URBAN TREE CANOPY

ASSESSMENT

FREMONT,

CALIFORNIA

NOVEMBER | 2020

CITY OF Fremont

PLANIT GEO™

mapping a greener future

AN ASSESSMENT OF
URBAN TREE CANOPY

FREMONT, CALIFORNIA

> **Someone is sitting in the shade today because someone planted a tree a long time ago.**
> **-Warren Buffet**

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5,346
ACRES OF CANOPY

14.4%
OF URBANIZED AREAS OF FREMONT WAS TREE CANOPY IN 2018

EXECUTIVE SUMMARY

PURPOSE OF THIS ANALYSIS

The City of Fremont is located within Alameda County, California (Figure 1). It is approximately 89 square miles, of which over 35 square miles are urbanized, non-open space areas. Across the city, trees along streets, in parks, yards, and natural areas constitute a valuable urban and community forest. This resource is a critical element of the region's green infrastructure, contributing to environmental quality, public health, water supply, local economies and aesthetics. The primary goal of this assessment was to provide a baseline and benchmark of the City's tree canopy and interpret the results across a range of geographic boundaries.

URBAN TREE CANOPY IN FREMONT

The City of Fremont contained 14.4% tree canopy cover in urbanized areas (13% citywide), 17% areas suitable for future tree plantings (36% citywide), and 69% areas unsuitable due to its current land use or other constraint such as wetland areas (51% citywide). Urban tree canopy (UTC) and possible planting area (PPA) percentages are based on land area which is equal to the total area minus water area. Other land cover types included 11% non-canopy vegetation (6% citywide); 7% soil/dry vegetation (20% citywide); 67% impervious (29% citywide); and 1% water (28% citywide) based on the City's 22,738 total urbanized acres. In further dividing the City's urban tree canopy, 83% was deciduous and 17% was evergreen.

ASSESSMENT BOUNDARIES

This study assessed UTC and PPA at multiple geographic scales in order to provide actionable information to a diverse range of audiences. By identifying what resources and opportunities exist at these scales, the City can be more proactive in their approach to protect and expand their urban tree canopy. Metrics were generated at the following geographies: the citywide boundary (1); city council districts (6); land use (8); parks (60) right-of-way by census block group (121); and census block groups (124).

RECOMMENDATIONS

The results of this analysis can be used to develop a continuing strategy to protect and expand the urban forest in Fremont. The UTC and PPA metrics can be used as a guide to determine where the city has been successful in protecting and expanding its urban forest resource. While also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Fremont can use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

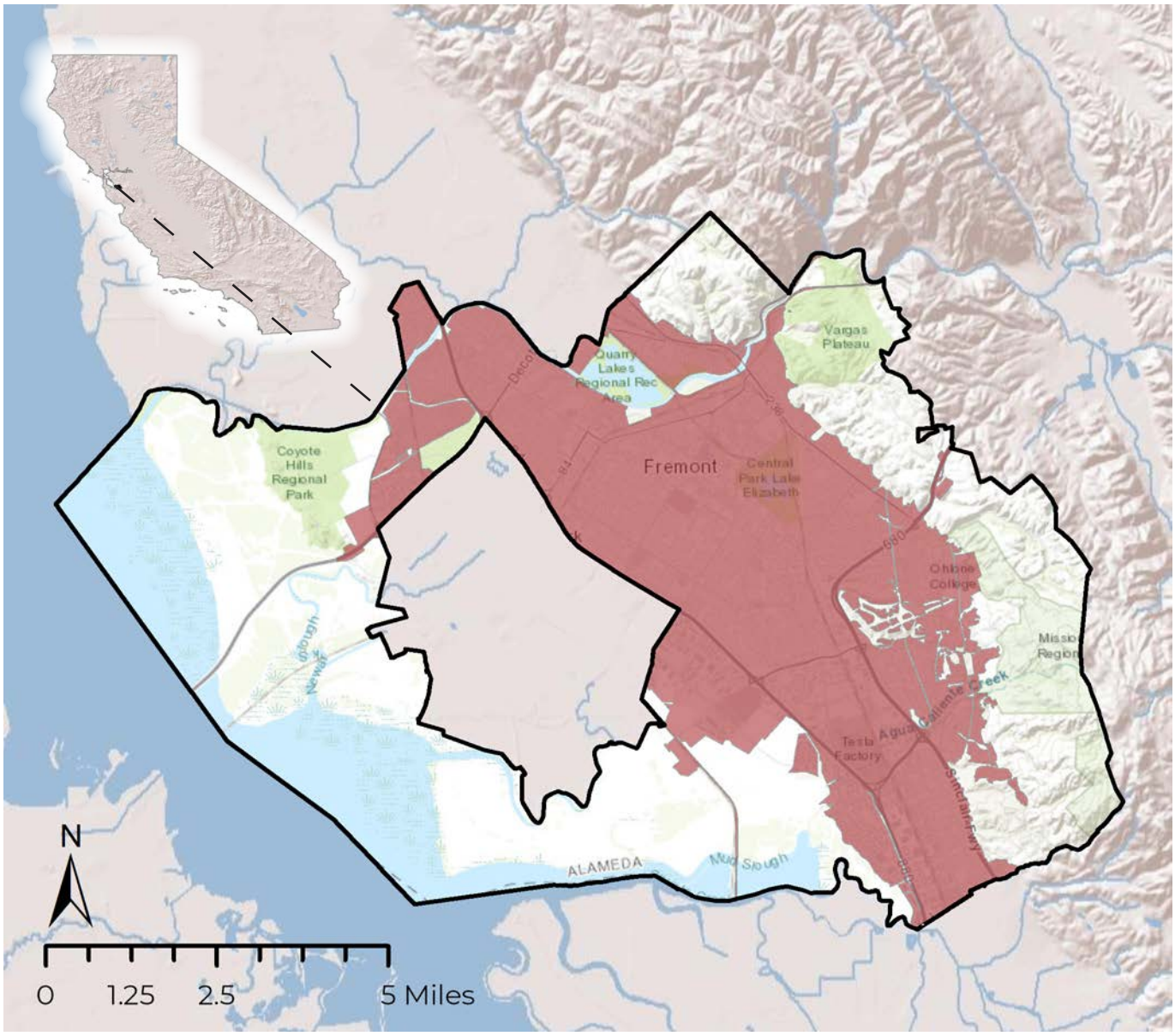


Figure 1. | Fremont occupies approximately 89 square miles in Alameda County, California. Urbanized, non-open space areas (red) include approximately 36 square miles .

14.4% URBAN TREE CANOPY

17% POSSIBLE PLANTING AREA

67% IMPERVIOUS SURFACE

Figure 2. | Based on an analysis of 2018 high-resolution imagery, the urbanized area of Fremont contains 14.4% tree canopy, 17% areas that could support canopy in the future, and 67% total impervious areas.

PROJECT METHODOLOGY

Land cover, urban tree canopy, and possible planting areas were mapped using the sources and methods described below. These datasets provide the foundation for the metrics reported at the selected geographic assessment scales.

DATA SOURCES

This assessment utilized high-resolution (1-meter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in July 2018 to derive the land cover dataset. The NAIP imagery was used to classify all types of land cover. Additional GIS layers provided by the City of Fremont were also incorporated into the analysis.

MAPPING LAND COVER

An initial land cover dataset was to be created prior to mapping tree canopy. The land cover data set is the most fundamental component of an urban tree canopy assessment. An object-based image analysis (OBIA) software program called Feature Analyst was used to classify features through an iterative approach. In this process, objects' spectral signatures across four bands (blue, green, red, and near-infrared), textures, and pattern relationships were considered. This remote sensing process used the NAIP imagery to derive five initial land cover classes. These classes are shown in Figure 3 and described in the Glossary on page 29.

After manual classification improvement and quality control were performed on the remote sensing products, additional data layers from the city (such as buildings, water bodies and wetlands) were utilized to capture finer feature detail and further categorize the land cover dataset.

URBAN TREE CANOPY | OTHER VEGETATION | SOIL AND DRY VEGETATION | IMPERVIOUS SURFACES | SURFACE WATER

Figure 3. | Five (5) distinct land cover classes were identified in the 2018 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Fremont's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in Fremont that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting. Possible planting areas were derived from the Non-Canopy Vegetation and Soil/Dry Vegetation layers. Unsuitable areas, or areas where it was not feasible to plant trees due to biophysical or land use restraints (e.g. golf course playing areas, recreation fields, etc.), were manually delineated and overlaid with the existing land cover data set (Figure 4). The final results were reported as PPA Vegetation, PPA Other, Total PPA, Unsuitable Vegetation, Unsuitable Impervious, Unsuitable Soil, Unsuitable Other, and Total Unsuitable.

Figure 4. | Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.

DEFINING ASSESSMENT LEVELS

In order to best inform the City Council and Fremont's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries (Figure 5). These boundaries include the city boundary, council districts, land use, right of way parks, and census block groups.

- The City of Fremont citywide boundary is the one (1) main area of interest over which all metrics are summarized.

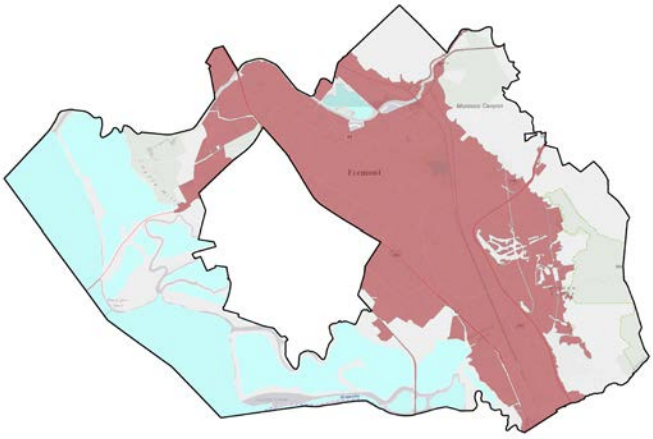
- The right-of-way (ROW) in Fremont was assessed. ROW refers to the areas that are publicly managed such as streets, sidewalks, and medians, and is helpful for quantifying the City's street trees. Right-of-way was assessed as one (1) feature and within each of the City's one hundred and twenty-four (124) U.S. Census block groups. By breaking down the land cover classification and tree canopy data into this detailed scale, city staff can make educated and precise decisions on where to direct resources for tree planting and management efforts on public lands that will have the most impact on the city's citizens.

- Tree canopy was analyzed for the six (6) council districts which cover Fremont to identify the amount of tree canopy as it relates to the individual voter districts and potentially to inform the council members and citizens residing in them.

- Eight (8) unique land use types were assessed to provide detail on tree canopy within the current human uses of land throughout Fremont. These areas are aggregates of the City's land use categories.

- Sixty (60) parks were assessed to determine how tree canopy is distributed in open and green spaces in Fremont.

- One hundred and twenty-four (124) census block groups were assessed to provide information at a small geographic scale. Census block groups (CBGs) are used by the U.S. Census Bureau to assure statistical consistency when tracking populations across the United States and can be valuable indicators of environmental justice as they are directly linked with demographic and socioeconomic data.



City Boundary

Council Districts

Land Use

Right-of-Way

Parks

Census Block Groups

Figure 5. | SIX (6) distinct geographic boundaries were explored in this analysis: the full city boundary with urbanized areas (red), city council districts, land use, right-of-way, parks, and U.S. census block groups.

STATE OF THE CANOPY AND KEY FINDINGS

The results and key findings of this study are presented on the following pages. These results, or metrics, help inform a strategic approach to identifying existing canopy and future planting areas. Urban tree canopy, possible planting area, and unsuitable percentages are based on land area. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification.

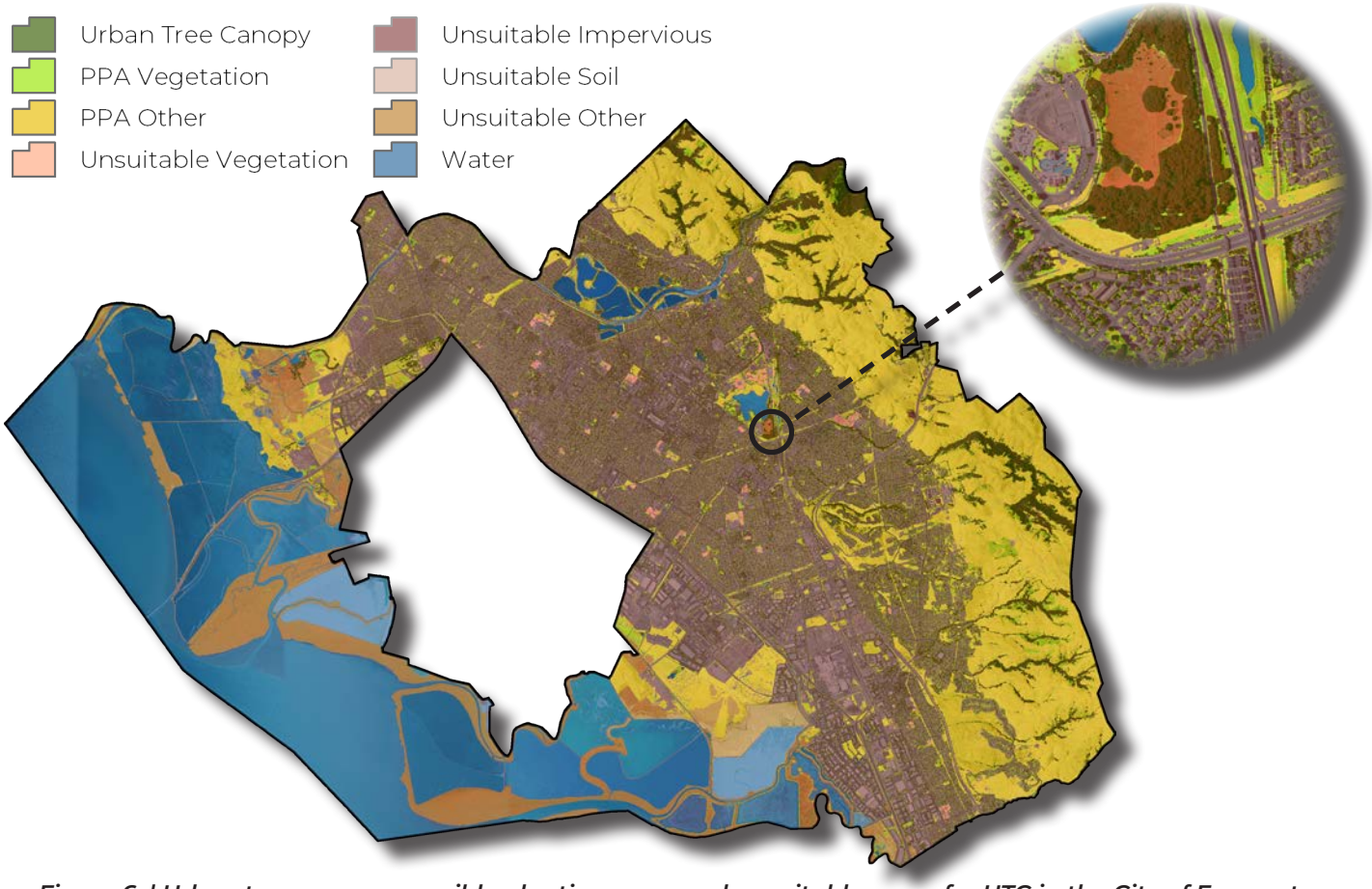


Figure 6. | Urban tree canopy, possible planting area, and unsuitable areas for UTC in the City of Fremont. Visit the City GIS maps at www.fremont.gov to see more detail.

CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover map as a foundation to determine possible planting areas throughout the City. Additional layers and information regarding land considered unsuitable for planting were also incorporated into the analysis. Note that the results of this study are based on land area, which excludes water bodies, as opposed to total area, which includes water bodies (note the difference between Total Acres and Land Acres in Table 1). The results presented on this page are for the urbanized areas of Fremont.

Results of this study indicate that within the urbanized area of Fremont, 3,239 acres are covered with urban tree canopy, making up 14.4% of the City's 22,553 land acres; 3,826 acres are covered with other vegetation or soil/dry vegetation where it would be possible to plant trees (PPA), making up 28% of the City; and the other 20,864 acres were considered unsuitable for tree planting, making up 51% of the City. The unsuitable areas include recreational sports fields, golf course playing areas, buildings, and wetlands.

Fremont Urban Tree Canopy Potential

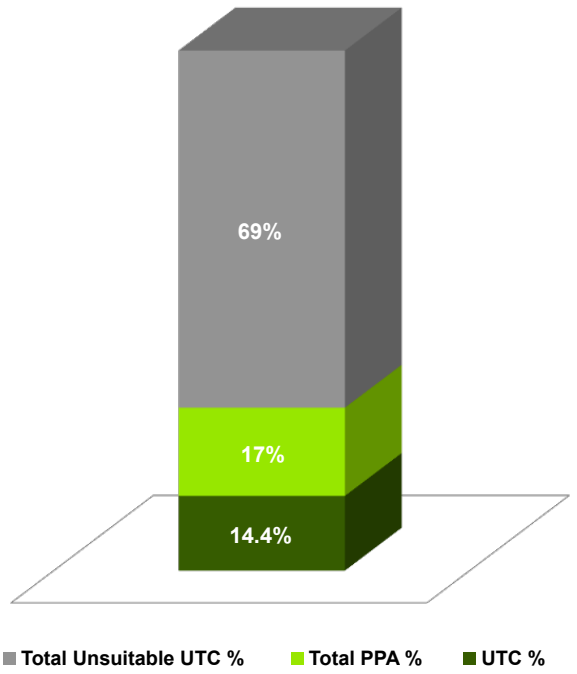


Figure 7. | Urban tree canopy, possible planting area, and area unsuitable for UTC in the City of Fremont.

Table 1. | Urban tree canopy assessment results by acres and percent. (Percentages based on land acres.)

City of Fremont Urbanized Area	Acres	%
Total Area	22,738	100%
Land Area	22,553	99%
Urban Tree Canopy	3,239	14%
Possible Planting Area	3,826	17%
Vegetation	2,256	10%
Other	1,570	7%
Unsuitable Area	15,488	69%
Impervious	15,172	67%
Vegetation	158	1%
Soil	9	0%
Other	148	1%

Bay Area Tree Canopy

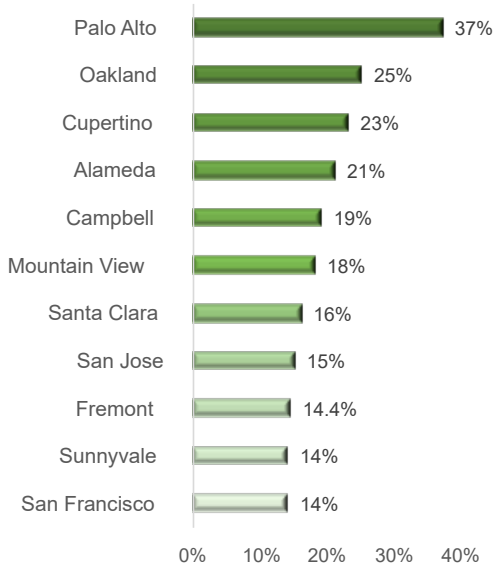


Figure 8. | Comparison of tree canopy in San Francisco Bay Area cities. Canopy cover within the urbanized areas of the city is comparable to that of San Francisco and Sunnyvale at 14%. (Cupertino data provided by PlanIT Geo. All others were taken from the City of Alameda Tree Canopy Assessment.)

URBAN TREE CANOPY BY COUNCIL DISTRICTS

UTC and PPA were assessed in six council districts. UTC varied across council districts. The lowest UTC was 10% (District 1 and District 5) and the highest was 20% (District 4). The other five districts had canopy cover within 5% of each other. PPA was greatly varied across council districts. The District with the highest PPA was District 4 (53%) and the lowest was District 3 (11%). The greatest opportunity for future canopy expansion was found in District 5 which contained 7,868 acres of PPA or 53% of all plantable space in Fremont.

Table 2. | Urban tree canopy assessment results by council districts. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each council district.

Council Districts	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Council District 1	4,621	11%	461	10%	9%	1,241	27%	8%
Council District 2	2,918	7%	400	14%	7%	433	15%	3%
Council District 3	2,349	6%	350	15%	7%	256	11%	2%
Council District 4	8,655	21%	1,760	20%	33%	4,605	53%	31%
Council District 5	19,817	48%	2,033	10%	38%	7,868	40%	53%
Council District 6	2,679	7%	342	13%	6%	433	16%	3%

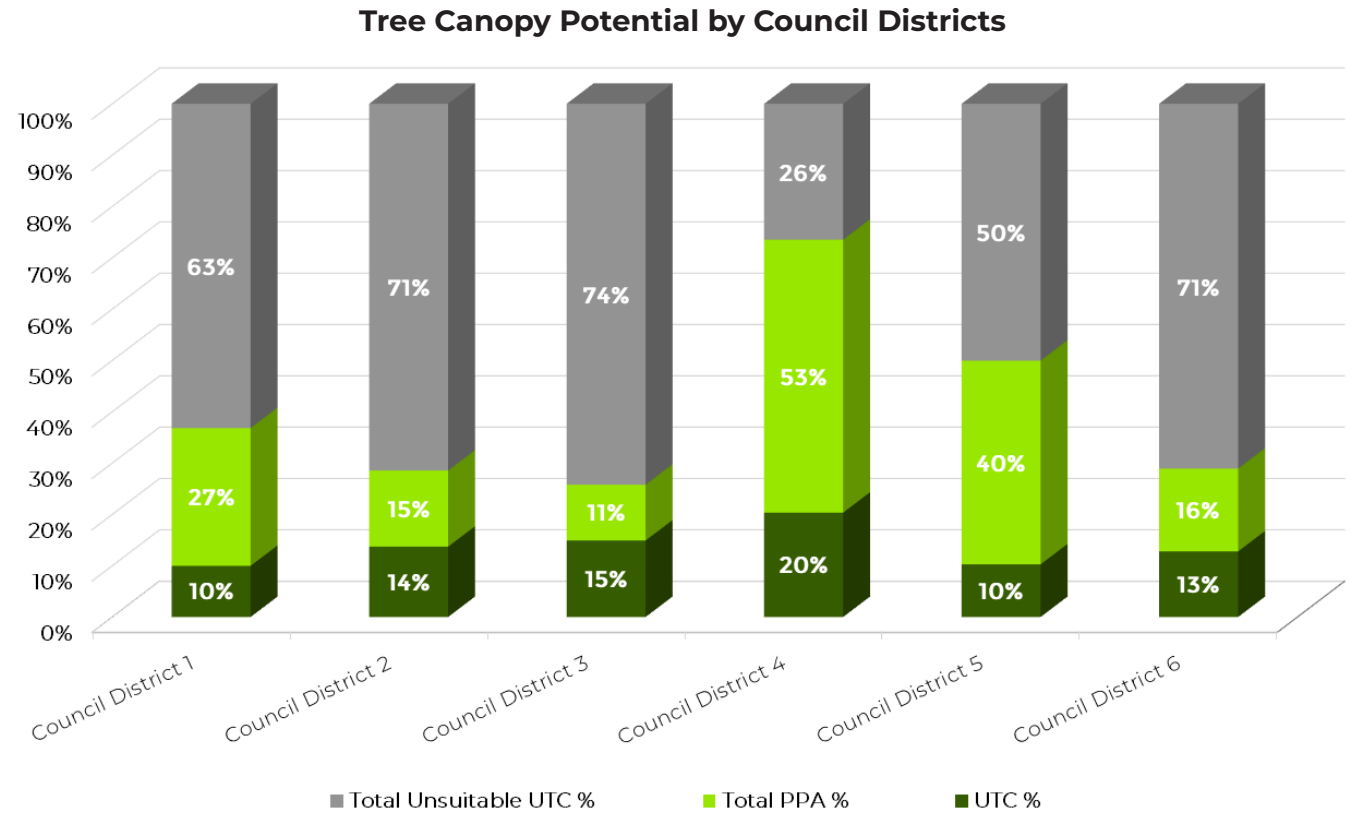


Figure 8. | Urban tree canopy, possible planting area, and area unsuitable for UTC by council districts.

URBAN TREE CANOPY BY LAND USE

UTC and PPA were assessed for the eight unique land use types found within Fremont. UTC varied across land uses. The lowest UTC was 4% found in the Innovation Center land use and the highest UTC was 18% found in Residential areas. PPA ranged from 7% in Commercial areas to 58% in Open Space. 45% of all canopy cover in Fremont was found in Open Space. Open Space also contained the largest amounts of both UTC and PPA in Fremont with 45% or 2,383 acres of UTC and 78% or 11,580 acres of PPA.

Table 3. | Urban tree canopy assessment results by land use. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the City's total UTC or PPA within each land use.

Land Use	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Commercial	1,578	4%	174	11%	3%	117	7%	1%
Industrial	3,641	9%	312	9%	6%	436	12%	3%
Innovation Center	837	2%	32	4%	1%	93	11%	1%
Open Space	19,802	48%	2,383	12%	45%	11,580	58%	78%
Public Facility	1,228	3%	122	10%	2%	374	30%	3%
Residential	12,567	31%	2,205	18%	41%	1,905	15%	13%
Right of Way	943	2%	53	6%	1%	242	26%	2%
Railroad Corridor	449	1%	66	15%	1%	94	21%	1%

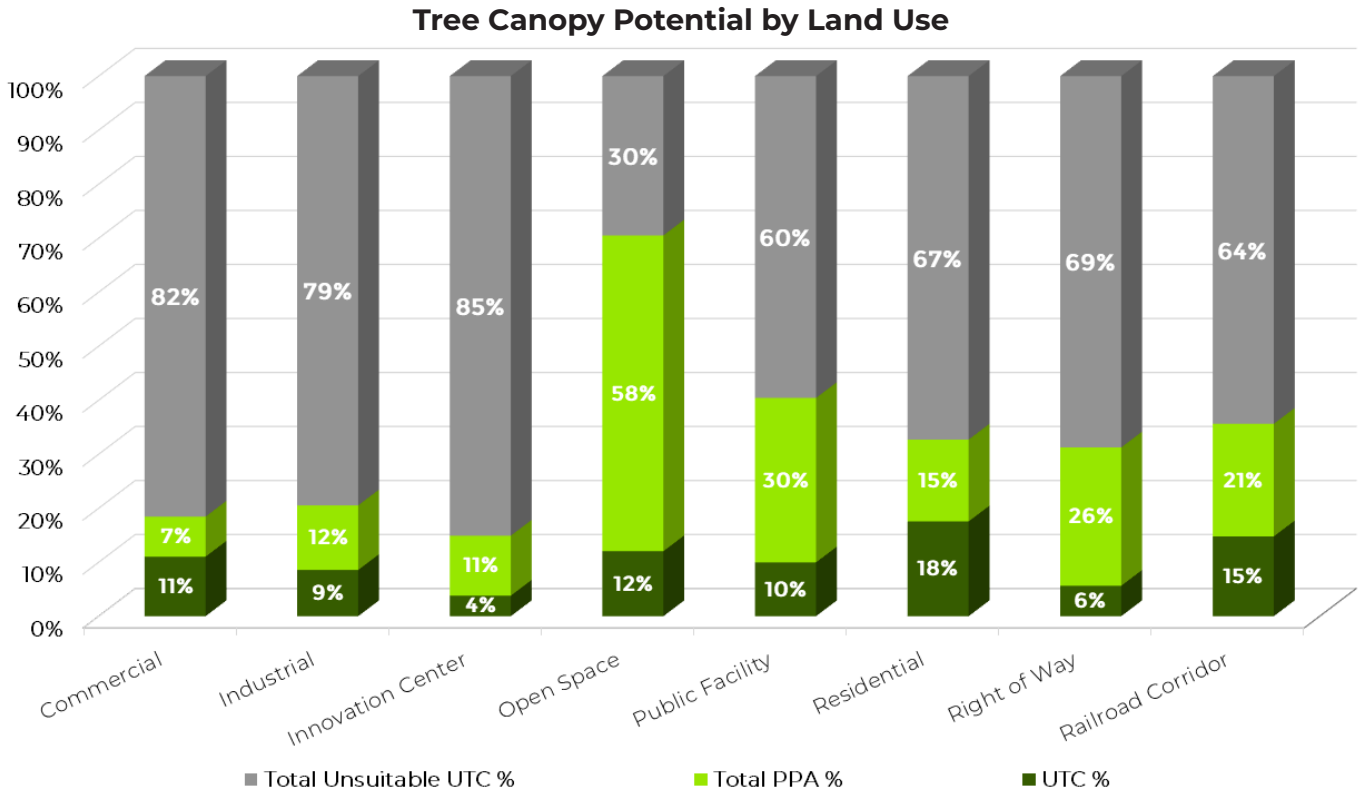


Figure 9. | Urban tree canopy, possible planting area, and area unsuitable for UTC by land use.

URBAN TREE CANOPY BY PARKS

UTC and PPA were assessed for 60 parks across Fremont. UTC varied greatly throughout parks in Fremont from 1% to 71%. The park with the lowest UTC was Pacific Commons Sports Park with 1% UTC. With 71% UTC Sabercat Historic Park had the highest coverage. PPA showed similar variation with the lowest PPA found in Peralta/ Dusterberry Park which had 2% PPA while the highest PPA was found in Pacific Commons Sports Park which had 93%. Fremont Central Park contained the largest portion of UTC and PPA in the City's parks with 48 acres or 26% of all UTC and 118 acres or 25% of all PPA.

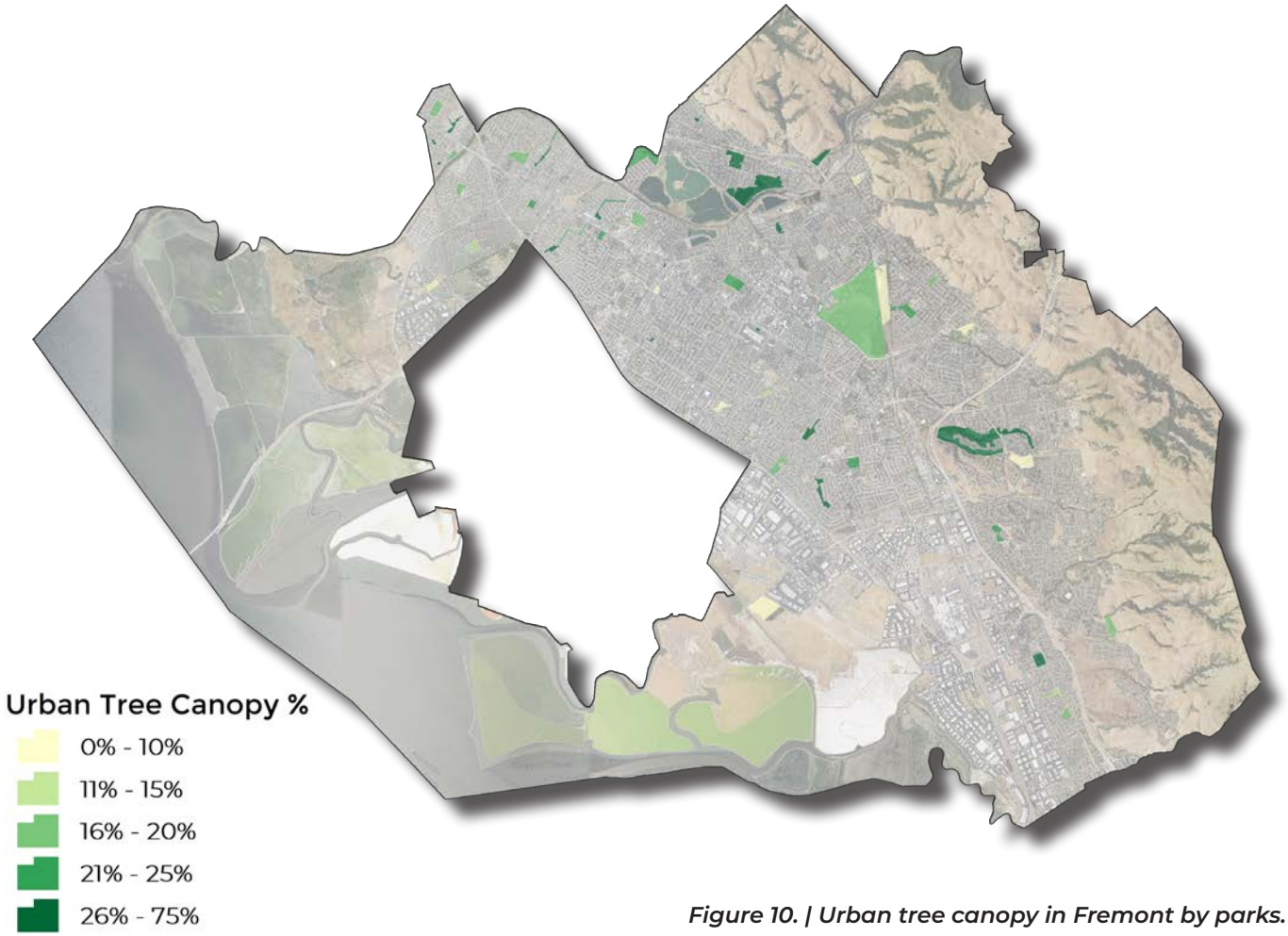


Figure 10. | Urban tree canopy in Fremont by parks.

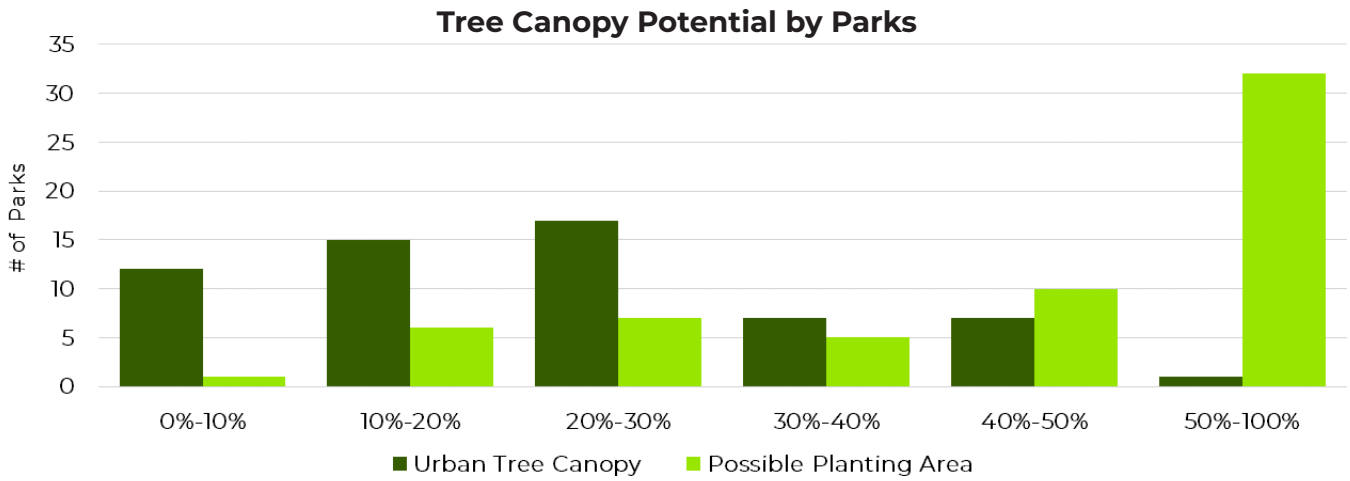


Figure 11. | Urban tree canopy and possible planting area in Fremont by parks.

URBAN TREE CANOPY BY CENSUS BLOCK GROUPS

Census block groups are linked to all demographic and socioeconomic U.S. Census data which makes them useful to a city and its residents for assessing the equitable distribution of tree canopy. Results indicated that UTC in Fremont is not uniformly distributed throughout the city. Some of the City's 124 census block groups contained less than 5% canopy cover, while others contained over 30%. The average canopy cover for a census block group in Fremont was 15%. Over 50% of census block groups had UTC higher than the citywide average of 13%. PPA also varied greatly and ranged from 0 to 88%. For the complete results by census block group, refer to the UTC Results spreadsheet.

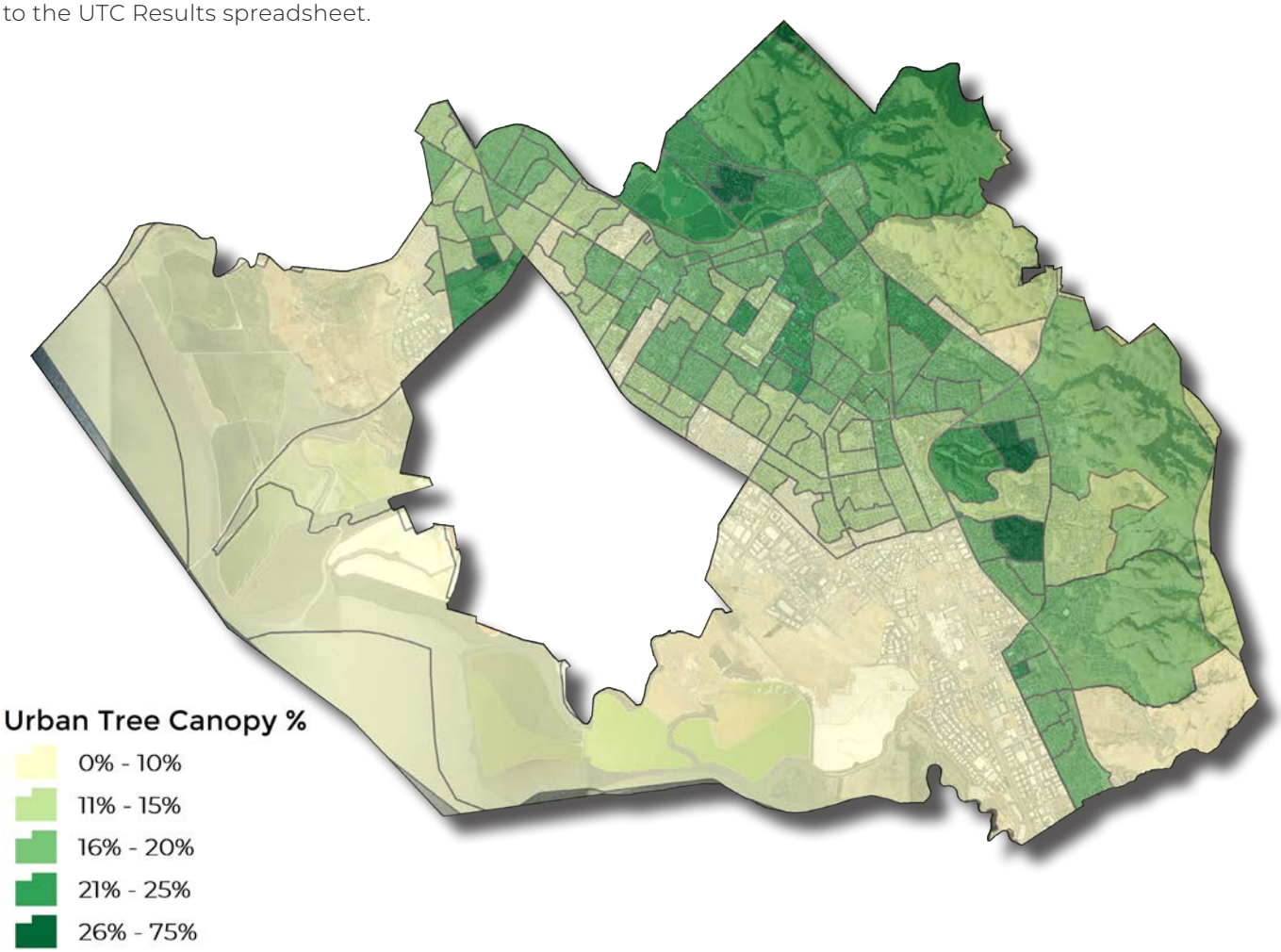


Figure 12: | Urban tree canopy in Fremont by census block groups.

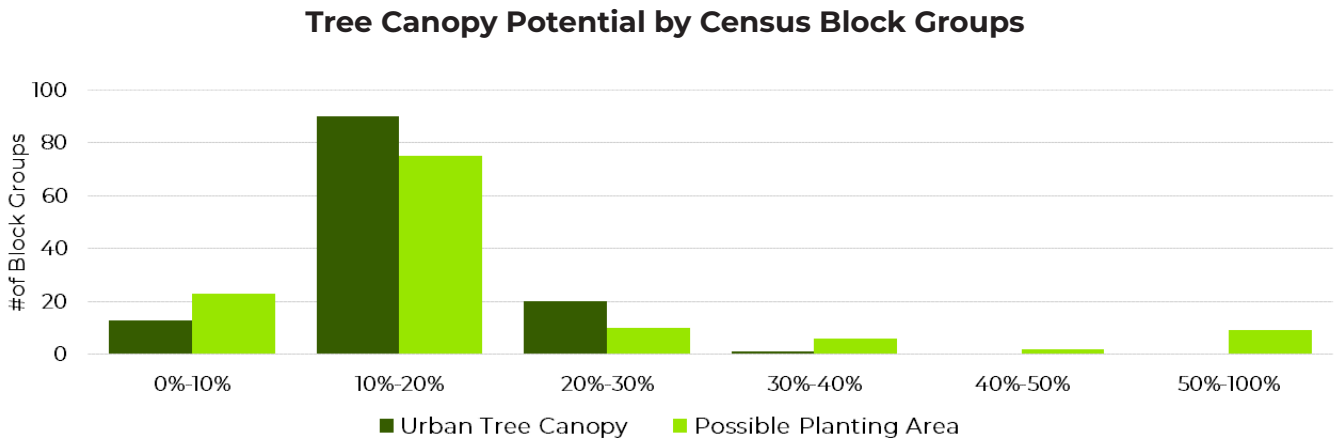


Figure 13: | Urban tree canopy and possible planting area in Fremont by census block groups.

URBAN TREE CANOPY BY RIGHTS-OF-WAY BY CENSUS BLOCK GROUPS

UTC and PPA have been evaluated in the right-of-way (ROW) at both the citywide level and also at the census block group scale. The total land area of ROW in Fremont is 4,840 acres. Results showed that the ROW in Fremont contained 11% UTC and 10% PPA. 76% of the ROW is impervious road surfaces. Trees in the ROW help improve air quality and combat the urban heat island effect. Since ROW is owned and managed by the City, possible planting areas located within them are good opportunities for increasing tree canopy cover. Combining ROW, census data, UTC, and PPA provides the City with the tools to determine where tree planting and management efforts on public lands will be most effective.

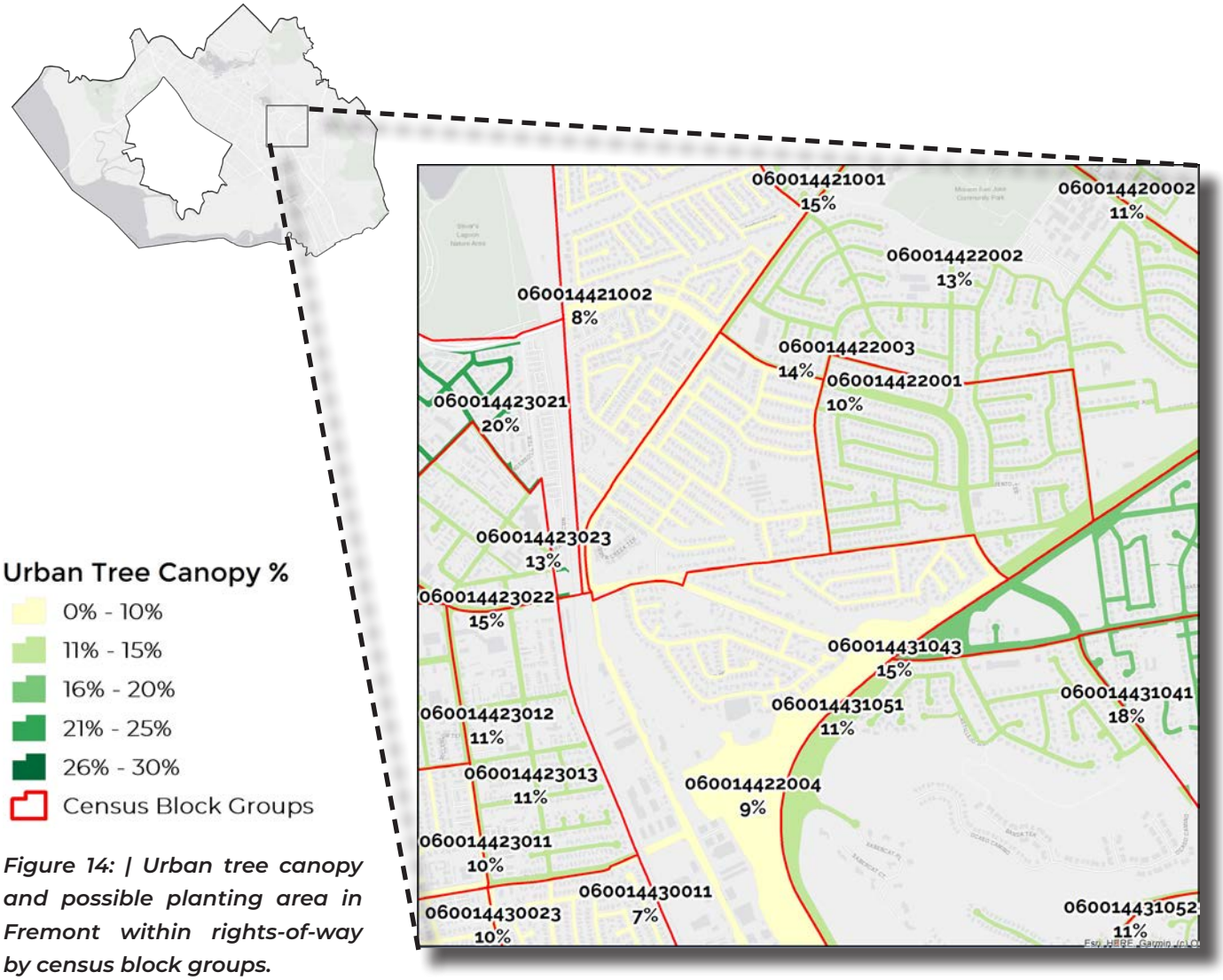


Figure 14: | Urban tree canopy and possible planting area in Fremont within rights-of-way by census block groups.

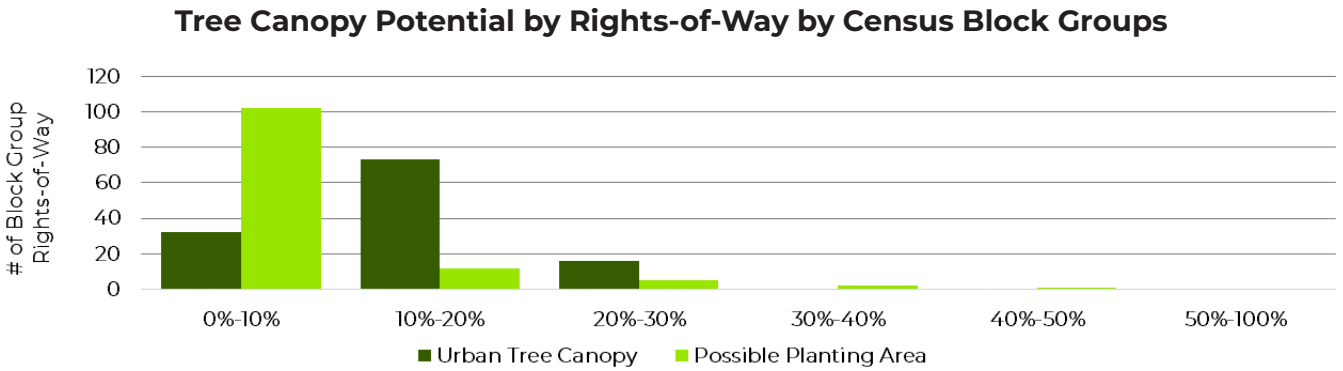


Figure 15: | Urban tree canopy and possible planting area in Fremont within rights-of-way by census block groups.

URBAN TREE CANOPY BY LAND OWNERSHIP

A city's urban forest typically consists of trees that are both publicly and privately managed. In Fremont, over 102,000 individual street and park trees were inventoried in publicly managed spaces. Tree canopy cover was 10% within these areas that make up about one-third of the total land area of the city. However, only about 27% of all tree canopy is publicly managed. The other 73%, or 3,900 acres, is managed privately by residents, HOAs, business owners, and other private landowners. The importance of engaging all private landowners, enacting codes to preserve existing tree canopy, and educating the public on the benefits of trees cannot be stressed enough if the City of Fremont is to maintain and expand its urban forest.

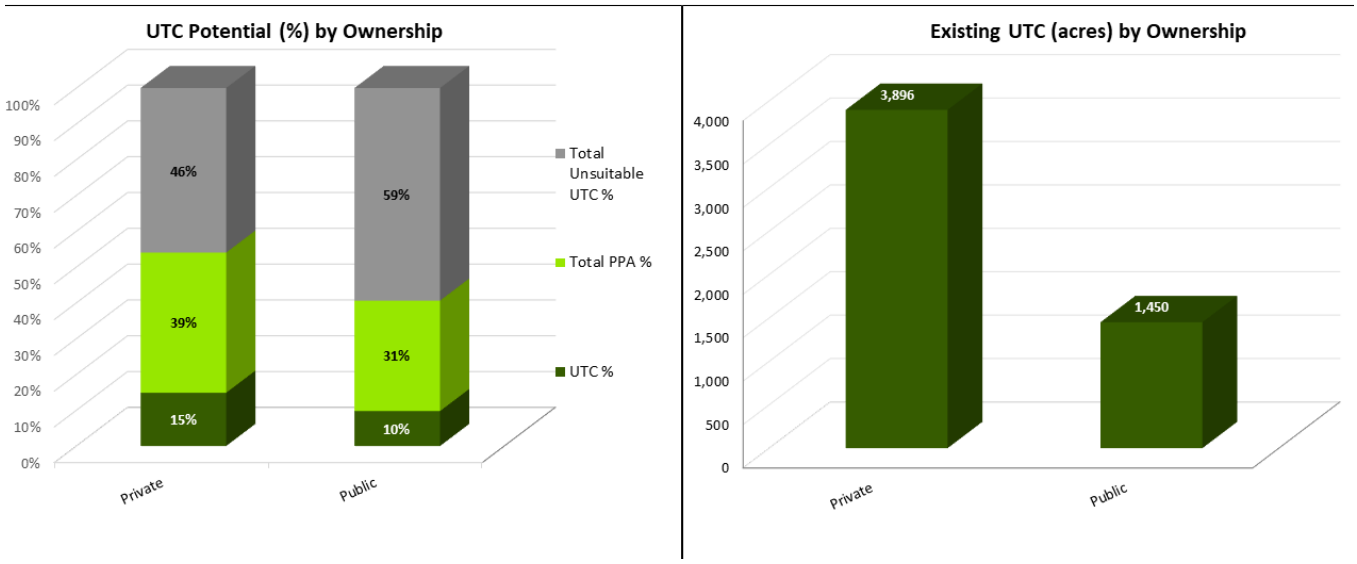


Figure 17. | Urban tree canopy and possible planting area in Fremont (%) by land ownership (left), and existing tree canopy by ownership (acres).

Figure 18. | Tree canopy is shown in green with individual inventoried trees shown as points. Grayed out areas represent publicly managed spaces.

QUANTIFYING ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by trees and forests in Fremont. The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction , and stored carbon.

AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperatures, and improve public health by reducing air pollutants which cause death and illness.

- The existing tree canopy in Fremont removes 234 tons of air pollution annually, valued at $2.4M.

STORMWATER AND WATER QUALITY

Trees and forests mitigate stormwater runoff which minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian land, and absorbs pollutants, thus improving water quality and habitats.

- On average, each acre of tree canopy in Fremont absorbs 20,000 gallons of water. This benefit of avoided runoff is valued at roughly $143 per acre/per year. Extrapolated citywide, this means that Fremont's existing tree canopy provides $766K annually in stormwater benefits.

CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a temperate forest, the rate and amount increase with age.

- Fremont's trees store approximately 235K tons of carbon, valued at $40M, and each year the tree canopy absorbs and sequesters approximately 6K tons of carbon dioxide, valued at $1M.

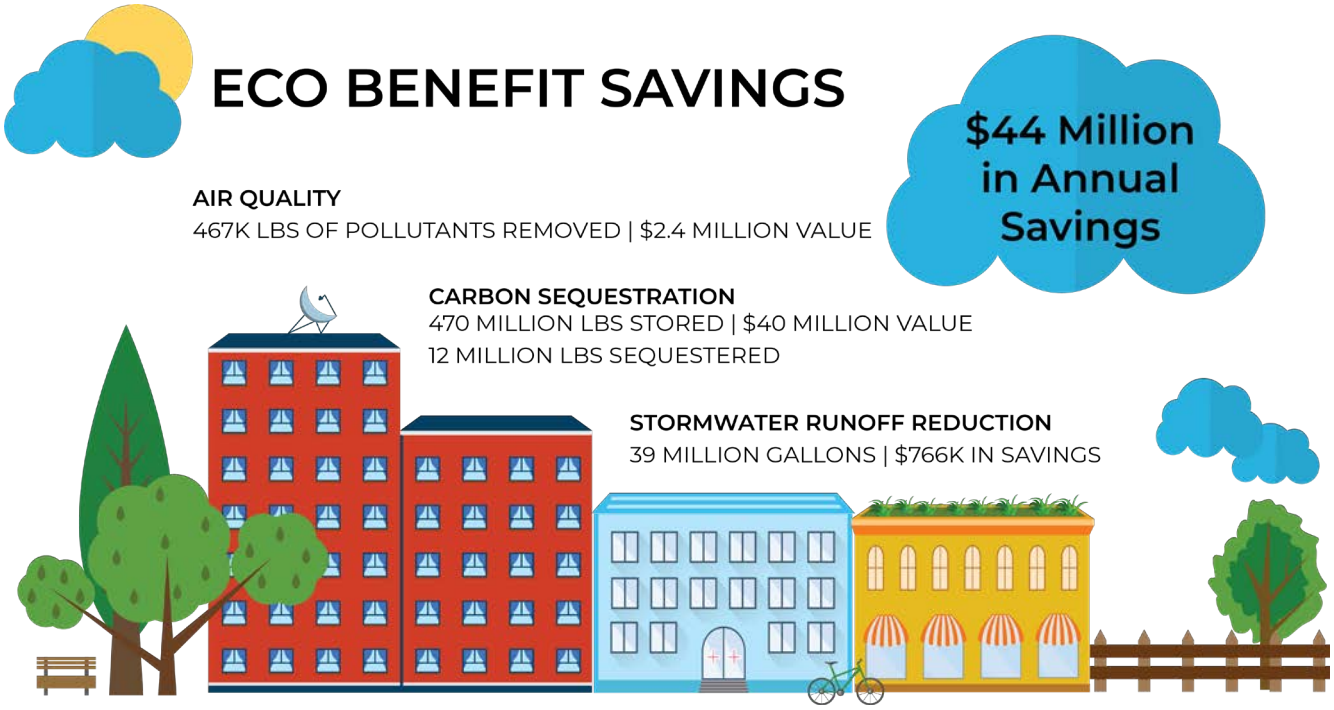


Figure 19. | Eco-benefit savings provided by Fremont's urban tree canopy.

CONCLUSIONS AND RECOMMENDATIONS

The City of Fremont has demonstrated that it values its natural resources and wants to maintain a healthy and sustainable urban environment. This tree canopy assessment represents an important first step in ensuring the long-term health of its urban forest. A greater percent of canopy cover can be achieved with proper planning, investment, and care of existing trees. The City should continue to monitor the health of the urban forest and implement the following recommendations to ensure the urban forest is considered during future city planning and development to sustain and enhance the benefits that trees provide to the community.

Target new tree plantings to benefit air-quality and reduce stormwater runoff.

1. Leverage the results of this assessment to promote the urban forest

To preserve, protect, and maintain Fremont's tree canopy, the City should have a tree canopy assessment performed on a regular interval. As the City changes, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Fremont with a wealth of environmental, social, and even economic benefits which relate back to greater community interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Fremont's urban forest.

The results of this assessment should be used to encourage investment in urban forest monitoring, maintenance, and management; to prepare supportive information for local budget requests/grant applications; and to develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues. The land cover and planting prioritization data should be disseminated to diverse partners for urban forestry and other applications while the data are current and most useful for decision-making and implementation planning. The information from this study can help establish canopy cover goals for the short- and long-term.

2. Use the planting site prioritization to identify plantable space within the right-of-way

The City and its various stakeholders can utilize the results of the UTC, PPA, and planting site prioritization analyses to identify the best locations on public land to focus future tree planting and canopy expansion efforts. Trees can play a large role in improving public health by improving air quality, reducing temperature, and making public spaces more inviting. Planting trees near impervious surfaces can offset the urban heat island effect, stormwater runoff and energy consumption. Plantable space in the right-of-way in many cases is near to high concentrations of impervious surfaces. Land cover analysis results revealed 28% of planting site points fell on public land or right-of-way and over 400 acres of plantable space currently exist within the right-of-way in Fremont. The priority planting analysis should be used to identify planting opportunities in areas with high concentrations of impervious surfaces, within the right-of-way, and on public lands throughout the City.

71% OF PLANTING SITE POINTS IN FREMONT WERE ON PRIVATELY OWNED LAND

3. Develop outreach programs towards private landowners

In Fremont 78% of PPA is found in areas designated as Open Space while residential areas contained 13% of all PPA in Fremont. The City should focus on community outreach and education programs to better inform citizens and private landholders of the environmental, social, and financial benefits that trees provide and consider other strategies to help preserve and grow the tree canopy in the nearly 4,000 acres of plantable space in urbanized areas. Tree giveaways, tree planting programs, and other incentives can be developed to further promote new tree plantings. In addition, the City should continue to conduct volunteer tree planting events to increase awareness levels in the community.

4. Use these results to inform updates to, and progress of, the City's General Plan 2030 Vision

Fremont's General Plan 2030 Vision states, "Maintain Fremont as a 'Tree City' by continuing to enhance the urban forest". The City has already demonstrated its commitment as a "Tree City" by completing this, its first tree canopy assessment. The results of this assessment should be used to guide and inform efforts toward achieving current urban forest goals, establishing new goals, and making decisions about the urban forest. Moving into the future the city should continue to monitor its urban forest by performing canopy assessments at regular intervals. By performing canopy assessments at regular intervals (every 5-10 years), Fremont can identify if trends in canopy growth or decline are due to short term changes or a part of a larger trend and track the impact of tree planting efforts. Finally, Fremont should consider implementing an urban forest management plan and set a citywide tree canopy percentage goal.

5. Use TreePlotter™ INVENTORY and CANOPY software to plan, evaluate, and manage trees and tree canopy

In addition to the examples above, the City can also use the incorporated TreePlotter™ tools (CANOPY and INVENTORY) to manage maintenance tasks, track plantings and explore a wide range of targeted, in-depth planting scenarios. CANOPY planting scenarios are based on UTC and PPA metrics and planting prioritization criteria such as energy conservation, stormwater reduction, urban heat island, vulnerable populations, and household income. CANOPY allows stakeholders to visualize existing land cover, create custom weighted priority planting maps, and quantify impacts that canopy growth or loss has on air quality and carbon sequestration in the City. These tools should be used to identify areas in most need of the benefits that trees provide.

REPORT APPENDIX

ACCURACY ASSESSMENT

Classification accuracy serves two main purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Even with high resolution imagery, very small differences in classification methodology and image quality can have a large impact on overall map area estimations.

The classification accuracy error matrix illustrated in Table A1 contain confidence intervals that report the high and low values that could be expected for any comparison between the classification data and what actual, on the ground land cover was in 2017. This accuracy assessment was completed using high resolution aerial imagery, with computer and manual verification. No field verification was completed.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS:

1. One thousand (1000) sample points, or approximately 15 points per square mile area in Fremont (89 sq.miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the NAIP aerial photo and assigned one of five generalized land cover classes ("Ref_ID") mentioned above by a technician.
3. In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis. In this case, no points were dropped.
4. An automated script was then used to assign values from the classification raster to each point ("Eval_ID"). The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified points (where reference ID does not equal evaluation ID) and corresponding land cover are inspected for necessary corrections to the land cover.[1]
5. Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved.

SAMPLE ERROR MATRIX INTERPRETATION

Statistical relationships between the reference pixels (representing the true conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Fremont's landscape. The error matrix shown in Table A1 represent the intersection of reference pixels manually identified by a human observer (columns) and classification category of pixels in the classified image (rows). The blue boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the number of pixels manually referenced to the column class that were classified as another category in the classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (93 + 44 + 251 + 214 + 336 = 938 / 100 = 94%), and the matrix can be used to calculate per class accuracy percentage's. For example, 93 points were manually identified in the reference map as Tree Canopy, and 103 of those pixels were classified as Tree Canopy in the classification map. This relationship is called the "Producer's Accuracy" and is calculated by dividing the agreement pixel total (diagonal) by the reference pixel total (column total). Therefore, the Producer's Accuracy for Tree Canopy is calculated as: (93/103 = .90), meaning that we can expect that ~90% of all 2018 tree canopy in the Fremont, FL study area was classified as Tree Canopy in the 2018 classification map.

1 Note that by correcting locations associated with accuracy points, bias is introduced to the error matrix results. This means that matrix results based on a new set of randomly collected accuracy points may result in significantly different accuracy values.

Conversely, the "User's Accuracy" is calculated by dividing the total number of agreement pixels by the total number of classified pixels in the row category. For example, 155 classification pixels intersecting reference pixels were classified as Tree Canopy, but 10 pixels were identified as Vegetation in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (93/98 = 0.95), meaning that ~95% of the pixels classified as Tree Canopy in the classification were actual tree canopy. It is important to recognize the Producer's and User's accuracy percent values are based on a sample of the true ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this land cover, and more importantly, tree canopy, were accurately mapped in Fremont in 2017. The largest sources of classification confusion exist between tree canopy and vegetation.

Table A1. | Error matrix for land cover classifications in Fremont, CA (2018).

Classification Data	Reference Data: Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	93	5	0	0	0	98
Vegetation	7	44	6	0	3	60
Impervious	3	6	251	3	3	266
Soil / Dry Veg.	0	10	16	214	0	240
Water	0	0	0	0	336	336
Total	103	65	273	217	342	1,000

Overall Accuracy = 94%

Producer's Accuracy	
Tree Canopy	90%
Veg. / Open Space	68%
Impervious	92%
Bare Ground / Soil	99%
Water	98%

User's Accuracy	
Tree Canopy	95%
Veg. / Open Space	73%
Impervious	94%
Bare Ground / Soil	89%
Water	100%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Fremont's urban tree canopy coverage and how well aligned the derived land cover data are with interpretations by the human eye. The high accuracy of the 2018 data indicates that regardless of how and when it was achieved, Fremont's current tree canopy can be safely assumed to match the figures stated in this report (approximately 13%).

GLOSSARY/KEY TERMS

Land Acres: Total land area, in acres, of the assessment boundary (excludes water).

Non-Canopy Vegetation: Areas of grass and open space where tree canopy does not exist.

Possible Planting Area - Vegetation: Areas of grass and open space where tree canopy does not exist, and it is biophysically possible to plant trees.

Possible Planting Area - Impervious: Paved areas void of tree canopy, excluding buildings and roads, where it is biophysically possible to establish tree canopy. Examples include parking lots and sidewalks.

Possible Planting Area - Total: The combination of PPA Vegetation area and PPA Impervious area.

Soil/Dry Vegetation: Areas of bare soil and/or dried, dead vegetation.

Total Acres: Total area, in acres, of the assessment boundary.

Unsuitable Impervious: Areas of impervious surfaces that are not suitable for tree planting. These include buildings and roads and all other types of impervious surfaces.

Unsuitable Planting Area: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

Unsuitable Soil: Areas of soil/dry vegetation considered unsuitable for tree planting. Irrigation and other modifiers may be required to keep a tree alive in these areas.

Unsuitable Vegetation: Areas of non-canopy vegetation that are not suitable for tree planting due to their land use.

Urban Tree Canopy (UTC): The “layer of leaves, branches and stems that cover the ground” (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of the urban forest. Tree canopy was generally taller than 10-15 feet tall.

Water: Areas of open, surface water not including swimming pools.

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NOVEMBER | 2020

URBAN TREE CANOPY

ASSESSMENT

FREMONT, CALIFORNIA

CITY OF Fremont

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