



**ARIZONA OFFICE OF ECONOMIC OPPORTUNITY**

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Office of the State Demographer

# Arizona Sub-County Population Projections, 2016-2050: Methodology Report

August 31, 2016

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# 1. BACKGROUND

Arizona Sub-County Population Projections, 2016 edition, are an update to the 2013-edition projections that were developed by the Office of Employment and Population Statistics (EPS), then a unit at the Arizona Department of Administration (ADOA). Both editions of population projections are prepared in accordance with Executive Order 2011-04. Relevant sections of the executive order are presented below:

Section 1: The Arizona Department of Administration (ADOA) shall be the agency designated to produce the official population estimates and projections for the State of Arizona.

Section 4: ADOA shall produce the official population projections for each year for a minimum of the next 25-year period. The projections shall be dated as of July 1 and shall include projections for the State, its counties, its incorporated jurisdictions, and the unincorporated balance of each county.

Section 6: ADOA shall release the projections for the State's incorporated jurisdictions and the unincorporated balance of each county as soon as possible following the release of the State and county projections, but no later than nine months thereafter.

Executive Order 2011-04 also allows ADOA to incorporate sub-county projections made by Regional Councils of Governments (COGs):

Section 8. ... The Regional Councils of Governments shall submit population projection data for incorporated jurisdictions and the unincorporated balance of the counties to ADOA no later than six months after ADOA's release of State and county population projections in order to be included in ADOA's projections.

For the 2013 edition, Central Arizona Governments (CAG), Maricopa Association of Governments (MAG), and Pima Association of Governments (PAG) made population projections for their respective member agencies in Gila, Pinal, Maricopa, and Pima counties. These projections were reviewed and adopted by ADOA and were released along with sub-county projections made by ADOA for places in the other 11 counties.

Executive Order 2011-04 further directs the use of these projections:

Section 10: Population estimates and projections produced by ADOA in accordance with this Executive Order shall be used by all State agencies for all purposes, including those required by federal law, which necessitates the development of population estimates or population projections.

Beginning August 6, 2016, producing population estimates and projections became the responsibility of the Arizona Office of Economic Opportunity (OEO) under A.R.S.§41-5402.

Unless and until there is a new executive order, OEO will continue to follow the directives established by Executive Order 2011-04 for ADOA.

For the 2016 edition, CAG, MAG, and PAG made population projections for their respective member agencies in Pinal, Maricopa, and Pima counties. These projections were reviewed and adopted by OEO and were released along with sub-county projections made by OEO for places in the other 12 counties. CAG, MAG, and PAG each provided its own methodology statement. The methods described in this document apply to the projections made by OEO.

## 2. METHODOLOGY

The 2016-2050 series of sub-county projections was based on the development work for the 2013 series. Preliminary projections were created by simply adjusting the 2013 series for all places to sum to the medium series county projections published in 2015. The following sections describe the initial development work for the 2013 series along with specific adjustments made in 2016 based on local knowledge and newly published population estimates and projections.

Development of the sub-county projections began with research into several different methods of population projection. Each method used different amounts of historical data and produced a wide range of results, some of which revealed inherent problems with their structures. The methods are briefly described below:

*Constant Share Method:*

$$P_{it} = (P_{il}/P_{jl}) P_{jt}$$

where,

$P_{it}$  is the population projection for small area ( $i$ ) in the target year ( $t$ );

$P_{il}$  is the actual or estimated population for small area ( $i$ ) in the launch year ( $l$ );

$P_{jt}$  is the population projection for larger area ( $j$ ) in the target year ( $t$ );

$P_{jl}$  is the actual or estimated population for larger area ( $j$ ) in the launch year ( $l$ ).

The Constant Share method assumes that the share of a place's population of a county remains constant over the projection horizon. This might not be a reasonable assumption for some places. The method forces places to grow at the same rate as the county, which may also be unreasonable in some areas.

*Shift-Share Method:*

$$P_{it} = (P_{jt}) [(P_{il}/P_{jl}) + ((z/y) ((P_{il}/P_{jl}) - (P_{ib}/P_{jb})))]$$

where,

$b$  denotes the base year;  
 $z$  is the number of years in the projection horizon (between launch year and year  $t$ );  
 $y$  is number of years in the base period.

The Shift-Share method accounts for changes in population shares over time. Over long projection horizons, it can lead to population losses for small areas that had declined or grew very slowly during the base period. It can result in a negative population.

*Share-of-Growth Method:*

$$P_{it} = P_{il} + [(P_{il} - P_{ib}) / (P_{jl} - P_{jb})] (P_{jt} - P_{jl})$$

The Share-of-Growth method assumes that a place's share of county growth will be the same over the projection period as in the base period. This can result in a negative population. Also, when the direction of growth for a place is opposite that of the county, the method incorrectly distributes the growth.

*Plus-Minus Distribution:*

$$\text{POSFACOR} = [\text{ABSUM} + (\text{CNTRLCHG} - \text{SUM})] / \text{ABSUM}$$

$$\text{NEGFACOR} = [\text{ABSUM} - (\text{CNTRLCHG} - \text{SUM})] / \text{ABSUM}$$

where,

SUM is the sum of the population changes experienced by each place within the base period;  
ABSUM is the sum of the absolute values of the population changes experienced by each place within the base period;  
CNTRLCHG is the projected county population change between the launch year and the target year.

The Plus-Minus method distributes the county population change to places based on the change occurring within the base period. POSFACTOR and NEGFACOR are applied to a place's growth since the launch year based on the direction of that growth. This takes into account that some places experienced growth in the opposite direction of its county. However, places with zero population may not receive any adjustment, and results can be negative.

The methods described above are collectively referred to as "ratio methods."

*GIS Boundary Matching*

Although most incorporated places existed in 1990 and 2000, many Census Designed Places (CDPs) that existed in 2010 did not in previous decennial censuses. Even if a CDP of the same name had existed for the previous censuses, it may have covered a much smaller or much larger area. Utilizing 2010 place boundaries and block-level census data and maps from 1990 and 2000, we created historical data for 1990 and 2000 for each place. These data were used as

alternative base data for the ratio methods we researched. If the historical data were correct, we would see a more accurate picture of where growth occurred in the CDPs. However, we suspect that this method did not work correctly in some counties due to inaccurate maps or block-level population data, especially for 1990. Instead of being used as inputs to create draft projections, these data were ultimately employed as a tool for discussion with the jurisdictions to better understand areas on a case-by-case basis.

#### *Forecast Model:*

Intercensal estimates for 1980-2010 and postcensal estimates for 2010-2012 were used as input to the SPSS 21 forecasting procedure for each incorporated place and unincorporated balance of county. The optimal forecast model (ARIMA, Holt, Brown, or Simple exponential smoothing model) for each place was chosen algorithmically by SPSS and used to forecast population from 2013 to 2050.

None of the methods reviewed were appropriate for all places. In many cases, the results of the ratio methods projected negative population or an unreasonable rate or direction of growth for smaller places. The forecast models<sup>1</sup> were chosen to produce the preliminary population projections for incorporated places and the unincorporated balance of counties because they were based on many more historical data points than the ratio methods and produced a higher percentage of feasible projections. These results were adjusted proportionately to achieve agreement with the official published population projection for each county. The population for each CDP was then created by distributing the adjusted balance of county estimates according to the Census 2010 share of the balance of county population.

Regional councils of government and several jurisdictions reviewed the preliminary projections. Their local knowledge about planned economic development, resource constraints, and demographic patterns in specific areas guided adjustments to the preliminary projections. Several rounds of consultation were conducted before the sub-county projections were finalized.

### **3. LOCAL KNOWLEDGE AND ADJUSTMENTS**

Adjustments to the preliminary sub-county projections were made on a case-by-case basis to create a reasonable picture of population change within each county. Whenever possible, the most recent general plans for incorporated places were reviewed and used as a “reasonableness check” on the preliminary and revised population projections. Implied population densities resulting from the projections were also reviewed for feasibility<sup>2</sup>.

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<sup>1</sup> Model statistics are available upon request for all incorporated places and the balances of county.

<sup>2</sup> MAG, CAG, and PAG produced their projections with land use models, which provided guidance to EPS on what population densities could be reasonably achieved over the horizon. All places within the state have sufficient room within the current geographic boundaries for the projected growth and do not require the assumption of future annexations.

Descriptions of the adjustments made in 2013 are retained in this report, and information on new adjustments made in 2016<sup>3</sup> is added.

**Apache County:**

All three incorporated places expect growth in the near-to-mid-term future due to two potash mines and a CO<sub>2</sub> pipeline. Based on comments from NACOG, 200 people were added to the preliminary 2020 projection for Springerville. The resulting growth rate was used to obtain the 2020 populations for St. Johns and Eagar. Then, an additional 200 was added to St. Johns' 2020 population assuming that it would be impacted even more due to its proximity to the mines. Linear interpolation was used to project population for 2013-2019. For all three places, 15 percent growth was assumed between 2020 and 2030 based on comments from NACOG. Linear interpolation was again used for the years in between. Given the start of a declining trend for the county as a whole, population was held constant for the three places beyond 2030. The assumption was that demographic forces that bring about population decline will be counter balanced by continued economic activities, resulting in a somewhat stable population. McNary's growth rate was set at the annualized rate of the Navajo County portion of the Fort Apache Reservation between 2000 and 2010. All other unincorporated areas were adjusted proportionately to bring the total population in line with the county control.

To make a more reasonable transition from the official 2015 population estimates to the 2016 projections, the following steps (referred to as the "Trend Adjustment") were performed for the incorporated places in Apache as well as for select places in other counties:

1. Calculate the average annual growth of a place between 2010 and 2015 using population estimates.
2. Apply the rate from Step 1 to the 2015 population estimate to obtain a projected population for 2016.
3. Find the difference between the draft 2016 projection and the adjusted 2016 projection from Step 2.
4. Add the value from Step 3 to the draft projections for each year from 2017-2050. This results in an adjusted projections series for the incorporated place.
5. Remaining areas are either left alone at their preliminary values or proportionately adjusted so that the sum of population from all places in the county equals the official county projection.

Following the Trend Adjustment, the 2016 projections for Eagar, Saint Johns and Springerville were refined by interpolation between the 2015 estimate and the 2017 projection. The balance of county projections for 2016-2050 were obtained by simple subtraction. McNary's projections from the 2013 were retained, while other CDPs were adjusted proportionately to reach agreement with the new balance of county projections.

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<sup>3</sup> These adjustments were made to the draft 2016 projections, which were created by controlling the 2013 series to the new 2015 medium series county projections.

**Coconino County:**

Direct adjustments were first made to four places. As background, growth in Flagstaff was 36 percent and 72 percent of the county's growth in the 1990s and 2000s, respectively. It was assumed that the growth in Flagstaff in the projection horizon to 2050 will be equal to 80 percent of the county's growth. Annual growth resulting from the preliminary projections was adjusted to meet this assumption. Populations in Fredonia and Tusayan were held constant from 2012 onward. Finally, Sedona's population was extrapolated using the linear trend from 1990-2010, which is the same logic used for its Yavapai part.

All CDPs were proportionately adjusted and re-evaluated for additional changes. We chose to hold the population of Supai constant at 209<sup>4</sup> from 2012 onward. We also adjusted Grand Canyon Village based on local consensus that it may grow to 2,150 in 2050. That figure was assigned to 2050, and linear interpolation was used for the years in between. The remaining CDPs were proportionately adjusted one more time for the final results.

For the 2016 series, the Trend Adjustment was applied to Flagstaff, Fredonia, Tusayan, and Williams. The balance of county received a proportional adjustment to meet the county control.

**Cochise County:**

Guided by feedback from SEAGO, we assumed that Sierra Vista will experience a growth of 20,000 between 2010 and 2050. We distributed these 20,000 people across the annual change predicted by the forecast model over the projection horizon. The population of Tombstone was held constant from 2012 onward in contrast to the continued decline shown by preliminary numbers. Feedback also suggested that the original projections for Benson, Bisbee, and Naco CDP were too low. Given the changes to Sierra Vista and Tombstone, adjustments were made proportionately to Benson, Bisbee, and Naco to bring the county total population in line with the control.

Douglas, Huachuca City, and Willcox received the Trend Adjustment for the 2016 series. Tombstone's population is believed to have stabilized and is unlikely to decline. We thus held the population constant at the 2015 level until 2050. All other places in the county, including the balance, received a proportional adjustment to meet the county control.

**Greenlee County:**

SEAGO suggested that projections for all places in the county were too low. Since the published county control does not coincide with SEAGO's expected growth at the place level, we were not able to revise projections upward. We decided to revisit this county after July 1, 2013 estimates were published. Although the sub-county projections were ultimately not revised, the methodology for producing the estimates in this county changed, taking into account new indicator data that was not previously reported. The resulting estimates for 2014 and 2015 more closely reflected the feedback received by SEAGO. In turn, the 2016 preliminary sub-county projections required little refinement. Both incorporated places received the Trend

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<sup>4</sup> This is 45% of the average population of the Havasupai Reservation over the last three censuses.



Adjustment, and the balance of county received a proportional adjustment to meet the county controls.

*Update on November 10, 2016:* In a revised publication, the annual growth from 2012 to 2013 was omitted from the standard Trend Adjustment calculation. This was an outlier that caused a spike for Clifton and a large drop for Balance of County in the population level from 2015 to 2016. Removing it resulted in a smoother and more reasonable transition.

**Graham County:**

No changes were made to the preliminary projections in 2013. Safford's preliminary projections in 2016 became the final series while Pima and Thatcher required a Trend Adjustment. The balance of county received a proportional adjustment to meet the county controls

**Gila County:**

Official sub-county projections for this county were produced by Central Arizona Governments (CAG) in 2013. They were reviewed and adopted by ADOA. OEO was responsible for sub-county projections for Gila County in 2016 and also added projections for several CDPs per CAG's request. The 2013 sub-county projections, produced by CAG, were first controlled to the new 2015 county projections; population from 2040-2050 was held constant before the control factor was applied. Hayden, Miami, Winkelman, and San Carlos were held constant at the 2015 level. We assumed that the opening of a casino would prevent population loss rather than result in small growth in Hayden and Winkelman. All other places were adjusted so that the sum of population in all places equaled the county control.

**La Paz County:**

Comments from WACOG led us to assume that Bouse, Ehrenberg, Vicksburg, and Wenden CDPs will grow annually at the same rate as the county over the 40-year horizon. Parker Strip and Salome CDPs will return to their 2000 population levels in 2050, and linear interpolation was used to obtain projections for the years in between. Quartzsite and the small balance of county (i.e. unincorporated areas that are not part of a CDP) were adjusted proportionately so that the county control was met.

In 2016, Parker received the Trend Adjustment, and all other places in the county received a proportional adjustment to meet the county control.

**Maricopa County:**

Official sub-county projections for this county were produced by Maricopa Association of Governments (MAG). They were reviewed and adopted by OEO. The methodology can be found

at <https://population.az.gov/sites/default/files/documents/files/pop-prj-04013-2016-2050-SocioEconMethodology-Final.pdf>

### **Mohave County:**

Bullhead City and Kingman were assumed to grow annually like the county. All CDPs were adjusted proportionately and re-evaluated. Eight CDPs<sup>5</sup> that were deemed unlikely to grow had their population held constant from 2012 onward. New Kingman-Butler CDP was recalculated using half the annualized rate it experienced between 2000 and 2010. The four CDPs<sup>6</sup> which were expected to take on more growth were then proportionately adjusted upward.

The final 2016 projections were created by controlling the 2013 series to the new county projections.

### **Navajo County:**

In Navajo county, we adjusted the projection for Winslow based on information about the construction of a wood mill. The assumption is that an estimated 900 jobs will be created by the construction and milling operations. Some of these jobs will be filled locally from the existing population; the jobs will also attract additional labor force and family from outside of the area. We assumed that the ultimate impact on population is 900. The jobs would be filled gradually by 2020, at which point the population will remain constant until 2050<sup>7</sup>.

Two potash mines will drive growth in Holbrook, which we assumed would take on the same annual growth rate as the county. The remaining four incorporated places in the county were projected using the share-of-growth method with base data from Census 2000 and Census 2010.

We allowed CDPs on the Navajo Reservation to decline by -18 percent over the projection horizon, which translates into an annualized rate that is approximately the same as the annualized growth (actually, decline) rate in the 2000-2010 period. This is also consistent with the projected population decline in the Apache County portion of the reservation. The remaining CDPs used the constant share method based on Census 2010 data.

In 2016, all incorporated places except Holbrook received the Trend Adjustment. A downward change resulted for Snowflake and Taylor which accommodated the closure of a paper mill with a loss of 308 jobs. The balance of county received a proportional adjustment to meet the county control.

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<sup>5</sup> Chloride, Kaibab, Katherine, Littlefield, Oatman, Truxton, Valentine, and Wikieup.

<sup>6</sup> Dolan Springs, Fort Mohave, Meadview, and Valle Vista.

<sup>7</sup> The deforestation project is expected to last only 10 years. Thus, population will be unlikely to continue to increase due to this industry.

**Pima County:**

Official sub-county projections for this county were produced by Pima Association of Governments (PAG). They were reviewed and adopted by OEO. The PAG methodology can be found at <https://population.az.gov/sites/default/files/documents/files/pop-prj-04019-2016-2050-PrjMethodology.pdf>

**Pinal County:**

Official sub-county projections for this county were produced by Central Arizona Governments (CAG) in cooperation with MAG. They were reviewed and adopted by OEO. The CAG methodology can be found at <https://population.az.gov/sites/default/files/documents/files/pop-prj-04013-2016-2050-SocioEconMethodology-Final.pdf>

**Santa Cruz County:**

The constant share method was used for all places from 2013-2050 based on estimates for July 1, 2012. These projections were adjusted by a simple factor to meet the new county controls for 2016-2050.

**Yavapai County:**

For Camp Verde, Chino Valley, Clarkdale, Cottonwood, and Dewey-Humboldt, we used the share-of-growth method with Census 2000 and Census 2010 as the endpoints. Wickenburg was held constant at 18 from 2012 onward. All CDPs and the small balance of county were then adjusted proportionately to account for the change in projections for the six incorporated places.

Prescott and Prescott Valley were adjusted to grow at one-third the 2000-2010 annualized rate. The effect was that Prescott Valley overtakes Prescott in 2014 following feedback that this will occur soon. We extrapolated the 1990-2012 growth linearly for Sedona from 2012 onward and assumed that Village of Oak Creek would grow like Sedona. Verde Village was assumed to follow Cottonwood's annual growth. The feedback from NACOG suggests that these two places are very similar.

Population levels for Bagdad, Seligman, and Yarnell were kept constant from 2012 onward, while Peeples Valley and Williamson were extrapolated at half the linear growth between 2000 and 2010 over the projection horizon. Cordes Lakes, Lake Montezuma, Paulden, and Spring Valley were adjusted to take on additional growth and bring the sum of population in line with the county control.

Two stages of refinement were performed in 2016. First, the Trend Adjustment was applied to Chino Valley, Dewey-Humboldt, Jerome, Prescott, and Prescott Valley. Camp Verde,

Cottonwood, and Sedona were held at their projected values from the 2013 series. The remaining places and balance of county received a proportional adjustment to meet the county control. Second, MAG provided OEO with projections for the Yavapai portion of Wickenburg. All other places were proportionately adjusted one more time to accommodate the figures produced by MAG.

**Yuma County:**

Somerton was set to grow at 20, 30, and 35 percent of the 2000-2010 annualized rate in 2013, 2014, and 2015, respectively, ramping up to 40 percent of the 2000-2010 annualized rate in 2016 to 2030. These assumptions resulted in a projected population slightly less than the city's general plan build-out medium projection for 2030. Growth is slowed to 30 percent of the 2000-2010 annualized rate for 2031-2050, producing a 2050 population projection that is close to the general plan's high build-out projection for 2030.

Wellton was assumed to grow linearly from 2016 to 2050 at the rate experienced between 2000 and 2012. However, in 2013, 2014, and 2015, 40, 60, and 80 percent of the linear rate was used to facilitate a smooth transition from the short-term pattern of growth to the long-term linear growth. From 2013-2015, the same percentages of growth were used for Yuma, however the base number was annualized growth from 2000 to 2010 instead of linear growth. The full annualized growth rate was used between 2016 and 2050.

Eight CDPs<sup>8</sup> where growth is deemed unlikely were set at a constant population level from 2012 through 2050. In three other CDPs<sup>9</sup>, total growth was set at 10 percent for the entire projection period, and population for years between 2012 and 2050 were linearly interpolated. Fortuna Foothills was expected to grow at a faster rate, equivalent to 70 percent of Yuma's annual growth rate. The remaining unincorporated place populations were projected using the constant share method.

San Luis, Wellton, and the balance of county received the Trend Adjustment in 2016. All other places in the county received a proportional adjustment to meet the county control.

## **4. RESERVATIONS**

Using GIS analysis, we identified all places that were wholly or partly contained by a reservation's boundary and the number of people each place contributed to the reservation population based on Census 2010. The proportion of population contributed by each place was applied to the final sub-county projections and summed to produce the projection for the

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<sup>8</sup> Aztec, Donovan Estates, Drysdale, El Prado Estates, Gadsden, Orange Grove Mobile Manor, Wall Lane, and Wellton Hills.

<sup>9</sup> Padre Rachitos, Rancho Mesa Verde, and Tacna.

whole reservation. There was one slight exception to this methodology in Navajo county. The portion of small balance of county within the Navajo Reservation was projected separately and then added to the population contributions from other places within the reservation boundary. The same methodology was used in 2016, except that the portion of the Navajo Reservation described above was not treated separately.

## **5. INCLUSION OF PLACES**

CAG, MAG, and PAG each made its own decision as to what places to include in sub-county projections. ADOA accepted those choices after determining that they meet the minimum requirement of Executive Order 2011-04. Working with Northern Arizona Council of Governments (NACOG), Southeastern Arizona Governments (SEAGO), and Western Arizona Council of Governments (WACOG), ADOA decided to produce population projections for all incorporated places, the unincorporated balance of counties, all CDPs, the small balance of counties, and Indian Reservations in 11 counties. Due to the high degree of variability and uncertainty, it was decided that CDPs with a Census 2010 population of less than 500 be excluded in the final publication of sub-county population projections.