bureau, QuickFacts, Lee County FL
[3] Bureau of Economic and Business Research, https://www.bebr.ufl.edu/population (accessed 2021-10-07)
[4] *Ibid*.
[5] Bureau of Economic and Business Research, https://www.bebr.ufl.edu/population (accessed 2021-10-07) search%20Reports/projections_2018_asrh.pdf, p. 40 (accessed 2021-10-12)
[6] https://data.census.gov/cedsci/table?tid=ACSDP5Y2019.DP05&g=0400000US12_0500000US12071 (accessed 2021-10-13)
[7] https://www.census.gov/quickfacts/fact/table/leecountyflorida,FL,US/PST045219 (accessed 2021-10-07)
[8] *Ibid*.
[9] *Ibid*.
[10] https://www.bebr.ufl.edu/sites/default/files/Research%20Reports/projections_2018_asrh.pdf (accessed 2021-10-12)
[11] R. Burris (email, 2021-10-13)
[12] Lee County Human and Veteran Services (2019), *2019 Needs Assessment for Lee County*
[13] https://flhealthcharts.com/ChartsReports/rdPage.aspx?rdReport=AgingInFlorida.Dashboard (accessed 2021-10-12)
[14] *Ibid.*
[15] www.census.gov/quickfacts/leecountyflorida (accessed 2019-08-26)
[16] www.flhealthcharts.com/ChartsReports/rdPage.aspx?rdReport=ChartsProfiles.AccessAndFunctionalNeeds (accessed 2019-08-26)
[17] www.flhealthcharts.com (accessed 2021-10-12)
[18] www.flhealthcharts.com/Charts/Brfss/DataViewer.aspx?bid=54
[19] https://flhealthcharts.com/Charts/OtherIndicators/NonVitalIndNoGrpCountsDataViewer.aspx?cid=8675 (accessed 2021-10-12)
[20] Percentages based on 2010 data, American Community Survey https://apps.mla.org/cgi-shl/docstudio/docs.pl?map_data_results (accessed 2019-05-30)
[21] www.census.gov/quickfacts/fact/table/leecountyflorida/PST045218 (accessed 2019-05-28)
[22] "Institutionalized population" represents anyone in correctional facilities for adults, juvenile facilities, and nursing facilities.
[23] https://www.sheriffleefl.org/corrections-2/ (accessed 2021-11-03)
[24] http://edr.state.fl.us/content/area-profiles/county/lee.pdf (accessed 2021-11-08)
[25] https://www.bea.gov/sites/default/files/2020-12/lagdp1220_2.pdf (accessed 2021-11-08)
[26] https://www.leecountybusiness.com/demographics/ (accessed 2021-11-08)
[27] https://data.bls.gov/pdq/SurveyOutputServlet (accessed 2021-11-08)
[28] https://www.leecountybusiness.com/healthcare/ (accessed 2021-11-08)
[29] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Florida/st12_2_0007_0007.pdf (accessed 2021-11-17)
[30] https://www.leecountybusiness.com/entrepreneurship/ (accessed 2021-11-08)
[31] https://www.swfleda.com/top-100-employers/ (accessed 2021-11-08)
[32] www.leevcb.com/media/31842/lee500-22415_5-yearinfographic_cy2013-cy2017_100218-6.pdf (accessed 2019-06-11)
[33] www.leevcb.com/media/33369/2018-lee-county-power-of-tourism.pdf (accessed 2019-06-11)
[34] Lee County VCB (2020), *The Beaches of Fort Myers & Sanibel*
[35] American Community Survey 5-Year Estimate (2019), Selected Economic Characteristics
[36] https://www.census.gov/quickfacts/leecountyflorida (accessed 2021-11-12)
[37] *ibid.*
[38] http://edr.state.fl.us/content/area-profiles/county/lee.pdf (accessed 2021-11-12)
[39] www.flhealthcharts.com/ChartsReports/rdPage.aspx?rdReport=ChartsProfiles.AccessAndFunctionalNeeds (accessed 2019-08-26)
[40] www.census.gov/quickfacts/fact/table/US,FL,leecountyflorida/LFE041217 (accessed 2019-08-12)
[41] Lee County GIS (Island_stats)
[42] https://library.municode.com/fl/lee_county/codes/land_development_code?nodeId=LADECO_APXHPRSPLI
[43] American Community Survey, 5-Year Estimate (2015-2019)
[44] https://www.leecountybusiness.com/transportation/ (accessed 2021-11-12)

[45] Lee County (2021), *Lee Plan*, Sect. II Future Land Use Element
[46] United State Department of Agriculture (2017), *Census of Agriculture: Florida: State and County Data*, Vol 1, Geographic Area Series, Part 9, p. 242, https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Florida/flv1.pdf
[47] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Florida/cp12071.pdf (accessed 2021-11-17)
[48] *ibid.*
[49] *ibid.*
[50] *ibid.*
[51] https://www.leegov.com/dcd/planning/hp/histdistricts, accessed (2021-10-11)
[52] Federal Emergency Management Agency (February 2021), Disaster Declarations for States and Counties, https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties (accessed 2021-11-19)
[53] *ibid.*
[54] https://www.fema.gov/disaster/declarations (accessed 2021-11-18)
[55] Lee County Storm Data 1950-2021, provided by the National Weather Service via email (November 2021)
[56] Federal Emergency Management Agency (March 2013), *Local Mitigation Planning Handbook*, Task 5 – Conduct a Risk Assessment, p. 5-1
[57] https://www.leegov.com/dcd/es/land/invasive (accessed 2021-11-18)
[58] https://www.leegov.com/parks/preserves/landmanagement (accessed 2021-11-17)
[59] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Eastern-Lubber-Grasshopper
[60] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Emerald-Ash-Borer-Trapping-Program
[61] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Exotic-Fruit-Fly-Pests
[62] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Giant-African-Land-Snail
[63] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Horntail-Snail-Eradication
[64] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Lychee-Erinose-Mite
[65] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Red-Palm-Mite
[66] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Laurel-Wilt-Disease
[67] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Avian-Influenza
[68] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Bovine-Spongiform-Encephalopathy-FAQ
[69] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/Eastern-Equine-Encephalitis
[70] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/Equine-Infectious-Anemia
[71] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/Equine-Piroplasmosis
[72] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/Rabies
[73] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/Strangles
[74] https://www.fdacs.gov/Consumer-Resources/Animals/Animal-Diseases/Florida-s-Reportable-Equine-Disease-Map/West-Nile-Virus
[75] https://myfwc.com/research/wildlife/health/program/
[76] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/Pest-Alerts
[77] https://www.fdacs.gov/Business-Services/Veterinarians/Reportable-Animal-Diseases
[78] "Lee homeowners win final judgment in citrus canker case," news-press.com, http://www.news-press.com/story/news/2014/08/31/lee-homeowners-win-final-judgment-citrus-canker-case/14885737
[79] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/CAPS
[80] https://www.fdacs.gov/Agriculture-Industry/Pests-and-Diseases/Plant-Pests-and-Diseases/CAPS/CAPS-Reports
[81] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Florida/st12_2_0006_0006.pdf (accessed 2021-11-17)
[82] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Florida/st12_2_0001_0001.pdf (accessed 2021-11-17)
[83] National Centers for Environmental Information (April 2021), *Coastal Erosion*, https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion (accessed 2021-11-18)

[84] 62B-36.002(5), Florida Administrative Code (F.A.C.)
[85] National Centers for Environmental Information (April 2021), *Coastal Erosion*, https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion (accessed 2021-11-18)
[86] Bluefin Beach House (2021) History of North Captiva Island, https://www.bluefinbeachhouse.com/en/history (accessed 2021-11-19)
[87] https://www.leegov.com/naturalresources/Documents/FDEP-Critically-Eroded-Beaches-07-2021.pdf (accessed 2021-11-19)
[88] https://floridadep.gov/sites/default/files/FDEP-Critically-Eroded-Beaches-07-2021_0.pdf (accessed 2021-11-19)
[89] i*bid.*
[90] *ibid*.
[91] Center for American Progress, M. Conathan, J. Buchanan, & S. Polefka (2014), *The Economic Case for Restoring Coastal Ecosystems*, p. 9
[92] The Heinz Center (April 2000), *Evaluation of Erosion Hazards*, p. xxi
[93] United States Geological Society, *Droughts: Things to Know* (n.d.), https://www.usgs.gov/special-topic/water-science-school/science/droughts-things-know?qt-science_center_objects=0#qt-science_center_objects (accessed 2021-11-22)
[94] National Centers for Environment Information, National Oceanic and Atmospheric Administration, *Did You Know? Definitions of Drought*, https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition (accessed 2021-11-22)
[95] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Drought Classifications*, https://www.weather.gov/riw/drought_index (accessed 2021-11-22)
[96] https://app.leegov.com/NaturalResources/ (accessed 2021-11-23)
[97] South Florida Water Management District (September 2008), *Water Conservation: A Comprehensive Program for South Florida*, p. 2
[98] State of Florida (2007), *Drought Action Plan*, Background on Droughts in Florida, p. 2
[99] South Florida Water Management District (n.d.), *The 2000-2001 Drought in South Florida, Part II: Water Management*, p. II-3-1
[100] State of Florida Department of Health (n.d.), *Extreme Drought 2006-2008*, https://flbrace.org/images/docs/drought-factsheet.pdf (accessed 2021-11-23)
[101] National Integrated Drought Information System, National Oceanic and Atmospheric Administration, *Drought Conditions for Lee County* (n.d.), https://www.drought.gov/states/florida/county/lee (accessed 2021-11-22)
[102] South Florida Water Management District (September 2008), *Water Conservation: A Comprehensive Program for South Florida*, p. 2
[103] Lee County Utilities, Lee County Board of Commissioners (n.d.), *Water Conservation*, https://www.leegov.com/utilities/customer-resource-center/water-conservation (accessed 2021-11-23)
[104] Lee County Utilities, Lee County Board of Commissioners (n.d.), *Water Conservation*, https://www.leegov.com/utilities/customer-resource-center/water-conservation (accessed 2021-11-23)
[105] National Integrated Drought Information System National Oceanic and Atmospheric Administration, Drought.gov: By Sector: Ecosystems (n.d.), https://www.drought.gov/sectors/ecosystems (accessed 2021-11-23)
[106] *ibid.*
[107] National Integrated Drought Information System, National Oceanic and Atmospheric Administration, Drought.gov: By Sector: Agriculture (n.d.), https://www.drought.gov/sectors/agriculture (accessed 2021-11-23)
[108] Centers for Disease Control and Prevention (May 2012), *Principles of Epidemiology in Public Health Practice: An Introduction to Applied Epidemiology and Biostatistics* (3rd ed), Lesson 1: Introduction to Epidemiology, Section 11: Epidemic Disease Occurrence, https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html (accessed 2021-11-23)
[109] Centers for Disease Control and Prevention (November 2021), *CDC Current Outbreak List*, https://www.cdc.gov/outbreaks/index.html
[110] World Health Organization (2021), *Outbreaks and Emergencies*, https://www.who.int/westernpacific/emergencies
[111] https://www.nytimes.com/interactive/2021/us/lee-florida-covid-cases.html (accessed 2021-11-23)
[112] Animal and Plant Health Inspection Service, U.S. Department of Agriculture (August 2021), *Questions and Answers: Results of Study on SARS-CoV-2 in White-Tailed Deer*, https://www.aphis.usda.gov/animal_health/one_health/downloads/qa-covid-white-tailed-deer-study.pdf
[113] Lee County VCB (2020), *The Beaches of Fort Myers & Sanibel*
[114] Regional Economic Research Institute, Florida Gulf Coast University (April 2020), *Coronavirus Economic Impact Survey*
[115] National Weather Service, *Heat Watch vs. Warning* (n.d.), https://www.weather.gov/safety/heat-ww (accessed 2021-11-22)

[116] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Climate: NOWData – NOAA Online Weather Data*, https://www.weather.gov/wrh/Climate?wfo=tbw (accessed 2021-11-23)
[117] State of Florida Department of Health (2015), *Health Effects of Summer Heat in Florida*, p. 1
[118] Centers for Disease Control and Prevention (December 2012), *Extreme Cold: A Prevention Guide to Promote Your Personal Health and Safety*, p. 1
[119] National Weather Service (n.d.), *Winter Weather Resources and Frequently Asked Questions*, https://www.weather.gov/safety/cold-outreach (accessed 2021-12-01)
[120] National Weather Service (n.d.), *Wind Chill Temperature Index*, https://www.weather.gov/media/safety/wind-chill-brochure.pdf (accessed 2021-12-01)
[121] National Weather Service (n.d.), *Wind Chill Warning vs Watch*, https://www.weather.gov/safety/cold-wind-chill-warning (accessed 2021-12-01)
[122] National Weather Service (n.d.), *Tampa Bay Original Climate Page*, https://www.weather.gov/tbw/tampabayoriginalclimatepage (accessed 2021-12-01)
[123] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Climate: NOWData – NOAA Online Weather Data*, https://www.weather.gov/wrh/Climate?wfo=tbw (accessed 2021-11-23)
[124] FloodSmart, Federal Emergency Management Agency (n.d.), *Glossary*, https://www.floodsmart.gov/definitions#F (accessed 2021-11-24)
[125] Scijinks, National Oceanic and Atmospheric Administration (n.d.), *Water and Ice: What Causes a Flood?*, https://scijinks.gov/flood/ (accessed 2021-11-24)
[126] *ibid.*
[127] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Flooding in Florida*, https://www.weather.gov/safety/flood-states-fl (accessed 2021-11-24)
[128] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Flood Warning vs. Watch*, https://www.weather.gov/safety/flood-watch-warning (accessed 2021-11-24)
[129] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Flooding in Florida*, https://www.weather.gov/safety/flood-states-fl (accessed 2021-11-24)
[130] National Ocean Service, National Oceanic and Atmospheric Administration (2021), *What is Storm Surge?*, https://oceanservice.noaa.gov/facts/stormsurge-stormtide.html (accessed 2021-11-24)
[131] Storm Surge Unit, National Hurricane Center, National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Storm Surge Overview*, https://www.nhc.noaa.gov/surge/ (accessed 2021-11-24)
[132] *ibid.*
[133] National Hurricane Center, National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Introduction to Storm Surge*, p. 3
[134] National Hurricane Center, National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Storm Surge Frequently Asked Questions*, https://www.nhc.noaa.gov/surge/faq.php#10 (accessed 2021-11-24)
[135] Federal Emergency Management Agency (December 2018), *Flood Insurance Study: Lee County, Florida and Incorporated Areas*, Sect. 2.3 Principal Flood Problems, p. 9
[136] Federal Emergency Management Agency (January 2020), *Glossary: Flood Zones*, https://www.fema.gov/glossary/flood-zones (accessed 2021-11-24)
[137] Emergency Management, Department of Public Safety, Lee County Board of Commissioners (n.d.), *Flood Zones*, https://www.leegov.com/publicsafety/emergencymanagement/plan/floodinfo/floodzones (accessed 2021-11-24)
[138] ibid.
[139] National Weather Service (November 30, 2021), email correspondence
[140] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Flood Related Hazards*, https://www.weather.gov/safety/flood-hazards (accessed 2021-11-24)
[141] Federal Emergency Management Agency (March 2020), *Coastal High Hazard Areas*, https://www.fema.gov/node/404318 (accessed 2021-11-24)
[142] National Weather Service, National Oceanic and Atmospheric Administration (n.d.), *Flood Related Hazards*, https://www.weather.gov/safety/flood-hazards (accessed 2021-11-24)
[143] Federal Emergency Management Agency (November 2021), *Community Rating System*, https://www.fema.gov/floodplain-management/community-rating-system (accessed 2021-11-29)
[144] K. Graham, National Hurricane Center (2019), *Water Impacts from Recent U.S. Landfalling Tropical Cyclones*, https://www.nhc.noaa.gov/outreach/presentations/FLGHC_2019_Keynote.pdf (accessed 2021-11-30)
[145] National Flood Insurance Program, Federal Emergency Management Agency (n.d.), *The Cost of Flooding*, https://www.floodsmart.gov/cost-flooding (accessed 2021-11-30)
[146] Lee County Storm Data 1950-2021, provided by the National Weather Service via email (November 2021)
[147] National Weather Service (n.d.), *Cold Weather Safety*, https://www.weather.gov/safety/cold (accessed 2021-12-01)
[148] National Weather Service (n.d.), *Wind Chill Warning vs Watch*, https://www.weather.gov/safety/cold-wind-chill-warning (accessed 2021-12-01)

[149] National Weather Service (n.d.), *Tampa Bay Original Climate Page*, https://www.weather.gov/tbw/tampabayoriginalclimatepage (accessed 2021-12-01)
[150] United State Department of Agriculture (2017), *Census of Agriculture: Florida: State and County Data*, Vol 1, Geographic Area Series, Part 9, p. 242, https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_2_County_Level/Florida/flv1.pdf
[151] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Thunderstorm Basics*, https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/ (accessed 2021-12-02)
[152] *ibid.*
[153] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Thunderstorm Types*, https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/types/ (accessed 2021-12-02)
[154] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Types of Damaging Winds*, https://www.nssl.noaa.gov/education/svrwx101/wind/types/ (accessed 2021-12-02)
[155] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Lightning Basics*, https://www.nssl.noaa.gov/education/svrwx101/lightning/ (accessed 2021-12-02)
[156] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Hail Basics*, https://www.nssl.noaa.gov/education/svrwx101/hail/ (accessed 2021-12-02).
[157] National Severe Storms Laboratory, National Oceanic and Atmospheric Administration (n.d.), *Severe Weather 10: Thunderstorm Basics*, https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/ (accessed 2021-12-02)
[158] Lee County Storm Data 1950-2021, provided by the National Weather Service via email (November 2021)
[159] J.T. Vogt et al., United State Department of Agriculture (August 2020), *Interactions Between Weather-Related Disturbance and Forest Insects and Diseases in the Southern United States*, https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs255.pdf
[160] Lee County Storm Data 1950-2021, provided by the National Weather Service via email (November 2021)
[161] *ibid.*
[162] National Oceanic and Atmospheric Administration (2021), *NOAA Historical Hurricane Tracks*, https://coast.noaa.gov/hurricanes/#map=4/32/-80 (last accessed 2021-12-02)
[163] Ready.Gov (n.d.), *Wildfires*, https://www.ready.gov/wildfires (accessed 2021-12-03)
[164] National Geographic (n.d.), *Resource Library: Encyclopedic Entry: Wildfires*, https://www.nationalgeographic.org/encyclopedia/wildfires/ (accessed 2021-12-03)
[165] A. Moore (2020), *Wildfires: Expert Answers to Your Burning Questions*, College of Natural Resource News, NC State University, https://cnr.ncsu.edu/news/2020/09/wildfires-expert-answers-to-your-burning-questions/ (accessed 2021-12-03)
[166] National Park Service (2018), *Wildfire Causes and Evaluations*, https://www.nps.gov/articles/wildfire-causes-and-evaluation.htm (accessed 2021-12-03)
[167] National Interagency Fire Center (n.d.), *Lightning-Caused Wildfires*, https://www.nifc.gov/fire-information/statistics/lightning-caused (accessed 2021-12-03)
[168] National Interagency Fire Center (n.d.), *Human-Caused Wildfires*, https://www.nifc.gov/fire-information/statistics/human-caused (accessed 2021-12-03)
[169] National Park Service (2018), *Wildfire Causes and Evaluations*, https://www.nps.gov/articles/wildfire-causes-and-evaluation.htm (accessed 2021-12-03)
[170] Congressional Research Service (October 2021), *Wildfire Statistics*, https://sgp.fas.org/crs/misc/IF10244.pdf
[171] National Park Service (2017), *Wildland Fire Spread and Suppression*, *Size and Intensity*, https://www.nps.gov/articles/wildland-fire-spread-and-suppression.htm (accessed 2021-12-03)
[172] U.S. Fire Administration, Federal Emergency Management Agency (n.d.), *What is the WUI?*, https://www.usfa.fema.gov/wui/what-is-the-wui.html (accessed 2021-12-03)
[173] United States Department of Agriculture (June 2015), *The 2010 Wildland-Urban Interface of the Conterminous United States*, https://www.fs.fed.us/nrs/pubs/rmap/rmap_nrs8.pdf
[174] Florida Department of Agriculture and Consumer Services (n.d.), *Wildland Urban Interface*, https://www.fdacs.gov/Forest-Wildfire/For-Communities/Firewise-USA/Wildland-Urban-Interface (accessed 2021-12-03)
[175] *ibid.*
[176] United States Department of Agriculture (June 2015), *The 2010 Wildland-Urban Interface of the Conterminous United States*, p. 16, https://www.fs.fed.us/nrs/pubs/rmap/rmap_nrs8.pdf
[177] Lee County Storm Data 1950-2021, provided by the National Weather Service via email (November 2021)
[178] Wildfire Risk Assessment Portal, Southern Group of State Foresters (n.d.), *Public Viewer*, https://www.southernwildfirerisk.com/Map/Public/#map-themes
[179] SouthWRAP Summary Report, (2017), *Southern Wildfire Assessment*

[180] National Park Service (2017), *Wildland Fire Spread and Suppression*, *Size and Intensity*, https://www.nps.gov/articles/wildland-fire-spread-and-suppression.htm (accessed 2021-12-03)
[181] A. Moore (2020), *Wildfires: Expert Answers to Your Burning Questions*, College of Natural Resource News, NC State University, https://cnr.ncsu.edu/news/2020/09/wildfires-expert-answers-to-your-burning-questions/ (accessed 2021-12-03)