Merced, California

Urban Forest Management Plan

2020

MERCED

DAVEY Resource Group

Merced, California

Urban Forest Management Plan

2020

Prepared For:
City of Merced
1776 Grogan Avenue
Merced, CA 95341

Prepared By:
Davey Resource Group, Inc.
6005 Capistrano Ave. Suite A
Atascadero, California 93422
Phone: 805-461-7500
Toll Free: 800-966-2021
Fax: 805-461-8501
www.davey.com/drg

Acknowledgements:

Funding for this project provided by the California Department of Forestry and Fire Protection as part of the California Climate Investments Program.

Table of Contents

Figures

Maps

Tables

Executive Summary

In 2018, the City of Merced contracted with Davey Resource Group, Inc. (DRG) to conduct a complete inventory of community trees (public trees) and to develop an Urban Forest Management Plan (UFMP). The Plan will help determine and prioritize maintenance needs for city-managed trees, as well as provide guidance for enhancing the urban forest (public and private trees).

Funding for this project was provided by the California Climate Investments Fire Prevention Grant Program. This grant program is intended to improve the public health in communities adjacent to forested areas through the reduction of greenhouse gas emissions and fire prevention.

The urban forest enhances the aesthetics of the community and provides numerous environmental benefits. Merced has a long history of urban forestry. Five years after the inception of the Tree City USA program in 1976, a nationwide program that provides criteria for communities to manage public trees, Merced obtained their designation and has maintained it for 39 years.

To establish benchmarks and provide a foundation for the UFMP, the plan development process included a comprehensive review and assessment of:

- Land cover across the community, including tree canopy, impervious surface, grass/low-lying vegetation, bare soils, and open water
- The community tree resource (public tree inventory), including composition and structure, benefits, and the benefit versus investment ratio
- Forestry operations, including funding and current service levels
- Guiding documents, including Vision 2030 General Plan, Municipal Code, state law, and other regulatory and policy documents
- Vision and guidance provided by partners and stakeholders

The review process determined that Merced has an established urban forestry program with dedicated forestry staff and a complete inventory of public trees. The land cover assessment revealed that the average canopy cover (public and private) across Merced is 12.1%. Public and private trees have sequestered (i.e. stored) more than 547 million tons of carbon (CO_2) and annually provide $293,589 in benefits to air quality and stormwater runoff reduction.

Analysis of the community tree resource (public trees) identified 44,107 trees in the current inventory. Each year, community trees are providing nearly $4.5 million in environmental and socioeconomic benefits. To replace the community tree resource with trees of the same size, species, and condition would cost more than $117 million.

Merced's Parks and Trees Divisions strive to maintain community trees on a 7-year pruning schedule. However, due to resources and operational challenges, most recent maintenance has been reactionary. The tree inventory found that the majority of Merced's community trees (~ 78%) require routine pruning (Table 1). Additionally, 2,570 trees are recommended for priority removal. This management plan outlines a schedule for addressing tree maintenance over the next 8 years, including new tree plantings.

Table 1: Summary of Primary Maintenance Needs

Priority Removals		
Priority 1 Removal	2.01%	885
Priority 2 Removal	1.24%	1,139
Priority 3 Removal	2.58%	546
Priority Pruning		
Priority 1 Prune	3.57%	1,573
Priority 2 Prune	9.34%	4,120
Routine Pruning		
Large Tree Routine Prune	34.11%	15,045
Small Tree Routine Prune	43.54%	19,204
Training Prune	3.62%	1,595

In addition to the management considerations, the Plan includes eight long-term goals to further support the community's vision for its urban forest (Table 2).

Table 2: Merced's Long-term Goals and Objectives

City of Merced Urban Forest Management Plan Long-term Goals			
Goals & Objectives	**Cost**	**Timeline**	**Priority**
Goal 1: Establish stable and predictable funding.			
Objective 1.1 Identify resources to fund tree maintenance.	$$$	1-5 Years	High
Goal 2: Efficiently maintain the community tree resource to manage risk, promote benefits, and enhance the health and resiliency of the urban forest.			
Objective 2.1 Establish a 5- to 7-year maintenance cycle to promote greater time management and efficiency.	$	8-Years	High
Objective 2.2 Create an Urban Forest Master Plan.	$$-$$$	10-Years	Low
Goal 3: Set a goal for canopy cover.			
Objective 3.1: Engage with community members to identify a canopy goal supported by the entire community.	$	1-5 Years	Moderate
Goal 4: Protect and preserve the M Street eucalyptus grove.			
Objective 4.1: Develop a specific plan for the M Street eucalyptus.	$	1-5 Years	High
Goal 5: Water trees, even during periods of drought.			
Objective 5.1 Educate and engage the community about irrigating City trees.	$	Ongoing	High
Goal 6: Identify solutions for wood utilization.			
Objective 6.1: Divert urban wood away from the landfill whenever possible.	$	Ongoing	Moderate
Goal 7: Develop mutually beneficial community partnerships.			
Objective 7.1 Provide opportunities for students and volunteers to enhance the community tree resource.	$	1-5 Years	Low-Moderate
Goal 8: Mitigate and reduce the risk of wildfire.			
Objective 8.1: Contribute to a fire safe community.	$	Ongoing	Low-Moderate

$ = less than $25,000 $$ = $25,000-$100,000 $$$ = more than $100,000

Introduction

Merced, situated approximately 110 miles southeast of San Francisco and 310 miles northwest of Los Angeles in California's Central Valley, has a population of approximately 86,750. Over the past nine years, the annualized growth rate was about 3.4%. In 2018, Merced County was the fastest growing county in the state (Miller and Sorci, 2018).

Merced has a semi-arid climate and experiences hot, dry summers and cool winters. The City is 171 feet above sea level and has an average of 262 days of sunshine a year (Climate in Merced, California, 2018). Annual precipitation averages 12 inches, mostly occurring from December through March. December is the coldest month, with an average low temperature of 36°F. Summers are typically hot and dry. July is the hottest month, with an average high temperature of 97°F (U.S. Climate Data, 2018).

The City of Merced was established in 1872, shortly after the formation of Merced County in 1855. As a result of the Central Pacific Railroad's arrival through the Central Valley, the City was selected as the county seat.

Merced County has long been one of the top agricultural producers in the country with a wide variety of crops grown. The City is ideally located to provide transportation for those crops because it sits at the nexus of two railroads and three highways. Traditionally, the community has relied on agribusiness and the Castle Air Force Base as the main drivers of the local economy. Following the closure of the Air Force Base, new diverse industry began to be located in the area and over the past twenty years the economy has expanded to include printing, boat construction, warehousing, distribution, and packaging. In 2005, the community and the University of California opened a campus. Local planning efforts are underway to accommodate campus development, which will eventually accommodate 25,000 students. The addition of the University has spurred another era of growth as the City moves into the twenty-first century.

Trees provide shade during the hot and dry moths of the summer.

In 1981, to promote their urban forest and to demonstrate the community's commitment to this resource, Merced became a Tree City USA. Notably, Merced was an early adopter of a tree ordinance that established rules and regulations considering trees and their care in 1954. By the late 1980s, approximately half of the cities in California had a tree ordinance in place (Bernhardt and Swiecki 1991). Merced's early adoption of a tree ordinance is an example of their commitment to urban forestry stewardship and interest in the long-term success of the urban forestry program. The first ordinance included regulations related to planting, pruning, and clearing utility lines; removing trees and permitting; harming trees; protecting trees during construction; assigning maintenance responsibilities; and defining penalties (all of which are still included in the current municipal code).

Merced has been a Tree City USA for 39 years.

In 2018, Merced contracted with Davey Resource Group, Inc. (DRG) to complete a tree inventory of public trees in parks, along streets and medians, and at City facilities. Following the inventory, DRG completed a resource analysis (2019) and a tree and land cover assessment (2019). These documents provided an overview of the current composition of the community tree resource, the expanse of tree canopy (both public and private trees), and the benefits provided by the urban forest resource.

The development of the Plan included a review of background documents, such as Merced's Vision 2030 General Plan and Municipal Code. Stakeholder interviews with the Department of Parks and Recreation, the Department of Public Works, Merced Garden Club, and Merced College, and the Tree Partners Foundation identified challenges and opportunities for managing Merced's community trees. With a changing climate, more frequent and longer periods of drought, and recent changes to water meters stakeholders indicated a need for additional education for residents on watering trees. Discussions with Parks and Recreation highlighted the need for increased species diversity to increase resistance to pests. Furthermore, Parks and Trees Divisions identified the need to address a backlog of outstanding service requests.

DRG reviewed maintenance tasks identified in the tree inventory and worked with Parks and Trees Divisions Staff to develop an 8-year Work Plan to prioritize management needs over the next eight years. The intent of the 8-year Work Plan is to set annual quotas for maintenance tasks to manage risks efficiently with available resources. The 8-year Work Plan can improve planning and

scheduling of maintenance tasks on daily basis, as well as, empower crews to address lesser priority tasks when time permits.

As part of the development of the Plan, a community meeting was held on Thursday, October 3rd, 2019, from 5:30 p.m. to 7:00 p.m. at the City Council Chambers to discuss the status and future of the City's urban forest. The meeting was advertised through social media, City emails, City website, and City newsletters. The meeting was attended by 10 community members, and therefore does not reflect the opinions of the community as a whole.

The meeting included a presentation about the community's urban forest and current program status. Following the presentation, attendees participated in a discussion and planning session to identify goals and objectives for the Urban Forest Management Plan. Attendees were asked to share their opinions on 1) preferred percent canopy cover in Merced, 2) locations for additional tree plantings, 3) management of M Street eucalyptus trees, 4) best incentives for increasing trees on private property, 5) education and outreach topics of interest, and 6) best opportunities for providing educational materials.

Community meeting participants were split between maintaining the current canopy cover of 12.1%, increasing it to 20%, and increasing it to 48% (potential canopy cover). In contrast, the majority of participants favored additional plantings along streets and in park strips and then opted for additional plantings at all other types of ground listed including parks, commercial areas, and parking lots.

Management options for the iconic eucalyptus trees on M Street were also discussed with community members, including the use of additional risk assessments, selective preservation of healthy trees, and the creation of an interpretive trail along M St, north of Yosemite Ave. Participants indicated their preference for replacement plantings of eucalyptus trees as trees are removed.

When asked about the best types of incentives to increase the number of trees on private property, participants overwhelmingly supported a water rebate/allocation over assistance with removal costs/replacements and tree vouchers.

Questions posed to participants about the best methods of outreach indicated that the majority of community members supported flyers/brochures. They also appreciated workshops as a form of outreach and education (but not social media). Community members were also most interested in educational topics focused on proper irrigation techniques and provide trees maintenance throughout their life.

Considering the feedback from community participants at the community meeting and challenges identified by stakeholders, eight long-term goals are also included in the Plan. These long-term goals are intended to be implemented beyond the 8-year Work Plan, which will support the overall health of the urban forest (both public and private trees) and the benefits this resource provides to the community.

Iconic eucalyptus grove on M Street.

Benefits of Trees

Trees in the urban forest work continuously to mitigate the effects of urbanization and development and protect and enhance lives within the community in many ways. Healthy trees are vigorous, producing more leaf surface and canopy cover area each year. The amount and distribution of leaf surface area are the driving force behind the urban forest's ability to produce services for the community (Clark et al, 1997). Services (i.e. benefits) include:

- Energy savings
- Air quality improvements
- Carbon dioxide reductions
- Stormwater management and water quality improvements
- Health, aesthetics, and socioeconomic benefits
- Wildlife benefits

Energy Savings

Urban trees and forests modify the climate and conserve energy in three principal ways:

- Producing shade for dwellings and hardscape reduces the energy needed to cool the building with air conditioning (Akbari et al, 1997)
- Tree canopies engage in evapotranspiration, which leads to the release of water vapor from tree canopies and cools the air (Lyle, 1996)
- Trees in dense arrangements may reduce mean wind speed and solar radiation below the top of the tree canopy by up to ~90% compared to open areas (Heisler and DeWalle, 1988)

An urban heat island is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities.

Trees reduce energy use in summer by cooling the surrounding areas and shading-built environments. Shade from trees reduces the amount of radiant energy absorbed and stored by hardscapes and other impervious surfaces, thereby reducing the urban heat island effect. Transpiration releases water vapor from tree canopies, which cools the surrounding area. Evapotranspiration, alone or in combination with shading, can help reduce peak summer temperatures by 2 to 9°F (1 to 5°C) (Huang et al, 1990). The energy saving potential of trees and other landscape vegetation can mitigate urban heat islands directly by shading heat-absorbing surfaces, and indirectly through evapotranspiration cooling (McPherson, 1994). Individual trees through transpiration have a cooling effect equivalent to two average household central air-conditioning units per day or 70 kWh for every 200 L of water transpired (Ellison et al, 2017). Studies on the urban heat island effect show that temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy cover and more vegetated suburban areas (Akbari et al, 1997).

Trees also reduce energy use in winter by mitigating heat loss. Trees reduce wind speeds by up to 50% and influence the movement of warm air and pollutants along streets and out of urban canyons. Urban canyons are streets flanked by dense blocks of buildings, which can

affect local conditions, including temperature, wind, and air quality. By reducing air movement into buildings and against conductive surfaces (e.g., glass and metal siding), trees reduce conductive heat loss from buildings, translating into potential annual heating savings of 25% (Heisler, 1986).

Three trees properly placed around a home can save $100 - $250 annually in energy costs. Shade from trees significantly mitigates the urban heat island effect: tree canopies provide surface temperature reductions on wall and roof surfaces of buildings ranging from 20-45°F and temperatures inside parked cars by 45°F. Reducing energy use has the added bonus of reducing carbon dioxide (CO_2) emissions from fossil fuel power plants.

Air Quality

Trees improve air quality in five fundamental ways:

- Lessening particulate matter (e.g., dust and smoke)
- Absorbing gaseous pollutants
- Providing shade and transpiration
- Reducing power plant emissions
- Increasing oxygen levels

Trees protect and improve air quality by intercepting particulate matter (PM_{10}), including dust, pollen, and smoke. The particulates are filtered and held in the tree canopy until precipitation rinses the particulates harmlessly to the ground. Trees absorb harmful gaseous pollutants like ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Shade and transpiration reduce the formation of O_3, which is created at higher temperatures. Scientists are now finding that some trees may absorb more volatile organic compounds (VOCs) than previously thought (Karl, 2010; Science Now, 2010). VOCs are carbon-based particles emitted from automobile exhaust, lawnmowers, and other human activities.

Trees protect and improve air quality.

Carbon Dioxide Reduction

As environmental awareness continues to increase, governments are paying particular attention to global warming and the effects of greenhouse gas (GHG) emissions. As energy from the sun (sunlight) strikes the Earth's surface, it is reflected into space as infrared radiation (heat). Greenhouse gases absorb some of this infrared radiation and trap this heat in the atmosphere, increasing the temperature of the Earth's surface. Many chemical compounds in the Earth's atmosphere act as GHGs, including methane (CH_4), nitrous oxide (N_2O), carbon dioxide (CO_2), water vapor, and human-made gases/ aerosols. As GHGs increase, the amount of energy radiated back into space is reduced and more heat is trapped in the atmosphere. An increase in the average temperature of the earth may result in changes in weather, sea levels, and land use patterns, commonly referred to as "climate change." In the last 150-years, since large-scale industrialization began, the levels of some GHGs, including CO_2, have increased by 25% (U.S. Energy Information Administration).

California's Global Warming Solutions Act (AB 32) passed in 2006 set the 2020 GHG emissions reduction goal into law. In December 2007, the California Air Resources Board (ARB) approved the 2020 emission limit of 427 million metric tons of carbon dioxide equivalent (CO_2). As of 2007, regulations require that the largest industrial sources of GHG must report and verify their emissions. In 2011, the ARB adopted the cap-and-trade regulation. Under a cap-and-trade system, an upper limit (or cap) is placed on GHG emissions. This cap can be applied to any source, industry, region, or other jurisdictional level (e.g., state, national, or global). Regulated entities are required to either reduce emissions to required limits or purchase (trade) emission offsets to meet the cap. In 2011, the ARB approved four offset protocols for issuing carbon credits under cap-and-trade, including the Forest Offset Protocol (ARB, 2011). This Protocol recognizes the key role forests play in fighting climate change. The United States Department of Agriculture Forest Service Urban Ecosystems and Social Dynamics Program (UEP) recently led the development of an Urban Forest Project Reporting Protocol.

The Protocol, which incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard (VCS), establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides urban forest managers in developing tree planting and stewardship projects that could be registered for GHG reduction credits (offsets). The Protocol can be applied to urban tree planting projects within municipalities, campuses, and utility service areas anywhere in the United States. Trees and forests reduce atmospheric carbon dioxide CO_2 in two ways:

- Directly, through growth and carbon sequestration
- Indirectly, by lowering the demand for energy

Trees and forests directly reduce CO_2 in the atmosphere through growth and sequestration of CO_2 in woody and foliar biomass. Indirectly, trees and forests reduce CO_2 by lowering the demand for energy and reducing CO_2 emissions from the consumption of natural gas and the generation of electric power.

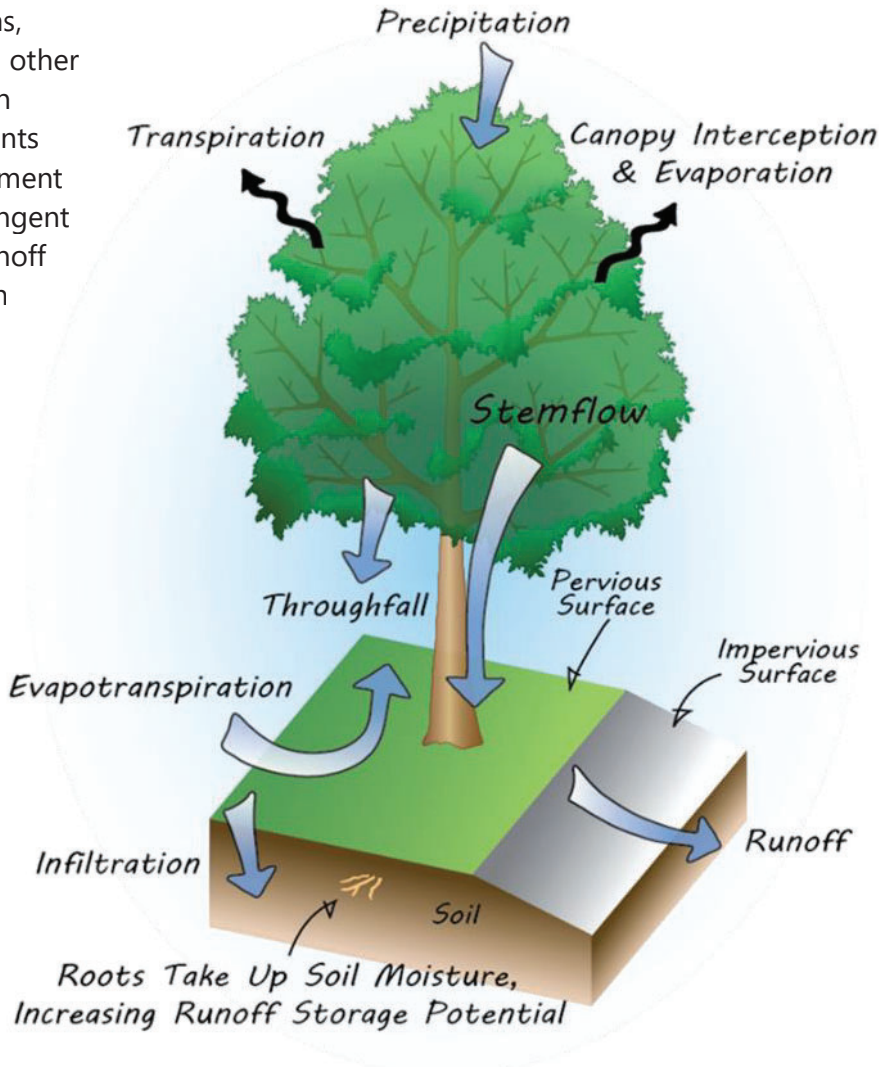
Trees and forests directly reduce CO_2 in the atmosphere through growth and sequestration of CO_2 in woody and foliar biomass.

Stormwater Management & Water Quality

Trees and forests improve and protect the quality of surface waters, such as creeks and rivers, by reducing the impacts of stormwater runoff through:

- Interception
- Increasing soil capacity and rate of infiltration
- Reducing soil erosion

Trees intercept rainfall in their canopy, which acts as a mini-reservoir (Xiao et al, 1998). During storm events, this interception reduces and slows runoff. In addition to catching stormwater, canopy interception lessens the impact of raindrops on barren soils. Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and snowmelt (McPherson et al, 2002). Each of these processes greatly reduces the flow and volume of stormwater runoff, avoiding erosion and preventing sediments and other pollutants from entering streams, rivers, and lakes. Urban stormwater runoff is a major source of pollution for surface waters and riparian areas, threatening aquatic and other wildlife as well as human populations. Requirements for stormwater management are becoming more stringent and costly. Reducing runoff and incorporating urban trees in stormwater management planning has the added benefit of reducing the cost of stormwater management, including the expense of constructing new facilities necessary to detain and control stormwater as well as the cost of treatment to remove sediment and other pollutants.



Health & Socioeconomic

Exposure to nature, including trees, has a positive impact on human health and wellness through improvements in mental and physical health, reductions in crime, and academic success.

Exposure to nature, including trees, has a positive impact on human health and wellness.

A study of individuals living in 28 identical high-rise apartment units found residents who live near green spaces had a stronger sense of community and improved mental health, coped better with stress and hardship, and managed problems more effectively than those living away from green space (Kuo, 2001). In a greener environment, people report fewer health complaints, more often rate themselves as being in good health, and having better mental health (Sherer, 2003). Other research has revealed lower incidence of depressive symptoms in neighborhoods with greater access to green space (Jennings et al, 2016).

Merced is susceptible to heat waves, which cause the most deaths worldwide out of any weather-related-natural disaster (estimated 12,000 deaths worldwide annually). Trees shade impervious surfaces and prevent the sun's rays from hitting them, thus reducing heat storage

and later release, which contribute to the urban heat island effect. Tall trees that create a large shaded area are more useful than short vegetation. Trees also contribute to cooler temperatures through transpiration, increasing latent heat storage (the sun's energy goes to converting water from its liquid to vapor form), rather than increasing air temperature (sensible heat). According to a study conducted by the Nature Conservancy, it is estimated that trees have the potential to reduce summer maximum air temperatures by 0.9 to 3.6° F (2016). Trees help to address public health concerns for both heat and air quality. Globally, an annual investment of $100 million in planting and maintenance costs would give an additional 77 million people a 1° C (1.8° F) reduction in maximum temperatures on hot days (McDonald et al, 2016).

A number of studies have examined the relationship between urban forests and crime rates. Park-like surroundings increase neighborhood safety by relieving mental fatigue and feelings of violence and aggression (Planning the Urban Forest: Ecology, Economy, and Community Development, 2009). In addition, landscaping around buildings leads to fewer crimes relating to property and violence (Kuo and Sullivan, 2001). Landscape vegetation can mitigate irritability, inattentiveness, and decreased control over impulses, all of which are well established psychological precursors to violence.

Residents who live near outdoor greenery tend to be more familiar with nearby neighbors, socialize more with them, and express greater feelings of community and safety than residents lacking nearby green spaces (Planning the Urban Forest: Ecology, Economy, and Community Development, 2009). Public housing residents reported 25% fewer domestic crimes when landscapes and trees were planted near their homes (Kuo, 2001). Two studies (one in New Haven, CT and the other in Baltimore City and County, MD) found a correlation between increased tree coverage and decreased crime rates, even after adjusting for a number of other variables, such as median household income, level of education, and rented versus owner-occupied housing in the neighborhoods that were studied (Gilstad-Hayden et al, 2015; Troy et al, 2012).

A 2010 study investigated the effects of exposure to green space at schools on the academic success of students at 101 public high schools in southern Michigan (Matsuoka, 2010). The study found a positive correlation between exposure to nature and student success measured by standardized testing, graduation rate, percentage of students planning to go to college, and the rate of criminal behavior. This trend persisted after controlling for factors such as socioeconomic status and race or ethnicity. Conversely, views of buildings and landscapes that lacked natural features were negatively associated with student performance.

Wildlife

Trees provide important habitat for birds, insects (including bees), and other animal species. Their greatest contributions include:

- Preservation and optimization of wildlife habitat
- Natural corridors for increased movement and dispersal

Trees and forest lands provide critical habitat (for foraging, nesting, spawning, etc.) for mammals, birds, fish, and other aquatic species. Trees can offer pollinators a valuable source of flowering plants. By including an array of flowering trees that provide pollen and nectar in

the urban forest, bees are provided with additional food sources. Increasing tree species diversity and richness contributes to greater numbers of bird species among urban bird communities (Pena et al, 2017). Wooded streets potentially function as movement corridors, allowing certain species, particularly those feeding on the ground and breeding in trees or tree holes, to fare well by supporting alternative habitat for feeding and nesting (Fernandez-Juricic, 2000). Greater tree density also contributes to bat activity in urban environments and improves outcomes for birds and bats (Threlfall et al, 2016).

Restoration of urban riparian corridors and their linkages to surrounding natural areas have facilitated the movement of wildlife and dispersal of flora (Dwyer et al, 1992). Usually habitat creation and enhancement increase biodiversity and complement many other beneficial functions of the urban forest. These findings indicate an urgent need for conservation and restoration measures to improve landscape connectivity, which will reduce extinction rates and help maintain ecosystem services (Haddad et al, 2015).

Wild turkeys in the shade of a tree.

Calculating Tree Benefits

Communities can calculate the benefits of their urban forest by using a complete inventory or sample data in conjunction with the USDA Forest Service **i-Tree** software tools (itreetools.org). This open-source, state-of-the-art, peer-reviewed software suite considers regional environmental data and costs to quantify the ecosystem services unique to a given urban forest resource.

Individuals can calculate the benefits of trees to their property by using **i-Tree** *Design* (www.itreetools.org/design).

i-Tree Design

Calculate My Tree Benefits

Urban Forest Resource

The development of the Plan included a land cover assessment. Tree canopy is the layer of leaves, branches, and stems of trees and other woody plants that cover the ground when viewed from above. Understanding the location and extent of tree canopy is critical to developing and implementing sound management strategies that will promote the smart growth and resiliency of Merced's urban forest and the invaluable services it provides. The land cover assessment provides a bird's-eye-view of the entire urban forest and includes consideration of tree canopy along with other primary land cover, including impervious surface, bare soils, and water. This information helps managers better understand tree canopy in relation to other geospatial data, including:

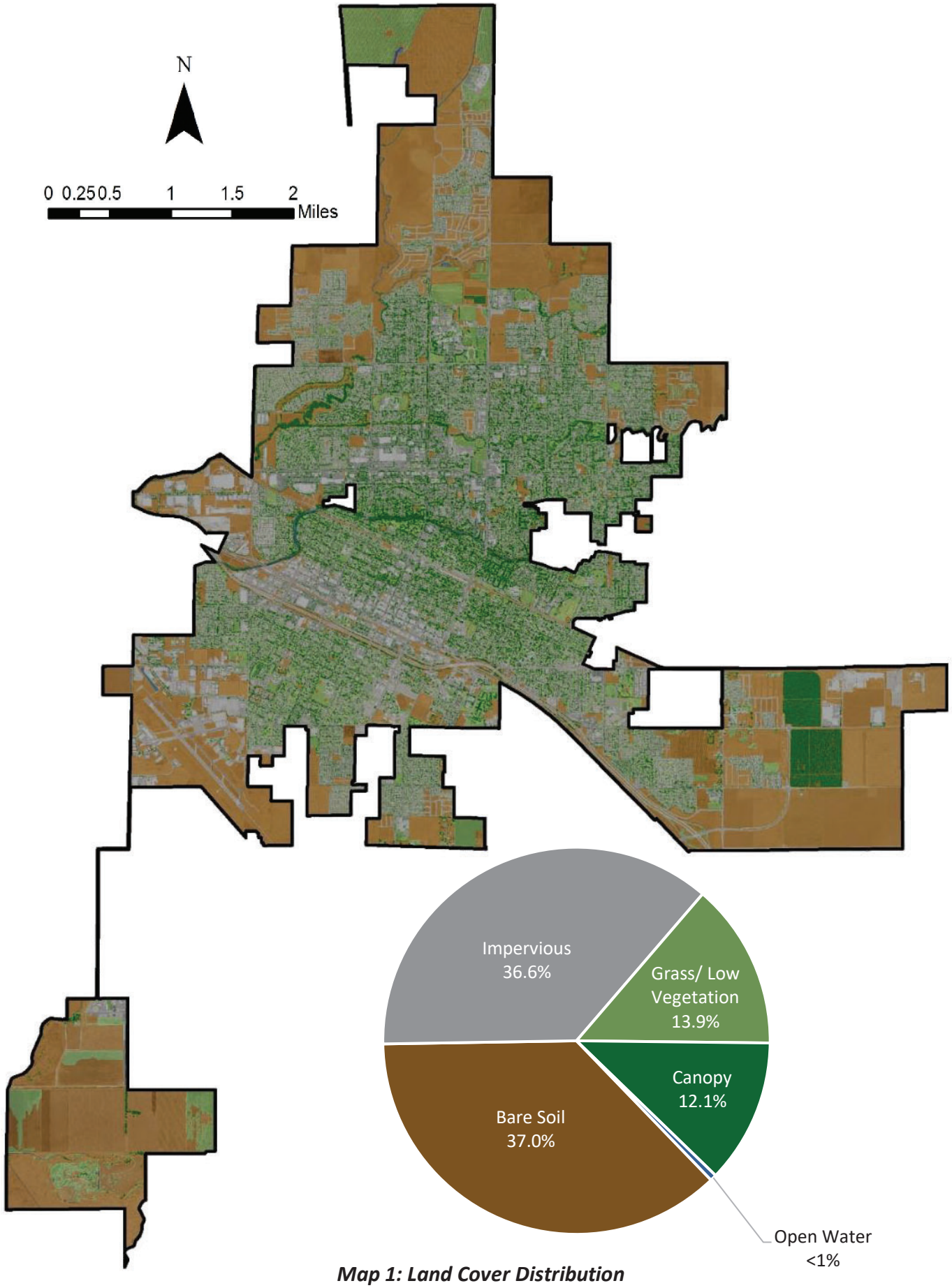
- Distribution of tree canopy within the community
- Geopolitical patterns in canopy distribution
- Identification of potential planting areas

The analysis does not distinguish between trees on public and private property since the benefits of trees extend beyond property lines. The information can be used by urban forest managers to explore tree canopy in conjunction with other available metrics, including geography, land use, and community demographics. This information also establishes a baseline for assessing future change.

Land Cover Summary

The City of Merced encompasses 23.3 square miles (14,941 acres), with 1,803 acres of tree canopy or 12.1% canopy cover. To date public and private trees have stored 547 million tons of carbon (CO_2) in woody and foliar biomass, valued at over $8.7 million. Excluding impervious surface (5,462 acres) and open water (79.3 acres), Merced contains approximately 8.4 square miles (5,369 acres) of land which has the potential to support tree canopy. The following characterizes land cover in Merced:

- 36.6% (5,462 acres) of impervious surface, including roads and structures
- 37.0% (5,523 acres) of bare soil
- 13.9% (2,075 acres) of grass/low-lying vegetation
- 104.1 acres of tree canopy in parks, an average of 28.2% canopy cover
- 172,776 pounds of air pollutants removed annually, including carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and particulate matter (PM_{10}), valued at $252,791
- 3.5 million gallons of stormwater runoff reduced annually, valued at $40,798
- 27.7 million tons of CO_2 removed annually, valued at $442,201
- 48% canopy potential (public and private trees)



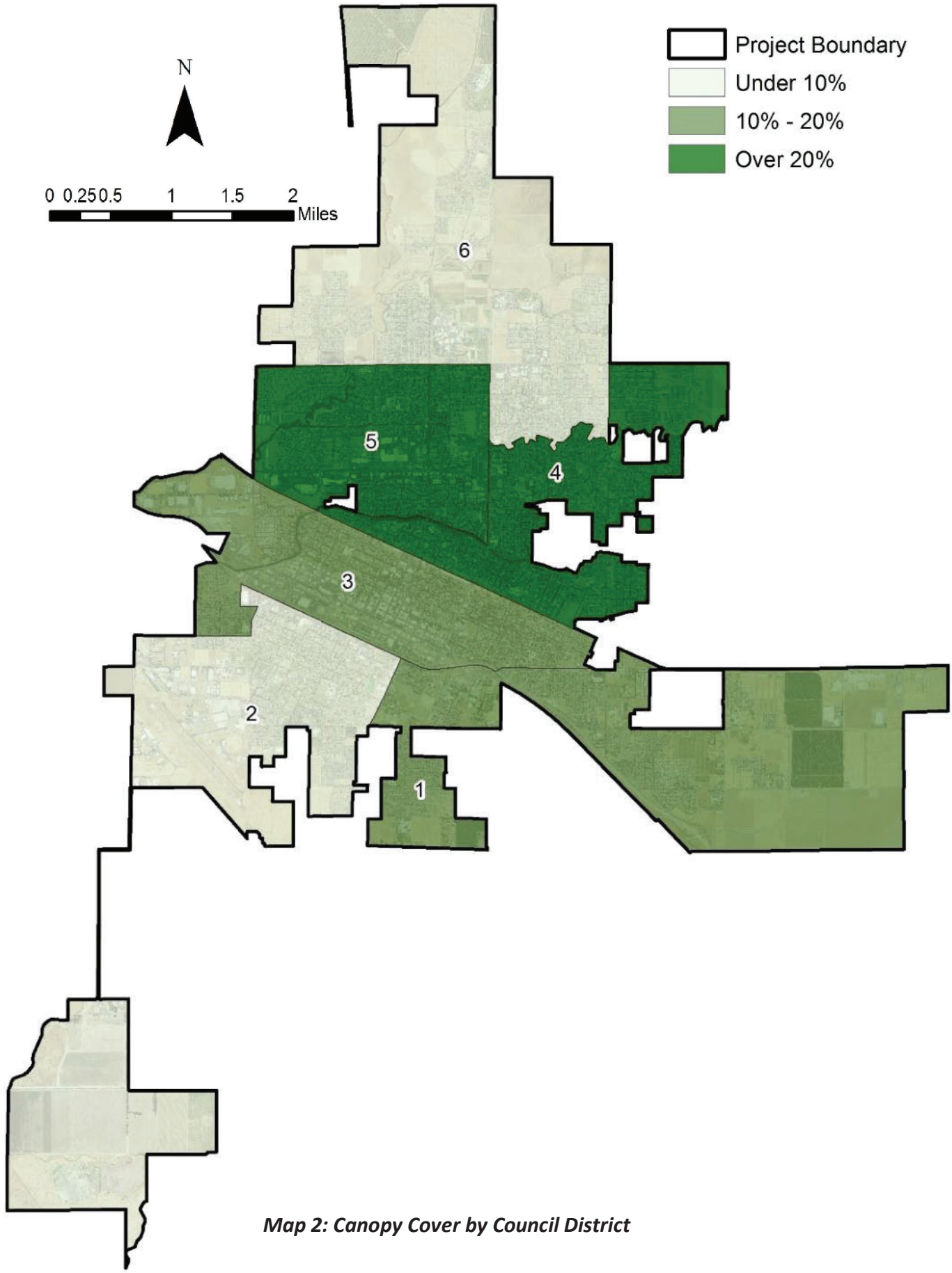
Map 1: Land Cover Distribution

Tree Canopy by Council District

Understanding the spatial distribution of canopy across the community can help inform future planting plans and canopy goals. Merced is divided into six council districts (Table 3). District 4 (1,627 acres) has the highest canopy cover at 23.6% and the greatest amount of tree canopy (3893.7 acres). District 2 (3,240 acres) has the lowest canopy cover at 5.7% and the greatest amount of impervious surface (1,073.2 acres). However, the analysis estimates that District 2 has approximately 902 acres of available planting space and the potential to reach 33.5% canopy cover.

Table 3: Combined Public and Private Canopy Cover by Council District

Council District	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/ Low Veg. Acres	Bare Soil Acres	Open Water Acres	Potential Plantable Acres	Potential Canopy %
1	3,111	338.62	**10.88**	957.47	301.07	1,511.22	2.70	1,442.43	57.25
2	3,240	183.73	**5.67**	864.92	443.80	1,732.27	15.51	901.82	33.50
3	1,854	286.38	**15.45**	1,073.24	243.60	231.54	18.82	468.30	40.71
4	1,627	383.75	**23.58**	704.08	310.34	215.84	13.14	490.64	53.74
5	1,544	332.86	**21.55**	841.86	218.65	149.08	2.03	334.44	43.21
6	3,563	277.12	**7.78**	1,019.98	557.20	1,681.74	27.11	1,729.84	56.32



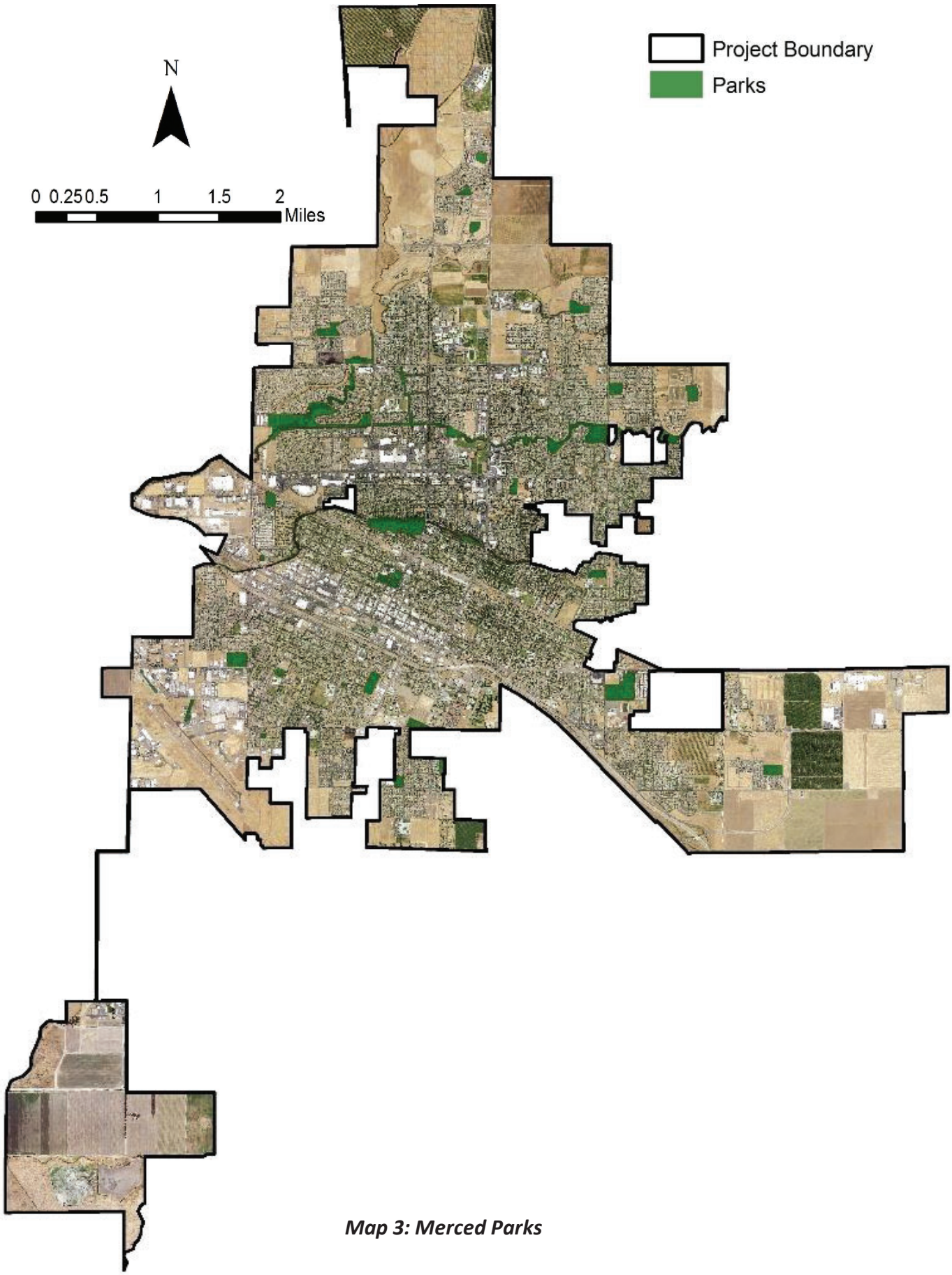
Map 2: Canopy Cover by Council District

Tree Canopy by Parks within City Limits

Merced has 46 parks, open space, and bikeways within city limits that encompass a total of 342 acres (Map 3). Together, these locations include 104 acres of tree canopy and an average canopy cover of 30.9%. Of Merced's top 10 largest parks, Santa Fe Strip has the highest level of canopy cover at 71.8%. Merced's largest park, Fahrens Park (47.6 acres) has 37.5% canopy cover (17.8 acres). Black Rascal Creek Bikeway/Park has the most acres of canopy with 22.7 total acres (50%), All of Merced's parks have the potential to support at least 50% canopy cover (Table 4).

Table 4: Canopy Cover by Merced's Top 10 Largest Parks within City Limits

Park Name	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/ Low Veg. Acres	Bare Soil Acres	Open Water Acres	Preferred Plantable Acres	Potential Canopy %
Fahrens Park	47.61	17.83	**37.45**	1.03	2.50	26.25	0.00	24.53	88.95
Black Rascal Creek Bikeway/Park	45.38	22.67	**49.96**	2.34	8.05	9.71	2.61	17.73	89.04
Applegate Park	32.12	14.15	**44.05**	4.07	10.60	1.14	2.16	11.75	80.64
Rahilly Park	28.02	14.01	**49.99**	0.83	12.02	0.24	0.92	12.27	93.78
Joe Herb Park	25.55	4.03	**15.76**	3.65	16.19	1.69	0.00	9.24	51.93
Richard Bernasconi Park	17.92	2.70	**15.04**	1.80	5.44	6.85	1.14	8.26	61.15
Youth Sports Complex	12.35	0.89	**7.22**	1.59	7.94	1.92	0.00	0.47	11.06
Courthouse Square Park	9.72	4.26	**43.79**	2.79	2.68	0.00	0.00	2.68	71.31
Santa Fe Strip Park	9.08	6.52	**71.78**	0.31	0.53	1.46	0.26	1.98	93.61
Davenport Park	8.85	0.85	**9.59**	0.63	5.62	1.45	0.30	4.70	62.73
All Other Parks Total	105.55	16.27	**15.41**	16.32	50.33	21.33	1.30	58.06	70.41
All Parks Total	**342.17**	**104.17**	**30.44**	**35.36**	**121.90**	**72.04**	**8.70**	**151.68**	**74.77**



Map 3: Merced Parks

Tree Canopy by Parking Lots

The amount of shade in a parking lot can have a big impact on reducing summertime temperatures. Unshaded asphalt surfaces are one of the greatest contributors to urban heat islands and can increase the overall ambient temperature of a community by as much as 9°F compared to air temperatures over adjacent rural areas (EPA). In warmer months, the difference in surface temperature between asphalt and vegetated (shaded) areas can be greater than 40°F. The composition and lack of solar reflection from an asphalt surface allows it to absorb and store greater amounts of solar energy (heat). Since asphalt stores heat so well, it remains warmer and releases stored heat long after the sun goes down (NASA Facts, 2000).

In addition to urban heat island effects, the cabin temperature of a car parked in full sun can quickly reach 160 degrees and dark surfaces can reach temperatures of 180-200 degrees (NOAA, 2012). Parking in the shade reduces temperatures and the emissions from parked vehicles, including nitrogen oxides (NO_2) and hydrocarbons, which are precursors to ozone (O_3) formation.

DRG analyzed 276 public and private parking lots in Merced (2012 GIS layer) for tree canopy cover. The parking lots cover a total of 461.5 acres and include 64.1 acres of tree canopy for an average canopy cover of 11.0%. Canopy cover ranges from 0% to 48%. The largest parking lot, Merced Marketplace, has 22.9 acres of tree canopy and 17.9% canopy cover. The smallest parking lot is less than an acre with 0% canopy cover. The maximum potential canopy cover for all parking lots is 17.6%.

Merced Marketplace has the highest canopy cover among the top 10 largest parking lots that were evaluated[1].

[1] Google Earth V 7.3.2.5776. (16 May 2018). Merced, CA. 37˚19'03.50" N 120˚ 29'49.80" W. eye alt 3281 ft. Google 2019. Retrieved 13 January 2020.

Parking in the shade reduces temperatures and the emissions from parked vehicles.

Priority Planting

To identify and prioritize planting potential, DRG assessed environmental features. It could be assumed that all pervious areas, including grass, shrubs, low-lying vegetation, and bare soil (7,598 acres) are potential tree planting locations. Realistically, not all of these areas are suitable for planting additional trees due to existing or intended site use (e.g., agricultural fields, sports fields, golf courses), site conditions, or other restrictions. Potential plantable areas are determined by excluding pervious areas that are unsuitable for planting and including impervious areas where trees could feasibly be added, such as in parking lot islands, along sidewalks, and near road edges.

The priority planting assessment considered site design and environmental factors, including proximity to hardscape, canopy fragmentation, soil permeability, slope, and soil erosion factors to prioritize potential planting sites on both public and private property for the greatest return on investment. The analysis identified 5,361 acres were additional trees should be considered, including:

- Very High –95 acres
- High –246 acres
- Moderate –384 acres
- Low –431 acres
- Very Low –4,204 acres

This analysis provides a snapshot of current conditions, where some existing young trees may not be fully accounted for. The land cover assessment prioritized potential planting areas with GIS remote sensing. Site visits are necessary to determine suitability and the actual number and location of planting sites.

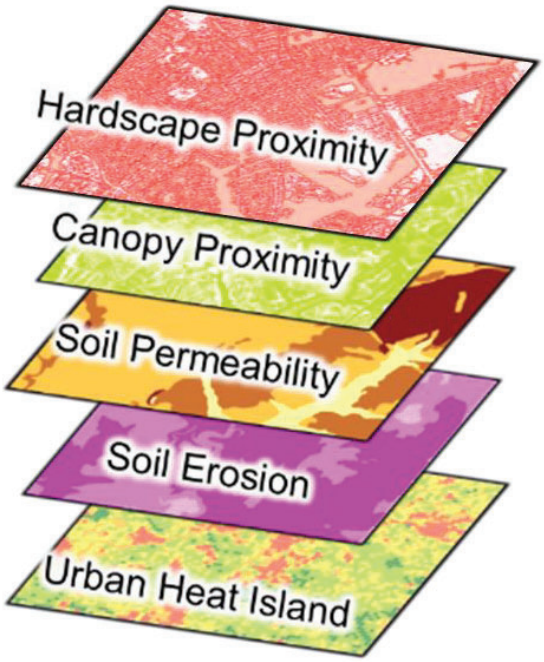
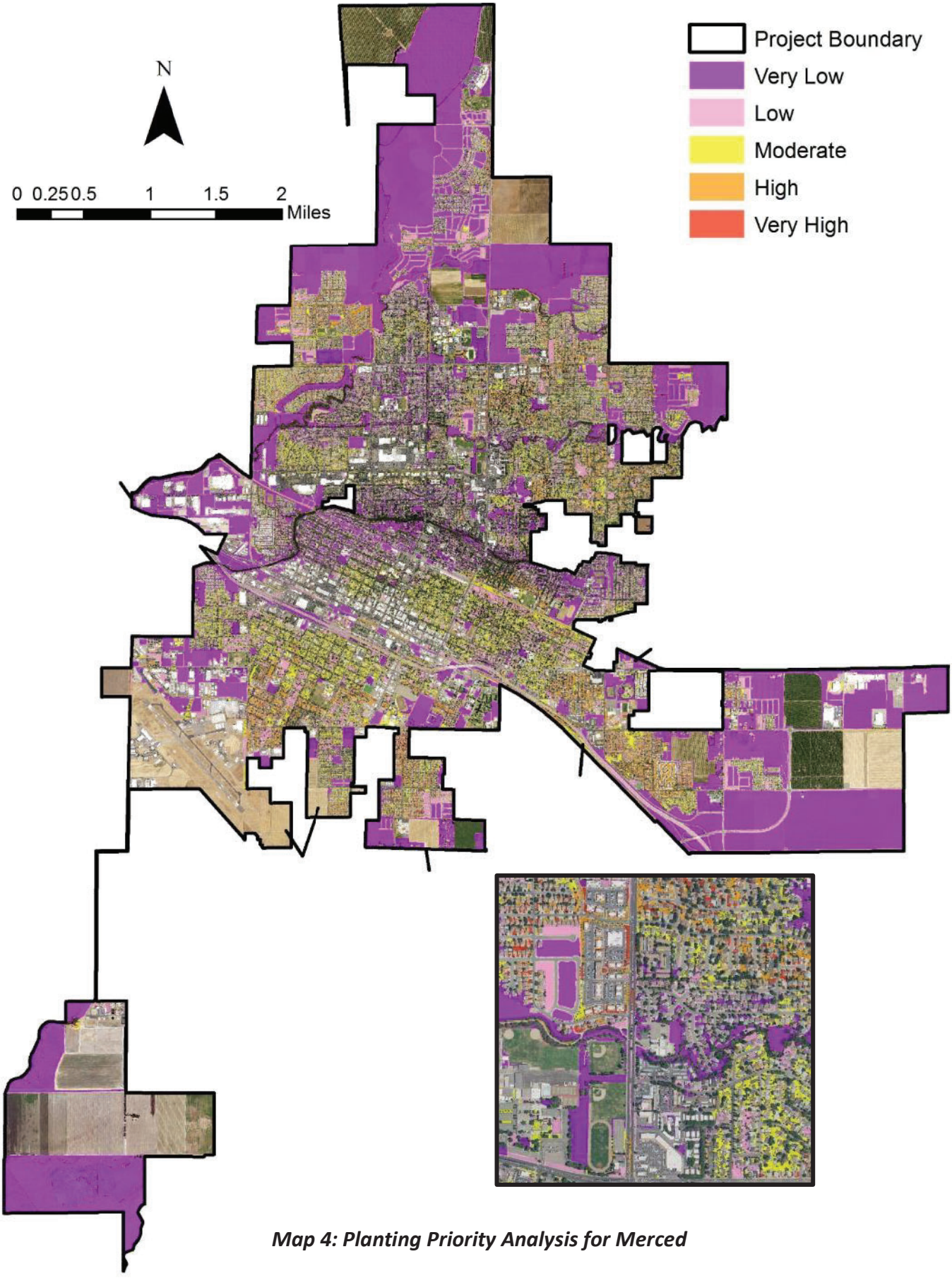


Figure 1: Data Layers that Create Priority Planting Map



Map 4: Planting Priority Analysis for Merced

Community Tree Resource

Community trees (publicly managed trees along City streets, in City parks, and around City facilities) play a vital role in Merced. They provide numerous tangible and intangible benefits to residents, visitors, and neighboring communities. The City of Merced recognizes that public trees are a valued resource, a critical component of the urban infrastructure, and part of the City's identity.

To support the preservation and management of community trees, the City contracted Davey Resource Group, Inc. (DRG) in 2018 to conduct a complete inventory. Completed in 2019, the inventory collected data on 44,107 trees and 11,010 available planting sites (including 1,048 stumps) in parks, on streets, and at City facilities. Data collection included species, size, condition, maintenance needs, and geographic location.

DRG used this data in conjunction with **i-Tree** *Streets* benefit-cost modeling software to develop a detailed and quantified analysis of the current structure, function, benefits, and value of the resource.

City trees, like those found in Elmer Murchie Park, provide numerous tangible and intangible benefits to residents, visitors, and neighboring communities.

Structure

A structural analysis is the first step towards understanding the benefits provided by these trees as well as their management needs. As of 2019, Merced's community tree resource includes 44,107 trees (6,830 park trees and 37,277 street trees) and 220 unique species. Considering species composition and diversity, relative age distribution (diameter at breast height, DBH), condition, canopy coverage, and replacement value, DRG determined that the following information characterizes the community tree resource:

- Chinese pistache (*Pistacia chinensis*, 16.0%), Arizona ash (*Fraxinus velutina*, 10.5%), gum (*Eucalyptus spp.,* 6.8%), and Raywood ash (*Fraxinus angustifolia*, 5.3%) are the most predominant species and represent nearly 39% of the overall resource.
- 58% of trees are less than 12 inches in diameter, indicating an established resource, with 8.5% of trees are larger than 24 inches in diameter
- 87.8% of trees are in fair or better condition
- 1.1 square miles (705.6 acres) of tree canopy and 4.7% of canopy cover in Merced
- Replacement of the 44,107 park and street trees with trees of equivalent size, species, and condition, would cost more than $117 million
- Storing 48,067 tons of carbon (CO_2) in woody and foliar biomass

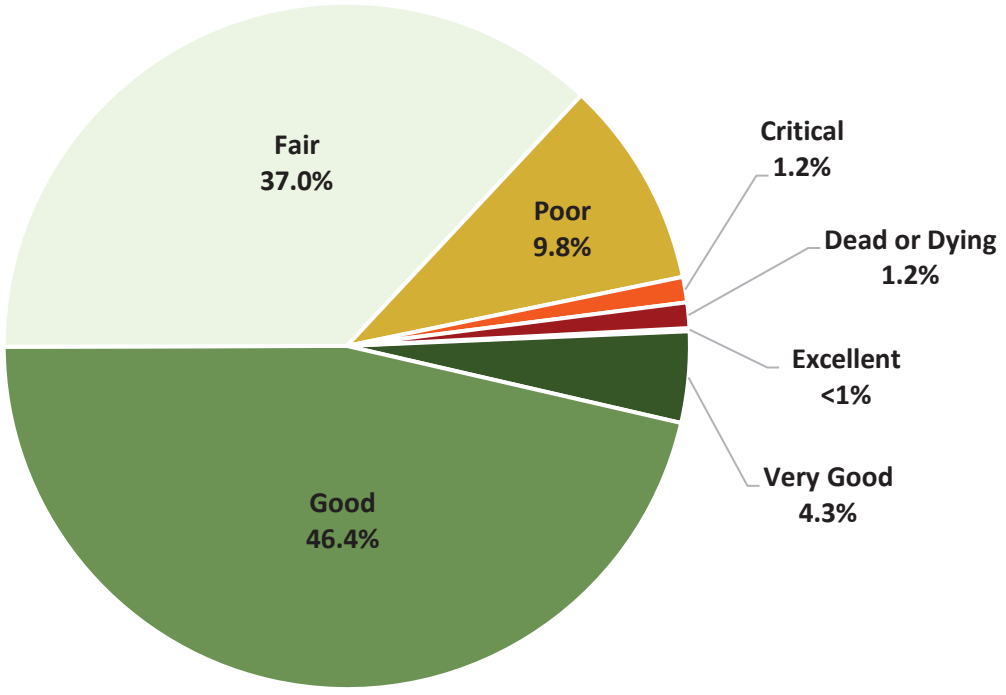


Figure 2: Condition of Community Trees

Species Diversity

Maintaining diversity in a public tree resource is important. Dominance of any single species or genus can have detrimental consequences if subject to stressful events. The widely recognized 10-20-30 rule recommends an urban tree population should consist of no more than 10% of any one species, 20% of any one genus, and 30% of any one family (Clark et al, 1997). The rule encourages greater genetic diversity, and thus, greater resilience.

At the species level, Chinese pistache (*Pistacia chinensis,* 16%) and Arizona ash (*Fraxinus velutina,* 10.5%) exceed the diversity standard (Figure 3). At the genus level, ash (*Fraxinus,* 22.8%) is exceeding the recommendation. Future plantings should focus on increasing diversity and reducing reliance on overused species.

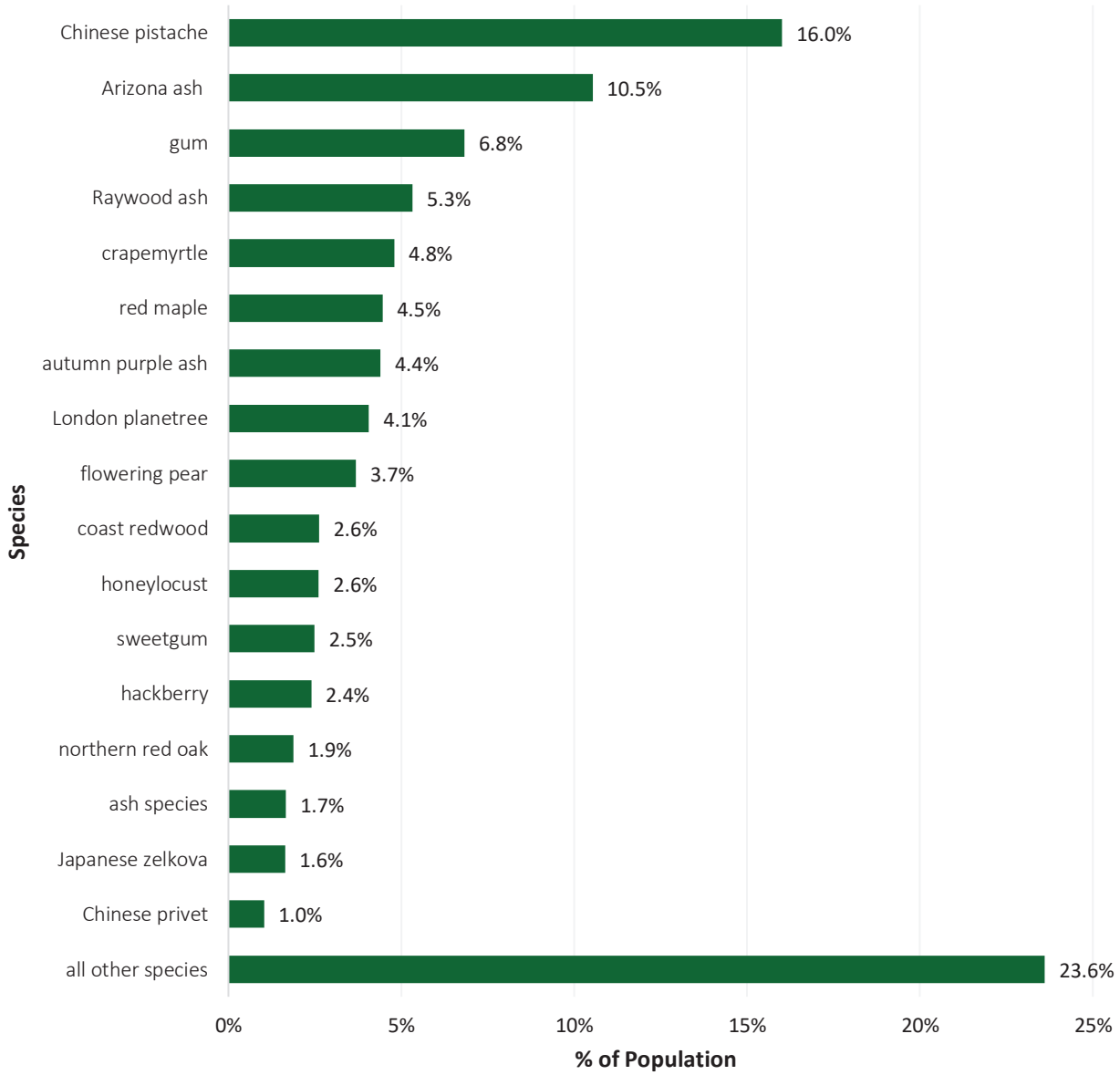


Figure 3: Most Prevalent Species of Community Trees in Merced

Benefits

Annually, community trees provide nearly $4.5 million in benefits to Merced. These benefits include:

- $1.2 million in energy use reduction (electricity and natural gas) through shading and climate effects
- $473,341 in air quality improvements
- $244,802 in intercepted stormwater
- $110,770 in additional sequestered atmospheric carbon (CO_2)
- $2.5 million in increased property values and other socioeconomic benefits

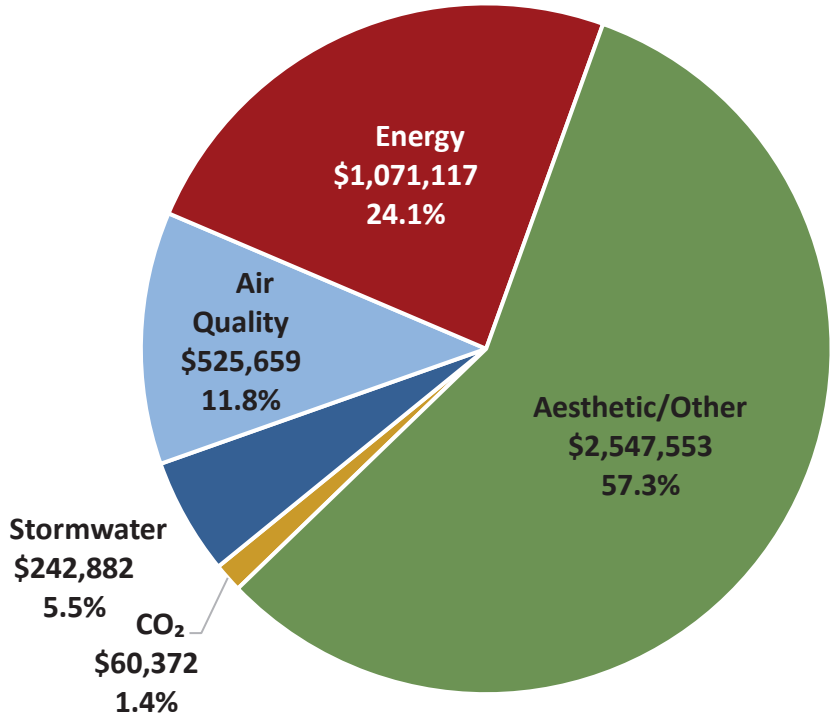


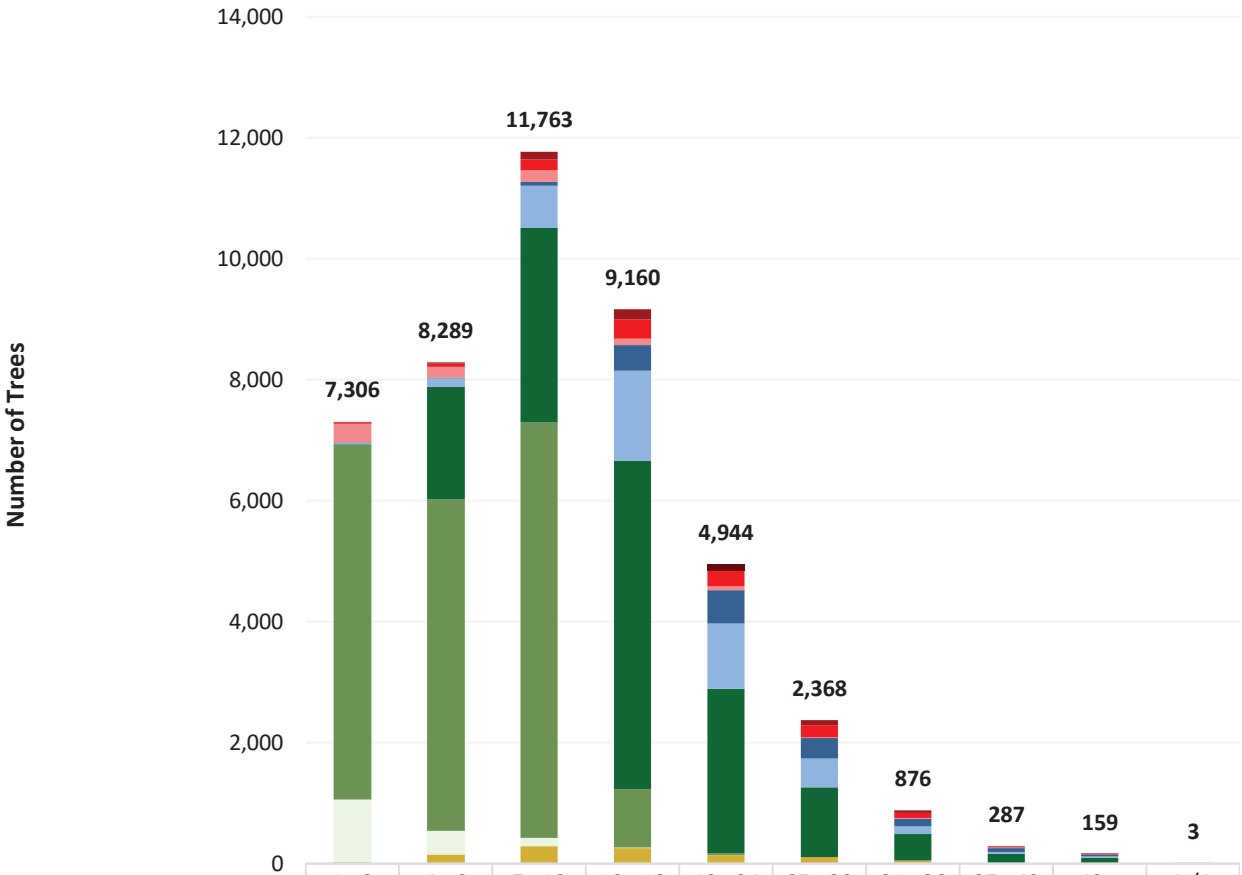
Figure 4: Annual Benefits of Community Trees in Merced

Return on Investment

The estimated annual budget to manage the community tree resource in Merced is over $1.2 million. The net annual benefit (benefits minus investment) provided by the community tree resource to the City is over $3.2 million. Therefore, Merced is currently receiving $3.67 in benefits for every $1 invested in community trees. The average net benefit for an individual tree in Merced is $73.34.

Inventory Summary

Merced's community tree resource includes 44,107 trees, 9,962 planting sites, and 1,048 stumps. Trees were assigned a primary maintenance task (pruning, removal, and stump grinding) (Appendix C). In total, 2,570 trees require removal, whereas most trees require pruning maintenance (Figure 5).



	1 - 3	4 - 6	7 - 12	13 - 18	19 - 24	25 - 30	31 - 36	37 - 42	43 +	N/A
Priority 1 Removal	13	20	118	167	106	76	34	10	2	0
Priority 2 Removal	21	57	184	314	255	204	88	13	3	0
Priority 3 Removal	311	181	194	108	58	16	12	5	0	0
Priority 1 Prune	1	4	59	422	551	336	126	63	31	2
Priority 2 Prune	30	146	697	1,490	1,082	479	130	37	29	0
Large Tree Routine Prune	4	1,859	3,223	5,428	2,725	1,147	434	144	81	0
Small Tree Routine Prune	5,863	5,478	6,863	967	27	2	2	0	1	1
Training Prune	1,038	389	134	11	1	0	0	0	0	0
Stump Removal	25	155	291	253	139	108	50	15	12	0
Totals	7,306	8,289	11,763	9,160	4,944	2,368	876	287	159	3

Diameter at Breast Height Class (Inches)

Figure 5: Summary of Maintenance Priorities

Removals

Priority 1 Removal

There are 546 trees that were identified as priority 1 removal (Table 5). Trees categorized as priority 1 removals have defects that cannot be cost-effectively or practically treated. The majority of the trees in this category have a high percentage of dead crown and pose an elevated risk of failure. This category also includes trees that are a potential danger to persons or property and that may cause a potential liability. Large dead and dying trees that have a high liability risks are also included in this category.

Table 5: Priority 1 Removals by Diameter (DBH Class)

Priority 1 Removal	
DBH Class	Number of Trees
1 - 3	13
4 - 6	20
7 - 12	118
13 - 18	167
19 - 24	106
25 - 30	76
31 - 36	34
37 - 42	10
43 +	2
Total	**546**

Priority 2 Removal

Merced has 1,139 trees designated as priority 2 removal. These trees, like the priority 1 removals, should be removed; however, are classified as priority 2 because they do not pose risks as significant as the priority 1 trees.

Table 6: Priority 2 Removals by Diameter (DBH Class)

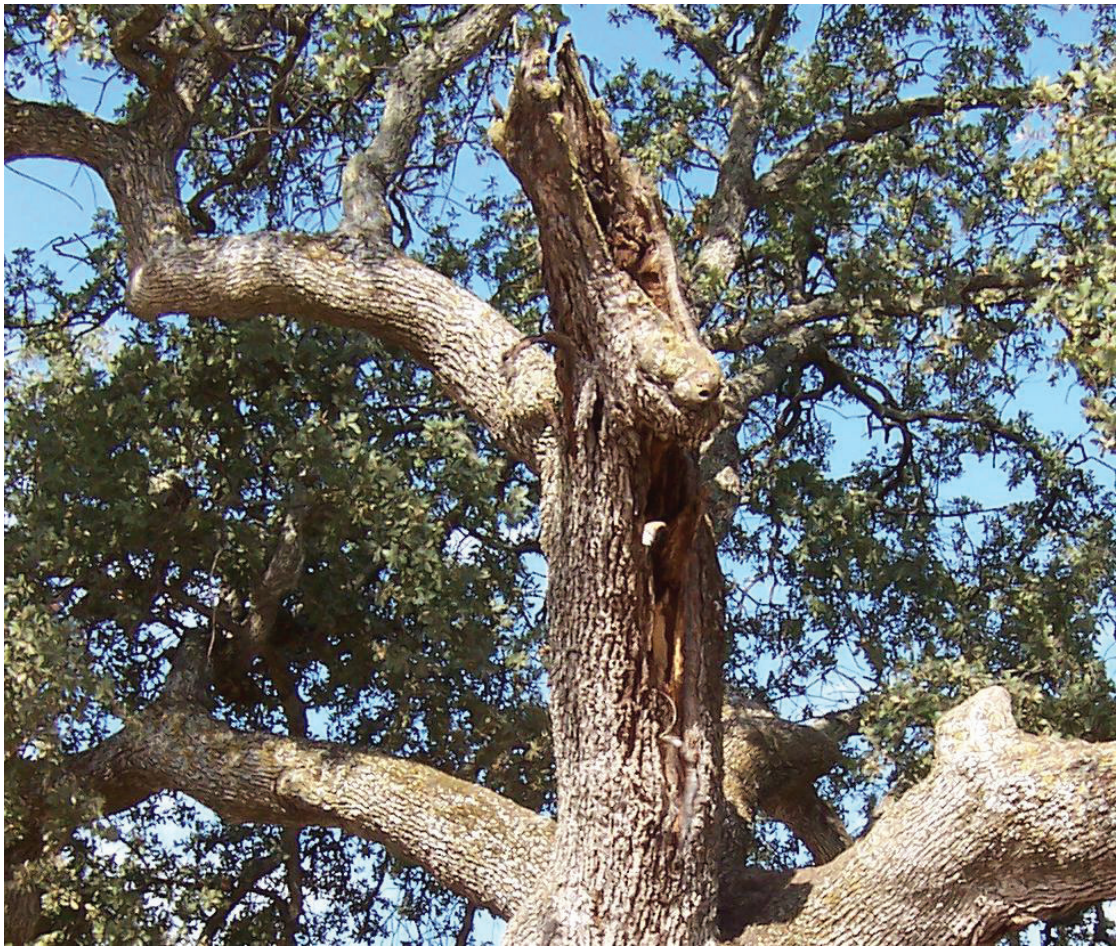
Priority 2 Removal	
DBH Class	Number of Trees
1 - 3	21
4 - 6	57
7 - 12	184
13 - 18	314
19 - 24	255
25 - 30	204
31 - 36	88
37 - 42	13
43 +	3
Total	**1,139**

Priority 3 Removal

There are 885 trees that are recommended for priority 3 removal. Trees with this designation should also be removed but have a lesser prioritization compared to the other removal categories as these trees pose minimal liability to persons or property.

Table 7: Priority 3 Removals by Diameter (DBH Class)

Priority 3 Removal	
DBH Class	**Number of Trees**
1 - 3	311
4 - 6	181
7 - 12	194
13 - 18	108
19 - 24	58
25 - 30	16
31 - 36	12
37 - 42	5
43 +	—
Total	**885**



Priority 1 removals have defects such as extensive internal decay that cannot be cost-effectively or practically treated.

Pruning

Priority 1 Prune

In total, 1,595 trees were recommended for a priority 1 prune. Trees that are recommended for trimming to remove hazardous deadwood, hangers, or broken branches. These trees have broken or hanging limbs, hazardous deadwood, and dead, dying, or diseased limbs or leaders greater than 4-inches in diameter.

Table 8: Priority 1 Prune by Diameter (DBH Class)

Priority 1 Prune	
DBH Class	Number of Trees
1 - 3	1
4 - 6	4
7 - 12	59
13 - 18	422
19 - 24	551
25 - 30	336
31 - 36	126
37 - 42	63
43 +	31
n/a	2
Total	**1,595**

Priority 2 Prune

Additionally, 4,120 trees recommended for a Priority 2 prune. These trees need pruning to remove hazardous deadwood limbs greater than two, but less than four inches in diameter.

Table 9: Priority 2 Prune by Diameter (DBH Class)

Priority 2 Prune	
DBH Class	Number of Trees
1 - 3	30
4 - 6	146
7 - 12	697
13 - 18	1,490
19 - 24	1,082
25 - 30	479
31 - 36	130
37 - 42	37
43 +	29
Total	**4,120**

Large Tree Routine Prune

Lastly, 15,045 trees were classified as large tree routine prune (Table 10). Some trees with this priority maintenance level were identified in poor or critical condition. Trees with the lesser condition ratings should be prioritized, because the condition of these trees may be improved through prompt response. For example, a tree in poor condition may require some management of mistletoe. If the mistletoe is removed, the condition of the tree may be improved with relief from this parasitic organism.

Table 10: Large Tree Routine Prune by Diameter (DBH Class)

Large Tree Routine Prune	
DBH Class	**Number of Trees**
1 - 3	4
4 - 6	1,859
7 - 12	3,223
13 - 18	5,428
19 - 24	2,725
25 - 30	1,147
31 - 36	434
37 - 42	144
43 +	81
Total	**15,045**

Small Tree Routine Prune

Small tree routine prune was assigned to 19,204 trees. Table 11 summarizes the number of trees prescribed small tree routine pruning and the DBH class.

Table 11: Small Tree Routine Prune by Diameter (DBH Class)

Small Tree Routine Prune	
DBH Class	**Number of Trees**
1 - 3	5,863
4 - 6	5,478
7 - 12	6,863
13 - 18	967
19 - 24	27
25 - 30	2
31 - 36	2
37 - 42	—
43 +	1
n/a	1
Total	**19,204**

Small tree care/pruning does not require many tools and can be completed in a relatively short amount of time. Ideally, small tree care would be conducted by staff when unrelated tasks have been completed early during a workday. To improve the ability of tree crews to address such tasks, crews have been provided mobile tablets to identify the location of small trees that need routine maintenance in the vicinity of regular scheduled work.

Training Prune

An additional 1,573 trees were recommended for a training prune (Table 12). Training prune is important for young trees, as minor pruning cuts can improve the overall structure of a tree and can result in reductions in more significant maintenance needs as the tree matures.

Table 12: Training Prune by Diameter (DBH Class)

Training Prune	
DBH Class	Number of Trees
1 - 3	1,038
4 - 6	389
7 - 12	134
13 - 18	11
19 - 24	1
25 - 30	—
31 - 36	—
37 - 42	—
43 +	—
Total	**1,573**

Stump Grinding

Stump grinding was recommended for 1,048 stumps (Table 13). These stumps should be removed through stump grinding.

Table 13: Stump Removals by Diameter (DBH Class)

Stump Removal	
DBH Class	Number of Stumps
1 - 3	25
4 - 6	155
7 - 12	291
13 - 18	253
19 - 24	139
25 - 30	108
31 - 36	50
37 - 42	15
43 +	12
Total	**1,048**

M Street Eucalyptus

Merced has 218 eucalyptus (*Eucalyptus spp.*) trees along M street. This iconic grove of eucalyptus once served as the entrance to Crocker – Huffman Water Company. Of the eucalyptus trees collected along M Street, 85% are greater than 12-inches in diameter (DBH), which suggests that this subsect of the overall population are well-established and mature trees (Figure 6). Mature trees can require more frequent maintenance. Of the M Street eucalyptus, 92% were observed at the time of the inventory to be in fair or better condition (Figure 7). Eucalyptus trees can often require more maintenance than trees of similar size and condition. Of the M Street eucalyptus, 55% were recommended for a priority 1 prune and another 11% were recommended for a priority 2 prune, which suggests that these trees have dead wood that requires attention (Figure 8). Large and small routine prunes were recommended for 31% of the M Street eucalyptus. Removals were recommended for 4% of M Street eucalyptus.

Merced has 218 eucalyptus (Eucalyptus spp.) trees along M street.

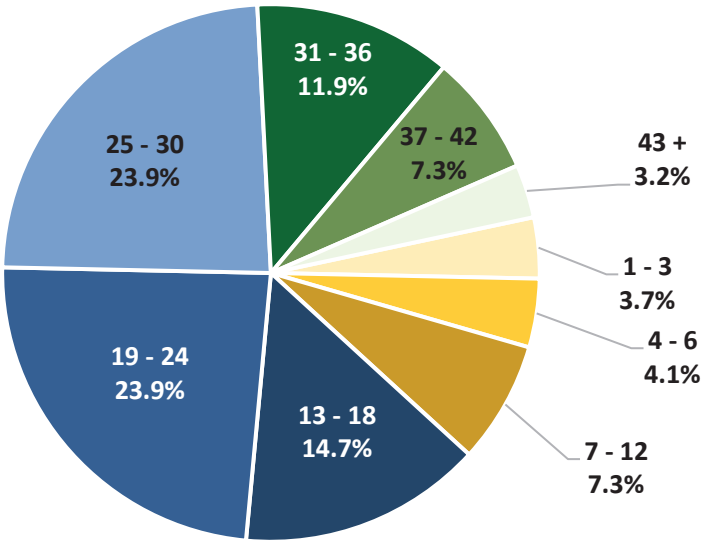


Figure 6: Summary of Diameter Classes for M Street Eucalyptus

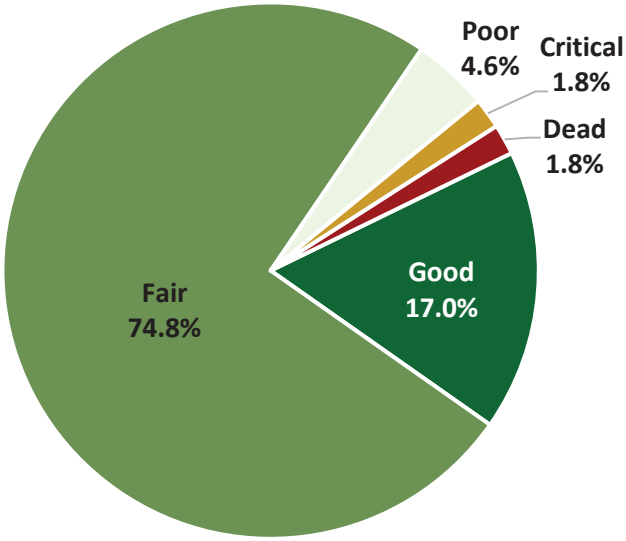


Figure 7: Condition Summary for M Street Eucalyptus

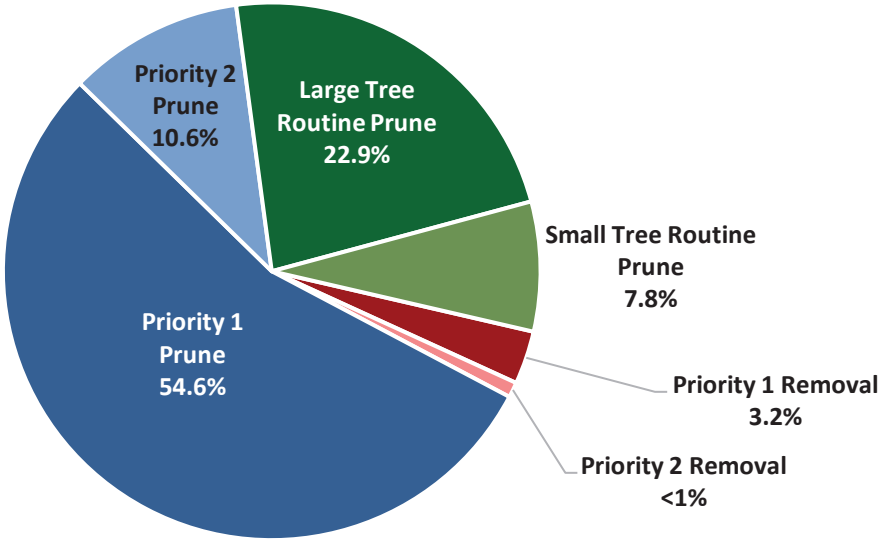


Figure 8: Summary of Maintenance Priorities for M Street Eucalyptus

Urban Forestry Operations

The Public Works Department oversees public trees in Merced through the efforts of the Trees Division and the Parks Division. The care of the City's public trees is led by the Public Works Supervisor of the Parks and Trees Divisions. The Public Works Supervisor of the Parks and Trees Divisions is responsible for the general operations, maintenance, and care of the parks system, maintenance districts, street trees, and related facilities. With the leadership within the City, the Trees Division is better positioned to respond to open service requests and the maintenance needs identified by the 2018-2019 tree inventory. As a result of the inventory, the Parks and Trees Divisions can prioritize maintenance needs and begin working towards a regular and predictable pruning cycle. Both Parks Division Staff and Trees Division Staff have responsibilities for trees, depending on the location of the tree and the level of urgency for the maintenance (i.e. potential impacts to persons or property or routine pruning).

Currently, none of the Parks and/or Trees Division Staff are certified arborists. Trees Division Supervisor identified training their employees to become certified tree workers and certified arborists as a way to invest in staff and ultimately improve their program.

The Trees Division refers to training materials produced by Kansas State University Research and Extension. Tree crews review safety tailgates bi-weekly. Crewmembers document their participation and understanding after review.

The City is currently conducting a rate study to evaluate rates for Green Waste. The new rates are expected to be implemented in the summer of 2020. Through the rate study process, Trees Division Staff are requesting to add more staff (currently the Division employs seven staff). Additionally, the Division is exploring the purchase of newer aerial lift trucks. With newer equipment and additional staff, the Trees Division would be able to improve response times to existing service requests.

Staff in the Parks and Trees Division are responsible for the care of all 44,107 trees in the public right-of-way, including, along streets, medians, in parks and open space, and City facilities. Services provided by the Parks and Trees Division include:

1. Tree Inventory Management
2. Tree Pruning
3. Tree Removal
4. Biomass Disposal and Utilization
5. Tree Planting
6. Tree Irrigation
7. Pest Management

Services

Tree maintenance involves inspecting, preserving, trimming, removing, and planting of trees along City property, including along streets, in parks, and at City facilities. Tree maintenance is conducted by staff in the Trees Division and Parks Division, with some exceptions (there are no arborists under contract with Merced for regular maintenance services). The Public Works Supervisor of the Parks and Trees Divisions estimated 60% of their time on the operations of the Trees Division and the remaining 40% on the Parks Division and other assigned duties. There are planned trainings to increase Parks Division Staff's knowledge for tree maintenance and will be expected to provide structural training for young trees within parks by 2020.

Residents can request service for their City tree by contacting the administration office of the Department of Public Works by phone or email. Residents can also submit service requests through a new City app-based tool "Merced Connect". Merced Connect allows residents to submit, track, and view nearby service requests through smartphones and tablets.

Parks and Trees Division Staff work diligently to fulfill open work orders generated through phone calls and emails, as well as the requests received through Merced Connect (an average of 60 work orders per week are generated). Parks and Trees Division Staff are observing correlations between the service requests and the maintenance needs identified by the tree inventory completed in 2019, most notably hangers, downed limbs, and requests for clearance along streets and sidewalks.

The Trees Division has two lift trucks, two lift/chipper trucks, two chipper trucks, 4 chippers, one stump grinder, and one dump truck. A commercial driver's license is required for their operation and therefore all tree trimmers must have a Class B license without airbrake restriction.

Tree Inventory Management

The City currently uses TreeKeeper 8™ to manage public trees. By 2020, all Departments will be integrating the tree inventory and other city assets into ESRI Enterprise System, a mapping and analytics platform. The Tree Division is currently running the ESRI Enterprise System and is able to add information such as maintenance tasks, assigned work, and add historical data on public trees to the system.

Tree Pruning

Historically the City has been on a 7-year tree maintenance cycle. However, with budget reductions beginning in 2008 and vacant positions, maintenance efforts have largely been reactionary (responding to service requests and hazards/emergencies). The current goal for urban forestry is to establish a regular maintenance schedule.

All regular pruning and tree removals are conducted by Parks and Trees Divisions Staff, except for trees that have conflict with utilities. In these cases, pruning and tree removals are conducted by Pacific Gas & Electric.

Tree Removal

Trees Division Staff are responsible for the removal of all dead, dying, or diseased public trees within the City (with the exception of extremely tall trees, which are contracted out). Maintenance of the Eucalyptus trees along Bear Creek and along M Street is frequently

conducted by Parks and Trees Divisions in conjunction with the California Department of Forestry and Fire Protection.

Biomass Disposal

There is a nationwide push to develop and expand the use of woody biomass, the woody parts of trees. Using woody biomass is a valuable tool for improving the economic viability of the management of urban trees, manufacturing, and mitigating climate change. One study estimated that approximately 17 million tons of woody biomass is generated annually from the removal of urban trees (Nowak and Crane, 2002). In California, there are on-going efforts to divert wood waste away from landfill, through the creation of rescue and reuse programs.

Merced is working towards zero waste in tree care operations, however, in instances of decay, undesirable wood, invasive tree species or pests, debris is disposed at the landfill. Partnerships with local businesses have diverted many debris from tree maintenance and removals away from the landfill. In anticipation of increased tree removals due to an aging tree population, more partnerships will likely be required to address the volume of wood debris, not only to avoid the costs of disposal, but also to reduce GHG emissions and sequester carbon for longer periods of time.

Previously, businesses in the community provided wood chip storage for the City. However, these arrangements are no longer viable because the businesses could not accommodate the volume of debris generated by the City. With the volume of trees proposed for maintenance and removal, it is critical for the City to explore new wood chip storage options to minimize landfill disposal costs. While it would be convenient to utilize chips in playgrounds in parks, playgrounds require engineered chips and therefore the chip debris from trees is not suitable for this purpose. Additionally, expanding mulch rings around trees in parks would likely cause issues for mowing these areas.

Tree Planting

The Trees Division, on average, plants approximately 400 trees annually with the help of volunteers. The majority of tree plantings are to replace trees that had previously been removed. Mortality of newly planted trees is not uncommon, especially during the hotter times of the year.

Some residents have planted trees within the public right-of-way that were not the most appropriate species for Merced's local climate. The Trees Division accepts the responsibility of caring for these trees and encourages residents to request trees to be planted by the City in these areas. To further encourage more appropriate species to be planted by residents, the Trees Division provides a species planting list. This list was updated simultaneously with the Urban Forest Management Plan and now reflects species that require less water and encourage greater diversity throughout the urban forest.

Right Tree, Right Place

Some species have been planted heavily at different periods in the history of Merced's urban forestry program. A few of these species are costly to maintain and are often poorly suited to the local climate.

Flowering pear (*Pyrus calleryana*) and Raywood ash (*Fraxinus oxycarpa*) are examples of high maintenance trees that were planted historically. Both species are prone to pest problems, as well as heaving sidewalks, and dropping nuisance fruit. In addition to conflicts with hardscape, poor branch structure is typical for these species, making them more susceptible to branch failure in wind events. With prolonged periods of drought, pests and storm events have exacerbated the maintenance needs for both species.

As a result of the high maintenance costs associated with these two species, the City has stopped planting them. In addition to poor species selection, unsuitable planting locations have resulted in conflicts with overhead utilities, heaving sidewalks, water meters, and fire hydrants. In some cases, large stature trees were planted in spaces that prohibited canopy growth and often result in the removal of trees prematurely. Conversely, in some locations, small stature species were planted in sites that could have accommodated larger trees.

Going forward, the City has elected to plant tree species that are more appropriate for the region (i.e. drought-tolerant) and install them in planting sites where trees are less likely to conflict with utilities and hardscape.

Tree Irrigation

Merced has dedicated staff responsible for irrigation systems in parks, at City facilities, and throughout maintenance districts. At present, Trees Division employees are responsible for watering newly planted trees with a portable watering system and are evaluating other irrigation options for newly planted trees. Street trees adjacent to residences are required to be irrigated by the property owner per Municipal Code.

In the past, residents were billed at a flat rate for their water usage. Most residents in Merced are billed at a base monthly rate of $31.00 as of July 1, 2019 (approximately 2% increases in base rates are planned for 2020 and 2021) (Water Rates). This base rate includes 20 Hundred Cubic Feet (HCF) or 14,960 gallons of water. For each hundred cubic feet or 748 gallons that exceeds the base rate, residents are charged $0.74. As a result of changes to the fee structure for water there is a perception that watering trees is a huge expense for households.

California Releaf recommends that newly planted trees be watered more often than mature trees; two to four times per week in the summer depending on the soil type (sandy soils require more frequent watering than clay soils). Every time a newly planted tree is watered, it should receive 10-20 gallons of water depending on the size of the root ball. Considering current watering schedules, a property owner can water at most three days a week.

Irrigation Cost Example:

Consider a scenario where a property owner used the entire 20 HCF allotment. If this hypothetical property owner has an adjacent street tree and provided the recommended 20 gallons of water at the frequency of three times a week, the total number of gallons per week would be roughly 60 gallons of water for the tree. Over a month, the property owner will have used approximately 240 gallons to water the tree, which does not exceed the hundred cubic feet of excess and therefore would pose no charge for any excess use. To exceed the base HCF and be charged for excess use, a property owner would have to water four street trees at the recommended rate. In which case, the property owner would be charged $0.74 for the additional use. Therefore, watering public trees, even if that water use exceeds the base rate, should not be an unreasonable cost for property owners.

Pest Management

Similar to all urban forests, Merced's urban forest experiences pest and disease problems. As this community is in close proximity to large urban centers and highly mobile populations, there is a possibility of pest introductions. These factors, coupled with the current changes in climate, make the community vulnerable to novel pests and diseases.

Mistletoe

A parasitic plant native to California, commonly referred to as broadleaf mistletoe (*Phoradendron macrophyllum*), can be problematic to several kinds of hardwood trees. Infections occur on tree branches and spread by seed. When the seeds germinate, root like structures penetrate the bark and absorb water and nutrients from the host tree (Torngren et al, 1980). Healthy trees can tolerate a few mistletoe branch infections, but the individual branches may be weakened or sometimes killed. Heavily infested trees may exhibit reduced vigor and stunted growth. In severe cases broadleaf mistletoe kills trees, especially if they are stressed by other factors such as drought or disease. Merced's Modesto ash are especially vulnerable to mistletoe infestation, these and the pear trees should be monitored.

Mistletoe on Modesto ash tree.

Verticillium wilt

Verticillium wilt is caused by several species of fungal pathogens in the genus Verticillium. Over 400 herbaceous and woody plants are impacted by verticillium wilt, including Chinese pistache (*Pistachia chinensis*), and the pathogen can persist in a dormant state in the soil for approximately ten years. Infected trees lack vigor, exhibiting small leaves or sparse canopies. Toward the end of the growing season, leaves may become limp and fall prematurely (Berlanger and Powelson, 2000). Several of the more susceptible trees include catalpa (*Catalpa*); maple (*Acer*); and ash (*Fraxinus*).

Asian longhorned beetle

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an invasive insect that threatens many hardwood trees. The beetle was introduced to the United States (Chicago, New Jersey, and New York City) in 1996. It was likely brought to the United States on wood pallets and other wood-packing materials. Currently, California does not have any ALB infestations, but this insect was detected in Sacramento County in 2005. Symptoms of infestations include flagging, or leaf yellowing, branch dieback, and weeping wounds. Feeding and tunneling damage caused by the immature stages of this beetle block the flow of water and nutrients throughout the tree. The known preferred hosts include many groups of hardwood trees such as maple (*Acer*); buckeye (*Aesculus*); birch (*Betula*); planetree (*Platanus*); willow (*Salix*); and elm (*Ulmus*).

Emerald ash borer

Emerald ash borer (EAB, *Agrilus planipennis*) has killed hundreds of millions of trees in North America. All species of ash are susceptible to EAB. This destructive, non-native, wood-boring pest attacks both stressed and healthy ash trees, killing trees with 2 to 3 years after infestation (NASPF, 2005). It is important to avoid planting additional ash trees because EAB has rapidly and consistently spread throughout the eastern United States.

Polyphagous shot hole borer

Although polyphagous shot hole borer (*Euwallacea* sp.) and Fusarium dieback are not currently a problem in Merced, they are present in southern California and research suggests that there is potential for spread northward. As a result of a wide host-range, many species of trees in Merced are vulnerable to this invasive pest (Mitchell, 2019).

Citrus greening

Citrus greening (*Candidatus liberibacter asiaticus*), a bacterial disease that causes bitter, hard fruit production, is among the most concerning pest as it threatens the viability of California's citrus crop. While citrus species represent less than 1% of the public tree population, many residences in Merced grow citrus trees. Due to quarantines in place to protect California's citrus crop, infected trees must be destroyed and disposed of appropriately (Grafton-Cardwell et al, 2019).

Granulate ambrosia beetle

The granulate ambrosia beetle (*Xylosandrus crassiusculus*) was first detected in South Carolina, USA in the 1970s, and has since spread to multiple states, but not yet California. This beetle feeds on heartwood tissues, but secondary cankers can form on the bark where beetle entrance and exit wounds occur. This ambrosia beetle has the potential to colonize healthy or stressed trees (Atkinson et al, 2000) and has a large hardwood host range. Known hosts in the United States include: maple (*Acer*); albizia (*Albizia*); hickory (*Carya*); redbud (*Cercis*); dogwood (*Cornus*); persimmon (*Diospyros*); beech (*Fagus*); locust (*Gleditsia* or *Robinia*); walnut (*Juglans*); goldenrain tree (*Koelreuteria*); crapemyrtle (*Lagerstroemia*); sweetgum (*Liquidambar*); tulip poplar (*Liriodendron*); magnolia (*Magnolia*); aspen (*Populus*); cherry (*Prunus*); pear (*Pyrus*); oak (*Quercus*); and elm (*Ulmus*) (Cole 2008).

Funding

The total annual budget for the City of Merced is approximately $255 million (Figure 9). The Department of Public Works operates with a budget of approximately $157 million and the Trees Division operates with a nearly $1.2 million-dollar annual budget.

The majority of funding for Public Works is produced through enterprise funds or in other words, residents pay for services provided by Public Works through their utility bill (water, wastewater, sewer, and refuse). The Trees Division receives its funds through refuse rates (recycling, trash, and green waste).

Additional funds for the City are provided by property assessments. City Staff and Council are responsible for distributing these funds.

The funding source for the care and maintenance of trees in Merced is dependent on the location of individual trees. For example, maintenance for trees in parks is funded through the parks budget. Maintenance for street trees is funded through the refuse budget.

Staff are required to keep a log of work completed to ultimately identify the tree location and funding source (a balance transfer occurs based on the allocation of funds). In some cases, a Parks employee will be asked to assist the tree staff.

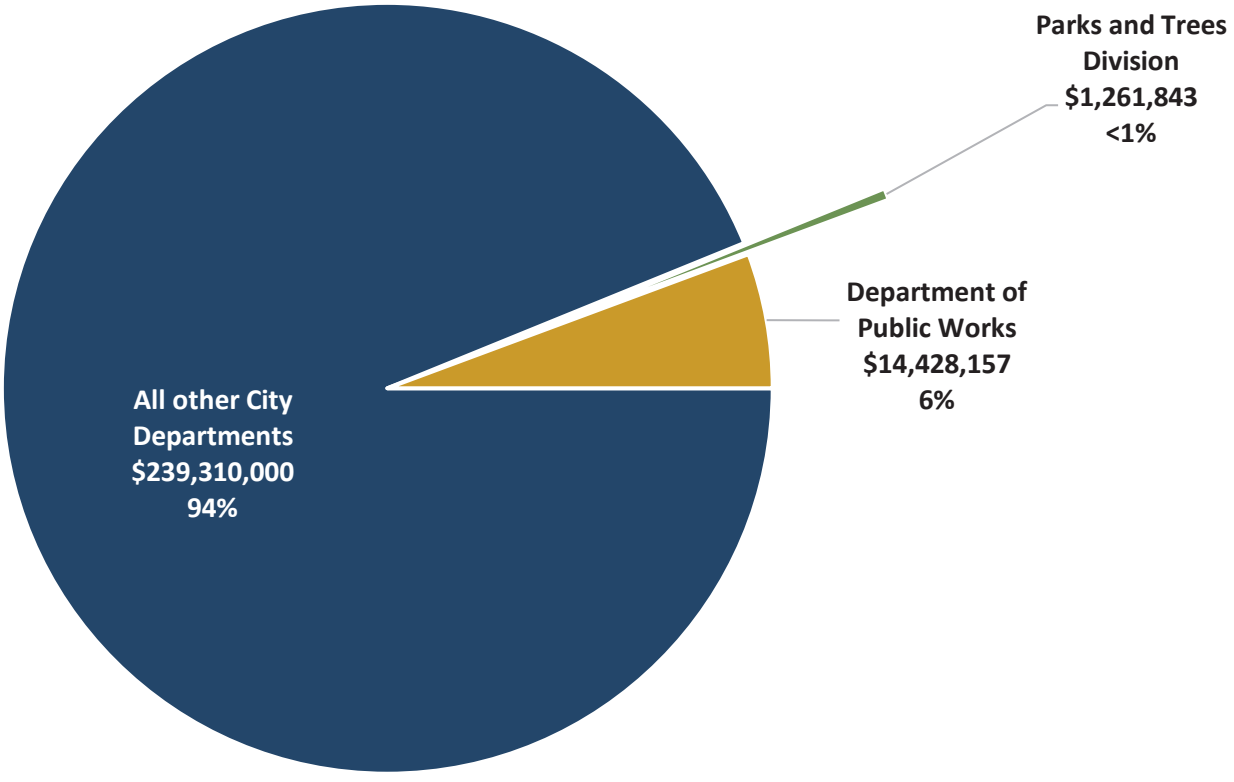


Figure 9: Merced Annual City Budget

Partners

Merced's Parks and Trees Divisions are responsible for the care of all public trees within the City. There are many other community groups and other City departments who have an important role in caring for the urban forest.

Merced Community College

Merced Community College offers degrees in Landscape Horticulture. Facilities such as greenhouses and a nursery provide opportunities for students to study and practice production of ornamental plants, including trees. The City is actively exploring opportunities to support the college, as well as, establish a production nursery which could include plant selection not readily available at other tree nurseries.

Tree Partners Foundation

In partnership with Merced Community College, the Tree Partners Foundation established a ten-acre botanical garden. The Tree Partners Foundation's mission is to empower the community through nature education by preserving, protecting, and enhancing the urban forest of the Central Valley (Tree Partners Foundation).

The Foundation provides educational programming on tree planting and maintenance. Additionally, the Foundation provides opportunities for citizen forestry classes, student internships, and stewardship programs. Through education, the Foundation aims to build a community that understands the importance and benefits of the urban forest and the tools to maintain and improve that resource.

Master Gardeners of Merced County

Master Gardeners of Merced County are individuals who have participated in the University of California Master Gardener Program. These Master Gardeners together offer workshops and talks on a variety of gardening and landscape topics throughout the year. Tree Planting in the Central Valley is among the numerous workshops the group has provided for the local community.

Merced Garden Club

Merced Garden Club is local non-profit dedicated to promoting an interest in horticulture, landscape design, gardening, and flower arranging. Group members communicate the importance and benefits of trees and encourage community members to plant trees.

Policies and Regulations

City policies and regulations provide the foundation for the Parks and Trees Divisions by outlining the requirements and specifications for the planting, installing, and caring for Merced's public trees. They also provide the regulatory framework for the protection and preservation of the urban forest assets as well as the enforcement of activities and issues that impact the community's trees. The development of Merced's Urban Forest Management Plan included a comprehensive review of City policies, development and construction standards, ordinances, and other regulations that apply to the urban forest. The following provides a summary of the relevant regulations that protect the City's urban forest.

Federal and State Law

California Urban Forestry Act

Section 4799.06-4799.12 of the California Public Resources Code defines a chapter known as the California Urban Forestry Act. The act defines trees as a "vital resource in the urban environment and as an important psychological link with nature for the urban dweller". The act also enumerates the many environmental, energy, economic, and health benefits that urban forests provide to communities.

The purpose of the act is to promote urban forest resources and minimize the decline of urban forests in the state of California. To this end, the act facilitates the creation of permanent jobs related to urban forestry and encourages coordination with state and local agencies to reduce or eliminate tree loss and prevent the introduction and spread of pests. The act grants the authority to create agencies and mandates that urban forestry departments shall provide technical assistance to urban areas across many disciplines. The act also authorizes and recommends numerous funding tools to achieve these goals.

Public Park Preservation Act

In addition to the protections provided by the California Urban Forestry Act, the Public Park Preservation Act of 1971 ensures that any public parkland converted to non-recreational uses is replaced to serve the same community.

Migratory Bird Treaty Act

Passed by Congress in 1918, MBTA defines that it is unlawful to pursue, hunt, take, capture, kill, possess, sell, purchase, barter, import, export, or transport any migratory bird, or any part, nest, or egg or any such bird, unless authorized under a permit issued by the Secretary of the Interior.

The act can impact forestry operations during times when birds are nesting and may delay work in order to avoid violating the MBTA.

Endangered Species Act

Signed in 1973, the Endangered Species Act provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend.

The listing of a species as endangered makes it illegal to "take" (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to do these things) that species. Similar prohibitions usually extend to threatened species.

Model Water Efficient Landscape Ordinance

To promote the conservation and efficient use of water and to prevent the waste of water, the State of California adopted the Model Water Efficient Landscape Ordinance (MWELO) in 2009 (later revised in 2015). It requires increases in water efficiency standards for new and retrofitted landscapes through the use of more efficient irrigation systems, greywater usage, and onsite stormwater capture, and by limiting the portion of landscapes that can be covered in turf.

California Senate Bill No. 606 and No. 1668

Approved by Governor Jerry Brown on May 31, 2018, these bills require cities and water districts to set permanent water conservation rules, even in non-drought years. Under the bills, each urban water provider is required to set target water use goals that must be approved by the State Water Resource Control Board by 2022. If agencies fail to meet these goals, potential fines as high as $10,000 a day may be issued. Standards are based on 55 gallons per person per day for indoor water use (later decreasing to 50 gallons by 2030) and regional based standards for outdoor use.

California Solar Shade Act

Passed in 1978, the Solar Shade Control Act supported alternative energy devices, such as solar collectors, and required specific and limited controls on trees and shrubs. Revised in 2009, the Act restricted the placement of trees or shrubs that cast a shadow greater than 10 percent of an adjacent existing solar collector's absorption area upon the solar collector surface at any one time between the hours of 10 a.m. and 2 p.m.

The Act exempts trees or shrubs that were planted prior to the installation of a solar collector, trees or shrubs on land dedicated to commercial agricultural crops, replacement trees or shrubs that were planted prior to the installation of a solar collector and subsequently died or were removed (for the protection of public health, safety, and the environment) after the installation of a solar collector, and trees or shrubs subject to city and county ordinance.

Merced Municipal Code

The Merced Municipal Code includes seven titles that provide considerations for trees:

Title 8 Health and Safety

Establishes fees related to the collection of garbage, green waste, street trees, and other wastes from residences. The Title also restricts tree limbs, shrubs or vines within two feet of fire alarm lines.

Title 12 Streets and Sidewalks

Restricts news racks from being placed near improved areas with trees.

Title 14 Public Places

Provides definitions for terms as the relate to the care of trees, shrubs, plants, and provides requirements for private tree work. Additionally, Title 14 contains the Chapter "Trees, Shrubs, and Plants" which requires that any person charged with maintaining wires, pipes or conduits who determines a need for the trimming, pruning, and removal of trees must file a written request with the director prior to the work being completed. The Chapter designates street trees as the property of the City and gives the director authority over the decisions regarding street trees. Additionally, the Chapter gives the director the authority to designate which species of trees may be planted on City property. The Chapter prohibits various maintenance, removal, or injury to trees without a permit and specifies the validation period for said permit. Watering of trees within parkways is designated by the Chapter as the responsibility of the adjacent property owner.

Title 15 Public Service

Describes circumstances when water restrictions apply, which may affect trees.

Title 17 Buildings and Construction

Prohibits any person from posting signs on trees. Provides landscape design standards and requires planting certain kinds and sizes of trees.

Title 18 Subdivisions

Allows for tree trimming where trees interfere with public utilities. Designates locations where tree planting and replacement are required in subdivisions.

Title 20 Zoning

Outlines the kind of trees that can be planted, and the potential use of evergreens for screening. Provides landscape design standards that are specific to trees for residential, business, and parking areas.

Vision 2030 General Plan

The City's Vision 2030 General Plan was adopted in 2012. The General Plan addresses land use, circulation, open space, conservation, housing, noise and safety within the City.

Chapter 3 encourages creating new neighborhoods and shopping districts with streets lined with trees and considers the planting of trees in parking lots in industrial areas.

Chapter 4 recommends continued utilization of trees to reduce the impacts of noise from roadways, as well as retention of parkstrip tree planting requirements and encourage the planting and preservation of shade trees.

Chapter 5 highlights the establishment of a Community Facilities District (CFD) in 2000, which included street trees.

Chapter 6 promotes the use of trees in street designs.

Chapter 7 summarizes the policies for open space lands and for the conservation of natural and man-made resources within the City, including protections for stands of trees, preservation of the City's Street Tree program, requirements for tree plantings in new developments, promotion of tree planting throughout the City, and utilization of trees as windbreaks.

Chapter 8 promotes an economically and environmentally sustainable community, by supporting policies that encourage improved air quality, strategies for reducing greenhouse gas emissions, and energy efficiencies.

8-Year Work Plan

Over the next eight years, the UFMP provides a roadmap through annual work plans to efficiently address the maintenance needs of all city-managed trees through prioritizing primary maintenance needs, followed by routine maintenance, and establishing a regular 8-year maintenance cycle. During this period, the City will work to address 56,639 maintenance tasks, including removals, pruning, routine maintenance, preventative maintenance, and tree plantings. (Table 14). The Plan does not include outstanding service requests, although most open service requests correlate with maintenance recommendations identified during the 2018-2019 tree inventory. The Plan also does not account for changes in priority maintenance needs. Parks and Trees Division Staff will continue to schedule work based on the highest known maintenance priority. The highest level of priority maintenance should occur first. In other words, if a tree that was recommended for a routine prune during the initial inventory collection, but a service request and further inspection indicated a heightened maintenance priority, lesser priorities should be organized accordingly. Once a priority maintenance task has been addressed, the tree, with the exception of removals, will be reassigned to the applicable maintenance cycle zone rotation (Table 15).

Year 1 Work Plan

In the interest of safety, year 1 will prioritized priority 1 removals. Trees with this recommendation have a high volume of dead wood or pose immediate risk to public safety. At a minimum, 315 trees with the recommendation of priority 1 removal (546 trees in total were recommended for priority 1 removal) should be addressed in year 1. Large trees or trees that are located at or near City facilities, schools, along major arterial roads should be addressed before small trees or trees within areas with lower occupancy rates.

To address priority 1 prunes (1,595 trees), the city will address at least 719 trees in year 1. Similarly, to priority 1 removals, trees with larger diameters or near public facilities recommended for priority 1 prune should be prioritized over those trees that are less than 6-inches in diameter.

Training prunes are extremely beneficial for the future health and structure of young trees. Most structural defects that occur in older trees could have been prevented through the strategic pruning of young trees. Training pruning can promote desirable and stable branch structure, which can result in reduced maintenance cost later in the life of the tree, as well as, extend the overall lifespan. Because training pruning is most beneficial for trees when they are young, the city will conduct training prunes on all 1,573 trees recommended for this specialized structural pruning within the first three years of the Plan (approximately 500 annually) otherwise many of the trees recommended for training prune will have grown and will likely require elevated maintenance and care. As trees are planted, additional training pruning will likely be necessary as trees are established. Some structural pruning can be completed as trees are planted, but most will require additional visitation within two years after establishment.

Table 14: 8-Year Maintenance Plan

Activity	Diameter Class (inches)	Annual Maintenance Plan (# of trees) Year 1 # of Trees	Year 2 # of Trees	Year 3 # of Trees	Year 4 # of Trees	Year 5 # of Trees	Year 6 # of Trees	Year 7 # of Trees	Year 8 # of Trees	Eight–Year # of Trees
Tree Removal (Priority 1, 2, & 3)	1 - 3	43	43	43	43	43	43	43	44	345
	4 - 6	20	34	34	34	34	34	34	34	258
	7 - 12	62	62	62	62	62	62	62	62	496
	13 - 18	74	74	74	74	74	74	73	72	589
	19 - 24	53	53	53	52	52	52	52	52	419
	25 - 30	37	37	37	37	37	37	37	37	296
	31 - 36	20	17	17	17	17	17	17	12	134
	37 - 42	4	4	4	4	4	4	2	2	28
	43 +	2	3							5
Activity Total(s)		**315**	**327**	**324**	**323**	**323**	**323**	**320**	**315**	**2,570**
Priority Pruning	1 - 3	4	4	4	4	4	4	4	3	31
	4 - 6	19	19	19	19	19	19	19	17	150
	7 - 12	95	95	95	95	95	95	94	92	756
	13 - 18	239	239	239	239	239	239	239	239	1,912
	19 - 24	205	204	204	204	204	204	204	204	1,633
	25 - 30	102	102	102	102	102	102	102	101	815
	31 - 36	32	32	32	32	32	32	32	32	256
	37 - 42	13	13	13	13	13	13	12	10	100
	43 +	8	8	8	8	8	8	8	4	60
	N/A	2								2
Activity Total(s)		**719**	**716**	**716**	**716**	**716**	**716**	**714**	**702**	**5,715**
Training Prune	1 - 3	390	390	258						1,038
	4 - 6	145	144	100						389
	7 - 12	80	54							134
	13 - 18	4	4	3						11
	19 - 24	1								1
	25 +									0
Activity Total(s)		**525**	**525**	**525**						**1,573**
Routine Pruning (8-year cycle based includes trees with no maintenance recommendation)	1 - 3	735	734	733	733	733	733	733	733	5,867
	4 - 6	918	917	917	917	917	917	917	917	7,337
	7 - 12	1,261	1,261	1,261	1,261	1,261	1,261	1,260	1,260	10,086
	13 - 18	800	800	800	800	800	800	800	795	6,395
	19 - 24	344	344	344	344	344	344	344	344	2,752
	25 - 30	145	144	144	144	144	144	144	140	1,149
	31 - 36	55	55	55	55	55	55	55	51	436
	37 - 42	18	18	18	18	18	18	18	18	144
	43 +	12	10	10	10	10	10	10	10	82
	N/A	1								1
Activity Total(s)		**4,289**	**4,283**	**4,282**	**4,282**	**4,282**	**4,282**	**4,281**	**4,268**	**34,249**
Planting		1,560	1,572	1,569	1,568	1,568	1,568	1,567	1,560	12,532
Training Prune				1,560	1,572	1,569	1,568	1,568	1,568	9,405
Activity Total(s)		**1,560**	**1,572**	**3,129**	**3,140**	**3,137**	**3,136**	**3,135**	**3,128**	**21,937**
Activity Grand Total		**7,408**	**7,423**	**8,976**	**8,461**	**8,458**	**8,457**	**8,450**	**8,413**	**66,046**

Routine pruning includes those trees that were recommended for both large and small routine prune. The type of prune can provide managers with a general idea of the equipment needed to complete the task (small routine prunes should not require climbing equipment or aerial lifts). In total, routine prunes identified by the inventory include 34,249 trees. When distributed across an eight-year period, roughly 4,300 trees should receive routine maintenance annually.

There are 9,962 potential tree planting locations within the City. Considering these sites and those created from the removal of trees recommended for priority removal, managers should aim to plant approximately 1,600 trees annually over the next eight years. In year 1, 1,560 trees should be planted.

Year 2 Work Plan

In Year 2, all priority 1 removals (231 remaining after year 1) will be completed and staff will begin to focus on priority 2 and 3 removals. In total, 315 priority 1 removals will occur, with larger diameter trees being addressed first.

Priority 1 prunes will continue to be prioritized in year 2 (approximately 876 remaining). At a minimum 716 priority 1 prunes will occur, with larger trees being the priority. Additionally, 525 trees recommended for training prunes and 4,283 large and small routine prunes will be incorporated into work schedules.

To replace trees removed during year 1 and to fill available planting sites identified during the inventory, 1,572 trees will be planted in year 2.

Year 3 Work Plan

In Year 3, any remaining priority 1 removals will be completed first (approximately 160 remaining from year 1 and 2). Additionally, priority 2 and 3 removals will begin (2,024 trees). When evenly distributed across years 3 through 8, approximately 320 removals will occur annually, for a total of 164 in year 3. Along with priority removals, priority 1 and 2 prunes will continue, with 716 priority prunes. Routine small and large prune will continue, as well, with 208 trees recommended for such maintenance activities. The remaining trees recommended for training pruning will occur intermittently with larger pruning activities. Trees planted in year 1 (1,560 trees), will be revisited and receive training pruning to promote good branch structure. Approximately, 1,569 trees will be planted.

Year 4 Work Plan

By year 4, all priority 1 removals will be complete. Priority 2 and 3 removals will continue. To replace trees removed in the previous years and to continue to plant potential planting sites, 1,568 trees will be planted. Approximately 716 priority pruning maintenance tasks will be conducted, along with 4,282 trees with large or small tree routine prunes. Crews will continue to incorporate training prunes for trees planted in year 2 into schedules whenever possible (1,572 trees).

Year 5 Work Plan

Year 5 includes 323 trees with priority 2 or 3 removals. To replace trees removed in the previous years and to continue to plant potential planting sites, 1,568 trees will be planted. Priority 2

pruning maintenance tasks will continue, 716 in total. At a minimum, 4,282 large or small tree routine prunes will also occur. Crews will continue to incorporate training pruning for trees planted in year 3 (1,569 trees) into schedules whenever possible.

Year 6 Work Plan

Year 6 includes 323 trees with priority 2 or 3 removals. To replace trees removed in the previous years and to continue to plant potential planting sites, 1,568 trees will be planted. Pruning maintenance includes 716 trees with priority 2 prunes and 4,282 trees with large or small tree routine prunes. Crews will continue to incorporate training pruning into schedules for newly established trees planted in year 4 (1,568 trees) whenever possible.

Year 7 Work Plan

Year 7 includes 320 trees with priority 2 or 3 removals. To replace trees removed in the previous years and to continue to plant potential planting sites, 1,567 trees will be planted. Pruning maintenance includes 714 trees with priority 2 prunes and 4,281 trees with large or small tree routine prunes. Crews will continue to incorporate training pruning into schedules whenever possible to structurally train newly planted trees from year 5 (1,568 trees).

Year 8 Work Plan

In the final year of the 8-year work plan, the remaining 315 removals will primarily be priority 3 removals, which are typically smaller trees. With an additional 1,560 tree plantings will have provided the community with an additional 9,962 trees, or 12,532 trees in total. The remaining 702 priority 2 prunes will be completed by the end of year 8. Routine pruning of large and small trees will include 4,268 trees. Training prunin will continue to address trees planted in year 6 (1,568 trees). Following the 8 year work plan, trees planted in years 7 and 8 will receive training pruning within 2 years after being planted.

Inspections and Inventory Management

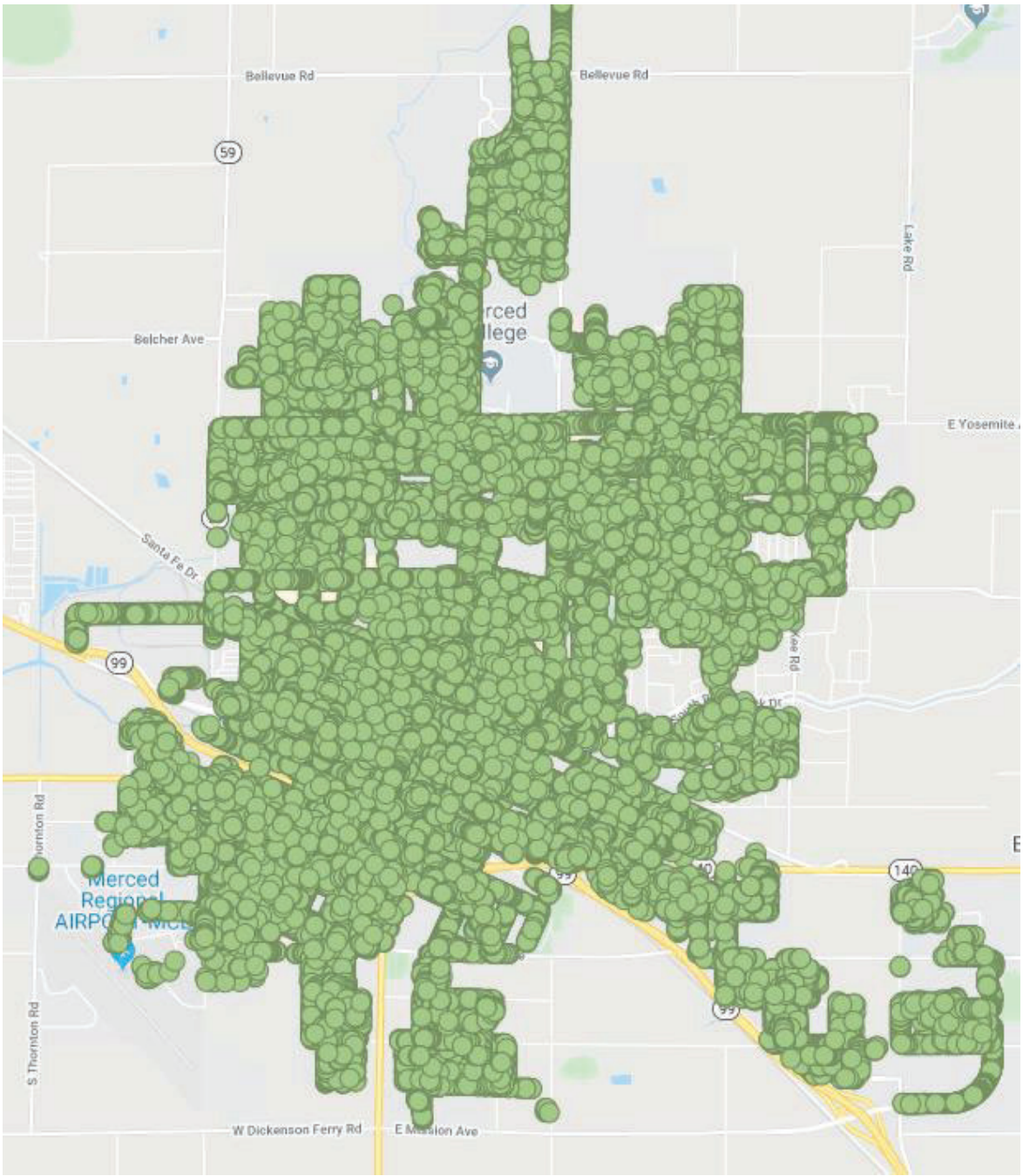
Over an eight-year period, approximately 56,639 maintenance tasks will have been completed. Meanwhile, over this period trees will continue to grow, and maintenance needs may change. Trees recommended during the 2018-2019 for training prunes, if not addressed early will likely require more pruning and larger equipment to address any pruning needs as they will have grown. In order to understand changing maintenance needs, trees should be inspected on the cycle year.

As maintenance occurs, inventory data attributes should be updated. While the inventory included the collection comprehensive information about every street and park tree, these trees will have grown since the original inspection. Along with documenting maintenance activities, tree condition and diameter should also be updated.

As Trees Division crews work through the work plan, regular inspections should also occur. Inspections should be scheduled based on Maintenance Cycle Zone (Table 15). Scheduling inspections and regularly updating the inventory can document changes in diameter, tree health, and identify new priority maintenance tasks. As an added benefit, regularly updating the inventory, reduces the need for future city-wide updates to the inventory.

With current inventory data, managers can track the overall health of City trees and identify species that may not be performing well or planting sites that do not support trees long-term. Understanding which species are inappropriate for the local climate or sites that continually prove to not support trees to maturity can reduce mortality rates, as well as, reduce future maintenance needs.

In addition to regular inspections, all maintenance staff with the City should be trained to identify immediate hazards. Then, Parks and Trees Divisions staff should be alerted of such hazards and work to address any immediate risks to public health and safety accordingly.



Merced's tree inventory as displayed in TreeKeeper 8.

Long-term Goals

In addition to the five-year maintenance plan, the project identified long-term goals to meet the community's vision for the future of the urban forest. The following goals and actions are intended to adequately manage the City's urban forest in a timely, and cost effective, and efficient manger. These goals consider both the preservation of the existing urban forest, as well as its expansion. As such, these goals are distributed between two focus areas tree canopy and the community tree resource.

Goal 1: Establish stable and predictable funding.

Stable and predictable funding is critical to effective and efficient management of the urban forest. Trees are living organisms, constantly growing and changing over time and in response to their environment. There are several factors that affect tree health and structure, including nutrition, available water, pests, disease, wind, and humidity. While it might seem like most changes to trees take a long time to occur, some specific maintenance is critical at certain stages of life. For instance, young trees benefit greatly from early structural pruning and training. Minor corrections that are simple can be applied with low costs when a tree is young. However, if left unattended they can evolve into very expensive structural issues and increase liability as trees mature. At which point it may be impossible to correct the issue without causing greater harm. Then again, over-mature trees often require more frequent inspection and removal of dead or dying limbs to reduce the risk of unexpected failure. A stable budget allows urban forest managers to program the necessary tree care at the appropriate life stage when it is most beneficial and cost effective.

With the maintenance identified by the 2018-2019 inventory and the high volume of service requests submitted on a weekly basis (an average of 60 generated every week) additional staff or contractors should be considered to address immediate risks and to promote tree health.

Objective: Identify resources to fund tree maintenance.

Actions:

1. Explore the use of revenues from the sale of cannabis to fund tree maintenance.
2. Consider a Park Overlay District to fund park tree maintenance.

Goal 2: Efficiently maintain the community tree resource to manage risk, promote benefits, and enhance the health and resiliency of the urban forest.

Efficiently managing the community tree resource is critical for maintaining the resource for future generations. While the 8-year Work Plan provides annual goals for maintenance tasks, establishing maintenance cycles can enhance productivity of tree crews, by scheduling maintenance tasks by Maintenance Zone. Combining the 8-year Work Plan with Maintenance Cycle Zones, managers can schedule maintenance to reduce drive-times between trees *and* meet annual maintenance goals. The City should begin maintenance in zones with higher volumes of priority maintenance (priority 1 removal and priority 1 prune).

Based on current maintenance needs, distribution of trees, and areas that may be incorporated into Merced, Parks and Trees Divisions Staff and DRG defined 10 Maintenance Zones (Appendix E). During the first years of the 8-year Work Plan, cycle pruning may be delayed. In fact, in the first two years all zones will require visitation to address higher priority maintenance. If maintenance quotas are met after the 8-year period, managers will be able to establish routine maintenance; visiting, inspecting, and addressing all maintenance trees within two maintenance zones per year, or a 5-year maintenance cycle. When the Parks and Trees Divisions establish routine maintenance cycles, the Maintenance Zone Map should be published on the City web page to communicate to residents when to expect tree maintenance.

Objective: Establish a 5- to 7-year maintenance cycle to promote greater time management and efficiency.

Actions:

1. Address highest maintenance priorities (i.e. risk) first.
2. Use Maintenance Cycle Zones (Table 15) to maximize efficiency and increase productivity in providing maintenance to community trees.
3. Publish Maintenance Cycle Zone Map on web page to communicate to residents when to expect maintenance for their City tree

Table 15: Summary of Maintenance Cycle Zone Maintenance Priorities

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Boundaries	South of Central Yosemite Hwy, East of Golden State Hwy (99)	South and West of Golden State Hwy (99) and East of M Street	West of M Street, East of Thornton Road, South of Golden State Hwy (99)	South of bear Creek, West of M Street, North of Golden State Hwy (99)	East of M Street, South of Bear Creek, West of McKee Road, North of 140 and Golden State Hwy (99)	North of Bear Creek, West of R Street, South of Yosemite	North of Yosemite, West of M Street, South of Bellevue	North of Bear Creek, West of G Street, South of Yosemite	North of Bear Creek, East of G Street, South of Yosemite	North of Yosemite, East of M Street
Total Trees	3,056	4,314	5,054	4,405	6,757	6,757	7,976	4,955	4,519	8,802
Priority 1 Removal	35	53	79	125	128	128	36	10	29	49
Priority 2 Removal	89	105	217	334	198	198	83	9	37	52
Priority 3 Removal	26	75	50	141	141	141	179	51	87	90
Priority 1 Prune	94	73	341	161	274	274	33	151	326	127
Priority 2 Prune	127	153	1,454	364	627	627	224	60	290	804
Total Priority Maintenance Tasks	**371**	**459**	**2,141**	**1,125**	**1,368**	**1,368**	**555**	**281**	**769**	**1,122**

In addition to establishing a 5-year maintenance cycles, the creation of an Urban Forest Master Plan. Unlike a Management Plan, an Urban Forest Master Plan, provides long-term visionary goals for the entire urban forest (both public and private trees).

Objective: Create an Urban Forest Master Plan.

Actions:

1. Conduct a land cover assessment to identify changes in tree canopy.
2. Conduct a resource analysis to monitor overall community tree performance and diversity.

Goal 3: Set a goal for tree canopy cover.

Merced currently has an average tree canopy cover of 12.1%, but tree canopy cover varies greatly across the City between council districts and land use. A community meeting held October 3rd, 2019 identified interest in establishing a canopy cover goal for Merced. Further exploration and communication with community members is advised to create a canopy goal that reflects the realities of the local climate, community values, and potential canopy cover as identified by the urban tree canopy assessment.

Objective: Engage with community members to identify a canopy goal supported by the entire community.

Actions:

1. Develop annual planting plans to achieve desired canopy cover.
2. Encourage equitable distribution of canopy cover across the community.
3. Preserve healthy mature and large stature trees.

Goal 4: Protect and preserve the M Street eucalyptus grove.

The eucalyptus trees along M Street are a recognizable feature in Merced and highly valued by the community for their historical context and ties with early ranching and the Crocker – Huffman Water Company. Eucalyptus trees were introduced to the US from Australia and were valued and planted by early settlers due to their fast growth and usefulness for windbreaks and shade. However, large-stature species (e.g., *E. globulus, E. camaldulensis*) are notorious for shedding branches and limbs. As a result, when maintained as a street tree, these species require additional attention and more frequent inspections to better manage their risk potential. The eucalyptus grove on M Street has some history of branch failure and the inventory identified 126 trees (57.8% that require priority attention and/or removal. Most of the trees are in fair or better condition. There is currently no supplemental irrigation to the grove.

Objective: Develop a specific plan for the M Street eucalyptus.

Actions:

1. Address priority removals and pruning needs identified by the tree inventory.
2. Identify and prioritize specific trees for preservation, based on size, aesthetic value, location, and condition.

a. Conduct level 2 and level 3 inspections as needed to make a final determination on preservation priority.
b. Engage the community to develop a specific plan for the preservation of eucalyptus on M Street.
c. Prioritize preservation of healthy trees.

3. Explore the development of an interpretive trail or path that illustrates the history of the allee.
4. Identify opportunities for successional planting and supplemental irrigation.

Goal 5: Water trees, even during periods of drought.

Water is critical for the survival of trees in Merced, especially with the increased frequency in periods of drought and a dry climate. Newly installed water meters have resulted in the perception of irrigation of City-planted trees as a large expense for adjacent property owners to incur. Parks and Trees Division Staff should distribute educational materials on how to properly water trees, as well as, water meter rate information to encourage residents to actively participate in the care of trees planted in the public right-of-way adjacent to their properties.

Objective: Educate and engage the community about irrigating City trees.

Actions:

1. Provide educational materials on proper watering of City trees.
2. Provide water meter fee information to detail the true cost of irrigating City trees.
3. Promote greater diversity in the community resource, through sourcing nursery stock from Merced Community College.

Goal 6: Identify solutions for wood utilization.

With the projected high volumes of removals and pruning maintenance that is expected to occur over the next eight years, Parks and Trees Division Staff should continue to seek out partnerships to reduce the volume of wood waste entering the local landfill, not only to reduce disposal costs, but to reduce the amount of carbon released into the atmosphere through decomposition. In addition, Parks and Trees Division Staff should explore lumber and milling businesses, which may be interested in milling and selling urban wood to local artisans.

Objective: Divert urban wood away from the landfill whenever possible.

Actions:

1. Explore additional partnerships with local businesses and artisans to divert wood waste from the landfill.
2. Explore the use of wood chips as biofuel.
3. Incorporate chips into the landscape, wherever possible.

Goal 7: Develop mutually beneficial community partnerships.

Merced already benefits greatly from the presence of both Merced Community College and the Tree Partners Foundation. Public Works should continue to nurture relationships with the Landscape Horticulture Department and the Tree Partners Foundation to facilitate educational

and research opportunities, as well as to provide the City with tree species which are not readily available through area nurseries. With appropriate facilitation, volunteers may also support training pruning for young trees. However, training and oversight will be critical to assure that best management practices are followed for both production of nursery stock and for training pruning, as mistakes that occur during the life of young trees can have negative affects throughout a tree's lifetime.

Objective: Provide opportunities for students and volunteers to enhance the community tree resource.

Actions:

1. Explore internship opportunities.
    a. Consider the usage of students or volunteers to provide training pruning for young trees.
    b. Continue to explore the incorporation of nursery production into educational programming.

Goal 8: Mitigate and reduce the risk of wildfire.

The occurrence of a wildfire is influenced by the current climatic conditions (temperature, humidity, wind) other environmental factors such as the type of surrounding vegetation, fuel structure and moisture content. Much of the Western United States experiences hot, dry summers, and many communities are adjacent to forested areas that are adapted to wildfires. The Wildland Urban Interface (WUI) describes a transition zone where homes are located on the edge of fire prone areas. There is an increased risk of personal injury or property damage resulting from a wildfire in the WUI. To promote a more fire adapted community, there must be support to locate WUI areas at risk of wildfire and engage in risk reduction activities (Cooke et al, 2016). In 2012, less than 10% of communities at risk of fire had a Community Wildfire Protection Plan (CWPP) in place (Jakes et al, 2012). Whether preparing by creating a CWPP or other community planning, the steps outlined need to be in the context of the community, consider the resources available, and generate a network of support for implementation of best management practices (Jakes et al, 2012).

Objective: Contribute to a fire safe community.

Actions:

1. Create a Community Fire Protection Plan.

Conclusion

Five years after the inception of the Tree City USA program, Merced obtained their designation and has maintained it for 39 years. This long-standing acknowledgement of the value of trees has instilled a sense of pride for Merced's community trees and its urban forest.

Merced is proud of its community trees and urban forest.

A land cover assessment revealed that the average canopy cover (public and private) across Merced is 12.1%. This resource has sequestered (i.e. stored) more than 547 million tons of carbon (CO_2) and annually provides $293,589 in benefits to air quality and stormwater runoff reduction.

Merced has an established urban forestry program. The Parks and Trees Division have tree crews and contractors that provide care to all community trees. With a complete public tree inventory, Parks and Trees Division Staff are better informed about the maintenance needs and the overall health of the community tree resource.

The 2018-2019 tree inventory identified 44,107 trees in parks, along streets, and in center medians that are mostly in fair or better condition. Each year, community trees are providing nearly $4.5 million in environmental and socioeconomic benefits the community. To replace the community tree resource with trees of the same size, species, and condition would cost more than $117 million.

The tree inventory identified that most trees require routine maintenance, with a small percentage of trees requiring removal or prioritized pruning. Routine pruning can occur over time, as it is more pressing to handle the higher priority items first.

Merced's Urban Forest Management Plan identifies an 8-year work plan, which identifies annual goals to guide maintenance planning and scheduling. The work plan outlines a schedule to complete all maintenance priorities identified by the tree inventory over the next eight years.

Based on a comprehensive review and assessment of land cover and the community tree resource (public tree inventory, forestry operations, guiding documents, and collaboration with community partners and stakeholders) the Plan identifies eight goals that will help support the community's greater vision for tree-lined streets, reduced noise pollution, greater incorporation of trees into

the community aesthetic, improvements in air quality, reductions in greenhouse gas emissions, and increased energy efficiency as defined in the Vision 2030 General Plan.

Among the eight goals identified by the Plan, a key goal is to establish stable and predictable funding. Trees are living organisms, constantly growing and changing over time and in response to their environment. There are a number of factors that affect tree health and structure, including nutrition, available water, pests, disease, wind, and humidity. While it might seem like most changes to trees take a long time to occur, some specific maintenance is critical at certain stages of life. For instance, young trees benefit greatly from early structural pruning and training. Minor corrections that are simple can be applied with low costs when a tree is young. However, if left unattended they can evolve into very expensive structural issues and increase liability as trees mature (at which point it may be impossible to correct the issue without causing greater harm). Over-mature trees often require more frequent inspection and removal of dead or dying limbs to reduce the risk of unexpected failure. A stable budget allows urban forest managers to program the necessary tree care at the appropriate life stage when it is most beneficial and cost effective.

A stable budget ensures that trees get the necessary tree care at the appropriate life stage.

Following the completion of the 8-year Work Plan, Merced's Parks and Trees Divisions will continue to maintain community trees on a 5 to 7-year pruning cycle. Maintaining trees on a cycle will ensure that all trees receive regular maintenance, which improves overall tree structure and health. When the cycle is established, managers should publish maintenance cycles on the City web page, to communicate to residents estimated timelines on when to expect maintenance for City-trees adjacent to their property. As the 8-year Work Plan progresses, inspections and regular updates to the inventory will be necessary, as trees will continue to grow during this period and their maintenance needs will change as well.

Tree canopy cover is critical for maintaining and enhancing the existing canopy. Because tree canopy cover includes both public and private trees, engaging the community in identifying an appropriate goal will ensure public buy-in and support. To support canopy cover and the long-

term management of community trees, creating an Urban Forest Master Plan is an important step towards sustaining the urban forest for future generations and can provide a necessary review of the progress on the goals of this Plan and also identify long-term goals for the entire urban forest.

The iconic grove of eucalyptus trees along M Street are a landmark in Merced. Originally planted by early settlers to serve as wind breaks, these trees are much appreciated by the community. As such, managers should work to protect and preserve the grove. While there is some history of branch failure for these trees, most of the trees were identified to be in fair or better condition during the inventory. With a specific plan for the M Street eucalyptus grove, managers can prioritize maintenance needs and explore the development of an interpretive trail or path to demonstrate the history of the allee to the community.

Climate change projections anticipate longer and more frequent periods of drought in California's central valley. These changes present a big threat to urban trees. State-led efforts to reduce water-usage and encourage water conservation have led to some confusion about the watering needs of trees. Educational materials on proper watering of trees and factual information on costs and fees associated with metered water can help residents understand the importance of water for trees and also counter misperceptions about the true costs for residents. Planting a greater diversity of tree species with low-water needs will further reduce the use and costs associated with irrigation, particularly during drought conditions.

Across the United States, there is a greater awareness of the volume of wood waste that is disposed of in landfills every year. To reduce greenhouse gas emissions and extend the amount of time that carbon is stored in woody biomass, there is a push to find alternative solutions to disposal and give urban wood a second life. In Merced, there are several existing partnerships with local businesses to reuse trees and wood debris. In anticipation of an increase in future removals due to an aging tree population, the volume of wood produced is also expected to rise. Merced should continue to seek out additional partnerships and explore the use of biofuel technologies to be a part of the global solution.

Ongoing partnerships with Merced Community College and the Tree Partners Foundation present an opportunity for facilitating educational outreach and for growing experimental species and species that are otherwise hard to acquire from commercial nurseries. Continued partnerships with these groups and other volunteer organizations will provide additional volunteers for urban forestry events and activities as well as providing research opportunities for students at the community college.

In the last 20 years, wildfire has devasted a number of communities across California. Because more communities are living within areas where the risk of wildfire is elevated, mitigation efforts are crucial to reducing that risk. Merced should work to mitigate and reduce the risk of wildfire by identifying WUI areas and developing a Community Fire Protection Plan that defines and implements best management practices to reduce the risk of wildfire.

Overall, the trees in Merced are in fair or better condition. Most trees will require routine maintenance over the next eight years. Long-term goals to establish a tree canopy cover goal; to improve efficiency and community safety; to build community partnerships; and to educate the community, will further advance Merced's urban forestry program. The creation of specific plans for managing the eucalyptus grove along M Street and developing a Community Fire Protection

Plan, will enhance overall public safety while contributing to the aesthetic of the City. Looking forward to the future, an Urban Forest Master Plan will ensure review of the progress of this Plan and also provide visionary goals to support the long-term health of the entire urban forest. Altogether, Merced is well equipped to sustain the urban forest for years to come.

Merced is well equipped to sustain the urban forest for years to come.

Appendix A: References

Akbari, H., D. Kurn, et al. 1997. Peak power and cooling energy savings of shade trees. Energy and Buildings 25:139–148.

Atkinson, T.H., J.L. Foltz, R.C. Wilkinson, and R.F. Mizell. 2000. Florida Insect Management Guide for insect borers of trees and shrubs. University of Florida. Entomology Circular 310. http://entnemdept.ufl.edu/creatures/trees/asian_ambrosia_beetle.htm

Berlanger, I. and M.L. Powelson. 2005. Verticillium wilt. The Plant Health Instructor. https://www.apsnet.org/edcenter/disandpath/fungalasco/pdlessons/Pages/VerticilliumWilt.aspx

Bernhardt, E., and Swiecki, T.J. 1991. Guidelines for Developing and Evaluating Tree Ordinances. Phytosphere Research, Vacaville, CA. https://ufei.calpoly.edu/files/pubs/guidelines.pdf

Clark JR, Matheny NP, Cross G, Wake V. 1997. A Model of Urban Forest Sustainability. J Arbor 23(1):17-30.

Climate in Merced, California. 2018. Sperling's Best Places. Retrieved from https://www.bestplaces.net/climate/city/california/merced

Cole, K.W. 2008. Granulate ambrosia beetle. Indiana Department of Natural Resources. http://www.in.gov/dnr/entomolo/files/ep-GranulateAmbrosiaBeetleFactsheet.pdf

Dwyer, et al. Assessing the Benefits and Costs of the Urban Forest. Journal of Arboriculture 18(5): September 1992.

Ellison, D. et al. 2017. Trees, forests and water: Cool insights for a hot world. Global Environmental Change. Volume 43. Pages 51-61. ISSN 09593780.https://doi.org/10.1016/j.gloenvcha.2017.01.002. Retrieved from: http://www.sciencedirect.com/science/article/pii/S0959378017300134

Eskalen, et al. 2017. Avocado: Polyphagous Shot Hole Borer and Kuroshio Shot Hole Borer. 2017. UC Pest Management Guidelines. UC IPM: Statewide Integrated Pest Management Program. Retrieved from: http://ipm.ucanr.edu/PMG/r8302011.html

Fernández-Juricic, Esteban. 2001. Avifaunal use of Wooded Streets in an Urban Landscape. Conservation Biology. Volume 14, Issue 2, pages 513-521. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1523-1739.2000.98600.x

Gilstad-Hayden et al. 2015. Greater tree canopy cover is associated with lower rates of both violent and property crime in New Haven, CT. Landscape and Urban Planning. Volume 143. Pages 248-253. ISSN 0169-2046. https://doi.org/10.1016/j.landurbplan.2015.08.005.Retrieved from: http://www.sciencedirect.com/science/article/pii/S0169204615001607

Grafton-Cardwel, Dr., Daugherty, Dr., Jetter, Dr., & Johnson, R. 2019. ACP/HLB Distribution and Management. University of California, Division of Agriculture and Natural Resources. Retrieved from https://ucanr.edu/sites/ACP/

Gross, Liza. 2013. KQED Science. Retrieved from https://www.kqed.org/science/4209/eucalyptus-california-icon-fire-hazard-and-invasive-species

Haddad, et al. 2015. Habitat fragmentation and its lasting impact on Earth ecosystems. Science Advances. 1. e1500052. 10.1126/sciadv.1500052.

Heisler GM. 1986. Energy Savings with Trees. J Arbor 12(5):113–125.

Heisler GM., and DeWalle, O.R. 1968. "Effects of windbreak structure on wind flow: Agriculture Ecosystems and Environments, 22123, pp. 41-69.

Jakes, P. J., Esposito, C., Burns, S., Cheng, A. S., Nelson, K. C., Sturtevant, V. E., and Williams, D. R. 2012. Best management practices for creating a Community Wildfire Protection Plan. Gen. Tech. Rep. NRS-89. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station. 27 p., 89, 1-27.

Kuo, F.E. and Sullivan, W.C. 2001. Environment and crime in the inner city: Does vegetation reduce crime? Environment and behavior, 33(3), pp.343-367.

Lyle, J.T., 1996. Regenerative design for sustainable development. John Wiley & Sons.

Matsuoka, Rodney. 2010. Student performance and high school landscapes: Examining the links. Landscape and Urban Planning. 97. 273-282

McDonald et al. 2016. Planting Healthy Air: A global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat. The Nature Conservancy. Retrieved from: 2002https://thought-leadershipproduction.s3.amazonaws.com/2016/10/28/17/17/50/0615788b-8eaf-4b4f-a02a8819c68278ef/20160825_PHA_Report_FINAL.pdf

McPherson, E.G., N. van Doorn, and J. de Goede, The State of California's Street Trees. 2015, Pacific Southwest Research Station, U.S. Forest Service: Davis, CA.

McPherson, E. 1994. Cooling urban heat islands with sustainable landscapes. In R. Platt, r. Rowntree, & P. Muick (Eds.), The ecological city (pp. 151–171). Amherst; University of Massachusetts Press.

McPherson, E. and J. R. Simpson. 2010. The tree BVOC index. Elsevier. Environmental Pollution. 159. 2088–2093. Retrieved from: https://www.fs.fed.us/psw/publications/mcpherson/psw_2011_mcpherson006.pdf

Miller and Sorci. "Believe it or not, Merced County's population is fastest growing in the state". Merced Sun Star. May 1, 2018. Retrieved from https://www.mercedsunstar.com/news/local/community/article210246639.html

Mitchell, Jessika. 2019. Shothole Borer. Davey Resource Group's Treesources. Retrieved from: http://www.davey.com/environmental-consulting-services/resources-news/shothole-borer/

NASA Facts. 2000. "NASA's 'Heat Hunters': Combating effects of the urban heat Island at the Global Hydrology and Climate Center. Retrieved from https://www.nasa.gov/centers/marshall/pdf/100409main_heathunters.pdf

The Nature Conservancy. Planting Healthy Air; A global analysis of the role of urban trees in addressing particulate matter pollution and extreme heat. 2016. Retrieved from: https://thought-leadership-production.s3.amazonaws.com/2016/10/28/17/17/50/0615788b-8eaf-4b4f-a02a-8819c68278ef/20160825_PHA_Report_FINAL.pdf

Nowak, D., and Crane, D. 2002. Carbon Storage and Sequestration by Urban Trees in the USA. Environmental Pollution 116:381-389.

Pena JCdC, Martello F, Ribeiro MC, Armitage RA, Young RJ, et al. (2017) Street trees reduce the negative effects of urbanization on birds. PLOS ONE 12(3): e0174484.https://doi.org/10.1371/journal.pone.0174484

Planning the Urban Forest: Ecology, Economy, and Community Development. 2009. American Planning Association. Edited by Schwab, James. Retrieved from: https://planning-org-uploadedmedia.s3.amazonaws.com/legacy_resources/research/forestry/pdf/555.pdf

Resource Analysis Merced, CA. 2019. Davey Resource Group, Inc.

Threlfall, Caragh & Williams, Nicholas & Hahs, Amy & J. Livesley, Stephen. 2016. Approaches to urban vegetation management and the impacts on urban bird and bat assemblages. Landscape and Urban Planning. 153. 28-39. 10.1016/j.landurbplan.2016.04.011.

Torngren, T. S., E. J. Perry, and C. L. Elmore. 1980. Mistletoe Control in Shade Trees. Oakland: Univ. Calif. Agric. Nat. Res. Leaflet 2571. http://ipm.ucanr.edu/PMG/PESTNOTES/pn7437.html

Tree Partners Foundation. Retrieved October 2019. Retrieved from: http://www.treepartnersfoundation.org/about.html

Troy, Austin; Grove, J. Morgan; O'Neil-Dunne, Jarlath. 2012. The relationship between tree canopy and crime rates across an urban-rural gradient in the greater Baltimore region. Landscape and Urban Planning. 106: 262-270.

Urban Tree Canopy Assessment Merced, CA. 2019. Davey Resource Group, Inc.

U.S. Climate Data. 2019. Climate Merced – California. Retrieved from https://www.usclimatedata.com/climate/merced/california/united-states/usca0695

Water Rates. Retrieved December 2019. Retrieved from: https://www.cityofmerced.org/departments/public-works/water/water-rates

Xiao, Q., McPherson, E.G., Simpson, J.R., Ustin, S.L. 1998. Rainfall Interception by Tracy's Urban Forest. Journal of Arboriculture. 24(4): 235-244.


Bob Carpenter
Neighborhood
Park

Appendix B: Acronyms

American National Standards Institute (ANSI)

- A Federation of United States industry sectors (e.g. businesses, professional societies and trade associations, standards developers, government agencies, institutes, and consumer / labor interest groups) that coordinates the development of the voluntary consensus standards system.

American Public Works Association (APWA)

- An organization that supports professionals who operate, improve, or maintain public works infrastructure by advocating to increase awareness, and providing education, credentialing, as well as other professional development opportunities.

Arboriculture

- The science, art, technology, and business of tree care.

Best Management Practices (BMP)

- Management practices and processes used when conducting forestry operations, implemented to promote environmental integrity.

Capital Improvement Projects (CIP)

- Infrastructure projects and equipment purchases identified by a government in order to maintain or improve public resources. Projects such as (1) constructing a facility, (2) expanding, renovating, replacing, or rehabilitating an existing facility, or (3) purchasing major equipment are identified, and then purchasing plans and development schedules are developed.

Climate Action Plan (CAP)

- Government lead initiatives to decrease greenhouse gas emissions and prepare for the impacts of climate change.

Community Urban Forest

- The collection of publicly owned trees within an urban area, including street trees and trees in parks and other public facilities.

Drip Line Area

- The area measured from the trunk of the tree outward to a point at the perimeter of the outermost branch structure of the tree.

Dutch Elm Disease (DED)

- A wilt disease of elm trees caused by plant pathogenic fungi. The disease is either spread by bark beetles or tree root grafts.

Emerald Ash Borer (EAB)

- The common name for *Agrilus planipennis,* an emerald green wood boring beetle native to northeastern Asia and invasive to North America. It feeds on all species of ash.

Greenhouse Gas (GHG)

- A gas that traps heat in Earth's atmosphere.

Geographic Information System (GIS)

- Computer-based tools designed to increase the organization and understanding of spatial or geographic data. Many different kinds of data can be displayed on one map for visualization and interpretation.

Integrated Pest Management (IPM)

- Using pest and environmental information to determine if pest control actions are warranted. Pest control methods (e.g. biological control, habitat manipulation, cultural control, plant resistance, and chemical control) are chosen based on economic and safety considerations.

i-Tree

- A computer program with tools used to determine the costs and benefits of urban trees based on inventory data, operations costs, and other factors.

International Society of Arboriculture (ISA)

- An international nonprofit organization that supports professionals in the field of arboriculture by providing professional development opportunities, disseminating applicable research findings, and promoting the profession.

Inventoried Trees

- Includes all public trees collected in the inventory as well as trees that have since been collected by city staff.

Major Maintenance

- Includes major trimming or pruning or cabling, and any other similar act, which promotes the life, growth, health or beauty of trees, excepting watering and minor pruning.

Major Trimming and Pruning

- The removal of branches of three inches in diameter or greater.

Migratory Bird Treaty Act (MBTA)

- A United States federal law adopted to protect migratory birds.

Natural Area

- A defined area where native trees and vegetation are allowed to grow and reproduce naturally with little or no management except for control of undesirable and invasive species.

Open Space

- A defined area of undeveloped land that is open to the public. The land can include native or naturalized trees and vegetation.

Plant Health Care (PHC)

- A program that consists of (1) routinely monitoring landscape plant health and (2) individualized plant management recommendations in order to maintain or improve the vitality, appearance, and safety of trees and other plants.

Personal Protective Equipment (PPE)

- Equipment worn to enhance workplace safety and minimize the risk to physical hazards (e.g. gloves, hard hats, bodysuits, and foot, eye, or ear protection).

Private Tree

- Any tree located on private property, including residential and commercial parcels.

Public Tree

- Any tree located in the public ROW, city park, and/or city facility.

Right Tree, Right Place

- The practice of installing the optimal species for a particular planting site. Considerations include existing and planned utilities and other infrastructure, planter size, soil characteristics, water needs as well as the intended role and characteristics of the species.

Specimen Tree

- Any tree of interest because of size or unusual species, other than a heritage tree, which is of good quality in terms of health, vigor or growth and conformity to generally, accepted horticultural standards of shape for its species, as designated by the city council upon the recommendation of the tree commission.

Street Tree

- Any tree growing within the tree maintenance strip whether or not planted by the city.

Structural and Training Pruning

- Pruning to develop a sound and desirable scaffold branch structure in a tree and to reduce the likelihood of branch failure.

Tree

- Any live woody plant having one or more well-defined perennial stems with a diameter at maturity of six inches or more measured at fifty-four inches above ground level (breast height).

Tree Canopy

- The layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Tree City USA

- A program through the Arbor Day Foundation that advocates for green urban areas through enhanced tree planting and care

Tree Risk Assessment Qualified (TRAQ)

- An International Society of Arboriculture qualification. Upon completion of this training, tree care professionals demonstrate proficiency in assessing tree risk.

Urban Forest

- The collection of privately owned and publicly owned trees and woody shrubs that grow within an urban area.

Urban Forest Master Plan (PLAN)

- A document that provides a comprehensive information, recommendations, and timelines to guide for the efficient and safe management of a city's tree canopy. The Plan uses adaptive management model to provide reasoned and transparent calls to action from an inventory of existing resources.

Urban Forestry

- The cultivation and management of native or introduced trees and related vegetation in urban areas for their present and potential contribution to the economic, physiological, sociological, and ecological well-being of urban society.

Urban Tree Canopy Assessment (UTC)

- A document based off of GIS mapping data that provides a birds-eye view of the entire urban forest and establishes a tree canopy baseline of known accuracy. The UTC helps managers understand the quantity and distribution of existing tree canopy, potential impacts of tree planting and removal, quantified annual benefits trees provide to the community, and benchmark canopy percent values.

Wildfire Urban Interface (WUI)

- A transition zone where homes are located on the edge of fire prone areas and are at an increased risk of personal injury or property damage resulting from a wildfire.

Appendix C: Methodology

Calculating Tree Canopy Benefits

Air Quality

The **i-Tree** *Canopy* v6.1 Model was used to quantify the value of ecosystem services for air quality. **i-Tree** *Canopy* was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi 2014).

Within the **i-Tree** *Canopy* application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In **i-Tree** *Canopy*, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to **i-Tree** *Canopy*. Those canopy percentages were matched by placing random points within the **i-Tree** *Canopy* application. Benefit values were reported for each of the five listed air pollutants.

Carbon Storage and Sequestration

The **i-Tree** *Canopy* v6.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. **i-Tree** *Canopy* was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration can be found in (Nowak et al, 2013).

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to **i-Tree** *Canopy*. Those canopy percentages were matched by placing random points within the **i-Tree** *Canopy* application. Benefit values were reported for carbon storage and sequestration.

Stormwater

The **i-Tree** *Hydro* v5.0 Model was used to quantify the value of ecosystem services for stormwater runoff. **i-Tree** *Hydro* was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology. This most recent version (v5.0) allows users to report hydrologic data on the city level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the **i-Tree** *Hydro* v5.0 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area and all municipalities that were included in the project area were used as inputs

into the model. Precipitation data from 2005-2012 was modeled within the **i-Tree** *Hydro* to best represent the average conditions over an eight-year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alterative Case set tree canopy equal to 0% and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 0.7% based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since **i-Tree** *Hydro* does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy.

Through model simulation, it was determined that tree canopy decreases the runoff volume in the project area by nearly 3.5 million gallons per year using precipitation data from 2005-2012. This equates to approximately 1,735 gallons per acre of tree canopy (3.5 million gals/1,735 acres).

To place a monetary value on storm water reduction, the cost to treat a gallon of storm/wastewater was taken from (McPherson et al, 1999). This value was $0.008 per gallon. Tree canopy was estimated to contribute roughly $40,798 to avoided runoff annually to the project area.

Priority Planting Analysis

The planting location polygons were created by taking all grass/open space and bare ground areas and combining them into one dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, etc. were removed from consideration. The remaining planting space was consolidated into a single feature and, then, exploded back out to multi-part features creating separate, distinct polygons for each location. Using zonal statistics, the priority grid raster was used to calculate an average value for each planting location polygon. The averages were binned into five classes with the higher numbers indicating higher priority for planting. These classes ranged from very low to very high. Resource Analysis Methodology

In 2018, the Merced provided public tree inventory data to Davey Resource Group, Inc. This inventory included details about each tree, including species, size, and condition. DRG formatted the data for use in **i-Tree** *Streets*, a STRATUM Analysis Tool (Streets v 5.1.5; **i-Tree** v 6.1.28). **i-Tree** *Streets* assesses tree population structure and the function of those trees, such as their role in energy use, air pollution removal, stormwater interception, carbon dioxide removal, and property value increases. To analyze the economic benefits of Merced's public trees, **i-Tree** *Streets* calculates the dollar value of annual resource functionality. This analysis combines the results of the tree inventory with benefit modeling data to produce information regarding resource structure, function, and value for use in determining management recommendations. **i-Tree** *Streets* regionalizes the calculations of its output by incorporating detailed reference city project information for 17 climate zones across the United States. Merced is in the Inland Valley Climate Zone. The reference city is Merced, CA.

- An annual resource unit was determined on a per tree basis for each of the modeled benefits. Resource units are measured as MWh of electricity saved per tree; MBtu of

natural gas conserved per tree; pounds of atmospheric CO_2 reduced per tree; pounds of NO_2, SO_2, O_3, PM_{10}, and VOCs reduced per tree; cubic feet of stormwater runoff reduced per tree; and square feet of leaf area added per tree to increase property values. Price values assigned to each resource unit (tree) were generated based on economic indicators of society's willingness to pay for the environmental benefits trees provide. Merced provided the estimated investment costs.

- Estimates of benefits are initial approximations as some benefits are difficult to quantify (e.g. impacts on psychological health, crime, and violence). In addition, limited knowledge about the physical processes at work and their interactions makes estimates imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Therefore, this method of quantification provides first-order approximations based on current research. It is intended to be a general accounting of the benefits produced by urban trees.
- **i-Tree** *Streets* default values from the Inland Valley Climate Zone were used for all benefit prices except for the median home value, and electrical and natural gas rates. Using these rates, the magnitude of the benefits provided by the public tree resource was calculated using **i-Tree** *Streets*. Electrical and gas rates, and program investment costs were supplied by public tree resource managers for Merced.

Inventory Collection

Methods of Inspection

Assessment of the trees was limited to visual inspection at ground level. Diameter to the nearest inch, and average canopy height to the nearest foot, were collected. All of the trees onsite were evaluated for condition and maintenance recommendations.

Limited Visual Assessment

Many factors can limit collecting specific and accurate data when performing only visual evaluations of trees. Future tree performance, potential response to treatments, responses to site disturbances or pruning, and responses to weather events cannot be predicted when performing visual assessments.

All observations were made from the ground (Level 2), and no root collar excavations or aerial inspections were requested or performed. No Resistograph®, ground-penetrating radar or other technologies were utilized during the inspection. The recommendations presented here are based on current data, photographs, and conditions that existed at the time of the evaluation and cannot be a predictor of the ultimate outcome for the trees in the future. The assumption of risk is the responsibility of the tree owner and risk reduction measures should include consideration of the level of risk the tree owner is willing to assume.

Technology

Trees were mapped on a pen tablet computer running ROVER ™, a DRG developed Geographic Information System (GIS) data collection tool and edited/updated for this survey. Using basemaps, such as digital aerial photos, trees were plotted with approximate locations and referenced to Global Positioning System coordinates for accuracy. During the assessment,

condition, maintenance need/priority, and observable defects were updated and are defined as follows:

Condition

The trees were individually rated based on a classification system developed by the International Society of Arboriculture (ISA). Condition indicates the current state of a tree's health, structural soundness, overall shape, and growth rate. Symptoms of poor condition include discoloration, decay, dieback, decreased internodal length, and/or disfigured or necrotic stems or roots. To some extent, condition class is also a reflection of the life expectancy of the tree. Crown development, trunk condition, major branch structure, twig growth rate, insects/diseases, and root condition are all considered. Classes are described below:

Excellent 100% condition class

The tree is nearly perfect in condition, vigor, and form. This rarely used category is generally applicable to small diameter trees that have been recently transplanted and are well established.

Very Good 90% condition class

Overall, the tree is healthy and satisfactory in condition, vigor, and form. The tree has no major structural problems, no mechanical damage, and may only have insignificant aesthetic, insect, disease, or structure problems.

Good 80% condition class

The tree has no major structural problems, no significant mechanical damage, may have only minor aesthetic insect, disease, or structure problems, and yet is in good health.

Fair 60% condition class

The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage, significant damage from non-fatal or disfiguring diseases, minor crown imbalance or thin crown, or stunted growth compared to adjacent trees. This condition also includes trees that have been topped but show reasonable vitality and show no obvious signs of decay.

Poor 40% condition class

The tree appears unhealthy and may have structural defects such as codominant stems, severe included bark, or severe trunk and/or limb decay. A tree in this category may also have severe mechanical damage, crown dieback, or poor vigor threatening its ability to thrive. Trees in poor condition may respond to appropriate maintenance procedures, although these procedures may be cost-prohibitive to undertake.

Critical 20% condition class

The tree has a major structural problem that presents an unacceptable risk, has very little vigor, and/or has an insect or disease problem that is fatal and may threaten other trees on the property.

Dead 0% condition class

This category refers only to dead trees.

Maintenance Recommendations

Maintenance recommendations were recorded in classes based on conditions observed in the individual trees. Structure, vigor and environment all contribute to the maintenance need.

Details of the classification system are below:

Priority 1 Removal

These trees have defects that cannot be cost-effectively or practically treated, have a high amount of deadwood, and pose an immediate hazard to property or person. The arborist recommends they be removed as soon as possible.

Priority 2 and 3 Removal

These trees are not as great a liability as priority 1 Removals, being smaller and/or far less hazardous, although they are also recommended for removal. Smaller dead trees and failed transplants are in this category. Large trees in this category are generally poorly sited, of inferior quality, and pose little to no threat to the community. Priority 2 Removals should be removed prior to Priority 3 removals.

Priority 1 Pruning

Trees in this category need pruning to remove hazardous deadwood limbs greater than four inches in diameter and/or have broken, hanging, or diseased scaffold limbs.

Priority 2 Pruning

These trees need pruning to remove hazardous deadwood limbs greater than two, but less than four inches in diameter.

Large Tree Routine Prune

These trees require routine horticultural pruning to correct structural problems or growth patterns that would eventually obstruct traffic or interfere with signs or buildings. Trees in this category are large enough to require bucket truck access or manual climbing.

Small Tree Routine Prune

These trees require routine horticultural pruning to correct structural problems or growth patterns that would eventually obstruct traffic or interfere with utility wires or buildings. These trees are small growing, mature trees that can usually be evaluated and pruned from the ground.

Training Prune

Trees in this category are young trees that require pruning to aid in the development of proper structure and form.

Stump Removal

These sites have stumps which need to be removed before a new tree can be planted.

Plant Tree

These sites are currently vacancies that would support the growth of a tree.

Plant

The size of the site is designated as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growing space available and the presence of overhead wires.

Further Inspection Required

Tree requires further inspection that is outside the scope of inventory collection.

Observations

In addition to prioritizing workloads for tree maintenance, observations were made at the discretion of the inventory arborist for each inventoried tree.

Site Observations

The collection included information on the following site observations:

- City Planted
- Clearance Required (from building, signs, and roads)
- Hardscape Damage–Damage to sidewalks and curbs by tree roots are noted
- Overhead Utilities–Trees whose crown is within ten feet of primary distribution lines and/or have been previously pruned away from the primary distribution lines

Appendix D: Industry Standards

ANSI Z133 Safety Standard, 2017

Reviews general safety, electrical hazards, use of vehicles and mobile equipment, portable power hand tools, hand tools and ladders, climbing, and work procedures.

ANSI A300

ANSI A300 standards represent the industry consensus on performing tree care operations. The standards can be used to prepare tree care contract specifications.

ANSI A300 Pruning Standard-Part 1, 2017

ANSI A300 Soil Management-Part 2, 2011

ANSI A300 Support Systems Standard-Part 3, 2013

ANSI A300 Construction Management Standard-Part 5, 2012

ANSI A300 Transplanting Standard-Part 6, 2012

ANSI A300 Integrated Vegetation Management Standard-Part 7,2012

ANSI A300 Root Management Standard-Part 8, 2013

ANSI A300 Tree Risk Assessment Standard a Tree Failure-Part 9, 2017

ANSI A300 Integrated Pest Management-Part 10, 2016

Includes guidelines for implementing IPM programs, including standards for Integrated Pest Management, IPM Practices, tools and equipment, and definition.

Best Management Practices (BMPs)

Integrated Pest Management, Second Edition, P. Eric Wiseman and Michael J. Raupp, 2016

Provides a comprehensive overview of the basic definitions, concepts, and practices that pertain to landscape Integrated Pest Management (IPM). The publication provides specific information for designing, planning, and implementing an IPM program as part of a comprehensive Plant Health Care (PHC) management system, including topics such as:

- IPM Concepts and Definitions
- Action Thresholds
- Monitoring Tools and Techniques
- Preventive Tactics
- Control Tactics
- Documentation and Recordkeeping

Integrated Vegetation Management, Second Edition, Randall H. Miller, 2014

A guide to the selection and application of methods and techniques for vegetation control for electric rights-of-way projects and gas pipeline rights-of-way. Topics included: safety, site evaluations, action thresholds, evaluation and selection of control methods, implementing control methods, monitoring treatment and quality assurance, environmental protection, tree pruning and removal, and a glossary of terms.

Managing Trees During Construction, Second Edition, Kelby Fite and E. Thomas Smiley, 2016

Describes tree conservation and preservation practices that help to protect selected trees throughout the construction planning and development process so that they will continue to provide benefits for decades after site disturbance, including planning phase, design phase, pre-construction phase, construction phase, and post-construction phase.

Root Management, Larry Costello, Gary Watson, and Tom Smiley, 2017

Recommended practices for inspecting, pruning, and directing the roots of trees in urban environments to promote their longevity, while minimizing infrastructure conflicts.

Special companion publication to the ANSI A300 Part 8: Tree, Shrub, and Other Woody Plant Management–Standard Practices (root Management)

Tree Planting, Second Edition, Gary Watson, 2014

Provides processes for tree planting, including site and species selection, planting practices, post-planting pruning, and early tree care. Other topics included are time of planting, nursery stock: types, selection, and handling, preparing the planting hole, planting practices, root loss and new root growth, redevelopment of root structure, pruning, palms, after planting, final inspection, and a glossary of terms.

Tree Inventories, Second Edition, Jerry Bond, 2013

Provides considerations for managing large numbers of trees considered as individuals rather than groups and serves as a guide for making informed decisions that align with inventory goals with needs and resources, including inventory goals and objectives, benefits and costs, types, work specifications, and maintaining inventory quality.

Tree Risk Assessment, Second Edition, E. Thomas Smiley, Nelda Matheny, and Sharon Lilly, 2017

A guide for assessing tree risk as accurately and consistently as possible, to evaluate that risk, and to recommend measures that achieve an acceptable level of risk, including topics: risk assessment basics, levels and scope of tree risk assessment, assessing targets, sites, and trees, tree risk categorization, risk mitigation: preventive and remedial actions, risk reporting, tree related conflicts that can be a source of risk, loads on trees, structural defects and conditions that affect likelihood of failure, response growth, description of selected types of advanced tree risk assessments.

Tree Shrub Fertilization, Third Edition, E. Thomas Smiley, Sharon Lilly, and Patrick Kelsey, 2013

Aides in the selection and application of fertilizers for trees and shrubs, including: Essential elements, determining goals and objectives of fertilization, soil testing and plan analysis, fertilizer selection, timing, application, application area, rates, storage and handling of fertilizer, sample fertilizer contract for commercial/ municipal clients.

Soil Management, Bryant Scharenbroch, E. Thomas Smiley, and Wes Kocher, 2014

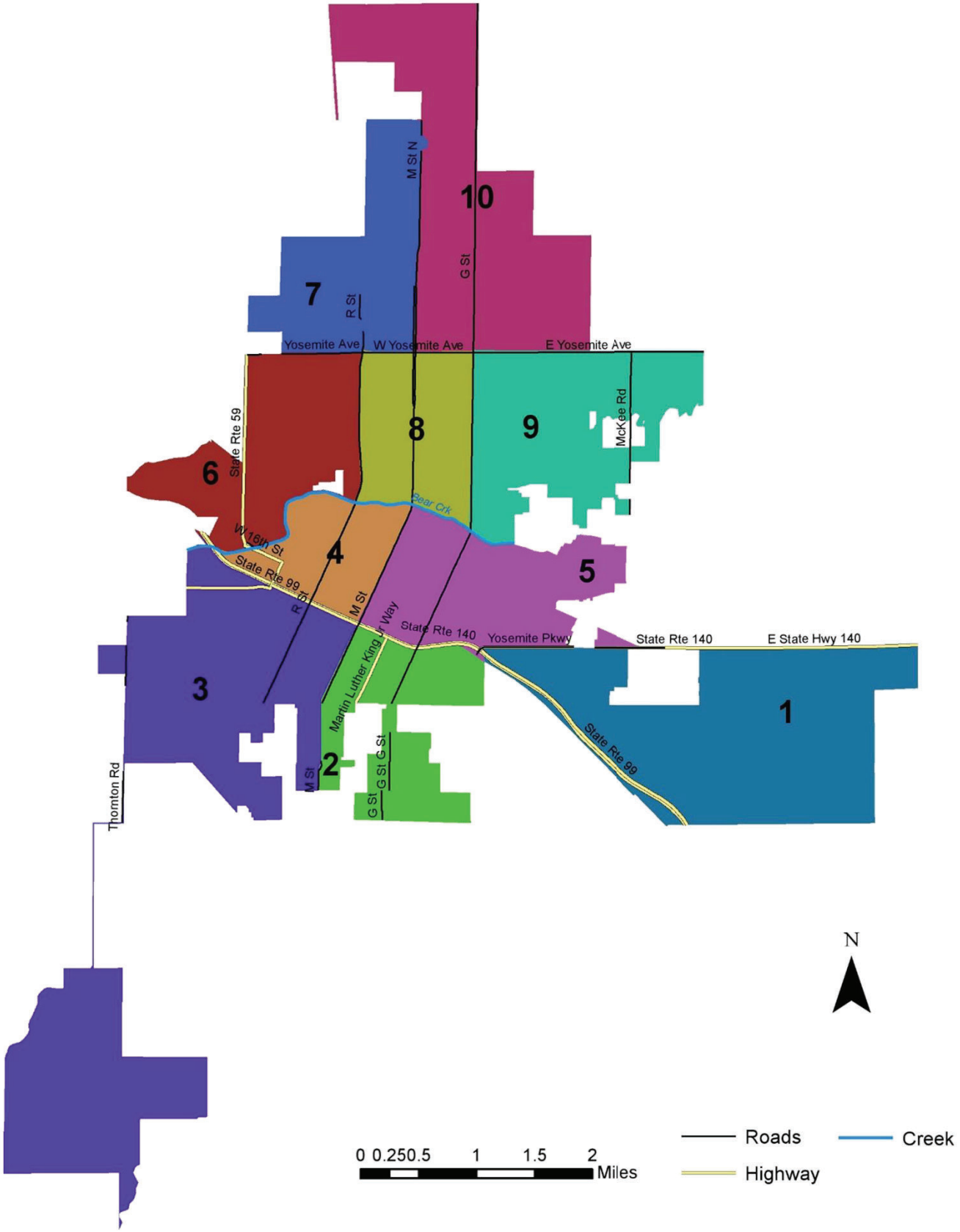
Focuses on the protection and restoration of soil quality that support trees and shrubs in the urban environment, including goals of soil management, assessment, sampling, and analysis, modifications and amendments, tillage, conservation, and a glossary of terms.

Utility Pruning of Trees, Geoffrey P. Kempter, 2004

Describes the current best practices in utility tree pruning based on scientific research and proven methodology for the safe and reliable delivery of utility services, while preventing unnecessary injury to trees. An overview of safety, tools and equipment, pruning methods and practices, and emergency restoration are included.

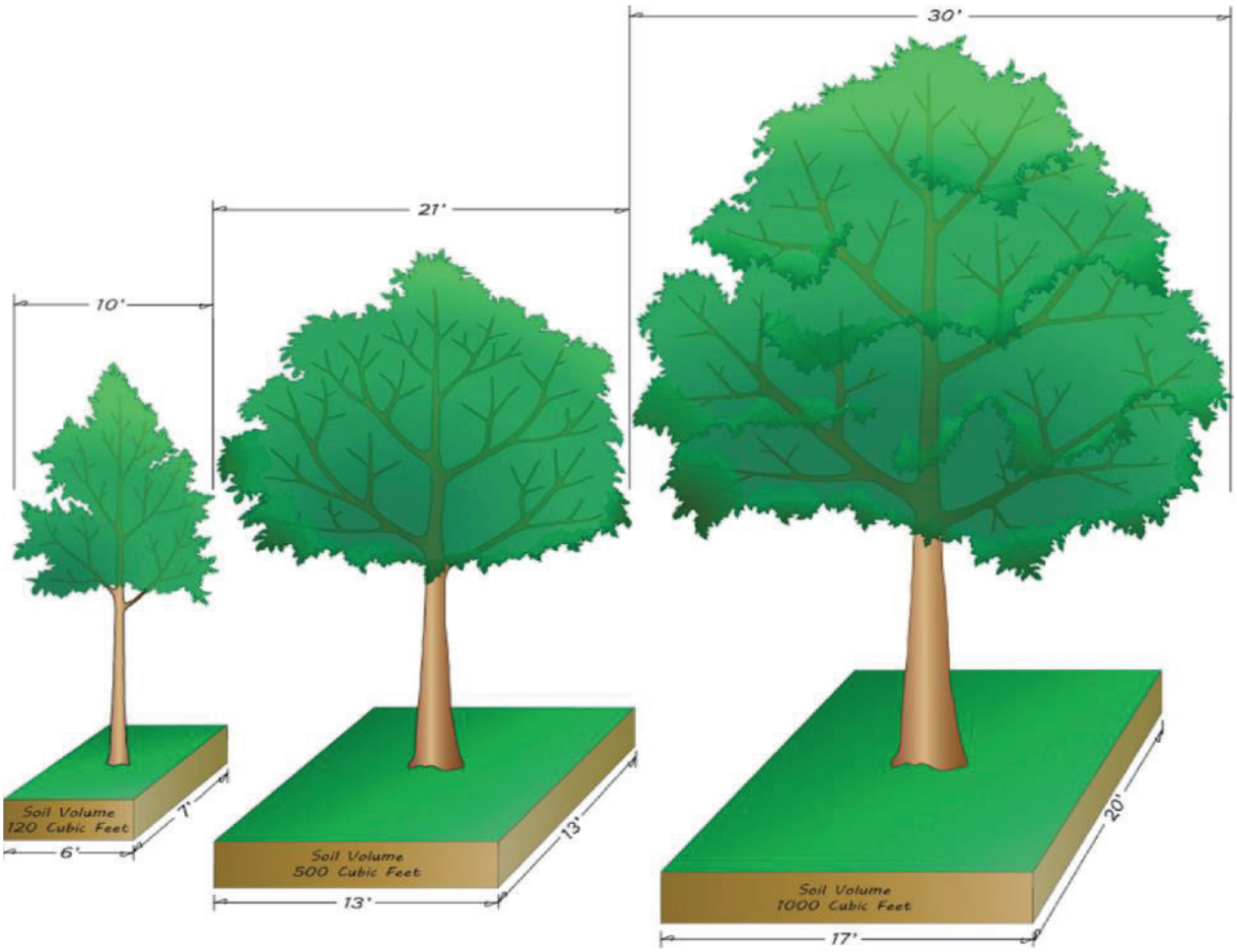
Appendix E: Maintenance Cycle Zone Map

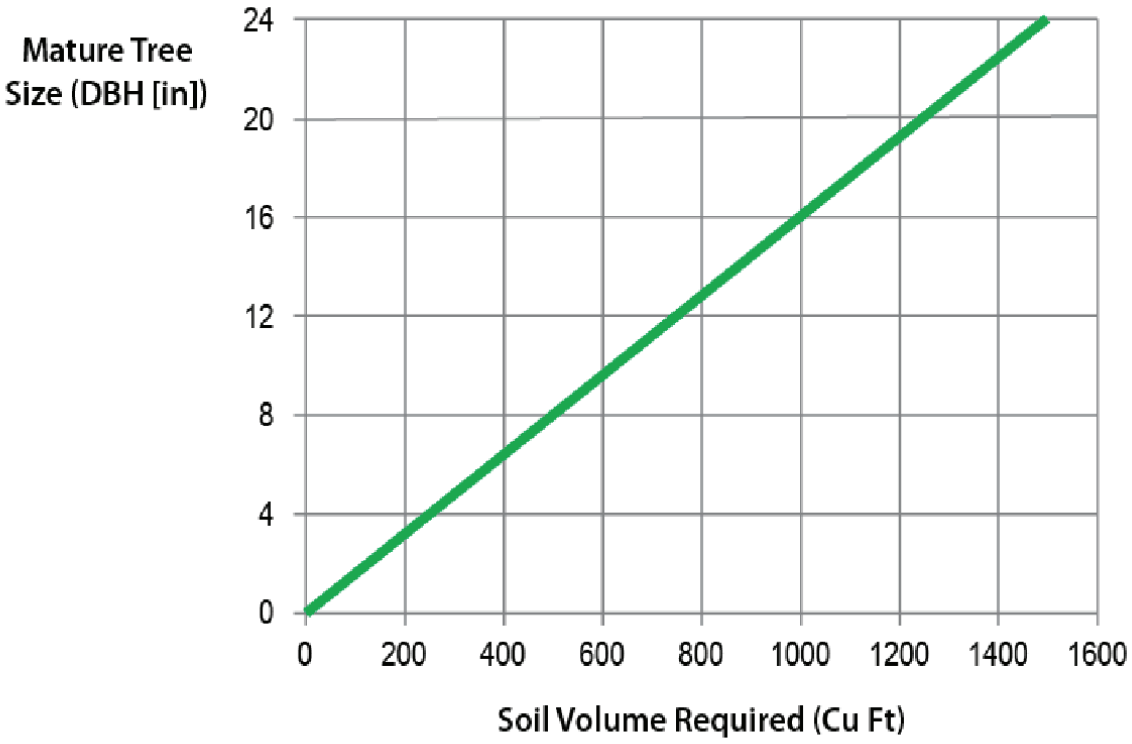
Map 5: Merced Maintenance Cycle Zone Map



Appendix F: Soil Volume and Tree Stature

Tree growth is limited by soil volume. Larger stature trees require larger volumes of uncompacted soil to reach mature size and canopy spread (Casey Trees, 2008).

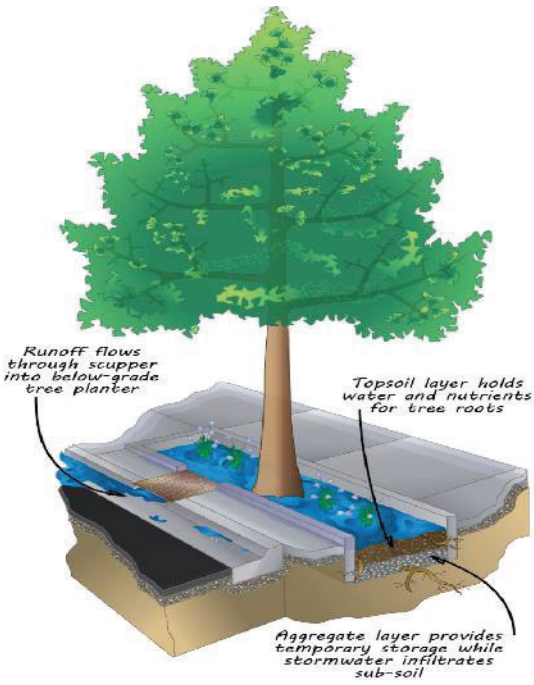



Mature Tree Size (DBH [in])
24
20
16
12
8
4
0
0
200
400
600
800
1000
1200
1400
1600
Soil Volume Required (Cu Ft)

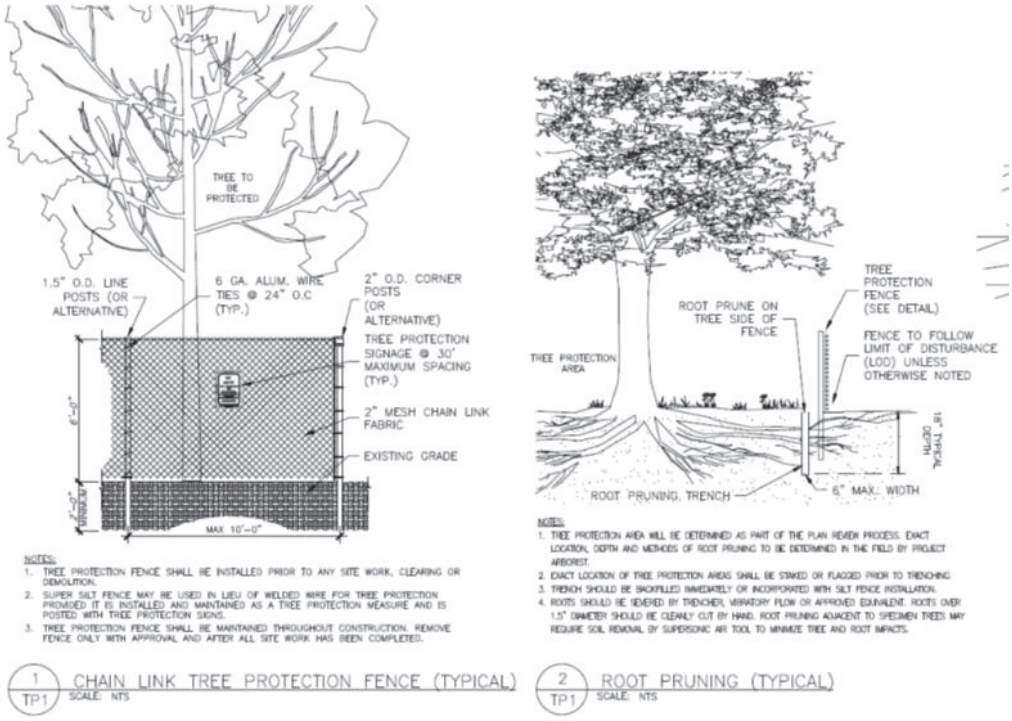
Appendix G: Alternative Planter Designs

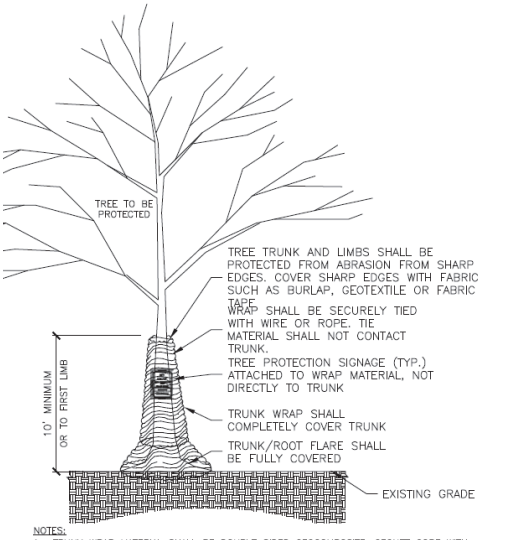
Stormwater tree pits are designed to collect runoff from streets, parking lots, and other impervious areas. Stormwater is directed into scuppers that flow into below-grade planters that then allow stormwater to infiltrate soils to supplement irrigation.

Bioswales are landscaped drainage areas with gently sloped sides designed to provide temporary storage while runoff infiltrates the soil. They reduce off-site runoff and trap pollutants and silt.



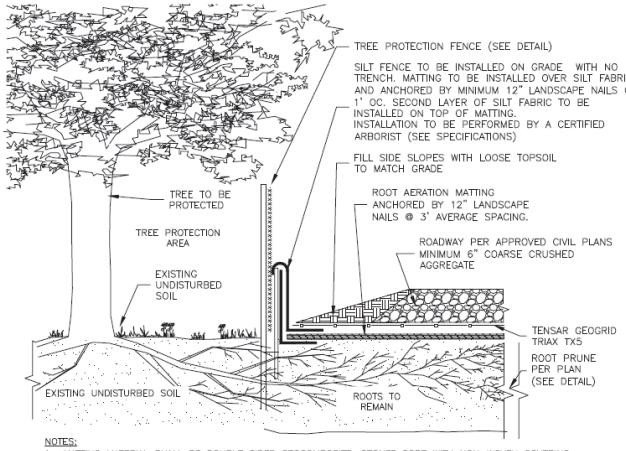
Tree Protection Zone – Example





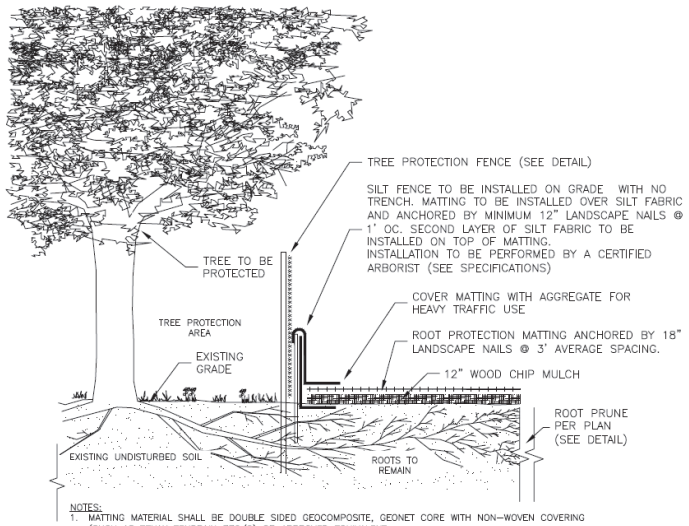
NOTES:
1. TRUNK WRAP MATERIAL SHALL BE DOUBLE SIDED GEOCOMPOSITE, GEONET CORE WITH NON-WOVEN COVERING (SUCH AS TENAX TENDRAIN 770/2) OR EQUIVALENT.
2. WRAP SHALL BE INSTALLED BY A CERTIFIED ARBORIST.
3. WRAP SHALL BE INSTALLED PRIOR TO ANY SITE WORK, CLEARING OR DEMOLITION.
4. WRAP SHALL BE MAINTAINED THROUGHOUT CONSTRUCTION. REMOVE WRAP ONLY WITH APPROVAL AND AFTER ALL SITE WORK HAS BEEN COMPLETED.
5. WRAP SHALL BE REMOVED PROMPTLY AFTER CONSTRUCTION.
6. MAJOR SCAFFOLD LIMBS MAY ALSO REQUIRE THIS PROTECTION AS DIRECTED BY THE PROJECT ARBORIST.

3 / TP1 TREE TRUNK & LIMB PROTECTION WRAP (TYP)
SCALE: NTS



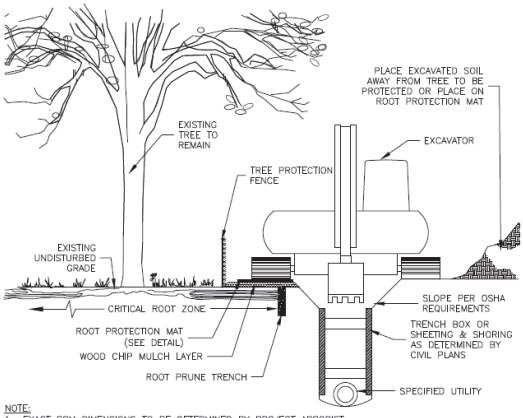
NOTES:
1. MATTING MATERIAL SHALL BE DOUBLE SIDED GEOCOMPOSITE, GEONET CORE WITH NON-WOVEN COVERING (SUCH AS TENAX TENDRAIN 770/2) OR APPROVED EQUIVALENT.
2. RAM SHALL BE ANCHORED BY 12" LANDSCAPE NAILS @ 3' AVERAGE SPACING.
3. RAM SHALL BE INSTALLED BY A CERTIFIED ARBORIST EXPERIENCED WITH THESE SYSTEMS.
4. ANY REQUIRED SITE PREPARATION/GRADING TO BE DONE USING SSAT TO MINIMIZE ROOT DAMAGE.
5. ALL ADJACENT WORK SHALL BE SUPERVISED BY CERTIFIED ARBORIST
6. GEOGRID SHALL BE TENSAR TRIAX TX5 OR APPROVED SUPERIOR.
7. AGGREGATE FILL SHALL BE TAPERED TO MATCH EXISTING GRADE WHOLLY ON RAM MATERIAL.
8. GEOGRID AND RAM PLACEMENTS SHALL BE OVERLAPPED BY 2'.
9. TOPSOIL MAY BE PLACED LOOSELY ON SIDE SLOPES AS REQUIRED TO MATCH GRADE. TOPSOIL SHALL NOT BE COMPACTED. RAM MUST EXTEND TO DAYLIGHT AND MAY BE TRIMMED AT FINAL TOE OF SLOPE.
10. SILT FENCE SHALL NOT BE TRENCHED AND MUST BE COORDINATED WITH ARBORIST FOR INSTALLATION.
11. EQUIPMENT/TRAFFIC SHALL NOT TRAVEL DIRECTLY ON RAM/GEOGRID. TRAFFIC MAY TRAVEL ON FINAL FILL ONLY.

4 / TP1 ROOT AERATION MATTING WITH GEOGRID FOR ROADWAY (TYP)
SCALE: NTS



NOTES:
1. MATTING MATERIAL SHALL BE DOUBLE SIDED GEOCOMPOSITE, GEONET CORE WITH NON-WOVEN COVERING (SUCH AS TENAX TENDRAIN 770/2) OR APPROVED EQUIVALENT.
2. RPM SHALL BE INSTALLED BY A CERTIFIED ARBORIST.
3. TO BE USED FOR DESIGNATED TEMPORARY CONSTRUCTION ACCESS AND STOCKPILE AREAS.
4. MATTING SHALL BE PLACED ON 12" WOOD CHIP MULCH UNLESS OTHERWISE DIRECTED.
5. FOR HEAVY TRAFFIC AREAS, MATTING SHALL BE COVERED WITH 6-8" WELL GRADED CRUSHED AGGREGATE. ADDITIONAL LAYERS OF GEOTEXTILE MAY BE NEEDED.

5 / TP1 TEMPORARY ROOT PROTECTION MATTING (TYPICAL)
SCALE: NTS



NOTE:
1. EXACT RPM DIMENSIONS TO BE DETERMINED BY PROJECT ARBORIST
2. ARBORIST TO COORDINATE WITH SITE SUPERINTENDENT FOR PIPE LAYOUT, DEPTH,SIZE OF EQUIPMENT, WIDTH OF TRENCH, AND OVERDIG TO DETERMINE LOCATION AND LAYOUT OF TREE PROTECTION.
3. ARBORIST TO COORDINATE WITH SITE SUPERINTENDENT FOR OVERHEAD CLEARANCE ISSUES. MAY REQUIRE SELECT PRUNING OR TEMPORARY GUYING.
4. ARBORIST TO MONITOR BACK FILL AND RESTORATION ADJACENT TO PROTECTED TREES.

6 / TP1 TREE PROTECTION FOR UNDERGROUND UTILITY (TYP)
SCALE: NTS

Appendix H: Urban Forestry Indicators & Gantt

Table 16: Indicators of a Sustainable Urban Forest

Indicators of a Sustainable Urban Forest		*Assessed Performance Level*		
		Low	**Medium**	**High**
The Trees	Urban Tree Canopy	X		
	Equitable Distribution		X	
	Size/Age Distribution		X	
	Condition of Public Trees - Streets, Parks			X
	Condition of Public Trees - Natural Areas			X
	Trees on Private Property		X	
	Species Diversity			X
	Suitability	X		
	Soil Volume	X		
The Players	Neighborhood Action		X	
	Large Private & Institutional Landholder Involvement	X		
	Green Industry Involvement		X	
	City Department/Agency Cooperation		X	
	Funder Engagement	X		
	Utility Engagement		X	
	Developer Engagement		X	
	Public Awareness		X	
	Regional Collaboration		X	
The Mgmt. Approach	Tree Inventory			X
	Canopy Assessment			X
	Management Plan			X
	Risk Management Program		X	
	Maintenance of Publicly Owned Trees (ROWs)		X	
	Planting Program		X	
	Tree Protection Policy		X	
	City Staffing and Equipment		X	
	Funding		X	
	Disaster Preparedness & Response		X	
	Communications			X
	Totals	*5*	*17*	*7*

Table 17: Indicators of a Sustainable Urban Forest: The Trees Assessment

THE TREES				
		Performance Levels		
Indicators of a Sustainable Urban Forest	Overall Objective or Industry Standard	Low	Medium	High
Urban Tree Canopy	Achieve the desired tree canopy cover according to goals set for the entire city and neighborhoods. Alternatively, achieve 75% of the total canopy possible for the entire city and in each neighborhood.	Canopy is decreasing. - and/or - No canopy goals have been set.	Canopy is not dropping, but not on a trajectory to achieve the established goal.	Canopy goal is achieved, or well on the way to achievement.
Location of Canopy (Equitable Distribution)	Achieve low variation between tree canopy and equity factors citywide by neighborhood. Ensure that the benefits of tree canopy are available to all, especially for those most affected by these benefits.	Tree planting and public outreach and education is not determined by tree canopy cover or benefits.	Tree planting and public outreach and education is focused on neighborhoods with low tree canopy.	Tree planting and public outreach and education is focused in neighborhoods with low tree canopy and a high need for tree benefits.
Age of Trees (Size and Age Distribution)	Establish a diverse-aged population of **public** trees across the entire city and for each neighborhood. Ideal standard: 0-8" DBH: 40% 9-17" DBH: 30% 18-24" DBH: 20% Over 24" DBH: 10%	No current information is available on size. - OR - Age distribution is not proportionally distributed across size classes at the city level.	Size classes are evenly distributed at the city level, though unevenly distributed at the neighborhood level.	Age distribution is generally aligned with the ideal standard diameter classes at the neighborhood level.
Condition of Publicly Owned Trees *(trees managed intensively)*	Possess a detailed understanding of tree condition and potential risk of all intensively managed, publicly owned trees. This information is used to direct maintenance actions.	No current information is available on tree condition or risk.	Information from a partial or sample or inventory is used to assess tree condition and risk.	Information from a current, GIS-based, 100% complete public tree inventory is used to indicate tree condition and risk.
Condition of Publicly-Owned Natural Areas *(trees managed extensively)*	Possess a detailed understanding of the ecological structure and function of all publicly owned natural areas (such as woodlands, ravines, stream corridors, etc.), as well as usage patterns.	No current information is available on tree condition or risk.	Publicly owned natural areas are identified in a sample-based "natural areas survey" or similar data.	Information from a current, GIS-based, 100% complete natural areas survey is utilized to document ecological structure and function, as well as usage patterns.
Trees on Private Property	Possess a solid understanding of the extent, location and general condition of trees on private lands.	No data is available on private trees.	Current tree canopy assessment reflects basic information (location) of both public and private canopy combined.	Detailed information available on private trees. Ex. bottom-up sample-based assessment of trees.
Diversity	Establish a genetically diverse population of publicly owned trees across the entire city and for each neighborhood. Tree populations should be comprised of no more than 30% of any family, 20% of any genus, or 10% of any species.	No current information is available on species. - OR -Fewer than five species dominate the entire tree population citywide.	No species represents more than 20% of the entire tree population citywide.	No species represents more than 10% of the entire tree population citywide.
Climate Resilience/Suitability	Establish a tree population suited to the urban environment and adapted to the overall region. Suitable species are gauged by exposure to imminent threats, considering the "Right Tree for the Right Place" concept and invasive species.	No current information is available on species suitability. - OR - Less than 50% of trees are considered suitable for the site.	50% to 75% of trees are considered suitable for the site.	More than 75% of trees are considered suitable for the site.
Space and Soil Volume	Establish minimum street tree soil volume requirements to ensure there is adequate space and soil for street trees to thrive. Minimum soil volumes by mature size: 1000 cubic feet for large trees; 600 cubic feet for medium trees; 300 cubic feet for small trees.	Minimum street tree soil volumes have not been established.	Minimum street tree soil volume has been established based on mature size of tree.	Minimum street tree soil volumes have been established and are required to be adhered to for all new street tree planting projects.

Table 18: Indicators of a Sustainable Urban Forest: The Players Assessment

THE PLAYERS				
Indicators of a Sustainable Urban Forest	**Overall Objective or Industry Standard**	**Performance Levels**		
		Low	**Medium**	**High**
Neighborhood Action	Citizens understand, cooperate, and participate in urban forest management at the neighborhood level. Urban forestry is a neighborhood-scale issue.	Little or no citizen involvement or neighborhood action.	Some active groups are engaged in advancing urban forestry activity, but with no unified set of goals or priorities.	The majority of all neighborhoods are organized, connected, and working towards a unified set of goals and priorities.
Large Private & Institutional Landholder Involvement	Large, private, and institutional landholders embrace citywide goals and objectives through targeted resource management plans.	Large private land holders are unaware of issues and potential influence in the urban forest. No large private land management plans are currently in place.	Education materials and advice is available to large private landholders. Few large private landholders or institutions have management plans in place.	Clear and concise goals are established for large private land holders through direct education and assistance programs. Key landholders and institutions have management plans in place.
Green Industry Involvement	The green industry works together to advance citywide urban forest goals and objectives. The city and its partners capitalize on local green industry expertise and innovation.	Little or no involvement from green industry leaders to advance local urban forestry goals.	Some partnerships are in place to advance local urban forestry goals, but more often for the short-term.	Long-term committed partnerships are working to advance local urban forestry goals.
City Department and Agency Cooperation	All city departments and agencies cooperate to advance citywide urban forestry goals and objectives.	Conflicting goals and/or actions among city departments and agencies.	Informal teams among departments and agencies are communicating and implementing common goals on a project-specific basis.	Common goals and collaboration occur across all departments and agencies. City policy and actions are implemented by formal interdepartmental and interagency working teams on all city projects.
Funder Engagement	Local funders are engaged and invested in urban forestry initiatives. Funding is adequate to implement citywide urban forest management plan.	Little or no funders are engaged in urban forestry initiatives.	Funders are engaged in urban forestry initiatives at minimal levels for short-term projects.	Multiple funders are fully engaged and active in urban forestry initiatives for short-term projects and long-term goals.
Utility Engagement	All utilities are aware of and vested in the urban forest and cooperates to advance citywide urban forest goals and objectives.	Utilities and city agencies act independently of urban forestry efforts. No coordination exists.	Utilities and city agencies have engaged in dialogues about urban forestry efforts with respect to capital improvement and infrastructure projects.	Utilities, city agencies, and other stakeholders integrate and collaborate on all urban forestry efforts, including planning, site work, and outreach/education.
State Engagement	State departments/agencies are aware of and vested in the urban forest and cooperates to advance citywide urban forest goals and objectives.	State departments/agencies and City agencies act independently of urban forestry efforts. No coordination exists.	State department/agencies and City agencies have engaged in dialogues about urban forestry efforts with respect to capital improvement and infrastructure projects.	State departments/agencies, City agencies, and other stakeholders integrate and collaborate on all urban forestry efforts, including planning, site work, and outreach/education.
Public Awareness	The general public understands the benefits of trees and advocates for the role and importance of the urban forest.	Trees are generally seen as a nuisance, and thus, a drain on city budgets and personal paychecks.	Trees are generally recognized as important and beneficial.	Trees are seen as valuable infrastructure and vital to the community's well-being. The urban forest is recognized for the unique environmental, economic, and social services its provides to the community.
Regional Collaboration	Neighboring communities and regional groups are actively cooperating and interacting to advance the region's stake in the city's urban forest.	Little or no interaction between neighboring communities and regional groups.	Neighboring communities and regional groups share similar goals and policy vehicles related to trees and the urban forest.	Regional urban forestry planning, coordination, and management is widespread.

Table 19: Indicators of a Sustainable Urban Forest: The Management Assessment

THE MANAGEMENT				
Indicators of a Sustainable Urban Forest THE MGMT APPROACH	**Overall Objective or Industry Standard**	**Performance Levels**		
		Low	**Medium**	**High**
Tree Inventory	Comprehensive, GIS-based, current inventory of all intensively managed public trees to guide management, with mechanisms in place to keep data current and available for use. Data allows for analysis of age distribution, condition, risk, diversity, and suitability.	No inventory or out-of-date inventory of publicly owned trees.	Partial or sample-based inventory of publicly owned trees, inconsistently updated.	Complete, GIS-based inventory of publicly owned trees, updated on a regular, systematic basis.
Canopy Assessment	Accurate, high-resolution, and recent assessment of existing and potential city-wide tree canopy cover that is regularly updated and available for use across various departments, agencies, and/or disciplines.	No tree canopy assessment.	Sample-based canopy cover assessment or dated (over 10 years old) high resolution canopy assessment.	High-resolution tree canopy assessment using aerial photographs or satellite imagery.
Management Plan	Existence and buy-in of a comprehensive urban forest management plan to achieve city-wide goals. Re-evaluation is conducted every 5 to 10 years.	No urban forest management plan exists.	A plan for the publicly owned forest resource exists but is limited in scope, acceptance, and implementation.	A comprehensive plan for the publicly owned forest resource exists and is accepted and implemented.
Risk Management Program	All publicly owned trees are managed for maximum public safety by way of maintaining a city-wide inventory, conducting proactive annual inspections, and eliminating hazards within a set timeframe based on risk level. Risk management program is outlined in the management plan.	Request-based, reactive system. The condition of publicly owned trees is unknown.	There is some degree of risk abatement thanks to knowledge of condition of publicly owned trees, though generally still managed as a request-based reactive system.	There is a complete tree inventory with risk assessment data and a risk abatement program in effect. Hazards are eliminated within a set time period depending on the level of risk.
Maintenance Program of Publicly Owned Trees *(trees managed intensively)*	All intensively managed, publicly owned trees are well maintained for optimal health and condition in order to extend longevity and maximize benefits. A reasonable cyclical pruning program is in place, generally targeting 5 to 7-year cycles. The maintenance program is outlined in the management plan.	Request-based, reactive system. No systematic pruning program is in place for publicly owned trees.	All publicly owned trees are systematically maintained, but pruning cycle is inadequate.	All publicly owned trees are proactively and systematically maintained and adequately pruned on a cyclical basis.
Maintenance Program of Publicly Owned Natural Areas *(trees managed extensively)*	The ecological structure and function of all publicly owned natural areas are protected and enhanced while accommodating public use where appropriate.	No natural areas management plans are in effect.	Only reactive management efforts to facilitate public use (risk abatement).	Management plans are in place for each publicly owned natural area focused on managing ecological structure and function and facilitating public use.
Planting Program	Comprehensive and effective tree planting and establishment program is driven by canopy cover goals, equity considerations, and other priorities according to the plan. Tree planting and establishment is outlined in the management plan.	Tree establishment is ad hoc.	Tree establishment is consistently funded and occurs on an annual basis.	Tree establishment is directed by needs derived from a tree inventory and other community plans and is sufficient in meeting canopy cover objectives.
Tree Protection Policy	Comprehensive and regularly updated tree protection ordinance with enforcement ability is based on community goals. The benefits derived from trees on public and private property are ensured by the enforcement of existing policies.	No tree protection policy.	Policies are in place to protect trees, but the policies are not well-enforced or ineffective.	Protections policies ensure the safety of trees on public and private land. The policies are enforced and supported by significant deterrents and shared ownership of city goals.
City Staffing and Equipment	Adequate staff and access to the equipment and vehicles to implement the management plan. A high-level urban forester or planning professional, strong operations staff, and solid certified arborist technicians.	Insufficient staffing levels, insufficiently trained staff, and/or inadequate equipment and vehicle availability.	Certified arborists and professional urban foresters on staff have some professional development but are lacking adequate staff levels or adequate equipment.	Multi-disciplinary team within the urban forestry unit, including an urban forestry professional, operations manager, and arborist technicians. Vehicles and equipment are sufficient to complete required work.
Funding	Appropriate funding in place to fully implement both proactive and reactive needs based on a comprehensive urban forest management plan.	Funding comes from the public sector only and covers only reactive work.	Funding levels (public and private) generally cover mostly reactive work. Low levels of risk management and planting in place.	Dynamic, active funding from engaged private partners and adequate public funding are used to proactively manage and expand the urban forest.
Disaster Preparedness & Response	A disaster management plan is in place related to the city's urban forest. The plan includes staff roles, contracts, response priorities, debris management and a crisis communication plan. Staff are regularly trained and/or updated.	No disaster response plan is in place.	A disaster plan is in place, but pieces are missing and/or staff are not regularly trained or updated.	A robust disaster management plan is in place, regularly updated and staff is fully trained on roles and processes.
Communication	Effective avenues of two-way communication exist between the city departments and between city and its citizens. Messaging is consistent and coordinated, when feasible.	No avenues are in place. City departments and public determine on an ad-hoc basis the best messages and avenues to communicate.	Avenues are in place but used sporadically and without coordination or only on a one-way basis.	Avenues are in place for two-way communication, are well-used with targeted, coordinated messages.

Table 20: Long-term Goals Gantt Chart

City of Merced Urban Forest Management Plan

Goals & Objectives	Cost	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Timeframe	Priority
Goal 1: Establish stable and predictable funding.														
Objective 1.1 Identify resources to fund tree maintenance.	$												1-3 Years	High
Goal 2: Efficiently maintain the community tree resource to manage risk, promote benefits, and enhance the health and resiliency of the urban forest.														
Objective 2.1 Establish a 5- to 7-year maintenance cycle to promote greater time management and efficiency.	$												8-Years	High
Objective 2.2 Create an Urban Forest Master Plan.	$$$												5-Years	Moderate
Goal 3: Set a goal for tree canopy cover.														
Objective 3.1 Engage with community members to identify a canopy goal supported by the entire community.	$												1-3 Years	High
Goal 4: Protect and preserve the M Street eucalyptus grove.														
Objective 4.1 Develop a specific plan for the M Street eucalyptus.	$												5 Years	High
Goal 5: Water trees, even during periods of drought.														
Objective 5.1 Educate and engage the community about irrigating City trees.	$												Ongoing	Moderate
Goal 6: Identify solutions for wood utilization.														
Objective 6.1 Divert urban wood away from the landfill whenever possible.	$												Ongoing	Moderate
Goal 7: Develop mutually beneficial community partnerships.														
Objective 7.1 Provide opportunities for students and volunteers to enhance the community tree resource.	$												Ongoing	Moderate
Goal 8: Mitigate and reduce the risk of wildfire.														
Objective 8.1 Contribute to a fire safe community.	$												Ongoing	Low

$ = less than $25,000 $$ = $25,000-$100,000 $$$ = more than $100,000