Climate Vulnerability Assessment

FINAL REPORT | **JULY 2024**

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About

Alachua County

Alachua County, in north-central Florida, is characterized by its landlocked geography. It is renowned as the location of the University of Florida, a prominent public research institution. With a population exceeding 250,000 residents, most of whom reside in and around Gainesville, Alachua County is a vibrant community. The County boasts abundant natural resources and parks, including the notable Paynes Prairie and freshwater springs.

Considering ongoing climate changes, Alachua County recognizes the importance of adapting and evolving. to address these challenges effectively, the County has undertaken a comprehensive Climate Vulnerability Assessment. This Assessment aims to identify key areas of vulnerability and determine optimal strategies for fostering resilience within the community. By proactively assessing risks and planning, Alachua County endeavors to create a more resilient and sustainable environment for its residents.

Climate Vulnerability

Alachua County faces vulnerability from various hazards that pose threats to its communities, businesses, and environment. These hazards can be natural, societal, or technological and can cause significant adverse impacts on human health, the environment, and the economy. Recognizing the importance of assessing vulnerability to climate change and natural hazards, it's crucial to understand that climate risks and associated losses aren't solely determined by the hazard itself. Societal and economic factors influencing preparedness and responses to such events are equally critical. To quantify these hazards and impacts, the County conducted a Climate Vulnerability Assessment.

Climate Vulnerability Assessment

A Climate Vulnerability Assessment in a municipality or county is a comprehensive analysis aimed at identifying and understanding the susceptibility of the municipality or county and its inhabitants to various risks and threats related to climate change. The assessment typically involves evaluating the municipal or county infrastructure, natural resources, socio-economic factors, and population demographics to determine potential vulnerabilities to hazards. The Climate Vulnerability Assessment provides foundational information to support decisions about preparing for and adapting to climate change. This Final Report details the results from the Climate Vulnerability Assessment performed for Alachua County.

Why this Matters to You

A Climate Vulnerability Assessment is crucial for residents and businesses because it provides valuable insights into how your community may be affected by climate change. Understanding these threats, vulnerabilities, and impacts will allow you to make informed decisions to protect yourself, your family, and your assets. It will also help you understand the decisions that Alachua County is making to respond to and reduce the impacts of climate change. This assessment will empower you with a tool to help you adapt to the changing climate, enhancing your resilience and safeguarding your well-being.

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Understanding the Analysis

This section summarizes the technical report titled, "Spatial Vulnerability Assessment Report."

Threats include a range of potential risks and hazards that could negatively impact the identified categories of critical assets within Alachua County. These threats may include natural disasters such as hurricanes, floods, or wildfires, which could endanger critical infrastructure, natural resources, and residential or commercial areas. For this assessment **three primary threats** were identified: (1) **extreme heat**, (2) **heavy rainfall**, and (3) **sea level rise**.

Other threats, which are not climate-induced and not directly examined in this analysis, include human-induced risks such as pollution, deforestation, and urbanization, which could affect the County's built environments and natural areas. Threats could also extend to socio-economic factors such as economic downturns and population growth, which may pose challenges to the resilience and stability of the community's assets. By systematically categorizing these threats and evaluating their potential impacts on different elements of the community's assets, the County can develop targeted strategies for mitigating risks and enhancing resilience.

KEY TERMS

Extreme Heat – Excessive and prolonged high temperatures, often surpassing normal seasonal averages, posing risks to health, infrastructure, and ecosystems.

Heavy Rainfall – Intense precipitation events characterized by significant amounts of rainfall over a short period, potentially leading to impacts such as flooding and infrastructure damage. Heavier periods of rain are expected with a changing climate.

Sea Level Rise - The gradual rise in the average global sea levels, primarily attributed to the melting of polar ice caps and expansion of our oceans resulting from an increase in global temperatures.

Each threat was reviewed in the context of the community's assets. The community's critical assets were divided into categories to evaluate potential vulnerabilities and risks. By adopting this structured approach, the diverse components of the County's built environment and natural areas could be evaluated.

Community assets evaluated include critical infrastructure and services as well as natural, cultural, and historical resources, homes, and businesses. These assets represent most of the County's built environment and natural areas. Table 1 shows the seven asset categories that were established.

For this analysis, the team evaluated the vulnerability of physical assets using property or parcel-based data within Alachua County. This approach enables a comprehensive evaluation of the County's built environment, including places where people live, work, and socialize.

Table 1.
Asset Categories and Types of Community Assets within Each Category.

ASSET CATEGORY	TYPES OF COMMUNITY ASSETS
Critical Infrastructure	Airport, Bus Terminal*, Communication Facility, Disaster and Debris Management Site, Drinking Water Facility*, Electric Facility*, Rail Facility, Solid Waste Facility*, Utility Property, Wastewater Facility*
Critical Community and Emergency Facilities	Community Center*, Correctional Facility*, Disaster Recovery Site*, Emergency Medical Services*, Fire Station*, Emergency Operation Center*, Healthcare Facility*, Higher Education, Hospital*, Law Enforcement, Municipal Property*, School*, Shelter*, State Government Property
Natural, Cultural, and Historic Resources	Cemetery*, Conservation Land, Historical and Cultural Assets, Parks*
Residential	Assisted Housing*, Assisted Living (Gainesville)*, Condominium, Miscellaneous Residential, Mobile Home Park*, Multifamily Property*, Nursing Home*, Residential Health Facility*, Single Family Property, Retirement Home*
Commercial	Daycare*, Gas Station*, Grocery Store*, Hotel, Industrial Property, Mining, Parking, Recreation, Rest Home, Timber, SNAP Store Retailer*, Stores, Miscellaneous Commercial Property, Commercial Retention Pond
Undeveloped Land	Vacant County Land, Vacant Commercial/Industrial Land, Vacant Institutional Land, Other Vacant Government Land
Services - Other	Food Bank*, Library*, Nonprofit, Relief Agency*, Religious, SNAP Store Retailer*

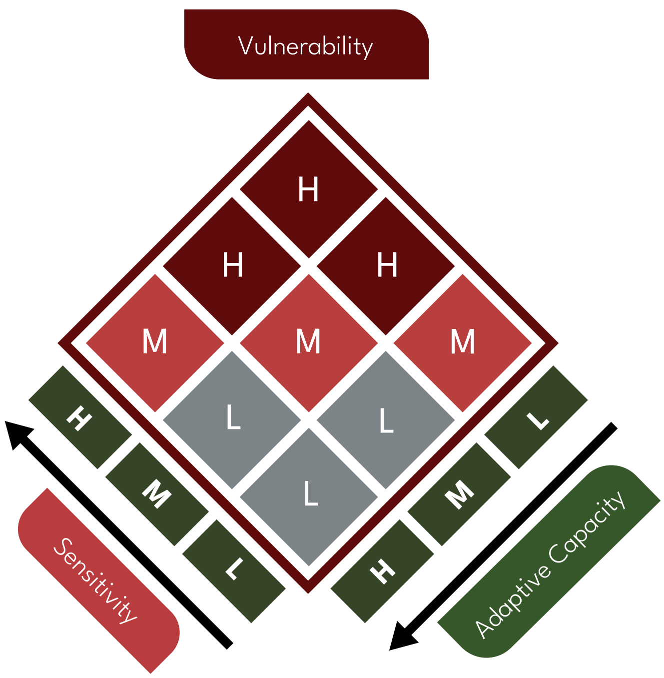
*Indicates a Critical Asset as defined by the Florida Department of Environmental Protection Flood Vulnerability Assessment Requirements.

The Assessment also includes locations of critical infrastructure and facilities where government and non-government entities provide services. Property-based information was also used to include natural areas in the Climate Vulnerability Assessment.

The Climate Vulnerability Assessment will identify specific **assets** at risk from specific **threats.** Vulnerability is quantification of how exposed an asset is to a particular threat and how easily it can be adapted or changed to reduce the exposure.

Threats can be defined as a range of potential risks and hazards that could negatively impact the identified categories of critical assets.

Assets can be defined as the identified categories of critical infrastructure, natural resources, residential or commercial areas, built environments, and natural areas, such as shown in Table 1.



What are the Important Components?

Vulnerability assessments evaluate three main components that, when combined, provide a quantifiable vulnerability:

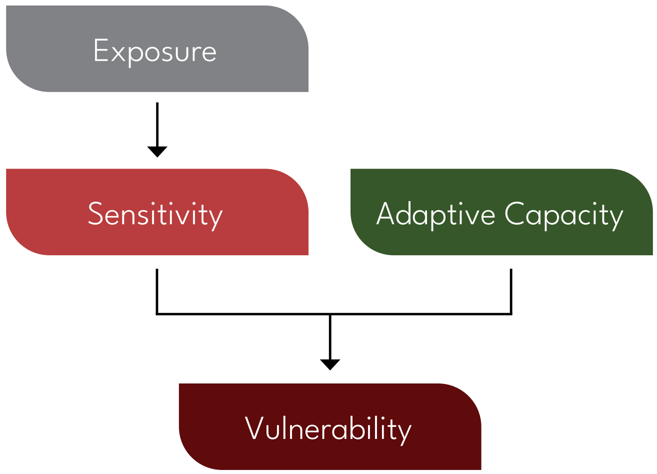
EXPOSURE - Exposure refers to the presence of people, assets, and ecosystems in areas where hazards can cause adverse effects.[1]

SENSITIVITY - Sensitivity measures the extent to which an exposed asset is impacted.

ADAPTIVE CAPACITY - Adaptive capacity represents an asset's ability to manage or endure the potential impact of the threat with minimal disruption or loss.

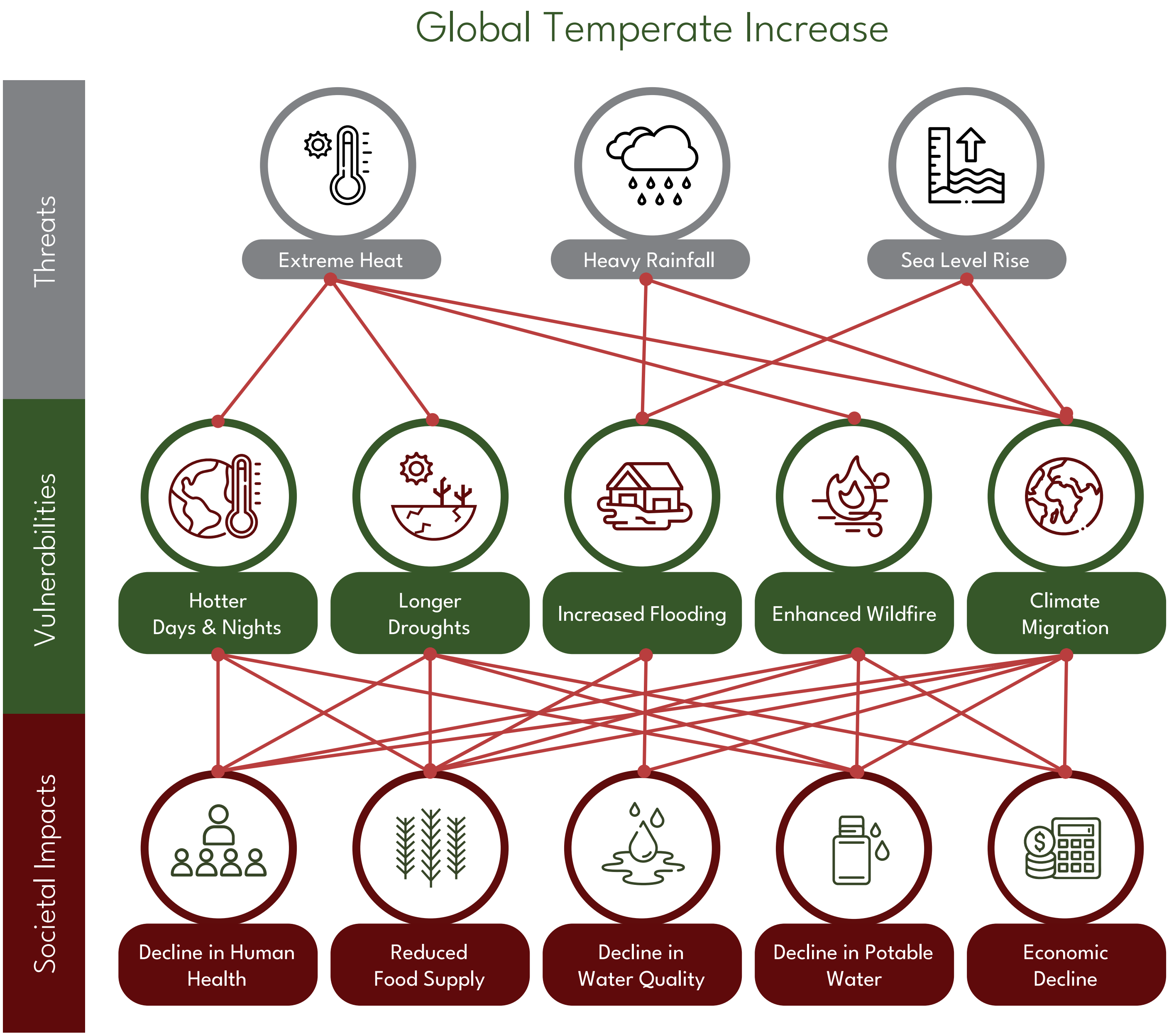
VULNERABILITY - The vulnerability of a community is determined by combining sensitivity and adaptive capacity levels, as illustrated in the figure below.

Assets with low sensitivity and high adaptive capacity are considered the least vulnerable, whereas those with high sensitivity and low adaptive capacity are deemed the most vulnerable. The levels of adaptive capacity are shown as **high (H)**, **medium (M)**, and **low (L)**.



Interconnected Climate Impacts

Through the Climate Vulnerability Assessment, we can understand how vulnerable an asset, or the community is to a particular threat. The graphic below demonstrates the interconnected nature of climate threats and how those threats increase our vulnerability and impact you and society, in general. For example, heavier rainfall will increase flooding and impact the food supply.



The remainder of this report explores **climate vulnerabilities and societal impacts** in more detail. Each of these sections are **based on detailed technical reports**.

Hotter Days & Nights

This section summarizes the technical report titled, "Critical Infrastructure and Land Use Climate Vulnerability Analysis - Task 3.1 - Climate Data Review."

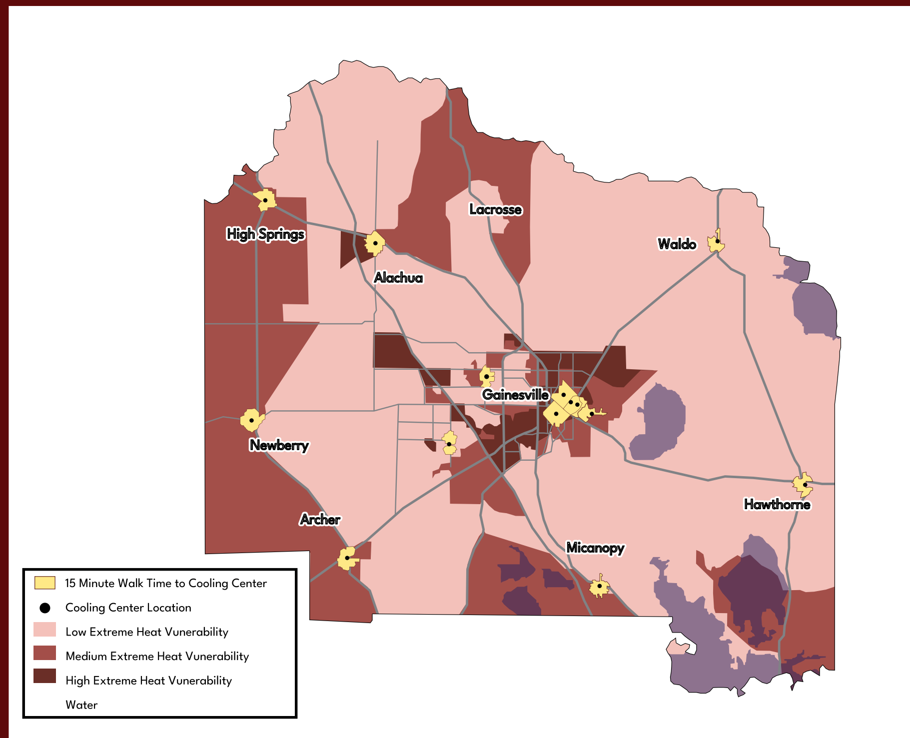
Many national and international meteorological organizations have published estimates that July 2023 was likely the world's hottest month, and 2023 is the hottest year on record since the start of recorded observations in the late 19th century. Models from the World Weather Attribution (a non-profit organization that studies the probability of weather events) and other research entities indicate that climate change is most likely responsible for the record-setting heat, and additional record-breaking temperatures are likely soon given current climatological trends.

Extreme heat incidents occur when outside temperatures exceed those typically experienced within a region and may strain or surpass climate control capabilities that are commonly available (i.e., increased need for effective air conditioning). These incidents may occur across the entire County over a few hours, days, and possibly weeks. These incidents may lead to heat-related health impacts and increased utility bills, most notably in lower-income households with weaker climate control capacities. These incidents may also impact power transmission systems, potentially resulting in brownouts and power outages. Brownouts can be defined as temporary reductions in electrical power distribution due to strain on the power transmission systems during extreme heat incidents. When outside temperatures exceed the average temperature for the area, there is an increased demand for air conditioning, which can overload the power transmission systems, leading to brownouts. Brownouts typically result in reduced voltage levels in the electrical grid, causing lights to dim and electrical appliances to operate less efficiently.

High temperatures will increase the need for air conditioning leading to **higher utility bills, heat-related illness,** and potential **failing window air conditioning units.**

The proportions of developed land cover, tree cover, and median household income were analyzed to assess vulnerability to extreme heat, including factors related to urban heat island effects. The proportion of developed land cover is an environmental indicator of exposure to higher temperatures, with urban areas often experiencing more intense heat due to the urban heat island effect. Tree canopy coverage contribute significantly to mitigating the heat island effect through shade provision and evaporative cooling, underscoring the importance of extensive tree canopy coverage as a gauge of environmental resilience. Additionally, the median household income is a social/financial indicator of adaptive capacity, or ability to adapt, to extreme heat. Individuals with a lower income level will have less access to extreme heat-protective measures, including adequate cooling, medical care, reliable transportation, etc. This socioeconomic disparity can exacerbate the impacts of extreme heat events, particularly in urban areas.

The Assessment approach combines exposure and adaptive capacity indicators to classify relative vulnerability for each census block group. Additionally, data on high-risk groups are overlaid for visualization, allowing separate assessments and tailored heat-management strategies based on specific group needs. The extreme heat assessment focused on public health at the neighborhood level by combining environmental indicators of urban heat island effect with social indicators.



Identified of Extreme Heat Vulnerability coincident with locations of Public Cooling Stations.

High heat vulnerability areas occur in the urban core of the City of Gainesville, the west part of Alachua County, and along sections of Interstate 75 between the Cities of Alachua and Gainesville. In Alachua County, the impact of extreme heat in neighborhoods with insufficient cooling as night and day temperatures and humidity increase with climate change can vary depending on the severity of the hazard and the vulnerability and inequitable socioeconomic conditions of the neighborhood. Although most households have air conditioners, interior cooling in some homes may need to be improved due to improperly sized and antiquated units. For example, window air conditioner units may no longer be sufficient. Insulation also plays a significant role in interior cooling, and inadequate insulation can lead to increased energy consumption and difficulty maintaining comfortable indoor temperatures, especially during extreme heat events.

Groups who are considered vulnerable to extreme heat, referred to as “at-risk” populations, have increased exposure/sensitivity or reduced adaptive capacity to extreme heat. Several populations are known to be more susceptible to extreme heat impacts than others. Student-athletes are susceptible to dehydration and heat-related illness from exposure during outdoor practice in an unshaded environment. 64 public schools and two higher education institutions, the University of Florida and Santa Fe College, are within Alachua County. These educational institutions provide physical education and athletic opportunities where students will be exposed to extreme heat conditions and susceptible to health impacts from the exposure. Infants and young children are also vulnerable to extreme heat and cannot recognize the signs and symptoms of heat exhaustion. They also lack knowledge on how to treat and prevent it. The figure above shows the locations of public schools within Alachua County; 16 of which are in block groups with high heat vulnerability. There are multiple schools in or surrounding the City of Alachua, which also have a high heat vulnerability block group.

As the climate of Alachua County changes, the area will see an increase in the number of very warm nights, longer consecutive periods of very warm nights, and a reduction in the number of freeze events. As shown in Table 2, this will impact many aspects of daily life, including agriculture and cooling needs.

Table 2.
Average Annual Number of Extreme Heat and Freeze Events over Assessment Periods.

	Number of Very Warm Nights (min. temp. >80˚F) (Days)	Longest Period of Consecutive Very Warm Nights (Days)	Number of Freeze Events (min. temp. <32˚F) (Days)	Longest Period of Consecutive Freeze Events (Days)
Baseline	0	0	7	3
2030	1	1	6	2
2040	1	1	4	2
2070	17	7	2	2
2100	73	28	0	0

Heat Index

The Heat Index measures how warm the air feels, accounting for humidity. Extended exposure to high Heat Index conditions, especially during physically demanding activities, can result in severe heat-related illnesses such as heatstroke and heat exhaustion. The Heat Index serves as a crucial indicator of outdoor safety for workers, with the National Oceanic and Atmospheric Administration (NOAA) issuing alerts when the Heat Index is forecasted to exceed 105˚F to 110˚F for two consecutive days.[2] NOAA outlines potential symptoms corresponding to four categories of heat index: Very Warm, Hot, Very Hot, and Extremely Hot. The assessment projected changes in the Heat Index from baseline to future assessment periods. This assessment involved calculating the average annual number of days when the daily minimum and maximum heat indices fall within each NOAA category for each assessment period, as detailed in Table 3 using the Lu and Romps (2022) method.[3] Table 3 shows the projected changes in the average annual number of days crossing each threshold for both the minimum and maximum daily Heat Index.

The Heat Index measures how warm the air feels, considering humidity levels. It includes both minimum and maximum values. The minimum Heat Index refers to the lowest Heat Index value recorded during a specific period, usually a day. Conversely, the maximum Heat Index represents the highest Heat Index value recorded during the same period. These indices help gauge the range of heat exposure experienced over time, providing valuable information for assessing potential health risks and safety measures.

Table 3.
Average Number of Days per Year that the **Maximum** Heat Index would trigger an NOAA Alert.

	Very Warm 80-89°	Hot 90-104°	Very Hot 105-129°	Extremely Hot ≥130°
Baseline	26	64	95	36
2030	23	51	94	53
2040	27	55	81	70
2070	24	54	75	107
2100	20	43	68	138

NOAA Heat Index

Likelihood of Heat Disorders with Prolonged Exposure and/or Strenuous Activity.

Temperature (˚F)

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

CAUTION
DANGER
EXTREME CAUTION
EXTREME DANGER

Temperature-Humidity Index (THI)

Another measure of heat is the Temperature-Humidity Index (THI). The THI is a measure that combines the effects of air temperature and humidity. The THI is widely used for weather safety and was developed to monitor and reduce heat stress-related losses of livestock. Animal species have different sensitivities to temperature and moisture levels in the air. For example, cattle can typically handle high temperatures. However, as humidity increases, the ability of cattle to handle the heat load decreases, and they exhibit signs of thermal stress. Lactating cows have even less tolerance. The effects of this stress can result in significant economic losses to the dairy industry due to cows' decreased milk production, fertility, feed intake, growth, and longevity. As climate changes the number of days with temperatures above the threshold that will create heat stress on the cow population in Alachua County will increase by 20-30% over the remainder of the century (Table 4).

Recent research has shown that there's a lot of variation in the thresholds for when cows get stressed from heat. While a Temperature-Humidity Index (THI) of 68 is often used as a sign of heat stress for cows producing milk, it's important to understand that this number isn't one-size-fits-all. It was specifically identified for certain types of dairy cows in dry climates, and it hasn't been confirmed for cows that aren't producing milk (dry cows). Dry cows can handle heat better than lactating cows because they're not producing milk and don't generate as much body heat.

Table 4.
Average Annual Temperature-Humidity Index (THI) counts on Daily **Minimum and Maximum** Temperatures.

	THI > 68 (Milk Producing)	THI > 77 (Dry Cows)
Baseline	122	228
2030	127	225
2040	135	238
2070	160	260
2100	189	271

Longer Droughts

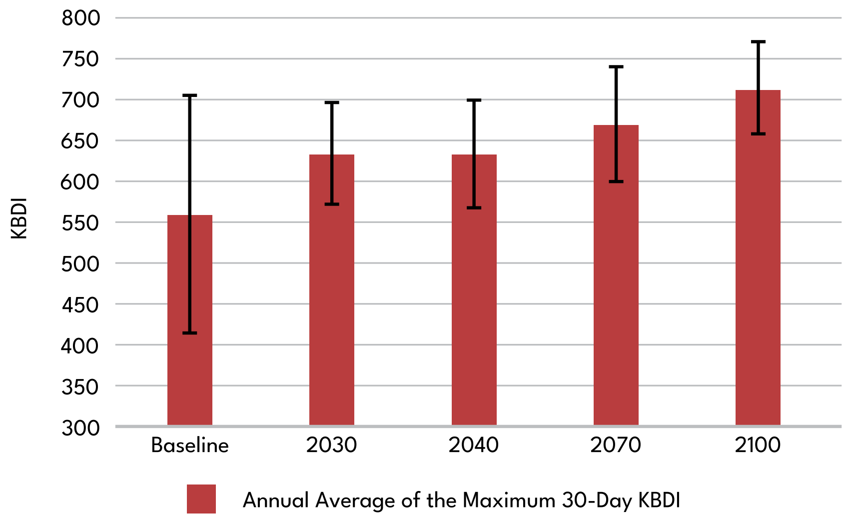
This section summarizes the technical report titled, "Critical Infrastructure and Land Use Climate Vulnerability Analysis - Task 3: Wildfire."

Insufficient water availability can cause plants to wither, resulting in crop failure and lower yields. Increased temperatures reduce yields of valuable crops such as blueberries. Reduced crop yield affects producers financially, resulting in lower wages and job losses (and potentially housing and meal loss) for farm workers. Urban water use can also increase during droughts, as property owners irrigate stressed landscapes.

Pastures and grazing lands also dry up during droughts, reducing feed availability for livestock. Flooded pastures can have the same impact. This forces farmers to seek alternative feed sources, which can be costly. Moreover, heat stress can negatively affect animal and farm worker health and reduce livestock productivity.

Several indices have been used in Florida to quantify drought. One common method involves tracking the number of consecutive dry days each year to assess changes in drought patterns due to climate change. The Keetch-Byram Drought Index (KBDI) is also frequently employed to classify drought severity in the southeast United States. The figure below shows the annual average of the maximum 30-day KBDI for reference.[4]

A higher Keetch-Byram Drought Index (KDBI) suggests a greater risk of prolonged drought because the soil lacks moisture, worsening the impacct of dry conditions over time.



The KBDI considers factors like recent rainfall, temperature, and soil moisture levels. When the KBDI is high, it indicates that the soil is very dry, making it more prone to drought conditions and increasing the likelihood of longer-lasting droughts.

Overall, drought happens when there is not enough water for a long period of time, and it starts causing problems for communities, people, and the environment. A drought may occur across the entire County over weeks, months, and even years.

Some potential impacts seen during a drought include:

- **Reduced Agricultural Production**
- **Decrease of Local Plants and Animals**
- **Increase in Sinkholes**
- **Increase in Wildfires**
- **Water Use Restrictions and Emergencies**

Increased Flooding

This section summarizes the technical report titled, "Critical Infrastructure and Land Use Climate Vulnerability Analysis - Task 3.1 - Climate Data Review."

Flooding

Alachua County consists of different hydrologic systems with varying flood characteristics. Hydrology looks at water comes from, where it goes, and how it behaves. These systems include fast-flowing streams and creeks that are sensitive to intense rainfall, large prairie systems such as Paynes Prairie that are affected by long-term seasonal changes in rainfall and aquifer levels, closed basins that are sensitive to multi-day rainfall volumes, and large riverine systems like the Santa Fe River that are sensitive to regional rainfall. Large regions of the County experience localized flooding in smaller closed basins during extended or high-volume storms. Certain areas of the County, particularly along the shores of Newnans, Orange, and Lochloosa Lakes; portions of Gainesville along Hogtown Creek; and the Santa Fe River floodplain are vulnerable to flooding from rising water. The County has created a high-resolution flood risk model to improve our understanding of flood risk that provides data on the estimated depth of flooding during different storm events. The model was used to evaluate present and future flood risk, considering projected changes in extreme precipitation events. The model results have highlighted regions of the County that are likely to experience significant changes in flood risk due to changing rainfall characteristics.

Rainfall-Induced Flooding

A high-resolution Countywide inundation model was developed. The model predicts inundation for extreme rainfall events. It has a variable grid resolution and relies on the latest Countywide digital elevation model. In addition to current conditions, flood risk is evaluated for two future time horizons – 2040 and 2070 – using regional rainfall change factors. The model is described in detail the Countywide Inundation Modeling Technical Memorandum submitted as part of this project. In a warming climate, the frequency, severity, and amount of extreme rainfall will continue to increase in the southeast United States.[5]

Flood vulnerability was evaluated for the County's assets, services, and infrastructure for three horizons:

1. Current 100-year rainfall-induced flooding;
2. 2040 100-year rainfall-induced flooding; and
3. 2070 100-year rainfall-induced flooding for the 1-day and 10-days storms.

A separate Vulnerability Analysis completed for the Florida Department of Environmental Protection Resilient Florida Program evaluated the vulnerability of critical assets to 100-year and 500-year rainfall-induced flooding under current, 2040, and 2070 conditions pursuant to Section 380.093, Florida Statutes. A compliant assessment will open up over $100 million in annual infrastructure funding from the State of Florida.

Flooding Assessment Rules

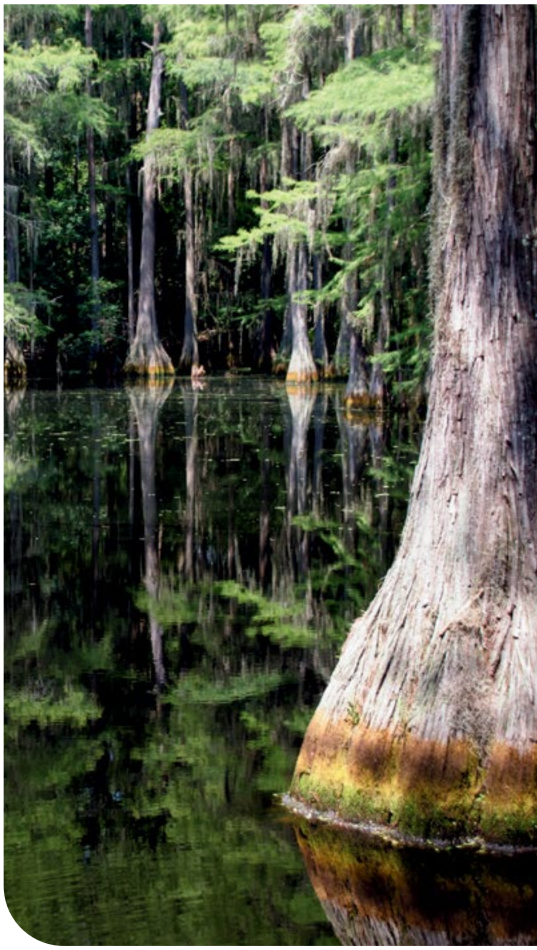
Similar to vulnerability to high heat, vulnerability to flooding combines sensitivity and the adaptive capacity of exposed assets. Rulesets, which are explained in Table 5, were used to classify each exposed community asset as having the "high," "medium," or "low" characteristics of sensitivity, adaptive capacity, and vulnerability.

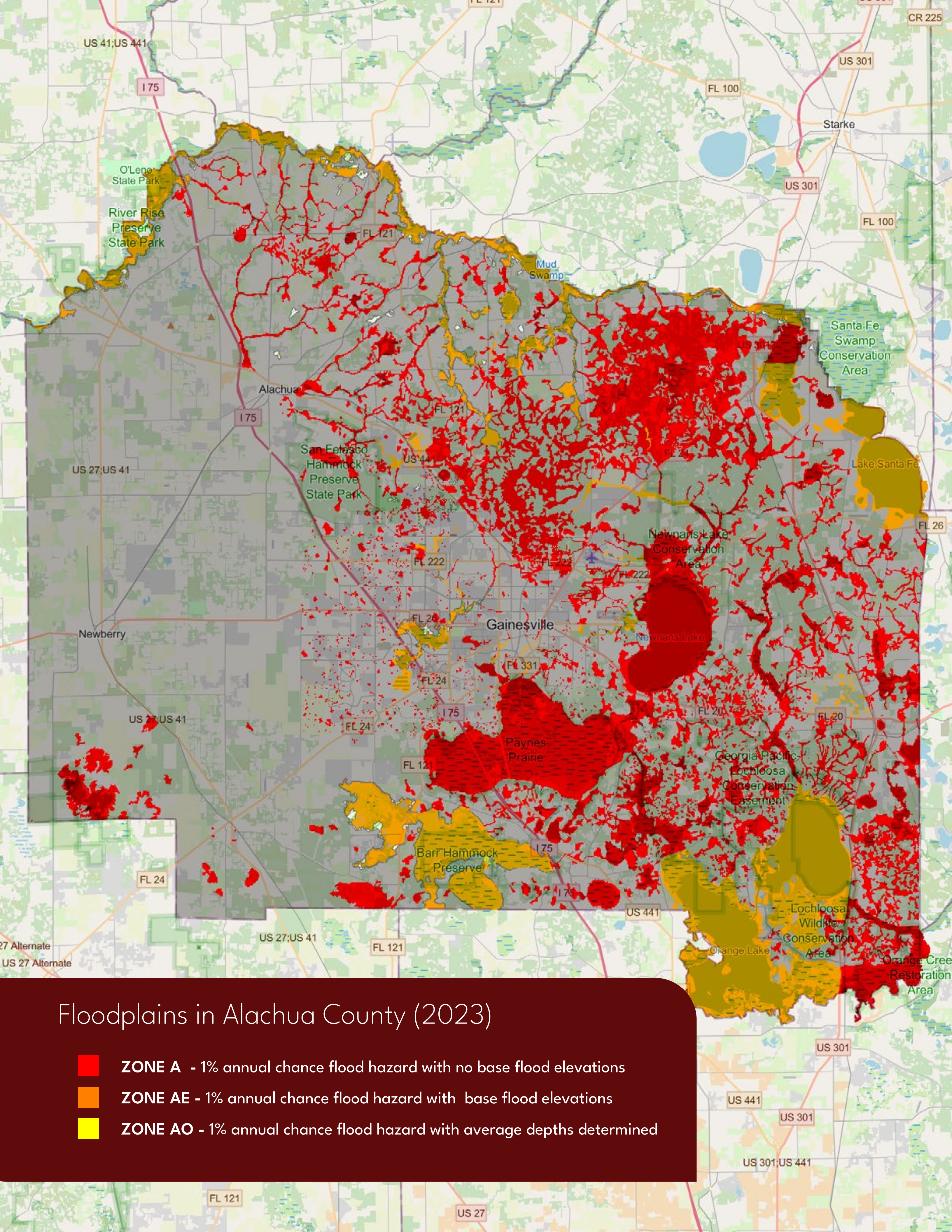
Table 5.
Summary of Rulesets used for Flooding Vulnerability Assessment.

THREAT	EXPOSURE	SENSITIVITY	ADAPTIVE CAPACITY
2020 100-year Rainfall-induced Flooding 2040 100-year Rainfall-induced Flooding 2070 100-year Rainfall-induced Flooding	Parcels exposed to the flood extent	**High:** Structure in inundation extent and criticality of impact is high **Medium:** Structure in inundation extent. **Low:** No structure in inundation extent (only land is exposed).	**High:** FFE >= 1 foot above maximum WSE OR structure outside flood extent. **Med:** The difference between FFE and maximum WSE is between 0 and 1 feet. **Low:** FFE below maximum WSE on the parcel

EXPOSURE – For this assessment, exposure means that an asset/property parcel is within an area that the model predicts will flood. Assets that are not exposed are not vulnerable or at risk of flooding.

VULNERABILITY – The structure's location and criticality are considered together for assessing sensitivity levels. Criticality looks at what would be impacted if the structure is exposed. This information is based on building footprints and type of asset use or nature of service provided. Properties with buildings within identified areas that flood have higher sensitivity compared to those with only land potentially affected. The second criterion of criticality is also applied in a binary manner where some asset types within an asset category are evaluated as having higher sensitivity based on the magnitude of impact or criticality of impact. For example, multi-family housing structures that accommodate more people are considered more critical than single-family properties. Similarly, a grocery store is considered more crucial than a retail or commercial property since it can provide a hub for access to food and other services like banking or pharmacy. Assets categorized as having a "high" level of sensitivity are those that meet both the criteria, i.e., their building footprint is within the flood extent, and the property use is considered critical. In this Assessment, high, medium, and low levels of adaptive capacity are determined by comparing the Finished Floor Elevation (FFE) of a building with the maximum Water Surface Elevation (WSE) within the building's footprint. If a building's FFE is below the maximum Water Surface Elevation, it is considered to have low adaptive capacity. Medium adaptive capacity is assigned to parcels with a building FFE within one foot above the maximum WSE. High adaptive capacity is designated to parcels where the difference between the FFE and maximum WSE is more than one foot.





Floodplains in Alachua County (2023)

- **ZONE A** - 1% annual chance flood hazard with no base flood elevations
- **ZONE AE** - 1% annual chance flood hazard with base flood elevations
- **ZONE AO** - 1% annual chance flood hazard with average depths determined

Flooding Assessment Results

Table 6 shows the amount of flood vulnerability predicted for community assets in Alachua County organized by asset categories. The table provides the total number of assets and the number and percentage of those assets with a medium or high vulnerability under the three flooding scenarios assessed. Of the nearly 90,000 property parcels or assets analyzed across the County (all categories except for Undeveloped Land), a little less than 5% are estimated to experience more than 1 foot of flooding above their Finished Floor Elevation (FFE) during a 100-year flooding event in current conditions. These properties have the lowest adaptive capacity. An additional 11% of properties are estimated to experience less than one foot of flooding during a current 100-year rainfall-induced flooding event.

Table 6.
Summary of Vulnerability Assessment Results by Asset Category.

ASSETS CATEGORY	TOTAL ASSETS	100-Year Rainfall -Induced Flooding		
		2020	2040	2070
Critical Infrastructure	735	116 (16%)	134 (18%)	141 (19%)
Critical Community and Emergency Facilities	1,955	383 (20%)	467 (24%)	515 (26%)
Natural, Cultural, and Historical Resources	7,361	543 (7%)	804 (11%)	910 (12%)
Residential	73,765	5,700 (8%)	9,080 (12%)	10,921 (15%)
Commercial	5,059	658 (8%)	881 (10%)	904 (11%)
Services - Other	811	137 (16%)	179 (21%)	205 (24%)
Undeveloped Land (Exposure Only)	14,009	7,161 (51%)	8,434 (60%)	8,939 (64%)

When we talk about **vulnerability**, we are looking at **how likely a building is to be affected by flooding** and **how well it can cope** with it. We decided this by considering two things: **where** the building is and **how important** it is.

If a building is right **in the flooded area** and **serves an important purpose**, like a hospital or housing many people, it is considered **highly sensitive**.

We also look at how high the building's floor is compared to the highest expected flood level. If the floor is below that level, the building **doesn't adapt well** to floods. If it is within one foot above that level, it **adapts moderately well**, and if it is more than one foot above, it is **good at adapting**.

Enhanced Wildfire

Climate Vulnerability

This section summarizes the technical report titled, "Critical Infrastructure and Land Use Climate Vulnerability Analysis - Task 3: Wildfire."

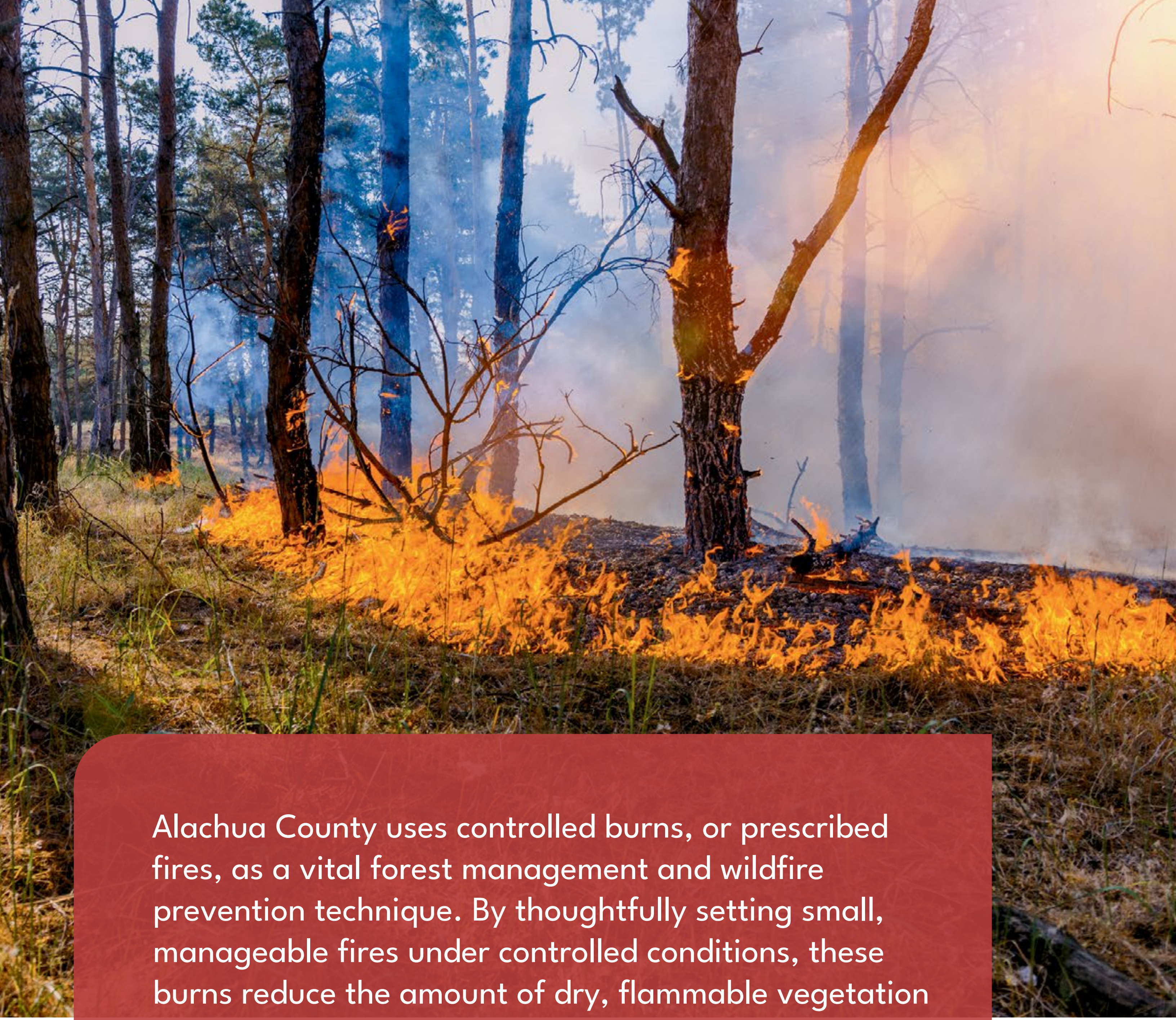
Wildland fires occur on lands that do not meet management objectives and therefore require a suppression response to avoid damage to natural areas or property and threats to life safety. The most at-risk portions of Alachua County are the wildland-urban interface, where community development meets wildland and rural areas where wildland fuels are present. Significant fuels are in each jurisdiction beyond the wildland-urban interface, encompassing a significant area of the County and impacting all jurisdictions. A few exceptions exist, such as developed retail or healthcare areas along Archer Road in Gainesville. Wildfires may rapidly spread over large land areas and may last for days or weeks. However, wildfires in Alachua County are typically well controlled. In addition to the potential for structural damage, wildland fires can cause significant losses and destruction for timber interests in Alachua County. The homes along the wildland-urban interface and agricultural interests are the most vulnerable. Individuals may receive acute or chronic injuries, and critical facilities may be damaged. All jurisdictions in Alachua County are vulnerable to wildfires and would experience similar impacts.[5]

Wildfires are essential for maintaining native biodiversity and ecosystem processes while having the potential for substantial environmental damage, significant impacts on silviculture, loss of property, loss of crucial infrastructure, disruptions to traffic, and smoke pollution. Alachua County includes various ecosystems with different fire-risk characteristics. Mitchel et al. (2014) provides and overview of fire interactions in the southeast United States and how climate change will likely influence those interactions.[6] Their assessment of fire risks for some forest and landscape types within the County is summarized as follows:

FORESTED WETLANDS: Fire risk is linked to hydroperiods and drought. With short hydroperiods, wetlands burn more frequently. With extended hydroperiods, wetlands experience more severe fires during droughts. Deep histosols (peaty soils) can sometimes burn, creating significant environmental changes through peat material loss and ash accumulation. For example, the fire in the Santa Fe Swamp in 2007 resulted in substantial water-quality impacts to Lake Santa Fe.

PINE FLATWOODS: Longleaf, slash pine, or a mixture of the two dominate these systems, and fires are naturally frequent (every three to five years). However, these systems can develop elevated fuel loads when fires are infrequent.

PLANTED PINE: Management practices significantly impact these systems. Monocultures of loblolly pine, slash pine, or longleaf pine become susceptible to fire. Long periods of fire suppression combined with drought can enhance this susceptibility.



Alachua County uses controlled burns, or prescribed fires, as a vital forest management and wildfire prevention technique. By thoughtfully setting small, manageable fires under controlled conditions, these burns reduce the amount of dry, flammable vegetation that can fuel larger, uncontrollable wildfires. This proactive approach not only helps maintain the health of ecosystems by promoting native species and reducing pests, but it also significantly lowers the risk of devastating wildfires. Controlled burns save money by decreasing the costs associated with firefighting, property damage, and disaster recovery.

Climate Migration

This section summarizes the technical report titled, "BEBR 2100 Population Projections for Alachua County Project Including Projections of Climate Migrants."

Population Projections

Florida's official popuation projections are available from the Bureau of Economic and Business Research at state and county levels. The projections only extend to 2050, lack spatial distribution data within counties (rendering accurate projections for cities, utilities, or smaller areas unattainable), and do not consider climate migration. Consequently, Alachua County recognized the necessity of developing a new forecast extending to 2100 with a finer spatial resolution and including climate migrants. This initiative was imperative to address the requirements of its Critical Infrastructure and Land Use Climate Vulnerability Analysis and facilitate informed future planning decisions.

An estimate of controlled and uncontrolled population forecasts was created through 2100 and shown in Table 7. Controlled estimates include the implementation of policies that may inhibit growth, while uncontrolled do not. The population would likely fall between the two estimates. Table 7 also provides an estimate of the number of climate migrants expected to move to Alachua County. The County will be a net recipient of climate migrants.

Alachua County could see an 8% increase in population by the end of the century just because of **climate migrants,** or people who move because of the impacts of climate change such as sea level rise.*

**These projections do not consider adaptation measures taken by other communities, which may reduce the number of climate migrants leaving those communities.*

Table 7.
Bureau of Economic and Business Research Popuation Projections for Alachua County Project

Population Forecast	2040	2070	2100
Original Forecast Not Controlled to State Forecast	335,614	297,942	461,573
Revised Forecast Controlled to State Forecast	328,767	366,628	404,535
Projected Forecast (Average of Controlled and Uncontrolled)	332,191	382,285	433,054

Although the impacts of drought and flooding may force families involved in the farming economy to migrate from rural parts of the County in search of better opportunities in different sectors, a more likely scenario is that this migration will be caused by in-migration from surrounding counties, driving up demand for farmland conversion to housing, which could cause a reduction in available agricultural land without proper urban planning. This can increase farm-worker unemployment and pressure on urban infrastructure and services. This influx of new residents into Alachua County, coupled with the challenges posed by climate change, underscores the urgent need for proactive planning and adaptation measures to ensure the resilience and sustainability of the County's communities and infrastructure. By fostering collaboration among stakeholders, implementing sustainable development practices, and investing in resilient infrastructure, Alachua County can effectively address the impacts of climate change, mitigate risks, and enhance the quality of life for current and future residents.

Without action, Alachua County faces **significant** impacts from climate change.

The next sections explore those impacts and recommend actions to reduce them.

Resident Health & Finances

This section summarizes the technical report titled, “Critical Infrastructure and Land Use Climate Vulnerability Analysis - Task 3.1 - Climate Data Review.”

Societal Impact

In Alachua County, the average daily maximum temperature will increase by approximately 6˚F by the end of the century, a substantial increase in average temperatures. Even more concerning is the combination of temperature and humidity. The project data show a 10-time increase in extremely hot days (based on a projected daily maximum Heat Index and National Weather Service classification of extremely dangerous conditions). The longer periods of hot days make working on farms or outdoor construction much more challenging.

As part of the overall Climate Vulnerability Assessment, Alachua County survived its residents to understand how they feel climate change will affect them and what they would like to see the County do to address those impacts. Note that the survey reached over 600 residents and provides general insight into the community’s feelings, but it is not a large enough sample to fully represent the entire community. Survey respondents are already worried about extreme heat. 58% agreed that extreme heat would impact them, and 61% noted they were concerned about the health impacts of extreme heat.

In the assessment of areas vulnerable to extreme heat, household median income at the census block group level is one of the two key indicators of adaptive capacity, or ability to withstand and thrive through extreme heat. The second indicator is the percentage of tree canopy cover, which directly relates to an area’s ability to stay cool, and percentage of developed land. Together, these indicators provide an understanding of where in our community extreme heat may impact community members hardest.

In areas vulnerable to extreme heat, we consider **household median income at the census block group level*** as one of the two indicators of adaptive capacity. The second indicator is the **percentage of tree canopy cover**. Additionally, we use the percentage of developed land as an indicator of exposure.

**Census Blocks are statistical divisions of census tracts, are generally defined to contain between 600 and 3,000 people, and are used to present data and control block numbering.[7]*

Impact Overview

In Alachua County, the impact of extreme heat in neighborhoods with insufficient cooling as night and day temperatures and humidity increase with climate change can vary depending on the severity of the hazard and the vulnerability and inequitable socio-economic conditions of the neighborhood. Although most households have air conditioners, interior cooling in some homes may need to be improved due to improperly sized and antiquated units. Inequitable health and financial effects include:

1. INCREASED HEALTH RISKS

Lack of proper cooling during hot weather can lead to various health issues. Extreme temperatures and humidity can cause heat-related illnesses in summer, such as heat exhaustion or heatstroke, especially for those who work outdoors. They can exacerbate certain medical conditions like respiratory problems and cardiovascular issues, particularly for those with pre-existing conditions, the elderly, children, and pregnant women.

2. INCREASED HEALTHCARE COSTS

Inadequate temperature regulation can increase healthcare costs as residents may require medical attention due to heat-related health problems. In addition to straining family finances, including lost wages, this can strain healthcare systems and public health resources. Those without access to health insurance face graver healthcare cost threats, which may dissuade some from seeking care.

3. INCREASED UTILITY BILLS AND FINANCIAL BURDEN

Residents may struggle to pay high utility bills as their demand for electricity increases to maintain a comfortable and safe indoor environment during extreme heat. This can result in financial hardship for individuals and families, particularly those on low incomes who already pay a disproportionate amount for electricity. Because cooling a residence during a 24-hour day is crucial – for instance, at night at home for daytime outdoor workers – home electricity shut-offs and families that limit cooling to avoid high bills can contribute to additional extreme heat mortality and morbidity. Mobile homes are less energy efficient than permanent structures and incur a higher cost per square foot for energy.

4. DECREASED ECONOMIC PRODUCTIVITY

Extreme temperatures can affect the ability of residents to work efficiently. In excessively hot conditions, productivity can decline, leading to potential economic losses for individuals and businesses. This is particularly true in the agricultural and construction sectors. In addition, employers may be required to change working hours to keep the workforce safe, which may cause difficulties for childcare. For instance, if the workday starts at dawn, goes to mid-morning, breaks, and then starts again in the evening childcare will become increasingly challenging.

Extreme temperatures can exacerbate certain medical conditions like respiratory problems and cardiovascular issues, particularly for those with pre-existing conditions, the elderly, children, and pregnant women.

Impact Overview continued...

6. INCREASED EDUCATIONAL DISRUPTIONS
Lack of adequate cooling in schools can disrupt the learning environment, and student-athletes have higher exposure. Extreme temperatures can affect students' concentration and overall academic performance.

7. DECREASED PROPERTY VALUES
Neighborhoods with a reputation for increased heat due to the urban heat island effect may experience reduced property values. Potential buyers and renters may be hesitant to invest in homes or apartments in such areas, impacting the overall economic stability of the community. Further, urban heat islands may impact economic assets in the County, including the University of Florida's football stadium in Gainesville, which we assume is an urban heat island based on the relative percentage of asphalt and dark roofs. Extreme heat during football games may reduce attendance and overall economic activity around the games.

8. INCREASED STRAIN ON SOCIAL SERVICES
As residents face mental and physical health and financial challenges due to extreme heat, an increased demand for social services and assistance programs may follow, further stretching public resources.

9. INCREASED AIR QUALITY IMPACTS
Respiratory distress from poor air quality increases as air temperature increases. Wildland Urban Interface (WUI) is expected to increase by 100% by 2100 and continue to increase beyond this century partly due to homes encroaching on natural and working lands. Wildfires create poor air quality for large regions; therefore, this issue also relates to WUI fires creating poor air quality in Alachua County. People with pre-existing conditions, including asthma, which disproportionately affects lower-income people due to more inadequate quality healthcare and living situations, are at greater risk of this distress.

Recommended Actions

To mitigate extreme heat impacts, governments, community organizations, and individuals must work together to address the issue. This may involve implementing green infrastructure and reflectivity policies. In addition to risk mitigation, decreasing heat morbidity and mortality requires adaptations like providing financial assistance to vulnerable residents to pay their electricity bills and promoting awareness of the health risks associated with extreme temperatures. It likely starts with an interagency or interdepartmental work group like the one created for this project, along with an Equity Advisory Council that engages the community and focuses on equitable engagement and actions.

Recommended Actions continued...

PHYSICAL INFRASTRUCTURE

ENCOURAGE COOL ROOFS, PAVEMENTS, AND SHADING

Develop policies that encourage cool roofs, pavement, and additional shading. Light-colored roofs and pavements reflect more sunlight than dark surfaces, reducing the amount of heat absorbed and radiated by buildings, roads, parking lots, and other surfaces.

HEAT ISLAND REDUCTION TO MITIGATE HEAT RISKS

Implement heat island reduction programs incorporate strategies such as planting trees, cool roofs, cool pavements, and green spaces. Furthermore, Low Impact Development Standards should be enhanced to further support cooler surfaces and green infrastructure, which are already provided in the County's Low Impact Development manual.

INCENTIVIZE BUILDING-INTEGRATED OR SELF-STANDING SHADE STRUCTURES

These structures can deflect solar radiation and provide a moment of reprieve from the sun.

ADVANCE GREEN INFRASTRUCTURE

Historically used for stormwater management. Implement policies, programs, and guidance that require and encourage green infrastructure as part of development and County infrastructure. Historically used for stormwater management, green infrastructure also cools the surrounding area by releasing moisture into the atmosphere, deflecting radiation, and shading.

ENSURE COUNTY-OWNED ASSETS HAVE AIR CONDITIONING

The County should ensure that all appropriate assets, including affordable housing, have adequately sized and efficient air conditioning. However, how this will impact utility bills should also be considered.

ENCOURAGE ENERGY EFFICIENT BUILDINGS

The County should prioritize adherence to green building standards such as Leadership in Energy and Environmental Design (LEED) or similar building standards, especially for affordable housing units. LEED is a widely recognized certification program that emphasizes environmentally sustainable and energy-efficient building practices. Energy efficient buildings often have lower long-term cooling costs and can better regulate indoor air temperatures.

Recommended Actions continued...

POLICY

BUILDING STANDARDS TO MITIGATE HEAT RISKS
Incorporate energy-efficient design features and materials that reduce heat gain and make mechanical cooling more efficient.

INCREASE NATURAL COOLING
Update policies to enhance community cooling through outdoor shading and natural landscapes.

EXPAND COOLING CENTERS
Prioritize new structures and retrofit old structures to serve as cooling centers during the hottest times of the year.

LOW IMPACT DEVELOPMENT
Update development standards to incentivize and encourage more green space, tree cover, and cooler surfaces. Low Impact Development has multiple benefits, such as reducing runoff volume and improving water quality.

ACCESS TO COOLED SPACES
Ensure that farm workers have access to air-conditioned spaces to cool off during the daytime and that overnight accommodations have air conditioning.

ENHANCE WATER CONSERVATION PROGRAMS
Enhancing and expanding access to water conversation programs will aid in reducing water demands, while also assisting residents in reducing water bills.

PLANNING

DEVELOP HEAT PREPAREDNESS AND EMERGENCY PLANS TO ADAPT TO EXTREME HEAT
This would be an operational plan during extreme heat conditions. Measures may include opening cooling centers to provide water, rest, cooling, and shade to vulnerable residents and workers and possibly changing work hours.

INCREASE AWARENESS OF THE RISK OF HEAT
Provide education on the dangers of heat, both internally with County staff and with those who work with the County, can help everyone better prepare for the impacts of extreme heat.

FINANCE

PROVIDE FINANCIAL ASSISTANCE TO VULNERABLE WHO HAVE INSUFFICIENT COOLING
Consider financial assistance for energy-efficient modifications (expand and enhance existing programs) and for disadvantaged community members facing utility shut-offs.

COMMUNICATION

PUBLIC EDUCATION CAMPAIGNS TO ADAPT TO EXTREME HEAT
Implement a public education campaign that heat is different now, encouraging residents and workers to stay safe. This would include best practices to avoid heat exhaustion, heat stroke, and even death. Also educate residents on how to identify heat-related illness symptoms.

PRIORITIZE REACHING THOSE WE DO NOT OFTEN HEAR FROM
Make it clear that certain groups are more vulnerable, including the elderly, the young, and pregnant women, and find methods to communicate with those groups directly.

Worsening Community Flooding

This section summarizes the technical report titled, "Task 3.2 – Focus Areas."

Societal Impact

Alachua County will experience a slight increase in long-term average annual rainfall through the end of the century. The County is also expected to have heavier rain events, meaning that the expected precipitation will occur in shorter periods. The area will experience more intense/extreme events (higher daily totals) due to additional energy in storms and a warmer atmosphere that can "hold more moisture" caused by climate change. A newly developed high-resolution flood model for Alachua County revealed that changing rainfall characteristics pose a greater risk of flooding. This projected increase in flood risk is particularly high in areas with internally drained basins, such as lakes and ponds.

Impact Overview

As precipitation intensity increases with climate change and impervious surfaces increase with climate migration, flooding can significantly impact Alachua County's neighborhoods and cultural resources nearby or within their boundaries. This impact can vary depending on the severity of the hazard, the vulnerability or age of the neighborhood, and the inequitable socio-economic conditions of the neighborhood. Older subdivisions were designed with stormwater regulations that were not as effective as today's standards, and multiple factors contribute to flooding in the community. Inequitable effects include:

1. FLOODING AND PROPERTY DAMAGE

The most obvious impact is the risk of flooding during heavy rainfall or storms. As Hurricane Irma demonstrated, floodwaters can inundate neighborhoods, causing household property damage, displacing residents, and disrupting daily life. High concentrations of internally drained basins without ways to move the water quickly may exacerbate the severity and frequency of flooding events. Uninsured or underinsured homeowners, renters, and small businesses face particular challenges, since they would not have access to funds to rebuild completely after a disaster. Also, those without the agency or power to work with legal and financial representatives are less likely to receive disaster recovery from state or federal support. Immediately following a flood event, the poorest, single parents, and the elderly are most vulnerable since they have fewer resources to care for their dependents and/or leave damaged areas.

2. AFFORDABLE HOUSING FLOOD IMPACTS

The analysis demonstrated a disproportionate number of assisted housing and affordable housing properties (manufactured and multifamily) is highly vulnerable compared to single-family, condominium, and other property types, suggesting that resources need to target these residents and property types.

Impact Overview continued...

3. INFRASTRUCTURE DAMAGE

Floodwaters can also damage critical infrastructure such as roads, bridges, utilities, community services, and environmental assets. Repairs and reconstruction can be costly and time-consuming, impacting the local economy and community services. Historically, disadvantaged populations around the United States have waited longer than wealthier populations for repairs or modernization that could have helped to avoid loss. In addition, power outages are frequent during and after storms. The actual outages are caused by wind, but people associate them with the rain and the flooding they see.

4. ECONOMIC LOSS

Frequent flooding in a neighborhood can lead to decreased property values, making it challenging for residents to sell their homes or attract new investments. Businesses may suffer losses due to property damage and disruption of operations. Economic issues may be both hyper-local and spread farther than the County at the same time: Rural livelihoods are impacted when I-75 is shut down, including increasing air quality impairments from trucks driving on rural roads closer to work and home, decreasing access, or increasing commutes to services and employment. Regional and national supply chains may be disrupted when this major artery is impacted.

5. DISPLACEMENT AND MIGRATION

Repeated flooding in designated and non-designated floodplain areas may force residents to relocate, causing population shifts and altering the demographics of the affected neighborhoods. Lower-income households may move into less-expensive property previously vacated due to flood impacts like mold. In addition, neighborhoods that flood less frequently and have historically contained high proportions of affordable housing (affordable housing that is not necessarily designated as traditional affordable housing) may face climate gentrification as wealthier residents offer to buy their property, causing lower-income people to move farther from jobs, schools, and affordable areas. Conversely, given flood pressures in other parts of the state, population increases due to climate migrants will start measurably increasing around 2040 by up to an additional 26,000 people by 2100 and beyond. This is a concern of 68% of the survey respondents. The population will grow and move due to current regulations, with an increase in density in some areas and a spread into rural areas. This will increase the number of properties and families exposed to flooding and exacerbate flooding by decreasing permeable surfaces.

6. PUBLIC HEALTH AND SAFETY

Floodwaters can pose risks to public health by contaminating water sources with pollutants, sewage, or chemicals. Additionally, flood events may require emergency evacuations, risking residents' safety. Evacuations are particularly challenging for the very young, the very old, the homebound, and those with mental and physical ailments. Protecting pets is a high priority for many families and can lead to decisions to remain in unsafe areas. Following a flood event, homes and businesses may become dangerous if standing water and persistent moisture in organic materials cause mold, impairing respiratory health.

Impact Overview continued...

7. CULTURAL, HISTORICAL, AND CRITICAL SITES

Floodplains may contain culturally significant resources, such as hospitals, religious sanctuaries, and schools. Flooding can damage or destroy these resources, resulting in cultural heritage and identity loss. In addition, the Climate Vulnerability Assessment highlights the vulnerability of places and services that are likely important for well-being and quality of life, including libraries, Supplemental Nutrition Assistance Program (SNAP) retailers, and community centers.

8. NATURAL ECOSYSTEMS

Floodplains often support diverse ecosystems that urban development or flood control measures can negatively impact. Flood prevention that alters the natural water flow or encroaches on these areas can disrupt wildlife habitats and reduce biodiversity. As climate migration increases and demand for new housing starts, dig and fill development may decrease the amount of permeable land that absorbs water (as mentioned above), thereby exacerbating flooding. Also, some natural ecosystems like prairies support grazing, and when these working lands are flooded, livestock is disrupted.

Recommended Actions

Several measures can be taken to mitigate the negative impacts of enhanced flooding on neighborhoods and cultural resources:

PHYSICAL INFRASTRUCTURE

FLOOD CONTROL INFRASTRUCTURE

Construct or improve flood control structures like levees, dams, and stormwater infrastructure and basins can help manage and reduce flood risks.

PLANNING

FLOODPLAIN MANAGEMENT

Implement effective floodplain management strategies, including proper land-use planning, zoning regulations, and stormwater management codes to reduce the exposure of communities to flood hazards.

- Given the expected climate change-driven migration, this is a crucial tactic for Alachua County. Increase housing density, allowing additional floors on existing structures and new structures, and requiring skinny streets and permeable surfaces in parking lots are all significant priorities that impact vulnerable people sometimes far from this built environment.
- Limitations or special requirements for building in the floodplain should include properties within at least the 100-year floodplain.
- Consider expected future flood extents rather than federally regulated 100-year floodplains for planning purposes.

Recommended Actions continued...

POLICY

ELEVATING STRUCTURES
In some places in the County, the state building code has a 1-foot freeboard requirement. Requirements to raise buildings and infrastructure above the base flood elevation can protect them from some flood damage.

CONSERVATION AND RESTORATION
Preserve natural floodplains, wetlands, prairies, and forests and restoring degraded ones can enhance their capacity to absorb floodwaters and support ecosystems. Alachua County's historical emphasis on natural area conservation and the survey results show how much County residents appreciate natural areas, making this an obvious priority.

DEVELOP FUTURE CONDITIONS MAPS FOR REGULATORY PURPOSES
The County should develop future conditions for regulatory permitting.

RENTAL PROPERTY PROTECTION
Develop policies and programs that ensure rental properties meet safety standards, such as no mold or working air conditioning.

ENCOURAGE PERVIOUS AREAS
Increase pervious areas that can naturally drain stormwater and improve water quality.

CLIMATE-ADJUSTED DESIGN RAINFALL
Require that rainfall change factors are used when designing stormwater infrastructure for available design storms and where appropriate.

FINANCE

STORMWATER OR OTHER FEES
Account for modernizing and improving the resilience of stormwater infrastructure to handle future rainfall in the County's stormwater fee.

PRIVATE PROPERTY ADAPTATION
Implement a Private Property Adaptation Program that will aid residents to find flood solutions and support to implement them. This could also be expanded to heat.

COMMUNICATION

FLOOD WARNING SYSTEMS
Install early warning systems can help residents evacuate and move their cars in time during flood events, preventing loss of life and property damage.

COMMUNITY EDUCATION
Raise awareness about flood risks and educating communities about preparedness measures can improve resilience.

Agricultural Changes & Our Food Supply

This section summarizes the technical report titled, "Task 3.2 – Focus Areas."

Societal Impact

Based on the best available science, in Alachua County the average daily maximum temperature will increase by approximately 6°F by the end of the century, a substantial increase in average temperatures. Even more concerning is the combination of temperature and humidity. The project data show a 10-time increase in extremely hot days, which makes working on farms or outdoor construction much more challenging.[3] As rainfall rates become more extreme, the existing 100-year floodplain may expand farther, creating challenges for farmers and farm workers.

The combination of hotter days, longer draught, and extreme rainfall will challenge Alachua County's econimically vital agriculture industry.

Impact Overview

As drought, extreme temperatures, and precipitation intensity increase with climate change, Alachua County's rural and agricultural areas may be significantly impacted. These impacts will challenge and disrupt farming, livestock, and rural livelihoods. Loss of plants due to drought was a concern of 72% of the survey respondents, followed by demands on freshwater and risk to food production concerning over 60% of respondents.

1. CROP FAILURE AND REDUCED YIELDS

Drought and heat can lead to water stress, reducing soil moisture and inadequate crop irrigation. Insufficient water availability can cause plants to wither, resulting in crop failure and lower yields. Increased temperatures reduce yields on valuable crops such as blueberries. Similarly, depending on the flooding duration and plant life stage, flooded crops (which are likely increasingly as the 100-year storm event is expected to increase in volume from 10 to 15 inches) can result in crop failure and lower yields. Reduced crop yield affects producers financially, resulting in lower wages and job loss (and potentially housing and meal loss) for farm workers.

Impact Overview continued...

2. INCREASING FERTILIZER USAGE

Because of the potential for decreasing crop yields, the farm sector may increase fertilizer use, impacting worker health and farm profitability. Surface-water and groundwater quality may be further degraded due to nutrient-contaminated runoff and nutrients leaching during infiltration. Rising nutrients in groundwater could impact community members who rely on domestic wells for potable water. For example, although snap beans will initially increase productivity and forage grass will remain viable, corn and snap beans will eventually decrease yield. Farmers will explore solutions to increase crop yields, and the impact of increased fertilizer use should be considered.

3. LIVESTOCK AND ANIMAL HUSBANDRY

During droughts, pastures and grazing lands dry up, reducing the availability of feed for livestock. Flooded pastures can have a similar effect. This forces farmers to seek alternative feed sources, which can be costly and have subsequent effects on the livelihoods of workers. Moreover, heat stress can negatively affect animal and farm worker health and reduce livestock productivity.

4. WATER SCARCITY

Although the drought hazard data contain a lot of variability, drought will increase from April to July. Drought can lead to water scarcity for agricultural activities, livestock, and domestic use. Demand will likely increase for water for agricultural purposes, potentially requiring modifications to current domestic uses allocations. Competition for limited water resources can also create tensions among farmers, communities, and other water users.

5. ECONOMIC LOSSES

Agricultural losses due to drought, flooding, and heat can result in significant economic setbacks for rural communities. Farm income declines, agricultural businesses suffer, and rural unemployment rates may rise. In addition to corn no longer being a viable crop, regardless of an increase in fertilizer and water use, dairy and dry cows will require 50 more days of active cooling by 2030.

6. SOIL EROSION

Drought and extreme temperatures can exacerbate soil erosion, especially when little vegetation is available to hold the soil in place. By considering factors such as rainfall and evapotranspiration, keeping agricultural production up without supplemented water will be difficult. In addition, soil erosion can lead to land degradation, making it even more challenging to grow crops in the future. It can contribute to water-quality degradation in streams that receive farm runoff.

7. FIRE RISK

Due to the projected increase in the severity of drought combined with the expanding wildland-urban interface and the potential for increased fuel loads, wildfire risk is expected to rise. As a result, managing wildfires will become more challenging. Wildfires pose a significant threat to infrastructure, the health of County residents, and water quality.

8. MIGRATION AND SOCIAL DISRUPTIONS

Although the impacts of drought and flooding may force families involved in the farm economy to migrate from rural parts of the County in search of better opportunities in different sectors, a more likely scenario is that this migration will be caused by in-migration driving up demand for farmland conversion to housing, which could cause a reduction in available agricultural land without proper urban planning. In either case, this can lead to increased farm-worker unemployment and pressure on urban infrastructure and services.

9. IMPACT ON BIODIVERSITY

Flood, drought, reduced freeze events, and heat can also affect the natural habitats of wildlife and plant species, potentially leading to shifts in biodiversity patterns. Species from south Florida are migrating north, which can cause increased competition and affect the ecosystem in unexpected ways.

This section summarizes the technical report titled, "Task 3.1.3 & 3.1.4 - Changes to Local and Regional Water Use and Changes to Surface and Groundwater Hydrology."

Water Supply and Surface Water

Water use projections are complicated not only by population change, changes in acreages of land uses, and changes in the portion of irrigated agriculture, but also by changes in climate. Although the drought hazard data are variable, drought will increase from April to July. Drought can lead to water scarcity for agricultural activities, livestock, and domestic use. Demand for water for agricultural purposes will likely increase, potentially requiring modifications to current domestic use allocations. Competition for limited water resources can also create tensions among farmers, communities, and other water users.

As part of the Climate Vulnerability Assessment for Alachua County, a report discussing predicted changes to local and regional water use and changes to surface- and groundwater hydrology was developed. Climate changes are expected to have impacts in some sectors of water use but are not expected to have the same degree of implications for all water use types. Separate projections were made for non-agricultural and agricultural water use to develop an overall estimate of future water use for Alachua County. These estimates were separated because of the different drivers and trends for these types of use.

Drought can lead to water scarcity for agricultural activities, livestock, and domestic use. Competition for limited water resources can also create tensions among farmers, communities, and other water users.

Agricultural Water Use

The extent of agricultural acreage in Alachua County has gradually decreased as land use has shifted to more urban land uses, with a decrease of 21,000 acres of agricultural lands between 1985 and 2015 in Alachua County. From 1985 to 2022, irrigated acreage increased by approximately 4,000 acres, or 47%. These conversions to irrigation are consistent with increased land values and crop prices, which encourage higher yields, increased predictability, and higher-value crops. Furthermore, crop modeling suggests that irrigation will become essential to maintain yields as temperatures rise.

The analysis considered three scenarios for future irrigated acreage to estimate agricultural water usage. For each scenario (low, medium, and high), we calculated average irrigation by multiplying the irrigated acres by the climate-adjusted irrigation rate. These calculations provide a range of projected agricultural water usage, indicating that overall irrigation could more than double if land continues to be converted to irrigated agriculture at the current rate. Alternatively, if agricultural acreage continues to decline and irrigated agriculture maintains its share of total acreage, we may experience a slight decrease in agricultural water usage.

Non-Agricultural Water Use

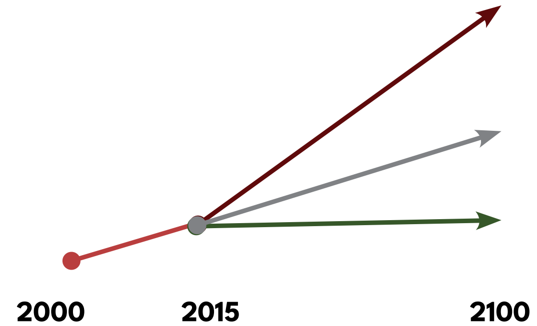
Water usage for all sectors except agriculture was estimated by combining historical trends and projected population changes. Although individual sectors were considered, estimating future use by sector did not seem advantageous for this study. To predict non-agricultural water usage, we calculated gross per capita water use for three scenarios to illustrate potential outcomes:

Low Estimate:
Per capita water use continues to **decrease,** following the trend observed between 2000 and 2015.

Medium Estimate:
Per capita water use **remains** at 2015 levels.

High Estimate:
Per capita water use **increases steadily** from 2015 (118 gallons per capita per day) to 2100 (137 gallons per capita per day).

This increase is driven by factors such as more irrigation for landscaping due to rising temperatures, increased use of automatic irrigation systems for lawns, and higher demands for power generation.



The calculated per capita water use values were multiplied by population estimates to forecast future water usage for each scenario. Estimates indicate that water usage will remain stable (low estimate) or nearly double from 2015 levels to the high estimate. The absence of ongoing decreases in water use is mainly due to the projected significant population growth in the County during the planning period.

Additional Agricultural Implications

In addition to evaluating natural hazards and socio-economic factors, the Climate Vulnerability Assessment delves into the agricultural implications of impending climate change. By studying the intersection of climate patterns and agricultural practices, the assessment offers critical insights into how Alachua County's agricultural sector may be affected in the future. This includes examining factors such as changing precipitation patterns, temperature fluctuations, and the increased frequency of extreme weather events, all of which could significantly impact crop yields, livestock management, and overall agricultural productivity. Agricultural production in Alachua County is pivotal for the local economy and the sustenance of its residents. Alachua County is responsible for producing several important agronomic row crops, including peanuts (5,000 acres), field corn (3,000 acres), and cotton and tobacco (400 acres). In addition to field crops, bahiagrass and bermudagrass are other important forage crops that are produced. Agriculture is the third largest employer in Alachua County and provides more than 27,000 jobs making up to 17.5% of the county's workforce.[8]

Agriculture indirectly sustains various local businesses such as banking, legal services, real estate, transportation, packing, marketing, and food distribution. Alachua County boasts over 180,000 acres of agricultural land, comprising 54% of the total land use. Most farms in the County (98%) are categorized as 'small farms' (less than 75 acres), with 88% being individually or family owned. Pastureland constitutes the most significant portion of agricultural land in Alachua County (37.5%), and cropland makes up only 31.3%.

Field maize production is important in Florida and the County since it is used for grain and silage and is widely used in the dairy and livestock industries (Wright et al., 2022).[9] Bahiagrass is the most common warm-season perennial grass grown in Florida and the County and is mainly used for livestock feed due to its adaptation to low soil fertility and low input management (Wallau et al., 2019).[10] Florida ranks first nationally in the production of snap beans (USDA NASS, 2022).[11] Snap bean production is an essential part of agriculture in the County since it is the second-most produced vegetable after watermelons. A suitable crop model for watermelon production was not available.

Crop simulation models were used to predict how future climate conditions will affect agricultural production in Alachua County. Three crop models were used to simulate a field (maize/corn), forage (bahiagrass), and vegetable (snap bean) crop in the County under four different management practices: 1) rainfed (non-irrigated) and non-fertilized, 2) rainfed and well-fertilized, 3) well-irrigated and non-fertilized, and 4) well-irrigated and well-fertilized.

By using crop simulation models and exploring various management scenarios, the team better understands how changing climate conditions may affect crop yields and overall agricultural productivity. Each crop type will be impacted by climate change in different ways, and crop-specific strategies will need to be developed.

Recommended Actions

To address these challenges, proactive measures are essential, including:

PHYSICAL INFRASTRUCTURE

WATER MANAGEMENT
Implement water management and conservation strategies, such as rainwater harvesting, greywater recycling, efficient irrigation techniques, and water storage systems.

AGRICULTURAL TECHNOLOGY
Invest in climate-smart agriculture and technologies to adapt to changing climatic conditions. For example, the County can work with the University of Florida to encourage partnerships and develop new technology to assist farmers in drought conditions.

POLICY

LAND MANAGEMENT
Require sustainable land management practices to prevent soil erosion and degradation, preserve agricultural land, reduce water use, protect water quality, and reduce wildfire risk.

HEAT STRESS PREVENTION PRACTICES
Implement policies that can reduce heat stress and related health risks, such as shade requirements or worker education.

AGGRESSIVE WATER CONSERVATION PROGRAMS
Reduce landscape irrigation, etc.
Implement polices that support and encourage smart irrigation systems in new developments and retrofits. Promote landscape polices that reduce water use.

FINANCE

WORKER RECOVERY
Find methods to support farmers and farm workers with financial assistance during challenging seasons.

LOCAL SUPPORT PROGRAMS
Develop programs that support consuming agriculture grown locally.

PLANNING

LAND USE
Consider existing land used for agriculture alongside population growth estimates to ensure that rural agricultural land remains protected over time.

DESKTOP EXERCISES
Hold desktop exercises with farmers (or partner with organizations) to understand how specific threats/ hazards may impact them and aid farmers in addressing those impacts.

COMMUNICATION

EVOLVING CROPS
Promote drought-resistant and heat-tolerant crop varieties to improve agricultural resilience.

FARMER EDUCATION
Educate farmers and workers on the health risks of extreme heat and drought and methods for prevention of those risks.

Conclusion

As Alachua County looks to the future, climate change will require a change in the way the County plans. The increase in temperatures, droughts, and precipitation will significantly impact the County, its operations, and the people who live and work there. In the coming years, the County will need to implement actions to prepare for these impacts.

The County needs to address the concerns by hardening infrastructure, implementing water management techniques, investing in agricultural technology, enacting County policies for land management, and creating plans to manage climate change concerns.

Finally, fostering collaboration and engagement with community members and stakeholders will be crucial for developing and implementing effective climate adaptation and mitigation strategies. Alachua County can build a sustainable and prosperous future for all its residents by working together toward a shared vision of resilience.

Alachua County can build a **sustainable** and **prosperous** future for all its residents by **working together** toward a **shared vision of resilience.**

Resources

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