BEBR 2100 Population Projections for Alachua County Project Including Projections of Climate Migrants

INTRODUCTION

The purpose of this project is to develop a long-range forecast for Alachua County that takes into consideration the potential impacts of climate change/sea-level rise (SLR). Florida's official population projections are available from the Bureau of Economic and Business Research (BEBR) at state and county levels. However, these are insufficient for this project as they (1) currently extend to a shorter horizon of 2050, (2) the spatial distribution of projected population within the county is not available (making reliable projections for cities, utilities, or other smaller areas impossible), and (3) they do not currently take climate migration into account. For these reasons, Alachua County needed to develop a new forecast through the year 2100, at a finer spatial resolution, and that included a forecast of climate migrants, to meet the needs of its Critical Infrastructure and Land Use Climate Vulnerability Analysis and support future planning decisions.

COUNTY-LEVEL POPULATION PROJECTIONS

Population growth for Alachua County was forecasted using BEBR's standard methodology for its state and county projections. BEBR's latest (2022) forecast for the state and Alachua County[1] extends to the year 2050. It was published on February 11, 2022 and is based on data including the 2020 Census[2] and BEBR's 2021 Estimates[3]. This 2050 forecast was then extended to 2070 and 2100 using standard BEBR methodology applied to extrapolations of natural increase and net migration. Because the sum of BEBR's official county forecasts were higher than the official state forecast, the county forecasts were reduced in proportion to their population growth to match BEBR's forecast for the state. For this project, because of the long forecast horizon and the likelihood that climate will reduce growth in the coastal counties disproportionally to the inland ones (like Alachua), an average of the original BEBR forecast and the one adjusted to the state total was selected. It is shown in bold in Table 1 below. Note that there is considerable uncertainty with an 80-year forecast, but these projections are reasonable and suitable for the purposes of this study.

Table 1. BEBR Population Projections for Alachua County Project

Population Forecast	2040	2070	2100
Original Forecast Not Controlled to State Forecast	335,614	397,942	461,573
Revised Forecast Controlled to State Forecast	328,767	366,628	404,535
Project Forecast (Average of Controlled and Uncontrolled)	**332,191**	**382,285**	**433,054**

Sea Level Rise Projections

There are various models for projecting sea level rise, multiple scenarios estimating its severity, and different impacts modeled for specific locations (or stations). Based on recent Florida-specific literature[4] and guidance from a sea level rise expert at the University of Florida[5], the latest consensus choice for Florida is the NOAA 2022 model of intermediate-high sea level rise for the local mean sea level (LMSL). Four stations in Florida were selected that are near likely sources of climate migrants to Alachua County, and averages of the four were calculated for 2040, 2070, and 2100. These data were collected using the NOAA Sea Level Rise Viewer[6], and the results are in Table 2 below. Other stations from potential sources of climate migrants to the county were evaluated as well (e.g., Daytona Beach, Ft. Myers), but the differences in values were miniscule and resulted in insignificant changes to climate migrants.

Table 2. NOAA 2022 Intermediate-High Sea Level Rise (SLR) Projections (feet)

Location	2040	2070	2100
Key West	0.92	2.62	5.35
St. Petersburg	0.95	2.62	5.35
Cedar Key	0.89	2.49	5.12
Mayport	0.95	2.59	5.18
AVERAGE	**0.93**	**2.58**	**5.25**

Climate Migrant Projections

Although there is significant research into the localized impacts of sea level rise, there is little research available attempting to quantify likely changes to human migration patterns at the county level due to sea level rise. Two such studies were identified and evaluated, and Hauer's 2017 study[7] was selected for use in this project. That study projected climate migration using sea level rise models and historical migration flows from IRS data. Hauer produced a scenario with human adaptation to reduce sea level rise and one without human adaptation. While Hauer points out that some adaptation to mitigate sea level rise may occur particularly in affluent areas, he features the "no adaptation" scenario in his charts and graphs. This was the scenario selected for this project.

Some adjustments had to be made to forecast net climate migrants for Alachua County. By 2100, the old sea level rise model relied upon in Hauer's 2017 work showed a rise of 1.8 meters (5.91 feet), and NOAA's 2022 Intermediate-High Projection scenario for the selected stations show an average rise of 5.25 feet. Also, the population Hauer projected for Alachua County was different from the latest BEBR forecast. To use the 2017 results with our current projections, Hauer's 2100 projection of net climate migrants was adjusted in proportion to the projected increases in SLR to the 1.8 meters (5.91 feet) used by Hauer. Proportional values were calculated based on sea level rise for 2040, 2070 and 2100, and then added to the BEBR projections. There are limitations to this approach, as the change in climate migrants may not be directly proportional to the change in sea level rise. However, because we lack climate migrant projections corresponding to the sea level rise projections for 2040 and 2070, this approach was reasonable and produced credible projections of climate migrants. The projections derived are in Table 3 below and reflect a projected increase in net migration to Alachua County due to sea level rise of more than 23,000 by 2100. Depending on the accuracy of the sea level rise models, BEBR's projections, and the assumptions made about climate migration, this may be low or may be high, but it is a reasonable forecast for this planning exercise.

Table 3. BEBR Population Projections for Alachua County Project with Climate Migrants

Population Forecast	2040	2070	2100
Average of the Controlled and Uncontrolled Forecasts	332,191	382,285	433,054
Projected Additional Net Migration Due to SLR	4,067	11,475	23,239
Projected Population Including Additional SLR Migration	**336,258**	**393,760**	**456,293**

GEOSPATIAL BUILD-OUT SUBMODEL

Once the county-level population forecast was made, a geographic information system (GIS) based "Build-out Submodel" was developed for Alachua County. Using a combination of property appraiser, 2020 Census and BEBR data, current (2021) parcel-level population was estimated. Those estimates were then controlled at city and county levels to the 2021 BEBR population estimates. Using those data in combination with future land use, historical development densities, planned developments, wetlands, and infrastructure considerations, maximum residential development (or "build-out") was forecasted at the property parcel level.

Parcels

The GIS parcel layer and county tax roll data were obtained from the county property appraiser's office. Required tax roll table fields include actual year built, Florida Department of Revenue land use code, and the total number of existing residential units for each parcel. In cases where values or fields were missing, other relevant information was extrapolated and used as a surrogate. For example, a combination of 2020 Census data and BEBR's annual surveys of large group quarters facilities were used to identify the number of residential units (and population) in some institutional parcels.

U.S. Census Data

Some of the essential data to translate parcels to population in the Build-out Submodel was derived from the 2020 Decennial Census. Average housing unit occupancy and average household size by census tract was calculated and then transferred to the underlying parcel data. These data were used to calculate the average population per housing unit, which enabled the estimation of household population from parcel-level housing unit estimates. BEBR surveys and/or Census Bureau population counts of group quarters facilities augmented property appraiser data to estimate the group quarters population.

Future Land Use

Future land use maps were used to help guide where and at what density residential development would likely occur. Although these future land use maps are often revised over time, they reflect the most up-to-date plan available for future growth areas and densities. The latest available future land use maps were obtained, and land uses and associated densities were assigned to the underlying parcels in the Build-out Submodel.

Build-out population was modeled for future land use classes that allow residential development. Development typically does not occur at the maximum densities allowed for each future land use category, so recent development densities were considered a better proxy for future densities than the maximum allowable density. For this reason, the median density of recent development was used as a proxy for future densities for each of the 83 future land use categories across the 10 jurisdictions. For example, if a city's medium density residential future land use designation allows up to 8 housing units per acre, but the median density of units built recently is 6.7 housing units per acre, the sub-model assumed future densities at 6.7 housing units per acre for that future land use designation in that jurisdiction.

Typically, the median density calculation was limited to the last 20 years of development within each unique combination of land use and jurisdiction, as more recent development was deemed a better proxy for future densities than older development. In some cases, limiting the historical data to the last 20 years resulted in too small a sample, so either county average values were used (extended beyond the jurisdiction) or a longer base period was used (not limited to the last 20 years). In those cases, the determination of which sample to use depended upon the heterogeneity of the category across county jurisdictions, the heterogeneity of historical densities prior to the last 20 years, and our professional judgement.

The results were vetted and occasionally modified by local planners, although some jurisdictions did not respond to the review requests. In the case of Unincorporated Alachua County, most of the future land use categories were assigned densities by county planning staff, overriding the median density calculations.

Wetlands

Wetlands (including surface water) are a limiting factor when forecasting development potential. Wetland types were identified that would be difficult and expensive to convert to residential development. A GIS feature class of these wetlands were overlaid with the county's parcels. The wetland area within each parcel was calculated, and if it exceeded 0.5 acres, it was subtracted from the total area of the parcel feature to determine the developable area in that parcel.

One exception was with residential parcels that were already developed or recently platted that had little or no developable area after wetlands were removed. Housing units on such parcels were generally not reduced by the wetland acreage, unless the parcel already had one or more housing units but was expected to have additional housing units at build-out (e.g., large rural/agricultural parcels with a single housing unit).

Conservation Areas

Conservation areas were provided by the county and used to prevent future residential development on parcels within those areas. Any current (2021) population was projected to exist in the future, but no new growth was allowed.

Administrative Boundaries

Each parcel in the Build-out Submodel was also attributed with administrative boundaries, including (1) city name (or unincorporated area) from the 2020 Census, and (2) water management district boundaries. These attributes enable queries and summaries of the population projections by any combination of these boundaries.

Planned Developments

The final step in the development of the Build-out Submodel was adjusting the maximum densities for parcels within planned developments to be consistent with approved development plans wherever their boundaries are available in a GIS format.

Build-out Density Calculation

Using GIS overlay techniques, attributes of the census, future land use, wetlands, administrative boundaries, and planned developments were attributed to the parcel data to develop the Build-out Submodel. This submodel estimates current population and forecasts the maximum population by parcel at build-out.

Figure 1 depicts the Build-out Submodel shaded by maximum housing units per acre at build-out.

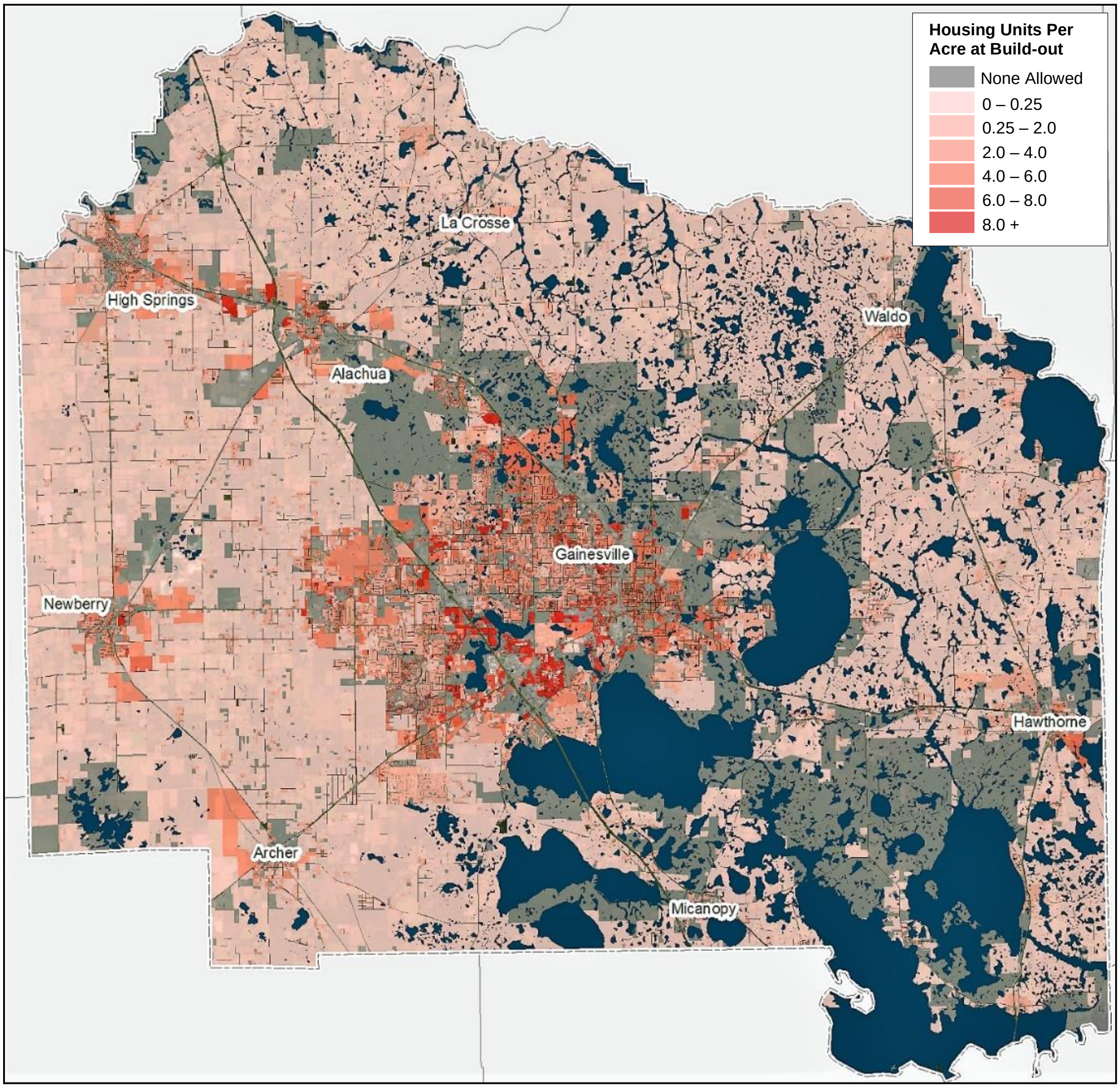

Figure 1. Alachua County Build-out Density Submodel

GROWTH DRIVERS SUBMODEL

The Growth Drivers Submodel is a raster (cell-based) GIS model representing the likelihood of development. The submodel is a continuous surface of 10-meter cells containing values of 0-100, with '100' having the highest development potential and '0' having the lowest development potential. It influences the Population Model by applying the historical relationship between certain spatial features deemed growth drivers and residential development.

These drivers were identified from transportation, property parcel, and land use/land cover data. They include the following:

1. Proximity to roads and interchanges (with each road type modeled separately)
2. Proximity to planned developments
3. Proximity to selected commercial parcels with land uses deemed attractors to residential growth
4. Proximity to existing residential development
5. Proximity to surface water bodies

The Growth Drivers Submodel is shown in Figure 2 below. High development potential is in red, moderate development potential is in yellow and low development potential is in greenish blue.

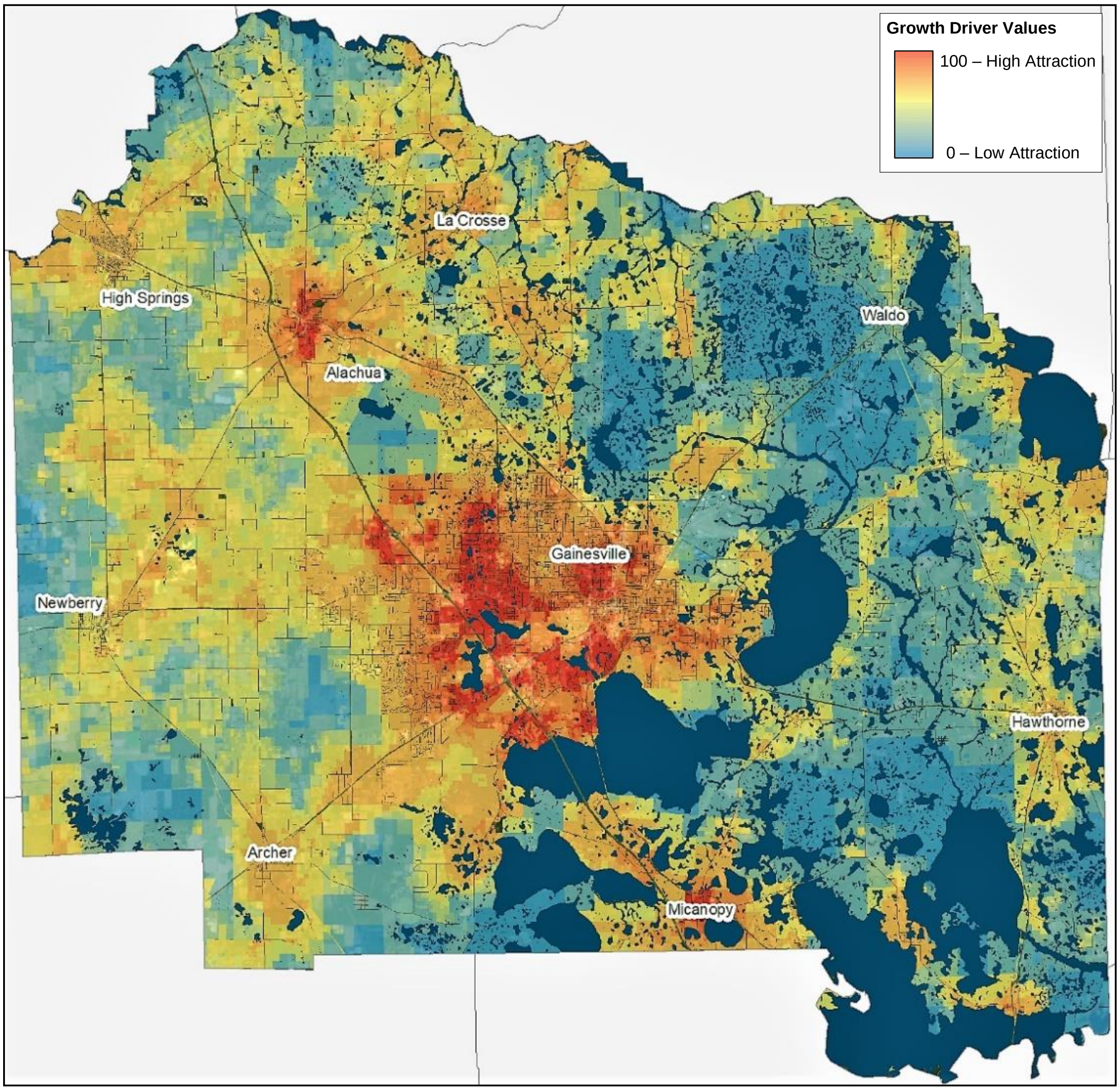

Figure 2. Alachua County Growth Drivers Submodel

Each of the drivers listed above were used as independent variables in a logistic regression equation. The result was a grid with values 0 through 100, for which a value of 0 represented the lowest relative likelihood of development, and a value of 100 represented the highest relative likelihood of development. These values were later used by the Small-Area Population Projection Model to rank undeveloped parcels based on their development potential, which is explained in the "Growth Calculation Methodology" section. Note that growth may still occur in areas assigned relatively low values from this model based on the historical growth trends. This model only guides projected growth within census tracts and when the county Model projection totals are below the BEBR targets.

GEOSPATIAL SMALL-AREA POPULATION FORECASTING MODEL

The Small-Area Population Forecasting Model integrates the Build-out Submodel and the Growth Drivers Submodel and makes the projection calculations using a combination of those submodels, historic growth trends, and growth controls from BEBR's county-level forecasts.

Historic Growth Trends

The historic growth trends were based on historic population counts from the 1990, 2000, 2010, and 2020 decennial censuses. For 1990, 2000, and 2010, census block population counts were summarized at the 2020 tract level and combined with the 2020 tract population counts. These counts were used to produce eleven tract level projections using five demographic extrapolation methods over multiple base periods. The highest and lowest calculations were discarded to moderate the effects of extreme projections, and the remaining projections were then averaged.

The five demographic extrapolation methods for projecting population utilized by the model were Linear, Exponential, Constant Share, Share-of-Growth and Shift-Share. Each of the five methods is a good predictor of growth in different situations and growth patterns, so using a combination was the best way to avoid the largest possible errors resulting from the least appropriate techniques for each census tract. This approach is similar to BEBR's county population forecast methods, but the base periods and the number of projections are somewhat different because annual estimates are not available at the tract level.

The calculations associated with the five statistical methods are described below. The launch year was 2021, and the projections were made for 2040, 2070, and 2100.

1. Linear: The Linear Projection Method assumes that the change in the number of persons for each census tract will be the same as during the base period[1]. Three linear calculations were made, 1990 to 2000, 2000 through 2020, and 2010 through 2020.
2. Exponential: The Exponential Projection Method assumes that each census tract's population will continue to change at the same percentage rate as during the base period[1]. One calculation was made from 2010 through 2020.

3. Constant Share: The Constant Share Projection Method assumes that each census tract's percentage of the county's total population will be the same as over the base year[1]. One calculation was made using the 2020 share of the county's population.
4. Share-of-Growth: The Share-of-Growth Projection Method assumes that each census tract's percentage of the county's growth will be the same as over the base period[1]. However, whenever population change was negative at the tract level, the "Plus-minus" variant of the Share-of-Growth Method was used. Three Share-of-Growth calculations were made, 1990 through 2020, 2000 through 2020, and 2010 through 2020.
6. Shift-Share: The Shift-Share Projection Method assumes that each census tract's percentage of the county's total annual growth will change by the same annual amount as over the base period[1]. Three Shift-Share calculations were made, 1990 through 2020, 2000 through 2020, and 2010 through 2020.
7. Averages: For 2040, eight calculations with base periods up to 20 years were used, the two lowest and two highest were excluded, and the remaining four were averaged. For 2070 and 2100, eleven calculations with base periods up to 30 years were used, the three lowest and three highest were excluded, and the remaining five were averaged.

Growth Calculation Methodology

The Population Projection Engine™ then automated growth calculations using the historic growth trends and queries of the Build-out and Growth Drivers Submodels. The methodology for calculating growth for each projection increment included the following steps:

1. Apply the tract-level projected growth to parcels within each tract, distributing growth to parcels with the highest driver values first.
2. Check growth projections against build-out population, and reduce any projections exceeding build-out to the build-out numbers.
3. After projecting growth for all census tracts in the county, summarize the resulting growth and compare it against countywide BEBR target growth. This step can lead to one of two scenarios:
    a. If the Small-Area Population Forecasting Model's projections exceeded the BEBR target growth, reduce the projected growth for all tracts by the percentage that the projections exceeded the BEBR target. This is more likely to occur with shorter projection horizons (e.g., five to 15 years), and did not occur in any of the model runs for this project.
    b. If the Small-Area Population projection model's projections were less than the BEBR target, develop parcels with the highest growth driver values and available capacity until the BEBR target growth is reached. This is more likely to be the case with longer projection horizons, and was the case for all model iterations (2040, 2070, and 2100) for both model runs (with and without climate migrants) for this project.

DELIVERABLES

Finally, the parcel level estimates and projections were delivered in Esri's File Geodatabase format with a single polygon feature class containing parcel-level results for the county. These GIS outputs are useful for quality assuring the results and inputs, for maintaining the model inputs over time, and for graphically depicting current population and projected future growth.

Figure 3 below is a map of parcels shaded to depict current (2021) population per acre.

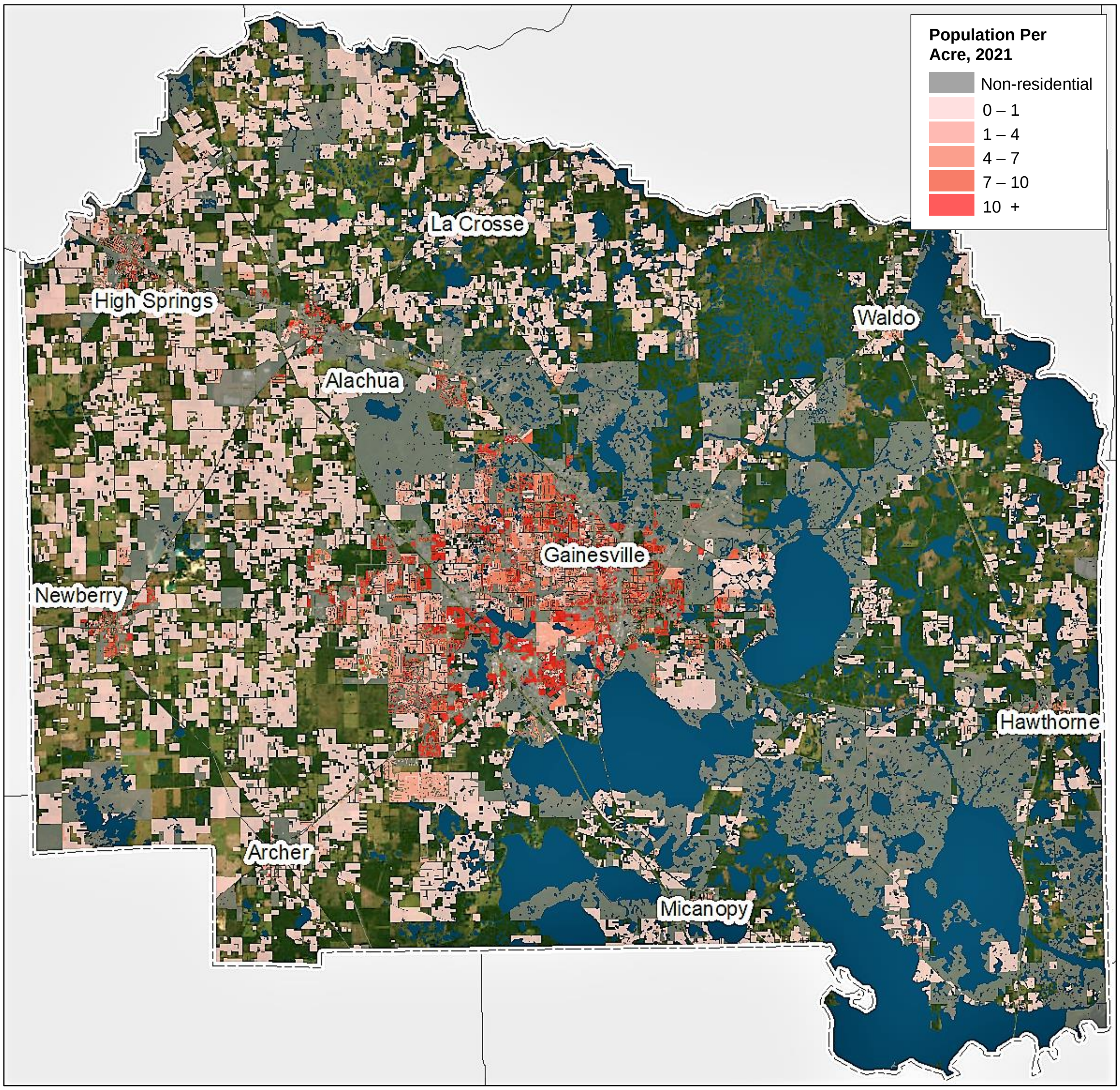

Figure 3. Alachua County 2021 population per acre

Figure 4 below is a map of parcels shaded to depict projected population per acre in 2100 including climate migrants.

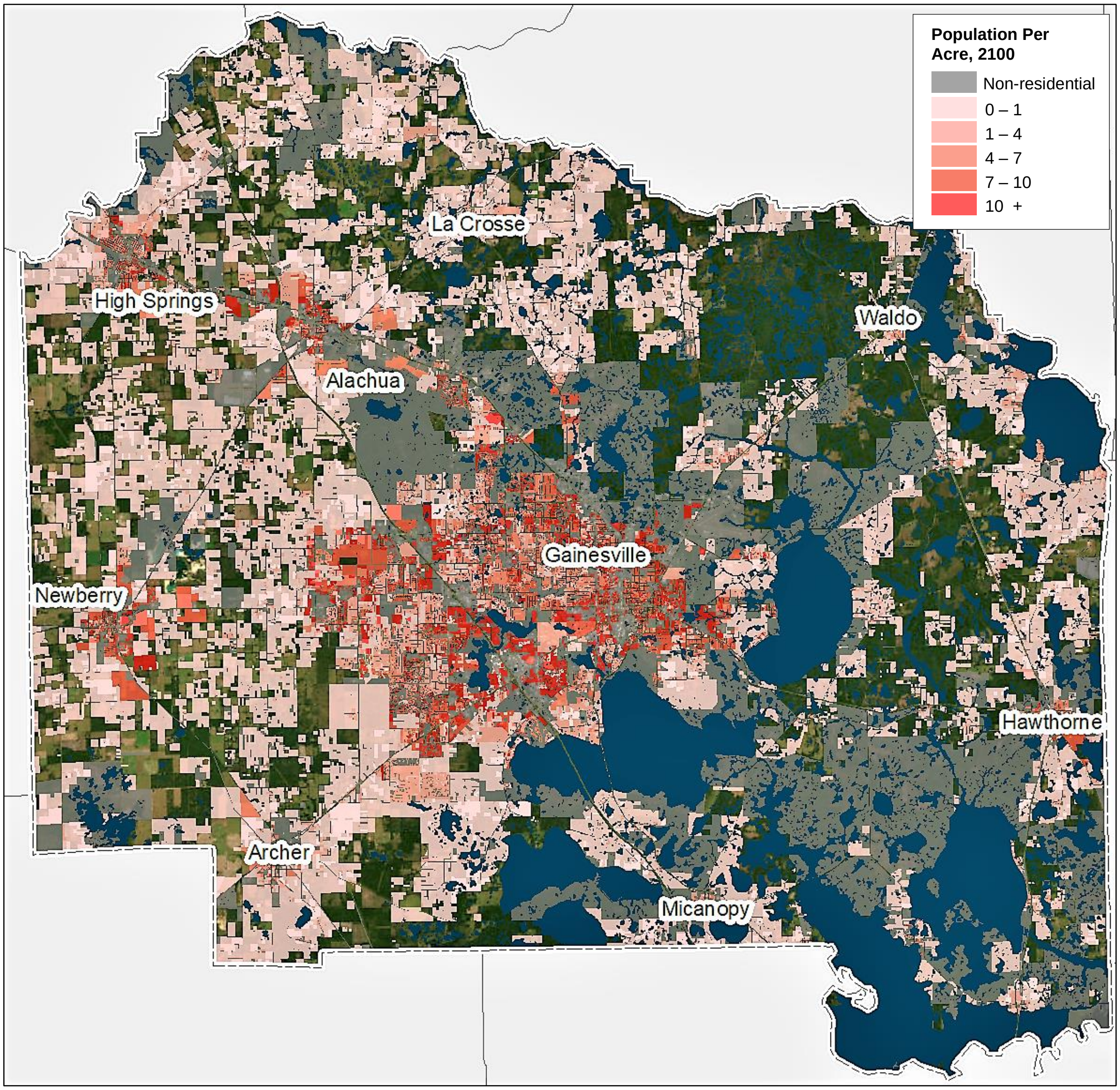

Figure 4. Alachua County 2100 projected population per acre

Figure 5 below is map that depicts parcels shaded based on the time period projected for development. Parcels with current (2021) population are shaded gray, parcels projected to be developed between 2021 and 2040 are shaded red, parcels projected to be developed between 2040 and 2070 are shaded yellow, and parcels projected to be developed between 2070 and 2100 growth are shaded green.

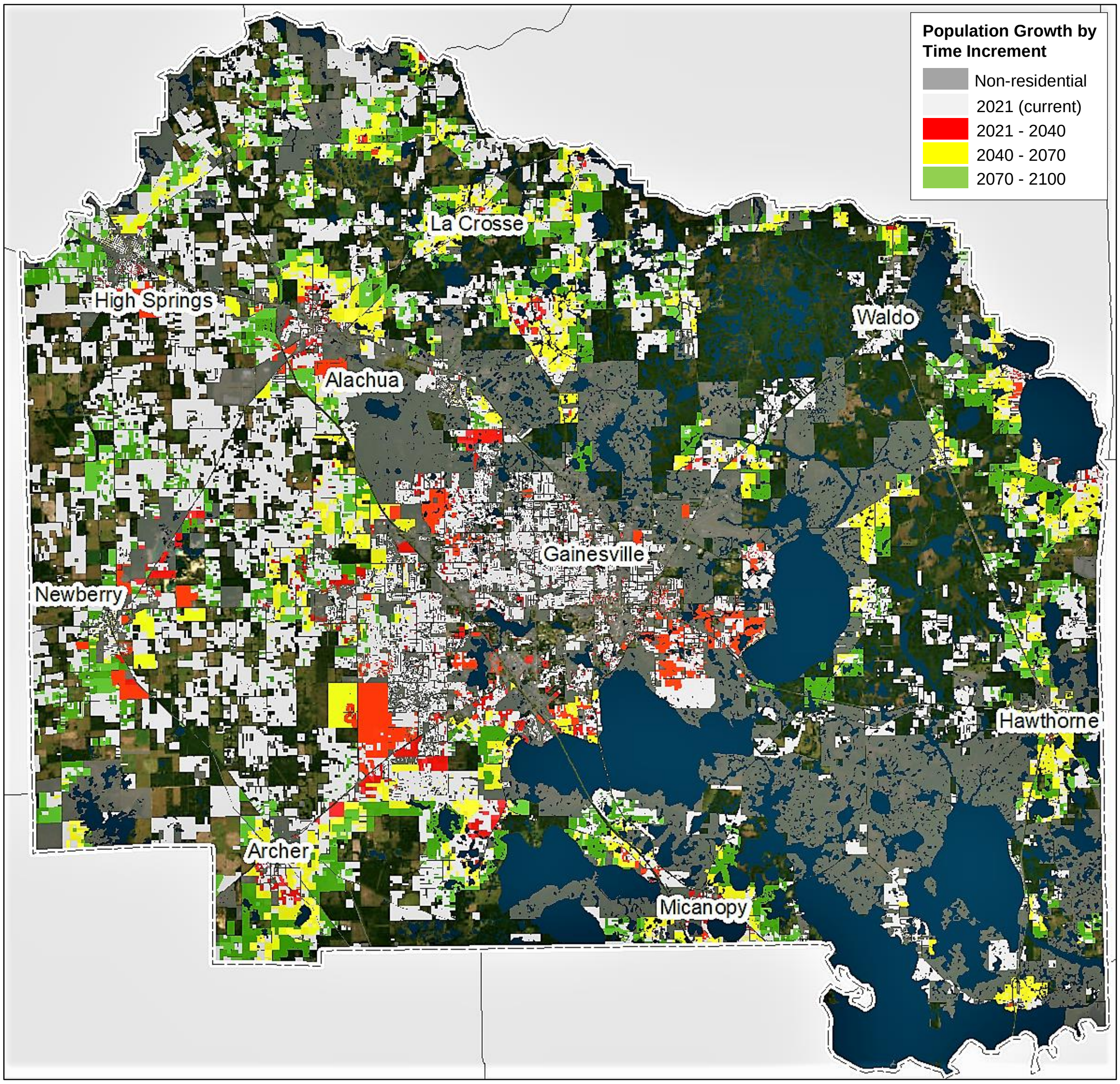

Figure 5. Alachua County forecasted population by time period

CONCLUSIONS

These projections reflect a likely scenario for population growth with additional climate migrants due to SLR/climate change. Although it is a forecast based on the best data available, there is a great deal of uncertainty in such a long-range forecast.

First, while we have a good understanding of where the direct impacts from SLR will be felt, the SLR models are less certain about when that will happen. Also, we do not know whether adaptation will occur, and if so, how long it will delay those impacts. Moreover, it is likely that a significant number of residents near the coasts but not directly impacted may be indirectly impacted, either by loss of employment, increasing cost of living, or other impacts that may cause them to leave.

Second, while Alachua County still has more births than deaths, Florida has more deaths than births, and all indications are the gap between the two will continue to widen into the foreseeable future. Therefore, Florida's net growth will be based entirely on net migration - both domestic and foreign. Growth in the state is already beginning to slow, and we do not know how insurance rates, SLR, worsening storms, and increasing temperatures will affect the desirability of Florida for current residents and future migrants. If residents leave areas that are directly impacted, will they leave their county of residence? Will they migrate to inland counties like Alachua? Or will they leave the state entirely? It is impossible to know the answers to these questions without extensive surveys and studies to attempt to predict the likely actions of current and potential future populations. These do not currently exist.

Third, there is always uncertainty with the population projections, particularly for 2070 and 2100. There are many reasons that these may be higher or lower in the future. Birth and death rates, in-migration, and out-migration may differ from what have been projected. Significant economic events in the US and abroad can dramatically affect migration. And, as mentioned previously, SLR, stronger storms, and cost of living increases in Florida may make the state less attractive a destination for retirees and other in-migrants.

This is an important first step in assessing potential impacts of climate change and sea level rise for Alachua County. It is likely that there will be more relevant research, studies, and data to leverage to refine the forecast in the future as SLR/climate change impacts continue to be studied. Because of the importance of this work to inform decision making, and because of the uncertainty with the forecast of these impacts, periodic updates (e.g., every five years) to this work is recommended.

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