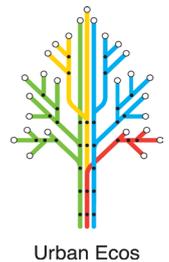
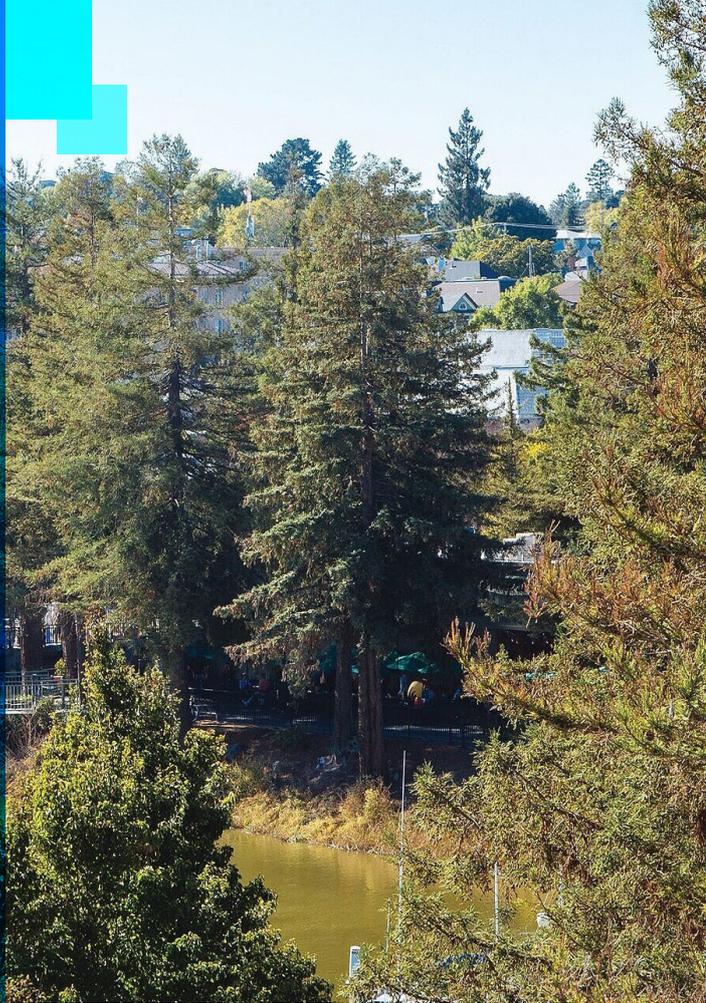


URBAN TREE CANOPY ASSESSMENT

CITY OF PETALUMA
SEPTEMBER | 2025





PETALUMA, CA

TREE CANOPY ASSESSMENT



As nature's largest and longest-lived creations, trees play an extraordinarily important role in our cities; they are living landmarks that define space, cool the air, soothe our psyches, and connect us to nature and our past.



**JILL JONNES, URBAN FORESTS:
A NATURAL HISTORY OF TREES
AND PEOPLE IN THE AMERICAN
CITYSCAPE**

PREPARED BY
PlanIT Geo, Inc., Arvada, Colorado

PREPARED FOR
The City of Petaluma

COMPLETED
September 2025

Funding for this project was provided by a grant administered by the California Department of Forestry and CAL Fire Protection's Urban and Community Forestry Program.

TABLE OF

CONTENTS

01 EXECUTIVE SUMMARY

04 PROJECT METHODOLOGY

08 STATE OF THE CANOPY AND KEY FINDINGS

28 TREE PLANTING PRIORITIZATION

31 PETALUMA TREE PLANTINGS & REGIONAL COMPARISONS

34 ECOSYSTEM BENEFITS

35 CONCLUSIONS AND RECOMMENDATIONS

37 REPORT APPENDIX



EXECUTIVE --- SUMMARY

BACKGROUND OF THIS ASSESSMENT

Petaluma is located in Sonoma County within the North Bay region of the San Francisco Bay Area. Its climate is classified as Mediterranean, which is characterized by warm, dry summers and cool, wet winters. Known for its charming historic downtown and a strong sense of community, the city features a dense suburban area that blends small-town appeal with modern amenities. Petaluma's urban tree canopy (UTC) is a defining feature of the city's landscape, comprising a diverse mix of native species, heritage oaks, and non-native ornamentals, which highlights the region's natural aesthetic and the influence of human stewardship. These tree-lined community gathering spaces benefit Petaluma by providing important ecological benefits such as shade, habitat, and improved air quality.

The city's identity is closely tied to its green spaces, supported by active community involvement. Petaluma has been a Tree City USA community for 22 years and is developing an Urban Forest Management Plan (UFMP). The UFMP is relying heavily on input from the community and a consortium of local urban forestry and environmental organizations that collectively form the Canopy Project.

The Canopy Project enables Petaluma to partner with organizations like ReLeaf Petaluma, a local non-profit organization dedicated to improving urban tree canopy cover in the city. This collaboration encourages resident engagement in tree plantings and maintenance. ReLeaf Petaluma has developed programs, such as the Neighborhood Tree Captains, which empower citizens to accelerate local greening efforts. Another program, the Residential Program, offers native trees to low-income neighborhoods to improve tree canopy and lessen the urban heat island effect in these areas. The city's vested interest in engaging with its local partners and organizations positions Petaluma to address urban forestry challenges in creative and unique ways.

The urban tree canopy in Petaluma is dynamic and continually shaped by both natural processes and human activities. While the city and surrounding region benefit from ongoing tree-planting efforts and the stewardship of local landowners, factors such as urban development, drought, disease, and changing climate conditions can contribute to canopy loss. These shifts make it challenging to gauge the extent of the changes in the urban forest without systematic monitoring. By leveraging aerial imagery and community-driven data, Petaluma can track changes in tree canopy coverage and identify areas where restoration or new plantings will have the greatest impact. This assessment focuses on Petaluma's urban tree canopy (UTC), exploring current coverage, opportunities for additional plantings, and recent trends.



Figure 1. Petaluma spans nearly 15 square miles (9,267 acres) and is located in the North Bay Region, approximately 40 miles north of San Francisco.

The benefits of Petaluma's urban forest are significant. Trees help reduce stormwater runoff, improve air quality, moderate temperatures, and enhance the character and charm of local neighborhoods. By employing data-driven assessments and engaging the community, Petaluma can refine its urban forestry policies, prioritize equitable canopy expansion, and ensure that its urban forest continues to thrive for future generations.

PROJECT METHODOLOGY

Based on imagery from the USDA's National Agriculture Imagery Program (NAIP), this study analyzed Petaluma's land cover from 2016 to 2022. This enables Petaluma stakeholders to revise existing programs and develop new priorities for protecting and expanding the urban forest. This study used machine learning techniques to create land cover data, facilitating more uniform comparisons in future tree canopy assessments. Following US Forest Service standards, this assessment focuses on tree canopy as a percentage of land, excluding water. The key goals of this tree canopy cover assessment include:

- ▶ Quantify the amount and location of tree canopy and other land cover types
- ▶ Analyze the change in canopy cover from 2016 to 2022
- ▶ Measure the ecosystem services provided by the tree canopy to the community
- ▶ Identify areas where tree canopy can be expanded (Possible Planting Area analysis)
- ▶ Determine priority areas for tree preservation and planting initiatives based on socioeconomic, environmental, and climate-related factors
- ▶ Provide data to inform future planning and to establish short-term and long-term canopy coverage goals

KEY TAKEAWAYS

Petaluma's tree canopy currently covers 14% of the city, with the most robust coverage found in the more rural areas in the southern parts of the city. Nearly three-quarters of all tree canopy is located on private property, where coverage is denser than in public spaces. Recent gains in canopy cover have been seen on both city-managed and privately owned lands, with each increasing by approximately 2 percentage points. The most significant gains have occurred on land designated for open space and parks, future planned developments, and lower density residential areas. These increases are primarily concentrated along the southern border of the city, where open space is greater and tree removal for development is less prevalent. Conversely, the urban core had the lowest canopy cover and has seen the most significant decline, with the center census block losing three percentage points, primarily due to tree clearing associated with highway construction.

In addition to their ecological importance, Petaluma's urban forest also provides environmental services. These benefits were calculated using i-Tree tools to quantify reductions in air pollutants, gallons of water mitigated from storm water runoff, carbon storage, and energy savings. Petaluma's existing trees provide substantial monetary benefits to the community, with an estimated total annual value of \$1,633,432—which translates to \$1,253 per acre.

There remains ample opportunity to further expand Petaluma's urban tree canopy. Even after excluding recreation fields and utility corridors from consideration, a substantial portion of the city remains suitable for new plantings. As 71% of the city is classified as private property, successful expansion hinges on strong engagement with private owners and community stakeholders. Residential properties, in particular, offer significant untapped potential. Key strategies for growth include outreach and communication to homeowners, incentive programs for planting and maintenance, collaboration with organizations dedicated to urban greening, and sustained partnership with groups like ReLeaf Petaluma.

This assessment highlights plantable space in areas with high public demand, such as playgrounds, around the spectator areas of sports fields, and in busy downtown corridors. Focusing on planting efforts in public spaces with low canopy cover or experiencing heavy use will maximize the benefits of the urban forest. This assessment's Tree Planting Prioritization section highlights several criteria to steer impactful planting:

- ▶ Locations with extensive impervious surfaces
- ▶ Areas with low existing canopy cover
- ▶ Neighborhoods susceptible to urban heat
- ▶ Underutilized spaces, including vegetated corridors with ample plantable space

Focusing on these underutilized areas will strengthen environmental equity, enhance air quality, and improve overall community livability. The choice of tree species remains crucial for enduring impact; planting a diverse array of drought-tolerant species suitable for Petaluma's Mediterranean climate supports resilience and sustainability.



Each year, Petaluma's urban forest provides more than \$1.6 million in ecosystem services. Every acre added brings an estimate \$1,253 more.

PROJECT

METHODOLOGY

DATA SOURCES

This assessment used high-resolution (60-centimeter) multi-spectral imagery obtained from the US Department of Agriculture's National Agriculture Imagery Program (NAIP), collected in 2022. The tree canopy dataset was created for the [California Department of Forestry and Fire Protection \(CAL FIRE\)](#) and has made this source data publicly available. Additionally, 60 cm resolution NAIP imagery from June 2016 was utilized for historical tree canopy classification. For more information on the data sources used, refer to the appendix on page 35.

MAPPING LAND COVER IN CALIFORNIA & IDENTIFYING TREES

The land cover data set is the most fundamental component of a tree canopy assessment. Tree canopy and land cover data from the EarthDefine US Tree Map (<https://www.earthdefine.com/treemap/>) provided a six-class land cover data set. The US Tree Map is produced using a modern machine-learning technique to extract tree canopy cover and other land cover types from NAIP imagery collected in May of 2022. These six classes are shown in Figure 2.

Tree canopy is defined as the “layer of leaves, branches, and stems that cover the ground” (Raciti et al., 2006) when viewed from above. It serves as the metric used to quantify the extent, function, and value of the urban forest. Trees were distinguished from shrubs and bushes using an object-based approach that considered their spectral characteristics, shape, size, and context. Typically, trees exhibit darker, denser foliage, have rounder and taller canopies exceeding 12 feet, and possess more uniform shapes. In contrast, shrubs are typically lighter in color, shorter, and irregularly shaped, often blending in with surrounding grasses.

An impervious surface does not allow water to pass through, preventing natural infiltration of rainwater into the ground. This land cover class is characterized by surfaces like roads, sidewalks, and rooftops. These surfaces increase water runoff from rain and heavy storms, which can contribute to flooding, water pollution, and the degradation of hardscapes.

Additionally, it is important to note the distinction between non-canopy vegetation and bare earth and soil, especially in regard to the naturally dry climate of California. Non-canopy vegetation refers to areas covered mainly by living grass and open space where there are no trees. This can include residential lawns and wild meadows. Bare soil refers to spots where plant material is dried and dead rather than green and living. This land class is often construction sites and land that has been cleared for development.





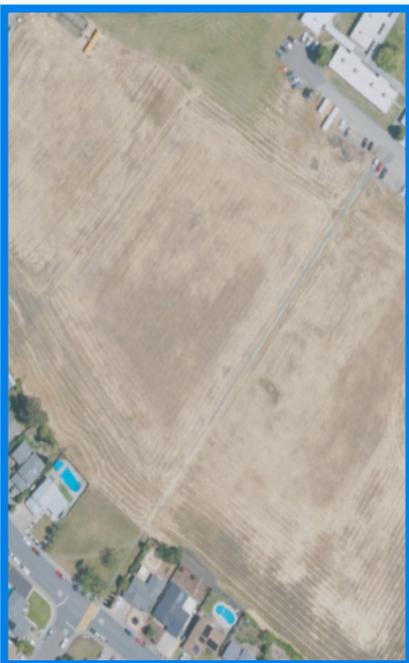
URBAN CANOPY



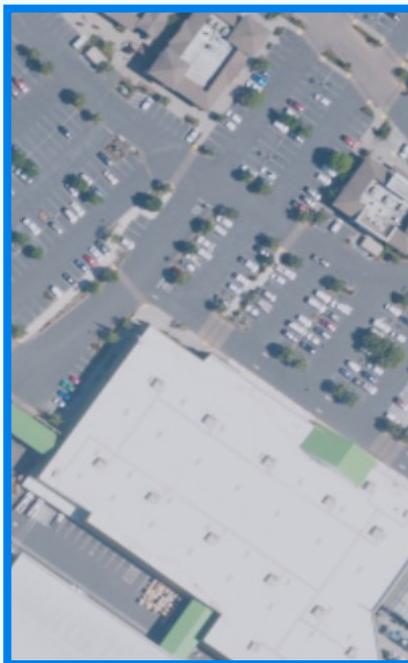
SHRUBS



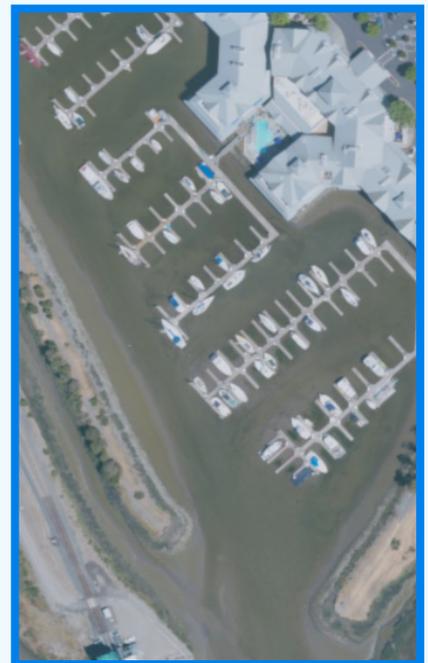
OTHER VEGETATION



BARE EARTH AND SOIL



IMPERVIOUS SURFACES



WATER

Figure 2. This study identified six (6) unique land cover classes within the 2022 assessment imagery: urban canopy, shrubs/scrubs, other low-lying vegetation, bare earth and soil, impervious surfaces, and water.

IDENTIFYING PLANTING OPPORTUNITIES AND LIMITATIONS

In addition to quantifying the City of Petaluma's existing tree canopy cover, areas where trees can be planted (PPA- Possible Planting Area or Potential Plantable Area) were also identified. To assess this, all land area in the City of Petaluma that was not currently tree canopy was classified as either possible planting areas or unsuitable for planting.



Planting in Petaluma's unique terrain requires special considerations due to the topography's variability and the limited access to water for irrigation. Proximity to existing developments and access to water are key challenges. Ground truthing is necessary to assess site conditions, as some areas may not be feasible for planting.

Possible planting areas were identified in two of the land cover classes: shrubs and other vegetation. Unsuitable areas or areas where it was not feasible to plant trees (e.g., recreation fields, utility corridors, cemeteries, etc.) were manually delineated and overlaid with the existing land cover data set (Figure 3). The results were reported as Urban Tree Canopy, Possible Planting Area, Unsuitable Impervious, Unsuitable Vegetation, Unsuitable Soil, or Water.



Figure 3. Vegetated areas where it would be feasible for tree plantings, but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These spaces primarily consisted of recreational sports fields, utility corridors, and golf course fairways.

DEFINING ASSESSMENT LEVELS

The analysis of Petaluma's urban tree canopy is presented at the city level first. To allow for comparisons at finer scales, canopy metrics are explored using different geographic boundaries as well, including **property ownership** (public land vs private land), **voting districts**, **census tracts and block groups**, **land use** (residential, industrial, open space, etc.), within **rights-of-way**, and a uniform grid of 1,000 **hexagons**.

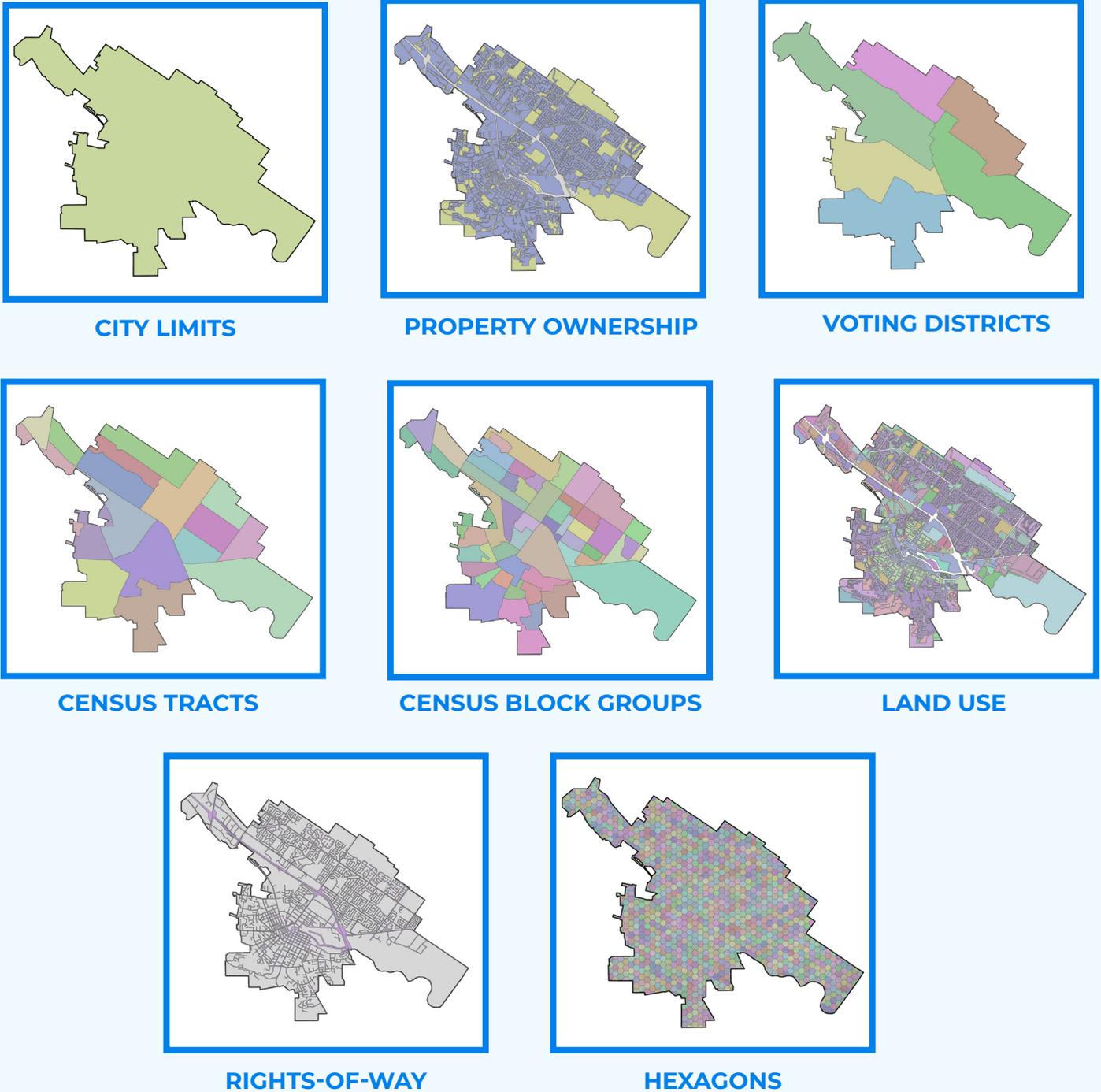


Figure 4. Eight (8) distinct geographic boundaries were explored in this analysis: Petaluma’s official city limits, property ownership, voting districts, census tracts, census block groups, land use, rights-of-way, and hexagons.

STATE OF THE CANOPY AND

KEY FINDINGS

The results of this study can be used to design a strategic approach for identifying existing canopy and future planting sites. The land cover data for 2022 has been summarized within the boundaries of Petaluma's city limits as of May 2025. This urban tree canopy assessment analyzed detailed land cover data to identify existing urban tree canopy and potential planting areas across the City of Petaluma.

This assessment report focuses exclusively on metrics within the city limits. Figure 5 illustrates the distribution of land cover in Petaluma and the percent coverage of each class by the total area of the city. Impervious surfaces made up the most significant portion of the city's area at 52%. Non-canopy vegetation, such as herbaceous plants and grass, accounted for 28%, while tree canopy covered 14% of the city. Both water bodies and areas of bare soil or dry vegetation each comprised 3% of the total area.

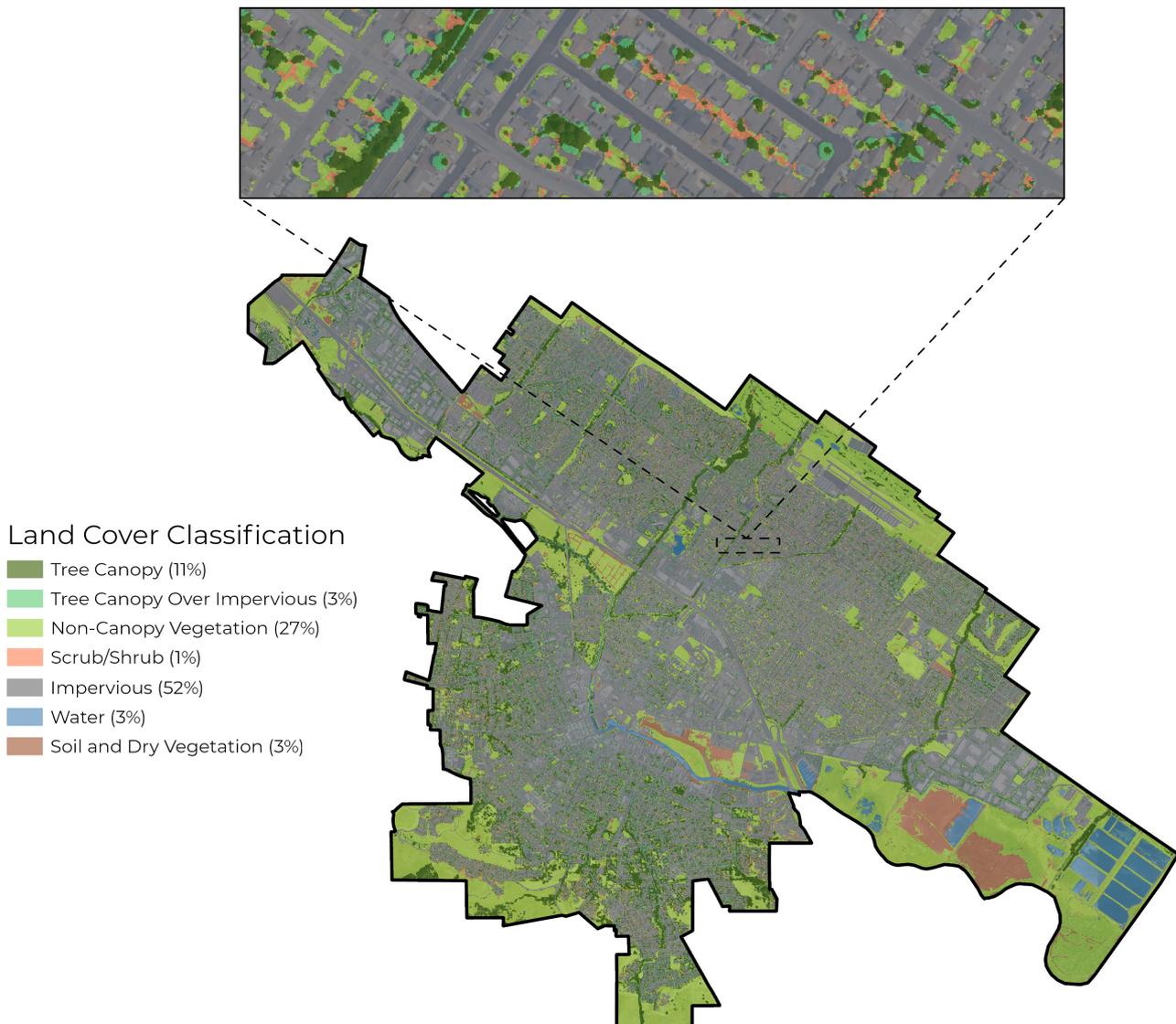


Figure 5. Land cover classification results (percentages based on the total area of Petaluma's City limits, including water bodies).



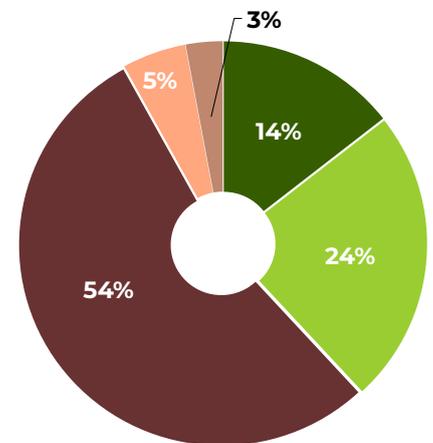
The City of Petaluma had 14% (1,303 acres) of its land area covered with tree canopy, with 24% (2,136 acres) of the land identified as suitable for future tree planting.

CITY-WIDE TREE CANOPY COVER

This assessment organizes results by a range of geographic boundaries to provide a detailed understanding of tree canopy distribution and change. For each assessment geography, the current canopy cover as of 2022 and changes since 2016 were analyzed, incorporating American Community Survey data into census block group-level data to help identify where planting opportunities align with community needs. This comprehensive approach supports the development and outreach of target programs, ensuring resources are directed to the highest-priority areas for urban greening. According to the US Forest Service's UTC assessment protocols, it is best practice to exclude surface water to ensure a more accurate and actionable assessment of urban forest resources and planting opportunities. In line with these guidelines, 246 acres of surface water were excluded from the analysis.

In 2022, the City of Petaluma had 14% (1,303 acres) of its land area covered with tree canopy, with 24% (2,136 acres) of the land identified as suitable for future tree planting. These plantable areas include residential yards, parks (excluding recreational fields), and other open spaces where new trees could be established. The remaining 62% was considered unsuitable for planting without significant land modifications. Of these unsuitable areas, impervious surfaces such as roads, parking lots, and buildings accounted for 54% (4,855 acres). Other unplantable spaces include highly maintained sports fields, utility corridors, golf course fairways, wetlands, and other areas where tree planting would conflict with infrastructure or ongoing land uses.

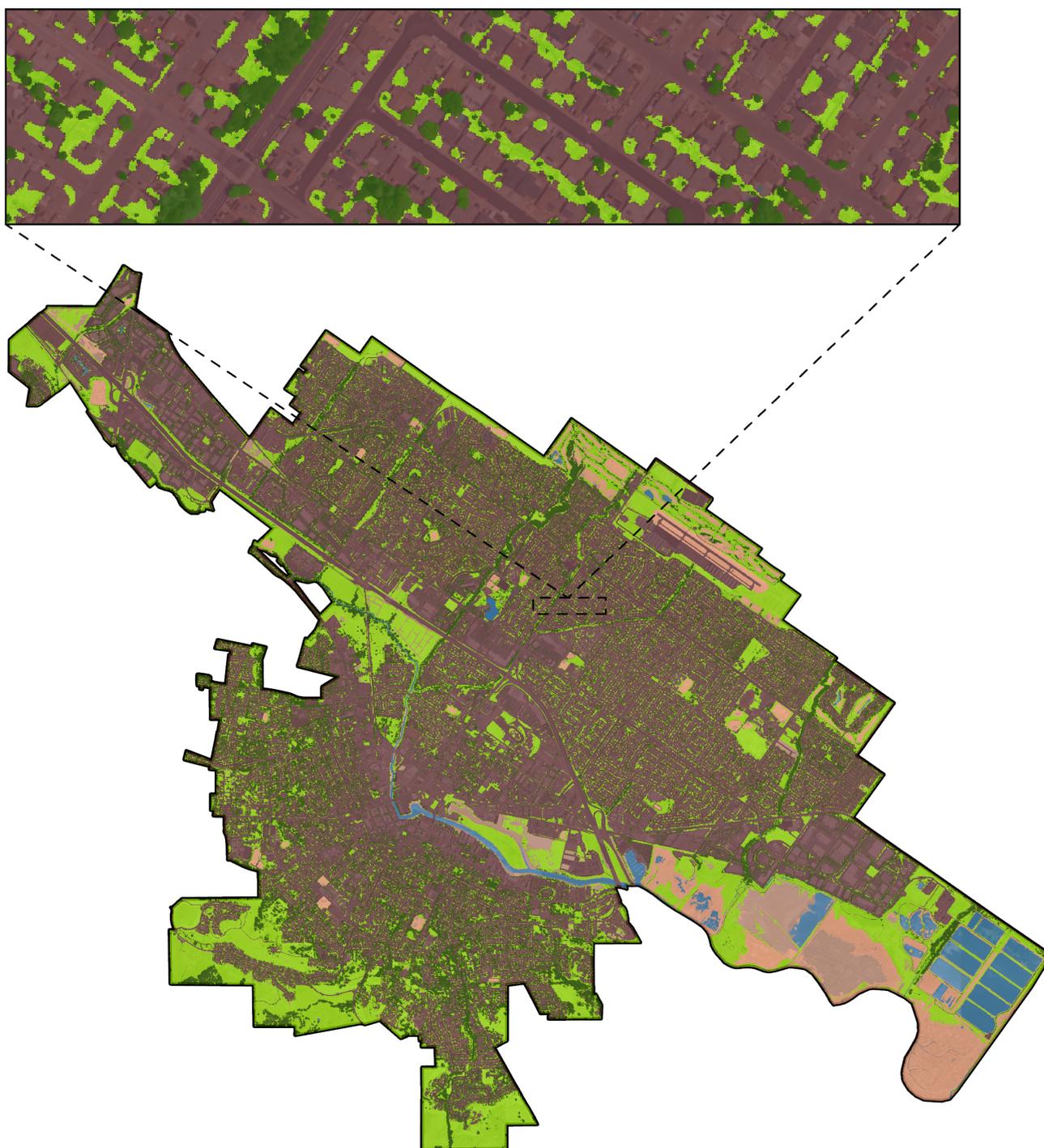
With 24% of city land still suitable for planting, Petaluma has significant potential to expand its urban forest, particularly in neighborhoods and public spaces, and enhance the benefits it provides to residents, wildlife, and the broader environment. Although impervious surfaces have been removed from the total plantable area, there are numerous specific sites within parking lots or school blacktops where planting trees could have benefits. Petaluma has already started undertaking planting projects throughout the city through the efforts of ReLeaf Petaluma. The Canopy Project, funded by a \$1 million from the USDA Forest Service, will continue to plant trees over the next few years (more information can be found in the section [Petaluma Tree Planting](#)).



■ Urban Tree Canopy % ■ Total Plantable Area %
 ■ Unsuitable Impervious % ■ Unsuitable Vegetation %
 ■ Unsuitable Soil %



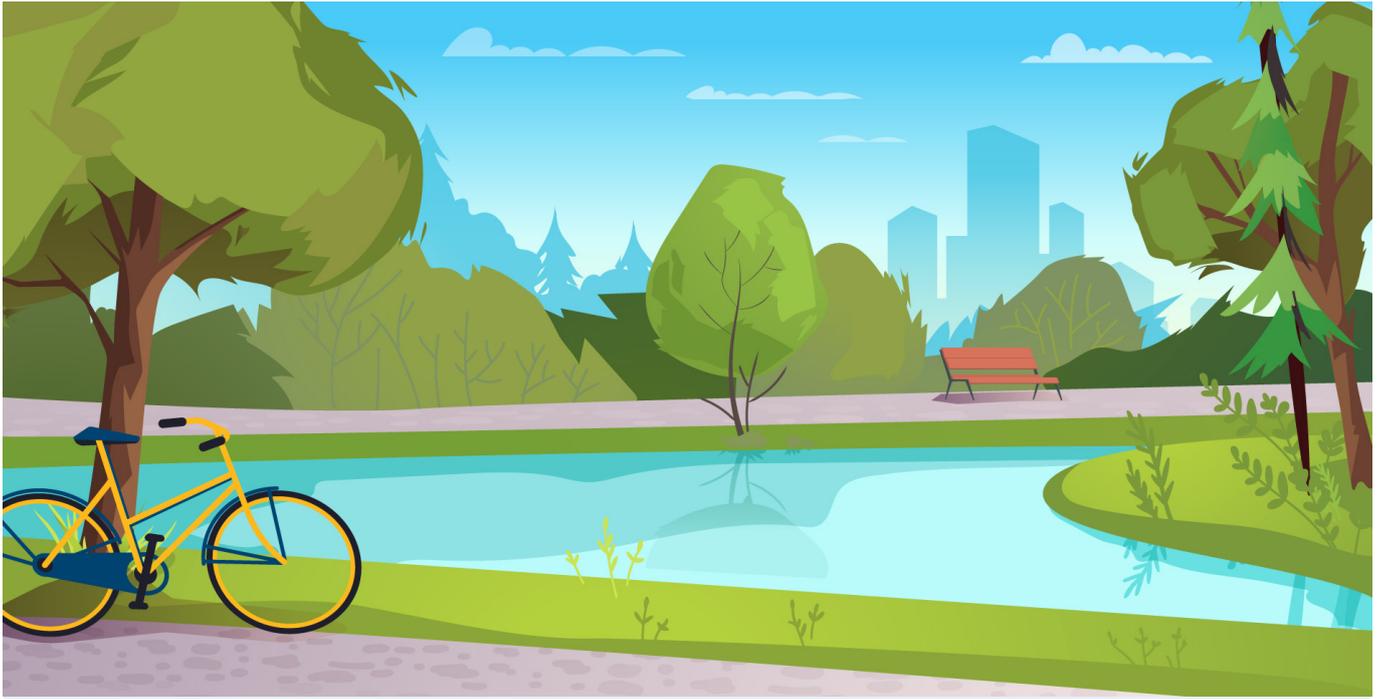
Figure 6. Tree canopy, possible planting area, and area unsuitable (impervious, soil, and vegetation) for planting throughout Petaluma as a percentage of land acres (percentages exclude water bodies).



Tree Canopy Potential

- Urban Tree Canopy (14%)
 - Potential Planting Area Vegetation (24%)
 - Unsuitable Vegetation (5%)
- Unsuitable Impervious (54%)
 - Unsuitable Soil (3%)
 - Water (% not included in distribution)

Figure 8. The map shows three main land cover classifications in Petaluma as a percentage of land area: existing tree canopy, areas suitable for planting new trees, and areas that are unsuitable for tree canopy. The inset map shows a detailed view of land cover classes to the east of East Washington Street.



CANOPY AND IMPERVIOUS SURFACES

Petaluma's 1,303 acres of urban tree canopy were further divided into subcategories based on whether the canopy was overhanging pervious or impervious surfaces. Tree canopy overhanging an impervious surface offers many ecological advantages, including localized cooling through shading and increased interception of rainfall, which enhances stormwater absorption.

Petaluma's UTC was predominantly overhanging pervious surfaces at 76%, while 24% was overhanging impervious surfaces. Increasing tree canopy over paved areas, such as rights-of-way, along streets, and on sidewalks, helps reduce urban heat, stormwater runoff, and noise and air pollution. These trees also protect hardscapes from deteriorating, lowering maintenance costs. Strengthening ordinances for planting in and around these areas can enhance these benefits. Targeted canopy expansion supports environmental resilience while balancing priorities like safety, accessibility, and infrastructure needs.

CITY-WIDE TREE CANOPY CHANGE

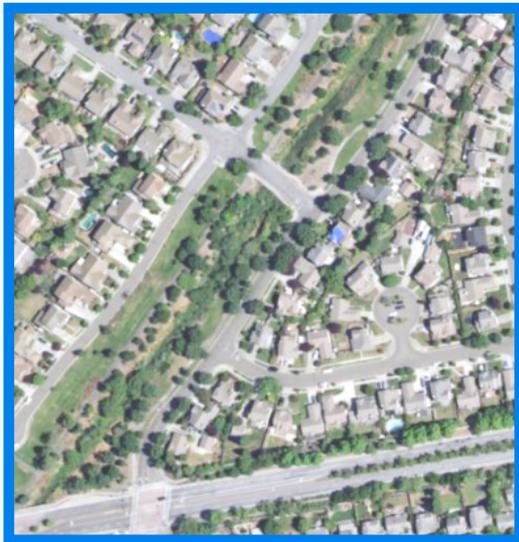
Tree canopy change was identified by comparing imagery captured from multiple years (June 2016 and May 2022). These changes help illustrate the impact of tree-planting initiatives started in previous years. In Petaluma, significant gains in tree canopy have occurred in riparian and recreational areas. For example, at Corona Creek, trees that have been planted or have regenerated naturally along the riparian buffer have matured, resulting in increased tree canopy (Figure 9). Another example is the walking trail path off Bordeaux Drive just south of the Petaluma Municipal Airport, where trees established before 2016 have continued to grow, expanding the overall canopy in this area (Figure 10). However, not all areas experienced gains in tree canopy. Some areas within Petaluma saw a decline in tree canopy, particularly in locations where new housing or city infrastructure has been developed (Figures 11 and 12).



Between 2016 and 2022, the City of Petaluma tree canopy increased by 2 percentage points, or a gain of 159 acres.

Canopy Gain from Maturation of Existing Trees

While tree canopy loss in urban areas is often associated with new development, significant canopy gains can also occur as existing trees mature, especially in riparian zones where water and nutrients are plentiful. In these areas, the natural growth of trees over time leads to increased canopy cover. The maturation of trees along Petaluma's riparian corridors demonstrates how investing in the preservation and care of these corridors can yield long-term ecological and community benefits as canopy increases year by year.



2016

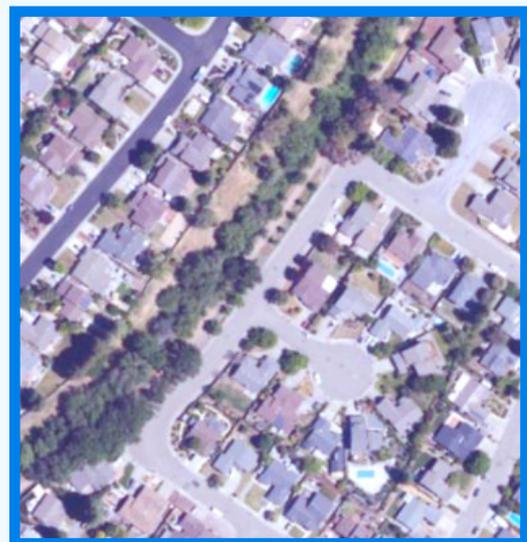


2022

Figure 9. An example of canopy growth near Corona Creek.



2016



2022

Figure 10. An example of canopy growth near the walking path off Bordeaux Drive.

Canopy Loss Due to Development

Tree canopy loss frequently results from residential and commercial development, as seen on Jefferson Street. When mature trees are removed, their ecological benefits are lost immediately. New plantings rarely offset this loss: smaller stature trees are often planted, young trees may not survive, and those that do need decades to match the ecological value of mature trees. Without adequate replacement, the continued loss of mature trees leads to lasting declines in canopy cover and diminishes the environmental services that support a healthy, livable urban environment.

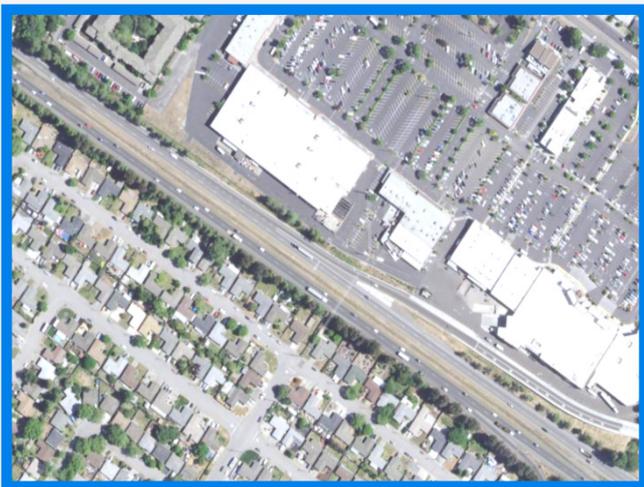


2016

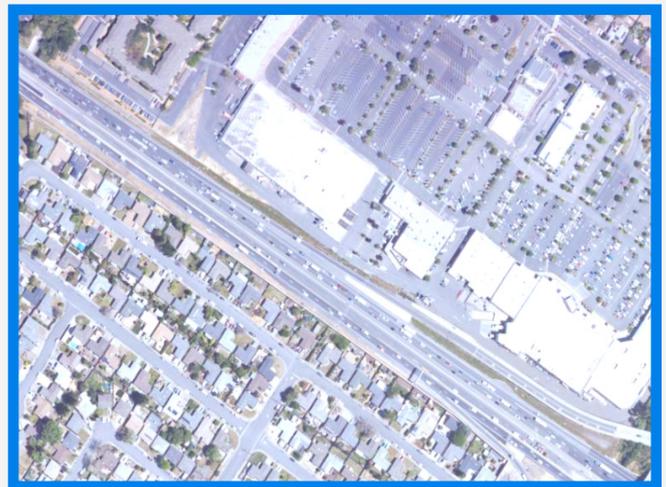


2022

Figure 11. Example of tree canopy loss in Petaluma due to infrastructure development.



2016



2022

Figure 12. Example of tree canopy loss in Petaluma due to Route 101 development.

Over the six-year study period, Petaluma's tree canopy increased. Within the city boundaries, canopy coverage increased by 159 acres, representing a relative increase of 14% from 2016 to 2022. An examination of additional assessment boundaries highlights areas throughout the city where the canopy has increased, remained relatively stable, or been lost. As development continues and land use evolves, protecting and expanding the tree canopy remains both a critical challenge and an important opportunity.

The city remains at risk for tree canopy loss due to environmental factors such as drought and wildfires, as well as urban development. For example, Petaluma experienced an atmospheric river storm, known as the "Pineapple Express," in March 2016, which brought periods of heavy rainfall and wind speeds up to 50 mph. In 2019 and 2021, Petaluma also experienced regional wildfires and prolonged drought. These severe weather events are becoming increasingly common and stand to impact Petaluma's urban tree canopy.

Canopy growth in Petaluma results from a combination of natural expansion of established trees, ongoing planting efforts by both residents and municipal programs, and natural regeneration through seed dispersal. Recognizing the importance of these trends, Petaluma is actively updating its Tree Ordinance to align with broader climate action goals, integrating these updates into the City's Climate Action Blueprint. By closely monitoring both canopy loss and gain, Petaluma is well-positioned to implement targeted strategies that safeguard mature trees, encourage climate-resilient planting, and ensure the long-term health and benefits of its urban canopy for all residents.



TREE CANOPY COVER BY PROPERTY OWNERSHIP

Tree canopy metrics were assessed across two categories of ownership: Public and Private, each of which presents unique opportunities and approaches for tree planting and maintenance. Private property makes up 71% of Petaluma’s total area and provides 873 acres of urban tree canopy, accounting for 77% of the city’s canopy coverage. Public property, comprising the remaining 29% of Petaluma’s total area, contained 262 acres or 23% of Petaluma’s urban forest canopy.

Relative to the size of each land type, the percentages of canopy cover is relatively even with 16% of private land and 12% of public land covered by tree canopy. **Private property presents the largest opportunity for expanding Petaluma’s urban forest, as it encompasses 1,138 acres of plantable space, compared to 880 acres of plantable space on public property.**

Petaluma demonstrates its commitment to growing its urban forest, with public spaces experiencing a 2 percentage point increase over six years, adding 44 acres of tree canopy during that time. Private property has also seen an improvement in tree canopy. In 2016, there were 764 acres of urban canopy, and by 2022, that number had increased to 873, representing a 110-acre rise over the study period. These upward trends in UTC underscore Petaluma’s commitment to improving environmental recreation, health, and beauty for the city and its residents.

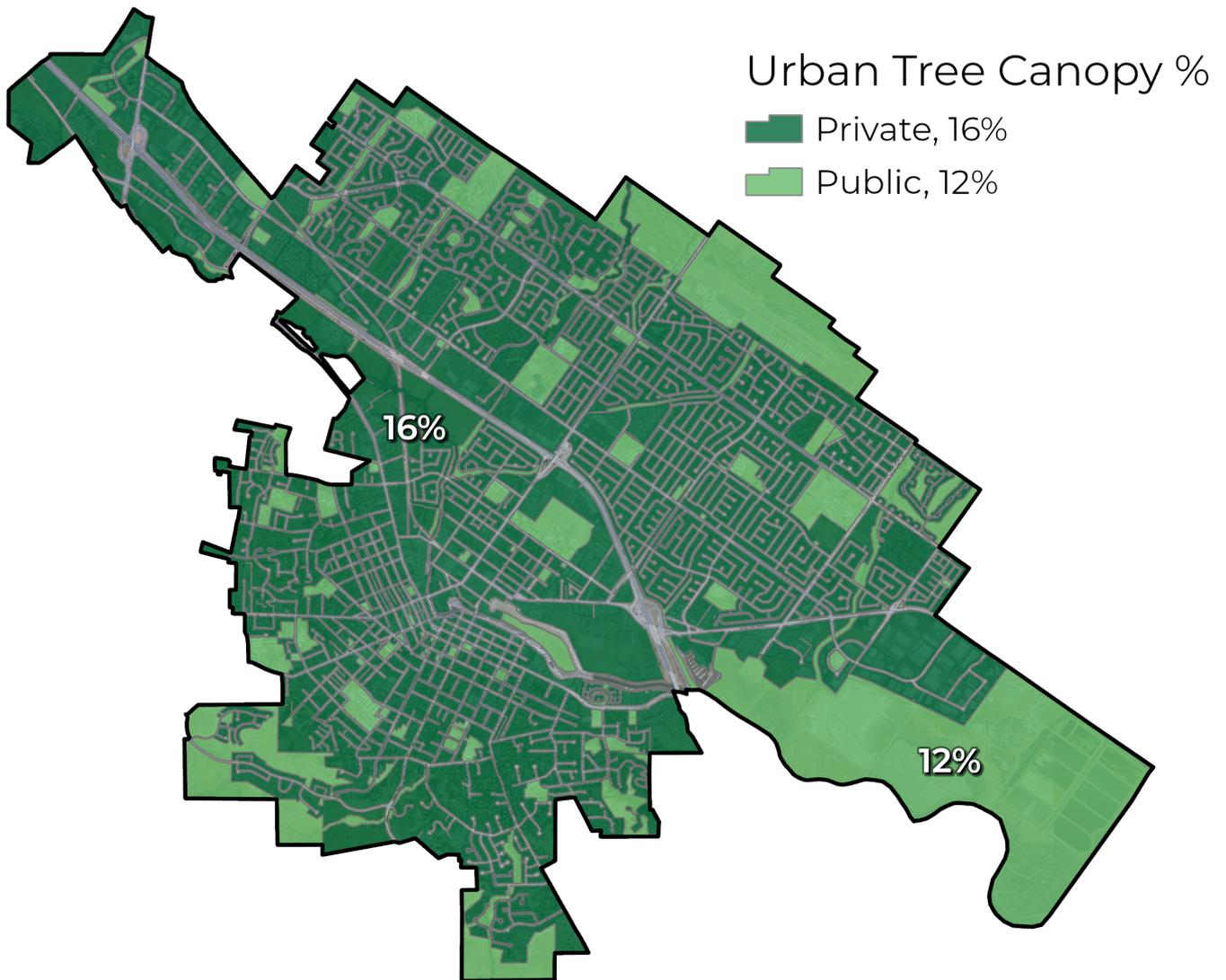


Figure 13. Depiction of property ownership types in Petaluma.

Table 1. Urban tree canopy metrics by ownership.

OWNER	URBAN TREE CANOPY (ACRES)	URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
Private	873	16%	1138	21%	3319	62%
Public	262	12%	880	41%	995	47%

Table 2. Urban tree canopy change metrics by ownership.

OWNER	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
Private	764	14%	873	16%	110	2%
Public	218	10%	262	12%	44	2%



TREE CANOPY COVER BY VOTING DISTRICTS

Conducting tree canopy assessments within political jurisdictions is beneficial for informing policy decisions and allocating resources for urban greening initiatives. The City of Petaluma is divided into six voting districts. While the size of each district varies, the average area for a district is 1,545 acres. Districts 5, 1, and 6 account for nearly 65% of the total urban tree canopy distribution. District 5 has the highest distribution of UTC at 29% and boasts the largest amount of possible planting area, with 581 acres available for planting. It should be noted, however, that most of the available planting space is in open space areas where the existing canopy reflects more natural, local conditions. Districts 4 and 3 have the lowest percentage of UTC distribution at 11% and 10%, respectively. While these districts have lower tree canopy percentages, they both have notable available space with a combined 705 acres. District 1 is the largest district, covering 2,011 land acres and accounting for 19% of the total UTC distribution. However, it has the most unsuitable acreage at 1,319 acres, which is 66% of its total area.

All of Petaluma’s voting districts saw an increase in tree canopy coverage from 2016 to 2022. The most significant increase in UTC was in District 5, with an increase of 55 acres (relative increase of 17%) over the six-year period. The smallest increase in tree canopy occurred in District 3, where there was a 10-acre increase with a relative change of 8%. The average increase in acreage amongst all the districts was 26, and the total increase was 159 acres of forest canopy from 2016 to 2022.

Table 3. Urban tree canopy metrics by voting district.

DISTRICT	URBAN TREE CANOPY (ACRES)	URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
1	254	13%	428	21%	1319	66%
2	195	18%	206	20%	653	62%
3	130	7%	404	22%	1288	71%
4	139	12%	301	26%	734	63%
5	372	22%	581	35%	712	43%
6	214	16%	215	16%	875	67%



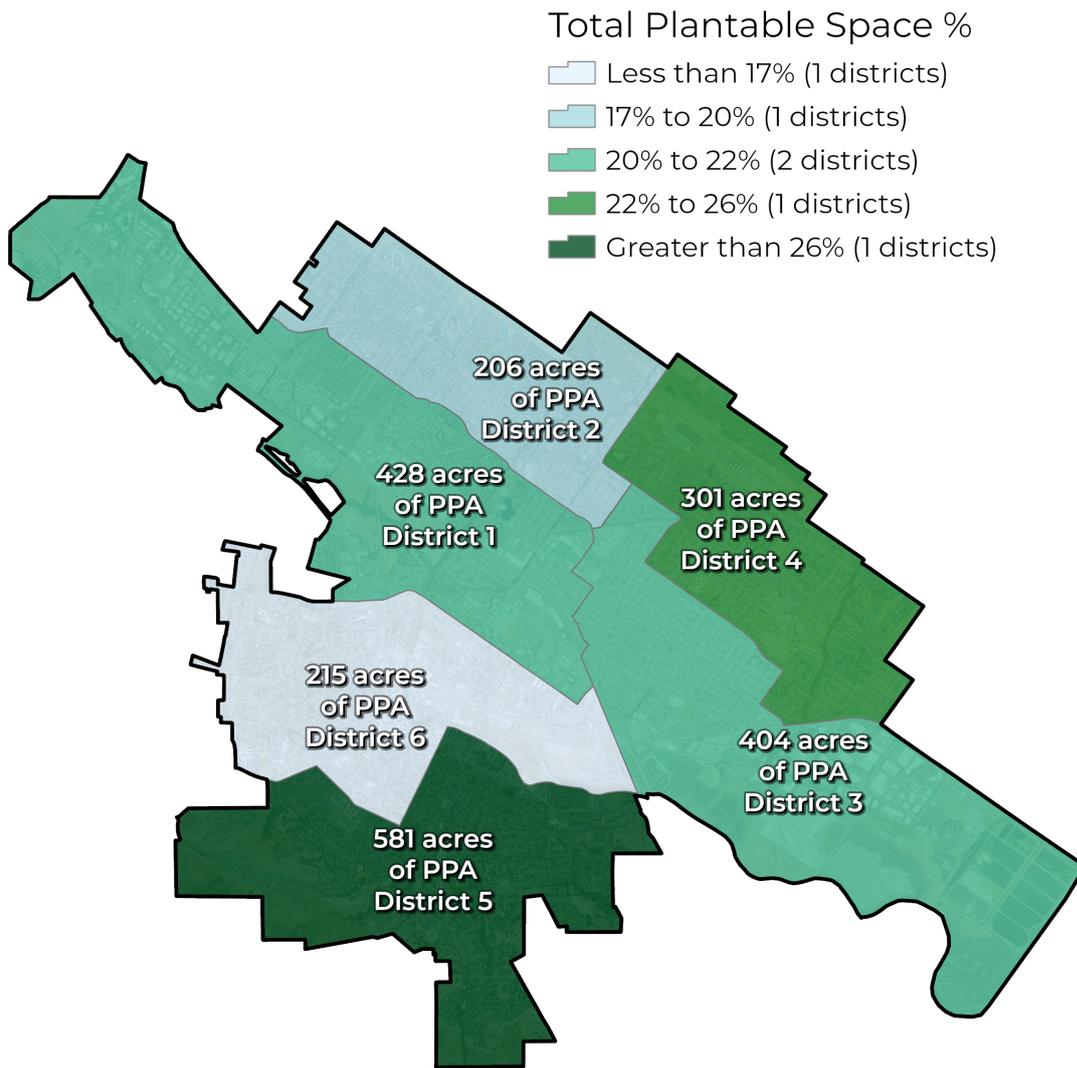


Figure 14. Depiction of potential plantable area in Petaluma by voting district.

Table 4. Urban tree canopy change metrics by voting districts.

DISTRICT	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
1	234	12%	254	13%	20	1%
2	167	16%	195	18%	28	3%
3	120	7%	130	7%	10	1%
4	117	10%	139	12%	21	2%
5	317	19%	372	22%	55	3%
6	189	15%	214	16%	25	2%

TREE CANOPY COVER BY CENSUS TRACTS AND BLOCK GROUPS

Urban tree canopy metrics were assessed at the census tract and census block group (CBG) levels, which is valuable for determining the equitable distribution of tree canopy throughout Petaluma, as these geographic units are linked to readily available demographic and socioeconomic data. Census tracts provide larger units for statistical analysis, representing populations ranging from 1,200 to 8,000 people. Census block groups are the second smallest unit of measure at which the U.S. Census publishes statistical data within a state, representing between 600 and 3,000 people.

Petaluma has 15 census tracts; the average UTC acreage amongst all the tracts is 87 acres. The tracts with the largest percentage of UTC (20% or higher) can be found in the residential areas to the south and northwest. Of Petaluma’s 54 census block groups, more than half (34 CBGs) have an urban tree canopy percentage of 13% or higher. Eleven of those 34 block groups have a UTC of 23% or higher. These areas are concentrated in residential neighborhoods located in similar areas to the census tracts, primarily in the northwest and southern parts of Petaluma.

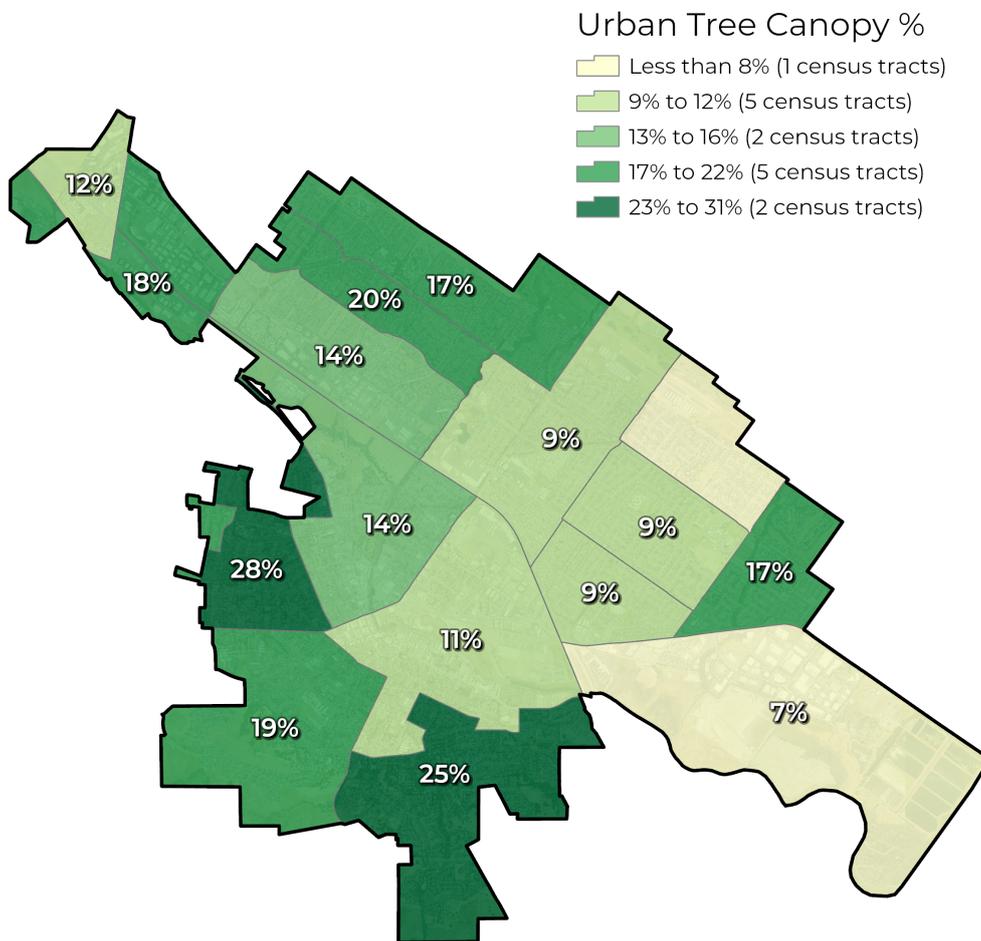


Figure 15. Urban tree canopy by census tracts.

The average amount of possible planting area is 40 acres amongst all the census block groups; however, there are four block groups located in the east and south of Petaluma that contain over 100 acres each of plantable space. One block group (60-971-50612-2) in the southeast corner of Petaluma, boasts the highest amount of PPA acreage, holding 310 acres of plantable space, about 7 times more than the average. Among the census block groups, around 85% have an impervious area percentage higher than 50% which significantly limits opportunities for expanding the urban tree canopy in these areas.

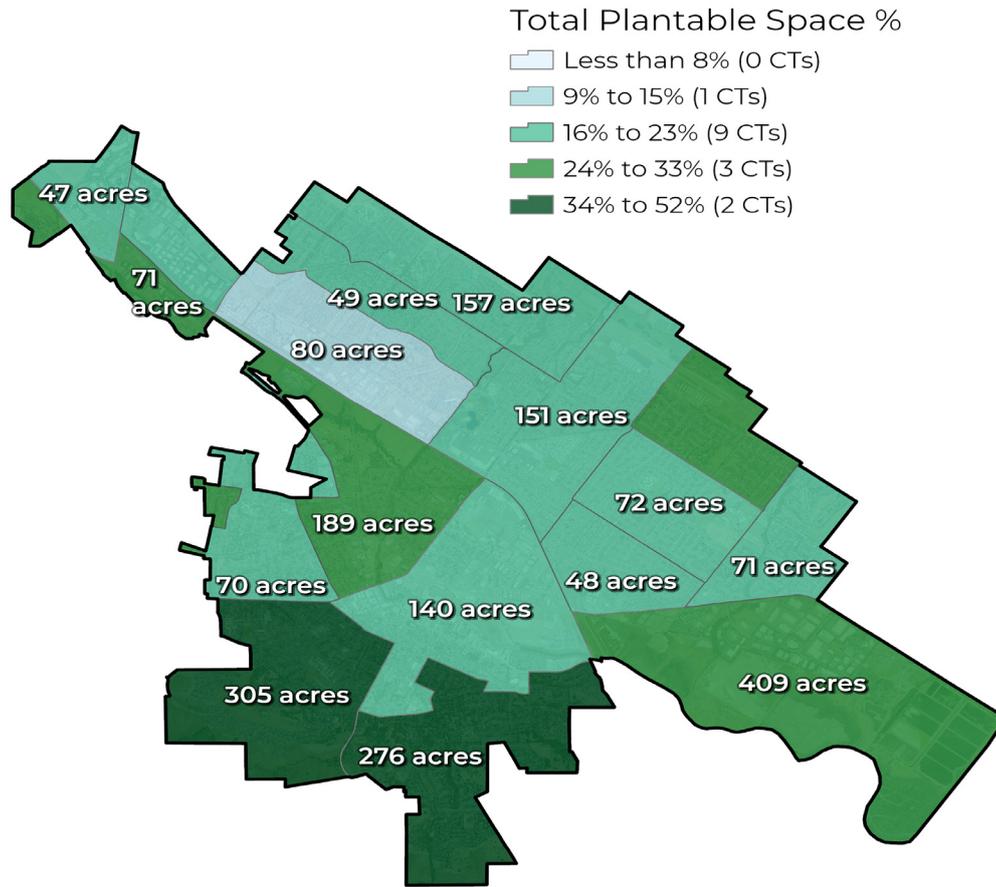


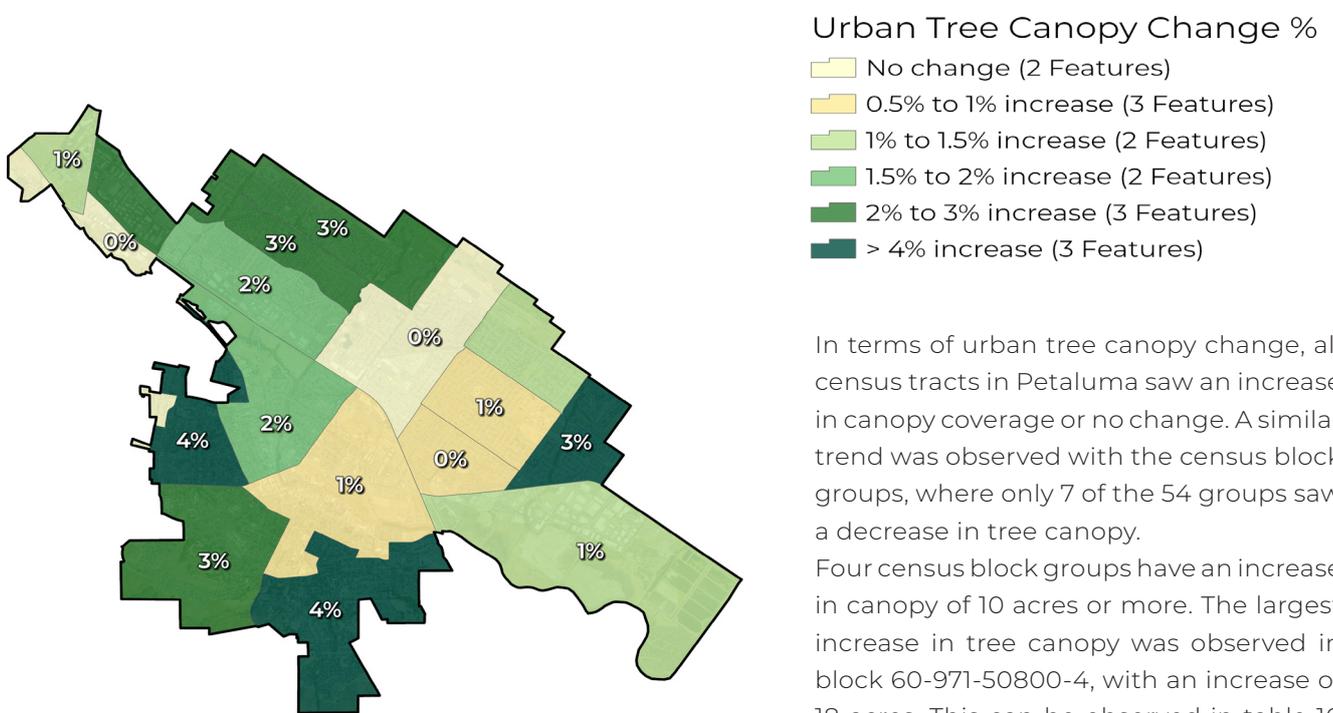
Figure 16. Possible plantable area by census tracts (CT). Potential planting acres are displayed within each census tract.

Table 5. Urban tree canopy metrics by census tracts.

CENSUS TRACT	URBAN TREE CANOPY (ACRES)	URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
60-971-51205	24	12%	47	23%	131	65%
60-971-50701	91	11%	140	16%	625	73%
60-971-50800	146	19%	305	39%	329	42%
60-971-50702	209	25%	276	34%	338	41%
60-971-51000	42	18%	71	31%	119	51%
60-971-50603	74	9%	151	19%	558	71%
60-971-50601	28	9%	48	15%	232	75%
60-971-50901	91	14%	189	28%	386	58%
60-971-50902	108	28%	70	18%	213	54%
60-971-50602	38	9%	72	17%	302	73%
60-971-50607	139	17%	157	19%	524	64%
60-971-50610	64	20%	49	15%	207	65%
60-971-50612	113	7%	409	27%	1000	66%
60-971-50611	57	17%	71	21%	209	62%
60-971-50609	79	14%	80	14%	409	72%

Table 6. Urban tree canopy change metrics by census tracts.

CENSUS TRACT	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
60-971-51205	21	10%	24	12%	2	1%
60-971-50701	85	10%	91	11%	6	1%
60-971-50800	123	16%	146	19%	23	3%
60-971-50702	177	22%	209	25%	32	4%
60-971-51000	42	18%	42	18%	0	0%
60-971-50603	76	10%	74	9%	-3	0%
60-971-50601	27	9%	28	9%	1	0%
60-971-50901	81	12%	91	14%	11	2%
60-971-50902	93	24%	108	28%	15	4%
60-971-50602	36	9%	38	9%	2	1%
60-971-50607	118	14%	139	17%	21	3%
60-971-50610	54	17%	64	20%	10	3%
60-971-50612	96	6%	113	7%	18	1%
60-971-50611	46	14%	57	17%	12	3%
60-971-50609	69	12%	79	14%	10	2%



In terms of urban tree canopy change, all census tracts in Petaluma saw an increase in canopy coverage or no change. A similar trend was observed with the census block groups, where only 7 of the 54 groups saw a decrease in tree canopy. Four census block groups have an increase in canopy of 10 acres or more. The largest increase in tree canopy was observed in block 60-971-50800-4, with an increase of 18 acres. This can be observed in table 10 in the appendix.

Figure 17. Urban tree canopy changes by census tract.

TREE CANOPY COVER BY LAND USE

Land use designations enable local governments to specify areas for specific land uses, guiding urban development and upholding community planning standards. Petaluma has over 20 land use classes; to streamline the analysis, detailed land-use classifications have been consolidated into more general categories, which include: Residential, Commercial, Greenspace, Mixed Use, Industrial, Education, and Agriculture. The classes with the highest amount of urban tree canopy area are Residential and Greenspace, with 691 and 236 UTC acres, respectively. These two land-use classes account for 81% of the tree canopy in Petaluma. These areas also have the highest distribution of possible plantable space, accounting for 72% of the total distribution. The Education class, which includes land used to house schools and educational centers, had 12% of its land covered by urban tree canopy. This class also had 54 plantable acres, or 21% of its land area available for planting.

During the six-year study period, only two classes experienced a decline or no change in their tree canopy. Specifically, Agricultural land saw a 1% reduction in urban tree canopy percentage from 2016 to 2022. In contrast, Industrial areas maintained stable canopy coverage, with no forested acres added or lost during this time. Every other class saw an increase in tree canopy, with Residential areas adding 95 acres (a 16% increase), the most among all the classes. Greenspaces increased tree canopy by 38 acres, and mixed-use areas expanded by 9 acres. Mixed-use areas are important to prioritize as they have increased impervious surfaces. The city should prioritize urban forest growth strategically in these areas to mitigate the urban heat island effect and enhance the ecosystem services provided to the surrounding natural areas.

Table 7. Urban tree canopy potential by generalized land use areas.

CLASS	URBAN TREE CANOPY (ACRES)	URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
Agriculture	3	5%	32	60%	19	35%
Commercial	87	12%	95	13%	563	76%
Education	32	12%	54	21%	172	67%
Greenspace	236	21%	647	56%	264	23%
Industrial	11	6%	29	15%	151	79%
Mixed Use	77	5%	353	24%	1023	70%
Residential	691	19%	809	22%	2123	59%

Table 8. Urban tree canopy changes by generalized land use classes.

CLASS	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
Agriculture	3	6%	3	5%	0	-1%
Commercial	79	11%	87	12%	8	1%
Education	27	10%	32	12%	5	2%
Greenspace	198	17%	236	21%	38	3%
Industrial	11	6%	11	6%	0	0%
Mixed Use	68	5%	77	5%	9	1%
Residential	596	16%	691	19%	95	3%

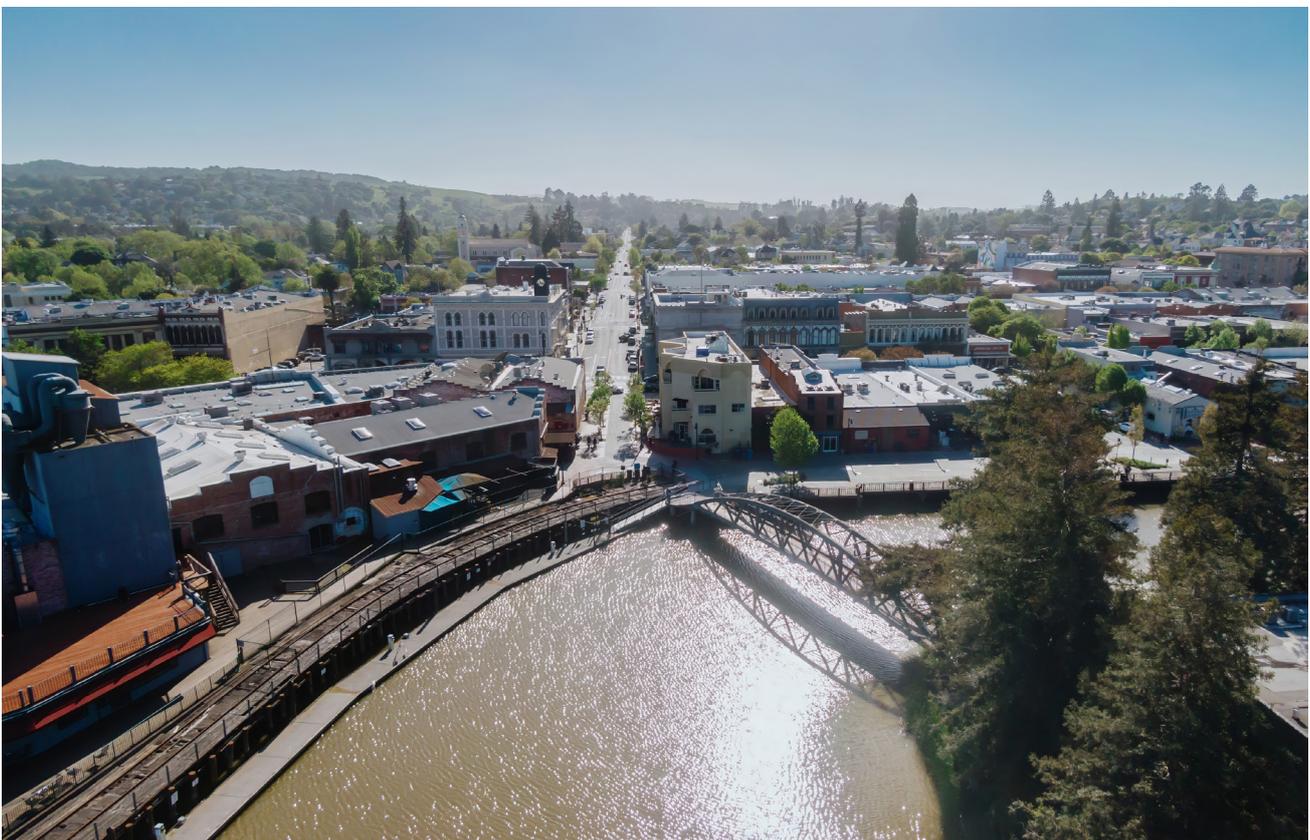
TREE CANOPY COVER BY RIGHTS-OF-WAY

Rights-of-way (ROW) are a critical focus in tree canopy assessments because they are highly visible public spaces that serve as valuable opportunities for green initiatives, directly benefiting the entire community. Petaluma's rights-of-way account for over 1,500 acres of the city's total area. The ROWs with the largest amount of existing canopy are in the northwest and southern parts of the city. Both areas are residential, with proximity to existing parks and recreation areas, including McNear Park to the south and Meadow View and Leghorn Park to the northwest. These same areas have seen stability or increases in their tree canopy over the six-year study period. The most significant decreases in tree canopy cover occur surrounding Route 101 in the middle of Petaluma. Due to the development of city infrastructure, these areas experienced a decline in urban tree canopy of around 1% to 3%.

Strategic Planting Priorities: High-PPA Rights-of-Way Near Downtown Petaluma

ROWs with the largest amount of plantable space are concentrated near downtown Petaluma, particularly along the Route 101 corridor. This area stands out as a prime candidate for new tree plantings for several reasons:

- ▶ **Abundance of Impervious Surfaces:** The prevalence of paved roads, sidewalks, and other non-permeable surfaces means there are fewer natural cooling elements, making the addition of tree canopy especially valuable.
- ▶ **High Traffic and Visibility:** Because this corridor is heavily traveled by both vehicles and pedestrians, increasing the tree canopy would have a noticeable and immediate benefit for a large segment of the community.
- ▶ **Significant Range of Planting Potential:** PPA values in this region vary from 6% up to 20%, indicating both opportunity and urgency for urban greening.



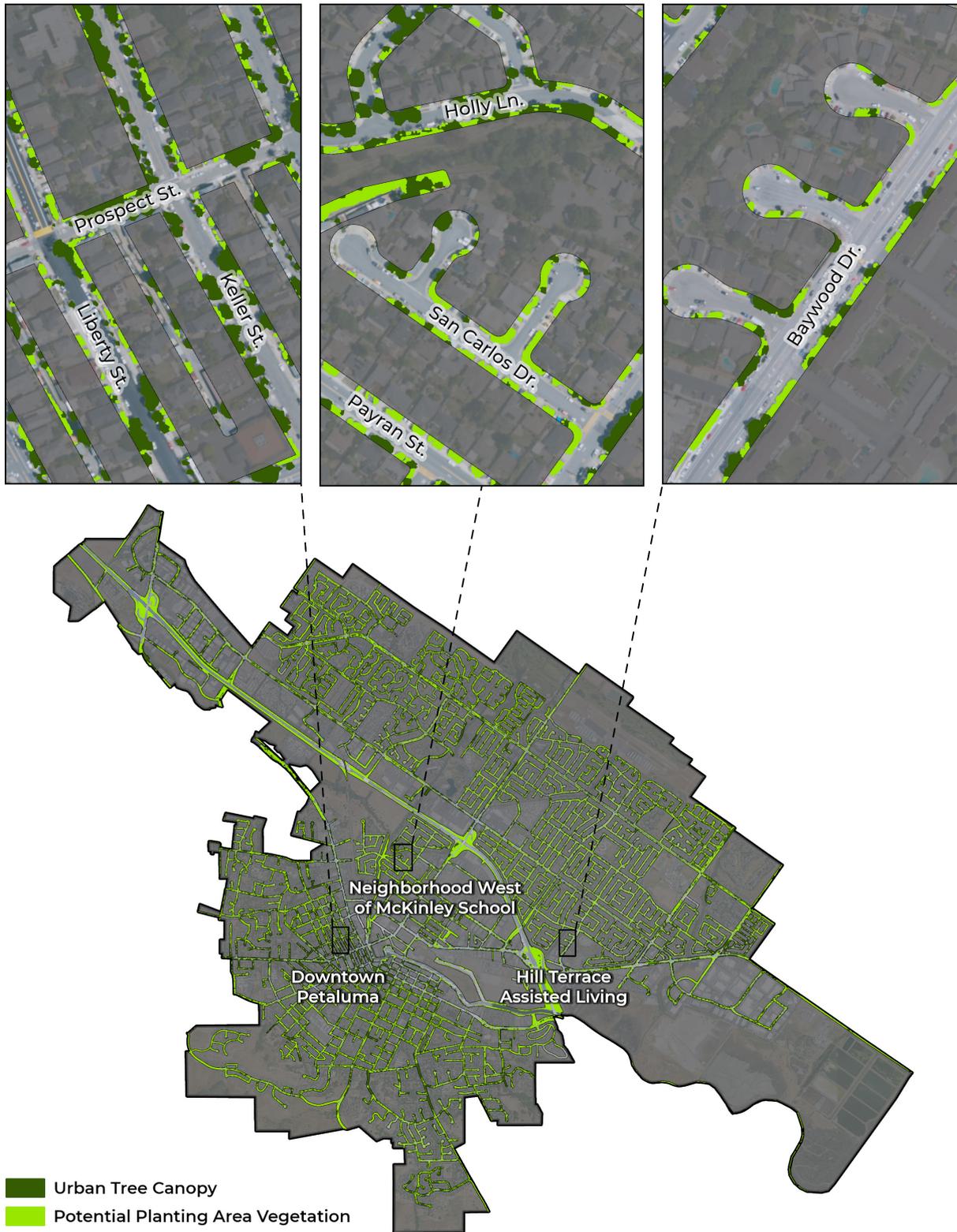


Figure 18. Urban tree canopy and potential planting area within rights-of-way.

The three inset maps in Figure 16 highlight areas selected based on three key criteria: higher PPA percentages, lower UTC percentages, and inclusion in the highest priority category identified by the census block group prioritization analysis (see Page 27). It’s important to note that PPA gives a broad indication of where planting might be possible but likely overestimates actual potential and does not specify precise locations for tree planting. These examples are intended to show areas where planting within public rights-of-way could be especially beneficial and where targeted planting efforts could have meaningful impact.

TREE CANOPY COVER BY HEXAGONS

Hexagons provide a consistent framework for assessing spatial patterns of urban forest cover. Unlike administrative boundaries, which can vary widely in area and shape, a uniform grid allows for direct comparison across the landscape and helps visualize where canopy coverage is high or low without the constraints of pre-existing geographies. Hexagons are also helpful in representing real natural features of an area. The following figures present maps that illustrate urban tree canopy, potential planting areas, and changes in canopy cover, providing clear visual insights into these key metrics.

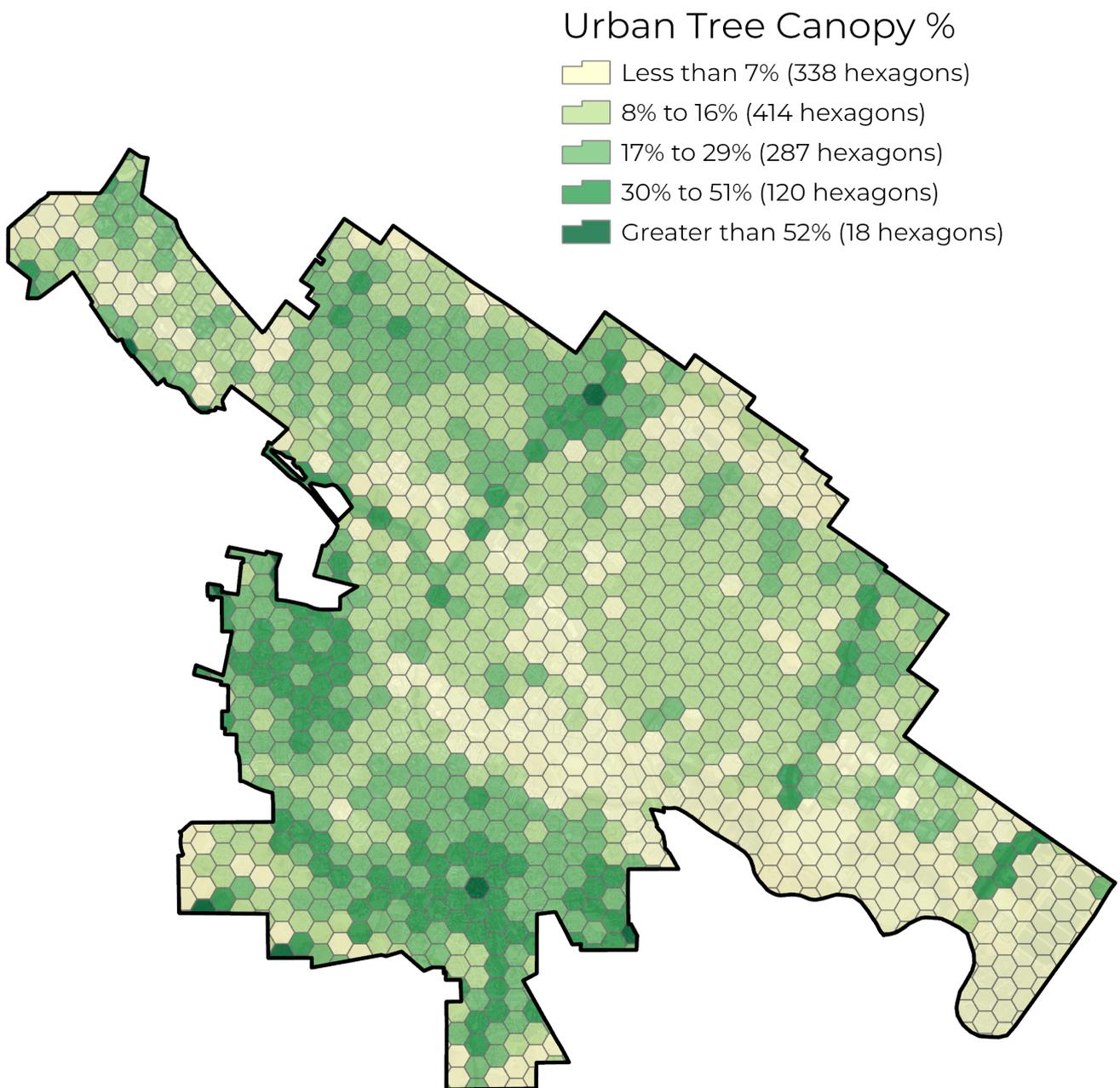


Figure 19. Urban tree canopy by hexagons. Each hexagon is approximately 9 acres.

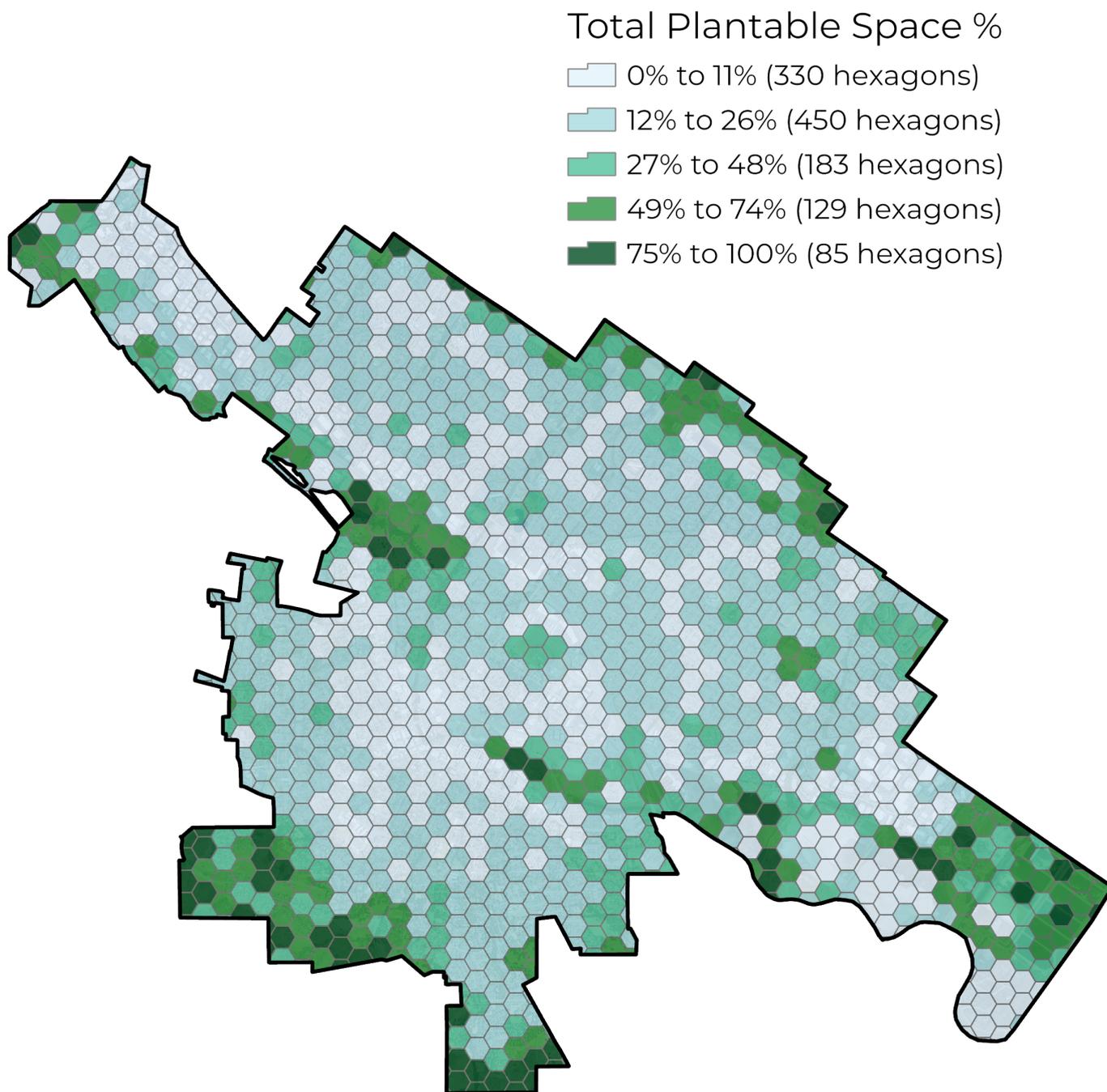


Figure 20. Potential plantable area by hexagons. Each hexagon is approximately 9 acres.

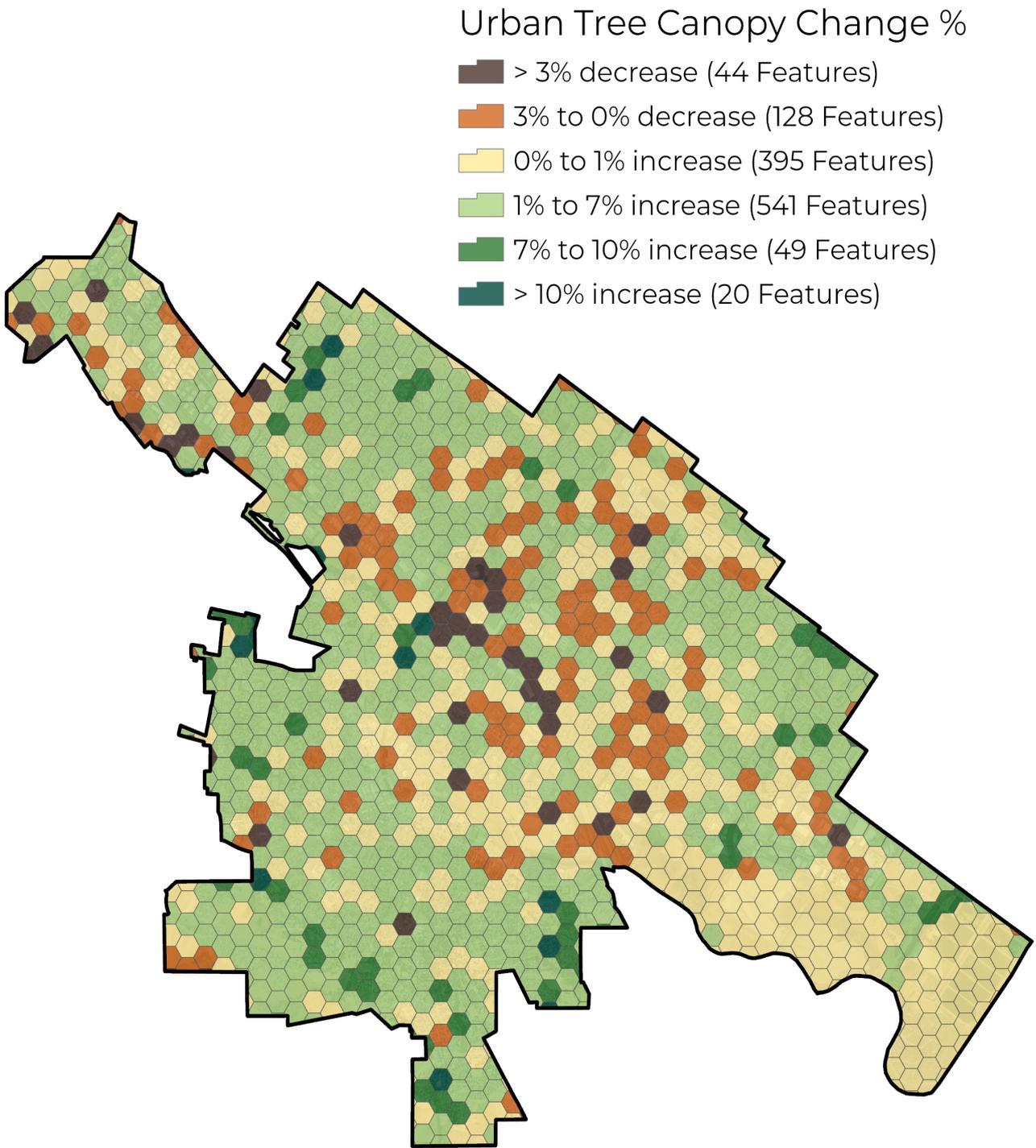


Figure 21. Urban tree canopy change by hexagons. Each hexagon is approximately 9 acres.

TREE PLANTING PRIORITIZATION

Increased tree canopy cover can provide a wide array of benefits to the local community and its residents and visitors. To locate specific areas in need, nine variables representing a range of socio-economic, demographic, and accessibility factors were analyzed at the census block group (CBG) level. The five socioeconomic variables incorporated into this assessment were sourced from the 2022 U.S. Census American Community Survey 5-year summary. Each variable was normalized and assigned equal weight in the prioritization criteria. The final score for each CBG was calculated by summing the normalized values.

The rankings range from high priority (dark blue) to low priority (light yellow) and were calculated for each criterion, as well as overall, to highlight where multiple needs overlap.

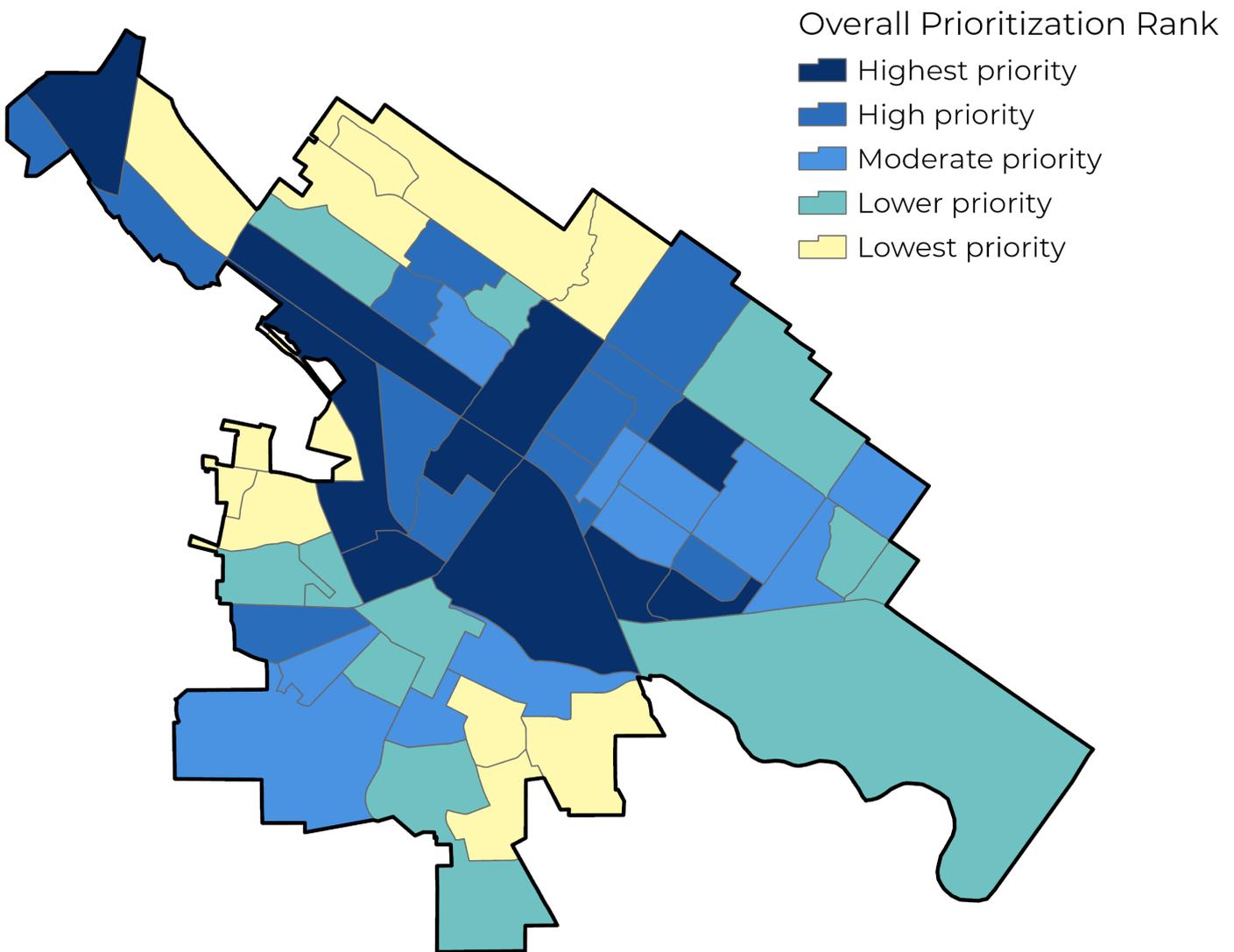
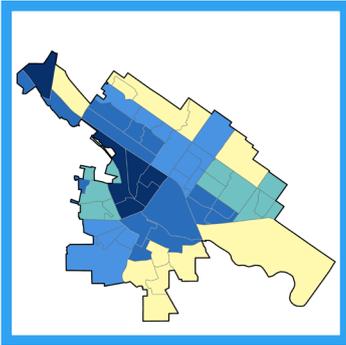
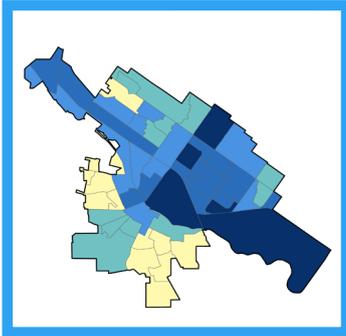


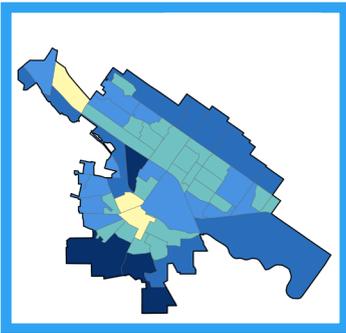
Figure 22. Overall prioritization score based on human health metrics, low tree canopy cover, potential plantable space, poverty rate, unemployment rate, vulnerable populations, median household income, educational attainment, and urban heat island metrics.



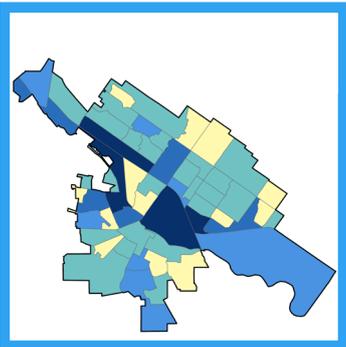
Human Health: This analysis is based on 2022 CDC PLACES health data, which generates model-based prevalence estimates of chronic health conditions, risk factors, and preventive behaviors. This composite index combines the prevalence of asthma, mental health issues, physical health challenges, and coronary heart disease. Higher composite scores indicate greater prevalence of these health challenges within the population. Studies have shown that higher canopy levels are associated with better health, so areas with higher overall scores are prioritized for tree planting.



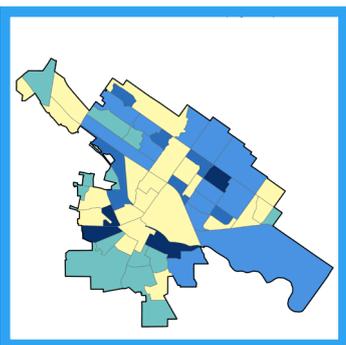
Low Existing Tree Canopy: Census block groups with lower tree canopy cover percentages and higher non-canopy land are prioritized for planting. This indicator highlights census block groups with low percentages of existing tree canopy cover. This criterion prioritizes census block groups with higher percentages of non-canopy-covered land.



Possible Urban Tree Canopy: Census block groups with greater plantable areas are prioritized for expanding urban tree canopy. Identifying census block groups that can support tree plantings is the first step in expanding future urban tree canopy cover. This indicator shows the percentage of each census block group that is available for planting, prioritizing those with a greater proportion of plantable area.

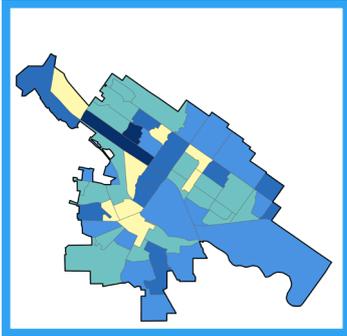


Poverty Rate: Census block groups with higher percentages of residents below the poverty level are prioritized for planting to address longstanding inequities in urban communities. This indicator shows the percentage of residents living below the federally designated poverty level, as reported by the U.S. Census American Community Survey 5-year summaries, highlighting census block groups where trees could enhance environmental and health benefits for residents.

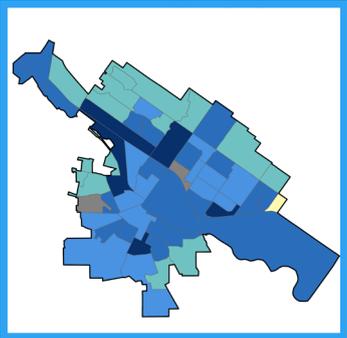


Unemployment Rate: Census block groups with higher unemployment rates are prioritized for planting opportunities. This indicator displays the percentage of the labor force that is not employed but actively seeking employment, as reported by the U.S. Census American Community Survey 5-year summaries. Census block groups with higher unemployment rates are prioritized for planting.

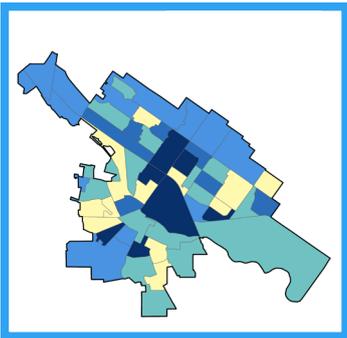




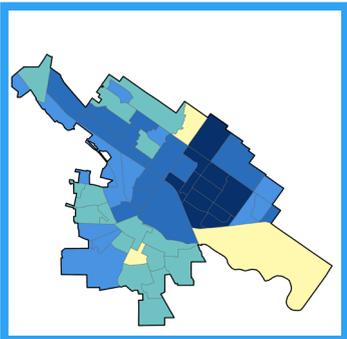
Vulnerable Population: Census block groups with larger ratios of residents under 18 or over 65 are prioritized for plantings. Trees provide essential environmental and health benefits to vulnerable populations. This indicator shows the ratio of residents under the age of 18 or over the age of 65 compared to the working-age population, as reported by the U.S. Census American Community Survey 5-year summaries. Census block groups with larger vulnerable population ratios are prioritized.



Median Household Income: Census block groups with lower median household incomes are prioritized for planting to address environmental inequality. Income inequality often overlaps with environmental inequality, where lower-income residents may reside in areas with more impervious surfaces and fewer trees, parks, and green spaces. This criterion prioritizes census block groups with lower median household incomes, as reported by the U.S. Census American Community Survey 5-year.



Educational Attainment: Census block groups with lower percentages of residents with a high school diploma or GED are prioritized for planting to improve outcomes. This indicator shows the percentage of the population without a high school diploma or GED, as reported by the U.S. Census American Community Survey 5-year summaries. Census block groups with lower educational attainment levels are prioritized, aligning with the observed benefits of trees on educational and social outcomes.



Urban Heat Island: Census block groups with higher surface temperatures are prioritized for planting to mitigate the effects of heat. Using LANDSAT surface temperature data collected on August 29, 2024, this indicator presents the average surface temperature in Fahrenheit for each census block group, ranging from 107°F to 116°F. Surface temperature, distinct from air temperature, is used for urban heat island analysis because it provides a measurement of how urban materials absorb and emit heat, allowing for detailed mapping of hot spots. Census block groups with higher average temperatures are prioritized for planting.



Prioritization Rank

- Highest priority
- High priority
- Moderate priority
- Lower priority
- Lowest priority

PETALUMA

TREE PLANTINGS

PETALUMA TREE PLANTINGS

Petaluma's recent tree planting efforts are part of a broader, community-driven movement to expand and sustain the city's urban forest. Between 2022 and 2025, the City of Petaluma planted a total of 1,993 new trees, primarily in public rights-of-way and city parks. After removing 138 trees located outside city limits, 1,855 trees were included in the analysis for future canopy projections. These trees ranged from bare-root seedlings to 15-gallon saplings, with about 70% planted as 15-gallon stock to improve survival rates and establishment.

A key caveat is that all of these trees were planted after the collection of the 2022 aerial imagery used in this assessment, so their contribution is not yet reflected in existing canopy data. Most were strategically planted in areas with low canopy coverage, including historically disadvantaged neighborhoods, to provide shade, mitigate heat, and enhance public spaces.

Petaluma's tree planting initiatives are supported by strong partnerships with local nonprofits, including ReLeaf Petaluma, Daily Acts, Rebuilding Together Petaluma, Point Blue Conservation, and Cool Petaluma. These organizations, along with the city, launched the Petaluma Canopy Project, which was funded in part by a \$1 million grant from the USDA Forest Service. The project aims to plant thousands of native trees across parks, schools, residential areas, and riverbanks, with a special focus on restoring native species, such as oaks, and improving canopy equity in underserved neighborhoods. The city's tree planting programs also benefit from Measure U, a voter-approved sales tax measure that has increased Petaluma's capacity to secure grants and invest in green infrastructure by supporting wildfire emergency response, public safety, and infrastructure improvements.



Community engagement is at the heart of Petaluma's approach. Initiatives like ReLeaf Petaluma's Residential Tree Program involve residents directly in greening their neighborhoods, offering free native trees, planting assistance, and ongoing care consultations. AmeriCorps teams and local volunteers have made significant contributions, planting hundreds of trees and participating in urban forestry education and advocacy efforts.

To project the future canopy coverage as these trees mature, each species was assigned a range for mature crown width. Recognizing that urban trees, especially those planted in rights-of-way and other constrained spaces, often do not reach their maximum potential canopy width, the lower end of the crown width range was used for these calculations. Based on this conservative estimate, if all 1,855 trees survive to maturity and achieve at least the lower bound of their species' crown width potential, they are expected to provide approximately 45 acres of new tree canopy within city limits, an area equivalent to about 34 football fields, and adding ecosystem benefits equivalent to about \$56,385 annually.

These efforts are guided by Petaluma's developing Urban Forest Management Plan, which sets long-term strategies for planting, maintenance, and community engagement to ensure a resilient and thriving urban forest for future generations.

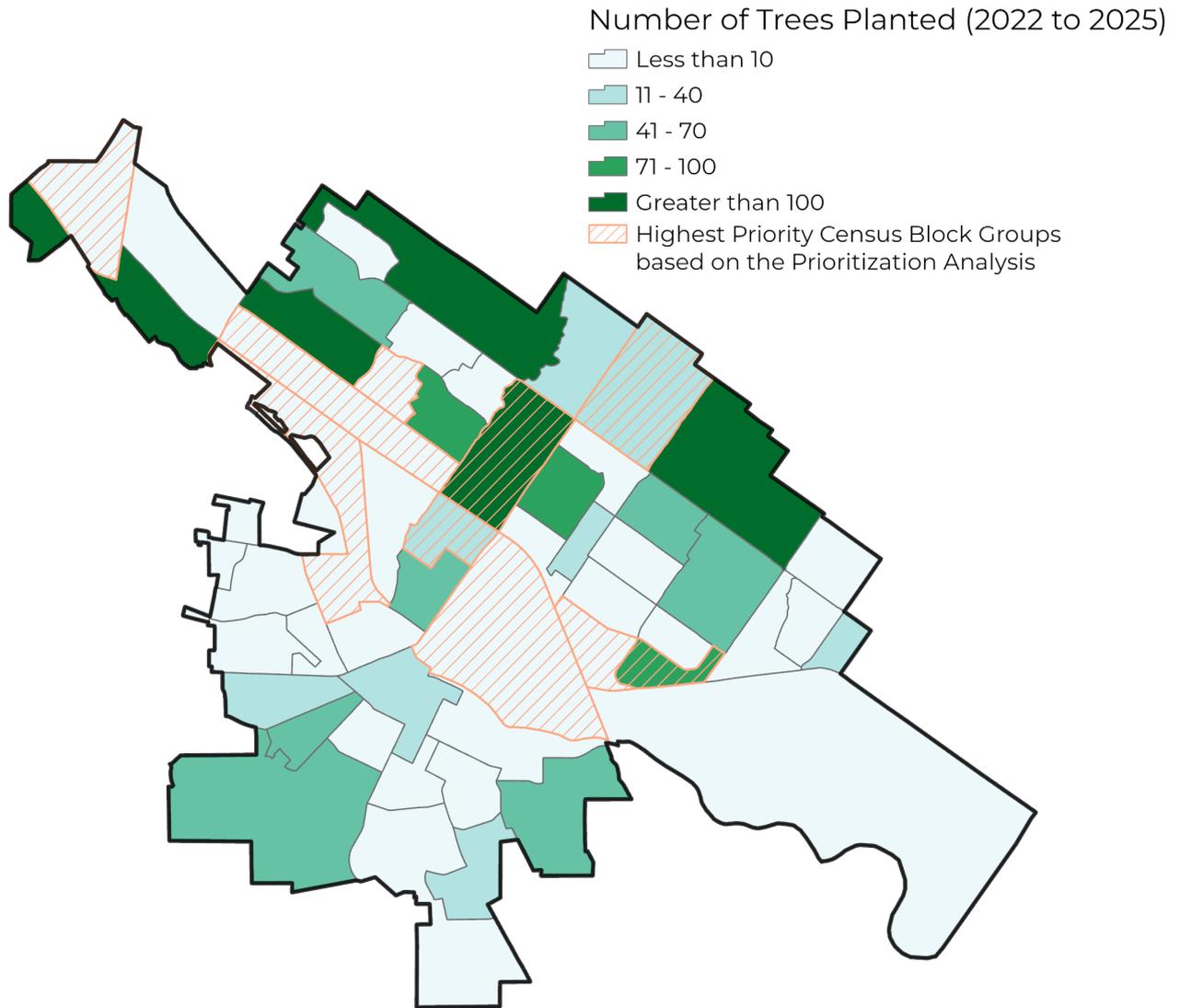


Figure 23. Number of trees planted in Petaluma from 2022 to 2025 by census block group.



Coast Live Oaks planted in 2023 in Wiseman Park. Wiseman Park had 117 trees of 8 different species installed between 2022 and 2025.

REGIONAL COMPARISONS

To establish effective urban tree canopy goals, it is important to compare Petaluma with similar municipalities in its ecological region. Petaluma sits within the California Coastal Sage, Chaparral, and Oak Woodlands Ecoregion (Level III)—a landscape noted for its Mediterranean climate, diverse native vegetation, and the prevalence of oak woodlands and chaparral communities.

Urban tree canopy data collected through a partnership between the USDA Forest Service and the Arbor Day Foundation offers comprehensive, high-resolution insights for all 2020 Census–designated urban areas in California. According to the National Urban Tree Canopy Application (TreeCanopy.US), the average tree canopy cover across urban areas within the California Coastal Sage, Chaparral, and Oak Woodlands Ecoregion was 14% in 2022—matching the canopy cover measured within Petaluma’s city limits.

Although Petaluma’s reported canopy percentage is based on municipal boundaries and the regional averages use census-designated urban area boundaries (which may differ slightly), these comparisons remain valuable. Petaluma’s 14% canopy cover aligns closely with the regional average, helping local policymakers and community organizations benchmark Petaluma’s progress and set informed goals for enhancing urban forestry in the future.

REGIONAL COMPARISON OF URBAN TREE CANOPY

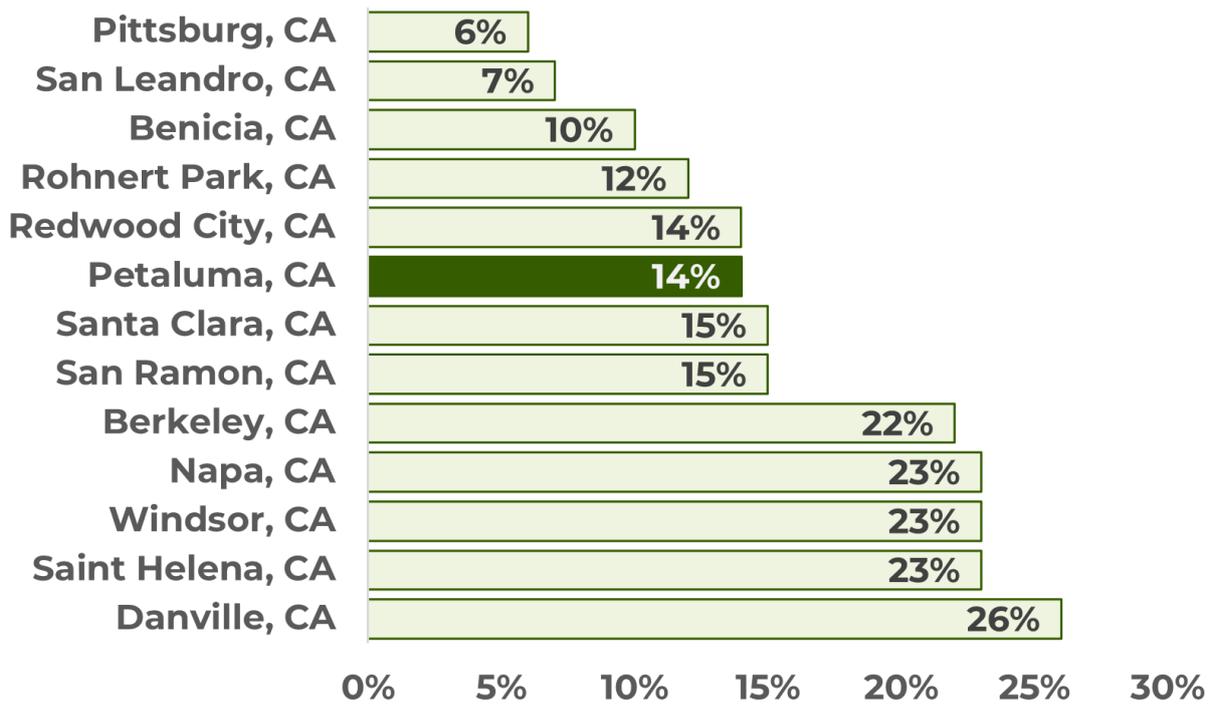


Figure 24. Regional comparison of canopy percentages across nearby California’s communities. Data sourced from The National Urban Tree Canopy Application.

Additionally, urban areas in this coastal ecoregion collectively experienced a very moderate increase in canopy (+0.1%) from 2016 to 2022, according to the National Canopy Application. Petaluma has achieved a 2% increase in its canopy cover, an improvement that exceeds the overall increase for this ecoregion. These comparisons, while not always perfectly aligned due to differing boundary definitions, provide valuable context for understanding Petaluma’s current position and for informing future canopy cover.

ECOSYSTEM BENEFITS

i-Tree tools were used to calculate the benefits and functions of Petaluma's tree canopy using the latest available research. Trees produce oxygen, indirectly reduce pollution by lowering air temperatures, and directly reduce air pollutants by capturing gases and dust, which can cause respiratory illness and death. Likewise, canopy coverage has been demonstrated to mitigate stormwater runoff, which in turn minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian areas, and absorb pollutants, thereby improving water quality and habitats. Trees play a crucial role in sequestering carbon from the atmosphere through photosynthesis and storing it in their biomass over the long term. Petaluma's existing canopy provides over \$1.6 million annually in avoided infrastructure costs and removes the following particulate matter from the air: 1,154 lbs of Carbon monoxide, 5,916 lbs of Nitrogen dioxide, 29,514 lbs of Ozone, 1,267 lbs of PM 2.5, and 7,084 lbs of PM 10. The total annual benefits from urban tree canopy coverage increase by an estimated \$1,253 per acre of added coverage, providing a significant incentive for Petaluma to expand its tree canopy coverage. Petaluma's canopy also provides an additional \$19.3 million in stored carbon.



MENTAL HEALTH

People without views of nature from their desks claimed 23% more sick days than workers with views of nature.



CLEANER AIR \$415,194

Each year, Petaluma's trees remove 22.5 tons of air pollutants from the air.



STORMWATER MANAGEMENT \$191,831

Petaluma's trees intercept about 21.5 million gallons of runoff annually.



CARBON STORAGE \$19,309,480

Petaluma's urban forest stores 163,617 tons of CO2.



CARBON SEQUESTRATION \$1,026,406

In one year, Petaluma's trees absorb 8,697 tons of CO2 from the atmosphere.



TOTAL ANNUAL BENEFITS

Petaluma's trees annually provide **\$1,633,432** in ecosystem benefits.

That equates to approximately \$1,253 per acre of canopy.

Figure 25. Ecosystem service benefits of Petaluma's canopy cover. Data sourced from i-Tree, the US Forest Service, the Arbor Day Foundation, and the U.S. Environmental Protection Agency.

CONCLUSIONS AND RECOMMENDATIONS

The City of Petaluma's 2022 tree canopy assessment reveals both the strengths and challenges of its urban forest. With 14% of the city's land area covered by tree canopy and 24% identified as suitable for future planting, Petaluma has a significant opportunity to protect and expand its green infrastructure. Petaluma has benefited from natural regeneration and growth, mainly in open spaces, which have increased the canopy by 2% (159+ acres). Regular, high-resolution assessments are crucial for tracking canopy trends, identifying priority planting areas, and informing adaptive management strategies. The assessment's detailed breakdown by land use, property ownership, and census block groups provides a roadmap for strategic action, ensuring that resources are directed to neighborhoods and public spaces with the greatest need and opportunity.

RECOMMENDATIONS

1. Target High-Priority Planting Areas Identified in the Assessment

Focus tree planting efforts in residential neighborhoods, parks, and other areas with the lowest existing canopy and the highest concentrations of impervious surfaces, which have overlapping socioeconomic needs, as identified through the prioritization analysis. Central Petaluma (particularly its downtown and densely populated residential areas) offers adequate plantable space and would benefit most from increased canopy. Planting in these areas can help mitigate urban heat island effects, manage stormwater, and improve environmental equity for residents.

2. Garner the Support of Residents for Green Initiatives

Although 71% of Petaluma is privately owned, the total number of plantable acres existing in both privately owned and publicly owned land is similar. Private land has 1,138 acres, while public land has 880 acres of plantable space. Engaging community organizations and residents alike will enable Petaluma to not only target private land for planting but also garner community support for greening public lands. Ensure that outreach and planting programs are accessible to all residents, with a focus on neighborhoods with high poverty rates, vulnerable populations, or large amounts of underutilized plantable space. Use American Community Survey data and heat island mapping to direct resources where they will have the greatest social and environmental impact. Petaluma has established strong connections with community members through its volunteer programs and Arbor Day events, so expanding the reach of these partnerships would build on this solid foundation.

3. Expand and Diversify Public Canopy

Continue to invest in tree planting and maintenance on city-owned lands, rights-of-way, and parks, where canopy gains have already been observed. Prioritize planting in parks and alongside streets with low canopy cover or high public use, such as community hubs, parks, and important gathering places. Utilize the city's plantable area analysis to maximize ecological benefits, including stormwater management and shade provision.

Select tree species that are adapted to Petaluma's climate, including those resilient to drought, heat, and severe weather events. This will help ensure long-term canopy survival and maximize ecosystem benefits. The city should update its recommended species list in the Urban Forest Management Plan in accordance with current climate projections and pest and disease risks.

4. Integrate Canopy Goals into City Planning

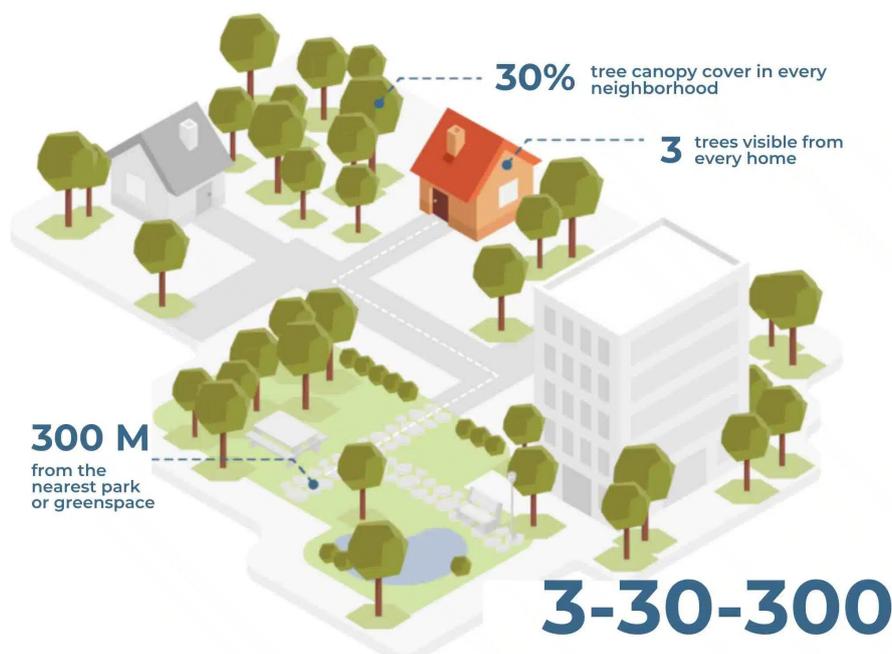
Utilize assessment data to establish an ambitious yet achievable, measurable citywide canopy cover goal. Set incremental, attainable targets by land use category, property type, and census block group to ensure all plantable spaces are fully utilized. Integrate tree protection and planting requirements into Petaluma's Urban Forestry Management Plan and Climate Action Framework, with special emphasis on new construction and redevelopment projects. Strengthen local ordinances to preserve mature trees and require replacement plantings when removals are unavoidable.

Currently, urban canopy cover stands at 23% in Napa, 22% in Santa Rosa, and 30% in El Verano, according to TreeCanopy.US. Petaluma can look to these neighboring communities as inspiration and set an ambitious yet achievable, SMART goals (specific, measurable, achievable, realistic, and time-bound). Releaf Petaluma has set a goal to plant 10,000 trees through various outreach programs. By committing to this growth, Petaluma stands to gain significant projected ecosystem benefits including improved shade and lower temperatures.

5. Use Urban Forestry Principles to Shape Petaluma's Urban Landscape

A widely recognized framework for urban forestry and city planning is the 3+30+300 principle, developed by Cecil Konijnendijk, Director of the Nature Based Solutions Institute. This community-focused approach suggests that residents should be able to see three significant trees from their window (at home, at school, or in an office), each neighborhood should strive for 30% tree canopy cover, and all residents should live within 300 meters (or roughly 330 yards) of a public green space. While this principle certainly does not serve as a "one-size-fits-all" approach, it can provide a flexible framework for developing local environmental policy.

By concentrating on just one of those guidelines, such as ensuring that every resident can see three significant trees, Petaluma can establish measurable and actionable objectives that provide real benefits to the entire community. This strategy enables the city to prioritize both equity and access, ensuring that the advantages of urban greenery are distributed fairly and effectively.



Source: <https://www.330300rule.com>

REPORT

APPENDIX

A. EXPANDED METHODOLOGY

1. Data Acquisition and Preparation

PlanIT Geo utilized 2022 EarthDefine US Tree Map data (derived from 60-centimeter multispectral NAIP imagery and LiDAR) and 60 cm resolution NAIP imagery from 2016 to map tree canopy and land cover. The tested accuracy of the US Tree Map in California is 99.3% according to EarthDefine's accuracy assessment using 1,150 random points throughout the state.

2. Land Cover Classification

Training labels for seven land cover classes—tree canopy (including overhanging impervious surfaces), shrub vegetation, herbaceous/grass, bare soil/dry vegetation, impervious surfaces, open water, and tree canopy over impervious—were developed using NAIP imagery, LiDAR, and external datasets. Identical Deep Convolutional Neural Network (DCNN) workflows were applied to both the 2016 and 2022 imagery for consistency, with hyperparameter-optimized models performing semantic segmentation. Post-classification refinements included knowledge-based rules (e.g., masking water bodies using NDWI) and manual QA/QC.

3. Possible Planting Areas Delineation

All areas lacking tree canopy were further classified as either suitable or unsuitable for planting. Unsuitable areas for canopy expansion (e.g., airports, sports fields, utility corridors) were excluded by manually digitizing these features. These areas, while vegetated and potentially suitable for tree planting from a biophysical perspective, are considered unsuitable due to land use constraints. The original seven-class land cover data was then converted into Urban Tree Canopy potential classes, resulting in the following final classifications: Possible Planting Area, Unsuitable Impervious, Unsuitable Vegetation, Unsuitable Soil, and Water. This refined classification provides a detailed spatial framework for prioritizing tree planting efforts.

4. Historical Canopy Change Analysis

The 2016 and 2022 tree canopy classifications were compared using GIS overlay analysis to quantify changes in canopy extent over the eight-year study period. This approach enabled the identification of areas where tree canopy was lost, gained, or remained stable, providing essential baseline data for evaluating the effectiveness of urban forestry initiatives. It should be noted that the 2016 historical tree canopy data is a single-class dataset; therefore, land cover change analysis was limited to the tree canopy class only. This methodology enables precise tracking of canopy changes since 2016 while maintaining methodological consistency across time periods, ensuring comparable results for long-term urban forest management planning.

5. Urban Heat Island

Data is derived from the thermal infrared sensor on Landsat satellites and is a key resource for environmental monitoring, climate research, and urban planning. Measurements capture the temperature of the Earth's surface, not the air temperature (which is what you typically see in weather reports). The measured "surface" could be soil, vegetation, buildings, or other types of land cover. This data collection method is especially helpful for recording the temperature of the built environment and recording temperature on impervious surfaces.

B. ACCURACY ASSESSMENT

Classification accuracy serves two primary purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, accuracy measures 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, slight differences in classification methodology and image quality can significantly impact overall map area estimations. The classification accuracy error matrix illustrated in Figure 26 contains confidence intervals reporting the high and low values that could be expected to compare the classification data and the actual on-ground land cover in 2022. This accuracy assessment was completed using high-resolution aerial imagery, with computer and manual verification. This study did not include field verification.

The internal accuracy assessment was completed in these steps:

230, or approximately 16 points per square mile area in Petaluma's full area of interest (14.5 sq. miles), were randomly distributed across the study area and assigned a random numeric value by a trained technician.

1. Each sample point was then referenced using the NAIP aerial photo and assigned one of the five generalized land cover classes ("Ref_ID") mentioned above.
2. If the technician could not discern the reference value from the imagery, the point was dropped from the accuracy analysis.
3. 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.
4. 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 actual conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Petaluma's landscape. The error matrix in Figure 24 represents the intersection of reference pixels manually identified by a human observer (columns) and the 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 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 ($31 + 61 + 115 + 10 + 7 = 224 / 230 = 97.4\%$), and the matrix can be used to calculate per-class accuracy percentages. 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 non-canopy vegetation is calculated as $224/230 = 0.97$, meaning that one can expect that ~97% of all 2022 tree canopy vegetation in the Glendale study area was classified as tree canopy in the 2022 classification map. This same procedure was utilized for tree canopy classifications as well.

Conversely, the “User’s Accuracy” is calculated by dividing the number of agreement pixels by the number of classified pixels in the row category. For example, 32 classification pixels intersecting reference pixels were classified as Tree Canopy, and 31 pixels were identified as canopy in the reference map. Therefore, the User’s Accuracy for Tree Canopy is calculated as $31/32 = .96$, meaning that ~96% 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 based on a sample of the existing ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this assessment accurately mapped land cover and, more importantly, tree canopy in Petaluma in 2022.

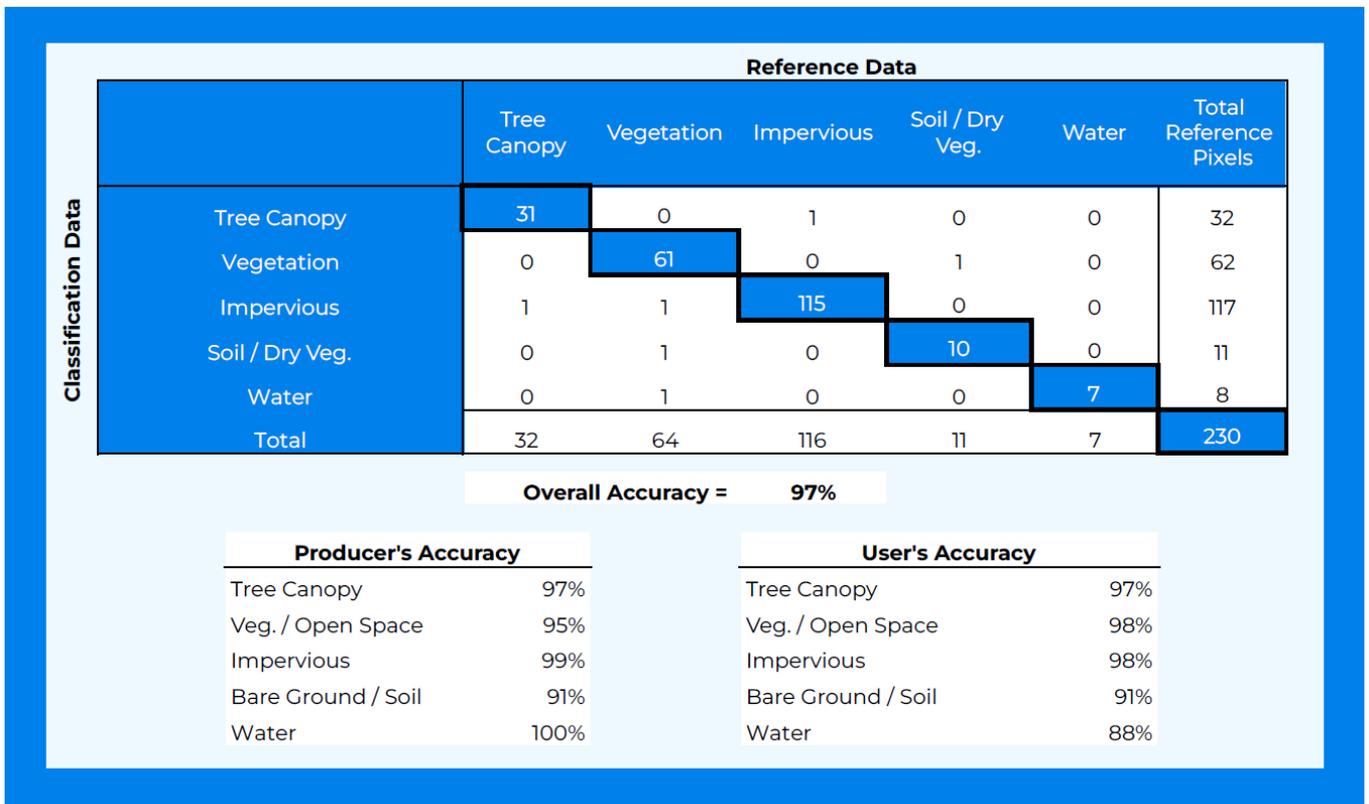


Figure 26. Accuracy assessment for Petaluma’s 2022 land cover raster.

C. ADDITIONAL DATA

1. Census Block Group Data

Urban tree canopy data by census block group in table format.

2. Rights-of-Ways Summarized by Census Block Group Data

Urban tree canopy data by rights-of-way summarized by census block group in table format.

Table 9. Urban tree canopy metrics by census block groups.

CENSUS BLOCK GROUP	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
60-971-50607-1	13	18%	7	10%	50	71%
60-971-50611-1	22	20%	34	31%	44	39%
60-971-50610-2	40	24%	27	16%	100	59%
60-971-50612-1	46	12%	99	27%	184	50%
60-971-50607-2	26	11%	18	8%	177	79%
60-971-50609-1	21	14%	29	19%	101	65%
60-971-50609-2	29	12%	28	11%	189	76%
60-971-50611-2	5	10%	7	15%	35	75%
60-971-50607-3	37	22%	40	24%	59	36%
60-971-50601-4	9	10%	15	16%	67	74%
60-971-50601-1	9	10%	13	14%	69	77%
60-971-50601-2	6	10%	8	13%	46	77%
60-971-50601-3	5	7%	12	18%	50	73%
60-971-50612-2	68	6%	310	27%	319	24%
60-971-50602-3	19	9%	46	22%	138	64%
60-971-50602-1	10	10%	15	14%	75	73%
60-971-50603-1	30	13%	29	13%	160	71%
60-971-50603-6	8	10%	10	13%	62	77%
60-971-50603-5	8	8%	12	11%	83	79%
60-971-50610-3	11	18%	7	11%	45	71%
60-971-50603-2	6	9%	9	14%	49	77%
60-971-50603-3	6	11%	7	14%	38	75%
60-971-50603-4	17	6%	83	32%	134	51%
60-971-50609-3	9	13%	8	12%	52	75%
60-971-50610-1	12	14%	14	17%	60	69%
60-971-50701-1	23	5%	106	22%	320	64%
60-971-50609-4	20	21%	14	15%	59	63%
60-971-50901-1	8	9%	5	6%	79	82%
60-971-50901-2	9	10%	12	13%	65	73%
60-971-50901-3	15	16%	17	18%	60	65%
60-971-50701-2	27	17%	16	10%	107	64%
60-971-50702-2	29	24%	29	24%	61	51%
60-971-50702-4	28	28%	14	14%	56	57%
60-971-50800-1	22	19%	21	17%	73	61%
60-971-50800-2	16	22%	8	11%	49	67%
60-971-50800-3	13	17%	8	11%	52	70%
60-971-50701-3	19	14%	7	5%	108	76%
60-971-50701-4	22	29%	11	14%	42	53%
60-971-50901-4	21	15%	71	50%	41	29%

CENSUS BLOCK GROUP	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
60-971-50901-5	38	15%	84	34%	123	49%
60-971-50902-4	16	26%	7	12%	37	62%
60-971-50902-3	29	26%	25	23%	56	51%
60-971-50902-1	23	25%	17	18%	51	56%
60-971-50902-2	40	31%	21	16%	67	52%
60-971-50702-3	94	25%	171	45%	111	29%
60-971-50702-1	58	26%	62	27%	105	46%
60-971-51000-3	12	31%	7	18%	20	51%
60-971-51000-1	30	15%	64	33%	96	50%
60-971-50800-4	95	19%	267	52%	145	28%
60-971-51205-2	24	12%	47	23%	106	52%
60-971-50611-4	15	20%	10	12%	53	68%
60-971-50607-4	64	18%	92	25%	191	52%
60-971-50611-3	15	15%	20	20%	62	61%
60-971-50602-2	9	9%	11	12%	75	79%

Table 10. Urban tree canopy change metrics by census block groups.

CENSUS BLOCK GROUP	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
60-971-50607-1	10	15%	13	18%	2	3%
60-971-50611-1	17	16%	22	20%	5	4%
60-971-50610-2	32	19%	40	24%	8	5%
60-971-50612-1	37	10%	46	12%	8	2%
60-971-50607-2	22	10%	26	11%	4	2%
60-971-50609-1	18	11%	21	14%	4	2%
60-971-50609-2	26	10%	29	12%	3	1%
60-971-50611-2	2	4%	5	10%	3	6%
60-971-50607-3	32	20%	37	22%	4	3%
60-971-50601-4	8	9%	9	10%	1	1%
60-971-50601-1	8	9%	9	10%	0	1%
60-971-50601-2	6	10%	6	10%	0	0%
60-971-50601-3	5	8%	5	7%	0	0%
60-971-50612-2	58	5%	68	6%	9	1%
60-971-50602-3	17	8%	19	9%	2	1%
60-971-50602-1	10	10%	10	10%	0	0%
60-971-50603-1	30	14%	30	13%	-1	0%
60-971-50603-6	8	10%	8	10%	0	0%
60-971-50603-5	8	7%	8	8%	0	0%

CENSUS BLOCK GROUP	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
60-971-50610-3	11	17%	11	18%	1	1%
60-971-50603-2	8	12%	6	9%	-2	-3%
60-971-50603-3	6	11%	6	11%	0	0%
60-971-50603-4	17	7%	17	6%	0	0%
60-971-50609-3	8	12%	9	13%	1	1%
60-971-50610-1	11	13%	12	14%	1	1%
60-971-50701-1	22	5%	23	5%	1	0%
60-971-50609-4	17	18%	20	21%	3	3%
60-971-50901-1	7	7%	8	9%	1	2%
60-971-50901-2	8	9%	9	10%	1	2%
60-971-50901-3	14	16%	15	16%	1	1%
60-971-50701-2	25	16%	27	17%	2	1%
60-971-50702-2	26	22%	29	24%	3	2%
60-971-50702-4	25	26%	28	28%	2	2%
60-971-50800-1	21	17%	22	19%	2	1%
60-971-50800-2	14	19%	16	22%	2	2%
60-971-50800-3	11	15%	13	17%	2	2%
60-971-50701-3	17	13%	19	14%	2	1%
60-971-50701-4	21	27%	22	29%	1	2%
60-971-50901-4	17	12%	21	15%	4	3%
60-971-50901-5	35	14%	38	15%	4	2%
60-971-50902-4	14	24%	16	26%	2	3%
60-971-50902-3	26	23%	29	26%	3	3%
60-971-50902-1	18	20%	23	25%	5	5%
60-971-50902-2	35	27%	40	31%	5	4%
60-971-50702-3	79	21%	94	25%	15	4%
60-971-50702-1	46	20%	58	26%	12	5%
60-971-51000-3	10	27%	12	31%	2	4%
60-971-51000-1	31	16%	30	15%	-2	-1%
60-971-50800-4	77	15%	95	19%	18	3%
60-971-51205-2	21	10%	24	12%	2	1%
60-971-50611-4	12	16%	15	20%	3	4%
60-971-50607-4	53	15%	64	18%	10	3%
60-971-50611-3	14	14%	15	15%	1	1%
60-971-50602-2	9	10%	9	9%	0	0%

Table 11. Urban tree canopy metrics by rights-of-way summarized by census block groups.

CENSUS BLOCK GROUP	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
60-971-50607-1	4	19%	0	2%	17	79%
60-971-50611-1	2	23%	1	8%	5	69%
60-971-50610-2	12	27%	2	4%	31	69%
60-971-50612-1	7	12%	1	2%	53	87%
60-971-50607-2	4	9%	6	13%	36	78%
60-971-50609-1	6	20%	1	3%	24	78%
60-971-50609-2	3	7%	6	12%	40	81%
60-971-50611-2	2	10%	1	4%	14	86%
60-971-50607-3	6	23%	1	2%	18	75%
60-971-50601-4	1	3%	5	14%	28	83%
60-971-50601-1	1	4%	0	1%	22	95%
60-971-50601-2	0	3%	0	1%	14	96%
60-971-50601-3	1	5%	0	3%	13	93%
60-971-50612-2	5	9%	10	17%	40	74%
60-971-50602-3	1	4%	1	1%	40	95%
60-971-50602-1	1	3%	0	1%	24	96%
60-971-50603-1	3	8%	2	5%	37	87%
60-971-50603-6	0	2%	0	1%	19	96%
60-971-50603-5	0	3%	0	1%	15	96%
60-971-50610-3	2	12%	0	2%	14	86%
60-971-50603-2	1	4%	2	6%	23	90%
60-971-50603-3	0	4%	0	1%	13	95%
60-971-50603-4	1	4%	0	1%	27	95%
60-971-50609-3	1	9%	0	1%	11	90%
60-971-50610-1	1	6%	0	2%	19	92%
60-971-50701-1	4	5%	10	11%	74	84%
60-971-50609-4	2	10%	0	3%	15	87%
60-971-50901-1	2	8%	1	3%	24	89%
60-971-50901-2	2	8%	1	6%	18	86%
60-971-50901-3	2	9%	2	9%	20	82%
60-971-50701-2	5	13%	2	5%	31	82%
60-971-50702-2	2	12%	1	3%	18	85%
60-971-50702-4	3	16%	1	3%	14	81%
60-971-50800-1	3	15%	1	5%	18	81%
60-971-50800-2	3	17%	0	2%	12	81%

CENSUS BLOCK GROUP	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	POTENTIAL PLANTING AREA (ACRES)	POTENTIAL PLANTING AREA %	UNSUITABLE SURFACE (ACRES)	UNSUITABLE SURFACE %
60-971-50800-3	2	12%	1	3%	16	85%
60-971-50701-3	7	17%	1	1%	36	82%
60-971-50701-4	4	26%	0	3%	12	71%
60-971-50901-4	1	4%	2	10%	14	85%
60-971-50901-5	3	9%	6	17%	27	74%
60-971-50902-4	3	18%	1	4%	13	78%
60-971-50902-3	2	13%	1	4%	14	83%
60-971-50902-1	3	16%	1	6%	14	77%
60-971-50902-2	3	17%	1	4%	16	79%
60-971-50702-3	9	24%	2	5%	25	70%
60-971-50702-1	5	14%	2	5%	27	81%
60-971-51000-3	1	15%	0	2%	5	83%
60-971-51000-1	2	7%	5	20%	19	72%
60-971-50800-4	6	13%	3	7%	38	80%
60-971-51205-2	2	5%	7	20%	27	75%
60-971-50611-4	1	11%	0	3%	11	86%
60-971-50607-4	10	17%	2	3%	47	81%
60-971-50611-3	1	5%	1	3%	24	92%
60-971-50602-2	1	3%	0	1%	24	96%



Table 12. Urban tree canopy change metrics by rights-of-way summarized by census block groups.

CENSUS BLOCK GROUP	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
60-971-50607-1	4	17%	4	19%	0	2%
60-971-50611-1	2	23%	2	23%	0	1%
60-971-50610-2	11	24%	12	27%	1	2%
60-971-50612-1	6	10%	7	12%	1	1%
60-971-50607-2	3	7%	4	9%	1	2%
60-971-50609-1	5	17%	6	20%	1	2%
60-971-50609-2	5	10%	3	7%	-2	-3%
60-971-50611-2	1	5%	2	10%	1	6%
60-971-50607-3	5	20%	6	23%	1	3%
60-971-50601-4	1	3%	1	3%	0	0%
60-971-50601-1	1	4%	1	4%	0	0%
60-971-50601-2	1	4%	0	3%	0	-1%
60-971-50601-3	1	5%	1	5%	0	0%
60-971-50612-2	4	7%	5	9%	1	2%
60-971-50602-3	1	3%	1	4%	0	0%
60-971-50602-1	1	3%	1	3%	0	0%
60-971-50603-1	5	11%	3	8%	-1	-3%
60-971-50603-6	0	2%	0	2%	0	0%
60-971-50603-5	0	3%	0	3%	0	0%
60-971-50610-3	2	11%	2	12%	0	1%
60-971-50603-2	3	11%	1	4%	-2	-7%
60-971-50603-3	1	5%	0	4%	0	-1%
60-971-50603-4	1	4%	1	4%	0	0%
60-971-50609-3	1	10%	1	9%	0	-1%
60-971-50610-1	1	6%	1	6%	0	-1%
60-971-50701-1	5	6%	4	5%	-1	-1%
60-971-50609-4	2	9%	2	10%	0	1%
60-971-50901-1	2	6%	2	8%	0	1%
60-971-50901-2	1	7%	2	8%	0	1%
60-971-50901-3	4	15%	2	9%	-1	-6%
60-971-50701-2	5	13%	5	13%	0	0%
60-971-50702-2	3	12%	2	12%	0	0%
60-971-50702-4	3	16%	3	16%	0	0%
60-971-50800-1	3	13%	3	15%	0	2%
60-971-50800-2	3	19%	3	17%	0	-2%

CENSUS BLOCK GROUP	2016 URBAN TREE CANOPY (ACRES)	2016 URBAN TREE CANOPY %	2022 URBAN TREE CANOPY (ACRES)	2022 URBAN TREE CANOPY %	2016-2022 CHANGE ACRES	RAW CHANGE %
60-971-50800-3	2	12%	2	12%	0	0%
60-971-50701-3	7	15%	7	17%	1	1%
60-971-50701-4	4	27%	4	26%	0	-2%
60-971-50901-4	1	5%	1	4%	0	-1%
60-971-50901-5	3	9%	3	9%	0	0%
60-971-50902-4	3	17%	3	18%	0	1%
60-971-50902-3	2	12%	2	13%	0	1%
60-971-50902-1	2	14%	3	16%	0	3%
60-971-50902-2	3	16%	3	17%	0	1%
60-971-50702-3	7	21%	9	24%	1	4%
60-971-50702-1	4	11%	5	14%	1	4%
60-971-51000-3	1	13%	1	15%	0	2%
60-971-51000-1	2	7%	2	7%	0	0%
60-971-50800-4	5	11%	6	13%	1	2%
60-971-51205-2	2	6%	2	5%	0	-1%
60-971-50611-4	1	10%	1	11%	0	1%
60-971-50607-4	9	16%	10	17%	0	1%
60-971-50611-3	1	5%	1	5%	0	0%
60-971-50602-2	1	3%	1	3%	0	0%



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.

Shrub: Areas of shrub or other leafy and woody vegetation (smaller than 6ft tall) that are not classified as tree canopy.

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

Total Acres: Total area, in acres, of the assessment boundary (includes water).

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.

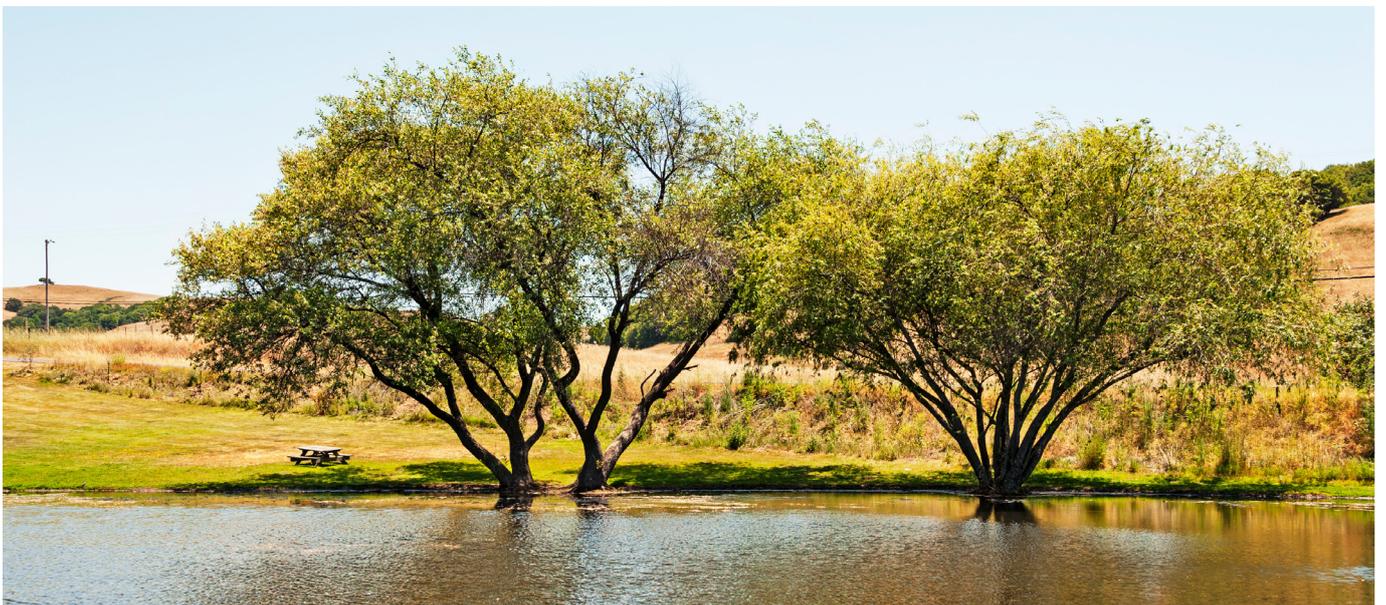
Unsuitable Planting Area: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

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.

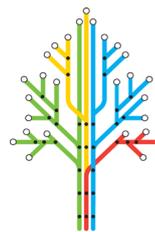
Urban Tree Canopy (UTC): The “layer of leaves, branches and stems that cover the ground” (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of the urban forest. Tree canopy was generally taller than 10-15 feet tall.

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



SEPTEMBER | 2025

TREE CANOPY COVER
ASSESSMENT
CITY OF PETALUMA



Urban Ecos