City of McFarland Urban Forest Plan

Concord Street, Santa Ana, CA - https://www.ocregister.com/2016/05/12/photos-jacaranda-flowers-cover-orange-county-streets-in-purple-haze/

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PROJECT REPORT

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City of McFarland Urban Forest Plan

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Executive Summary

The City of McFarland lies within Kern County in California. It is a small city with a population of a little over 15,000, and most residents work in agriculture, as the Central Valley is the most productive agricultural area in California. McFarland's population is over 95% Hispanic. The City is identified as a disadvantaged community due to its low median income and its high pollution burden, among the highest in the state. McFarland faces issues with air quality, flooding, and public health, as does much of Kern County.

Urban forests are one area of opportunity for cities affected by problems such as air pollution and high energy costs for air conditioning to reduce these problems and many others. Urban forests are the collection of trees and other woody vegetation within a given area or jurisdiction. Urban trees and vegetation have been shown to provide a wide variety of benefits to humans, including improved mental and physiological health, improved air and water quality, mitigated noise and aesthetic impacts, reduced stormwater runoff, and reduced urban heat island effect. Urban trees also provide various economic benefits, from reduced energy costs through shading buildings to increased property values and property tax revenues. Various studies have shown that urban trees tend to provide net financial benefits, and this has held true specifically for other Central Valley cities. This wide variety of benefits, combined with the financial returns gained, means that urban forests provide an opportunity for cities to improve the "triple bottom line" of people (social benefits), planet (environmental benefits), and profit (financial returns).

As McFarland has a hot, dry climate, only some tree species will be appropriate for planting. Several characteristics were used to select appropriate species, starting by eliminating any species not appropriate for USDA hardiness zone 9b and for loamy soils, giving a baseline compatibility with McFarland's environment. The remaining species were then chosen focusing primarily on drought tolerance and low water use, high branch strength and low root damage potential, wide canopies for maximum shade, and aesthetic appeal. The final list of recommended tree species can be found in Chapter 4.

Trees should be planted and oriented strategically to maximize the benefits derived, including maximizing shade on buildings, and maximizing overall size of the tree which increases the benefit magnitude. Chapter 5 makes recommendations to this end. Chapter 5 additionally outlines key areas in McFarland identified by the City of McFarland General Plan Update (2020) and suggests tree species and strategies appropriate for each area, such as the Downtown Infill area using patterns of small to moderate sized, attractive trees to line main streets to help create a distinctive and attractive streetscape.

Urban trees must be cared for regularly over the short and long-term to become as healthy and large as possible and provide the maximum potential benefits to cities and residents. Guidelines for tree planting strategies and maintenance are outlined in Chapter 6, and an implementation strategy is discussed in Chapter 7, including estimated potential costs and funding sources.

1. Introduction

This Urban Forest Plan, prepared specifically for the City of McFarland, is intended to serve as a guiding document for the City's future development with respect to the urban forest. It contains principles and suggestions for tree selection, tree location, tree maintenance, and an implementation strategy tailored to the context and needs of McFarland. Using this document, the City will have a strategy to improve and increase the urban forest which can guide the large amount of new development projected to occur to the south of the City in the next two decades. Development of a strong and healthy urban forest is one important step in the creation of a healthier, more prosperous, and more resilient McFarland.

The urban forest is the collection of trees, and more widely any woody plant growth, within an urban area. The management of urban forests is called urban forestry. In many cases, urban forests consist mostly of trees that were spared during urban development. However, it is now becoming more widely understood that a healthy and dense urban forest can provide numerous benefits to urban areas. Research conducted over the past few decades has shown that a wide variety of benefits for humans can be obtained from trees and urban forests, including health benefits, environmental benefits, and economic benefits. Examples of health benefits include reduced stress and anxiety levels and lower blood pressure (Hartig et al., 2003; Horiuchi et al., 2013). Environmental benefits include a reduction in the urban heat island effect, a phenomenon where urban areas with many paved, concrete, and dark surfaces absorb and hold heat and become hotter than their surrounding areas, improved air quality and sequestration of carbon dioxide (CO_2), as well as economic benefits including reduced building heating and cooling costs and increased property values (Bolund and Hunhammar, 1999; Escobedo et al., 2008; McPherson, Simpson, Xiao, and Wu, 2011). These benefits will be described in further detail in Chapter 3 of this plan.

Urban forests may be able to provide a wide variety of benefits, but if care is not taken in the planning and management of the urban forest, the magnitude of the benefits can decline, and costs can potentially outweigh benefits. However, with good planning and management, urban forests can be a lucrative and sustainable investment. Many factors must be considered in choosing which trees to plant, where to plant them, how and when to care for them, and how to pay for and implement strategies to improve the urban forest. In tree selection, canopy size, mature height, growth rate, longevity, drought tolerance, branch strength, and susceptibility to fire must all be considered, among other factors. Performed in tandem with tree selection is tree location, accounting for the relative location of buildings and infrastructure, shade creation, right of way availability, speed of growth and mature size, and other factors. Many cities also like to create unique and visually striking areas with consistent types and spacings of trees, such as lining a main boulevard with tall palm trees on both sides. Once trees are selected and planted, they must be maintained regularly, typically requiring irrigation for some time, periodic pruning, and litter removal. Care must be taken to ensure that trees do not interfere with utility infrastructure or buildings and that branches do not become a safety hazard. None of these activities can take place effectively, however, without an implementation plan and funding sources. Thus, to obtain the most benefits with the lowest costs, a plan is needed to guide the development and maintenance of the urban forest. Each of these phases are addressed in Chapters 4, 5, 6, and 7 of this plan.

The City of McFarland, California, is a small agricultural community about 25 miles north of Bakersfield, California. Just over 80% of the workforce is in agricultural production or processing, with about 36% of the population living below the poverty line in 2017 compared to Kern County's 23% and California's 15% (Background Report, 2019, p. 24). The City has ongoing issues raising and maintaining the money they need to provide adequate planning and municipal services. Further, the City is within the San Joaquin Valley Air Basin, which is out of attainment for multiple air pollutants including ozone and particulate matter 2.5 and 10 (PM 2.5 and PM 10). It is in the 75th-80th percentile in CalEnviroScreen, a mapping tool that shows the burden of pollution and socioeconomic factors of communities in California, with the entire surrounding area in the 91st-100th percentile, indicating a high pollution and economic burden. Trees absorb some air pollutants into their leaves and serve as sites for deposition of other pollutants, removing them from the air and improving air quality for humans. McFarland also suffers from a lack of hospital or emergency room and has only two medical clinics, and Kern County in general suffers from some of the highest rates of deaths related to diabetes, coronary heart disease, and cerebrovascular diseases in California.

Tackling this wide variety of issues will require a variety of solutions, and the combined efforts of many people and organizations. Increasing the size of the urban forest in McFarland is one solution that would help improve air quality, improve psychological and physiological health for residents, reduce heating and cooling costs for the City and for residents, and increase property values, as well as improving resilience to climate change and sequestering CO2, a greenhouse gas (GHG) that is one of the primary drivers of climate change.

2. Background and Setting

Between September of 2019 and March of 2020, the second year cohort of students in the Master's in City & Regional Planning program at California Polytechnic State University at San Luis Obispo (Cal Poly SLO) prepared a background report and a draft updated General Plan for the City of McFarland as part of their coursework. This Urban Forest Plan is an extension of and supplement to this existing work.

2.1 The City of McFarland

The City of McFarland lies in the Central Valley in Kern County, California. It is located approximately 25 miles north of Bakersfield, the nearest major city. Figure 2-1 shows the location of McFarland within Kern County and California, while Figure 2-2 shows a more detailed view of the City through the City of McFarland General Plan Update (2020) conceptual land use map. McFarland covers approximately 2.7 square miles.

Figure 2-1: Location of McFarland in Kern County and California (Source: 2016 General Plan Amendment EIR)

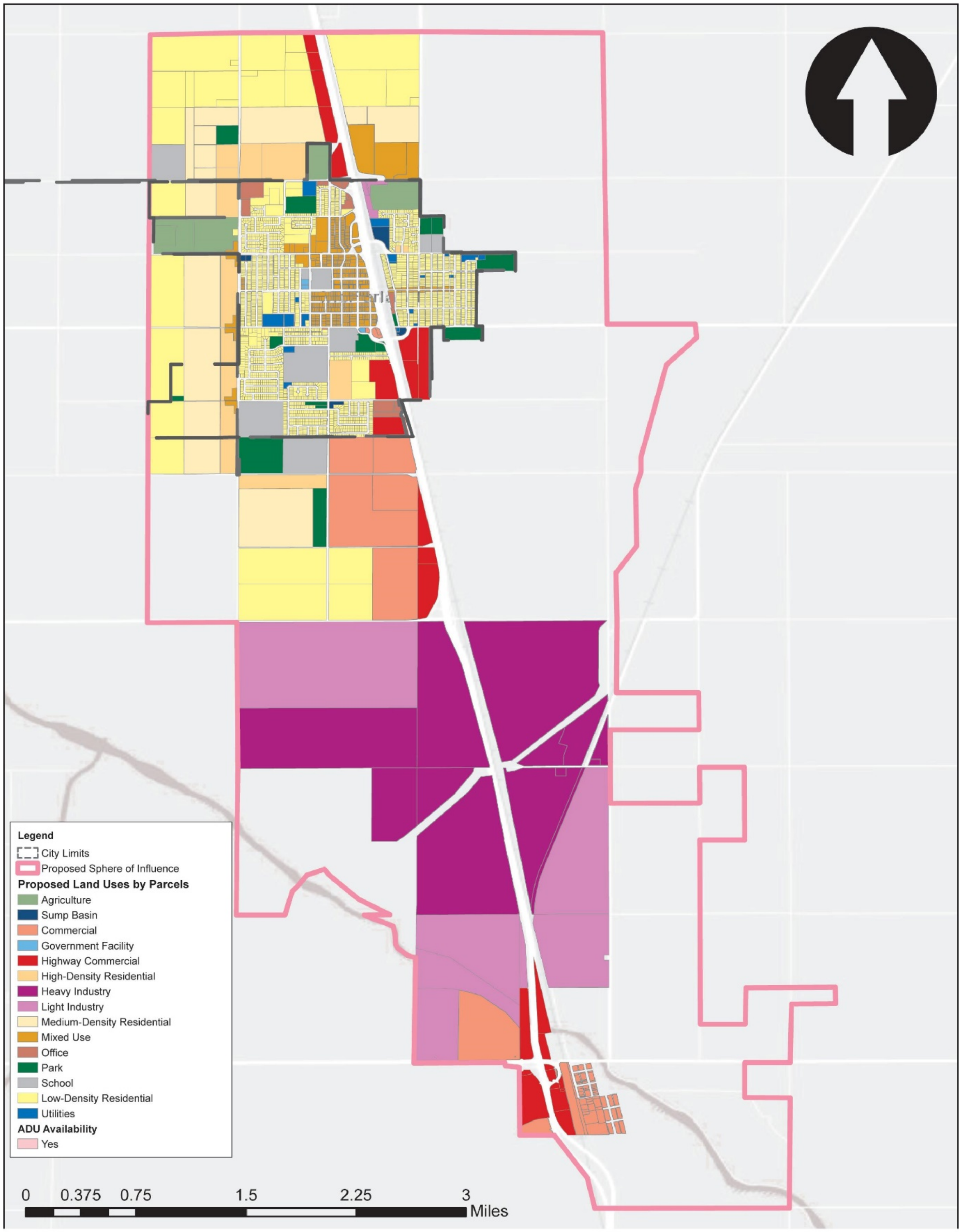


Figure 2-2: Proposed land use map from the City of McFarland General Plan Update, 2020

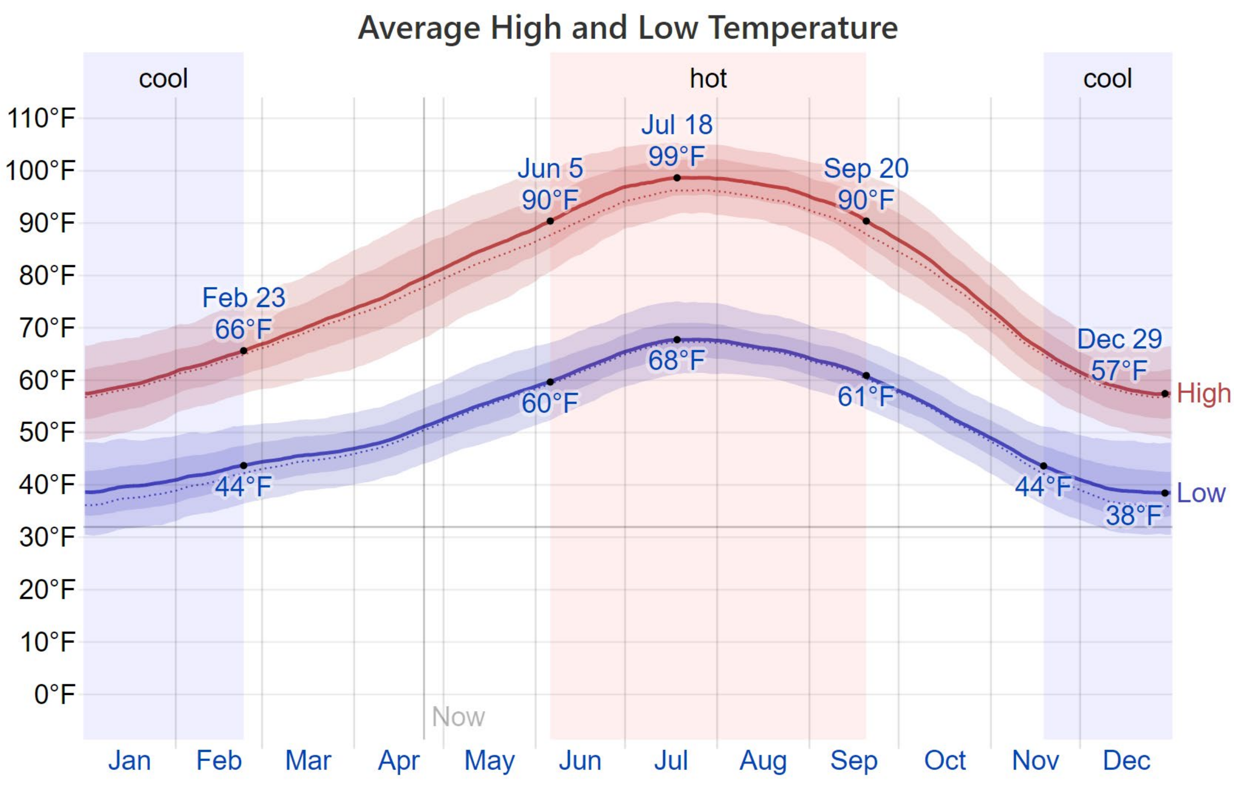
The City had a population of just over 13,000 in 2015, about 15,242 in 2019, and the population is projected to increase to approximately 23,690 by 2040 (General Plan, 2020, p. xx). The median household income is just over $35,000 per year, 69% of the median of Kern County and

52% of the median of California (Background Report, 2019, p. 22-23). Approximately 96% of the population of McFarland identifies as Hispanic or Latino, and 36% of the population is below the poverty line (Background Report, 2019, p. 23-24). In 2017, the median age in McFarland was about 26, compared to California's 36 years. (Background Report, 2019, p. 19-20)

McFarland is an agricultural community, with 80% of the workforce employed in the agriculture sector (Background Report, 2019, p. 86). Open space, orchards, and active farming lands surround McFarland and there are many agricultural processing facilities in the wider area. The area is known for producing grapes, almonds, and dairy. The City was featured in the 2015 movie *McFarland USA* based on the true story of the high school cross country team winning nine state championships over fourteen years under the guidance of coach Jim White.

2.2 Environment and Climate

McFarland has a hot, semi-arid climate according to the Koppen climate classification system. It has hot, dry, sunny summers and cool, partly cloudy winters. It is essentially flat in its topography. As seen in Figure 2-3, the temperature over the year varies between about 38 to 99 degrees Fahrenheit, rarely reaching below 30 or above 105 degrees Fahrenheit, and humidity remains consistently around zero (Weather Spark, 2020).



The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. The thin dotted lines are the corresponding average perceived temperatures.

Figure 2-3: Chart of average temperature throughout the year in McFarland (Source: Weather Spark, 2020)

From June to September, the average daily high temperature is over 90 degrees Fahrenheit, and from November to February, the average daily high temperature is below 66 degrees Fahrenheit, defining the hot and cold seasons in McFarland, respectively. McFarland receives an average of just over seven inches of precipitation per year, with the majority falling as rain between November and April. Hourly average wind speeds range from about 4-7 miles per hour over the year. The growing season, defined as the longest continuous period of non-freezing temperatures over the year, is about 11 months, with mid-December to mid-January being the excluded month (Weather Spark, 2020).

Almost all soil within the boundaries of the City of McFarland consists of McFarland Loam, with Kimberlina Fine Sandy Loam, Delano Sandy Loam, and Wasco Sandy Loam interspersed in the surrounding area, as seen in Figure 2-4. The City is surrounded by Prime Farmland, a designation assigned by the United State Department of Agriculture (USDA) for lands most well suited to producing crops because of their physical and chemical characteristics (Background Report, 2019, p. 132-134).

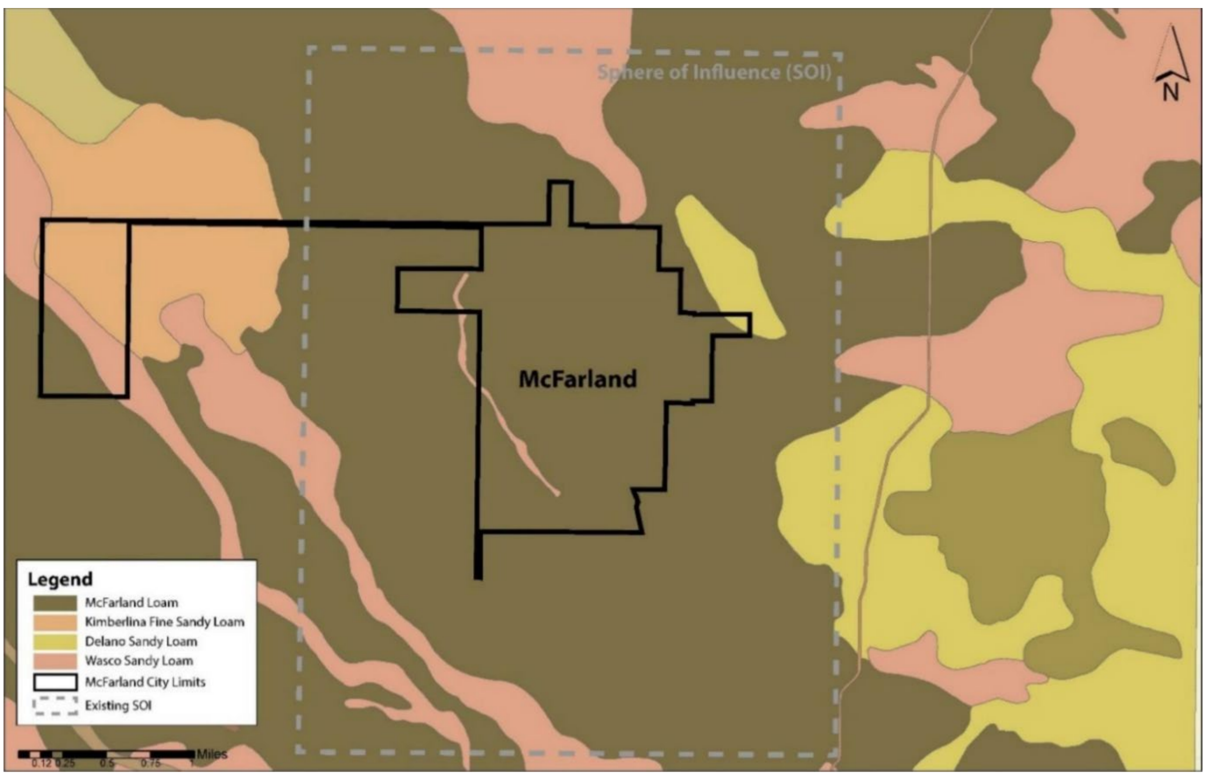


Figure 2-4: Map of soils in and around McFarland (Source: Background Report, 2019, p. 120)

McFarland is within the USDA hardiness zone 9b, a metric based on the average annual minimum winter temperature (in this case, 25 to 30 degrees Fahrenheit). Hardiness zones in the US vary between 0 (the coldest) and 12 (the warmest) and provide a general idea of which plants can survive in different locations based on their ability to survive the cold. For comparison, other cities in hardiness zone 9b include Sacramento, California, Tucson, Arizona, New Orleans, Louisiana, and Orlando, Florida.

As a Central Valley community in the San Joaquin Valley Air Basin, the City has poor air quality. The San Joaquin Valley Air Basin is not in attainment with federal PM2.5 or ozone standards, and is not in attainment with state PM10, PM2.5, or ozone standards (Background Report, 2019, p. 152). The City is in the 75th-80th percentile range of CalEnviroScreen, a mapping tool that shows the relative burden of pollution and socioeconomic hardship in communities across the state of California, as seen in Figure 2-5. The area surrounding McFarland is in the 91st-100th percentile, indicating the most pollution and socioeconomic burden relative to communities across California (Background Report, 2019, p. 171).

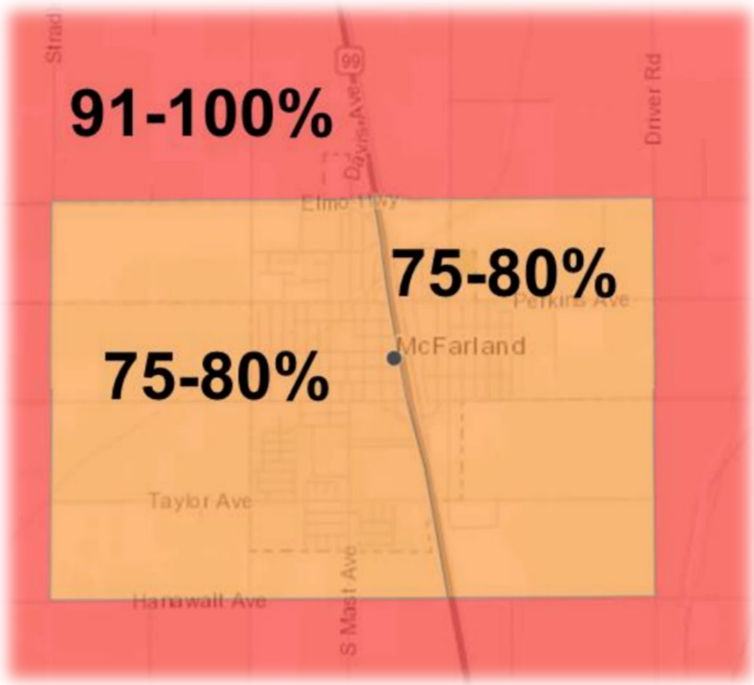


Figure 2-5: CalEnviroScreen percentile map of McFarland (Source: Background Report, 2019, p. 171)

3. Literature Review

In recent decades, major advancements have been made in research around trees and other urban vegetation. This research has begun to quantify the various benefits of urban trees and vegetation and the results so far are quite promising, with trees providing a wide variety of health, environmental, and economic benefits, and often providing a positive financial return on investment.

3.1 Health Benefits of Trees

It has been established through research over the past few decades that exposure to trees in urban settings provide various psychological and physiological health benefits to humans. With respect to physical health, for example, three studies of surgery patients whose rooms had plants in them found those patients had reduced intake of analgesics, improved physiological responses, and reported decreased pain, fatigue, and anxiety, as well as greater satisfaction with their room relative to patients in rooms without plants, as seen in Figure 3-1, (Park, 2006), while an earlier study found that surgery patients who had a view of trees through a window in their hospital rooms had shorter postoperative stays, fewer negative comments regarding nurses, and reduced analgesic intake relative to patients who had views of brick walls (Ulrich, 1984).

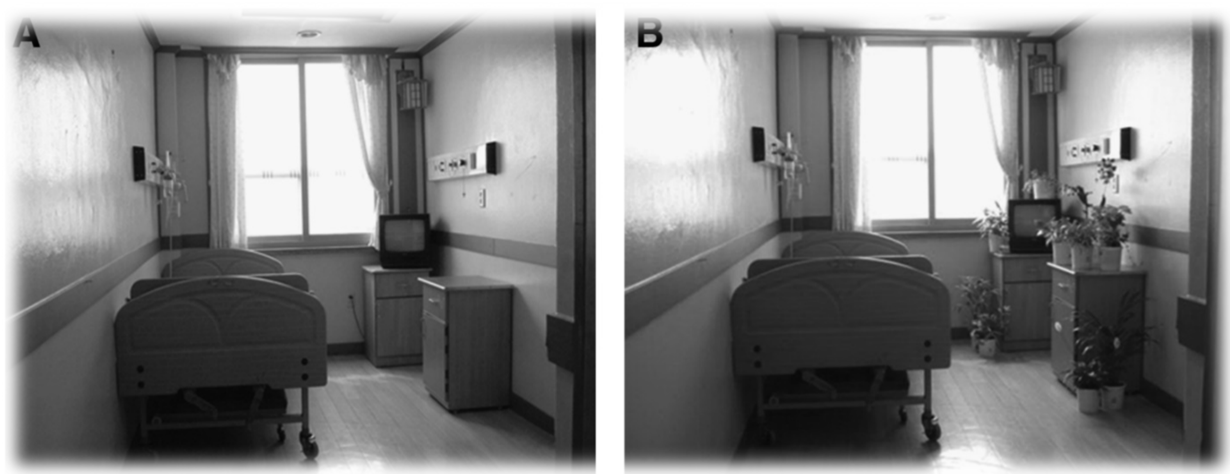


Figure 3-1: Hospital rooms without (A) and with (B) ornamental plants, from Park, 2006

The benefits of a simple view of nature are surprisingly significant. For example, one study found that inmates whose cells had views of nature suffered fewer physical problems such as digestive illnesses and headaches, and found they required medical treatment less often relative to inmates whose cells had views of buildings or other inmates (West, 1986).
It seems that plants can even improve pain tolerance, as measured by the length of time subjects were willing to endure submerging their hands in ice water, and it further appears that the presence of colorful/visually interesting objects did not have the same effect (Lohr and Pearson-Mims, 2000). Other studies on the physiological effects of exposure to nature and vegetated areas in humans show that such exposure can reduce blood pressure, improve mood, and reduce anger, and can reduce salivary cortisol, which is an indicator of stress levels (Hartig et al., 2003; Horiuchi et al., 2013).

Zooming out to a larger scale, in one study, data on public health in Wisconsin and satellite imagery of neighborhood greenness were utilized to find that higher levels of neighborhood greenness were associated with reduced intensity of depression and anxiety, evidence that governments and cities in general could increase the density of vegetation in residential areas and accrue major benefits to the psychological health of residents (Beyer et al., 2014). A study in Scotland found that greater presence of green space was associated with reduced stress levels and lower cortisol levels (Roe et al., 2013), while a similar but larger study of Dutch residents found similar results, namely that those living in areas with more green space had much better self-reported health indicators such as reported stress and fatigue levels relative to those in neighborhoods with less green space, even after controlling for socioeconomic status and various demographic factors (Vries, Verheij, Groenewegen, and Spreeuwenberg, 2003). The conclusions from that study have been found in several other countries, including England, Australia, Denmark, and Japan, evidence that the benefits of green spaces apply across highly varied cultures and environments (Steg and de Groot, 2012).

Figure 3-2: Trees along State Route 99 in McFarland, California (Source: LA Times)

Neighborhood greenness in Miami-Dade County in Florida was found to correlate very strongly with better health in Medicaid beneficiaries after adjusting for various confounding variables, and found that this relationship was actually stronger in poorer neighborhoods compared to wealthier ones, suggesting an equity improvement aspect to urban vegetation (Brown et al., 2016). The spread of the Emerald Ash Borer in the Midwestern US between 1990 and 2010 killed over 100 million trees and afforded a natural experiment which showed that the loss of trees increased deaths due to cardiovascular and lower respiratory illnesses, as well as caused an increase in crime proportional to the intensity of infestation (Donovan et al., 2013; Kondo, Han, Donovan, and Macdonald, 2017). A study examining depressed subjects found that they had greatly improved mood and short-term memory after a 50-minute walk through a natural setting, but not through an urban setting (Berman et al., 2012), and it is further known that similar cognitive benefits are afforded to non-depressed individuals (Berman, Jonides, and Kaplan, 2008), more evidence that increasing the density of urban vegetation would provide cognitive (and therefore, economically productive) benefits to citizens.

3.2 Environmental Benefits of Trees

It is further well established that urban vegetation, including street trees, provide various ecosystem services, or natural cycles and processes that benefit humans. These benefits vary widely, including air and water quality improvement, as well as reduced heating and cooling loads for shaded and shielded buildings and reduced urban heat island effect.

Figure 3-3: Paseo del Prado in Madrid, Spain, with ample shade from trees (Source: "Shade" by 99% Invisible)

In warm, sunny times of the year, trees shade buildings and houses as in Figure 3-3, reducing the cooling load placed upon them and thus reducing use of air conditioning. In winter, trees reduce wind speed, which lessens the heating load and thus the burning of natural gas or use of electricity for heating the home (Bolund and Hunhammar, 1999). Trees also filter air pollution, with one study estimating that up to 70-80% of pollutants in the air on streets and in parks could be filtered with a high enough density of trees and other vegetation (Bolund and Hunhammar, 1999). A study of the urban forest in Santiago, Chile, found that it was a cost-effective way to abate PM10 levels (Escobedo et al., 2008). Trees absorb pollutants through their leaves and serve as objects for pollutants to deposit onto, and it is estimated that urban park trees alone remove 75,000 tons of pollutants (an estimated value of about $500 million/year) in the US (Nowak and Heisler, 2010).

A study of the effects of street trees in Los Angeles found that percentage of shaded tree cover in city blocks explained more than 60% of land surface temperature variations, and that blocks with more than 30% tree cover could be five degrees Fahrenheit cooler than blocks with cover of 1% or less, and that tree shade appears to be the main source of cooling and not surface evapotranspiration, as irrigated grass provided almost no temperature benefit (Pincetl, Gillespie, Pataki, Saatchi, and Saphores, 2012). Trees, as well as other vegetation, help reduce runoff of precipitation and flatten out the peak flow of stormwater, mitigating flooding risks and improving groundwater recharge (Bolund and Hunhammar, 1999). A study of canopy interception of street trees in Sacramento found that trees likely provide significant water quality benefits through reduction of pollutant washout, especially in smaller precipitation events (Xiao, McPherson, Simpson, and Uston, 1998). In the Central Valley specifically, reductions in interior air temperatures of houses completely shaded by trees ranged from 2 degrees Fahrenheit for insulated houses to 6 degrees Fahrenheit for uninsulated houses, presenting an opportunity for significant savings on air conditioning through planting of shade trees (Heisler, 1986). All of these benefits come along with an opportunity for improved aesthetic appeal within a community, including trees with unusually colored leaves such as those of the Jacaranda tree in Figure 3-4.

Figure 3-4: Purple Jacaranda trees providing shade and aesthetic appeal in South Pasadena, California (Source: David McNew, Getty Images)

Trees absorb carbon dioxide (CO_2) and “store” it as carbon in their biomass. The CO_2 absorbed by a tree and “stored” as biomass is referred to as being “sequestered,” which gives us the commonly used phrase “carbon sequestration” to refer to the entire process. When examining the effect of an item or process on CO_2 in the atmosphere, a life cycle analysis is the best tool to use, as it considers impacts and emissions from every part of the subject being studied. A life cycle analysis was conducted for the existing and projected effects of the Million Trees Los Angeles project, which found that the project would be a net CO_2 sink, or would overall reduce CO_2 in the atmosphere considering all emissions, including emissions associated with irrigation, trimming and pruning equipment, and other maintenance requirements (McPherson, Kendall, and Albers, 2014). Another study conducted on urban green space in Leipzig, Germany found that urban tree cover is a net CO_2 sink, and that maintenance and other CO_2 emissions were significantly lower than the amount of CO_2 sequestered by the trees, though under scenarios with high mortality rates (4% per year or more) the carbon sequestration benefits were significantly reduced (Strohbach, Arnold, and Haase, 2012). Different tree species have different amounts of carbon they can potentially sequester, but this is primarily based on mature height, longevity, and growth rate, and secondary carbon reductions such as energy conservation are a major component of the net CO_2 reduction (Nowak, Stevens, Sisinni, and Luley, 2002). To minimize CO_2 emissions and maximize CO_2 reductions, it is recommended to plant long-lived, fast-growing, low-maintenance tree species that are large when mature and well-suited to the site conditions, maintain trees to improve their survival and lifespan, minimize fossil fuel use in maintenance, use or landfill wood from dead or removed trees, and plant trees so as to maximize energy conservation (Nowak, Stevens, Sisinni, and Luley, 2002). Mulching trees that are dead or removed for other reasons results in rapid decomposition and return of sequestered CO_2 to the atmosphere, while using the same trees to create wood products (furniture, plywood, etc.) or putting them in established landfills will keep much more of the CO_2 sequestered (Nowak, Stevens, Sisinni, and Luley, 2002). Burying trees beneath a sufficient layer of soil also reduces the rate of decomposition significantly and presents a potential solution where reuse or landfilling is impractical (Zeng, 2008).

Figure 3-5: Visualization of Melbourne, Australia's potential for urban greening with street trees, parks, and green roofs (Source: Yale Climate Connections)

3.3 Economic Benefits of Trees

Many studies have shown that higher property values correlate with greater density of green space and tree canopy area, indicating that property owners in many areas are willing to pay more money for properties and residences in greener locations (Payton et al., 2008) Even in California, where property taxes are limited under Prop 13, a study of the Million Trees Los Angeles (MTLA) initiative indicated that if the proposed million trees were actually planted, the city could accrue benefits of between $1.33-$1.95 billion (depending on tree mortality rates), and that about 81% of these economic benefits would be derived from aesthetic/placemaking/well-being benefits (as measured by property sale prices), though these benefits were not discounted over time (McPherson, Simpson, Xiao, and Wu, 2011). Those benefits, on average every year, work out to between $38 and $56 per tree planted. Street trees result in direct savings through lower energy costs for citizens and people who work in the city with the trees. Street trees can reduce energy use significantly, even in difficult climates:

> "In Chicago it has been shown that an increase in tree cover by 10%, or planting about three trees per building lot, could reduce the total energy for heating and cooling by US $50–90 per dwelling unit per year. The present value of long-term benefits by the trees was… more than twice the present value of costs." (Bolund and Hunhammar, 1999)

Several studies have found that between lower energy usage, deposition of air pollution, CO_2 sequestration, stormwater runoff reduction, and property value increase, street trees provide economic benefits multiple times over their cost to install and maintain. A study in Lisbon, Portugal found a return to the City of about $4-5 per $1 spent on tree upkeep (Soares et al., 2011). A study out of Adelaide in Australia determined that the average street tree in the City provides roughly $170 in net benefits per year (Killicoat, Puzio, & Stringer, 2002).

A study based in California examined data from almost a million street trees in 50 cities across the state; the 9.1 million street trees that exist in total in the state remove about 567,000 tons of CO_2 per year, the equivalent of taking 120,000 cars off the roads, and the return on investment from ecosystem services provided, on average, is just under $6 per $1 spent on management (McPherson, Doorn, & Goede, 2016). A study of communities in the San Joaquin Valley, which includes McFarland, found that adding just two to three trees around homes in Fresno could result in savings of over $100 annually on energy costs (McPherson, Simpson, Peper, and Xiao, 1999a). The same study found that urban trees in Sacramento County was effective at reducing ozone and PM10, reducing air temperatures, and reducing emissions from gasoline evaporation from vehicles, creating savings in multiple areas and for multiple stakeholders (McPherson, Simpson, Peper, and Xiao, 1999a). The estimated annual benefits of residential yard trees in the San Joaquin Valley were found to be about $10 for a small tree (about 12 feet tall) ranging up to almost $65 for large trees (40+ feet tall) (McPherson, Simpson, Peper, and Xiao, 1999a). Another study of single-family homes in Sacramento, California, with a climate quite similar to McFarland's, found that the average amount of shade provided by trees to the houses saved about 5% on electricity in the summer, and that one London Planetree like those in Figure 3-5 (*Platanus spp.*) planted on the west side of a house would reduce net summertime carbon emissions from electricity use by 31% over 100 years (Donovan and Butry, 2009).

Figure 3-6: London Plane Tree (Platanus x hispanica) lining a path (Source: Architectural Plants)

A study of single family home sales in Portland, Oregon, found that the amount of canopy cover and the number of street trees fronting a house accounted for over $8,000 dollars (about 3%) out of the total average selling price of a house, and that when comparing the increased property taxes to the amount spent by the City of Portland on tree management, the cost/benefit ratio for the City is almost 1:12 (about $4.6 million spent for a ~$54 million increase in property taxes) (Donovan & Butry, 2010). Even when looking at the potential costs related to trees breaking sidewalks and cracking pavement, researchers have found that the shading effects of trees typically help protect pavement more than the roots cause damage, depending on species, and the various economic benefits of the trees easily outweigh the costs of pavement repair either way (McPherson & Muchnick, 2005). These studies, spanning multiple countries, continents, and both hemispheres, show that street trees provide directly measurable economic benefits across multiple mechanisms and environmental service provisions.

Davis, California, a city west of Sacramento in Yolo County, is known for its urban forestry program. It had a population of about 70,000 as of 2018 and a very similar, but slightly cooler and wetter climate than McFarland. A study of Davis' street trees found that in Fiscal Year (FY) 1999, public street trees saved an estimated $274k in reduced energy costs, $279k in improved local air quality, $102k in atmospheric CO_2 reductions, $24k in stormwater management cost reductions, and over $1m in increased property values for a total benefit package of $1.7m

(Maco and McPherson, 2003). The City of Davis spent an estimated $450k on their urban trees in FY 1999, including planting new trees, pruning, removing dead trees, treating diseases, and repairing sidewalk damage, giving a cost benefit ratio of approximately 1:3.8, meaning the community received $3.80 worth of benefits for every $1 spent on the trees (Maco and McPherson, 2003). A study of Modesto's urban forest for FY 1997-1998 found the City spent $2.6m in exchange for total benefits of $4.95m, a net benefit of just over $2.3m (McPherson, Simpson, Peper, and Xiao, 1999b).

3.4 Summary of Benefits

A summary of the benefits of urban trees can be found in Table 1, based on the reviewed literature. The benefits are categorized as they are in the previous sections – Health/Social, Environmental, and Economic benefits, despite many of the benefits overlapping these groups significantly.

Table 1: Benefits of Urban Trees

Health/Social	Environmental	Economic
• Reduced anxiety and depression	• Reduced fossil fuel use through energy conservation	• Higher property values and property tax revenue
• Reduced stress and fatigue	• Reduced air pollution	• Reduced expenses for repairing pavement
• Reduced temperatures combat heat related illness and death	• Habitat for wildlife, supporting biodiversity and ecosystem health	• Lower costs for electricity/gas by shading/protecting buildings
• Improved blood pressure	• Carbon sequestration, net carbon reduction	• Improved air and water quality, reducing need for more expensive measures
• Improved mood and reduced salivary cortisol	• Reduced urban heat island effect (UHIE)	

Urban trees provide a wide variety of benefits across multiple domains and interests. The myriad of health benefits suggests that urban forestry programs should be expanded to help improve public health, and it is currently unclear how much savings could be realized in terms of reduced healthcare costs and improved productivity. Planting more urban trees would improve the health of ecosystems in cities, providing habitat for wildlife, cooling areas affected by the urban heat island effect (UHIE), and reducing air pollution through absorption and energy conservation. Urban trees seem to be greatly beneficial economically, providing returns in multiples of the investment required and reducing costs for energy, air pollution removal, and road and sidewalk repairs. Examining the mechanisms that each of these benefits utilize can help determine ways to maximize them. For example, energy savings from shade on buildings can be maximized by placing trees in locations where they will block the intense sun of the mid-day and afternoon, and by increasing canopy size. Larger trees with more foliage absorb more air pollutants, sequester more carbon, and provide more shade and stormwater runoff reduction. Overall, urban trees appear to provide benefits far beyond their costs, especially in hot places where shade can save significant amounts of energy.

4. Tree Selection

Careful consideration of tree species to be planted is necessary to ensure good compatibility of the trees with the environment they will be planted in. Given that specific benefits are desired from the planting of urban trees, such as those outlined in Chapter 3, those benefits should be focused on when selecting a palette of recommended trees. For example, if a city mostly desires shade and stormwater runoff benefits, then selecting trees with a wide and dense canopy to provide significant shade and capture rainfall would be best. Further, a variety of trees is necessary due to planting restrictions in certain areas, such as needing shorter and less invasive trees near utility poles or other overhead infrastructure. Each of the factors that must be considered in urban tree selection is examined in further detail in section 4.1. Diversity of trees is another important aspect of urban tree selection, as without diversity, much of a city's urban forest can be killed or stunted by just one or two pests or environmental conditions like drought. With diversity, some trees may die or not grow well, but the majority will likely survive and help to maintain a relatively healthy urban forest.

McFarland has a hot and dry climate, making drought tolerance and water use a major consideration in selection appropriate species. Branch strength and root damage potential are important factors to consider as well, as broken branches and root damage to other physical infrastructure can increase maintenance costs and present danger to the public. McFarland is in USDA hardiness zone 9 (minimum annual average temperature of 20 to 30 degrees Fahrenheit), and all trees suggested in section 4.3 are suitable for this zone. Every tree suggested is appropriate in loamy soils and many are also appropriate in clay and silty soils, and all the soils in McFarland are loamy soils.

4.1 Selection Criteria

4.1.1 Mature Size

Mature size refers to the maximum height of the tree at maturity, or when it has stopped growing vertically. Different species can vary significantly in height, and different heights are appropriate for different locations and conditions. For example, shorter trees of 25' or less are favored for planting near utility poles and other overhead infrastructure to avoid interference between lines and foliage, while taller trees are favored as specimen trees and for maximum provision of shade, stormwater runoff reduction, air pollution absorption, and carbon sequestration. Taller trees must generally be located further away from buildings than shorter trees, or be planted with adequate engineered soils and root barriers that support root growth away from buildings, sidewalks, and pavement, because their roots grow further out from their trunk than roots of shorter trees.

4.1.2 Canopy Size

Canopy size refers to the horizontal width of the tree's canopy of leaves at maturity. As with mature size, canopy size can vary greatly between species, from under 10' for some narrow or small trees up to 70' or more for larger trees. Canopy size affects how close a tree should be planted to buildings and other infrastructure, and it is the primary determinant of the amount of shade provided by a tree alongside canopy density. Wider canopies are thus especially desirable for shade trees.

4.1.3 Growth Rate

Growth rate refers to how fast a tree grows vertically per year. Faster growth rates help generate more of the benefits of urban trees faster, by providing more shade and more biomass, but faster growth rates can also mean more maintenance requirements. Generally, a faster growth rate means a faster return on investment for the planting of a new tree.

4.1.4 Longevity

Longevity refers to the maximum number of years a tree can be expected to survive. Often urban trees do not survive for the maximum possible years, as their living conditions are much harsher than trees in forests or open spaces, but even so, choosing trees with longer lifespans means they will have to be replaced less often, reducing costs. Trees that live less than 20 years may not provide a net benefit, and new trees need to be irrigated much more frequently than established trees, so it is best to plant trees that will live as long as possible.

4.1.5 Biogenic Volatile Organic Compound (BVOC) Emissions

Trees produce volatile organic compounds (VOCs) which interplay with other air pollutants and can make air quality worse by contributing to smog formation. Trees also absorb air pollutants and sequester CO2, and the cycle and balance of these pollutants is complicated. In general, planting trees with lower BVOC emissions will lead to greater total emissions reductions and less risk of exacerbating existing air quality issues like those of the San Joaquin Valley Air Basin. However, tree emissions are relatively low compared to sources like vehicles, so even a tree with high BVOC emissions, if it lives long enough, will create a net air quality benefit.

4.1.6 Drought Tolerance

McFarland’s climate is hot and dry, with limited precipitation concentrated primarily in the winter. California in general experiences cyclical droughts, which may be intensified or extended by climate change. Thus, drought tolerant trees are preferred, as they are more likely to survive with less water, and typically require less irrigation to establish successfully. Water is a valuable resource in the Central Valley, due to its scarcity and use in agriculture, so maximizing water efficiency of urban trees is a very high priority. Not every tree has to be drought tolerant, as irrigation will often be installed anyway, but the greater proportion of trees that are drought tolerant, the greater proportion that will weather periods of extended drought. As with longevity, more drought tolerant trees reduce costs over time related to maintenance and replacement.

4.1.7 Soil Texture

Soil texture is classified as one of three types or a mixture thereof: clay, loam (silt), and sand, depending on the physical composition of the soil. Different soil textures affect how well plants grow, and some plants are not well suited to growing in certain types of soil. McFarland’s soils are all loams, and all suggested trees are suitable for loamy soils, with many also being appropriate for two or all three textures of soil.

4.1.8 Branch Strength

Branch strength refers to the resistance of branches to breaking and falling from the tree. Branches that fall from trees can damage utility infrastructure, buildings, fences, and other structures, block roads and sidewalks, and can also present a danger to people. Branches must be pruned occasionally, and trees with weaker branches will have to be monitored and pruned more closely and more often, increasing costs.

4.1.9 Root Damage Potential

Roots from trees can damage various parts of other urban infrastructure. For example, roots can cause sidewalks to raise up or “heave”, creating cracks and uneven surfaces, which can be dangerous or even make the sidewalk impassable. Roots can also cause damage to asphalt surfaces, and they can damage underground utility lines, especially water and sewer mains, with the incredible pressure they can apply over time.

4.1.10 Fire Resistance

Wildfire is a recurring hazard in California. McFarland is fortunate to be in an area with a very low risk of wildfire, so fire resistance is not a factor of great concern, but it is still essential to keep in mind to avoid creating unnecessary risk where it did not exist before. Fire resistant trees are able to survive many fires and are less likely to contribute to the spread of a fire, whereas trees with unfavorable resistance may have flammable sap, be especially vulnerable to death from fire, or have branches or foliage that create a high risk of spreading fire.

4.1.11 Allergenicity

Some trees produce pollen and other chemicals that can cause allergic reactions in some people. This factor is important to keep in mind for planting trees in locations with many children, such as near schools or daycares. Minimizing the number of allergenic trees in such locations, and not creating excessive concentrations of allergenic trees in new planting areas, will help reduce frequency and intensity of allergic reactions.

4.1.12 Toxicity

Some trees produce toxic seeds or other botanical parts that can cause health issues if consumed or touched. Toxicity is thus to be avoided as much as possible. Out of the trees suggested for McFarland in section 4.3, only two are toxic, and they are both oaks, where the acorns and leaves can be toxic in large quantities. This means the risk to humans is relatively low, as eating a large quantity of acorns or leaves is neither easy nor pleasant, with the risk to cattle and other foraging livestock animals being higher.

4.1.13 Wildlife Attracted

Some trees provide habitat, food, or other resources for various wildlife species. This is typically a desirable aspect of urban trees, as trees encourage a healthy diversity of wildlife which people often enjoy watching and interacting with. In some cases, attraction of bees to a given area may not be desirable, such as in interior areas of playgrounds or schools.

4.1.14 Suggested Uses

Suggested uses for each tree are described in categories:

- Screen trees have dense foliage and provide visual separation between areas
- Specimen trees are typically either very large at maturity or have some other aesthetic value such as unique color or attractive habit that makes them visually arresting
- Riparian trees are suitable for planting along bodies of water
- Buffer strip trees are typically used near agricultural lands to protect soil and water quality and reduce erosion

- Street trees vary in size, but are typically visually attractive, provide moderate to significant shade, and grow relatively well in the stressful conditions along roadsides or in medians
- Shade trees typically have dense and wide canopies, are often tall, and are planted primarily to provide shade for streets, sidewalks, and/or buildings

These suggestions are just that, suggestions, and do not mean that different species cannot be used for other purposes as appropriate.

4.2 Tree Diversity

Different species, genera, and families of trees have different levels of susceptibility to different diseases, pests, and stressors. A community with only one species of tree would find itself with a 100% tree mortality rate if any pest, disease, or stressor that affected that tree came to the area, a complete devastation of the urban forest. A community with only one of each species of tree spread out across genera and families would have a very hard time finding enough appropriate trees, and would look very strange at a visual level, but would likely have very little issue with most pests and diseases and be completely protected from mass die-off of trees.

Tree diversity is therefore a balancing act, not having too many of one species or genera of tree while also not having such a wide variety that maintenance and watering becoming excessively complicated. Many cities in recent history have had too many of one species or genera, leading to major tree die-offs to pests and diseases such as the Emerald Ash Borer and chestnut blight. This had led to the development of rules of thumb for tree diversity, such as the 10-20-30 rule adopted by, for example, the City of Thousand Oaks, California's Forestry Master Plan and the City of Longview, Washington's Urban Forest Maintenance and Management Plan, which means no more than 10% of all trees should be one species, no more than 20% of trees from the same genus (e.g. Quercus or oaks), and no more than 30% of trees from the same family (e.g. Pinaceae or pines). The City of Alameda, in its Master Street Tree Plan, has adopted an even stricter rule of 5% maximum for species, 10% maximum for genus, and 15% maximum for family. This creates greater diversity but is even harder to adhere to than the 10-20-30 rule and requires significant resources to be invested in keeping track of the urban forest. It is still better than the 10-20-30 rule, but in McFarland's case, a 5-10-15 rate is likely to be an aspirational goal for future plans, after time has passed to allow for a full tree inventory and for experience to be gained with urban forest management.

McFarland, at a minimum, should adopt the 10-20-30 rule of thumb to be applied at a city-wide level. The implementation of this can vary, however. For example, many cities like to plant a few types of trees together in one area to create a cohesive visual appeal. This can conflict with strict adherence to the 10-20-30 rule in some cases. The best option is an adaptive management style that generally seeks to follow the 10-20-30 rule, but which allows for reasonable exceptions in order to achieve other outcomes first, such as creating an avenue with just two or three tree species planted alongside it to create a unique and distinctive part of the city. Additionally, to follow the rule, a full tree inventory should be completed to find out what the current state of McFarland's urban forest is, and what should be planted going forward.

4.3 Recommendations

What follows is a list of recommended tree species for the City of McFarland. Common and scientific names, as well as genus and family, are included, as are botanical details such as size and growth rate as well as justification for choosing each species. Given the explanations of the criteria listed above, it should be reasonably clear even without explanation why each tree was selected. Every tree listed can grow in USDA hardiness zone 9, and is appropriate for loamy soils, which comprise all soils in and around McFarland. This list can be viewed in spreadsheet form, with all botanical details and characteristics relevant to selection included, in Appendix 1. This is not an exhaustive list of species that could be appropriate for McFarland; many other species not listed may be excellent choices depending on their characteristics. Images are all obtained from Cal Poly's Urban Forest Ecosystems Institute's Selectree website.

African Fern Pine (*Afrocarpus falcatus*), family Podocarpaceae

The African Fern Pine is a large tree often used as a specimen tree. It is a long-lived tree that grows at a moderate rate. It is moderately drought-tolerant and requires moderate irrigation. It is neither allergenic nor toxic, has low root damage potential, and low BVOC emissions. It is a visually striking tree at maturity, reaching a great height and adopting a pleasing rounded canopy shape. This combination of factors makes it an attractive tree with few major issues for cities that would provide an excellent specimen tree option for McFarland.

Aleppo Pine (*Pinus halepensis*), family Pinaceae

The Aleppo Pine is a large, fast-growing species of pine. It is long-lived, drought-tolerant, and has low irrigation requirements. It has strong branches and moderate potential for root damage. It is allergenic but not toxic. It attracts birds and squirrels and is best used as a specimen or shade tree. Its low water needs, drought tolerance, and longevity make it an appropriate choice for McFarland.

<u>Atlas Cedar</u> (*Cedrus atlantica*), family Pinaceae

The Atlas Cedar is another very large, long-lived tree species. It is drought tolerant and requires little irrigation, with moderate branch strength and root damage potential. It is not allergenic or toxic and grows at a slow to moderate rate. It is the only tree species on the list which is described as unfavorable in terms of fire resistance. It is best used as a screen or street tree. It requires significant space to grow to its maximum potential. The longevity, drought tolerance, and low water use, combined with a lack of major disadvantages, make it a good choice for McFarland.

<u>Australian Willow</u> (*Geijera parviflora*), family Rutaceae

The Australian Willow is a small to moderate size tree, with a fast growth rate and medium longevity. It is drought-tolerant and requires moderate to little irrigation. It has medium branch strength and low root damage potential, is not allergenic or toxic, and attracts bees. It is best used as a screen or street tree. The drooping habit of its leaves creates a unique visual appeal with dense shade. Its water requirements and lack of major disadvantages makes it a good choice for urban forests in climates like McFarland's.

<u>Cajeput Tree</u> (*Melaleuca quinquenervia*), family Myrtaceae

The Cajeput tree is a small to moderate sized tree with a moderate growth rate. It is long-lived, with high BVOC emissions, moderate branch strength, and low root damage potential. It is drought-tolerant and requires little irrigation. It can be allergenic, but not toxic, and is attractive to bees and birds. It is best used as a screen or riparian tree. Its water requirements, longevity, low root damage potential, dense foliage for shade, and wildlife attraction make it an appropriate choice for McFarland.

<u>California Ash</u> (*Fraxinus dipetala*), family Oleaceae

The California Ash is a typically small to moderate sized tree with a moderate growth rate, medium-high longevity, and low BVOC emissions. It is native to California, drought-tolerant, and has low irrigation needs. It has medium to strong branches, low root damage potential, and is fire resistant. It is allergenic but not toxic, attracts birds, and is best used as a screen tree. The low water requirements, strong branches, and fire resistance make it a very attractive tree for a city like McFarland.

<u>Chisos Oak</u> (*Quercus canbyi*), family Fagaceae

The Chisos Oak is a moderately sized tree with a moderate growth rate and high longevity. It has high BVOC emissions, is very drought-tolerant, and has moderate to low irrigation requirements. It has strong branches, low root damage potential, and is not allergenic or toxic, while also attracting birds and squirrels. It is best used as a street tree or shade tree. Its water requirements, strong branches, and lack of disadvantages make it a great tree for McFarland's needs.

<u>Chinese Hackberry</u> (*Celtis sinensis*), family Cannabaceae

The Chinese Hackberry is a large, long-lived tree with a moderate growth rate and low BVOC emissions. It is drought-tolerant and has low irrigation needs, with moderate branch strength and root damage potential. It is allergenic, but not toxic, and attracts birds. It is best used as a specimen tree, a street tree, or shade tree. Its low water requirements and lack of major disadvantages in other criteria make it a good choice for McFarland.

<u>Chinese Pistache</u> (*Pistacia chinesis*), family Anacardiaceae

The Chinese Pistache is a small to medium sized, long-lived tree with a low to moderate growth rate and moderate BVOC emissions. It is drought-tolerant and has low irrigation needs, with strong branches and low root damage potential. It is allergenic, but not toxic, and attracts birds. It is best used as a screen tree or a street tree and is a very popular street tree in many parts of California. It is an attractive tree with leaves that change colors in the fall. As with the previous trees, its water requirements and lack of major disadvantages in other criteria make it a good choice for McFarland.

<u>Crape Myrtle</u> (*Lagerstroemia indica*), family Lythraceae

The Crape Myrtle is a small to moderate sized, long-lived tree with a low to moderate growth rate and negligible BVOC emissions. It is drought-tolerant and has moderate irrigation needs, with moderately strong branches and low root damage potential. It is neither allergenic nor toxic and attracts birds. It is best used as a screen tree. Its drought tolerance, low BVOC emissions, and lack of major disadvantages in other criteria make it appropriate for McFarland.

<u>Desert Museum Palo Verde</u> (*Parkinsonia x 'Desert Museum'*), family Fabaceae

The Desert Museum Palo Verde is a small, fast-growing, long-lived tree with moderate BVOC emissions. It is drought-tolerant and has low irrigation needs, with moderately strong branches and low root damage potential. It is neither allergenic nor toxic. It attracts bees and has fragrant yellow flowers. It is best used as a screen, specimen, or street tree, and its small size makes it a utility friendly tree. Its drought tolerance, low BVOC emissions, lack of allergenicity and toxicity, attractive flowers, and attraction for bees make it an excellent choice for McFarland.

<u>Desert Willow</u> (*Chilopsis linearis*), family Bignoniaceae

The Desert Willow is also a small to moderate sized, fast-growing, long-lived tree with moderate BVOC emissions. It is native to the deserts of California, Texas, and Mexico, and is drought-tolerant and has low irrigation needs just like the Desert Museum Palo Verde, with moderately strong branches and low root damage potential. It is neither allergenic nor toxic and attracts bees. It is best used as a screen tree. Its attractive and unique appearance, drought tolerance and low irrigation needs, lack of allergenicity and toxicity, and attraction for bees make it an excellent choice for McFarland.

<u>Evergreen Pear</u> (*Pyrus kawakamii*), family Rosaceae

The Evergreen Pear is also a small to moderate sized, fast-growing, long-lived tree, but with low BVOC emissions. It is not drought-tolerant, one of only three species listed here that is not, and has moderate irrigation needs, with moderately strong branches and low root damage potential. It is neither allergenic nor toxic and attracts birds. It is best used as a screen tree. It is an attractive tree with distinct white flowers. It would be best suited for landscapes which already receive regular water, or which will receive regular water once constructed.

<u>Goldenrain (Golden Rain) Tree</u> (*Koelreuteria paniculata*), family Sapindaceae

The Golden Rain Tree is a moderate sized, long-lived tree with a slow growth rate and high BVOC emissions. It is drought-tolerant and has moderate irrigation needs, with moderately strong branches and low root damage potential. It is allergenic but not toxic and is smog tolerant. It is best used as a screen or street tree. Its drought tolerance, smog tolerance, attractive foliage and yellow flowers, dense shade, and lack of major disadvantages in other categories make it an appropriate choice for McFarland.

Holly Oak (*Quercus ilex*), family Fagaceae

The Holly Oak is a moderate to large sized, long-lived tree with a slow to moderate growth rate and high BVOC emissions. It is not drought-tolerant but has low irrigation needs. It has strong branches and low root damage potential. It is allergenic and toxic, and thus care should be exercised if placing it near schools or playgrounds. It is best used as a street tree. Its attractive shape, dense shade, and low irrigation needs make it an appropriate choice for limited uses in McFarland.

Italian Stone Pine (*Pinus pinea*), family Pinaceae

The Italian Stone Pine is a moderate to large sized, long-lived tree with a fast growth rate. It is drought-tolerant and has low irrigation needs. It has weak branches and low root damage potential. It is allergenic but not toxic and attracts birds and squirrels. It is best used as a specimen, shade, or street tree. Its unique foliage flattens and broadens with age to create an unusual visual appeal and providing shade while allowing a relatively unobstructed view from even second story windows. Its drought tolerance, low irrigation needs, attractive mature form, and significant provision of shade make it a good option for various uses within McFarland.

<u>Lemon Bottlebrush</u> (*Callistemon citrinus*), family Myrtaceae

The Lemon Bottlebrush is a small, moderate- to long-lived tree with a fast growth rate. It is drought-tolerant and has low irrigation needs, with high BVOC emissions. It has moderately strong branches and low root damage potential and is favorable for its fire resistance. It is allergenic but not toxic. It attracts bees and birds. It is best used as a screen or street tree. Its flowers are attractive red bottlebrush shapes. Its drought tolerance, low irrigation needs, attractive flowers, and provision of dense shade make it a good option for various uses within McFarland.

<u>London Plane Tree</u> (*Platanus x hispanica*), family Platanaceae

The London Plane Tree is a very large, long-lived tree with a fast growth rate. It is moderately drought-tolerant and has moderate irrigation needs, with high BVOC emissions. It has strong branches and is the only recommended tree with high root damage potential. The London Plane Tree is favorable for its fire resistance. It is allergenic but not toxic and attracts bees. It is best used as a towering street tree. It is one of the most popular street trees in the state of California, and is overplanted in many areas, but it remains a good choice for its ability to provide significant shade while allowing sunlight through in winter as it is deciduous, losing leaves in the fall.

Marina Madrone (*Arbutus 'Marina'*), family Ericaceae

The Marina Madrone is a moderate sized, long-lived tree with a moderate growth rate. It is drought-tolerant when established and has low to moderate irrigation needs. It has strong branches and low root damage potential. It is neither allergenic nor toxic and attracts birds. It is best used as a screen or street tree. It is an attractive tree with unusual reddish bark and pink-red flowers. Its drought tolerance, low to moderate water needs, strong branches, and lack of allergenicity and toxicity, on top of its attractive appearance, make it an excellent choice for McFarland.

Pindo Palm (*Butia capitata*), family Arecaceae

The Pindo Palm is a small, moderate- to long-lived tree with a slow to moderate growth rate. It is drought-tolerant and has moderate irrigation needs. It has strong branches and low root damage potential. It is slightly allergenic but not toxic and attracts mammals. It is best used as a specimen, buffer strip, or street tree. Its small stature is unusual for a palm tree, and the Pindo is utility friendly due to its limited height. Its utility friendliness combined with its drought tolerance and strong branches make it a good option for placement under utility lines or other overhead infrastructure in McFarland.

<u>Shoestring Acacia</u> (*Acacia stenophylla*), family Fabaceae

The Shoestring Acacia is a small to moderate sized, moderate- to long-lived tree with a fast growth rate. It is drought-tolerant and has low irrigation needs. It has weak branches and low root damage potential. It is allergenic but not toxic and attracts birds. It is best used as a specimen or street tree. It has unusual narrow, linear leaves and has a weeping habit, giving it a unique visual appeal. It provides light shade, and its attractive appearance and drought tolerance make it a good option as an ornamental urban tree for McFarland.

<u>Strawberry Madrone or Strawberry Tree</u> (*Arbutus unedo*), family Ericaceae

The Strawberry Madrone or Strawberry Tree is a small to moderate sized, long-lived tree with a slow to moderate growth rate and low BVOC emissions. It is drought-tolerant and has low irrigation needs. It has weak branches and low root damage potential. It is allergenic but not toxic and attracts birds. It is best used as a specimen or street tree. It has white to pink flowers and orange to red fruit, giving it a unique visual appeal and its name. It provides light shade, and its attractive appearance and drought tolerance make it a good option as an ornamental urban tree for McFarland.

Toyon (*Heteromeles arbutifolia*), family Rosaceae

The Toyon is a small, long-lived, California native tree with a slow to moderate growth rate and low BVOC emissions. It is drought-tolerant and has low irrigation needs. It has moderately strong branches and low root damage potential. It is neither allergenic nor toxic and attracts bees and birds. It is best used as a screen tree, and it is utility friendly given its small stature. It has attractive red berries, white flowers, and leaves with a distinctive ridged edge. Its small size makes it a good option for planting near utility infrastructure, supported by its drought tolerance, low irrigation needs, and wildlife friendliness without any allergenicity or toxicity.

Tulip Tree (*Liriodendron tulipifera*), family Magnoliaceae

The Tulip Tree is a very large, long-lived, and fast-growing tree with moderate BVOC emissions. It is one of the three trees in this list that is not drought-tolerant, and it is the only tree that has high irrigation needs. Its branches are moderate to strong, and the tree has moderate root damage potential. It is allergenic but not toxic and attracts birds. It is best used as a specimen, shade, or street tree. It has fragrant bark and flowers, with attractive yellow flowers and color changing leaves. It should only be used in locations where regular water is already being provided or would be provided anyway and should be limited in number.

<u>Valley Oak</u> (*Quercus lobata*), family Fagaceae

The Valley Oak is another California native, a massive, long-lived, and fast-growing tree with moderate BVOC emissions. It typically reaches 50 to 70 feet tall but can reach over 150 feet and at maturity has a very wide canopy, typically around 50 feet but with the potential to reach about 100 feet across. It is moderately drought-tolerant with low irrigation needs. Its branches are moderate to strong, with moderate root damage potential. The Valley Oak is favorable for its fire resistance. It is allergenic and toxic and attracts birds and squirrels, so care should be taken when choosing locations and schools and playgrounds should be avoided. It is best used as a specimen, riparian, or shade tree. It has fragrant bark and flowers, with attractive yellow flowers and color changing leaves. It should only be used in locations where regular water is already being provided or would be provided anyway and should be limited in number.

<u>Weeping Bottlebrush</u> (*Callistemon viminalis*), family Myrtaceae

The Weeping Bottlebrush is a small, long-lived, and fast-growing tree with high BVOC emissions. It is drought-tolerant with moderate irrigation needs. Its branches are moderately strong, and it has low root damage potential. It is favorable for its fire resistance. It is allergenic but not toxic and attracts bees and birds. It is best used as a screen or street tree, and its short height make it a utility friendly tree when pruned regularly. It is a very attractive tree with bright red flowers and a pleasant weeping habit. Its attractiveness combined with drought tolerance, fire resistance, and lack of disadvantages besides allergenicity make it a good choice for use in McFarland.

5. Tree Location

Deciding where best to put trees is a process that occurs alongside tree selection. The desired outcomes of planting urban trees affect what tree should be planted where. For example, one of the major benefits of urban trees discussed in Chapter 3 is provision of shade. Shade helps keep buildings cool in hot weather, reduces evaporative emissions of cars, reduces strain on air conditioners, saves money and reduces emissions by reducing energy used for air conditioning, helps extend the life of pavement and sidewalks, and helps reduce temperatures in urban areas to combat the urban heat island effect (Bolund and Hunhammar, 1999; Donovan and Butry, 2009; Heisler, 1986; McPherson & Muchnick, 2005; McPherson, Simpson, Peper, and Xiao, 1999a; Pincetl, Gillespie, Pataki, Saatchi, and Saphores, 2012). Locating trees to create shade requires consideration of the position of the sun, orientation of buildings and streets, potential interference with utilities, height and canopy size of trees, and availability of right-of-way (the land owned and controlled by the city or county, typically including the street, sidewalk, and planting buffers or medians). Other desired benefits require other considerations, such as stormwater runoff reduction, which is best achieved with large trees with wide canopies and stormwater infrastructure that directs stormwater to bioswales and retention basins that incorporate trees, providing stormwater runoff reduction, stormwater quality improvement, and free irrigation of trees. All of this requires money and space to construct, creating a balancing act of land use allocation which often leaves landscaping and trees as an afterthought installed purely to comply with local ordinances. However, by recognizing the benefits and cost savings that can be achieved with substantial and well-managed tree presence, as well as by providing appropriate guidance for developers, cities can encourage the growth of dense, healthy, diverse urban forests.

5.1 Location Considerations

Various factors must be considered at the micro (individual level) and macro (group level) scales. Every individual tree that is planted must be considered in context of the site, and at a larger scale, there are many general principles that will help maximize benefits and reduce conflicts with utilities and infrastructure. Additionally, a city might wish to create distinct neighborhoods or zones which have different palettes of trees, adding unique atmosphere and visual appeal. The following sections detail both micro and macro considerations for the context of McFarland.

5.1.1 Shade

Shade is one of the primary desirable outcomes obtained from planting trees in urban areas. Sunlight helps trees grow, whereas sunlight on buildings heats them, creating a greater need for cooling. In climates that are sunny and hot for much of the year, such as the climate of McFarland, shade trees can provide significant cooling benefits, reducing temperatures and electricity used for cooling. One study of Central Valley homes found reductions in interior air temperatures of 2 degrees Fahrenheit for insulated houses and up to 6 degrees Fahrenheit for uninsulated houses that were completely shaded by trees, presenting an opportunity for significant savings on electricity costs associated with air conditioning through the planting of shade trees near occupied and climate controlled buildings (Heisler, 1986). In winter, sunlight on the home is desirable when average temperatures are low, as in McFarland. Deciduous trees lose their leaves in fall, reducing their shading of buildings and thus allowing more heating from sunlight. Evergreen trees retain their leaves throughout the year, meaning they provide the same shade in summer and winter, requiring attention to the location of planting and the angle of the sun in summer (higher in the sky) and winter (lower in the sky).

In the San Joaquin Valley in midsummer, the sun rises and shines on the northeast and east sides of buildings in the morning, passes overhead slightly to the south at mid-day, and shines on the west and northwest sides of buildings in the afternoon until sunset (McPherson, Simpson, Peper, and Xiao, 1999a). Temperatures are highest in the early to mid-afternoon, when the sun is still shining intensely, and heat has built up over the course of the day. Therefore, shading the west and northwest sides of buildings is most important to provide the maximum shade benefits, followed by the east and northeast sides (McPherson, Simpson, Peper, and Xiao, 1999a). In winter, the sun is lower in the sky to the south, so trees should not be planted to the south in such a way that they block potential heat gain that would be desirable in winter. Heat gain from sunlight is the greatest when it passes through windows, so shading windows is the priority in summer followed by roofs and walls. Trees should be planted so that their crowns at adolescence and/or maturity shade the building, meaning the height of the tree and the distance from the house must both be accounted for. Shading pavement, patios, concrete pads and driveways, and any other surfaces with dark colors or where people congregate also provides significant benefits to average temperatures and improves comfort. Shading air conditioners can reduce their energy use, given that care is taken not to plant anything so close that it would interfere with airflow (McPherson, Simpson, Peper, and Xiao, 1999a). A set of general principles to maximize shade benefits from urban trees follows:

- Shade the west and northwest sides of buildings, followed by the east and northeast.
- Avoid shading the south sides of buildings to retain heat gain in winter; use deciduous trees. Plant near the house and prune lower branches to maximize summer shade and minimize winter shade.
- Shade windows when possible, but any building surface works.
- All else being equal, larger trees provide more shade than smaller trees. Where space allows, larger trees should be planted to maximize benefit to cost ratios.
- Plant trees no closer than 10 feet from buildings. Preferably, plant trees about 25-50 feet away from buildings for shade purposes depending on the mature height of the trees. Use columnar trees if shade is desired with limited space away from a building.
- Shade air conditioners without obstructing airflow.
- Avoid planting trees near overhead or underground utilities whenever possible. Choose short trees that are no more than 20-25 feet tall at maturity if trees must be planted within about 20 feet of overhead utilities.
- Shading parked cars reduces evaporative emissions, so parking lots should be covered with combinations of tree canopy, shade structures, and/or solar carports.
- Shading pavement with trees provides a net benefit when accounting for the costs associated with root damage (McPherson and Muchnick, 2005).

For shading of pavement and streets, trees should be planted in medians and on the sides of roads. For streets oriented north-south, plant trees on the east and west sides, and for streets oriented east-west, plant moderately sized to tall trees on the south side primarily to maximize summer shade and minimize winter shade.

5.1.2 Parking Lots

Parking lots present an excellent opportunity to reap the benefits of shade from trees. Shading pavement and parked cars helps to reduce air temperatures and evaporative emissions from engines (McPherson, Simpson, Peper, and Xiao, 1999a). Many cities require that a certain percentage of parking lot surface area be shaded by a certain date after construction to allow time for trees to grow. The City of Davis, for example, requires than 50% of paved parking lot surfaces be shaded with tree canopies within 15 years of the issuance of the building permit (McPherson, Simpson, Peper, and Xiao, 1999a). Other cities require one tree per a given number of parking spots. Trees in parking lots typically do not grow to their maximum potential due to compaction of soils and lack of favorable temperature and moisture regimes. Ideally, trees should be planted in long stretches of soil, with engineered soils or subsoil structures to support root growth to allow for maximum usable soil volume. The fact that trees grow best with this setup of connected soil also lends itself to Low Impact Development (LID), which directs stormwater into swales and other structures with plants and rocks to settle, retain, clean, and infiltrate stormwater instead of sending it down gutters, wasting it and requiring it to be dealt with downstream. Combining trees with green stormwater infrastructure in this way takes advantage of winter rainfall to irrigate trees, while also providing all the benefits associated with reduced stormwater runoff and improved runoff quality. Bioswales with established vegetation, including trees, can reduce runoff pollutant levels by over 90% while also reducing air

Figure 5-1: Low Impact Development - a bioswale receiving stormwater runoff from a streetscape (Source: State College of Pennsylvania)

temperatures, improving property values, and reducing flooding risk, which has been identified as an issue in east McFarland particularly (Xiao, McPherson, Zhang, Ge, and Dahlgren, 2017; Background Report, 2019, p. 117). An example of LID can be seen in Figure 5-1.

However, care must be taken in both the establishment of any ordinances and in their enforcement. In Sacramento, a study of 15 parking lots found that they had many vacant spots even at peak use hours, and that they would provide only about half the required shade (27% versus 50% coverage) 15 years after construction. This lack of shading resulted in a projected $2.2m worth of potential benefits lost (McPherson, 2001). Parking lots are suboptimal environments for tree growth and size maximization due to soil compaction, pollution from runoff, and high temperatures. However, various measures and principles can be utilized to maximize tree growth, survival, and minimize costs (adapted from McPherson, 2001):

- Reduce parking minimums to reduce unnecessary parking spaces and paved areas. Encourage use of one-way aisles and shared and angled parking to reduce overall paved area required.
- Use LID measures such as bioswales, pervious pavement, retention basins, and others to reduce stormwater runoff, improve runoff quality, and irrigate trees. These methods also usually provide improved soil volume for better tree growth.
- Require tree wells and islands to be at least 4x4 feet for small trees (<25ft), 6x6 feet for medium sized trees (25-45ft), and 8x8 feet for large trees (>45ft). These are bare minimums – more area will be better for the trees and allow them to grow larger and faster. Seek maximization of continuous soil volume with strips and islands instead of cutouts.
- Require that soil in tree wells and islands be excavated to a depth of at least 4 to 6 feet. Some cities have adopted minimum soil volume requirements to encourage growth of large, healthy trees; this may be a good choice for McFarland. Typical minimum soil volumes are 400-600 cubic feet of rootable soil volume for small trees and 1,500 cubic feet for larger trees, with more being better (Minnesota Pollution Control Agency, 2014).
- Take advantage of open spaces with uncompacted soils. Planting trees in an open grassed area next to a sidewalk is better for the trees, and less expensive, than planting trees in cutouts in the sidewalk (Gilman, 2015).
- Require use of engineered soil mixes or subsoil structures in tree wells and islands to keep soil from becoming compacted when constructing new parking lots.
- Require businesses to irrigate, prune, and otherwise care for trees in their parking lots on a regular basis. Enforce a minimum level of irrigation and care. Require replacement of dead trees within a given period of time.
- Require lights to be placed in such a way that they will not require excessive pruning of trees to prevent blocking of light.
- Remember to retain species diversity to prevent complete loss. Require that no more than 25% of trees in a given lot be of the same species. Direct developers to use appropriate tree species that are less common in McFarland to promote city-wide diversity.

- Specific tree spacing requirements should be developed with advice from a professional arborist.
- Allow and encourage construction of solar carports on top of parking lots. These provide more shade than would likely ever be provided by trees alone. If a project involves installation of solar carports, allowance should be made for it to have fewer trees than would normally be required due to the space taken up by the solar panels.
- Remind developers that higher upfront capital costs are exchanged for savings over time related to energy use, stormwater runoff reduction and quality improvement, and improved property values. An incentive program for stormwater infrastructure with high tree density and low irrigation requirements should be explored, allowing more area to be built on or allowing more units to be built, depending on the project.

5.1.3 Windbreaks

Trees located near buildings provide windbreaks, which can help reduce heat loss in winter, though it can also prevent some wind cooling in summer (Heisler, 1986). Windbreaks can potentially provide up to a 10 to 12% savings in heating fuel for typical frame houses, though this can vary significantly depending on local climate and individual orientation of trees and buildings (Heisler, 1986). This consideration is much less important than provision of shade for McFarland, as cooling is a much greater demand than heating over the course of a year, but it is still worth keeping in mind. Wind direction is mostly evenly distributed during the winter months in McFarland, with a slightly higher proportion of wind blowing from the south (Weather Spark, 2020). Since trees are recommended to be planted to the west and east of buildings to provide the maximum shade benefits over the course of the year, and shade benefits in McFarland's climate have much greater potential for savings than windbreak benefits, little consideration of windbreaks is necessary.

5.1.4 Sidewalks and Tree Wells

As explained in Chapter 3, street trees provide a wide variety of benefits to the public, including psychological and physiological health benefits, shade, reduced air temperatures, more attractive scenery, and better air quality, on top of other economic and environmental benefits. Trees encourage travel by walking and beautify urban spaces, and McFarland has recognized this, having conducted multiple projects over the past several years involving tree planting and streetscape improvement throughout the City. Planting trees along sidewalks like those in Figure 5-3, typically in structures referred to as tree wells, provides shade for pavement and pedestrians and making the street a more pleasant place to be, especially in the summer when temperatures are high and the sun shines intensely.

Figure 5-2: Japanese Pagoda Trees on East 2nd Street in New York City (Source: Gordon Price)

Tree wells are cutouts in sidewalks and planting strips along roads or other paved or concrete surfaces where trees grow. Tree wells are often undersized and result in poor tree growth or damage to the tree or sidewalk, as in Figure 5-3. The tree in Figure 5-3 also has a metal tree well grate around it, which restricts growth and girdles trees as they become larger, damaging their trunks. Ideally, tree wells should be combined into planting strips that allow maximum soil volume to be shared between trees, in addition to encouraging improved soil moisture regimes.

Figure 5-3: Tree well with metal grate raised by root growth in Richmond, VA (Source: SeeClickFix)

Tree grates are not necessary and can be harmful to trees, so they should be replaced with pavers, bricks, assorted rocks, granular ground cover like decomposed granite or stone dust, or nothing but mulch (Gilman, 2015). These types of cover allow for movement and modular replacement instead of poured concrete slabs which are invasive and expensive to replace.

There are many techniques and technologies that can be used to allow roots to grow around or under sidewalks and paved surface, including root channeling, use of engineered soils, use of pavers, reinforced concrete to resist cracking, and others (Gilman, 2015). Recommendations for planting trees in and around sidewalks and tree wells/islands follow:

- Preferentially plant trees in open spaces (i.e. areas not covered by pavement, sidewalks, or buildings) rather than in sidewalk cutouts to increase available soil volume and reduce installation costs.
- As with parking lots, require tree wells in sidewalks to be 4x4 feet minimum for small trees, 6x6 feet minimum for medium sized trees, and 8x8 feet minimum for large trees, with these being minimums and larger sizes being better. Encourage project design to create areas of continuous open soil for trees.
- Require space around trees in wells/islands to be left open or to use a permeable groundcover such as gravel, mulch, decomposed granite, or grass. Do not allow tree grates to be used.
- Encourage use of engineered soil mixes, subsoil structural supports, root channeling, and other techniques as appropriate for proposed projects to increase rootable soil volume and prevent tree growth stunting and premature death.
- Require trees planted within 15-20 feet of overhead utilities to have a maximum height of 25’ to minimize interference. Utility companies are typically responsible for pruning trees near utility lines, though it benefits cities to have less risk of power outages and infrastructure damage, and this pruning should be performed as often as necessary to keep trees healthy and away from utility lines.
- If sidewalks become damaged, avoid cutting tree roots at all costs, by bridging with metal pieces, rerouting the sidewalk, or replacing the surface with gravel or rock dust. If roots need to be cut, the tree should typically be removed completely to avoid risk of toppling during high winds.

5.1.5 Industrial and Commercial Areas

Industrial and commercial areas should follow all the guidelines mentioned in the previous sections. In general, some commercial and most industrial uses have large parcels which can accommodate very large trees in their site design. Planting of large trees should be required as part of project planning, following all principles previously mentioned such as allowing plenty of soil volume, grouping trees in strips or islands instead of cutouts, and allowing stormwater from impervious surfaces (e.g. parking lots and roofs, etc.) to be directed into vegetated swales with as many trees as space allows.

5.2 Summary of Recommendations

5.2.1 Shade

- Shade the west and northwest sides of buildings, followed by the east and northeast.
- Avoid shading the south sides of buildings to retain heat gain in winter; use deciduous trees. Plant near the house and prune lower branches to maximize summer shade and minimize winter shade.
- Shade windows when possible, but any building surface works.

- All else being equal, larger trees provide more shade than smaller trees. Where space allows, larger trees should be planted to maximize benefit to cost ratios.
- Plant trees no closer than 10 feet from buildings. Preferably, plant trees about 25-50 feet away from buildings for shade purposes depending on the mature height of the trees. Use columnar trees if shade is desired with limited space away from a building.
- Shade air conditioners without obstructing airflow.
- Avoid planting trees near overhead or underground utilities whenever possible. Choose short trees that are no more than 20-25 feet tall at maturity if trees must be planted within about 20 feet of overhead utilities.
- Shading parked cars reduces evaporative emissions, so parking lots should be covered with combinations of tree canopy, shade structures, and/or solar carports.
- Shading pavement with trees provides a net benefit when accounting for the costs associated with root damage (McPherson and Muchnick, 2005).

5.2.2 Parking Lots

- Reduce parking minimums to reduce unnecessary parking spaces and paved areas. Encourage use of one-way aisles and shared and angled parking to reduce overall paved area required.
- Use LID measures such as bioswales, pervious pavement, retention basins, and others to reduce stormwater runoff, improve runoff quality, and irrigate trees. These methods also usually provide improved soil volume for better tree growth.
- Require tree wells and islands to be at least 4x4 feet for small trees (<25ft), 6x6 feet for medium sized trees (25-45ft), and 8x8 feet for large trees (>45ft). These are bare minimums – more area will be better for the trees and allow them to grow larger and faster. Seek maximization of continuous soil volume with strips and islands instead of cutouts.
- Require that soil in tree wells and islands be excavated to a depth of at least 4 to 6 feet. Some cities have adopted minimum soil volume requirements to encourage growth of large, healthy trees; this may be a good choice for McFarland. Typical minimum soil volumes are 400-600 cubic feet of rootable soil volume for small trees and 1,500 cubic feet for larger trees, with more being better (Minnesota Pollution Control Agency, 2014).
- Take advantage of open spaces with uncompacted soils. Planting trees in an open grassed area next to a sidewalk is better for the trees, and less expensive, than planting trees in cutouts in the sidewalk (Gilman, 2015).
- Require use of engineered soil mixes or subsoil structures in tree wells and islands to keep soil from becoming compacted when constructing new parking lots.
- Require businesses to irrigate, prune, and otherwise care for trees in their parking lots on a regular basis. Enforce a minimum level of irrigation and care. Require replacement of dead trees within a given period of time.
- Require lights to be placed in such a way that they will not require excessive pruning of trees to prevent blocking of light.

- Remember to retain species diversity to prevent complete loss. Require that no more than 25% of trees in a given lot be of the same species. Direct developers to use appropriate tree species that are less common in McFarland to promote city-wide diversity.
- Specific tree spacing requirements should be developed with advice from a professional arborist.
- Allow and encourage construction of solar carports on top of parking lots. These provide more shade than would likely ever be provided by trees alone. If a project involves installation of solar carports, allowance should be made for it to have fewer trees than would normally be required due to the space taken up by the solar panels.
- Remind developers that higher upfront capital costs are exchanged for savings over time related to energy use, stormwater runoff reduction and quality improvement, and improved property values. An incentive program for stormwater infrastructure with high tree density and low irrigation requirements should be explored, allowing more area to be built on or allowing more units to be built, depending on the project.

5.2.3 Sidewalks and Tree Wells

- Preferentially plant trees in open spaces (i.e. areas not covered by pavement, sidewalks, or buildings) rather than in sidewalk cutouts to increase available soil volume and reduce installation costs.
- As with parking lots, require tree wells in sidewalks to be 4x4 feet minimum for small trees, 6x6 feet minimum for medium sized trees, and 8x8 feet minimum for large trees, with these being minimums and larger sizes being better. Encourage project design to create areas of continuous open soil for trees.
- Require space around trees in wells/islands to be left open or to use a permeable groundcover such as gravel, mulch, decomposed granite, or grass. Do not allow tree grates to be used.
- Encourage use of engineered soil mixes, subsoil structural supports, root channeling, and other techniques as appropriate for proposed projects to increase rootable soil volume and prevent tree growth stunting and premature death.
- Require trees planted within 15-20 feet of overhead utilities to have a maximum height of 25’ to minimize interference. Utility companies are typically responsible for pruning trees near utility lines, though it benefits cities to have less risk of power outages and infrastructure damage, and this pruning should be performed as often as necessary to keep trees healthy and away from utility lines.
- If sidewalks become damaged, avoid cutting tree roots at all costs, by bridging with metal pieces, rerouting the sidewalk, or replacing the surface with gravel or rock dust. If roots need to be cut, the tree should typically be removed completely to avoid risk of toppling during high winds.

5.3 Potential Tree Locations in McFarland

In the City of McFarland General Plan Update, five key growth areas for the City are identified. These include (1) Downtown Infill, (2) Northwest Expansion, (3) Whisler Road Neighborhood, (4) Southern Commercial Corridor, and (5) Famoso Industrial and Commercial Center. These key growth areas were identified using surveys of the area and input from the community. Figure 5-4 shows these key growth areas in McFarland and its proposed future Sphere of Influence.

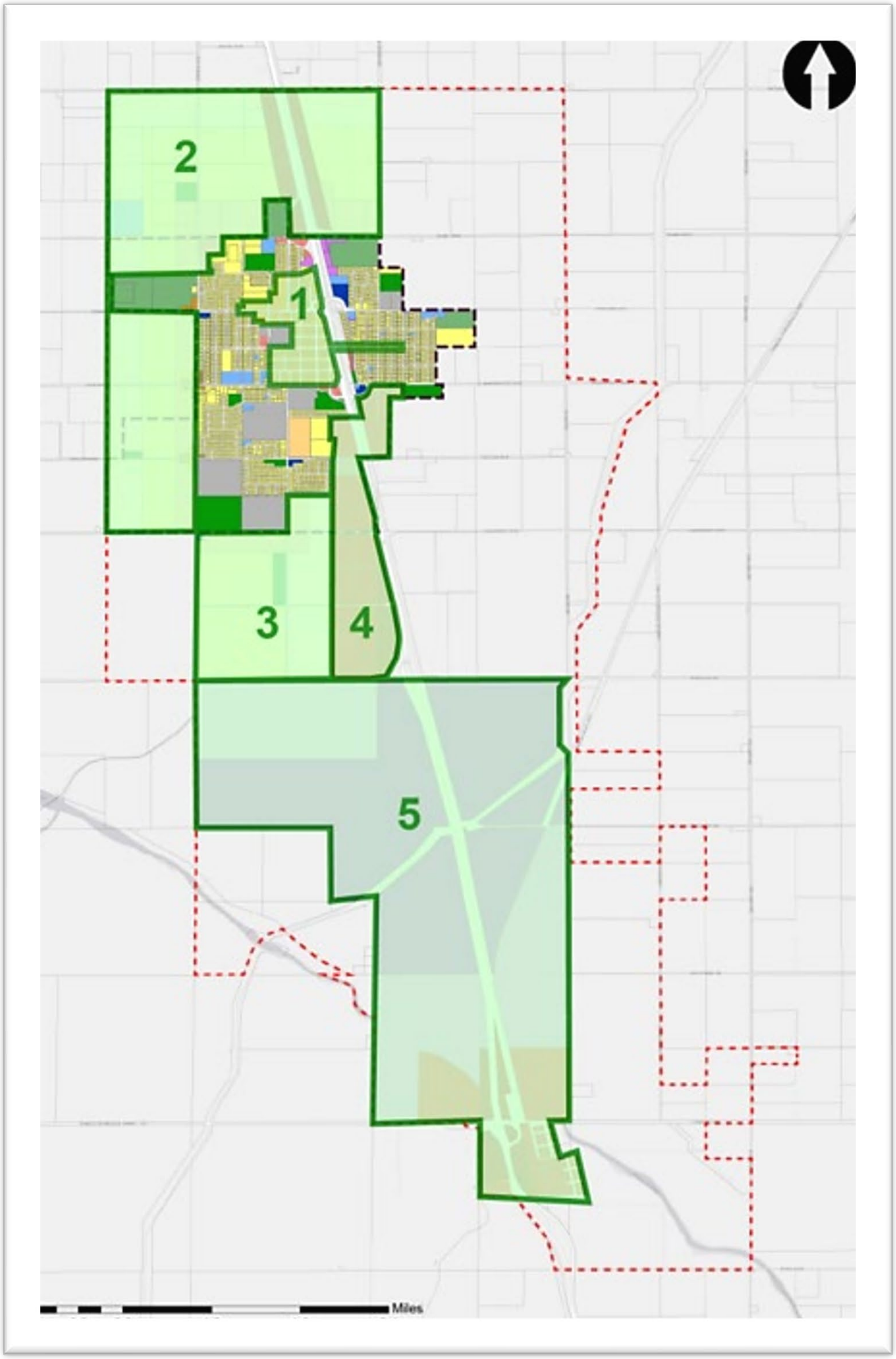


Figure 5-4: Map of key growth areas identified in the General Plan Update (Source: General Plan, 2020)

These areas serve different purposes in the future vision for McFarland. For example, the Downtown Infill area (1) is intended to be a lively, pedestrian friendly, commercial hub that attracts residents and tourists. Small to moderate sized ornamental shade and street trees, such as Marina Madrone are appropriate for planting in planting strips along streets, in landscaped areas, and alongside buildings in this area. The Famoso Industrial and Commercial Center (5), appropriately, is to consist of industrial and commercial uses. Industrial and commercial uses typically have large parcels and can plan for very large trees, such as African Fern Pine and Valley Oak, to provide maximum shade to buildings that will be occupied and/or climate controlled. Large trees also help reduce visual impacts of industrial development, improve air quality, and help absorb the large amounts of stormwater runoff that can be produced on large, contiguous impervious surfaces commonly found in industrial lots.

The Downtown Infill area (1) would be best served with small to moderate sized ornamental shade and street trees. From the list of recommended species in Chapter 4, several would be appropriate: Australian Willow, California Ash, Chinese Pistache, Crape Myrtle, Desert Museum 'Palo Verde', Desert Willow, Evergreen Pear, Golden Rain Tree, Lemon Bottlebrush, Marina Madrone, Pindo Palm, Shoestring Acacia, Strawberry Madrone, Toyon, and Weeping Bottlebrush. These types of trees are appropriate for the smaller available areas typically found in a downtown area, and their attractiveness improves the atmosphere, drawing in residents and potentially tourists to spend more time walking and enjoying the downtown. It is important to keep in mind that the suggested species are not an exhaustive list of species that would be appropriate, and that other species with characteristics such as low water use, drought tolerance, smog tolerance, and other advantages exist and may be selected and planted.

Within the Downtown Infill area, East and West Kern Avenues present an opportunity for improved connection between the two sides of McFarland, as noted in the updated proposed General Plan's Preferred Growth Alternative. Street trees could be used to help improve the sense of connection in this area. Planting rows of the same species all together or planting a regular pattern of a few species of tree along the side of Kern Avenue between 5th Street and State Route 99 on the west and between San Pedro Street and State Route 99 on the east would create a cohesive visual corridor. If the City chooses to expand or improve the pedestrian crossing connecting the two sides of Kern Avenue, the construction period would present the perfect opportunity to plant shade trees and ornamental trees. Figure 5-5 shows the existing state of Kern Avenue and how it might look in the future; notice the street trees and use of contiguous open soil for planting.

The Northwest Expansion area (2) is proposed to be primarily residential, ranging from low to high density. Any of the recommended trees from Chapter 4 could be utilized in this area, depending on the spacing of housing and site design. As this is currently mostly undeveloped area, large trees could be planned along streets to provide extensive shade, significant stormwater benefits, and create a memorable area in McFarland with a visually striking streetscape. Trees such as the Atlas Cedar, Italian Stone Pine, London Plane Tree, or Tulip Tree would be appropriate to plant for such a purpose, although repeating patterns of any 1-3 species can create visual interest, not just these very large trees. The parts of this area that are near State Route 99 would be best served by trees that are smog tolerant and generally hardy, to resist damage from the traffic emissions and heat from the roadway. Planting specimen trees and attractive street trees along Garzoli Avenue and Elmo Highway would create two intersecting streets with visual interest and help create landmarks to delineate the outer edges of the City, as well as appealing gateways to welcome people driving in from outside.

Figure 5-5: Kern Avenue in downtown McFarland (above) and a rendering of a potential future state (below) (Source: General Plan, 2020)

The proposed Whisler Road Neighborhood (3) consists of a mix of residential and commercial uses. The same trees and concepts that apply to the Northwest Expansion area apply here – any size tree will work, and attractive ornamental trees can be used to create unique and appealing streetscapes. Smog and pollution tolerance are less of an issue for this area. Garzoli Avenue and Mast Avenue run north to south, and Hanawalt Avenue, Nill Avenue, and Whisler Road run east to west. Lining these main streets with trees would benefit future residents of this area and create a distinctive grid pattern of tree-lined streets, giving the neighborhood a unique character to set it apart from other areas of McFarland. Figure 5-6 shows the existing Whisler Road and a potential vision for the future, again with large contiguous soil volumes and street trees.

Figure 5-6: Existing Whisler Road (above) and a potential vision for the future (below) (Source: General Plan, 2020)

The proposed Southern Commercial Corridor (4) should utilize large trees where possible and select trees that are hardy, smog-tolerant, and have low irrigation needs, as the corridor straddles State Route 99 and will be subject to high levels of vehicle emissions. Large trees will provide the most shade, air quality, and stormwater benefits, reducing impacts from the cars and trucks passing by. Figure 5-7 shows the existing area and what it might look like in the future, again depicting large contiguous soil volumes for street trees. Planting buffer strips of trees along State Route 99 would help reduce noise and air pollution and improve the aesthetic appeal of the area. Planting trees along Hanawalt and Nill Avenues would connect the area and State Route 99 to the Whisler Road Neighborhood to the west and encourage commercial development along these streets with shade and an improved pedestrian atmosphere.

Figure 5-7: Existing Southern Commercial Corridor (above) and potential future vision (below) (Source: General Plan, 2020)

The proposed Famoso Industrial and Commercial Center (5) should also utilize large trees wherever possible for maximum benefits and return on investment. Projects on larger parcels can more easily plan to accommodate larger trees in areas with large contiguous soil volumes. By requiring large trees to be planted when constructing industrial uses, stormwater runoff can also be planned for, as large contiguous volumes of soil with vegetation are ideal for treating and infiltrating runoff. Figure 5-8 shows the existing area and what it might look like in the future. The City's priority for this area should be planting trees alongside State Route 99 while requiring commercial and industrial development to plant as many large trees as feasible to create energy savings and aid stormwater treatment.

Figure 5-8: Famoso Industrial and Commercial Center existing conditions (above) and potential future state (below) (Source: General Plan, 2020)

Additionally, there is ample opportunity to plant trees and obtain benefits on public/City property. Schools in McFarland, for example, have enough space to plant dozens of trees to obtain benefits from shade, improved air quality, and the variety of other benefits urban trees provide. Every school in McFarland, with the possible exception of the Browning Road STEAM Academy, has ample space on the east, west, or both sides of buildings to plant shade trees. This presents an opportunity for long-term energy use reduction and savings on electricity. Planting trees on school grounds further presents an excellent opportunity for hands-on outdoor learning. The benefits of trees can be explained to students of any age, adjusting the complexity and details as appropriate, and some students may be able to help plant or care for the trees. Some parks within the City, such as Browning Road Park and Blanco Park, could also accommodate more trees which could be clustered in open areas or near picnic tables to create attractive areas of contiguous shade. Finally, open areas along State Route 99 and the exit ramps within McFarland would be excellent places to plant large, hardy trees to create shade and a distinctive visual character for the City, while also improving air quality and blocking noise. Combining trees and other vegetation with noise barriers or sound walls would provide even better noise reduction benefits while allowing the City room to create a well-planned, water-wise, attractive highway transition area. The planned expansion of the City provides an opportunity to create a community with dense canopy coverage and a thriving urban forest from the ground up, as new development can be required to include more trees than it has in the past. Overall, there is ample opportunity in McFarland for planting of more trees, and there is still a large amount of marginal utility to be gained by planting more trees.

6. Tree Planting and Maintenance

Regular maintenance is essential to support young trees and ensure they establish and survive to maturity, when they typically provide the maximum return on investment. Trees are most vulnerable when they are young, as they have less established, shallower root systems and are less resilient to stressors and pests. Caring for trees attentively when they are young gives them a much better chance of surviving and therefore costing less by not having to be removed and replaced. Care for adolescent and mature trees is important as well but can be on a less regular schedule as trees become older. Irrigation needs are typically highest, for example, for the first year of a tree's life in arid climates, followed by the second and third years, and then the fourth and fifth. After about five years, most trees are reasonably well established and can tolerate a less frequent irrigation schedule, though they require more water at one time to support their larger biomass. Figure 6-1 shows the potential for aesthetic improvement of streets with new, young trees, which when cared for properly, can create a cool, welcoming streetscape with visually interesting and dense canopy coverage.

Given the complexity of managing and adequately caring for the thousands of trees that ideally would be planted throughout the City over the next decades, McFarland should hire an arborist or collaborate with nearby cities like Wasco and Delano to jointly hire an arborist to be shared among the cities. An alternative that is likely more expensive in the long run is to contract with a private arborist or tree management company to provide consultation and guidance for McFarland staff, officials, and developers, as well as tree maintenance services for the City.

6.1 Tree Planting

Tree planting is relatively straightforward, but care must still be taken to avoid mistakes that can compromise the health or stability of the trees. Before the actual planting takes place, young trees must be procured from a nursery or otherwise obtained. Selecting a nursery and buying trees from them is an activity that is best done with significant planning ahead of time. For example, nurseries can be contracted with to obtain bulk discount rates and to grow young trees that are of the appropriate species and size desired. Once the stock has been acquired, trees must be planted in the appropriate location. The size of the planting hole, the replacing of soil around the tree, the use of stakes, and other factors come into play, with good, consistent planting practices resulting in healthy, stable trees.

6.1.1 Acquiring Trees

McFarland has the great advantage of being in the middle of a heavily agricultural area with a high concentration of nurseries to select stock from. In the short term, the City should easily be able to find a variety of appropriate tree species which have appropriately sized stock by examining the inventory of various nurseries. In the long term, the City should negotiate a contract with one or two nurseries to provide a substantial proportion of the City's desired urban trees. A contract with a limited number of nurseries provides negotiating power and ensures a more consistent delivered product for the City. Bulk discount rates should be obtained when possible as more trees are needed for revitalization and new development. If the City has available land, it could contract with a nursery or use its own staff to plant smaller trees, grow them to larger sizes, and transplant them as needed.

Whether growing trees on City land or contracting with nurseries, McFarland should be looking for young, healthy trees of about 1-3 inches diameter at base height (dbh or DBH) for maximum growth potential over the long-term. Trees larger than this tend to grow slower since they lose a much higher proportion of their roots when being transplanted (Watson, 1985).

Figure 6-1: Young trees planted along a street in Portland, Oregon. The trees would do better in a connected planting strip. (Source: Environmental Services Department of Portland, Oregon)

6.1.2 Planting Trees

Once nursery stock has been selected, it must be put in the ground to fulfill its destiny. This is typically carried out by a City's Public Works, Building, or Parks and Recreation Department, as is the majority of urban tree maintenance. While specific tree planting guidelines are available from various organizations, such as the International Society of Arboriculture, in general, new trees should be planted in a hole about the same height as their root ball and two to three times as wide. The root flare, or the bottom part of the tree trunk where roots come out and create a wider base, should be above the soil line to ensure maximum stability. The hole should be backfilled with the native soil, or an amended soil mix, and a small berm should be built in a circle about one to three feet away from the trunk to create a well for water to settle and drain in. Mulch can then be applied around the tree to aid soil moisture retention and provide organic matter, but it should not be covering or touching the trunk to avoid problems with roots growing too high (McPherson, Simpson, Peper, and Xiao, 1999a). Planting, staking, and mulching of a public tree in the Central Valley costs about $25, and the trees themselves cost about $25-60 depending on where they are purchased from (McPherson, Simpson, Peper, and Xiao, 1999a).

6.2 Types of Maintenance

There are several types of maintenance needed to keep urban trees healthy, strong, and not interfering with other types of urban infrastructure. Maintenance is an essential practice that saves money in the long run by improving tree survival rates and tree longevity, reducing costs associated with damage to utilities and infrastructure, and maximizes growth and foliage density to obtain the most benefits.

6.2.1 Irrigation

Regular irrigation is a crucial piece of urban tree maintenance. In arid regions such as the Central Valley of California, very few young trees could survive in urban conditions without supplemental water provided by humans for at least the first year or two of their lives, and many trees require some supplemental water for their entire lives during extended dry periods over summer or during droughts. Water supply is a constant concern in California, where major cities exist in dry areas and water is moved around the state from mountains and reservoirs for agriculture and residential use. Because water is such a precious resource, drought tolerance and water needs were among the most important considerations when choosing appropriate tree species for McFarland in section 4.3. Choosing trees that will require minimal amounts of supplemental irrigation will reduce long-term costs and ensure a better chance of survival. Minimization irrigation needed is crucial, but since some irrigation will always be necessary in arid climates, care should be taken to irrigate only as much as necessary with minimal waste, unlike the situation in Figure 6-2.

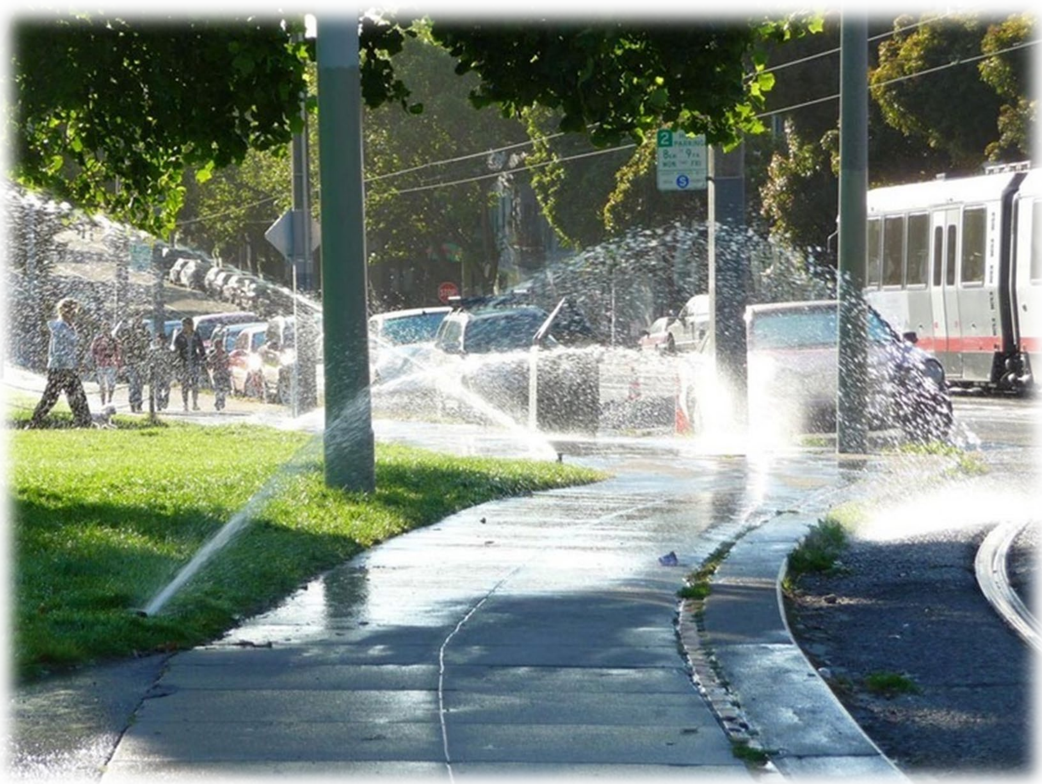


Figure 6-2: Water being wasted by sprinklers spraying onto hard surfaces in San Francisco (Source: SeeClickFix)

Ideally, irrigation of urban trees would occur by a large system of subsurface or drip irrigation lines releasing water over a period of hours to soak into deeper soil layers. This type of irrigation provides water slowly over time and feeds it directly to the roots, with no wasted water flowing across the surface or wetting the foliage of the plant where it provides little to no benefit. This type of irrigation also reduces evaporative losses since water is quickly absorbed and protected by the soil surface. However, drip irrigation systems can be complicated and expensive to set up, especially across large areas. They are likely appropriate for some areas and types of development, such as parking lot planting strips, but may not be feasible to use widely across an entire city. Other solutions will likely need to be combined to provide adequate irrigation for each tree across McFarland, such as gator bags (see Figure 6-3), irrigation from a truck, and watering by residents as part of an “adopt-a-tree” program or similar.

Figure 6-3: Gator bags (bags that provide water to trees over time and are manually refilled periodically) applied to a row of street trees (Source: Peterson Companies)

The cost of irrigation of a public street or park tree with a municipal water truck, according to studies of communities in the San Joaquin Valley, is about $38 per year per tree for the first five years after planting (includes the price of labor, equipment, and water) (McPherson, Simpson, Peper, and Xiao, 1999a). Thus, there is great incentive to establish drip irrigation systems alongside the planting of new trees to eliminate this ongoing cost and need to coordinate who or what will irrigate new trees. Drip irrigation can be installed in areas with established, mature trees, but this can damage the existing root systems and is more difficult than installing with new construction.

Use of wastewater to help irrigate street trees is a potentially viable method for McFarland to reduce potable water use. It has been demonstrated that secondary treated wastewater could be safely used to irrigate root and leafy crops, so it stands to reason that trees, which are even less sensitive than smaller root and leafy crops to pollutants and other stresses, could also be irrigated with secondary treated wastewater (Farhadkhani et al., 2018). McFarland's wastewater treatment facility currently produces around 1 million gallons per day (1 mgd) of secondary treated wastewater (Background Report, 2019, p. 38, 202, 206) which is discharged onto land specially set aside for the purpose of receiving wastewater effluent. If some of this water could be redirected and used to irrigate trees, McFarland could actually save money on water that would otherwise have to be bought for irrigation, as well as on expansion of the wastewater treatment facility and the land it uses for discharging effluent. This wastewater could be applied to the City's trees by either a system of drip irrigation or by a municipal water truck, or it could be used to refill gator bags. To implement such a system of wastewater irrigation would likely require significant extra study to determine feasibility, including whether the particular effluent from McFarland's wastewater treatment facility could be used to safely irrigate trees without causing any long-term harm for the soil or people nearby, and whether the effluent would require any further treatment to be safely and efficiently applied for tree irrigation.

6.2.2 Pruning

Pruning is another important tree maintenance activity that involves trimming branches and foliage that are weak, diseased, interfere with utilities or other infrastructure, or that do not fit the desired shape of the tree; an example of a tree before and after pruning can be seen in Figure 6-4.

Figure 6-4: A large tree before and after pruning (Source: Golden Oak Tree Service)

Pruning is not required frequently for any one tree, but in a community with thousands of trees, it can become a weekly activity. Pruning is required less often for more mature trees, but when it is required, it is more difficult, typically requiring a professional tree trimming company with specialized equipment to conduct efficiently. For smaller, younger trees, pruning can be done cheaply by hand. Case studies of Modesto and Fresno, two other cities in the Central Valley of California, found that they pruned trees once a year for the first three years, costing an average of $2.36 per inch of trunk diameter (DBH) each year, and then pruned trees once every six years, spending an average of $6-9 per tree per year (McPherson, Simpson, Peper, and Xiao, 1999a). Typically, a city's Parks and Recreation or Public Works Departments are primarily responsible for pruning, often aided by residents and/or non-profits or volunteer organizations.

6.2.3 Litter Removal

Many types of trees produce litter, such as seeds, leaves, sap, or fruit, which falls to the ground and often becomes a nuisance. Wet fruits, for example, can fall and break open, or be broken by cars or pedestrians, creating a sticky, slippery mess on sidewalks and streets, or hundreds of flying seed pods can clog storm drains and build up into unsightly piles of decaying organic matter. Figure 6-5 depicts flowers on a sidewalk creating just such a nuisance.

Figure 6-5: Silver Maple flowers coating a sidewalk in Columbus, Ohio (Source: Bob Klips)

The litter of many trees is negligible in volume and does not require regular cleanup, but some trees have significant litter that will require removal to avoid creating extra risk of falls for pedestrians. As litter is comprised of various botanical products from the trees, different species create litter at different times of year (some drop flowers after they bloom in spring, some drop seeds in fall, some drop fruits once they've fully matured in summer, etc.) and so regular observation and/or recordkeeping will be required to dispatch cleanup crews as necessary. Litter from trees that does not gather on sidewalks, streets, or other areas that people access and use regularly may not need to be removed. Some types of litter can increase fire risk if not cleared, but none of the recommended species of tree drop significant flammable litter, and McFarland is in a low fire risk area, so this is unlikely to present a problem. A more likely problem is clogging of storm drains. The City should observe performance of the storm drains during storms and plan preventative maintenance by removing litter from drains that become clogged before each rainy season, during the early fall. Based on data from Fresno and Modesto, litter removal from normal growth and storms cost on average $1.27 per tree per year (McPherson, Simpson, Peper, and Xiao, 1999a).

6.2.4 Tree Removal

As urban trees die, they should be removed as soon as possible and replaced so that the shade and other benefits they provided can be obtained again. Dead trees also become unstable and weak and should be removed in urban areas purely for safety reasons regardless of whether a new tree is planted or not. Dead trees are usually cut into pieces and woodchipped, but mature trees can also be cut just before they die, and their wood used to create wood products like planks or furniture. Using the wood of urban trees requires planning and processing capacity, but it can help offset the cost of the urban forest program and create a stronger political case for funding the urban forest if it directly produces profitable goods, in addition to reducing energy costs and increasing property values and property tax revenue. Trees that need to be removed due to disease, pest infestation, or death should be easily noticed during other regular maintenance such as pruning. Replacing trees that are removed is crucial to maintaining a dense urban forest and continuing to obtain the benefits that urban trees provide, as if trees are removed and not replaced, the size of the urban forest drops. If space allows, replacing one removed tree with two new trees is likely to provide a greater net benefit than replacing only one tree. Information from other Central Valley cities indicates that it costs $12 per inch DBH to remove and dispose of public trees, including their stumps (McPherson, Simpson, Peper, and Xiao, 1999a).

6.2.5 Disease and Pest Prevention

Different species of trees are susceptible to different types of diseases and pests, such as anthracnose, a fungal disease, or the invasive shot hole borer, a beetle that attacks dozens of commonly planted trees across California. The key tool used to fight disease and pests is tree diversity, which makes large die-offs much less likely since most diseases and pests only attack a limited number of different tree species. If McFarland successfully follows the 10-20-30 guideline suggested in section 4.2, half the battle against diseases and pests would be won. The next best tool is simply regular maintenance and checking of trees where diseases or pests are suspected or observed. The earlier an issue is caught, the more likely it can be effectively treated, saving the tree stress, damage, and possible death. This issue underscores the need for McFarland to hire or contract with an arborist or a tree management company. While maintenance and regularly checking the health of trees may seem like an unnecessary or low-priority expense, it is worth keeping in mind that quality tree maintenance saves trees from dying and improves their health and size, all of which result in more benefits being obtained for less total investment. Case studies of other Central Valley cities showed an average expenditure of $0.15 per tree per year for disease and pest control, negligible compared to the cost of replacing trees that would die without treatment and prevention (McPherson, Simpson, Peper, and Xiao, 1999a).

6.3 Maintenance Schedule

McFarland should adopt a regular maintenance schedule for urban trees, as well as encourage and guide residents to maintain and support trees on their properties. Regular maintenance improves tree health over the long run, reduces mortality of young trees, and saves money by reducing frequency of replacement and increasing ecosystem services provided with larger, healthier trees (Gilman, 2015). General guidelines for frequency of each maintenance type are described above but repeated here all together.

Irrigation needs depend on the type of tree, its location, its size, and its age. Young trees typically require frequent watering just after planting, with frequency of watering reducing from every day or every other day down to once a week and once a month during dry periods as the trees age for most low-water-use species (McPherson, Simpson, Peper, and Xiao, 1999a). Once a full tree inventory has been conducted, a comprehensive watering schedule can be prepared to ensure the urban forest remains healthy and growing strongly.

Pruning is typically needed once every year or two when a tree is young, and every three to ten years when it is mature, depending on the age and location (McPherson, Simpson, Peper, and Xiao, 1999a). Trees planted in areas where they will not interfere with any view, infrastructure, or access can be left unpruned, or pruned only to keep them healthy. Data from Fresno and Modesto indicate that average annual costs per tree for infrastructure repair, litter/storm cleanup, litigation/liability, and inspection/administration total about $6 (McPherson, Simpson, Peper, and Xiao, 1999a). $4.26 of this cost per tree goes to infrastructure repair, so an urban forestry program that has strict and well-enforced guidelines for tree placement and sizing can likely expect lower costs.

An arborist or tree management company will have business infrastructure in place to help create basic maintenance schedules, and will have the expertise to advise on the needs of different species, particular pests to apply prevention treatments for, and other such factors.

7. Implementation Strategy

Plans and programs require implementation strategies for them to operate effectively. Excellent plans and ideas can be created and prepared, but without someone to carry out, monitor, and manage the actions called for in the plan, as well as pay for the whole operation, they can be worth nothing. Implementation of a plan requires effort and collaboration from multiple stakeholders within a city over a long period of time, including financial support from City Council. For McFarland, collaboration will be required between various departments and agencies, including the Planning Department, the Recreation and Parks District, and the McFarland Unified School District. The community should ideally be engaged in the entire urban forest management process and feel a sense of both responsibility and pride in helping maintain and grow the urban forest while reducing labor costs for the City. There is additionally an opportunity to collaborate with nearby cities such as Wasco and Delano to pool and share resources, hire jointly held staff, and share information, taking advantage of economy of scale to achieve better results for urban forests and better outcomes and benefits for residents. Budgeting must be considered as a crucial piece of implementation, and some budget must be allocated specifically for maintenance and development of McFarland's urban forest in order to achieve the greatest benefits and savings, as without care and management, urban trees become net financial and environmental losses. Finally, the actual activities associated with maintenance of trees, such as planting, mulching, watering, and pruning must be scheduled, and some party must be responsible for each step. Making clear plans and allocating responsibilities ahead of time will ensure the most efficient use of limited resources.

7.1 Responsible Parties

The agencies and departments within the City of McFarland that have a direct interest in and are best suited to planting, maintaining, and caring for trees are the Planning Department, the Economic Development Department, the Recreation and Parks District, and the Public Works Department. Direct responsibility for the management and care of the trees, such as ensuring regular irrigation, pruning, and other maintenance needs, is likely best suited to the Public Works Department for non-park areas and the Recreation and Parks District for park areas. However, if these responsibilities are already allocated in a way that is satisfactory to all parties, future increased responsibilities could be allocated according to the existing system. The McFarland Unified School District is another agency that with a vested interest in the urban forest, as an improved urban forest means healthier children. The School District stands to save money on energy costs while also creating an excellent educational opportunity by having students involved in the planting, care, and monitoring of the trees on school grounds.

Volunteers are often involved in urban forest management, whether through dedicated 501(c)(3) non-profit organizations, informal community organizing, or through a collaboration with cities. A group of trained volunteers can care for most young trees and can help reduce labor costs for cities while also providing an opportunity for residents to learn about trees and nature while socializing and working outdoors. If volunteers are part of an urban forest management strategy, however, there must be clear guides as to who is responsible for what or for which trees. This will be discussed further in section 7.2, but it is important to keep in mind that urban forests are green infrastructure, providing quantifiable benefits to cities that should be properly valued and cultivated, with money dedicated to trees just as money is dedicated to road repair, sidewalk construction, and parks.

Collaboration with other cities, public agencies, and non-profits will result in a better resource pool for the urban forest in McFarland. As mentioned previously, McFarland should hire an arborist or contract with a tree management company to manage their urban forest. The nearby cities of Wasco and Delano should be engaged to see if they would be interested in a mutual agreement to pool resources for urban forestry, as well as any public agency in the area. More staff can be hired, and better coordination can be achieved, by working together with other cities in very similar economic and environmental conditions. Economy of scale can be achieved by sharing resources such as databases of street trees, GIS files, optimal maintenance schedules for different trees, or model ordinances. Urban forests have region-wide benefits, so resources should be sought from throughout the entire region rather than only within McFarland.

7.2 Community Engagement

A street tree or urban forest program is an excellent opportunity for McFarland to build positive relationships with residents, encourage a sense of responsibility and ownership in residents, and obtain a variety of public health, environmental, educational, and economic benefits at the same time. “Adopt-a-road” programs are relatively common across the US, in which organizations keep a section of road clear of litter through volunteer cleanup efforts, and “adopt-a-tree” programs could be utilized in a similar way, reducing maintenance costs for the City as residents who adopt trees would be responsible for the first few years of pruning (before trees become too tall for hand tools), cleanup, and irrigation. If residents are more actively involved in planting and caring for their urban trees, they will value the trees more and be more satisfied with them than if they were planted and cared for by city staff (Sommer, Learey, Summit, and Tirrell, 1994) and will be more likely to support an expanded urban forest management plan and a greater allocation of budget to caring for and planting more urban trees. Participation can be encouraged with plaques installed on or near trees to honor residents who help plant or care for them, which also provide an opportunity for education if information about the tree (such as species, mature size, or estimated annual benefits) is included on the plaque. Implementing an urban forest management plan, depending on what system of management the City chooses to use, can create job opportunities if the City chooses to hire or utilize its own staff or if it chooses to contract with an outside firm. This has the dual benefit of recycling money invested in the urban forest through residents and the local economy rather than sending it out of the City to external businesses.

Making information about the urban forest more accessible to residents can also encourage greater community engagement. For example, some cities maintain Geographic Information Systems (GIS) inventories of their urban trees which can be accessed by anyone to see where urban trees are, what their species is, and sometimes other information such as tree size, date of planting and size at planting, or estimated value of provided benefits. In some cases, residents can contribute data about the urban forest, such as being able to enter information on new trees in a public database, opening up even further opportunities for engagement with the urban forest. These types of arrangements can potentially help reduce financial strain on cities by using volunteer time instead of paying for someone to conduct the work, but they should be used as supplements to a city-funded urban forest program, and should not be relied on as the primary method of getting work done.

7.3 Estimated Costs

Urban forests require significant investment for maintenance and development in order to achieve maximum benefits, and as shown earlier, urban forests typically provide a net financial benefit to cities, including other cities in the Central Valley and across California (McPherson, Doorn, & Goede, 2016; McPherson & Muchnick, 2005; McPherson, Simpson, Peper, and Xiao, 1999a). Accordingly, it is most fiscally responsible for cities to dedicate a portion of their budget to the maintenance and development of their urban forests as it provides a long-term investment and comes with a wide variety of public health and environmental benefits.

Information from other cities in the Central Valley is available to help give an estimate of potential costs for McFarland. McPherson, Simpson, Peper, and Xiao (1999a) gathered data and comments from urban foresters, residents, utility companies, and public agencies, and used electricity and natural gas costs, stormwater treatment costs, CO2 and other air pollutant control costs, among other information, to model and estimate total costs and benefits for the urban forests of Fresno, Modesto, Sacramento, and the Sacramento area. Fresno is located approximately 85 miles north of McFarland along State Route 99, and all the cities are in USDA hardiness zone 9b, meaning their climates are relatively similar to McFarland's and that data on their urban forests should apply well to estimating costs and benefits for McFarland's urban forest.

Data from this study indicates that planting, staking, and mulching a public tree costs about $25, average annual pruning costs are $6-9 per tree, tree removal costs $12 per inch DBH, average pest and disease control costs are $0.15 per tree, and irrigation costs were about $1.50 over one year for a large tree. Additional annual average per tree costs were $4.26 for infrastructure repair, $1.27 for litter/storm cleanup, $0.27 for litigation/liability, and $0.19 for inspection/administration. Adding these costs gives an initial cost of $25 per tree, $13.64-16.64 per tree per year, and a one-time cost of $36-300 per tree for removal. Assuming conservatively that the average tree lives 40 years and assuming a high removal cost of $300, the average tree would cost about $21.77 per year. Benefits include the price of net annual energy savings (cooling and heating), the price of annual air quality improvement (from pollutant absorption and avoided power plant emissions), the price of annual CO2 reductions, the price of annual stormwater runoff reductions, and the price of annual property value and other benefits (the various other environmental and health benefits). The net annual benefits over a 40-year period were calculated in this study to be $1-8 for a small tree (a Crape Myrtle), $26-37 for a medium tree (a Chinese Pistache), and $48-63 for a large tree (a London Plane Tree). It was found that larger trees provide a much greater return on investment as they provide significantly greater benefits without significantly higher capital costs. These net annual benefit values can be even greater for residential yard trees planted strategically to the west of houses to maximize energy savings. The results of this study suggest that setting aside money for McFarland's urban forest would be a prudent financial investment. Connecting budgets for programs that address some of the same problems urban trees can help with to the budget for the urban forest helps support long-term financial viability for the urban forest and creates co-benefits that other programs often do not, such as improved psychological health for residents.

One potential avenue of cost reduction detailed in section 6.2.1 is use of treated wastewater for irrigation. Based on the average irrigation costs from McPherson, Simpson, Peper, and Xiao (1999a), which are likely lower than irrigation costs in 2020, use of treated wastewater could save $60+ per tree over a 40-year period. If McFarland had 1,000 trees to irrigate, this would mean savings of $60,000+ over the same 40-year period, or enough money to plant, stake, and mulch at least 2,400 trees (based on the $25 cost to plant a public tree from the same study). Another avenue of cost reduction is planning very carefully to avoid infrastructure damage. Since it was found that about $4.26 per year was spent on infrastructure damage by urban trees in other Central Valley cities, a city that takes care to ensure properly sized tree wells, clustering of trees with contiguous soil volume, regular pruning and maintenance, and preferential planting of trees in areas and at distances where they will not damage infrastructure, could possibly see significant savings on repair costs. For example, if McFarland could reduce the cost of repairs to $2.26 per year per tree, with 1,000 trees, the City could save $80,000 over a 40-year period, enough to plant, stake, and mulch 3,200 new trees. Keeping in mind that urban trees typically provide net financial benefits, any cost savings on their upkeep means larger net benefits and a more financially sustainable urban forest program.

7.3.1 Long-term Budgeting for Trees

Trees require water and care over time, requiring money to be spent on staff. Pruning and other maintenance activities, as well as manual watering in areas without automatic irrigation, requires basic labor several times over the life of every individual tree. Management and scheduling for tree care requires semi-skilled to skilled labor of a planner, arborist, or a contracted tree or landscape management company. Therefore, budgets for the urban forest cannot be limited to one-time influxes for planting or batch maintenance. With a reduced but stable budget, trees are likely to live longer and provide a full return on investment, rather than dying young and often and becoming net losses. Further, urban trees are green infrastructure, providing many of the benefits of different types of gray infrastructure (e.g. concrete gutters and sewers for stormwater drainage), and should be treated at least as equal to other infrastructure budgets, such as curb repair and stormwater control. Few other types of infrastructure provide as wide a variety of benefits as urban trees do, and since it has been established that urban forests typically provide a significant positive return on investment, adequate funding for developing and managing the urban forest should be a priority for McFarland just as flood control and pavement management are.

Given this, budget for urban trees should be included as a piece of other, larger budgets. For example, McFarland's Capital Improvement Plan (CIP) should include as part of any project where trees could be used to provide shade or other benefits, a small percentage of the budget dedicated to trees, perhaps 0.5-2% of a project's total budget, or more as needed to plant and have long-term funds for maintenance of new trees. Additionally, the CIP could include, as a standalone item, funding for the urban forest and urban forest projects. Another long-term, stable funding option would be to impose a small increase in water fees for residents to cover the costs of irrigating the urban forest. Allocating a portion of stormwater utility fees is another good option for long-term funding of trees as part of projects to reduce runoff and improve runoff quality.

Another potential method of funding the urban forest is special improvement districts or business improvement districts. These are areas in which property owners have voted to voluntarily impose a tax on themselves to pay for some set of services or improvements. If the City could persuade businesses to create such districts, it could reduce the financial strain on itself while still enjoying many of the benefits of the urban trees it could then plant and maintain. These arrangements can be difficult and laborious to set up, but they have the advantage of having buy-in from many community members and not being a mandate, but a desire on the part of property owners to better their community.

Development conditions can and should be required for all new construction to include trees where feasible for shade and all the other benefits they provide. Maintenance and replacement can further be required by ordinance. As mentioned in section 5.1.5, developers should be reminded that healthy, large trees save them money they would otherwise spend on energy, stormwater mitigation, air pollution mitigation, etc. and that they will see a net financial benefit from planting trees strategically on their properties and around their buildings. Planting of trees can also be part of mitigation measures for air quality, stormwater runoff, noise, aesthetics, and other environmental impacts caused by development, setting up a positive incentive for developers to plant trees and strategically place them to maximize benefits.

California has a cap-and-trade program, in which pollutant emissions are capped at a certain level and permits to pollute are bought and sold among utilities, private companies, and other organizations. Urban forests can be registered as projects that capture carbon, earning money for the jurisdiction containing the trees. The City of Santa Monica, for example, registered a project to add 1,000 trees to its urban forest as a carbon offset project. This provides a potential revenue stream to reduce maintenance costs for the urban forest.

Another possible funding source is the Kern County Public Health Department. Given that urban trees provide so many benefits to public health, from improved mental and physiological health to reduced air pollution and heat-related illnesses, a strong argument can be made that investing in urban forests is a financially and socially prudent decision. In Santiago, Chile, for example, urban forests and urban forest management were found to be cost-effective strategies for reducing PM10, more cost-effective than many other strategies in use such as conversion of buses to run on natural gas (Escobedo et al., 2008). PM10 is one of the air pollutants for which the San Joaquin Valley Air Basin is not in attainment, so using urban forests to help reduce PM10 and other pollutant levels would be an efficient way to improve public health.

A long-term strategy for funding is creation of a trust or endowment, which is a sum of money invested into a portfolio, typically some combination of stocks, municipal bonds, and treasury notes. The interest obtained from the investment is then used to fund the program on an ongoing basis, ideally never drawing down the principal (the original amount invested that then earns interest), or even increasing it over time to increase the annual interest. For example, if McFarland obtained $2,000,000 in grant funding to develop and maintain its urban forest, and the grant funder allowed it, the $2,000,000 could be invested and at a very conservative 4% annual rate of return, it would generate $80,000 per year in perpetuity. Obtaining a large enough sum of money to create a sufficient endowment can be difficult and is likely only to occur through a grant. McFarland has applied for and received grants in the recent past, so seeking grants for urban forestry should be efficient and well worth the time and money for the City.

7.3.2 Grants for Urban Trees

Grants are sums of money awarded by various organizations, typically to achieve progress towards some desired outcome. Grants are awarded based on many different criteria, but in general, obtaining the maximum amount of the desired benefit is the primary criteria. In many cases, disadvantaged communities are given higher priority or greater consideration in the grant application process under the logic of obtaining the greatest marginal returns on investment (that is, help those who are worst off as much as possible, as they benefit more from a given amount of investment). Urban forestry, fortunately, has a variety of benefits and thus can be a valid project for multiple types of grants. Some grants directly seek the planting of trees, recognizing the benefits trees bring to local communities and the global carbon balance, while other grants seek air quality or water quality improvement, environmental education, or energy use reduction. Grants are typically one-time investments, but they can be large, from thousands to hundreds of thousands up to millions of dollars. Grants provide an excellent return on investment for cities with fewer resources and revenues, as they require little more than a staff person to write grant applications and communication between departments to make the necessary information available. What follows is a list of grants and grant-giving organizations who fund tree planting projects.

California ReLeaf

State's volunteer coordinator for urban forestry in partnership with the California Department of Forestry and Fire Protection (Cal Fire). Supports community-based tree planting programs, coordinates and offers grants, and advocates for urban forestry. Regularly helps coordinate grants for tree planting from the US Forest Service, Cal Fire, the US Environmental Protection Agency (EPA), etc.

Cal Fire

Cal Fire administers various urban forestry grants, including a recurring program that funds tree planting programs to capture carbon as part of the California Climate Investments program, using funds from the state's cap-and-trade system. This grant program prioritizes disadvantaged communities, which means McFarland is positioned to be competitive for funding. It has three categories of eligible projects; one funds tree planting and site improvements to benefit trees, another funds tree maintenance, management, planning, and mapping, and another funds wood/biomass utilization for trees that would have been removed anyway.

US Federal Government Grants

The US federal government administers a wide variety of grants under several of its departments such as the Department of Energy and the Department of Agriculture that are relevant to or usable for urban forestry. Grants are searchable and applications can be filled out electronically. Periodic review of grants should be undertaken, as grants close and new grants open regularly.

California State Bonds

Every two years, California voters can vote on propositions which often grant the state authority to issue bonds to fund various things like schools or environmental protection. Funds from these bonds are disbursed in the same manner as a grant. There are often propositions which allocate funds for various environmental or health related purposes which could be used for urban forest development and maintenance. For example, Prop 68 in 2018 provided money for environmental protection, water infrastructure, and flood control projects, three purposes urban trees could fulfill.

8. Glossary of Terms

Arborist	A professional who cultivates, manages, and/or studies trees and other woody plants.
Carbon Dioxide (CO2)	A gaseous form of carbon emitted by vehicles and industrial processes which is the primary man-made driver of climate change through intensification of the greenhouse effect.
Climate change	Long-term changes in the climate of the Earth related to the greenhouse effect and human activities, including average precipitation and temperature changes.
Contiguous soil volume	Contiguous soil refers to soil that is not separated by any hardscape feature such as a sidewalk or utility trenching – a planting strip is a strip of contiguous soil. Trees planted with greater contiguous soil volume grow healthier root systems and attain better health and size than trees with little contiguous soil volume.
Engineered soil	Manufactured soil mixtures with specific ratios of sand, silt, clay, organic matter, and other amendments, used to achieve improved soil characteristics such as little settling, good root growth, and good drainage.
General Plan	A comprehensive, long-term plan for the development of a city that examines a wide range of issues such as land use, circulation, housing, and safety, among others.
GIS	Geographic Information Systems. A type of computer software that enables organization, manipulation, and analysis of many types of data linked to geographic areas, such as topography, vegetation, and population. Often used to create maps.
Low Impact Development	Also known as LID, a system of planning and engineering design using green infrastructure (vegetation, trees, and soil) to manage stormwater runoff and reduce environmental impacts associated with it.
Mulch	A layer applied on top of soil, usually wood chips, bark chips, or other organic matter, that helps retain soil moisture, reduce weed growth, and improve aesthetics of landscaped areas.
PM2.5	Particulate matter with a diameter <2.5 micrometers, an air pollutant that contributes to heart and lung diseases as well as birth defects.
PM10	Particular matter with a diameter <10 micrometers, an air pollutant that contributes to heart and lung diseases.
Tree well	An often too-small cut-out area of a road or sidewalk which is intended for a tree.
Urban forest	A forest or collection of trees that grow in a city, town, or other urbanized area.

Urban heat island effect A phenomenon in which urban areas become and remain significantly warmer than the surrounding areas due to human influence (especially creation of dark and heat-trapping surfaces like pavement and concrete).

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10. Appendix A

Common Name	Scientific Name	Family	Mature Size	Canopy Size	Growth Rate	Longevity	BVOC Emissions	Drought Tolerant	Water Use	Soil Texture	Branch Strength	Root Damage Potential	Fire Resistance	Allergenic	Toxic	Wildlife Attracted	Evergreen/Deciduous	California Native	Best Uses
African Fern Pine	Afrocarpus falcatus	Podocarpaceae	50-65'	25-50'	M	L	L	Moderate	Moderate	CLS	M	L		No	No	None	E	No	SP, BS
Aleppo Pine	Pinus halepensis	Pinaceae	30-60'	20-40'	F	L	L	Yes	Low	CLS	S	M		Yes	No	Birds, Squirrels	E	No	SP, SH
Atlas Cedar	Cedrus atlantica	Pinaceae	45-65'	35-50'	S-M	L	L	Yes	Low	CLS	M	M	U	No	No	None	E	No	SC, ST
Australian Willow	Geijera parviflora	Rutaceae	25-35'	20'	F	M	L	Yes	Low-Moderate	CLS	M	L		No	No	Bees	E	No	SC, ST
Cajeput Tree	Melaleuca quinquenerv	Myrtaceae	20-40'	15-25'	M	L	H	Yes	Low	CLS	M	L		Yes	No	Bees, Birds	E	No	SC, R
California Ash	Fraxinus dipetala	Oleaceae	20-25'	15-20'	M	M-L	L	Yes	Low	CLS	M-S	L	F	Yes	No	Birds	D	Yes	SC
Chisos Oak	Quercus canbyi	Fagaceae	40-50'	30-50'	M	L	H	Yes	Low-Moderate	CLS	S	L		No	No	Birds, Squirrels	E to partly D	No	ST, SH
Chinese Hackberry	Celtis sinensis	Cannabaceae	40-65'	35-50'	M	L	L	Yes	Low	CLS	M	M		Yes	No	Birds	D	No	SP, ST, SH
Chinese Pistache	Pistacia chinesis	Anacardiaceae	25-35'	25-35'	S-M	L	M	Yes	Low	CLS	S	L	C	Yes	No	Birds	D	No	SC, ST
Crape Myrtle	Lagerstroemia indica	Lythraceae	25'	25'	S-M	L	N	Yes	Moderate	CLS	M	L		No	No	Birds	D	No	SC
Desert Museum Palo Verde	Parkinsonia x 'Desert Mu	Fabaceae	15-20'	20-25'	F	L	M	Yes	Low	CLS	M	L		No	No	Bees	D	No	SC, SP, ST
Desert Willow	Chilopsis linearis	Bignoniaceae	15-30'	10-20'	F	L	M	Yes	Low	LS	M	L		Yes	No	Birds	D	Yes	SC
Evergreen Pear	Pyrus kawakamii	Rosaceae	15-30'	15-30'	F	L	L	No	Moderate	CLS	M	L		No	No	Birds	E to partly D	No	SC
Goldenrain (Golden Rain) Tre	Koelreuteria paniculata	Sapindaceae	20-35'	25-40'	S	L	H	Yes	Moderate	CLS	M	L		Yes	No	None	D	No	SC, ST
Holly Oak	Quercus ilex	Fagaceae	30-60'	30-60'	S-M	L	H	No	Low	CLS	S	L		Yes	Yes	Birds, Squirrels	E	No	ST
Italian Stone Pine	Pinus pinea	Pinaceae	40-80'	40-60'	F	L	U	Yes	Low	LS	W	L		Yes	No	Birds, Squirrels	E	No	SP, SH, ST
Lemon Bottlebrush	Callistemon citrinus	Myrtaceae	20-25'	25'	F	M-L	H	Yes	Low	CLS	M	L	F	Yes	No	Bees, Birds	E	No	SC, ST
London Plane Tree	Platanus x hispanica	Platanaceae	70-85'	50-70'	F	L	H	Moderate	Moderate	CLS	S	H	F	Yes	No	Bees	D	No	ST
Marina Madrone	Arbutus 'Marina'	Ericaceae	40-50'	40'	M	L	U	When established	Low-Moderate	CLS	S	L		No	No	Birds	E	No	SC, ST
Pindo Palm	Butia capitata	Arecaceae	15-25'	10-12'	S-M	M-L	U	Yes	Moderate	CLS	S	L		Some	No	Mammals	E	No	SP, BS, ST
Shoestring Acacia	Acacia stenophylla	Fabaceae	20-30'	10-20'	F	M-L	U	Yes	Low	CLS	W	L		Yes	No	Birds	E	No	SP, ST
Strawberry Madrone (Strawb	Arbutus unedo	Ericaceae	20-35'	20-35'	S-M	L	L	When established	Low	CLS	S	L	F	Yes	No	Birds	E	No	SC, ST, SH
Toyon	Heteromeles arbutifolia	Rosaceae	15-25'	8-15'	S-M	L	L	Yes	Low	CLS	M	L	C	No	No	Bees, Birds	E	Yes	SC
Tulip Tree	Liriodendron tulipifera	Magnoliaceae	60-80'	40'	F	L	M	No	High	CL	M-S	M		Yes	No	Birds	D	No	SP, SH, ST
Valley Oak	Quercus lobata	Fagaceae	50-70'	50'	F	L	M	Moderate	Low	LS	M-S	M	F	Yes	Yes	Birds, Squirrels	D	Yes	SP, R, SH
Weeping Bottlebrush	Callistemon viminalis	Myrtaceae	15-20'	15-20'	F	L	H	Yes	Moderate	CLS	M	L	F	Yes	No	Bees, Birds	E	No	SC, ST

Mature Size: Mature height in feet. Under about 25 feet is considered "utility friendly."

Canopy Size: Typical canopy size in feet.

Growth Rate: F = Fast, M = Medium, S = Slow. Growth rates are relative and assume irrigation, with fast being at least 24 inches per year of growth and slow being 12 or fewer inches per year.

Longevity: L (Long) >30 years, M (Medium) 15-30 years, S (Short) <15 years. In general, tree lifespan is shorter in Kern County than in the northern and eastern US, both for individual species and for the entire urban forest.

BVOC Emissions: N = Negligible, L = Low, M = Medium, H = High, U = Unknown. Biogenic volatile organic compounds contribute to smog formation.

Water Use: Water use is relative. Low typically means only summer irrigation is needed, 2-4x per month, Moderate means regular summer irrigation is needed and supplemental irrigation may be needed in winters with low rainfall. High indicates a need for regular irrigation throughout the year. Each species has particular preferred watering schemes which are beyond the scope of this table.

Soil Texture: C = Clay, L = Loam, S = Sand. CLS = Clay, Loam, or Sand.

Branch Strength: W = Weak, M = Moderate, S = Strong.

Root Damage Potential: L = Low, M = Moderate, H = High.

Fire Resistance: U = Unfavorable, F = Favorable, C = Conflicting, blank = unknown.

Evergreen/Deciduous: E = Evergreen, indicating leaves stay on the tree are and are green year round. D = Deciduous, indicating leaves fall from the tree in fall/winter and regrow in spring/summer.

Best Use: SC = Screen, SP = Specimen, R = Riparian, BS = Buffer strip, C = Container, ST = Street tree, SH = Shade tree. Each use is described in detail in the Urban Forest Plan.