TECHNICAL MEMORANDUM

CRITICAL INFRASTRUCTURE AND LAND USE CLIMATE VULNERABILITY ANALYSIS

TO: Shane Williams, PE

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DATE: November 15, 2023

SUBJECT: Task 3 – Wildfire
Jones Edmunds Project No. 01560-157-01

1 PURPOSE AND OBJECTIVES

Wildfire is essential for maintaining native biodiversity and ecosystem processes while having the potential for substantial environmental damage, including significant impacts on silviculture, loss of property, loss of crucial infrastructure, disruptions to traffic, and smoke pollution. This Technical Memorandum summarizes the Jones Edmunds Team's analysis of projected changes in threats associated with wildfire risk in Alachua County. We used this information to support the vulnerability analysis.

2 OVERVIEW

The United Nations (UN) (2022) identified worldwide land use, fire suppression, and climate change as altering wildfire characteristics. Smith et al. (2020) reviewed 116 articles published between 2013 and 2019 and found a strong consensus that climate change increases the likelihood of fire occurrence. In addition, Kelley et al. (2021) estimated that by 2100 the global increase in wildfire events will be between 31 and 52 percent, assuming Representative Concentration Pathways (RCP)2.6 and between 36 and 57 percent, assuming RCP6.0.The Alachua County vulnerability assessment has generally assumed an RCP of 8.5.

Alachua County includes various ecosystems with different fire-risk characteristics. Mitchel et al. (2014) overviewed fire interactions in the southeast United States and how those are likely to be influenced by climate change. The Mitchel et al. assessment of fire risks for some forest and landscape types within the County is summarized as follows:

- Forested Wetlands: Fire risk is linked to hydroperiod and drought. With short hydroperiods, wetlands burn more frequently. With extended hydroperiods, wetlands experience more severe fires during droughts. In addition, deep histosols (peaty soils) can sometimes burn, creating significant environmental changes through the loss of peat

material and ash accumulation. For example, the fire in the Santa Fe Swamp in 2007 resulted in substantial water-quality impacts on Lake Santa Fe.
- Pine Flatwoods: Longleaf, slash pine, or a mixture of the two dominate these systems, and fires are naturally frequent (every 3 to 5 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.

3 CLIMATE DATA

Jones Edmunds assessed wildfire risks for a baseline period and four future periods:

- Baseline (2005 to 2014)
- 2030 (2025 to 2034)
- 2040 (2035 to 2044)
- 2070 (2065 to 2074)
- 2100 (2091 to 2100)

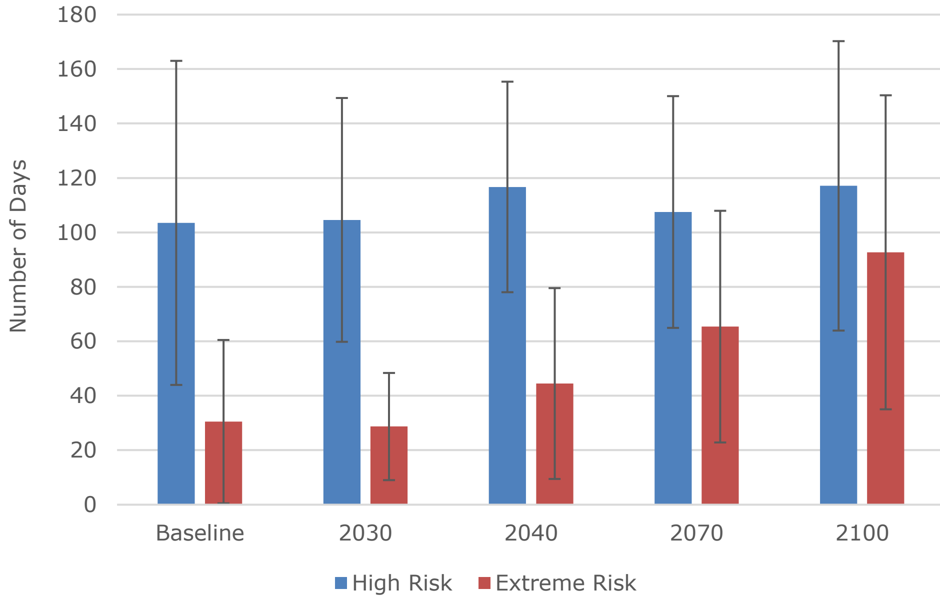
We downloaded daily data from the Inter-Sectoral Impact Model Intercomparison Project (ISMIP) 3b for fossil-fueled development (SSP5)-8.5 based on the Geophysical Fluid Dynamics Laboratory (GFDL) Earth System Model 4 (ESM4) models for each of the time frames:

- Maximum air temperature (tasmax).
- Minimum air temperature (tasmin).
- Precipitation (pr).
- Incoming solar radiation (surface downwelling shortwave radiation [rsds]).

The Jones Edmunds Team analyzed the Global Climate Model (GCM) climate data described in Section 3.2. We used weather data from the GCM to compare baseline conditions in Alachua County to predicted conditions for 2030, 2040, 2070, and 2100. Climate indices help predict the change in fire risk due to weather. For example, the Keetch-Byram Drought Index (KBDI) is often used in Florida to indicate the daily relative fire risk. In addition, the KBDI has been used in recent studies to predict how changes in future climatic conditions may influence wildfire potential (Gannon and Steinberg, 2021; Liu et al., 2013).

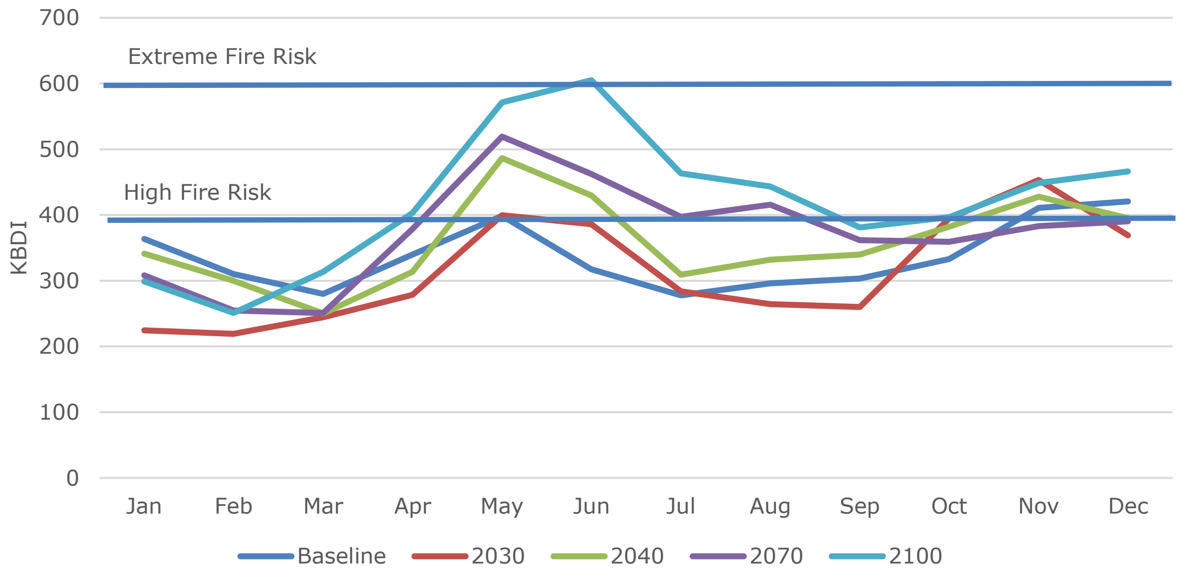
The KBDI ranges from 0 (no moisture deficit) to 800 (maximum moisture deficit). This index increases after days with no rainfall and decreases after rain events. The extent of the increase or decrease depends on the amount of precipitation and the maximum daily temperature. The Florida Fire Service calculates the KBDI using daily precipitation totals, maximum daily temperature, and soil type. High KBDI values indicate favorable conditions for the occurrence and spread of wildfires. Liu et al. (2013) characterized days with KBDI indices between 400 to 599 as posing a *high risk* for wildfires and 600 to 800 as posing an *extreme risk* for wildfires. Based on this classification, Figure 3-1 summarizes the average annual number of days with each level of wildfire risk for the assessment periods.

Figure 3-1 Average Annual Count of High and Extreme Risk Wildfire Days



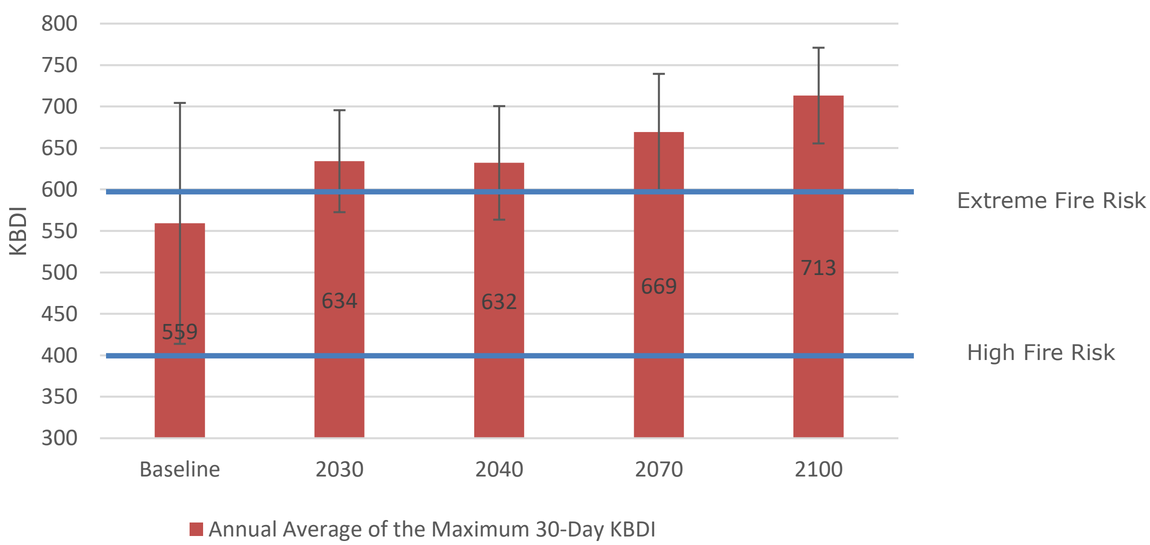
The Jones Edmunds Team used the KBDI to investigate the intensity and frequency of high-risk wildfire days over the assessment periods. First, we calculated the daily KBDI for Alachua County over each assessment period. Then, we used daily precipitation and maximum temperature values from the GCM to compare the length and severity of high-fire-risk days from the baseline period to future periods. Figure 3-2 illustrates the change in average monthly KBDI over the assessment periods. This figure shows a projected increase in average monthly KBDI in the summer months, with average monthly KBDI indicating high-risk conditions for wildfires in early summer from 2040 to 2100. Fire risk remains high throughout the summer months from 2070. KBDI is dependent on both increasing temperature and decreasing precipitation. Both variables are expected to increase over time. Therefore, these values suggest that temperature changes will contribute more to fire risk than precipitation changes. A number of studies indicates this (Liu et al. (2013), Flannigan et al. (2005))

Figure 3-2 Comparison of Average Monthly KBDI Values Under Future Climate Conditions for Alachua County



Additionally, the Jones Edmunds Team compared the average of the annual maximum 30-day KBDI for the assessment periods. We calculated the 30-day KBDI as a 30-day sliding average. Figure 3-3 displays this information, representing how fire-risk severity may change over time. Figure 3-3 also demonstrates the standard deviation of the annual maximum KBDI during each evaluation period showing that fire risk would become more severe under the climate change scenario we evaluated. Under this scenario, Alachua County would likely experience 30 days of extreme fire risk every year by 2070.

Figure 3-3 Annual Average of the Maximum 30-Day KBDI



4 WILDLAND-URBAN INTERFACE

The wildland-urban interface (WUI) is a significant factor driving wildfire risk. The WUI is the area where wildland and forest vegetation meet built structures. This interface is where wildfire poses the highest risk to people and infrastructure. Unfortunately, this interface is also where a fire is more likely to start because of human activity, and the presence of built structures makes controlling wildfires more challenging. Therefore, understanding the possible change in the WUI will be necessary for planning and mitigating fire risk in the future.

The methods for determining WUI vary from study to study. The two thresholds for determining WUI are land vegetation cover and structure density. In the literature, researchers commonly analyze structure density at the scale of census blocks. This scale can lead to errors because an entire census block is labeled a specific density when housing is concentrated in only one portion of the census block. Recently, the use of building footprints became accessible through a dataset released by Microsoft. Few studies have used this approach, although it offers a more accurate count of structures. Projections of future structure locations were not available for Alachua County. However, as an earlier part of this project, the Bureau of Economic and Business Research (BEBR) developed projections of future population density at the parcel scale for the County. Therefore, the Jones Edmunds Team chose an intermediate approach and used parcels to estimate future structure density and the associated WUI.

Radeloff et al. (2018) mapped the WUI change across the United States from 1990 to 2010 using the census block approach. The study found that the WUI in Alachua County increased from 300 square miles in 1990 to 383 square miles in 2010. The Jones Edmunds Team completed an analysis of the WUI based on 2021 parcel data and found that the WUI was approximately 316 square miles. The method used by Jones Edmunds omits areas of land that have a structure density of zero. These include roadways and areas between built-up parcels and likely account for the slightly reduced value of WUI land compared to the Radeloff et al. values.

Expanding populations are likely to cause the WUI in Alachua County to continue growing. The Jones Edmunds Team calculated the WUI based on the projected population density information provided by BEBR for the County for 2040, 2070, and 2100 and compared these to the WUI we calculated based on the 2021 population density provided by BEBR. The projected population densities include population increase due to projected climate migration.

Based on the definitions of WUI provided by the Federal Register, Intermix WUI represents land areas with more than one house/40 acres surrounded by 1.9 square miles of at least 50-percent vegetated wildland. The Interface WUI represents land areas with more than one house/40 acres within a distance of 1.5 miles of at least 1.9 square miles of 75-percent vegetated wildland. The following summarizes the steps we completed to calculate the WUI:

- Analyzing the WUI for Alachua County at the parcel scale.
- Determining house density for each parcel, assuming 2.49 persons per household. We based our assumption on the US Census Bureau's report for Alachua County.

- Accounting for non-residential buildings by using building counts from the Alachua County Property Appraiser.
- Classifying land as vegetated or non-vegetated based on the definition of WUI provided by the Federal Register and the fuel vegetation cover layer of LANDFIRE (a US Geological Survey [USGS] land cover resource).
- Selecting and merging parcels with more than 50-percent and 75-percent vegetation cover to identify continuous areas of vegetated land larger than 1.9 square miles for Intermix and Interface WUIs, respectively.
- Determining which parcels would remain vegetated with future population increases by assuming that developers would clear most natural vegetation from parcels with a projected population density of more than 1.8 people/acre.
- Classifying parcels with a housing density of more than one house/40 acres within the unbroken tract of 50-percent vegetated land as *Intermix*.
- Classifying parcels with a housing density greater than one house/40 acres within 1.5 miles of the unbroken tract of 75-percent vegetated land as *Interface*.

The results of the parcel analysis show a continued increase in the WUI land area in Alachua County. Table 4-1 and Figure 4-1 show each assessment year's combined (Intermix and Interface) WUI values. In addition, Table 4-1 shows the percent increase from the baseline year of 2021 to each assessment year until 2100. Figures 4-2 through 4-5 show the mapped extent of the WUI projected by the Jones Edmunds Team for the County in 2021, 2040, 2070, and 2100.

Table 4-1 Change in WUI Land

	WUI Land (mi^2)	Increase From Baseline (%)
2021	316	-
2040	419	33
2070	529	67
2100	623	97

Note: mi^2 = square miles.

Figure 4-1 WUI Under Current and Future Climate Conditions for Alachua County

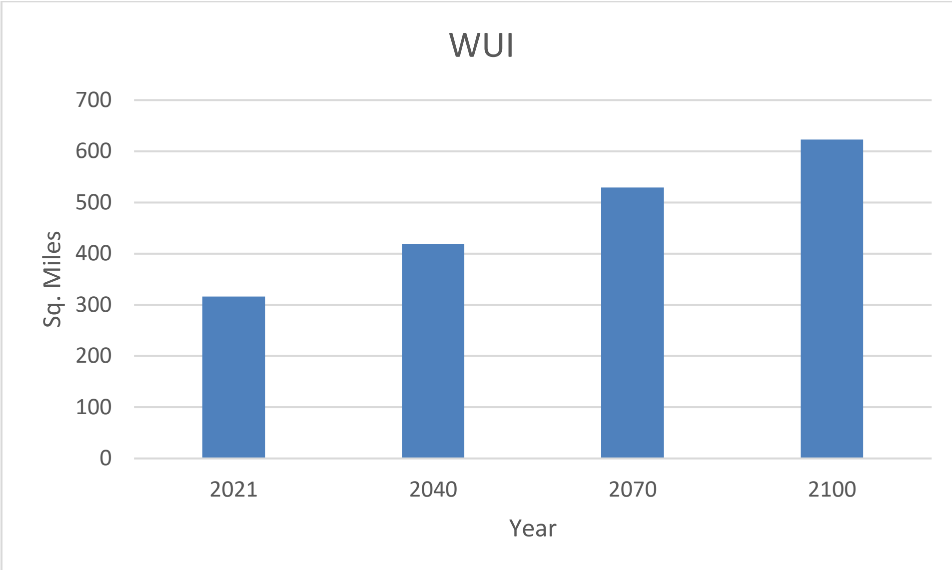


Figure 4-2 2021 WUI Parcels for Alachua County

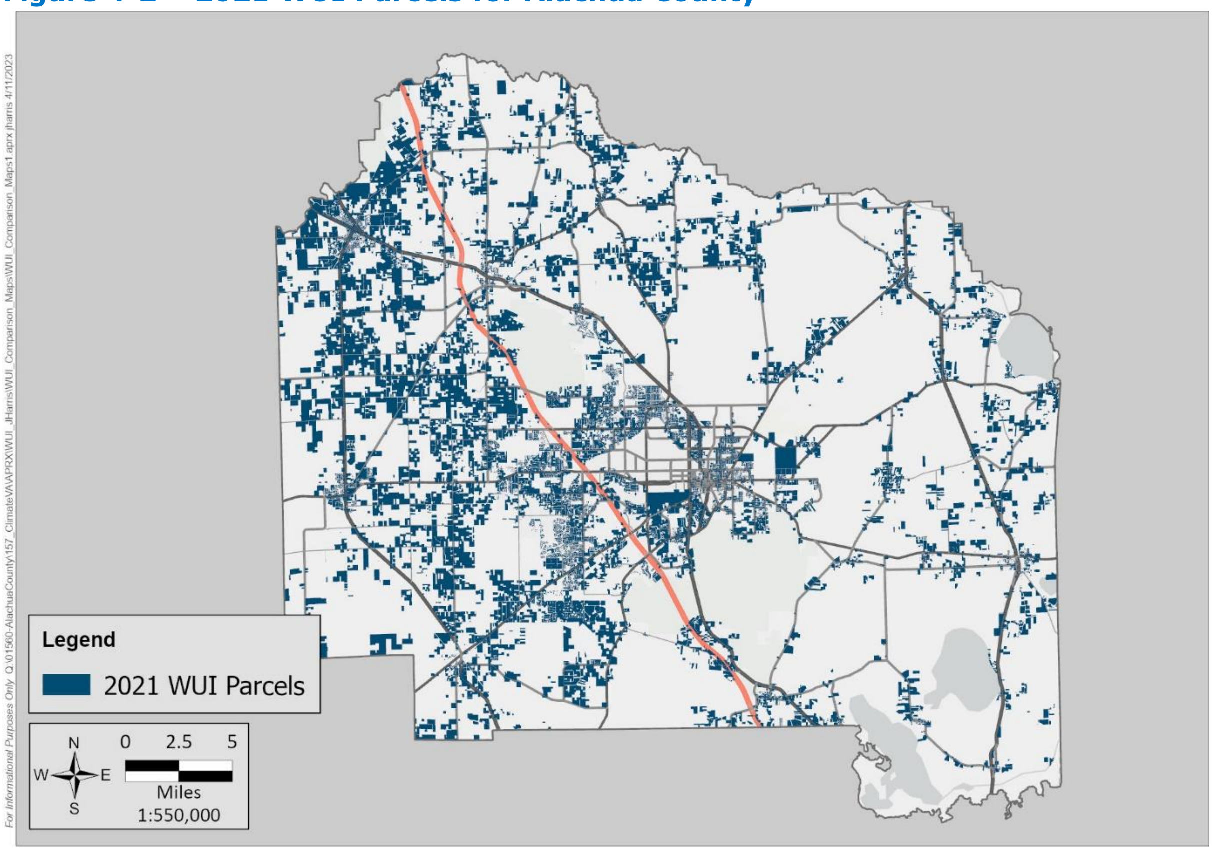


Figure 4-3 2040 WUI Parcels for Alachua County

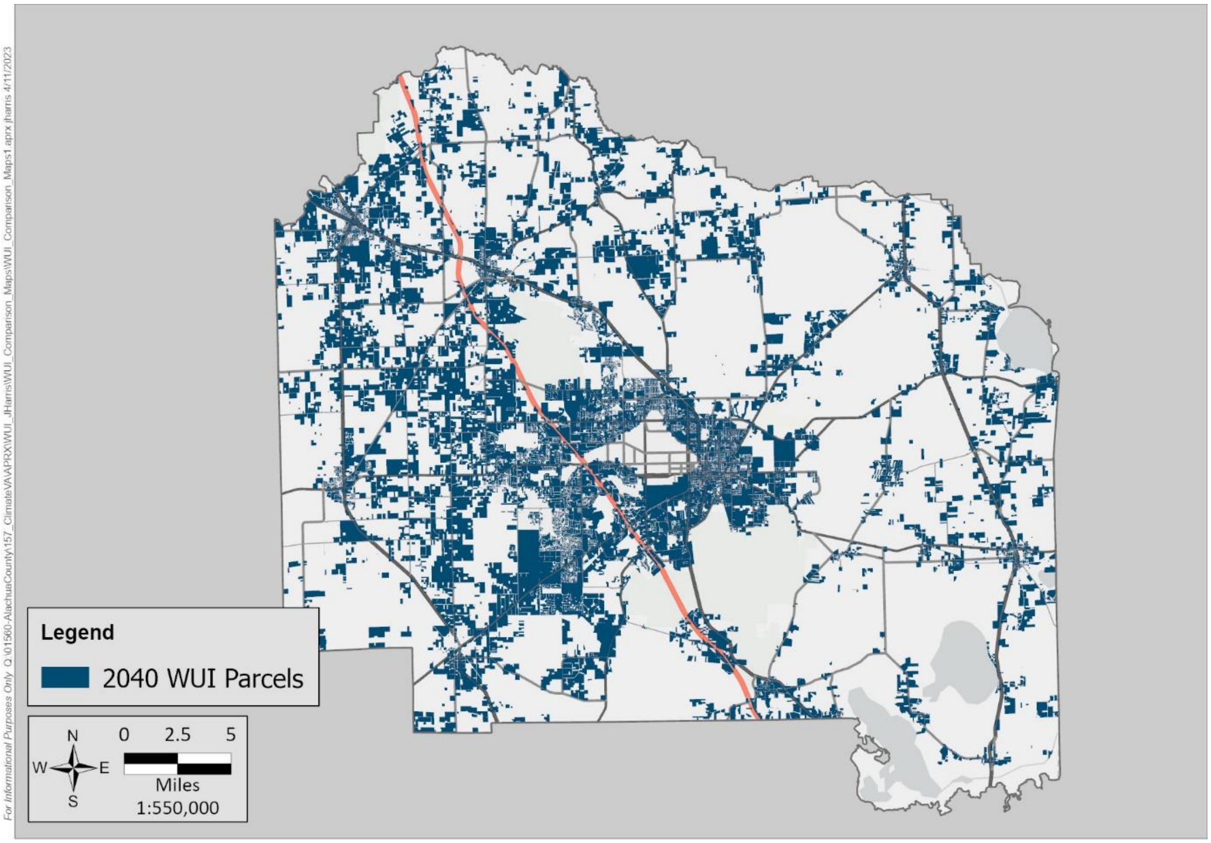


Figure 4-4 2070 WUI Parcels for Alachua County

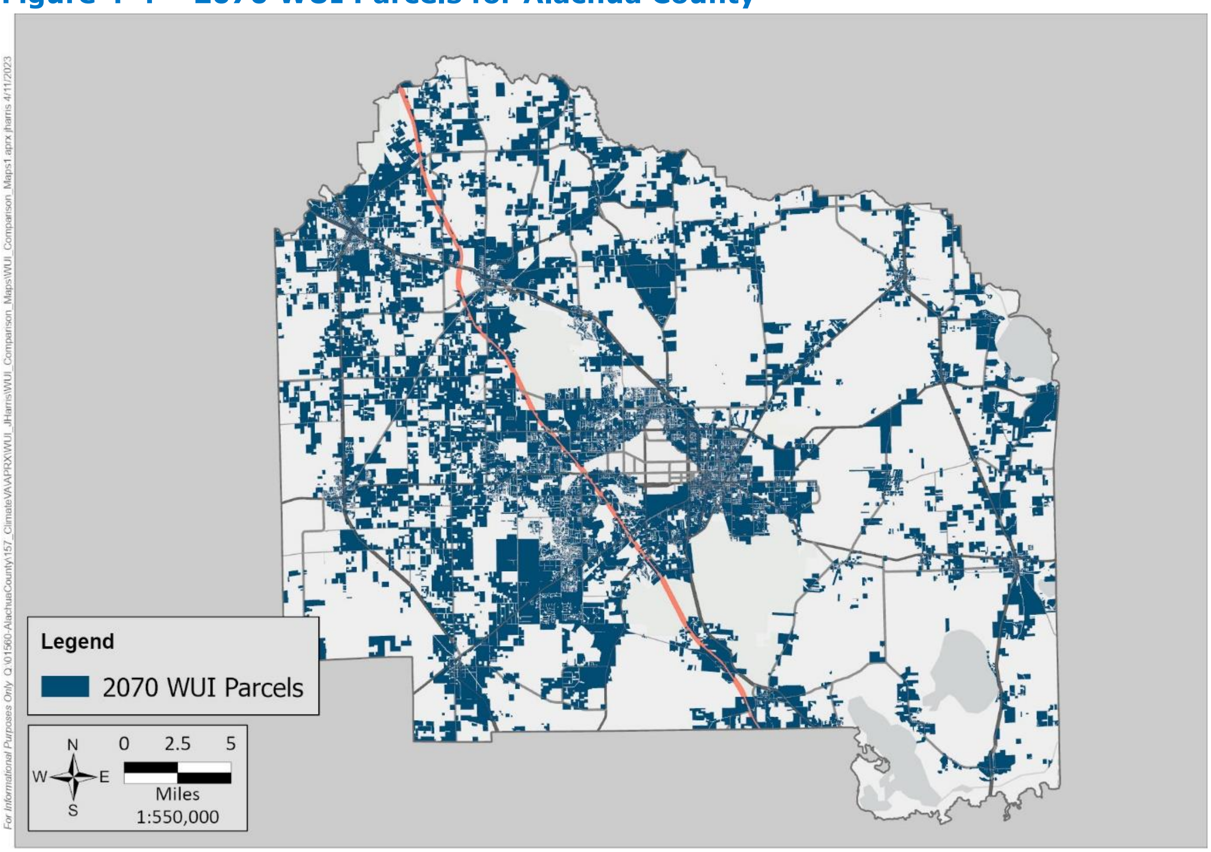
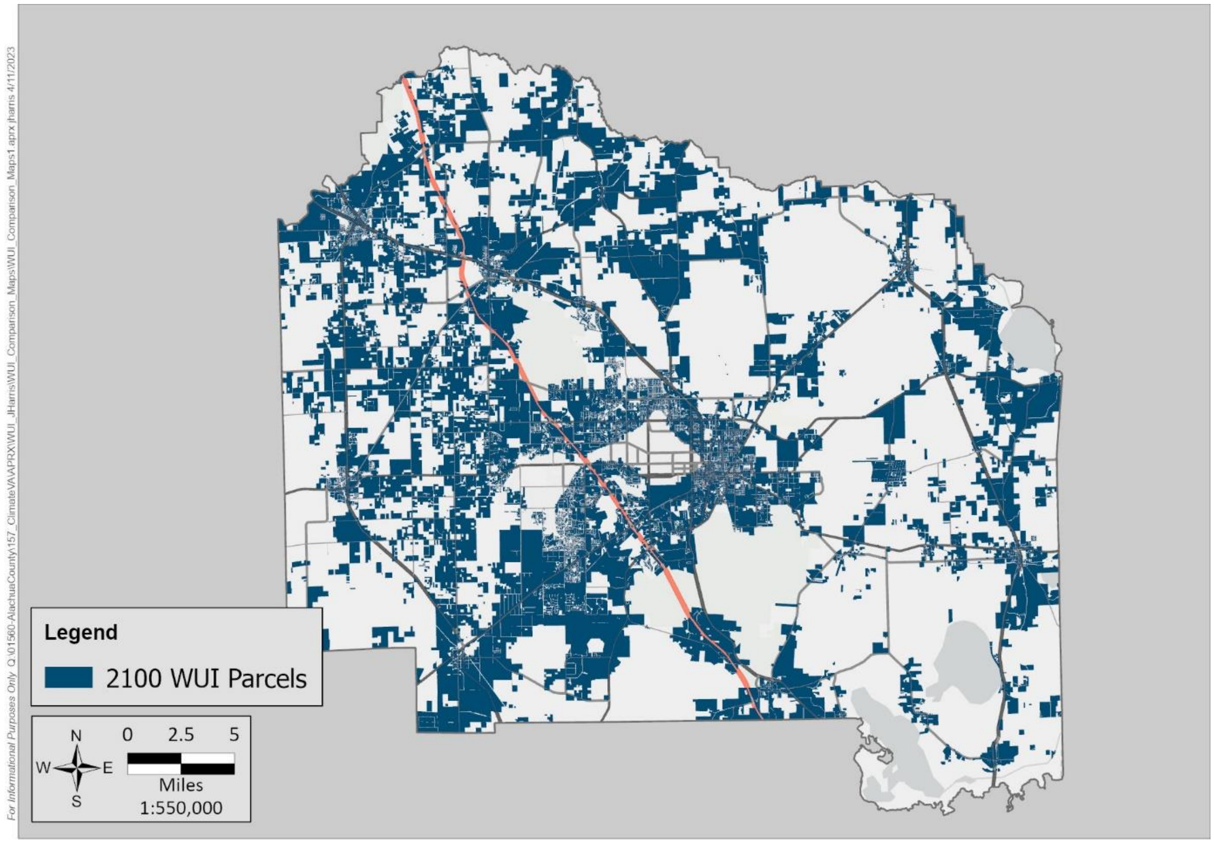


Figure 4-5 2100 WUI Parcels for Alachua County



5 OTHER FIRE RISK CONSIDERATIONS

Many other factors may impact forest systems and increase their vulnerability to fire. These include hurricanes, tropical low systems, changing species composition, changing fuel loads, and changing management strategies. Projected climate change will likely impact these factors. The following summarizes these projected impacts:

- Hurricanes can significantly impact forest systems. For example, Kelley et al. (2021) found that Hurricane Michael severely affected a longleaf pine woodland approximately 100 miles from the Florida coast in 2018. The study looked at mesic (moist) and xeric (dry) sites and estimated that the forests would take 10 to 35 years to recover from the loss of trees and vegetation (carbon losses) caused by the hurricane. These fallen trees and debris serve as fuel for wildfires. For example, the Florida Forest Service noted that the 2022 Bertha Swamp Road Fire, a 33,000-acre fire in the Florida Panhandle, was fueled by "vegetation left behind from Hurricane Michael." Projected hurricane intensity and frequency changes will likely increase the wildfire risk associated with hurricanes.
- Tropical low systems can also promote fire. For example, the Georgia-Florida Bay Fire Complex, the largest fire in this region in 50 years, was driven by a stationary tropical low-pressure system that led to consistently strong winds (Mitchel et al., 2014). In addition, forecasts of increasing tropical activity associated with global warming could exacerbate this fire-risk potential.
- Changing species composition may also impact wildfire risk. For example, Mitchel et al. (2014) noted that many areas of the southeast are likely to experience an increase in

the flammability of vegetation. However, Mitchel et al. (2014) also note that a reduction in the total fuel load forecast for the middle of this century could offset this increase. In addition, the Jones Edmunds Team has observed an increase in the planting of loblolly pine for silviculture within Alachua County and has noted that – when not managed appropriately – this planted pine can be particularly susceptible to wildfire.

- Continued adaptation and improvement of fire management practices could offset some of the projected increases in wildfire risk. Developing plans for managing wildfire fuels is critical for reducing wildfire risk. Alachua County's continued investment in the *Alachua County Forever* program has protected almost 40 square miles of the County. This investment significantly benefits the County by better managing these areas and helping mitigate some wildfire risks.

6 CONCLUSION

The Jones Edmunds Team evaluated the effect of climate change scenarios on wildfire risk in Alachua County. Our analysis of frequently used climate indices indicates that the risk of wildfire could increase significantly with the number of extreme fire-risk days almost tripling by 2100. We also used projected growth in the County to evaluate how the WUI may be impacted and found that the WUI is projected to double by 2100, potentially increasing the impacts of wildfire on the community. In addition, other factors such as increased hurricane intensity, more tropical low systems, and changing species composition may further increase the risk of wildfire.

7 REFERENCES

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