

2019 Sub-County Population Projections for Jurisdictions in Pima County

Pima Association of Governments

1. Background

Executive Order 2011-04 designated the Arizona Office of Economic Opportunity (AOEO) as the State agency responsible for developing official population estimates and projections for the State of Arizona. Regional Councils of Governments (COGs) are requested to assist AOEO in preparing the projection series. COGs, in accordance with AOEO policy, also have the option to produce sub-county population projections to incorporate with the series from AOEO. As a COG, Pima Association of Governments (PAG) signed a petition on January 31st, 2019 to generate the 2019 sub-county population projection series for incorporated jurisdictions and the unincorporated balance of Pima County.

2. Sub-county Population Projection in Pima County

2.1 Assumptions

Sub-county population projections of all municipalities and unincorporated Pima County are developed based on the 2018 boundaries of each municipality as of July 1st. These boundaries remain unchanged throughout the projection horizon. Future annexations or de-annexations cannot be predicted and are therefore not considered by this methodology.

Using the established geographical boundaries PAG estimated the population growth capacity of each jurisdiction. This calculated capacity was held constant across the forecast horizon to ensure that the projected population of each municipality can be absorbed by current planning standards. PAG examined future land use plans and American Community Survey (ACS) 5-year estimates to establish a population growth cap for each jurisdiction based on the availability of developable land at current population densities. These constraints were defined by analysis of metrics such as total buildable land and the maximum of permitted dwelling units on vacant, infill, and redevelopable land. When a municipality reaches the limit of its growth capacity, its population will plateau. PAG assumes these constraints are stable and fixed within each jurisdiction's boundary for the entirety of the projection period.

In 2018, the Arizona Office of Economic Opportunity (AOEO) produced 2018-2055 population projections for Pima County. The sub-county population PAG has developed adopts the Pima County control total established by AOEO.

2.2 Methodologies

Following jurisdictional stakeholder discussion and recommendations PAG developed four population projections. These are:

1. The Time Series method
2. The 2016 Population Share method,
3. The average of the Time Series & the 2016 Population Share methods
4. The 2013-18 Growth % Share method.

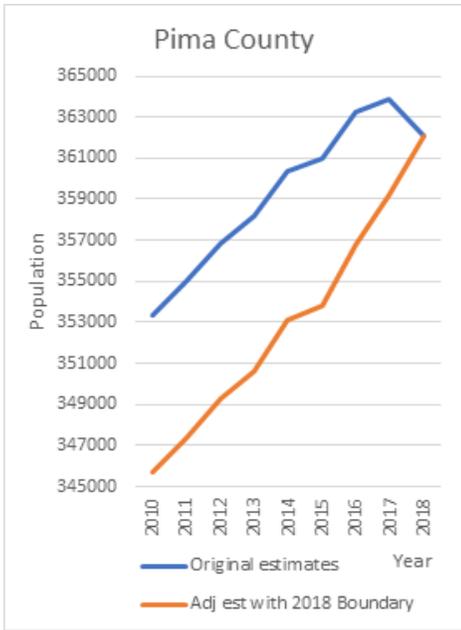
PAG's jurisdictional members reached consensus to recommend the average of the Time Series and the 2016 Population Share methods. These two methodologies are discussed in detail below.

2.2.1 The Time Series Analysis Method

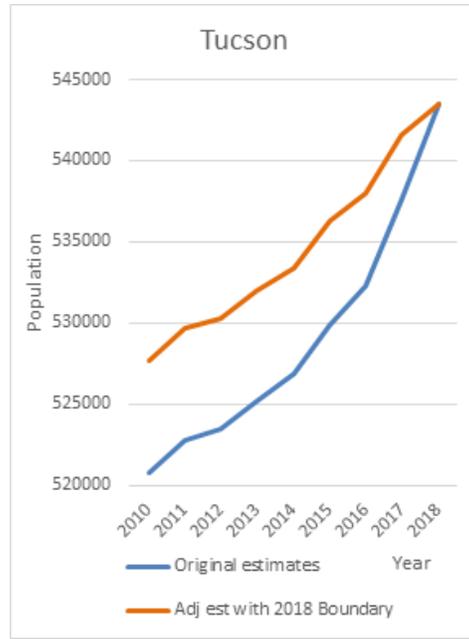
The Time Series method uses historical population estimates to project a time series trend for future growth of each municipality. As input for the time series, PAG used July 1st State population estimates by jurisdiction from 1980 to 2018, with exceptions for the Town of Sahuarita (1995 to 2018 only) and the City of South Tucson (2010 to 2018 only).

As the time series method relies principally on a historical trend to forecast growth potential into the future, it is important to count the historic population within a consistent municipal boundary across the entire time series to avoid annexation bias. For that reason, historical sub-county population estimates were adjusted based on 2018 jurisdictional boundaries to control for political annexations. Population projections series were then set to proceed from the fixed 2018 boundaries.

PAG adjusted the annexed population backward from 2018 using available 2010-2018 annexation data from AOEO. Unincorporated Pima County's original historical population trend (in blue) shows a recent significant drop by out-annexation(Figure 1(a)). Without any historical trend adjustment to account for annexation, a jurisdiction like unincorporated Pima County could show negative growth despite increasing population. In this case, the out-annexed population was reduced sequentially and accumulatively over the 2010-2018 period to rectify the impact of this bias on the historical population trend. The orange trend line in Figure 1(a) represents the adjusted population growth. The orange trend line of Figure 1(b), by contrast, shows the population gained by the City of Tucson through annexation applied sequentially and accumulatively from 2010-2018. This adjustment corrects for the sudden increase in population caused by recent City annexations that could, uncorrected, overestimate the forecasted growth trend line.



(a) Pima County



(b) City of Tucson

Figure 1. Historical Population Adjustment

After the adjustment for annexation, PAG estimated a time-series population projection using Brown’s linear exponential smoothing time series model, which implements an exponentially weighted moving average as shown in Equation (1).

$$\hat{Y}_{t+1} = \alpha [Y_t + (1-\alpha)Y_{t-1} + (1-\alpha)^2Y_{t-2} + (1-\alpha)^3Y_{t-3} + \dots] \quad (1)$$

Where, Y_t = the population input in year t , \hat{Y}_{t+1} = the estimated population in year $t+1$, and α = a constant smoothing factor between 0 and 1.

To find the optimal α , PAG utilized Excel’s “What if Analysis” toolset to generate values for the minimized Sum of Squared Errors (SSE). The smallest SSE values represent those forecast values closest to real observations. The value of Y is computed recursively from its own previous value, while $(1-\alpha)$ becomes a discount factor exponentially weighting the previous value. In another words, the model gradually gives more weight to the most recent observations than the past, older observations.

The statistical result of the model is shown in Table 1.

Table 1 Time-Series Model Statistics

<u>Jurisdiction</u>	<u>Model Type</u>	<u>R-Squared</u>	<u>MAPE</u>
Marana	Brown	0.9984	6.02%
Oro Valley	Brown	0.9961	4.95%
Sahuarita	Brown	0.9961	4.88%
South Tucson	-	-	-
Tucson	Brown	0.9876	1.08%
Unincorporated Pima	Brown	0.9885	1.80%

The Mean Absolute Percentage Error (MAPE) is the average difference between the actual observations and the forecasted values and measures the prediction accuracy of the model. R-squared represents the difference between total variation and the explained variation proportionate to total variation. It also measures the goodness of fit of the forecast equation. Both R-squared and MAPE scores shown in this table suggests the model equation has a close fit to the observations. The model does not provide a meaningful result for the City of South Tucson due to a lack of data combined with an oscillating historical population pattern. In addition, the City of South Tucson has no significant growth pattern and no specific development plan was available. PAG assumes no population growth in South Tucson for the population projection period. As discussed in Section 2.1, a growth capacity was calculated and applied to each jurisdiction. The Town of Oro Valley reaches the maximum growth capacity only in 2035. Final adjustments were made to match growth of all jurisdictions with the 2018 Pima County control total.

2.2.2 The 2016 Population Share Method

In 2016, PAG generated sub-county population projections for Arizona Department of Administration with three methods:

1. A Time Series model was developed based on the 2016 AOEO sub-county population projection series. PAG applied additional benchmarking and smoothing techniques to fine-tune population growth trends by jurisdiction.
2. A Destination Choice model was developed using an optimization algorithm for population migration. For the subarea -- the jurisdictional or sub-jurisdictional area -- attraction probability was estimated using a multinomial logit model that determines where population growth due to migration might occur together with natural population growth.
3. A Sub-area Allocation (SAM) Land Use model reviewed multiple factors to estimate the growth suitability for each 0.5-acre parcel throughout the region. The model allocates the required regional population growth based on the probability calculated from the suitability score.

The final recommended method for the 2016 sub-county projections took the average of the three methods above. This average combined different factors which influence the population and employment growth and allocations.

PAG’s 2019 sub-county projections take each jurisdiction’s 2016 approved population share ratio (pop-to-county total), and applies it to the new 2018 county control total with the new annexation adjustments. Between 2016 and 2018, a number of major annexations occurred after the 2016 sub-county projections were generated. With the new 2018 boundaries, the county shares of each jurisdiction are corrected from the original 2016 shares. The 2051-55 period was projected with the 2016 share ratio for 2050. The Town of Oro Valley reaches the maximum growth capacity in 2053 and population remains constant afterward. Final adjustments were made to match with the 2018 Pima County control total.

2.2.3 Final Consensus: The Average of the Historical Time Series & the 2016 Population Share Method

Each forecast method focuses on different factors that impact future growth in different aspects. The Time Series method focuses on the recent population trend. The 2016 Population Share method, by contrast, relies more on land use development associated with accessibility change in forecast years. Jurisdictional stakeholders discussed these two major factors from the Time-Series analysis and the 2016 Population Share Method and reached a consensus decision to average the two methods. The averaging method has the advantage of balancing the influence of all factors in the equation. The Town of Oro Valley reaches its maximum capacity for population in 2053 and final adjustments were made to match the county control total.

3. Results

A proposal to recommend final 2019 sub-county population projections using the average of the Time Series and the 2016 Population Share Method was approved at the PAG’s Population Technical Subcommittee (PopTech) meeting on April 4th, 2019. Table 2 shows the result of this averaging method.

Table 2. The Average of the Time Series and the 2016 Population Share Method

	Marana	Oro Valley	Sahuarita	South Tucson	Tucson	Unincorporated Pima County	Total
2018 Pop	47,213	45,184	30,575	5,677	543,505	362,047	1,034,201
2055 Pop	104,491	55,850	56,938	5,689	628,971	425,137	1,277,075
18-55 Total Growth	57,278	10,666	26,363	12	85,466	63,090	242,874
18-55 Annual Growth	1,548	288	713	0	2,310	1,705	6,564
18-55 Annual Growth Rate	3.28%	0.64%	2.33%	0.01%	0.42%	0.47%	0.63%
2018 County Share	4.57%	4.37%	2.96%	0.55%	52.55%	35.01%	100.00%
2055 County Share	8.18%	4.37%	4.46%	0.45%	49.25%	33.29%	100.00%
Change of Share	3.62%	0.00%	1.50%	-0.10%	-3.30%	-1.72%	0.00%

This population projection series meets the requirement that it matches the county population control total by AOEO. The projection series from this method shows the Town of Marana to be the fastest growing jurisdiction averaging 3.28% annual growth until 2055, followed by the Town of Sahuarita with 2.33% annual growth. The City of Tucson remains the largest jurisdiction with a 49.25% share of total county population in 2055. Unincorporated Pima County is projected to have 0.47% annual growth, but the Town of Oro Valley is projected to have slower growth at the end of the series because it will reach the capacity limit. The City of South Tucson is expected to have a stable population.

Figure 2 and 3 show each jurisdiction’s growth rate and its relative share of county population, combining 2010-2018 adjusted population estimates and the 2019-2055 population forecast.

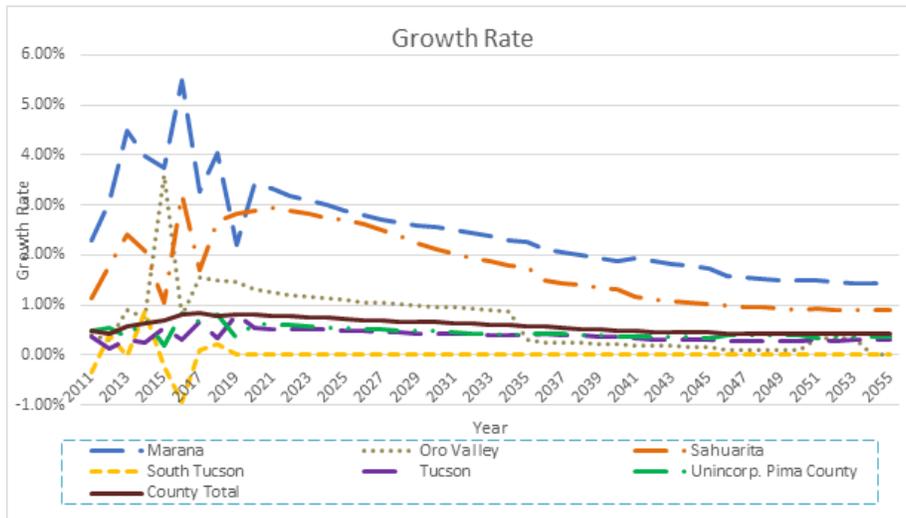


Figure 3 Growth Rate of County Total and Jurisdictions

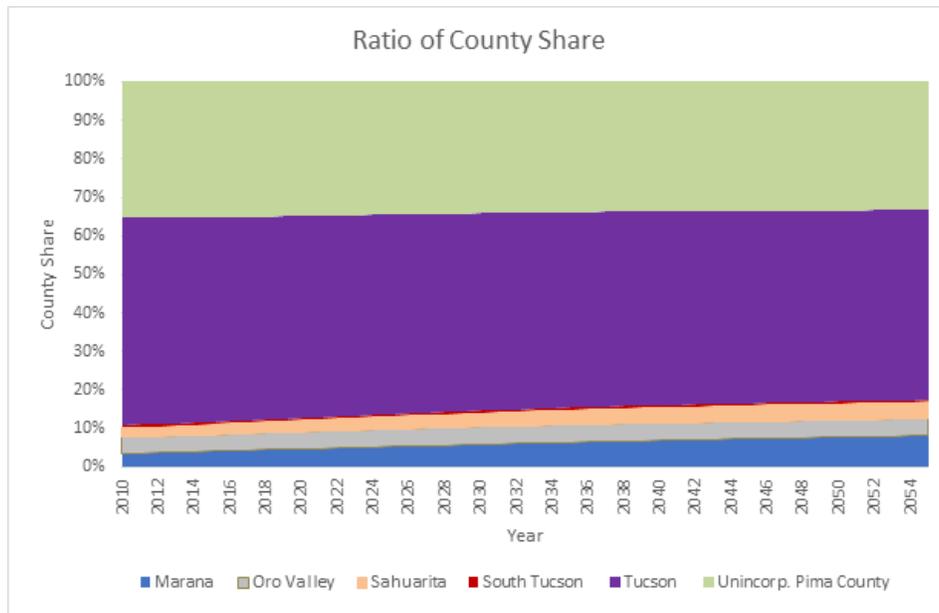


Figure 3 Jurisdictions Population Share of County

The technical recommendation by PAG's jurisdictional stakeholders was approved by the PAG Management Committee at its meeting on May 8, 2019 followed by the approval of the Regional Council on May 23, 2019.