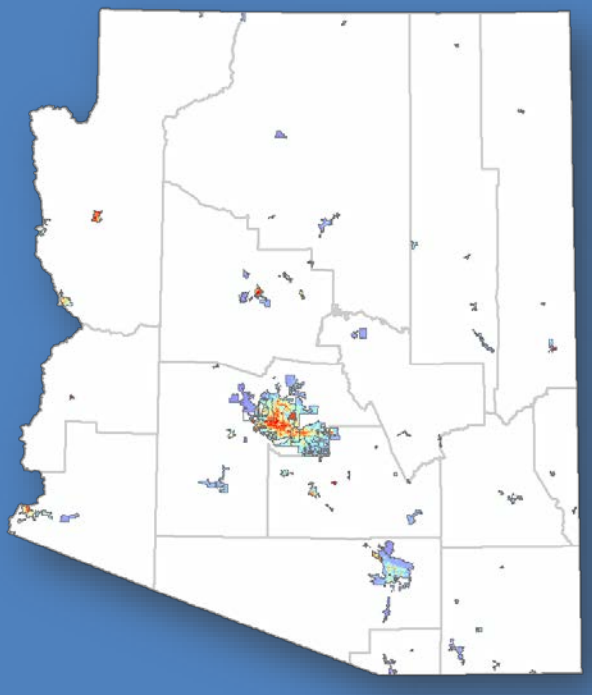
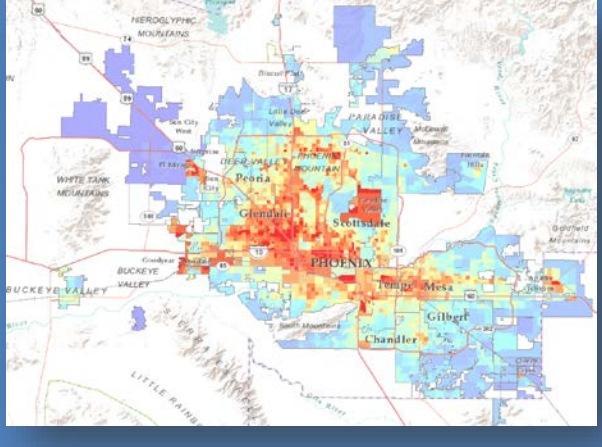
Urban and
Community Forestry

2017 Arizona Shade Tree Planting Prioritization

Planning Analysis for the Department of Forestry and Fire Management





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I. Executive Summary

This report summarizes the intent, methodology, and results of the 2017 revision of the 2016 Shade Tree Planting Prioritization analysis of the Urban and Community Forestry Program (UCF) at the Arizona Department of Forestry and Fire Management (DFFM). The purpose of the analysis was to assess existing urban forests in Arizona's communities and identify shade tree planting needs.

The spatial analysis, based on U.S. Census Block Group polygons, generated seven sub-indices for criteria identified by an expert panel: population density, lack of canopy cover, low-income, traffic proximity, sustainability, air quality, and urban heat effect. The seven sub-indices were combined into one Shade Tree Planting Priority Index and further summarized into a Shade Tree Planting Priority Ranking. The resulting reports, maps, and GIS data provide compiled information that can be easily used for identifying areas for strategic shade tree planting within a community or across Arizona's major cities and towns.

The analysis has been welcomed and its results anticipated before its release by local, state, and academic urban forest professionals. However, this being the first spatio-quantitative analysis effort of its kind by DFFM, time is needed to tell the effectiveness of the analysis and products. The analysis and products represent a work in progress which is expected to improve as better data becomes available and analysis criteria and methods are improved.

This report is limited at conveying the scale and depth of the analysis results which – for more detailed use – are best explored through print and interactive maps or the GIS data available through the UCF Program webpage at https://dffm.az.gov/forestry-community-forestry/urban-community-forestry/projects.

II. Introduction

The analysis and results presented in this document were developed by the Urban and Community Forestry program (UCF) at the Arizona Department of Forestry and Fire Management (DFFM). The majority of Arizona's urban forests are located on private property, but they also include forests in and along urban parks, street trees, landscaped boulevards, public gardens, washes and wetlands, greenways, and nature preserves. While "urban" or "community" forests account for only 5.3% of all the land in Arizona, 85% of the state's population fall within urban and community forests. Management of forests and trees within these lands has important implications for air and water quality, energy conservation through shading, diversity of wildlife habitat, maintenance of property values, and an improved quality of life for Arizona citizens.

DFFM's UCF Program is a cooperative forestry program, funded primarily by the USDA Forest Service (USDA FS), that focuses on the stewardship of urban natural resources. UCF provides technical assistance, education and other resources – responding to the needs of urban areas by helping communities maintain, restore and improve urban forest ecosystems throughout Arizona. DFFM works directly with partners throughout Arizona to build healthy and sustainable communities by promoting urban forestry awareness, and by fostering local action. Ultimately, the Community Forestry Program seeks to increase awareness and appreciation of urban forests in Arizona.

In 2014, the Arizona Community Forestry Committee (advisory committee to the Arizona State Forester and the UCF Program) recommended the analysis of existing urban forest resources within Arizona in order to identify areas within the state that would benefit from future tree planting efforts. The 2017 revision of the 2016 Arizona Shade Tree Planting Prioritization analysis represents an ongoing, strategic effort to spatially and quantitatively assess existing urban forests in communities and identify shade tree planting needs.

A. Intent

The intent of the Shade Tree Planting Prioritization analysis is to:

- Rapidly and strategically assess Arizona's urban forest communities to inform Urban and Community Forestry planning.
- Identify Arizona's underserved cities and communities based on state-wide, best available, and relevant socio-economic and environmental data.
- Account for a city's commitment to their urban forest (sustainability) as it applies to UCF partnerships and projects.
- Keep spatial and quantitative analysis simple and transparent.
- Generate summaries and geospatial products for internal and public dissemination.

The analysis and products will inform future DFFM priorities for program delivery and may be used directly by communities for their management needs.

B. Target Audience

Although the Shade Tree Planting Prioritization analysis and resulting products are intended primarily to inform UCF program planning, their use by Arizona's communities and others to improve the urban forests are encouraged. However, please note that the analysis results are limited and caution should be used when drawing conclusions that exceed the data intent and limitations. See the Methodology section below for a detailed description.

C. How to Use and Cite

Use is granted to public agencies, educational institutions, non-profit organizations and private individuals for non-commercial purposes. For commercial use of the Department of Forestry and Fire Management maps and data see Arizona Revised Statutes 39-121.03. The Department makes no warranties, implied or expressed, with respect to accuracy and use of this data for any specific purpose. Users are required to make their own assessment of the data for any specific use.

Cite this product as: ***UCF. 2017 Arizona Shade Tree Planting Prioritization. Phoenix: Arizona Department of Forestry and Fire Management, 2017.***

III. Methodology

The Shade Tree Planting Prioritization analysis parameters and spatial units were determined by available data and expert opinion. The Arizona Community Forestry Committee, which is UCF's advisory panel and is comprised of local, state, and private sector urban forest managers and experts, suggested a number of socio-economic and environmental measures to be considered in the analysis. The initial list of general topics included population numbers, urban forest cover, poverty, traffic, sustainability (urban tree as well as UCF project viability), air quality, urban heat island effects, and food security. Existing state- and nation-wide datasets were a good fit for most topics; but, in a few cases alternate datasets had to be created or found. Due to limited data availability, food security was not included as a factor.

For better cross comparison, the selected datasets were converted into a normalized index with a value range between 0 ("cool") and 1 ("hot"):

```
normalized index value = (score value – score min) / (score max – score min)
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All indices have been calculated for a polygon intersection between 2010 Census Block Group polygons and major towns and cities in Arizona (see Analysis Area section below for details). Next, all 7 indices were averaged by adding them together and dividing them by 7 to generate a final score. For a more equitable comparison, the final Shade Tree Planting Prioritization Index was calculated by normalizing the final score by groups of communities with similar population sizes. Besides normalizing all scores between 0 and 1, we did not apply any statistical corrections or preference weights to the 7 sub-indices. See the Methodology Summary section on page 14 for a summary table of the analysis steps.

D. Analysis Area

The Shade Tree Planting Prioritization summary areas are major towns and cities in Arizona. When it comes to municipal-level urban forest management, UCF primarily partners with incorporated cities and towns because they have the mandate and means to manage their urban forest directly. Generally, non-incorporated towns rely on their County to provide administration and services. However, the incorporated boundary of many cities and towns includes large swaths of unpopulated or rural areas and, in many cases, even land that is not open to development such as USDA FS or other land. In order to both capture incorporated areas (administrative mandate) and urbanized areas (high population density), we had to selectively run intersects between Arizona State Land Departments (ASLD) 2016 Incorporated Cities polygons and 2010 U.S. Census' Urbanized Areas polygons (See Figure 1). For most cities in the Greater Phoenix metropolitan area, the incorporated boundaries were good representations of the urban forest. In the case of unincorporated towns and major tribal cities, we solely relied on Census' Urbanized Areas polygons. See Table 1 for a list of cities and their analysis area types.

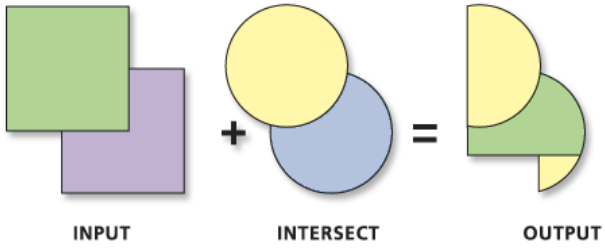


Figure 1. GIS Intersect operation (Esri).

For the spatial analysis unit, we relied on 2010 U.S. Census Block Group polygons for Arizona because most socio-economic and environmental GIS data were available through EPA's EJSCREEN GeoDB at that scale. We intersected the Arizona-wide Block Group polygons with the custom major towns and cities polygons to create the final spatial analysis units for this analysis. The resulting dataset had 4,154 polygons with 36 "slivers" – minuscule polygons resulting from the intersect operation. Sliverswere not included in the analysis (attribution set to NULL).

Analysis area errors in the initial 2016 release have been corrected for Sahuarita, Green Valley, and Mammoth. A few of Safford's incorporated easements were not captured correctly in the 2016 release and remain unchanged in the 2017 update.

Table 1: Cities' analysis area, canopy cover estimates, and population classes. Cities with 2017 analysis area updates are denoted with an *.

City	County	Analysis Area		Canopy Cover		Population Class
		Type	sqr. miles	Estimate	SE (±)	
Apache Junction	Maricopa	Incorporated	35.0	4.0%	0.98%	10,001 to 50,000
Avondale	Maricopa	Intersection	19.8	6.8%	1.25%	50,001 to 100,000
Benson	Cochise	Intersection	2.5	4.5%	1.04%	1,001 to 5,000
Bisbee	Cochise	Urbanized	3.1	7.0%	1.28%	5,001 to 10,000
Buckeye	Maricopa	Intersection	10.5	3.0%	0.85%	50,001 to 100,000
Bullhead City	Mohave	Intersection	19.2	2.3%	0.75%	10,001 to 50,000
Camp Verde	Yavapai	Urbanized	6.2	12.0%	1.62%	10,001 to 50,000
Carefree	Maricopa	Incorporated	5.5	6.3%	1.21%	1,001 to 5,000
Casa Grande	Pinal	Urbanized	22.3	5.8%	1.17%	50,001 to 100,000
Cave Creek	Maricopa	Incorporated	37.6	4.8%	1.07%	5,001 to 10,000
Chandler	Maricopa	Urbanized	64.8	7.5%	1.32%	100,001 and higher

City	County	Analysis Area		Canopy Cover		Population Class
		Type	sqr. miles	Estimate	SE (±)	
Chinle	Apache	Urbanized	3.4	2.7%	0.82%	1,001 to 5,000
Chino Valley	Yavapai	Intersection	9.1	3.8%	0.95%	10,001 to 50,000
Clarkdale	Yavapai	Incorporated	2.4	3.8%	0.95%	1,001 to 5,000
Clifton	Greenlee	Urbanized	3.4	3.2%	0.89%	1,001 to 5,000
Colorado City	Mohave	Urbanized	4.5	4.3%	1.01%	1,001 to 5,000
Coolidge	Pinal	Urbanized	4.2	4.8%	1.07%	10,001 to 50,000
Cottonwood	Yavapai	Incorporated	5.5	9.8%	1.48%	10,001 to 50,000
Dewey Humboldt	Yavapai	Incorporated	18.7	4.8%	1.06%	1,001 to 5,000
Douglas	Cochise	Intersection	4.0	4.3%	1.01%	10,001 to 50,000
Duncan	Greenlee	Incorporated	2.7	1.3%	0.56%	1 to 1,000
Eagar	Apache	Intersection	4.3	10.8%	1.55%	1,001 to 5,000
El Mirage	Maricopa	Incorporated	10.0	3.3%	0.89%	10,001 to 50,000
Eloy	Pinal	Intersection	3.0	4.7%	1.05%	10,001 to 50,000
Flagstaff	Coconino	Urbanized	34.8	18.5%	1.94%	50,001 to 100,000
Florence	Pinal	Urbanized	2.9	4.0%	0.98%	10,001 to 50,000
Fountain Hills	Maricopa	Intersection	20.3	3.3%	0.89%	10,001 to 50,000
Fredonia	Coconino	Incorporated	8.5	2.0%	0.71%	1,001 to 5,000
Gila Bend	Maricopa	Incorporated	64.3	2.5%	0.78%	1,001 to 5,000
Gilbert	Maricopa	Incorporated	68.1	6.8%	1.25%	100,001 and higher
Glendale	Maricopa	Incorporated	59.1	7.0%	1.28%	100,001 and higher
Globe	Gila	Intersection	3.8	4.7%	1.06%	5,001 to 10,000
Goodyear	Maricopa	Intersection	3.7	2.3%	0.75%	50,001 to 100,000
Green Valley*	Pima	Urbanized	13.3	16.3%	1.85%	10,001 to 50,000
Guadalupe	Maricopa	Incorporated	0.8	5.7%	1.16%	5,001 to 10,000
Hayden	Gila	Incorporated	1.3	6.0%	1.19%	1 to 1,000
Holbrook	Navajo	Intersection	2.4	2.5%	0.78%	5,001 to 10,000
Huachuca City	Cochise	Incorporated	2.7	1.0%	0.50%	1,001 to 5,000
Jerome	Yavapai	Incorporated	0.8	3.5%	0.92%	1 to 1,000
Kayenta	Navajo	Urbanized	2.6	2.5%	0.78%	5,001 to 10,000
Kearny	Pinal	Incorporated	2.7	12.0%	1.63%	1,001 to 5,000
Kingman	Mohave	Urbanized	23.8	3.0%	0.86%	10,001 to 50,000
Lake Havasu City	Mohave	Urbanized	29.6	3.0%	0.85%	50,001 to 100,000
Litchfield Park	Maricopa	Intersection	3.3	10.8%	1.55%	5,001 to 10,000
Mammoth*	Pinal	Incorporated	1.0	16.5%	1.86%	1,001 to 5,000
Marana	Pima	Intersection	18.9	4.3%	1.01%	10,001 to 50,000
Maricopa	Pinal	Intersection	13.4	3.0%	0.86%	10,001 to 50,000
Mesa	Maricopa	Incorporated	137.1	6.3%	1.21%	100,001 and higher
Miami	Gila	Intersection	0.8	4.8%	1.07%	1,001 to 5,000
Nogales	Santa Cruz	Urbanized	24.9	8.7%	1.41%	10,001 to 50,000
Oro Valley	Pima	Incorporated	34.9	11.5%	1.60%	10,001 to 50,000
Page	Coconino	Intersection	3.2	3.5%	0.92%	5,001 to 10,000
Paradise Valley	Maricopa	Incorporated	15.3	16.0%	1.83%	10,001 to 50,000
Parker	La Paz	Intersection	1.5	3.2%	0.89%	1,001 to 5,000
Patagonia	Santa Cruz	Incorporated	1.2	9.7%	1.48%	1 to 1,000
Payson	Gila	Urbanized	7.8	16.3%	1.85%	10,001 to 50,000
Peoria	Maricopa	Intersection	46.8	6.8%	1.25%	100,001 and higher
Phoenix	Maricopa	Intersection	373.1	6.0%	1.19%	100,001 and higher
Pima	Graham	Intersection	1.8	4.0%	2.00%	1,001 to 5,000
Pinetop-Lakeside	Navajo	Urbanized	10.4	28.8%	1.85%	1,001 to 5,000
Prescott	Yavapai	Intersection	20.0	15.8%	1.82%	10,001 to 50,000
Prescott Valley	Yavapai	Incorporated	19.6	3.3%	0.89%	10,001 to 50,000

City	County	Analysis Area		Canopy Cover		Population Class
		Type	sqr. miles	Estimate	SE (±)	
Quartzsite	La Paz	Urbanized	2.8	5.0%	1.09%	1,001 to 5,000
Queen Creek	Maricopa	Incorporated	28.0	5.3%	1.12%	10,001 to 50,000
Safford	Graham	Incorporated	9.6	5.0%	1.09%	5,001 to 10,000
Sahuarita*	Pima	Intersect	9.6	11.5%	1.60%	10,001 to 50,000
San Carlos	Gila	Urbanized	4.2	5.2%	1.12%	1,001 to 5,000
San Luis	Yuma	Intersection	3.4	3.0%	0.86%	10,001 to 50,000
Scottsdale	Maricopa	Intersection	99.9	9.0%	1.43%	100,001 and higher
Sedona	Coconino / Yavapai	Urbanized	4.7	17.0%	1.88%	10,001 to 50,000
Show Low	Navajo	Urbanized	8.9	19.8%	1.98%	10,001 to 50,000
Sierra Vista	Cochise	Urbanized	30.3	3.2%	0.89%	10,001 to 50,000
Snowflake	Navajo	Urbanized	3.1	6.8%	1.26%	5,001 to 10,000
Somerton	Yuma	Intersection	3.4	3.5%	0.92%	10,001 to 50,000
South Tucson	Pima	Incorporated	1.0	3.3%	0.89%	5,001 to 10,000
Springerville	Apache	Incorporated	11.8	1.8%	0.66%	1,001 to 5,000
St. Johns	Apache	Intersection	2.2	6.8%	1.25%	1,001 to 5,000
Star Valley	Gila	Incorporated	23.4	6.0%	1.19%	1,001 to 5,000
Superior	Pinal	Intersection	1.2	7.0%	1.28%	1,001 to 5,000
Surprise	Maricopa	Incorporated	107.8	4.3%	1.01%	100,001 and higher
Taylor	Navajo	Intersection	1.8	3.8%	0.95%	1,001 to 5,000
Tempe	Maricopa	Incorporated	40.0	4.5%	1.04%	100,001 and higher
Thatcher	Graham	Intersection	2.7	3.8%	0.95%	5,001 to 10,000
Tolleson	Maricopa	Incorporated	5.4	2.3%	0.75%	5,001 to 10,000
Tombstone	Cochise	Incorporated	6.2	1.0%	0.50%	1,001 to 5,000
Tucson	Pima	Intersection	273.6	8.7%	1.41%	100,001 and higher
Tusayan	Coconino	Incorporated	16.8	13.8%	1.73%	1 to 1,000
Wellton	Yuma	Incorporated	28.9	2.3%	0.75%	1,001 to 5,000
Wickenburg	Maricopa	Intersection	2.2	10.3%	1.52%	5,001 to 10,000
Willcox	Cochise	Urbanized	1.7	3.0%	0.85%	1,001 to 5,000
Williams	Coconino	Intersection	1.8	8.3%	1.38%	1,001 to 5,000
Winkelman	Gila/Pinal	Incorporated	0.7	5.5%	1.14%	1 to 1,000
Winslow	Navajo	Intersection	8.4	1.5%	0.61%	5,001 to 10,000
Youngtown	Maricopa	Intersection	1.5	5.0%	1.10%	5,001 to 10,000
Yuma	Yuma	Urbanized	57.8	3.8%	0.95%	50,001 to 100,000

E. Population Density Index

The Population Density Index is based on a normalized population density (people per square mile) derived from the 2010 Census population count for each Census Block Group in Arizona. The 2010 Census and 2017 EPA data were provided by EPA through their EJSCREEN GeoDB (https://www.epa.gov/ejscreen/download-ejscreen-data).

F. Lack of Canopy Cover Index

The inverse index for urban forest cover was based on results of the 2015-2017 Arizona Urban Tree Canopy Cover analysis (AZUTM; https://dffm.az.gov/azutm) by UCF and the Advanced Resource Technology Lab, University of Arizona (ART Lab). The percent urban canopy cover estimates with a Standard Error of equal to or less than ±2 % were calculated for the same major town and city polygons as in this analysis (see Table 1 above). The i-Tree Canopy statistical analysis relies on

random sampling of Google Maps imagery and expert interpretation of the land cover at the sample location (i-Tree Canopy online tool https://canopy.itreetools.org/). The resulting % estimated canopy covers were inversed and normalized to generate a "lack of canopy cover" index.

> The canopy cover estimates should not be taken as absolutes but as a comparative estimate between Arizona's major towns and cities.

A city's urban tree cover estimate can vary largely depending on analysis choices such as:

- The analysis area - e.g. incorporated boundary vs. urbanized area; all vs. public vs. private trees
- Measurement method – e.g. remote sensing vs. on-the-ground measurements
- Analysis and sampling method – ranging from complete canopy surface measurements to statistical sampling

The 2015-2017 Arizona Urban Tree Canopy Cover analysis goal was to rapidly capture all cities in Arizona and to provide a comparative estimate.

We also looked at the USDA FS and NLCD 2011 Tree Canopy data product (http://www.mrlc.gov/nlcd11_data.php) as a higher resolution (contiguous U.S. at 30 m) alternative to our i-Tree Canopy analysis results (one estimate per city). However, we found that USDA FS's Tree Canopy data product consistently and significantly underestimates urban tree cover in Arizona's communities – especially those in the Southwest Desert. Our partners at the ART Lab were not able to determine a defensible way to correct the USDA FS's Tree Canopy data given our i-Tree Canopy results.

G. Low-Income Index

For the Low-Income index, we used a normalized version of 2017 EPA EJSCREEN's Percent Low-Income measure per Census Block Group. The measure is described as:
"Percent of individuals whose ratio of household income to poverty level in the past 12 months was less than 2 (as a fraction of individuals for whom ratio was determined). Calculated from the Census Bureau's American Community Survey 2010-2014."
(EPA; https://www.epa.gov/ejscreen/glossary-ejscreen-terms; see U.S. Census Poverty Thresholds at http://www.census.gov/topics/income-poverty/poverty.html)

H. Traffic Proximity Index

The Traffic Proximity Index is a normalized version of the 2017 EPA EJSCREEN Traffic Proximity and Volume measure. EJSCREEN's measure is described as:
"Count of vehicles per day (average annual daily traffic) at major roads within 500 meters (or nearest one beyond 500 m), divided by distance in meters. Calculated from U.S. Department of Transportation National Transportation Atlas Database, Highway Performance Monitoring System, 2014, retrieved 4/2015."
(EPA; https://www.epa.gov/ejscreen/glossary-ejscreen-terms)

I. Sustainability Index

This index attempts to strategically capture improved conditions for UCF and community collaboration success and - in the end - the improved chance for successful, long-term management of individual urban trees. In this analysis round, we selected Arizona communities that maintained a Tree City USA status in 2017 (where 1 = yes and 0 = no). Tree City USA is a national certification program for cities and towns sponsored by the Arbor Day Foundation to advance tree planting and tree care and is coordinated by DFFM-UCF in Arizona (https://www.arborday.org/programs/treecityusa). The certification program comes with a set of policy and fiscal commitments to maintain the urban forest. Tree City USA certification is one of several measures for evaluating UCF grant applications.

We also searched for other Non-Governmental Organizations (NGOs) that provide tree planting and maintenance support and incentives for public spaces such as Keep Phoenix Beautiful and Trees for Tucson. A consultation with 15 County Master Gardener Cooperative Extension programs (https://extension.arizona.edu/master-gardeners) and Keep Arizona Beautiful affiliated programs (http://kazb.org/partners/affiliate-program/) showed that such local NGOs were rare and that the Tree City USA certification of 29 Arizona cities was the best available proxy to urban forest "commitment."

J. Air Quality Index

The Air Quality Index is the sum of two air quality measures provided by 2017 EJSCREEN at the Census Block Group level (EPA; https://www.epa.gov/ejscreen/glossary-ejscreen-terms):

- Ozone level in air
  "Ozone summer seasonal avg. of daily maximum 8-hour concentration in air in parts per billion, 2012. Source: EPA Office of Air and Radiation"
- PM2.5 level in air
  "Particulate matter (PM2.5) levels in air, micrograms per cubic meter (µg/m^3) annual average, 2012. Source: EPA Office of Air and Radiation"

Both EPA air quality measures were normalized, added together (Figure 2) and the results were normalized again. The measures were selected because of frequent surface-level Ozone warnings in the Greater Phoenix metropolitan region and because urban tree leaves are more effective in capturing fine particulate matter (PM2.5) than course particulate matter (PM10).

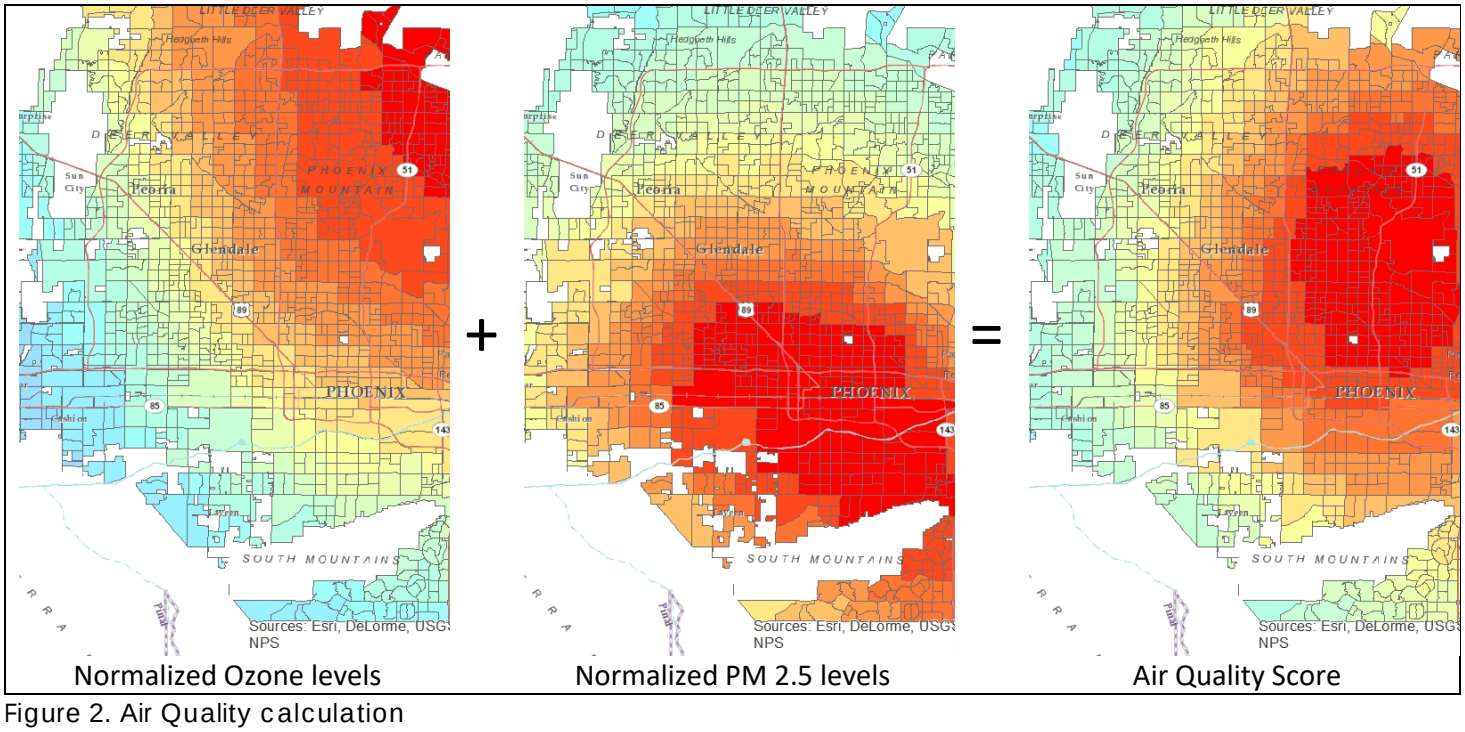


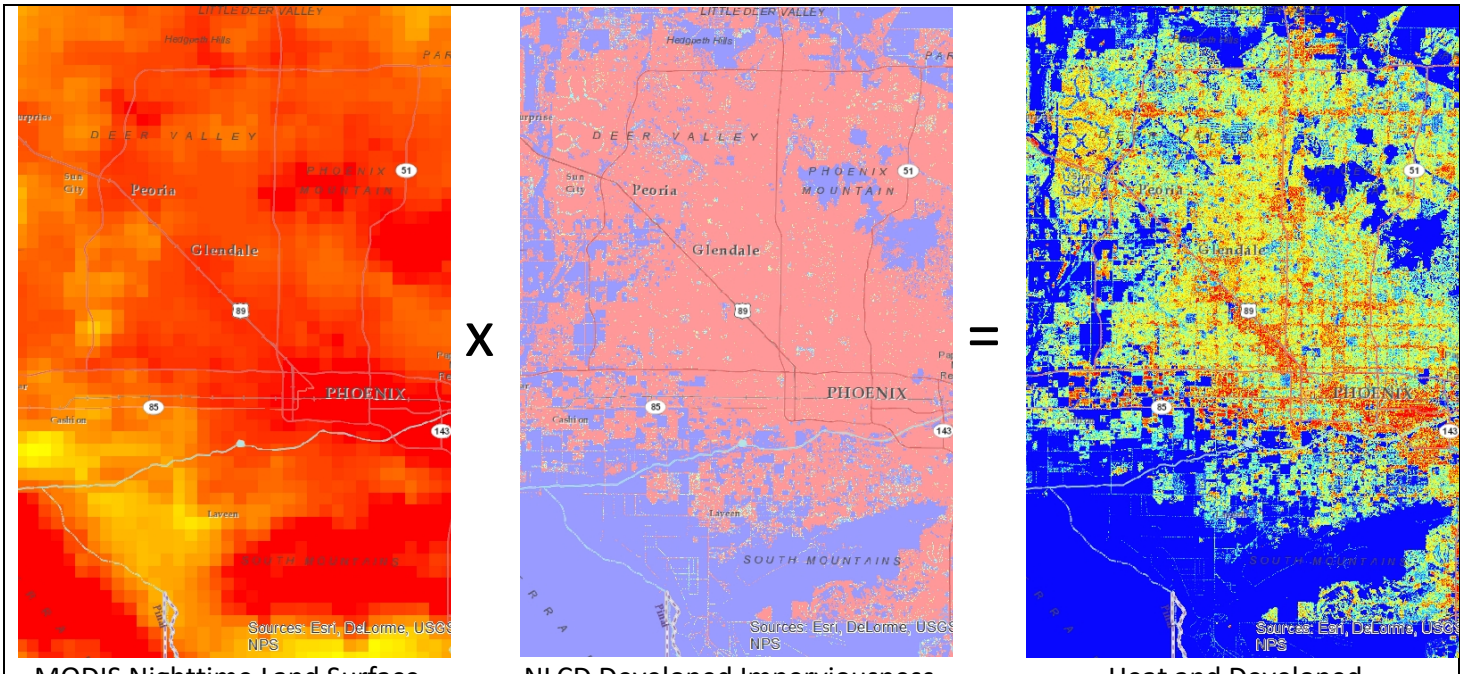
Figure 2. Air Quality calculation

K. Heat and Developed Imperviousness Index

At the time of this analysis, there were no Urban Heat Island (UHI) data available for all of Arizona. As an UHI stand-in, we developed a measure based on the product of nightly land surface temperature and percent developed land surface imperviousness:

- 2013-2015 MODIS Nightly Land Surface Temperature (Kelvin)
  The average of nightly surface temperature satellite data (MOD11A2) at 1 km resolution for the same 8-day period in June for 2013, 2014, and 2015 (https://modis-land.gsfc.nasa.gov/temp.html).
- NLCD 2011 Percent Developed Imperviousness model (%)
  A sub-product of the North American Land Cover Database (NLCD) analysis at 30 m resolution (http://www.mrlc.gov/nlcd11_data.php).

June is generally the hottest month in Arizona and, everything else being equal, local night time surface temperatures tend to be higher in built-up and rocky areas than in vegetated areas. By multiplying night time surface temperature with % developed imperviousness (Figure 3), we were able to emphasize temperatures in developed areas (roofs and pavement) over temperatures in non-developed, rocky areas. Note that higher temperature areas with limited developed impervious surfaces may have the same score as low temperature but highly developed areas. The final score was determined at a 30 m resolution, averaged for each analysis polygon, and then normalized to create this index.



MODIS Nighttime Land Surface Temperature (F) | NLCD Developed Imperviousness (%) | Heat and Developed Imperviousness Score

Figure 3. Heat and Developed Imperviousness calculation

L. Shade Tree Prioritization Index

A Master Score was calculated by averaging all 7 sub-indices per analysis polygon. For a more equitable comparison of towns and cities we used ASLD 2015 Cities (https://land.az.gov/) and U.S. Census Designated Places population estimates to sort the communities into six population "weight classes" (Table 2). The Master Index was calculated by normalizing all analysis polygons belonging to a group of cities and towns within the same population weight class. This means that each of the six population weight classes will always have analysis polygons with an index value ranging from 1 ("hot") to 0 ("cold").

Table 2. Shade Tree Planting Prioritization Index's population weight classes, number of towns and cities, and number of Tree City USA members as of 2017.

Population Weight Class	Towns and Cities	Tree City USA
1 to 1,000	6	1 (16.7%)
1,001 to 5,000	28	3 (10.7%
5,001 to 10,000	16	2 (12.5%)
10,001 to 50,000	28	8 (28.6%)
50,001 to 100,000	7	6 (85.7%)
100,001 and larger	10	9 (90.0%)
Sum	**95**	**29**

Due to the seven factors involved in determining the final Shade Tree Prioritization Index, any combination of them may drive a higher index value. Some sub-indices are more region-wide drivers such as Air Quality in the metropolitan areas or Lack of Canopy Cover in desert climates. Some indices, such as Low-Income and Traffic Proximity, can be a main differentiating driver

within a community. Overall, the Sustainability index is often the biggest driver in differentiating smaller communities within the same geographic area.

M. Methodology Summary

Index	Description	Data Source	Calculation
A Population Density	2010 Census population density per Census Block Group (pop / square mile)	EPA EJSCREEN; Census Bureau	*Index* = normalized *population density*
B Lack of Canopy Cover	2015-2017 i-Tree Canopy urban canopy cover estimate per incorporated or major community (%)	UCF	*Index* = normalized *% urban tree cover*
C Low-Income	2010 Census population at below two times the poverty level per Census Block Group (%)	EPA EJSCREEN; Census Bureau	*Index* = normalized *% Low-Income*
D Traffic Proximity	EPA traffic proximity index per Census Block Group	EPA EJSCREEN	*Index* = normalized *traffic proximity index*
E Sustainability	2017 Tree City USA status per incorporated community (1, 0)	Tree City USA	*Index* = normalized *Tree City USA status*
F Air Quality	Combination of EPA Ozone and PM2.5 concentration scores per Census Block Group	EPA EJSCREEN	*Score* = normalized *Ozone concentration* + normalized *PM 2.5 concentration* *Index* = normalized *Score*
G Heat and Developed Imperviousness	Product of Nightly MODIS Land Surface Temperature (LST, 1 km resolution) averages (June 2013, 2014, 2015; in Fahrenheit) and NLCD 2011 Percent Developed Imperviousness (%, 30 m)	MODIS; NLCD	*Score* = normalized *average MODIS LST* x normalized *NLCD Imperviousness* *Index* = normalized *Score*
Shade Tree Planting Prioritization Index	The **Master Score** is the average of all sub-indices per analysis polygon. The **Master Index** is based on normalizing the Master Score per analysis polygon among towns with similar population sizes (2015 ASLD): • 1 to 1,000 — 6 communities • 1,001 to 5,000 — 28 communities • 5,001 to 10,000 — 16 communities • 10,001 to 50,000 — 28 communities • 50,001 to 100,000 — 7 communities • 100,001 and larger — 10 communities	ASLD (2015 city population); Census Bureau	$Score = \frac{(A + B + C + D + E + F + G)}{7}$ *Index* = normalized *Scores* grouped by Population Class

IV. Results

The results of the 2017 Arizona Shade Tree Planting Prioritization analysis are primarily comparative in nature. The Prioritization Index compares neighborhoods on a Census Block Group level within a community (Figure 4) and the city-level Prioritization Ranking compares major cities and towns within the same population size classes (Figure 5; Table 3). The simple, expert opinion based spatial model is not meant to provide an absolute measure but help the ongoing effort of identifying areas within Arizona's urban communities that would benefit from future tree planting. The indices' values range from 0 or "cold" to 1 or "hot." This analysis and results represent a work in progress which is expected to change as better data becomes available and analysis criteria and methods improve.

N. 2017 Shade Tree Planting Prioritization Index Maps

The spatial analysis results are available for download on the UCF Project web site at https://dffm.az.gov/2017-shade-tree-planting-prioritization. Among the available products are:

- This planning report
- Interactive online map of the Prioritization Index, its sub-indices, and the city level averages
- GIS data in Esri format

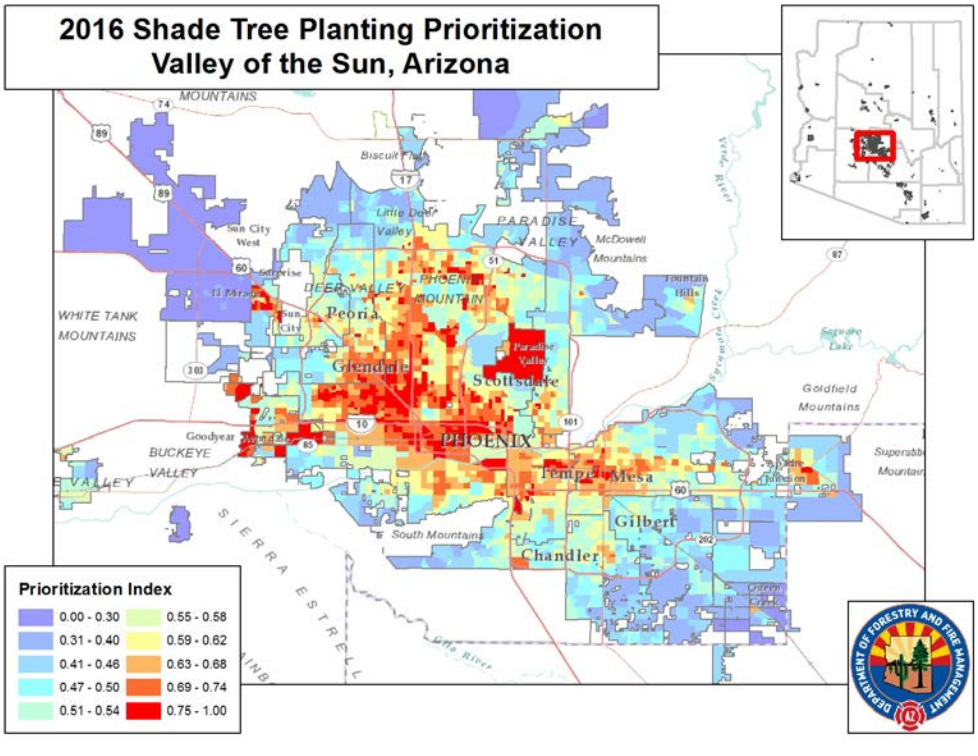


Figure 4: Shade Tree Planting Prioritization Index for greater Phoenix metropolitan area.

O. 2017 Arizona Shade Tree Planting Prioritization Ranking

The Shade Tree Planting Prioritization Ranking is a high level summary of Arizona's major cities and towns to assess existing urban forests and identify shade tree planting needs for UCF Program

Planning (Figure 5). For the Prioritization Ranking, cities and towns were grouped into six population size classes and then ranked from high (#1) to low (#27) priority according to their average Shade Tree Planting Prioritization Index (see Table 3). The Priority Index average was calculated as the statistically and spatially un-adjusted average of all analysis polygons found within a city's analysis area. The analysis polygons are based on 2010 Census Block Groups which *"are statistical divisions of census tracts [,] are generally defined to contain between 600 and 3,000 people"*, and tend to shrink in size with increased population density (U.S. Census https://www.census.gov/geo/reference). Therefore, the Priority Index average of a city tends to be more biased towards high population density neighborhoods (i.e. more and smaller Block Groups) than low density neighborhoods (i.e. fewer and larger Block Groups).

Tree City USA certification (Sustainability Index) tends to be one of the strongest drivers for a city's high ranking. Tree City USA certification is one measure of a community's commitment to their urban forest and it is one of several measure when evaluating grant applications to UCF. However, the Prioritization Ranking is only a general tool based on available data which does not necessarily account for local or regional special conditions and needs.

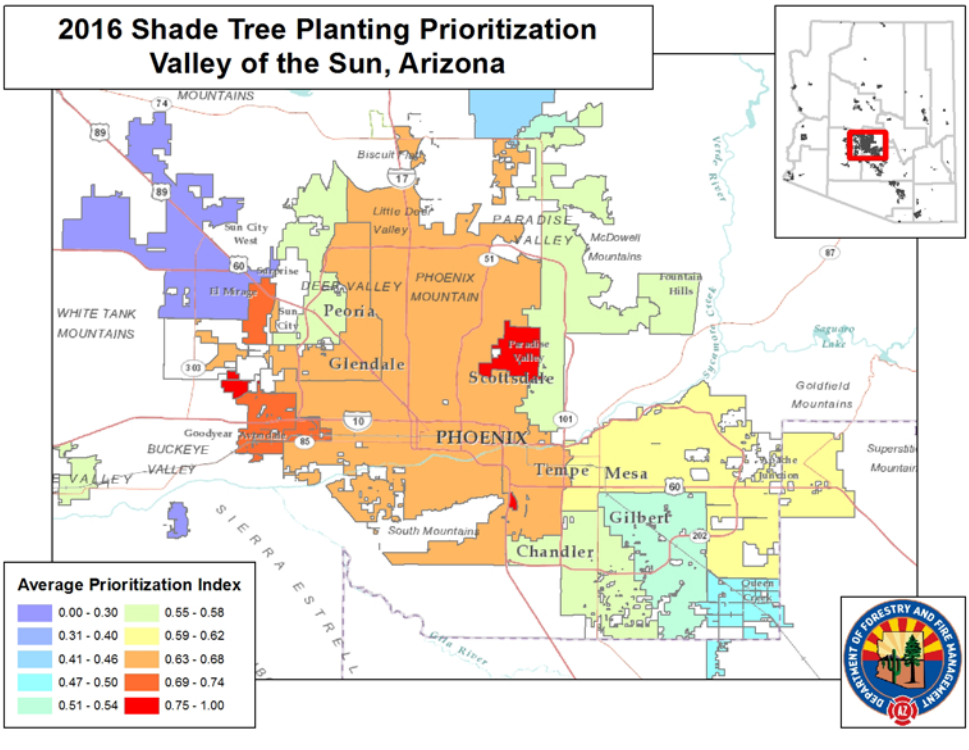


Figure 5: Average Prioritization Index for greater Phoenix metropolitan area.

Table 3. 2017 Arizona Shade Tree Planting Prioritization Ranking. The Arbor Day Foundation logo denotes 2017 Tree City USA communities.

Population 1 to 1,000	1,001 to 5,000	5,001 to 10,000	10,001 to 50,000	50,001 to 100,000	100,001 and higher
1. Patagonia	1. Quartzsite	1. Guadalupe	1. Coolidge	1. Yuma	1. Phoenix
2. Duncan	2. Eagar	2. Snowflake	2. Kingman	2. Avondale	2. Tempe
3. Hayden	3. Miami	3. Litchfield Park	3. Prescott Valley	3. Casa Grande	3. Glendale
4. Jerome	4. Superior	4. South Tucson	4. Paradise Valley	4. Lake Havasu City	4. Mesa
5. Winkelman	5. Willcox	5. Tolleson	5. Florence	5. Buckeye	5. Peoria
6. Tusayan	6. Colorado City	6. Youngtown	6. Marana	6. Flagstaff	6. Chandler
	7. San Carlos	7. Winslow	7. Camp Verde	7. Goodyear	7. Scottsdale
	8. St. Johns	8. Holbrook	8. El Mirage		8. Gilbert
	9. Clarkdale	9. Globe	9. San Luis		9. Tucson
	10. Fredonia	10. Thatcher	10. Bullhead City		10. Surprise
	11. Carefree	11. Cave Creek	11. Somerton		
	12. Benson	12. Safford	12. Apache Junction		
	13. Chinle	13. Kayenta	13. Show Low		
	14. Parker	14. Page	14. Maricopa		
	15. Pima	15. Bisbee	15. Fountain Hills		
	16. Tombstone	16. Wickenburg	16. Eloy		
	17. Springerville		17. Douglas		
	18. Clifton		18. Queen Creek		
	19. Williams		19. Cottonwood		
	20. Taylor		20. Sierra Vista		
	21. Pinetop - Lakeside		21. Chino Valley		
	22. Huachuca City		22. Nogales		
	23. Dewey Humboldt		23. Payson		
	24. Gila Bend		24. Prescott		
	25. Kearny		25. Sedona		
	26. Star Valley		26. Sahuarita		
	27. Wellton		27. Oro Valley)		
	28. Mammoth		28. Green-Valley		

V. Terms and Definitions

Term	Definition
ART Lab	Advanced Resource Technology Lab, University of Arizona
ASLD	Arizona State Land Department
AZUTM	Arizona Urban Tree Map – a UCF effort to help urban communities with their urban tree inventories
DFFM	Arizona Department of Forestry and Fire Management
EPA	Environmental Protection Agency
EJSCREEN	EPA's Environmental Justice Screening and Mapping Tool
GeoDB	Geospatial database used in Ersi's GIS software
GIS	Geographic Information System
LST	Land Surface Temperature
MODIS	Moderate-Resolution Imaging Spectroradiometer satellite sensor
NLCD	National Land Cover Database hosted by the Multi-Resolution Land Characteristics Consortium
Tree City USA	"A tree planting and tree care program sponsored by the Arbor Day Foundation for cities and towns in the United States." Wikipedia
UCF	Urban and Community Forestry program at DFFM
Urban Forest	Urban forests are trees for people - the collection of trees in and around populated areas that occur naturally or have been planted and are typically managed
Urban Area	"A Census-designated area consisting of a central core and adjacent densely settled territory that together contain at least 2,500 residents." Wikipedia
USDA	United States Department of Agriculture
USDA-FS	USDA Forest Service

VI. Credits and References

Figure and Image Credits

Figure 1: Esri ArcMap help documentation
http://desktop.arcgis.com/en/arcmap/10.3/tools/coverage-toolbox/how-intersect-works.htm

Arbor Day Foundation logo: © 2017 Arbor Day Foundation

All other figures: Urban and Community Forestry, DFFM

References

AZUTM: Arizona Urban Tree Map https://dffm.az.gov/azutm

EJSCREEN: Environmental Justice Screening and Mapping Tool https://www.epa.gov/ejscreen

i-Tree Tools http://www.itreetools.org

Wikipedia, The Free Encyclopedia. https://en.wikipedia.org

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