Tree Guidelines for Inland Empire Communities

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Tree Guidelines for Inland Empire Communities

Executive Summary

Communities in the Inland Empire region of California contain over 8 million people, or about 25% of the state's population. The region's inhabitants derive great benefit from trees because compared to coastal areas, the summers are hotter and air pollution levels are higher. The region's climate is still mild enough to grow a diverse mix of trees. The Inland Empire's climate is influenced by the ocean less than 15% of the time and extends from Ojai east to Simi Valley, Glendale, Alhambra and Riverside, as well as south to Escondido.

The role of urban forests – trees in parks, yards, public spaces, and along streets – is to improve environmental quality, increase the economic, physical and social health of communities, and foster civic pride. Urban forests will be important to quality of life as these communities continue to grow in the next decade. Urban and community forestry has been recognized as a cost effective means to address a variety of important community and national issues from improving air quality to combating global warming.

This guidebook analyzes the multitude of benefits that trees can provide to communities and residents. By determining the community and homeowner savings from planting trees and subtracting the cost, this study found that trees more than pay for themselves. Over a 40-year period, after subtracting costs, every large tree produces savings of approximately $2,600 to $3,400 depending on whether it is a public or private tree. This amount decreases with the tree's size with medium trees saving about $1,300 to $2,300 and small public trees costing $80 while small private trees save $560.

Who Should Read This Guide

Local Elected Officials
Public Works Employees
City and County Planners
Developers and Builders
Architects and Landscape Architects
Energy Professionals
Air & Water Quality Professionals
Healthcare Advocates
Homeowners
Neighborhood Activists and Organizers
Arborists
Environment Advocates
Community Foresters
Tree Advocacy Organizations
Concerned Citizens

Trees can have far reaching affects on the quality of air and water in our communities, on the amount of money we spend to cool and heat our houses, on the value of our property, and on the attractiveness of our neighborhoods and public spaces. They affect our moods and our health, as well as the health of our children.

This guidebook addresses the benefits of urban and community forests and how you can reap these benefits for your community, your neighborhood, and your family including:

- Improving environmental quality by planting trees,
- Planting trees to reduce energy consumption and save money and
- Choosing tree species that reduce conflicts with power lines, sidewalks and buildings.

- Developing and promoting tree planting and maintenance programs in your community.
- Finding sources of funding and technical assistance for planting trees in your community.

Inland Empire communities can promote energy efficiency through tree planting and stewardship programs that strategically locate trees to shade buildings, cool urban heat islands, and minimize conflicts with power lines and other aspects of the urban infrastructure. Also, these same trees can provide additional benefits by reducing atmospheric carbon dioxide (CO_2), improving air quality, reducing stormwater runoff, increasing property values, enhancing community attractiveness, and promoting human health and well-being. The simple act of planting trees provides opportunities to connect residents with nature and with each other. Neighborhood tree plantings and stewardship projects stimulate investment by local citizens, business, and government in the betterment of their communities.

Energy Benefits

Rapid urbanization of cities during the past 50 years has been associated with a steady increase in downtown temperatures of about 0.7° F per decade. As temperature increases, energy demand for cooling increases as do carbon dioxide emissions from fossil fuel power plants, municipal water demand, unhealthy ozone levels, and human discomfort and disease.

Trees and other greenspace may lower air temperatures 5-9° F. Because summer weather of Inland Empire communities is relatively warm, potential energy savings from trees are greater than for coastal regions. Computer simulations of annual cooling savings for an energy efficient home in Riverside indicate that shade from two 25-foot tall trees on the west side and one on the east side are estimated to save $57 each year or about 23% of the home's cooling cost. Evapotranspirational cooling from these three trees is estimated to double these savings provided that a large enough number of trees were planted to reduce summertime temperatures in the neighborhood. Simulated savings for the same residence in San Diego were about 50% of this amount due to cooler summer temperatures.

Urban forests improve climate and conserve building energy use by:

- Shading, which reduces the amount of radiant energy absorbed and stored by built surfaces,
- Evapotranspiration, which converts liquid water in leaves to vapor, thereby cooling the air, and
- Wind speed reduction, which reduces the infiltration of outside air into interior spaces.

Air Quality Benefits

Urban forests can reduce atmospheric carbon dioxide (CO_2) in two ways: ❶ trees directly store CO_2 as woody and leafy biomass while they grow and ❷ trees around buildings can also reduce the demand for heating and air conditioning, thereby reducing emissions associated with electric power production.

Urban trees provide direct air quality benefits by:

- Absorbing gaseous pollutants (ozone, nitrogen oxides) through leaf surfaces,
- Intercepting particulate matter (e.g., dust, ash, pollen, smoke),
- Releasing oxygen through photosynthesis, and
- Transpiring water and shading surfaces, which lowers local air temperatures, thereby reducing ozone levels.

Most trees emit various biogenic volatile organic compounds that can contribute to ozone formation. The ozone forming potential of different tree species varies considerably and can be found in the tree selection chapter.

Trees that shade asphalt surfaces and parked vehicles reduce emission of hydrocarbons that come from leaky fuel tanks and worn hoses as gasoline evaporates. These evaporative emissions are a principal component of smog and parked vehicles are a primary source. Initial calculations indicate that planting trees in parking lots throughout the region could reduce hydrocarbon emissions comparable to the levels achieved through the local air quality district's currently funded programs (e.g., graphic arts, waste burning, vehicle scrappage).

Water Quality Benefits

Urban stormwater runoff is a major source of pollution. Trees improve water quality by:

- Intercepting and storing rainfall on leaves and branch surfaces, thereby reducing runoff volumes and delaying the onset of peak flows,
- Increasing the capacity of soils to infiltrate rainfall and reduce overland flow, and
- Reducing soil erosion by diminishing the impact of raindrops on barren surfaces.

Urban forests can provide other water benefits. Irrigated tree plantations can be a safe and productive means of wastewater disposal. Reused wastewater can recharge aquifers, reduce stormwater treatment loads, and create income through sales of wood products.

Social Benefits

Trees provide a host of aesthetic, social, economic, and health benefits that should be included in any benefit-cost analysis. For example, trees:

- Abate noise, by absorbing high frequency noise which are most distressing to people,
- Create wildlife habitat, by providing homes for many types of wildlife,
- Reduce exposure to ultraviolet light, thereby lowering the risk of harmful health effects from skin cancer and cataracts,

- Provide pleasure, whether it be feelings of relaxation, or connection to nature,
- Provide important settings for recreation,
- Improve individual health by creating spaces that encourage walking,
- Create new bonds between people involved in tree planting activities,
- Provide jobs for both skilled and unskilled labor for planting and maintaining community trees,
- Provide educational opportunities for residents who want to learn about nature through first-hand experience, and
- Increase residential property values (studies indicate people are willing to pay 3-7% more for a house in a well-treed neighborhood versus in an area with few or no trees).

Urban Forest Costs

Costs for planting and maintaining trees vary depending on the nature of tree programs and their participants. Generally, the single largest expenditure is for tree trimming, followed by tree removal/disposal, and tree planting. An initial analysis of data for Sacramento and other cities suggests that households typically spend about $5-10 annually per tree for pruning, removal, pest/disease control, irrigation, and other tree care costs.

Other costs associated with urban trees include:

- Pavement damage caused by roots,
- Flooding caused by leaf litter clogging storm sewers,
- Green waste disposal and recycling (can be offset by avoiding dumping fees and purchases of mulch), and
- Irrigation costs.

Cost-effective strategies to retain benefits from large street trees while reducing costs associated with root-sidewalk conflicts are needed. The tree selection list in Chapter 6 contains information on appropriate parkway widths to minimize hardscape damage.

Residential Tree Selection and Location for Solar Control

The ideal shade tree has a fairly dense, round crown with limbs broad enough to partially shade the roof. Given the same placement, a large tree will provide more building shade than a small tree. Deciduous trees allow sun to shine through leafless branches in winter.

When selecting trees, match the tree's water requirements with those of surrounding plants. Also, match the tree's maintenance requirements with the amount of care different areas in the landscape receive.

Evergreens are preferred over deciduous trees for windbreaks because they provide better wind protection. The ideal windbreak tree is fast growing, visually dense, and has stiff branches that do not self-prune. Incense cedar and Canary Island pines are among the best windbreak trees for Inland Empire communities.

The right tree in the right spot saves energy. In midsummer, the sun shines on the northeast and east sides of buildings in the morning, passes over the roof near midday, then shines on the west and northwest sides in the afternoon. Air conditioners work hardest during the afternoon when temperatures are highest and incoming sunshine is greatest. Therefore, a home's west and northwest sides are the most important sides to shade. The east side is the second most important side to shade.

Trees located to shade south walls can block winter sunshine and increase heating costs, because during winter the sun is lower in the sky and shines on the south side of homes. The warmth the sun provides is an asset, so do not plant evergreen trees that will block southern exposures and solar collectors.

General Tree Planting Recommendations include:

- Trees on the west and northwest sides of homes provide the greatest energy benefit; trees on the east side of homes provide the next greatest benefit,
- Plant only deciduous trees on the south side of homes to allow winter sunlight and heat,
- Plant evergreen trees as windbreaks,
- Shade trees can make paved driveways and patios cooler and more comfortable spaces,
- Shading your air conditioner can reduce its energy use, but do not plant vegetation so close that it will obstruct air flow around the unit,
- Keep trees away from overhead power lines and do not plant directly above underground water and sewer lines.

Tree Location and Selection in Public Places

Locate trees in common areas, along streets, in parking lots, and commercial areas to maximize shade on paving and parked vehicles. By cooling streets and parking areas, trees reduce emissions from parked cars that are involved in smog formation. Large trees can shade more area than smaller trees, but should be used only where space permits. Remember that a tree needs space for both branches and roots.

CO_2 reductions from trees in common areas are primarily due to sequestration (storage in biomass). Fast-growing trees sequester more CO_2 initially than slow-growing trees, but this advantage can be lost if the fast-growing trees die at younger ages. Large growing trees have the capacity to store more CO_2 than do smaller growing trees. To maximize CO_2 sequestration, select tree species that are well-suited to the site where they will be planted.

Contact your local utility company before planting to locate underground water, sewer, gas, and telecommunication lines. Note the location of power lines, streetlights, and traffic signs, and select tree species that will not conflict with them. Keep trees at least 30 feet away from street intersections to ensure visibility. Avoid locating trees where they will block illumination from street lights or views of street signs in parking lots, commercial areas, and along streets. Avoid planting shallow rooting species near sidewalks, curbs, and paving.

The ideal public tree is not susceptible to wind damage and branch drop, does not require frequent pruning, produces little litter, is deep-rooted, has few serious pest and disease problems, and tolerates a wide range of soil conditions, irrigation regimes, and air pollutants. Because relatively few trees have all these traits, it is important to match the tree species to planting site by determining what issues are most important on a case-by-case basis.

A Checklist for Designing Your Tree Program

- Establish the Organizing Group
- Draw a "Road Map"
- Set Priorities
- Send "Roots" into the Community
- Provide Timely, Hands-on Training and Assistance
- Nurture Your Volunteers
- Obtain High-Quality Nursery Stock
- Develop a List of Recommended Trees
- Commit to Stewardship
- Use Self-Evaluation to Improve
- Educate the Public
- Envision the Future

Program Design

A successful shade tree program is likely to be community-wide and collaborative. Fortunately, lessons learned from urban and community programs throughout the country can be applied to avoid pitfalls and promote success.

Tree planting is a simple act, but planning, training, selecting species, and mobilizing resources to provide ongoing care require considerable forethought. Successful shade tree programs will address all these issues before a single tree is planted.

What Can Local Governments Do?

Local government has a long history of preserving and expanding the urban forest. Below are some recommended steps for further local government involvement. Appendices B and C provide more background materials, contact information and a list of funding resources.

Require Shade Trees in New Development

Trees can help to reduce energy costs, improve air and water quality, and provide urban residents with a connection to nature.

Trees reduce cooling needs during hot summers by shading buildings and cooling the air through evapotranspiration. Computer simulations show that an energy-efficient home in Riverside could save $57 in annual energy costs if two 25-foot tall trees were placed on the west side of the home and an additional tree was planted on the east side. Properly placed trees can also act as wind barriers, keeping outside air from entering interior spaces, potentially reducing both heating and cooling needs.

Tree selection and placement is critical to optimizing the potential benefits of trees. See Chapter 4, "General Guidelines for Selecting, Planting and Establishing Healthy Trees," for more information. The City of Redding requires one new tree to be planted for every 500 sq. ft. of closed space for residential, one per 1,000 sq ft for commercial, and one per 2,000 sq ft for industrial. Credits are given for the preservation of existing trees.

The City of Escalon is requiring street trees in its new Farinelli Ranch subdivision to shade street pavement, lower ambient temperatures and reduce the cooling needs of neighboring homes. Narrowing streets increased shade cover while lowering development costs. These combined actions are projected to reduce annual energy use for cooling by 18% per home.

Require Shade Trees in Parking Lots

Emissions from parked cars are a significant contributor to smog. By shading asphalt surfaces and parked vehicles, trees reduce the emission of hydrocarbons that occur when gasoline evaporates from leaky fuel tanks and worn hoses.

The City of Davis requires that 50% of paved parking lot surfaces be shaded with tree canopies within 15 years of the building permit being issued. The City of Redding requires one tree per four parking spaces.

Proper planting procedures, including an adequate planting area and effective irrigation techniques, along with ongoing monitoring and maintenance are essential to the survival and vitality of parking lot trees. The City of Davis is currently using a community tree group, Tree Davis, to assist in annual inspections of parking lot trees.

Davis is also pursuing innovative construction methods that would provide parking lot trees with a larger rooting area without compromising the structural integrity of the paved surfaces. Soils underneath parking lots are usually very compact, offering parking lot trees limited root space. This can compromise the ability of parking lot trees to survive and thrive. As part of a parking lot renovation and plaza construction project in downtown Davis, the City installed a structural soil mix around the parking lot and plaza trees as an alternative to standard aggregate base. The structural soil mix, developed by Cornell University, provides the compaction needed below parking lot paving surfaces while providing an accessible rooting environment for the parking lot trees.

Adopt a Tree Preservation Ordinance

This ordinance can be used to protect and enhance your community's urban forest. Many cities and counties require a permit to remove a tree or build, excavate or construct within a given distance from a tree. At least one tree should be planted for every tree that is removed.

Hire or Appoint a City Forester/Arborist

The California Energy Commission's *Energy Aware Planning Guide* recommends that a single person should be responsible for urban tree programs, including "planting and maintenance of public trees, tree planting requirements for new development, tree protection, street tree inventories and long-range planning." A number of cities maintain full-time arborists who are employed through the Public Works or Parks and Recreation Departments.

Conduct a Street Tree Inventory and Establish a Maintenance Program

A healthy urban forest requires regular maintenance. A street tree inventory identifies maintenance needs. A management plan prioritizes spending for pruning, planting, removal and protection of trees in the community.

Adopt a Landscaping Ordinance to Encourage Energy Efficiency and Resource Conservation

Trees placed in proper locations can provide cooling relief and reduce summer air-conditioning needs. Shrubs, vines and ground covers can also be used to lower solar heat gain and reduce cooling needs. Because summer weather of Inland Empire communities is relatively warm, potential energy savings from trees are greater than for coastal regions.

The City of Irvine's Sustainability in Landscaping Ordinance outlines guidelines for developing and maintaining landscapes that conserve water and energy, optimize carbon dioxide sequestration, increase the production of oxygen, and lower air conditioning demands. The ordinance encourages the City to develop and promote programs and activities that educate residents about the benefits of sustainable landscaping. The ordinance also discourages the use of inorganic fertilizers, pesticides and herbicides.

Use Tree Planting to Strengthen Communities and Increase Resident Involvement

Research shows that residents who have participated in tree planting events are more satisfied with trees and their neighborhood than are residents where trees have been planted by the city, a developer, or volunteer groups without resident involvement.

Through the City of Long Beach's Neighborhood Improvement Tree Project, city staff worked with neighborhood groups, the Conservation Corps of Long Beach, and local businesses to plant trees in physically distressed neighborhoods during the spring of 1998. Five hundred volunteers helped to plant over 800 trees. City staff report that the event provided local residents with a sense of empowerment and helped to strengthen community ties.

Utilize Funding Opportunities to Plant Trees and Maintain the Urban Forest

California ReLeaf, the urban forestry division of the Trust for Public Land, maintains an extensive list of funding resources for urban forestry and education projects. See Chapter 5 and Appendix B for more information.

The *Energy Aware Planning Guide* proposes including street tree planting in the capital budget for road building which may help to secure funding.

Cities with municipal utilities may want to use their public benefit funds towards street and shade tree projects. With the assistance of the Sacramento Tree Foundation, the Sacramento Municipal Utility District's (SMUD) Sacramento Shade program has planted over 250,000 trees in the Sacramento region. SMUD began its program in 1990. SMUD's overall goal is to plant 500,000 trees.

Since October 1992, the City of Anaheim Public Utilities' TreePower Program has provided free shade trees to residents, businesses and schools. Anaheim's Neighborhood Services, Code Enforcement and Community

Policing Departments help to expand the program's reach into individual neighborhoods. Through TreePower, the City has planted over 10,000 trees.

Local Government Contacts

Shade Trees in New Development

City of Redding, Planning Division
Phil Carr, Associate Planner
760 Parkview Ave.
Redding, CA 96049-6071
☎(530) 225-4020

City of Escalon
J.D. Hightower, City Planner
P.O. Box 248
Escalon, CA 95320
☎(209) 838-4110

Shade Trees in Parking Lots

City of Davis, Planning and Building Department
Ken Hiatt, Associate Planner
23 Russell Blvd.
Davis, CA 95616
☎(530) 757-5610
e-mail: KHiatt@mail.city.davis.ca.us

(see also City of Redding)

Landscaping Ordinance to Encourage Resource Efficiency

City of Irvine
Steve Burke, Landscape Superintendent
P.O. Box 19575
Irvine, CA 92623-9575
☎(949) 724-7609

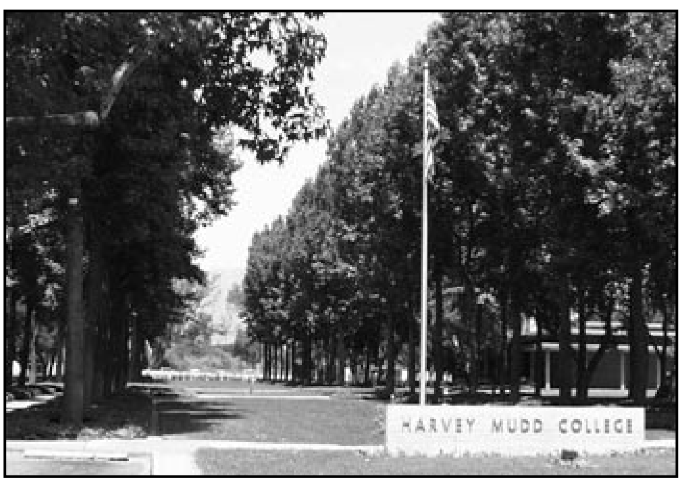
Collaboration with Local Community Groups and Tree Organizations

City of Long Beach, Community Development Department
Craig Beck, Community Development Analyst
333 West Ocean Blvd., 3rd Floor
Long Beach, CA 90802
☎(562) 570-6866

California ReLeaf
c/o Trust for Public Land
Martha Ozonoff, Program Manager
926 J St., Suite 201
Sacramento, CA 95814
☎(916) 557-1673
e-mail: martha.ozonoff@tpl.org

City of Anaheim Public Utilities
TreePower
P.O. Box 3222
Anaheim, CA 92803
☎(714) 491-8733

Sacramento Municipal Utility District (SMUD)
Energy Services Department
☎(916) 455-2020
www.smud.org

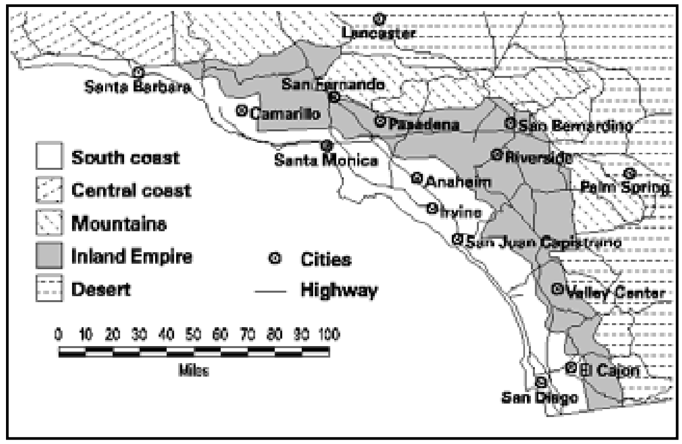



ITALIAN GRILL

The green infrastructure is a significant component of coastal Inland Empire cities.

Introduction

Communities in California's Inland Empire region contain over 8 million people comprising about 25% of the state's total population. The region's inhabitants derive great benefit from trees because compared to coastal areas the summers are hotter and air pollution levels are higher. The region's climate is still mild enough to grow a diverse mix of trees. The Inland Empire region's climate is influenced by the ocean less than 15% of the time and extends from Ojai east to Simi Valley, Glendale, Alhambra, and Riverside, as well as south to Escondido (Figure 1). The region's boundaries correspond with Sunset climate zones 18, 19, 20, and 21 (Brenzel 1997). Occasionally winter temperatures will drop below 10° F (–12° C) in the cold-winter portions of this region (Sunset zone 18).



1. The Inland Empire region extends from Ojai to Riverside and south to cities such as Escondido.

Sustaining healthy community forests is important to quality of life as many Inland Empire communities continue to grow during the next decade. The role of urban forests to enhance the environment, increase community attractiveness, and foster civic pride will take on greater significance as communities strive to balance economic growth with environmental quality and social well-being.

Trees connect people with nature and each other

Inland Empire communities can promote energy efficiency through tree planting and stewardship programs that strategically locate trees to shade buildings, cool urban heat islands, and minimize conflicts with power lines and other aspects of the urban infrastructure. Also, these same trees can provide additional benefits by reducing atmospheric carbon dioxide (CO_2), improving air quality, reducing stormwater runoff, increasing property values, enhancing community attractiveness, and promoting human health and well-being. The simple act of planting trees provides opportunities to connect residents with nature and with each other. Neighborhood tree plantings and stewardship projects stimulate investment by local citizens, business, and government in the betterment of their communities (Figure 2).

What will this guidebook do?

This guidebook addresses a number of questions about the energy conservation potential and other benefits of urban and community forests in the Inland Empire:

- What is their potential to improve environmental quality and conserve energy?
- Where should residential and public trees be placed to maximize their cost-effectiveness?
- Which tree species will minimize conflicts with power lines, sidewalks, and buildings?
- What are important features of successful shade tree programs?

- What sources of funding and technical assistance are available?

Answers to these questions should assist policy makers, urban forest managers, non-profit organizations, design and planning professionals, utility personnel, and concerned citizens who are planting and managing trees to improve their local environments and build better communities.

2. Tree planting and stewardship programs provide opportunities for local residents to work together to build better communities.

What's in the Guidebook

This guidebook is organized as follows:

Chapter 1. Provides background information on the energy conservation potential of trees in the Inland Empire, and describes other benefits and costs associated with trees.

Chapter 2. Quantifies annual benefits and costs of maintaining a typical large, medium, and small shade tree for a period of 40 years after planting in a residential yard and a public site (street, park, or common open space).

Chapter 3. Illustrates how to apply urban forest benefit-cost information to issues in your community.

Chapter 4. Presents guidelines for selecting and siting trees in residential yards and public open space.

Chapter 5. Describes key components of shade tree programs and tips to increase their cost-effectiveness. This chapter also contains information on sources of technical assistance.

Chapter 6. Contains a tree selection list with information on tree species recommended for shading and atmospheric CO_2 reduction in Inland Empire communities.

Chapter 7. Lists references cited in the guide.

Chapter 8. Provides a glossary with definitions for technical terms used in the guide.

Appendix A. Contains tables that list annual benefits and costs at five-year intervals for 40 years after planting.

Appendix B. Presents funding opportunities for California communities.

Appendix C. Contains information on local government programs and ordinances.

1. Identifying Benefits and Costs of Urban and Community Forests

In this chapter, we take an in-depth look at benefits and costs of public and privately managed trees. First, we describe the benefits of community forests and their economic value. Second, we show that even though these benefits are highly desirable, they will come with a cost.

Benefits

Saving Energy

Heat islands increase temperatures

Buildings and paving increase the ambient temperatures within a city. Rapid growth of California cities during the past 50 years is associated with a steady increase in downtown temperatures of about 0.7° F (0.4° C) per decade. Because electric demand of cities increases about 1-2% per 1° F (3-4% per °C) increase in temperature, approximately 3-8% of current electric demand for cooling is used to compensate for this urban heat island effect (Akbari et al. 1992).

Warmer temperatures increase CO_2

Warmer temperatures in cities compared to surrounding rural areas has other implications, such as increases in carbon dioxide emissions from fossil fuel power plants, municipal water demand, unhealthy ozone levels, and human discomfort and disease. These problems are accentuated by global climate change, which may double the rate of urban warming.

What can trees do?

In the Inland Empire, there is ample opportunity to "retrofit" communities with more energy efficient landscapes through strategic tree planting and stewardship of existing trees. Accelerating urbanization hastens the need for more energy-efficient landscapes in new development.

How trees work

Urban forests modify climate and conserve building energy use through:

- Shading, which reduces the amount of radiant energy absorbed and stored by built surfaces,
- Evapotranspiration, which converts liquid water in plants to vapor, thereby cooling the air, and
- Wind speed reduction, which reduces the infiltration of outside air into interior spaces (Simpson 1998).

Trees lower temperatures

Trees and other greenspace within individual building sites may lower air temperatures 5° F (3° C) compared to outside the greenspace. At the larger scale of urban climate (6 miles or 10 km square), temperature differences of more than 9° F (5° C) have been observed between city centers and more vegetated suburban areas.

Urban forests cool

The relative importance of these effects depends on the size and configuration of vegetation and other landscape elements (McPherson 1993). Generally, large greenspaces affect climate at farther distances (300 to 1,500 ft, or 100 to 500 m distance) than do smaller greenspaces. Tree spacing, crown spread, and vertical distribution of leaf area influence the transport of cool air and pollutants along streets, and out of urban canyons.

For individual buildings, solar angles and infiltration are important. Because the summer sun is low in the east and west for several hours each day, tree shade to protect east and especially west walls helps keep buildings cool. Rates at which outside air infiltrates into a building can increase substantially with wind speed. In cold windy weather the entire volume of air in a poorly sealed home may change two to three times per hour. Even in newer or tightly sealed homes, the entire volume of air may change every two to three hours. Windbreaks reduce air infiltration and heat loss from buildings.

Shade saves $

Because summer weather of Inland Empire communities is relatively warm, potential energy savings from trees are greater than for coastal regions. Computer simulation of annual cooling savings for an energy efficient home in Riverside indicated that the typical household spends about $250 each year for air conditioning (1,929 kWh, 3.1 kW peak). Shade from two 25-foot tall (7.5 m) trees on the west and one on the east was estimated to save $57 each year, a 23% reduction (438 kWh) (Simpson and McPherson 1996). Evapotranspirational cooling from these three trees can double these savings provided that a large enough number of trees are planted to reduce summertime temperatures in the neighborhood. Simulated savings for the same residence in San Diego were about 50% of this amount because of cooler summer temperatures.

Reducing Atmospheric Carbon Dioxide

Trees reduce CO_2

Urban forests can reduce atmospheric CO_2 in two ways: ❶ trees directly sequester CO_2 as woody and foliar biomass while they grow, and ❷ trees near buildings can reduce the demand for heating and air conditioning, thereby reducing emissions associated with electric power production.

Society creates CO_2

On the other hand, CO_2 is released by vehicles, chain saws, chippers, and other equipment during the process of planting and maintaining trees. Eventually, all trees die and most of the CO_2 that has accumulated in their woody biomass is released into the atmosphere through decomposition.

Regional variations in climate and the mix of fuels that produce energy to heat and cool buildings influence potential CO_2 emission reductions. Southern California Edison, Los Angeles Department of Water and Power, and San Diego Gas and Electric provide electricity to Inland Empire communities. Carbon dioxide emissions from plants operated by these utilities vary depending on the mix of fuels used to generate the power. The CO_2 emissions factor for the Inland Empire is approximately 0.84 lb CO_2/kWh, 11% greater than the California state average.

What is the complete CO_2 picture?

To provide a complete picture of atmospheric CO_2 reductions from tree planting it is important to consider CO_2 released into the atmosphere through tree planting and care activities, as well as decomposition of wood from pruned or dead trees. The combustion of gasoline and diesel fuels by vehicle fleets, and equipment such as chainsaws, chippers, stump removers, and leaf blowers is a relatively minor source of CO_2. Typically, CO_2 released due to tree planting, maintenance, and other program related activities is about 2-8% of annual CO_2 reductions obtained through sequestration and avoided power plant emissions (McPherson and Simpson 1999).

Financial value of CO_2 reduction

One of the most comprehensive studies of atmospheric CO_2 reductions by an urban forest found that Sacramento's six million trees remove approximately 304,000 t (1.2 t/ha) of atmospheric CO_2 every year, with an implied value of $3.3 million (McPherson 1998). Avoided power plant emissions (75,600 t) accounted for 32% of the amount sequestered (238,000 t). The amount of CO_2 reduction by Sacramento's urban forest offsets 1.8% of total CO_2 emitted annually as a byproduct of human consumption. This savings could be substantially increased through strategic planting and long term stewardship that maximizes future energy savings from new tree plantings, as with the Cities for Climate Protection program (McPherson 1994, ICLEI 1997).

The City of Chula Vista joined the Cities for Climate Protection program and adopted urban forestry as one means to reduce CO_2 emissions to a level below the 1990 base. Using computer simulations, we estimated that annual CO_2 reductions 15 years after planting would range from 411-536 lb depending on location for a 24-foot tall tree (McPherson and Simpson 1998). Given this emission reduction rate, 29-39 trees are required to offset average annual emissions on a per capita basis in Chula Vista (15,811 lb/capita). Chula Vista's relatively mild summers resulted in relatively low avoided power plant emissions associated with reduced air conditioning load. Thus, the majority of CO_2 reductions in Chula Vista were due to sequestration.

Improving Air Quality

Trees and ozone relationship

Urban trees provide air quality benefits by: ❶ absorbing pollutants such as ozone and nitrogen oxides through leaf surfaces, ❷ intercepting particulate matter (e.g., dust, ash, pollen, smoke), ❸ releasing oxygen through photosynthesis, and ❹ transpiring water and shading surfaces, which lowers local air temperatures, thereby reducing ozone levels.

In the absence of the cooling effects of trees, higher air temperatures contribute to ozone formation. Most trees emit various biogenic volatile organic compounds (BVOCs) such as isoprenes and monoterpenes that can contribute to ozone formation. The ozone forming potential of different tree species varies considerably and is listed in Chapter 6. A computer simulation study for the Los Angeles basin found that increased tree planting of low BVOC emitting tree species would reduce ozone concentrations and exposure to ozone (Taha 1996). However, planting of medium- and high-emitters would increase overall ozone concentrations.

11 million trees can save $273 million

Although air quality in Southern California has been improving in recent years, the region continues to experience periods of poor air quality. Continued progress is needed to meet mandated air quality standards (South Coast Air Quality Management District, 1997). The extent to which urban trees reduce pollutants from the air in Inland Empire communities has not been well-documented. However, examination of new, potentially cost-effective approaches to improving air quality, such as urban tree planting, are receiving increased attention. One study for the entire Los Angeles region found that 20 years after planting, 11 million trees would save $93 million in air conditioning costs and $180 million due to ozone reductions (Rosenfeld et al. 1998). The total annual savings of $273 million averages about $25 per tree, assuming no trees die after planting. Air pollution benefits focused on NO_x reductions because this pollutant is involved in ozone formation.

In Sacramento, the total value of annual air pollutant uptake produced by Sacramento County's six million trees was $28.7 million, nearly $5 per tree on average (Scott et al. 1998). The urban forest removed approximately 1,606 short tons (1,457 metric tons) of air pollutant annually. Trees were most effective at removing ozone and particulate matter (PM_{10}). Daily uptake of NO_2 and PM_{10} represented 1-2% of emission inventories for the county. Pollutant uptake rates were highest for residential and institutional land uses.

Trees "eat" pollutants and save money

Other studies in Coastal Southern California and the San Joaquin Valley highlight recent research aimed at quantifying air quality benefits of urban trees. We estimated that the annual value of pollutant uptake by a typical medium-sized tree in Coastal Southern California was $20 and in the San Joaquin Valley it was about $12 (McPherson et al. 1999a; 2000). The $20 per tree value is four times the $5 amount reported for Sacramento due to larger tree sizes and higher pollutant concentrations in the Southern California study.

What about hydrocarbons?

Recently, trees in a Davis, CA parking lot were found to benefit air quality by reducing air temperatures 1-3° F (0.5-1.5° C) (Scott et al. 1999). By shading asphalt surfaces and parked vehicles the trees reduce hydrocarbon emissions from gasoline that evaporates out of leaky fuel tanks and worn hoses. These evaporative emissions are a principal component of smog, and parked vehicles are a primary source. Initial calculations indicate that planting trees in parking lots throughout the region could reduce hydrocarbon emissions comparable to the levels achieved through the local air quality district's currently funded programs (e.g., graphic arts, waste burning, vehicle scrappage).

Reducing Stormwater Runoff

Trees protect water and soil

Urban stormwater runoff is a major source of pollution entering the Pacific Ocean and its tributaries. After large storm events certain beaches are temporarily closed to swimming due to unhealthy levels of pollutants (Condon and Moriarty 1999). Finding the source of these pollutants is difficult because the region is so large and "hot spots" appear and disappear quickly. A healthy urban forest can reduce the amount of runoff and pollutant loading in receiving waters:

- Leaves and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows,
- Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow,
- Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.

Trees reduce runoff

Studies that have simulated urban forest effects on stormwater report annual runoff reductions of 2-7%. Annual interception of rainfall by Sacramento's urban forest for the urbanized area was only about 2% due to the winter rainfall pattern and predominance of non-evergreen species (Xiao et al. 1998). However, average interception loss for the land with tree canopy cover ranged from 6-13% (150 gal per tree on average), close to values reported for rural forests. In Modesto each street and park tree is estimated to reduce stormwater runoff by 845 gal (3.2 m^3) annually, and the value of this benefit is $6.76 (McPherson et al. 1999b). We estimated that a typical medium-sized tree in Coastal Southern California intercepts 2,380 gal ($4.72) annually (McPherson et al. 2000). Broadleaf evergreens and conifers intercept more rainfall than deciduous species because of the winter rainfall pattern.

And can dispose of waste water

Urban forests can provide other hydrologic benefits. For example, irrigated tree plantations or nurseries can be a safe and productive means of wastewater disposal. Reused wastewater can recharge aquifers, reduce stormwater treatment loads, and create income through sales of nursery or wood products. Recycling urban wastewater into greenspace areas can be an economical means of treatment and disposal, while at the same time providing other environmental benefits.

Aesthetics and Other Benefits

Beautification

Trees provide a host of aesthetic, social, economic, and health benefits that should be included in any benefit-cost analysis. One of the most frequently cited reasons that people plant trees is for beautification. Trees add color, texture, line, and form to the landscape. They soften the hard geometry that dominates built environments. Research on the aesthetic quality of residential streets has shown that street trees are the single strongest positive influence on scenic quality. Consumer surveys have found that preference ratings increase with the presence of trees in the commercial streetscape. Well-landscaped business districts were found to have significantly higher priced goods and increased patronage compared to a no-tree district (Wolf 1999).

Increased property values

Well-maintained trees increase the "curb appeal" of properties. Research comparing sales prices of residential properties with different tree resources suggests that people are willing to pay 3 -7% more for properties with ample tree resources versus few or no trees. One of the most comprehensive studies of the influence of trees on residential property values was based on actual sales prices found that each large front-yard tree was associated with about a 1% increase in sales price (Anderson and Cordell 1988). This increase in property value resulted in an estimated increase of $100,000 (1978 dollars) in the city's property tax revenues. A much greater value of 9% ($15,000) was determined in a U.S. Tax Court case for the loss of a large black oak on a property valued at $164,500 (Neely 1988).

Psychological benefits

The social and psychological benefits provided by urban forests improve human well-being. Research indicates that views of vegetation and nature bring relaxation and sharpen concentration. Hospitalized patients with views of nature and time spent outdoors needed less medication, slept better, and were happier than patients without these connections to nature (Ulrich et al.1985). Trees reduce exposure to ultraviolet light, thereby lowering the risk of harmful health effects from skin cancer and cataracts. Other research shows that humans derive substantial pleasure from trees, whether it be feelings of relaxation, connection to nature, or religious joy (Dwyer et al. 1992). Trees provide important settings for recreation in and near cities. Just the act of planting trees has social value in that new bonds between people often result.

Noise reduction

Certain environmental benefits from trees are more difficult to quantify than those previously described, but can be just as important. Noise can reach unhealthy levels in cities. Trucks, trains, and planes can produce noise that exceeds 100 decibels, twice the level at which noise becomes a health risk. Thick strips of vegetation in conjunction with land forms or solid barriers can reduce highway noise by 6-15 decibels. Plants absorb more high frequency noise than low frequency, which is advantageous to humans since higher frequencies are most distressing to people (Miller 1997).

Wildlife habitat

Although urban forests contain less biological diversity than rural woodlands, numerous types of wildlife inhabit cities and are generally highly valued by residents. For example, older parks, cemeteries, and botanical gardens often contain a rich assemblage of wildlife. Remnant woodlands and riparian habitats within cities can connect a city to its surrounding bioregion. Wetlands, greenways (linear parks), and other greenspace resources can provide habitats that conserve biodiversity (Platt et al. 1994).

Jobs

Urban forestry can provide jobs for both skilled and unskilled labor. AmeriCorps and other programs are providing horticultural training to youth planting and maintaining trees in community forests across California.

Also, urban and community forestry provides educational opportunities for residents who want to learn about nature through first-hand experience (McPherson and Mathis 1999).

The environmental, social, and economic benefits of urban and community forests come with a price.

Costs

Planting and Maintaining Trees

Cities spend about $19 per tree

In 1997, California cities spent an average of $5.35 per resident on tree programs, or about $19 per tree (Thompson and Ahern 2000). This expenditure represents a slight increase from $4.36 per resident in 1992. Generally, the single largest expenditure is for tree trimming, followed by tree removal/disposal, and tree planting.

Most trees in new residential subdivisions are planted by developers, while cities/counties and volunteer groups plant most trees on existing streets and park lands. The "State of Urban and Community Forestry in California" report found that tree planting has not kept pace with removals, 25% more trees are removed than planted. Moreover, limited growing space in cities is responsible for increased planting of smaller, shorter-lived trees that provide fewer benefits compared to larger trees (Thompson and Ahern 2000).

Residents spend about $5-$10 per tree

Annual expenditures for tree management on private property have not been well-documented. Costs vary considerably, ranging from some commercial/residential properties that receive regular professional landscape service to others that are virtually "wild" and without maintenance. An initial analysis of data for Sacramento and other cities suggests that households typically spend about $5-10 annually per tree for pruning and pest and disease control (McPherson et al. 1993, McPherson 1996).

Despite Southern California's balmy climate, newly planted trees require irrigation for about three years. Installation of drip or bubbler irrigation can increase planting costs by $100 or more per tree. Once planted, 15-gal trees typically require 100-200 gal per year during the establishment period. Assuming a water price of $0.99/Ccf, annual irrigation water costs are initially less than $1 per tree. However, as trees mature their water use can increase with an associated increase in annual costs. Trees planted in areas with existing irrigation may require supplemental irrigation.

Power plants consume water in the process of producing electricity. For example, coal-fired plants use about 0.6 gal/kWh of electricity provided. Trees that reduce the demand for electricity can also reduce water consumed at the power plant (McPherson et al. 1993).

Conflicts with Urban Infrastructure

Tree roots and sidewalks can conflict

Californians are spending millions of dollars each year to manage conflicts between trees and power lines, sidewalks, sewers, and other elements of the urban infrastructure. In San Jose alone, the backlogged repair cost for all damaged sidewalks is $21 million. Statewide, cities are spending a fraction of the total amount needed to repair all damaged sidewalks and curbs. In 1998 California cities spent a total of $71 million ($2.36 per capita) on sidewalk, curb and gutter repair, tree removal and replacement, prevention methods, and legal/liability costs (McPherson 2000). Some cities spent as little as $0.75 per capita while others spent $6.98 per resident. These figures are for street trees only and do not include repair costs for damaged sewer lines, building foundations, parking lots, and various other hardscape elements. When these additional expenditures are included, the total cost of root-sidewalk conflicts in California is well over $100 million per year. Dwindling budgets are forcing an increasing number of cities to shift the costs of sidewalk repair to residents. This shift especially impacts residents in older areas, where large trees have outgrown small sites and infrastructure has deteriorated.

Cost of conflicts

According to the "State of Urban and Community Forestry in California" reports, the consequences of efforts to control these costs are having alarming effects on California's urban forests (Bernhardt and Swiecki 1993, Thompson and Ahern 2000):

- ➢ Cities are continuing to "downsize" their urban forests by planting far more small-statured than large-statured trees. Although small trees are appropriate under power lines and in small planting sites, they are less effective at providing shade, absorbing air pollutants, and intercepting rainfall than large trees.
- ➢ 25% of the responding cities are removing more trees than they are planting.
- ➢ Sidewalk damage is the second most common reason that street and park trees are removed. We lose thousands of healthy urban trees and forgo their benefits each year because of this problem.

Use the right tree to fix conflicts

Collectively, this is a lose-lose situation. Cost effective strategies to retain benefits from large street trees while reducing costs associated with infrastructure conflicts are needed. Matching the growth characteristics of trees to conditions at the planting site is one strategy. The tree selection list in Chapter 6 contains information on the rooting and crown size characteristics of recommended trees.

Trees can damage sewer lines

Tree roots can damage old sewer lines that are cracked or otherwise susceptible to invasion. Sewer repair companies estimate that sewer damage is minor until trees and sewers are over 30 years old, and roots from trees in yards are usually more of a problem than roots from trees in planter strips along streets. The later assertion may be due to the fact that sewers become closer to the root zone as they enter houses than at the street. Repair costs typically range from $100 for rodding to $1,000 or more for excavation and replacement.

Cleaning up after trees

Most communities sweep their streets regularly to reduce pollution from surface runoff to streams and the ocean. Street trees drop leaves, flowers, fruit, and branches year round that constitute a significant portion of debris collected from city streets. When leaves fall and winter rains begin, leaf litter from trees can clog sewers, dry wells, and other elements of flood control systems. Costs include additional labor needed to remove leaves and property damage caused by localized flooding. Clean-up costs also occur after wind storms. Although these natural crises are infrequent, they can result in large expenditures.

Shade can defer street maintenance

Tree shade over streets can offset some of these costs by protecting the street paving from weathering. The asphalt paving on streets contains stone aggregate in an oil binder. Without tree shade, the oil heats up and volatilizes, leaving the aggregate unprotected. Vehicles then loosen the aggregate and much like sandpaper, the loose aggregate grinds down the pavement. Streets should be overlaid or slurry sealed about every 10 years over a 30-40 year period, after which reconstruction is required. A slurry seal costs approximately $0.27 per sq ft or $50,000 per linear mile. Because the oil does not dry out as fast on a shaded street as it does on a street with no shade trees, this street maintenance can be deferred (Figure 3). It is estimated that the slurry seal can be deferred from every 10 years to every 20-25 years for older streets with extensive tree canopy cover in Modesto (personal communication, John Brusca, Streets Superintendent, City of Modesto, November 17, 1998).

3. Although large trees can increase clean-up costs and repair costs to sidewalks compared to small trees, their shade can extend the life of street surfaces and defer costs for re-paving.

Wood Salvage, Recycling and Disposal

Nearly all California cities are recycling a portion of their green waste. In 1997 the state's tree programs recycled about 70% of their wood waste as mulch, compost, solidwood, and energy (Thompson and Ahern 2000). In most cases, the net costs of waste wood disposal are about 1% of total tree care costs as cities and contractors strive to break-even (hauling and recycling costs are nearly offset by revenues from purchases of mulch, milled lumber, and wood products) (personal communication, Pat Mahoney, President, West Coast Arborists, Inc., October 29, 1999). Hauling waste wood is the primary cost in Southern California, where virtually all waste wood is now recycled. Portable mills are increasingly used to produce lumber that is sold or worked to create park benches, picnic tables, and other wood products.

Greenwaste recycling saves $

Claremont recycles 87% of its municipal wood waste and this saves the City about $22,000 a year in landfill costs. Eighty percent of the recycled wood is turned into mulch, 17% into compost, and 3% into firewood (personal communication, Dan Hardgrove, City of Claremont, June 11, 2000).

2. Quantifying Benefits and Costs of Community Forests in Inland Empire Communities

In this chapter, we present estimated benefits and costs for trees planted in typical residential and public sites. Because benefits and costs vary with tree size, we report results for large (Shamel ash), medium (jacaranda), and small (crape myrtle) statured trees. Tree growth rates and dimensions are based on street tree data obtained in Claremont. To make our calculations realistic, we assume that a typical number of the trees planted die over the 40-year period (23%).

Our estimates are initial approximations

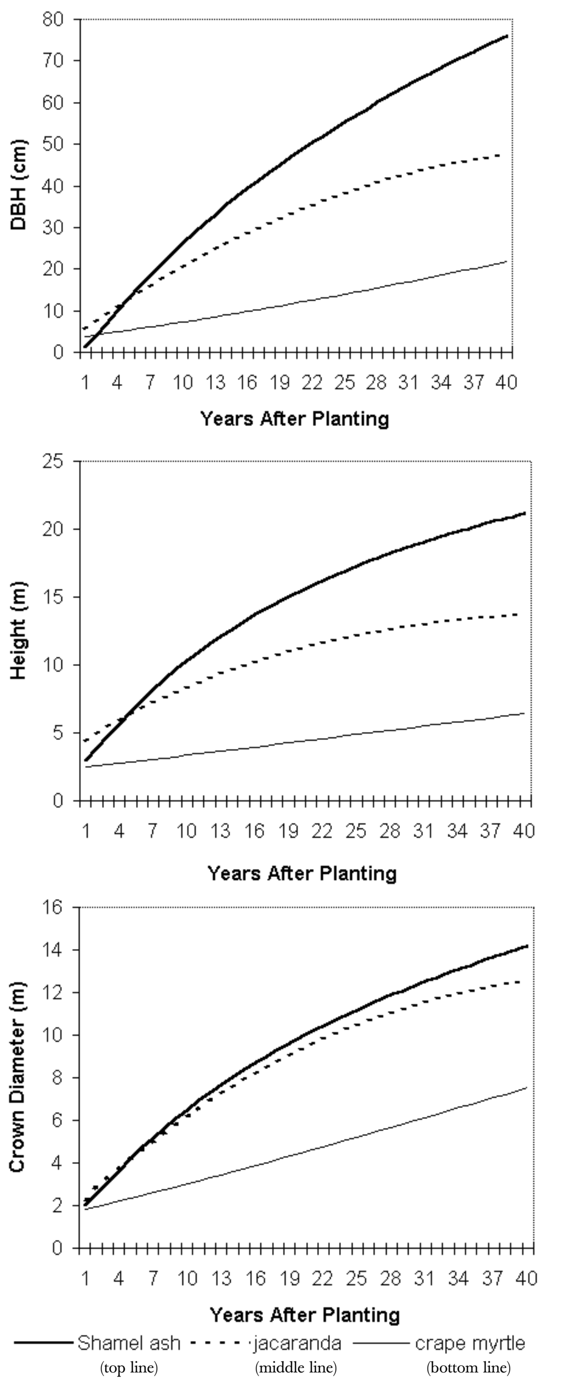
Our estimates of benefits and costs are initial approximations. Some benefits and costs are intangible or difficult to quantify (e.g., impacts on psychological health, crime, and violence). Our limited knowledge about the physical processes at work and their interactions make estimates very imprecise (e.g., fate of air pollutants trapped by trees and then washed to the ground by rainfall). Tree growth and mortality rates are highly variable and benefits and costs depend on the specific conditions at a site (e.g., tree species, growing conditions, maintenance practices). These estimates provide a general understanding of the magnitude of benefits and costs for typical private and public tree planting programs given the underlying assumptions.

Procedures and Assumptions

Approach

How we priced benefits and costs

In this study, annual benefits and costs are estimated for newly planted trees in three residential yard locations (east, south, and west of the dwelling unit) and a public streetside/park location for a 40-year planning horizon. Prices are assigned to each cost (e.g., planting, pruning, removal, irrigation, infrastructure repair, liability) and benefit (e.g., heating/cooling energy savings, air pollution absorption, stormwater runoff reduction) through direct estimation and implied valuation of benefits as environmental externalities. This accounting approach makes it possible to estimate the net benefits of plantings in “typical” locations and with “typical” tree species. To account for differences in the mature size and growth rates of different tree species we report results for large (*Fraxinus uhdei*, Shamel ash), medium, (*Jacaranda mimosifolia*, jacaranda), and small (*Lagerstroemia indica*, crape myrtle) trees. Mature tree height is frequently used to distinguish between large, medium, and small species because matching tree height to available overhead space is an important design consideration. We use leaf surface area as another indicator of differences in mature tree size because many functional benefits of trees are related to leaf-atmosphere processes (e.g., interception, transpiration, photosynthesis), and therefore, benefits increase as leaf surface area increases. Tree



4. Tree dimensions are based on data from street trees in Claremont. Data for the "typical" large, medium, and small trees are from the Shamel ash, jacaranda, and crape myrtle, respectively.

growth rates and dimensions are based on measurements taken for about 30 street trees of each species in Claremont (Figure 4).

How we reported results. We report results in terms of annual values per tree planted, but our calculations assume that 22.5% of the trees die and are removed during the 40-year period (annual mortality rates of 1% for the first five years and 0.5% for the remaining 35 years). This mortality rate is based on rates reported by contact persons and found in other studies (Miller and Miller 1991, Nowak et al. 1990). Hence, the accounting approach "grows" trees in different locations and directly calculates the annual flow of benefits and costs as trees mature and die (McPherson 1992).

Our approach directly connects benefits and costs with tree size variables such as trunk diameter at breast height (dbh), tree canopy cover, and leaf surface area. For instance, pruning and removal costs usually increase with tree size expressed as dbh inches (cm). For some parameters, such as sidewalk repair, costs are negligible for young trees but increase relatively rapidly as tree roots grow large enough to heave pavement. For other parameters, such as air pollutant uptake and rainfall interception, benefits are related to tree canopy cover and leaf area.

Most benefits occur on an annual basis, but some costs are periodic. For instance, street trees are pruned on cycles and removed in a less regular fashion, when they pose a hazard or soon after they die. We report most costs and benefits for the year that they occur. However, periodic costs such as for pruning, pest and disease control, and infrastructure repair are presented on an average annual basis. Although spreading one-time costs over each year of a maintenance cycle does not alter the 40-year nominal expenditure, it can lead to inaccuracies if future costs are discounted to the present.

How we arrived at values for benefits and costs. Tree management costs were directly estimated based on surveys with municipal foresters in Claremont, La Verne, and six Southern California arborists. Lacking local data, we relied on survey results from Sacramento residents to estimate the frequency of contracted tree care activities for trees in yards (McPherson et al. 1993, Summit and McPherson 1998). Findings from computer simulations are used in this study to directly estimate energy savings. Society's willingness to pay for the air quality and stormwater runoff improvements were used to value these benefits. For example, air quality benefits are estimated using transaction costs, which reflect the average market value of pollutant emission reduction credits in 1998 for the South Coast Air Quality Management District. If a corporation is willing to pay $1 per pound for a credit that will allow it to increase future emissions, then the air pollution mitigation value of a tree that absorbs or intercepts one pound of air pollution should be $1.

Calculating Benefits

Air Conditioning and Heating Energy Savings

How we calculated shade effects

We assume that residential yard trees are within 60 ft (18 m) of homes so as to directly shade walls and windows. Shading effects of these trees on building energy use are simulated for large, medium, and small trees at three tree-building distances, following methods outlined by McPherson and Simpson (1999). The large tree (Shamel ash) is leafless December- January and has a visual density of 80% during summer and 37% during winter. The medium tree (jacaranda) is leafless during May and June, with a leaf-off visual density of 30% and leaf-on density of 83%. The small tree (crape myrtle) is leafless December-March and has a leaf-off visual density of 30% and a summer density of 74%. Results for each tree are averaged over distance and weighted by occurrence of trees within each of three distance classes: 28% 10-20 ft (3-6 m), 68% 20-40 ft (6-12 m), and 4% 40-60 ft (12-18 m) (McPherson and Simpson 1999). Results are reported for trees shading east-, south-, and west-facing surfaces. Our results for public trees are conservative in that we assume that they do not provide shading benefits. In Modesto, 15% of total annual dollar energy savings from street trees were due to shade and 85% due to climate effects (McPherson et al. 1999a).

How we calculated climate effects

In addition to localized shade effects, which are assumed to accrue only to residential yard trees, lowered air temperatures and wind speeds from increased neighborhood tree cover (referred to as climate effects) produce a net decrease in demand for summer cooling (reduced wind speeds by themselves may increase or decrease cooling demand, depending on the circumstances) and winter heating. To estimate climate effects on energy use, air temperature and wind speed reductions as a function of neighborhood canopy cover are estimated from published values following McPherson and Simpson (1999). Existing canopy cover (trees + buildings) was estimated to be 40%. Canopy cover is calculated to increase by 6%, 17% and 24% for mature small, medium, and large trees at maturity, respectively, based on an effective lot size (actual lot size plus a portion of adjacent streets and other rights-of-way) of 8,000 sq ft (743 m^2), and assuming one tree per lot on average. Climate effects are estimated as described previously for shading by simulating effects of wind and air temperature reductions on energy use. Climate effects accrue to both public (Figure 5) and private trees.

We used a prototype building

The prototype building used as a basis for the simulations is typical of post-1980 construction practices, and represents 20-40% of the total single family residential housing stock in Inland Empire communities. This house is a two story, stucco, slab-on-grade building with a conditioned floor area of 2,070 sq ft (192 m^2), window area (double-glazing) of 325 sq ft (30 m^2), and wall and ceiling insulation of R11 and R25, respectively. The central cooling system has a seasonal energy efficiency ratio (SEER) of 10, and the natural gas furnace an annual fuel utilization efficiency (AFUE) of 78%. Building footprints are square, reflective of average impacts for a large building population (McPherson and Simpson 1999). Buildings are simulated with 1.5-ft (0.45-m) overhangs. Blinds have visual density of 37%, and are assumed closed when the air conditioner is operating. Summer thermostat settings are 78° F (25° C); winter settings are 68° F (20° C) during the day and 60° F (16° C) at night. Because the prototype building is more energy efficient than most other construction types our projected energy savings are relatively conservative. The energy simulations rely on typical year climate data from Riverside.

5. Although park trees seldom provide energy benefits from direct shading of buildings, they provide settings for recreation and relaxation as well as modify climate, sequester carbon dioxide, reduce stormwater runoff, and improve air quality.

How we calculated energy savings. Dollar value of energy savings are based on average residential electricity and natural gas prices of $0.12 per kWh (California Energy Commission, 1996) and $0.60 per therm (California Energy Commission, 1998), respectively. The former is the average of prices for Riverside, San Bernardino, Los Angeles, Orange, San Diego, Santa Barbara and Ventura counties; the latter the average of Southern California Gas and San Diego Gas & Electric residential prices forecast for the year 2000. Homes are assumed to have central air conditioning and natural gas heating. Results are reported at five-year intervals.

Atmospheric Carbon Dioxide Reduction

How we calculated the value of reduced CO_2 emissions

Conserving energy in buildings results in reduced emissions of CO_2 at power plants. These avoided emissions are calculated as the product of energy savings for cooling and heating and the respective CO_2 emission factors for electricity and natural gas (Table 1). Emissions factors for electricity (Table 1) are weighted by the approximate average fuel mix for utilities serving Southern California: Southern California Edison, Los Angeles Department of Water and Power, and San Diego Gas and Electric. This value is 49% natural gas, 17% coal, and 34% other, the latter assumed to have no emissions (California Energy Commission 1994). The value of CO_2 reductions (Table 1) is based on social costs associated with increased global warming (California Energy Commission 1994).

How we calculated carbon storage

Sequestration, the net rate of CO_2 storage in above- and below-ground biomass over the course of one growing season, is calculated using tree height and dbh data with biomass equations for jacaranda (Pillsbury et al. 1998). Lacking equations for Shamel ash and crape myrtle, formulas for Modesto ash (*Fraxinus velutina* 'Modesto') and jacaranda were substituted, respectively. Volume estimates are converted to green and dry weight estimates (Markwardt 1930) and divided by 78% to incorporate root biomass. Dry weight biomass is converted to carbon (50%) and these values are converted to CO_2. The amount of CO_2 sequestered each year is the annual increment of CO_2 stored as trees add biomass each year.

Power equipment releases CO_2. A national survey of 13 municipal forestry programs determined that the use of vehicles, chain saws, chippers, and other equipment powered by gasoline or diesel results in the average annual release of 0.78 lb of CO_2/inch dbh (0.14 kg CO_2/cm dbh) (McPherson and Simpson 1999). We use this value for private and public trees, recognizing that it may overestimate CO_2 release associated with less intensively maintained residential yard trees.

Decomposition releases CO_2. To calculate CO_2 released through decomposition of dead woody biomass we conservatively estimate that dead trees are removed and mulched in the year that death occurs, and that 80% of their stored carbon is released to the atmosphere as CO_2 in the same year.

Table 1. Emissions factors and values for air pollutants.

	– Emission Factor[1] –		
	Electricity lbs/MWh	**Natural gas lbs/MBtu**	**Value[2] $/lb**
CO_2	840	116	0.015
NO_2	1.78	0.1020	12.49
SO_2	1.06	0.0006	4.62
PM_{10}	0.124	0.0075	6.20
VOCs	0.054	0.0054	1.92

1 U.S. Environmental Protection Agency 1998.

2 \$30/ton for CO_2 (California Energy Commission 1994) and values for all other pollutants are based on transaction costs for emission reduction credits (Cantor Fitzgerald Environmental Brokerage Services 1999).

Air Quality Improvement

Reductions in building energy use also result in reduced emissions of air pollutants from power plants and space heating equipment. Volatile organic hydrocarbons (VOCs) and nitrogen dioxide (NO_2), both precursors of ozone (O_3) formation, as well as sulfur dioxide (SO_2) and particulate matter of <10 micron diameter (PM_{10}) are considered. Changes in average annual emissions and their offset values are calculated in the same way as for CO_2, again using utility-specific emission factors for electricity and heating fuels (US EPA 1998), with the value of emissions savings (Table 1) based on the price of emission reduction credits for the South Coast Air Quality Management District (Cantor Fitzgerald Environmental Brokerage Services 1999).

How we calculated pollutant uptake by trees

Trees also remove pollutants from the atmosphere. The hourly pollutant dry deposition per tree is expressed as the product of a deposition velocity $V_d = 1/(R_a+R_b+R_c)$, a pollutant concentration C, a canopy projection area CP, and a time step. Hourly deposition velocities for each pollutant are calculated during the growing season using estimates for the resistances R_a, R_b and R_c estimated for each hour throughout a "base year" (1994) using formulations described by Scott et al. (1998). Hourly concentrations for NO_2, SO_2, and O_3 (ppm), daily total PM_{10} (μg^{-3}, approximately every sixth day) for 1994 were obtained from the California Air Resources Board (California Air Resource Board 1999) for the Azusa monitoring station. See Scott et al.

(1998) for details of the methods employed. We use implied values from Table 1 to value emissions reductions; and the implied value of NO_2 for ozone. Hourly meteorological data (e.g., air temperature, wind speed, solar radiation) for 1994 was obtained from a California Department of Water Resources monitoring site located in Claremont.

How we estimated BVOC emissions from trees

Annual emissions of biogenic volatile organic compounds (BVOC) were estimated for the three tree species (Shamel ash, jacaranda, crape myrtle) using the algorithms of Guenther et al. (1991, 1993). Annual emissions were simulated during the growing season over 40 years. The emission of carbon as isoprene is expressed as a product of a base emission rate adjusted for sunlight and temperature (µg-C g^{-1} dry foliar biomass hr^{-1}) and the amount of (dry) foliar biomass present in the tree. Monoterpene emissions are estimated using a base emission rate adjusted for temperature. The base emission rates for the three species were based upon values reported in the literature (Benjamin et al. 1996). All three species are defined as "low emitters" because they emit little (<0.01 µg-C g^{-1} dry foliar biomass hr^{-1}) or no BVOCs. We, however, assigned a total base emission rate of 0.1 µg-C g^{-1} dry foliar biomass hr^{-1} (i.e., 0.04 each for isoprene and monoterpene and 0.02 for other VOCs) to all three species. This total base emission rate is approximately mid-range for the "low emitter" category. Hourly emissions were summed to get monthly and annual emissions. Annual dry foliar biomass was derived from field data collected in Claremont during the summer of 2000. The amount of foliar biomass present for each year of the simulated tree's life was unique for each species. We used 1994 hourly air temperature and solar radiation data from Claremont as model input. This model year was chosen because it most closely approximated long-term climate records for the area of interest.

How we calculated net air quality benefits

Net air quality benefits were calculated by subtracting the costs associated with BVOC emissions from benefits due to pollutant uptake and avoided power plant emissions. These calculations do not take into account the ozone reduction benefit from lowering summertime air temperatures, thereby reducing hydrocarbon emissions from anthropogenic and biogenic sources. Simulation results from Los Angeles indicate that ozone reduction benefits of tree planting with "low-emitting" species exceed costs associated with their BVOC emissions (Taha 1996).

Stormwater Runoff Reduction

How we estimated rainfall interception by tree canopies

A numerical simulation model is used to estimate annual rainfall interception (Xiao et al. 1998). The interception model accounts for water intercepted by the tree, as well as throughfall and stem flow. Intercepted water is stored temporarily on canopy leaf and bark surfaces. Once the leaf is saturated, it drips from the leaf surface and flows down the stem surface to the ground or evaporates. Tree canopy parameters include species, leaf area, shade coefficient (visual density of the crown), and tree height. Tree height data are used to estimate wind speed at different heights above the ground and resulting rates of evaporation. The volume of water stored in the tree crown is calculated from crown projection area (area under tree dripline), leaf area indices (LAI, the ratio of leaf surface area to crown projection area), and water depth on the canopy surface. Species-specific shade coefficients and tree surface saturation (0.04 inch or 1 mm for all three trees) values influence the amount of projected throughfall. Hourly meteorological and rainfall data for 1996 from the Claremont California Irrigation Management Information System (CIMIS) are used for this simulation. Annual precipitation during 1996 was 20.6 inches (523 mm), somewhat greater than the 30-year average annual precipitation of 16.2 inches (411 mm) for the region (U.S. Dept. of Commerce 1970-1999). A more complete description of the interception model can be found in Xiao et al. (1998).

How we calculated the water quality benefit of intercepted rainfall

To estimate the value of rainfall intercepted we consider current expenditures for flood control and sanitary waste treatment. During small rainfall events excess capacity in sanitary treatment plants can be used to treat stormwater. In the Los Angeles region it costs approximately $1.37/Ccf ($0.00183/gal) to treat sanitary waste (Condon and Moriarty 1999). We use this price to value the water quality benefit of rainfall interception by trees because the cost of treating stormwater in central facilities is likely to be close to the cost of treating an equal amount of sanitary waste. To calculate water quality benefit the treatment cost is multiplied by gallons of rainfall intercepted after the first one-tenth inch has fallen for each event (24-hr without rain) during the year. The first one-tenth inch (0.025 mm) of rainfall seldom results in runoff. Thus, interception is not a benefit until precipitation exceeds this amount.

How we calculated the flood control benefit

As part of the TreePeople's program called T.R.E.E.S. (Trans-agency Resources for Environmental and Economic Sustainability), it was determined that over $50 million ($500,000/sq mile) is spent annually controlling floods in the Los Angeles area (Condon and Moriarty 1999). We assume that rainfall interception by tree crowns will have minimal effect during very large storms that result in catastrophic flooding of the Los Angeles River and its tributaries (133-year design storm). Although storm drains are designed to control 25-year events, localized flooding is a problem during these smaller events. Following the economic approach used in the T.R.E.E.S. cost-benefit analysis, we assume that $50 million is spent per year for local problem areas and the annual value of peak flow reduction is $500,000 per square mile for each 25-year peak flow event (Jones & Stokes Associates, Inc. 1998). A 25-year winter event deposits 6.7 inches (169 mm) of rainfall during 67 hours. Approximately $0.0054/gal ($1.44/m^3) is spent annually for controlling flooding caused by such an event. This price is multiplied by the amount of rainfall intercepted during a single 25-year event to estimate the annual flood control benefit. Water quality and flood control benefits are summed to calculate the total hydrology benefit.

Aesthetics and Other Benefits

Many benefits attributed to urban trees are difficult to translate into economic terms. Beautification, privacy, wildlife habitat, shade that increases human comfort, sense of place and well-being are products that are difficult to price. However, the value of some of these benefits may be captured in the property values for the land on which trees stand. To estimate the value of these "other" benefits we apply results of research that compares differences in sales prices of houses to statistically quantify the amount of difference associated with trees. The amount of difference in sales price should reflect the willingness of buyers to pay for the benefits and costs associated with the trees. This approach has the virtue of capturing what buyers perceive to be as both the benefits and costs of trees in the sales price.

Some limitations to using this approach for the present study include the difficulty associated with ❶ determining the value of individual trees on a property, ❷ the need to extrapolate results from studies done years ago in the east and south to California, and ❸ the need to extrapolate results from front yard trees on residential properties to trees in other locations (e.g., back yards, streets, parks, and non-residential land uses).

A large tree adds $1,727 to home value

Anderson and Cordell (1988) surveyed 844 single family residences and found that each large front-yard tree was associated with a $336 increase in sales price or nearly 1% of the average sales price of $38,100 (in 1978 dollars). We use this 1% of sales price as an indicator of the additional value an Inland Empire resident would gain from sale of residential property with a large tree. The sales price of residential properties varies widely by location within the region. For example, 1999 median home prices ranged from $77,500 in Perris to $698,000 in San Marino (California Association of Realtors 1999). In September 1999, the average home price for 71 communities in the Inland Empire region was $195,862 (California Association of Realtors 1999). The value of a large tree that adds about 1% to the sales price of such a home is $1,727. Based on growth data for a 40-year-old Shamel ash tree, such a tree is 69-ft (21m) tall, 46-ft (14m) crown diameter, with a 30-in (76cm) trunk diameter and 8,960 sq ft (832 m^2) of leaf surface area.

How we calculated the base value of a street tree

To calculate the base value for a large street tree, we treat street trees similar to front yard trees, but recognize that they may be located adjacent to land with little value or resale potential. An analysis of street trees in Modesto sampled from aerial photographs (8% of population) found that 15% were located adjacent to non-residential or commercial land uses (McPherson et al. 1999b). We assume that 33% of these trees, or 5% of the entire street tree population, produce no benefits associated with property value increases. Although the impact of parks on real estate values has been reported (Hammer et al. 1974; Schroeder 1982; Tyrvainen 1999), to our knowledge the on-site and external benefits of park trees alone have not been isolated (More et al. 1988). After reviewing the literature and recognizing an absence of data, we assume that park trees have the same impact on property sales prices as street trees. Given these assumptions, the typical large street and park trees are estimated to increase property values by $0.18 and $0.19/sq ft of leaf surface area, respectively ($1.98 and $2.08/m^2). Assuming that 85% of all public trees are on streets and 15% are in parks, we calculate a weighted average benefit of $0.185/sq ft of leaf surface area ($1.99/m^2). To estimate annual benefits this value is multiplied by the amount of leaf surface area added to the tree during one year of growth.

To calculate the base value for a large tree on private residential property we assume that a 40-year old Shamel ash tree in the front yard will increase the property's sales price by $1,727. Approximately 75% of all yard trees are in backyards (Richards et al. 1984). Lacking specific research findings, we arbitrarily assume that backyard trees have 75% of the impact on "curb appeal" and sale price compared to front-yard trees. The average annual aesthetic benefit for a tree on private property is $0.16/sq ft of leaf area ($1.69/m^2).

Calculating Costs

Planting Costs

Planting costs are twofold, the cost for purchasing the tree and the cost for planting, staking, and mulching the tree. Based on our survey of Southern California arborists and data from the Cities of Claremont, La Verne, Santa Monica, and Beverly Hills, we assume that the total cost for purchasing, planting, staking, and mulching a 15-gal (57 l) container public tree is $95. The total cost is $106 for a residential yard tree.

Trimming Costs

How we calculated trimming costs

After studying data from municipal forestry programs and their contractors we assume that during the first three years after planting, young public trees are trimmed once a year at a cost of $10.25 per tree. Thereafter, small public trees are trimmed on a three-year cycle at $20.25 per tree until their height exceeds 18 ft (5.5 m) and more expensive equipment is required. Medium-sized trees (taller than 18 ft [5.5 m] and less than 46 ft [14 m]) are trimmed on a six-year cycle at a cost of $66 per tree. The cost increases to $125 per tree for large trees (taller than 46 ft) on a 12-year cycle. After factoring in trimming frequency, annualized costs are $10.25, $6.68, $11, and $10.42 for public young, small, medium, and large trees, respectively.

Our survey of Sacramento residents indicated that 15% of households with trees never prune their residential yard trees. Moreover, the percentage of households that contract for tree trimming increases as tree height increases: 0% for young trees (< 3 years), 6% for small trees (< 20-ft tall), to 60% for medium trees (20-40-ft tall), and 100% for large trees (>40-ft tall). Similarly, the frequency of pruning decreases with tree height from once every two years for small trees, to every 10 years for medium trees, and every 20 years for large trees. Based on these findings and pruning prices charged by

Southern California arborists ($59, $257, $585 and for small, medium, and large trees, respectively), we calculate that the average annual cost for trimming a residential yard tree is $1.50, $13.09, and $24.86 for small, medium, and large trees. These prices factor in pruning frequency and include costs for waste wood recycling.

Tree and Stump Removal and Disposal

The costs for removing public and private trees are $12 per inch dbh. Stump removal and wood waste disposal costs are $6 per inch dbh for public and private trees. The total cost for both tree sites is $18 per inch dbh.

A 39-year-old Shamel ash tree, illustrative in this guidebook of a large tree.

Pest and Disease Control

Public trees receive treatments to control pests and disease on an as needed basis. In Inland Empire communities this expenditure is small, averaging about $0.17 per tree per year, or $0.01 per inch dbh.

We assume that approximately 85% of households with trees do not treat their trees to control pests or disease. The percentage of households that contract for pest and disease control increases as tree height increases, from 6% for small trees (< 20-ft tall), to 60% for medium trees (20-40-ft tall), and 100% for large trees (>40-ft tall). The frequency of treatment decreases with tree height from once every two years for small trees, to every 10 years for medium trees, and every 20 years for large trees. Based on these findings and treatment prices charged by arborists ($130, $85, and $40 for large, medium, and small trees), we calculate that the average annual cost for pest and disease control ranges from $0.18-$1.00 per residential yard tree, and averages $0.07 per inch dbh.

Irrigation Costs

In most landscape situations trees require relatively little supplemental irrigation after establishment because they are planted in irrigated areas and can use existing sources of water. The cost for irrigating a public street or park tree is $15 per year for the first three years after planting. This price is for labor and equipment to irrigate young trees with a municipal water truck. The cost for irrigation water over the 40-year period is calculated as described below.

Irrigation costs for residential yard trees assume that the irrigation system is in-place, and supplemental water is applied at a maximum rate of 800 gal/year (3,028 l) for a mature tree. Assuming that water is purchased at a price of $0.99 Ccf (personal communication, Dan Hardgrove, City of Claremont, June 11, 2000) and the mature tree has 8,960 sq ft (832 m^2) of leaf area, the annual price is $0.0001/sq ft of leaf area. Hence, annual irrigation water cost is assumed to increase with tree leaf area.

Other Costs for Public and Private Trees

Other costs associated with the management of trees include expenditures for infrastructure repair, root pruning, litter clean-up, litigation, liability, inspection, and administration.

How we calculated costs of infrastructure conflicts and liability

Tree roots can cause damage to sidewalks, curbs, paving, and sewer lines and can be responsible for costly legal actions due to trip and fall claims. Our analysis of survey data on sidewalk repair and mitigation expenditures from nine Southern California communities found an average annual cost of $4.18 per tree and annual payments for trip and fall claims and legal staff salaries for tree-related cases averaged $1.81 per tree (McPherson 2000). Data from the City of Santa Monica's street tree survey indicate that sidewalk damage was present at 25% of all tree sites and the incidence of sidewalk damage varied with tree trunk size (McPherson et al. 2000). We assume that the same relationships occur for litigation/liability costs in Inland Empire communities. Annual infrastructure and liability expenditures per tree ranged from $1.10 (0-6 inch dbh) to $6.47 (19-24 inch dbh) and $0.48 (0-6 inch dbh) to $2.80 (19-24 inch dbh), respectively (McPherson et al. 2000). Because street trees are in closer proximity to sidewalks and sewer lines than most trees on private property we assume that repair and legal costs are 25% of those for public trees (McPherson et al. 1993).

Litter and storm clean-up costs

The average annual per tree cost for litter clean-up (i.e., street sweeping) is $3.63 ($0.23/inch dbh). This value is based on a poorly documented assumption that 10% of total street sweeping costs are attributed to tree litter clean-up. Because most residential yard trees are not littering the street with leaves we assume that clean-up costs for private trees are 25% of those for public trees.

Inspection and administration costs

Municipal tree programs have administrative costs for salaries of supervisors and clerical staff, operating costs, and overhead. Data from Claremont, La Verne, Santa Monica, and Beverly Hills indicate that the average annual cost for inspection and administration associated with street and park tree management is $3.46 per tree ($0.22/inch dbh).

Calculating Net Benefits

Approach

Benefits are for property owners and entire communities

Trees produce benefits that accrue on-site and off-site. For example, property owners with on-site trees not only benefit from increased property values, but they may also benefit directly from improved human health (i.e., reduced exposure to cancer-causing UV radiation) and greater psychological well-being through visual and direct contact with plants. On the cost side, increased health care may be incurred because of nearby trees, as with allergies and respiratory ailments related to pollen. We assume that these intangible benefits and costs are reflected in what we term "aesthetics and other benefits." The property owner can obtain additional economic benefits from on-site trees depending on their location and condition. For example,

An 18-year-old jacaranda, representative of medium trees in this guidebook.

judiciously located on-site trees can provide air conditioning savings by shading windows and walls and cooling building microclimate. This benefit can extend to the neighborhood because trees provide off-site benefits. For example, adjacent neighbors can benefit from shade and air temperature reductions that lower their cooling costs. Neighborhood attractiveness and property values can be influenced by the extent of tree canopy cover on individual properties. The community can benefit from cleaner air and water, as well as social, educational, and employment and job training benefits that can reduce costs for health care, welfare, crime prevention, and other social service programs. Reductions in atmospheric CO_2 concentrations due to trees can have global benefits.

The sum of all benefits. To capture the value of all annual benefits (B), we sum each type of benefit as follows:

$$B = E + AQ + CO_2 + H + A$$

where

E = value of net annual energy savings (cooling and heating)

AQ = value of annual air quality improvement (pollutant uptake, avoided power plant emissions, and BVOC emissions)

CO_2 = value of annual carbon dioxide reductions (sequestration, avoided emissions, release due to tree care and decomposition)

H = value of annual stormwater runoff reductions (water quality and flood control)

A = value of annual aesthetics and other benefits

The sum of all costs is

On the other side of the benefit-cost equation are costs for tree planting and management. Expenditures are borne by property owners (irrigation, pruning, and removal) and the community (pollen and other health care costs). Annual costs for residential yard trees (C_Y) and public trees (C_P) are summed:

$$C_Y = P + T + R + D + I + S + C + L$$

$$C_P = P + T + R + D + I + S + C + L + A$$

where

P = cost of tree and planting

T = average annual tree trimming cost

R = annual tree and stump removal and disposal cost

D = average annual pest and disease control cost

I = annual irrigation cost

S = average annual cost to repair/mitigate infrastructure damage

C = annual litter and storm clean-up cost

L = average annual cost for litigation and settlements due to tree-related claims

A = annual program administration, inspection, and other costs.

Net benefits. Net benefits are calculated as the difference between total benefits and costs (B – C).

A 15-year-old crape myrtle, representative of small trees in this guidebook.

Limitations of this Study

This analysis does not account for the wide variety of trees planted in Inland Empire communities or their diverse placement. It does not incorporate the full range of climatic differences within the region that influence potential energy, air quality, and hydrology benefits. There is much uncertainty associated with estimates of aesthetics and other benefits and the true value of hydrology benefits because science in these areas is not well developed. We consider only two cost scenarios, but realize that the costs associated with planting and managing trees can vary widely depending on program characteristics. As described by example in Chapter 3, local cost data can be substituted for the data in this report to evaluate the benefits and costs of alternative programs.

Future benefits are not discounted to present value. In this analysis, results are presented in terms of future values of benefits and costs, not present values. Thus, our findings do not incorporate the time value of money or inflation. We assume that the user intends to invest in community forests and our objective is to identify the relative magnitudes of future costs and benefits. If the user is interested in comparing an investment in urban forestry with other investment opportunities it is important to discount all future benefits and costs to the beginning of the investment period.

Findings of this Study

Average Annual Net Benefits

Average annual net benefits increase with size of tree

Average annual net benefits per tree (40-year total / 40 years) increase with mature tree size:

- –$2 to $14 for a small tree
- $33 to $57 for a medium tree
- $66 to $85 for a large tree
  (see Appendix A for detailed results).

Large trees provide the most benefits

This finding suggests that average annual net benefits from large-growing trees such as the Shamel ash can be substantially greater than from small trees like crape myrtle. Average annual net benefits for the small, medium, and large street/park trees are –$2, $33, and $66, respectively. Average annual costs ($17) slightly exceed benefits ($15) for the small crape myrtle, in part because the deciduous canopy does not provide year round air pollutant uptake and rainfall interception. The residential yard tree opposite a west-facing wall produces the largest average annual net benefits. Benefits for the small, medium, and large trees are $14, $57, and $85, respectively. Residential yard trees produce net benefits that are greater than public trees primarily because of lower maintenance costs and larger energy savings from building shade.

Net annual benefits at year 40

The large residential tree opposite a west wall produces a net annual benefit of $138 at year 40 and $3,400 total over 40 years. Forty years after planting the large Shamel ash in a public site produces an annual net benefit of $113. Over the entire 40-year period it produces a stream of net benefits that totals to $2,640. Benefits for 40 years total to $1,320 for the medium jacaranda in a street/park location. Although benefits from small trees are offset by their costs initially, net benefits are $560 over the 40-year period for the yard tree opposite a west-facing wall. Costs exceed benefits during the first 15 years for the small trees because of initial expenditures for planting and irrigation (Figures 6 and 7). By year 10 and thereafter, the medium trees provide net benefits.

Net annual benefits at year 20

Twenty years after planting, annual net benefits for a residential yard tree located west of a home are estimated to be $78 for a large tree, $63 for a medium tree, and $17 for a small tree (Table 2). The total value of environmental

Table 2. Estimated value of net annual benefits from a small-, medium- and large-sized residential yard tree opposite the west-facing wall 20 years after planting for Inland Empire communities.

BENEFIT CATEGORY	SMALL TREE 14 ft tall, 15 ft spread LSA = 382 sq. ft.		MEDIUM TREE 37 ft tall, 31 ft spread LSA = 2,522 sq. ft.		LARGE TREE 51 ft tall, 36 ft spread LSA = 3,802 sq. ft.	
Electricity savings ($0.12/kWh)	90 kWh	$10.61	206 kWh	$24.38	228 kWh	$26.95
Natural gas ($0.60/therm)	-266 kBtu	-$1.59	-445 kBtu	-$2.65	-309 kBtu	-$1.84
Carbon dioxide ($0.015/lb)	59 lb	$0.88	326 lb	$4.90	422 lb	$6.33
Ozone ($12.49/lb)	0.19 lb	$2.36	0.70 lb	$8.75	1.26 lb	$15.73
NO_2 ($12.49/lb)	0.17 lb	$2.11	0.67 lb	$8.34	1.02 lb	$12.69
SO_2 ($4.62/lb)	0.05 lb	$0.24	0.15 lb	$0.68	0.19 lb	$0.87
PM_{10} ($6.20/lb)	0.13 lb	$0.80	0.57 lb	$3.56	0.87 lb	$5.42
VOCs ($1.92/lb)	0.001 lb	$0.008	0.003 lb	$0.024	0.005 lb	$0.010
BVOCs ($1.92/lb)	-0.004 lb	-$0.007	-0.011 lb	-$0.022	-0.024 lb	-$0.047
Rainfall Interception ($0.002/gal)	80 gal	$0.16	1,427 gal	$3.64	1,641 gal	$4.45
ENVIRONMENTAL SUBTOTAL		**$15.59**		**$51.58**		**$70.57**
Other Benefits		$3.74		$27.26		$35.66
Total Benefits		$19.32		$78.84		$106.23
Total Costs		$2.59		$15.85		$27.76
NET BENEFITS		**$16.73**		**$63.00**		**$78.47**

This analysis assumes that the tree is strategically located to shade the west side of a typical building.
Other benefits include benefits and costs not accounted for such as increased sales price of property, scenic beauty, impacts on human health and well-being, wildlife habitat, and recreation opportunities.

LSA=leaf surface area

Table 3. Tree numbers by age class and estimated annual net benefits for three street tree species in Claremont.

	< 10 yrs	10-19 yrs	20-29 yrs	30-39 yrs	40+ yrs	Total
Shamel ash (#)	77	83	103	65	17	345
$/tree	3	47	75	103	113	–
Total $	231	3,904	7,725	6,695	1,921	20,476
jacaranda (#)	462	288	124	48	10	932
$/tree	-13	26	47	5	51	–
Total $	-6,005	7,490	5,824	2,644	510	10,464
crape myrtle (#)	750	385	404	217	298	2,054
$/tree	-25	-2	4	6	11	–
Total $	-18,750	770	1,617	1,302	3,278	-13,323

benefits alone ($71) are over two times greater than annual costs ($28) for the large Shamel ash at this time. For the medium jacaranda, environmental benefits total $52 and tree care costs are $16. Annual environmental benefits are $16 for the 20-year-old small yard tree, while management costs are $3.

What is the net benefit for an urban forest?

The average annual net benefit for a population of trees can be estimated using data presented here and in Appendix A. For example, the City of Claremont's street and park tree inventory indicates that there are about 24,000 trees and 345 are Shamel ash (1%), 932 are jacaranda (4%), and 2,054 are crape myrtle (9%). Table 3 shows the distribution of these trees among age classes and the estimated annual net benefits assuming costs and benefits described in this report. The total annual net benefits produced by the Shamel ash, jacarandas, and crape myrtles are $20,476 ($59 per tree), $10,464 ($11 per tree), –$13,323 (–$6 per tree), respectively. Together, trees belonging to these three species account for 14% of Claremont's tree population and their benefits exceed costs by approximately $17,000 ($5 per tree). Chapter 3 shows how to adjust benefit and cost data to account for impacts of a proposed change in a street tree planting program.

Average Annual Costs

Costs increase with size of tree

Average annual costs for tree planting and care increase with mature tree size:

- $8 to $17 for a small tree
- $18 to $27 for a medium tree
- $24 to $31 for a large tree (see Appendix A for detailed results).

Table 4. Estimated annual costs for a small-, medium- and large-sized public tree and private, residential yard tree located opposite the west-facing wall 20 years after planting for Inland Empire communities.

	SMALL TREE 14 ft tall, 15 ft spread LSA = 382 sq. ft.		MEDIUM TREE 37 ft tall, 31 ft spread LSA = 2,522 sq. ft.		LARGE TREE 51 ft tall, 36 ft spread LSA = 3,802 sq. ft.	
COSTS ($/yr/tree)	Private: West	Public Tree	Private: West	Public Tree	Private: West	Public Tree
Tree and Planting	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Trimming	$1.32	$5.85	$11.45	$9.63	$21.75	$9.11
Remove and Dispose	$0.41	$0.41	$1.18	$1.18	$1.66	$1.66
Pest & Disease	$0.24	$0.24	$0.68	$0.68	$0.95	$0.95
Infrastructure Repair	$0.24	$0.97	$1.10	$4.42	$1.41	$5.66
Irrigation	$0.04	$0.04	$0.26	$0.26	$0.39	$0.39
Clean-Up	$0.24	$1.82	$0.69	$5.20	$0.97	$7.31
Liability and Legal	$0.10	$0.42	$0.48	$1.91	$0.61	$2.45
Administration and Other	$0.00	$0.87	$0.00	$2.47	$0.00	$3.48
Total Costs	**$2.59**	**$10.60**	**$15.85**	**$25.74**	**$27.76**	**$31.02**
Total Benefits	$19.32	$11.47	$78.84	$63.18	$106.23	$91.86
Total Net Benefits	**$16.73**	**$0.87**	**$63.00**	**$37.44**	**$78.47**	**$60.84**

Larger trees are more expensive to maintain

Given our assumptions and the dimensions of these trees, it is two to four times more expensive to maintain a large tree than a small tree (Table 4). Average annual maintenance costs for private trees are $8-24 per tree, less than estimated costs of $17-31 for a public tree. Tree trimming is the single greatest cost for private and public trees ($7-10/year per tree). For private trees, annualized expenditures for tree planting are the second most important cost. For public trees, annual litter clean-up costs average from $2-6 per tree, while sidewalk repair/root pruning costs range from $2-4 per tree. Strategies are needed to reduce these costs so that municipalities can use their limited funds to plant and care for more trees rather than remediate the problems caused by trees. Planting, administration, and liability/legal costs are other important costs for public street/park trees.

Average Annual Benefits

Average benefits increase with size of tree

Average annual benefits (40-year total / 40 years) also increase with mature tree size:

- $15 to $22 for a small tree
- $60 to $75 for a medium tree
- $97 to $109 for a large tree (see Appendix A for detailed results).

Larger trees produce more energy savings

Mature tree size matters when considering net energy benefits. A large tree produces two to four times more savings than a small tree due to greater extent of building shade and increased evapotranspirational cooling. Also, energy savings increase as trees mature and their leaf surface area increases, regardless of their mature size (Figures 6 and 7).

West is best

Average annual net energy benefits for residential trees are estimated to be greatest for a tree located west of a building because the heating penalty associated with winter shade is minimized ($7). A yard tree located south of a building produces the least net energy benefit, while a tree located east of a building provides intermediate net benefits. Winter shade from the small crape myrtle opposite south-facing walls increases heating costs more than shading and climate benefits reduce cooling costs. Thus, this small tree is a net energy cost at this location. The medium-sized jacaranda and large Shamel ash provide net energy benefits at all locations, despite being in-leaf during some of the winter months. Their large air conditioning savings during summer ($14-26 annual average) more than offset heating costs associated with winter shade ($2-7). These results indicate that energy savings are substantial in the warm Inland Empire climate of California. Annual savings can be doubled through strategic placement of solar friendly tree species to maximize summer shade and minimize attenuation of winter sunlight.

Benefits greatest for aesthetics and property values

Aesthetic benefits and air quality improvement are the two largest benefit categories. Average annual aesthetic benefits account for 25%-45% of total benefits for the small ($5-6 per year), medium ($23-27), and large tree ($37-43). These values reflect the region's relatively high residential real estate sales prices and the beneficial impact of urban forests on property values and the municipal tax base.

Aesthetic and other benefits are slightly greater for the public street/park tree than the residential yard tree because of the assumption that most yards trees are in the backyard where they have less impact on the sales prices of residential property than front yard trees. This assumption has not been tested so there is a high level of uncertainty associated with this result.

Large trees remove more air pollutants

Air quality benefits are defined as the sum of pollutant uptake by trees and avoided power plant emissions due to energy savings, minus BVOCs released by trees. Air quality benefits provide 30% to 50% of the total average annual benefits for the small ($7), medium ($23) and large tree ($37). Benefit values are greatest for O_3 and NO_2 removal, each averaging as high as $17 and $14 per year for the large tree. The average implied value of PM_{10} and SO_2 removal is $6 and $1, respectively for the Shamel ash. On average, the large tree removes 3.5 lb (1.6 kg) of pollutants from the air each year. The cost of BVOCs released by these low-emitting tree species is negligible and similar to the benefit from avoided VOCs emissions from power plants due to energy savings. Pollutant uptake benefits far exceed the benefits of avoided pollutant emissions.

Large trees remove more CO_2

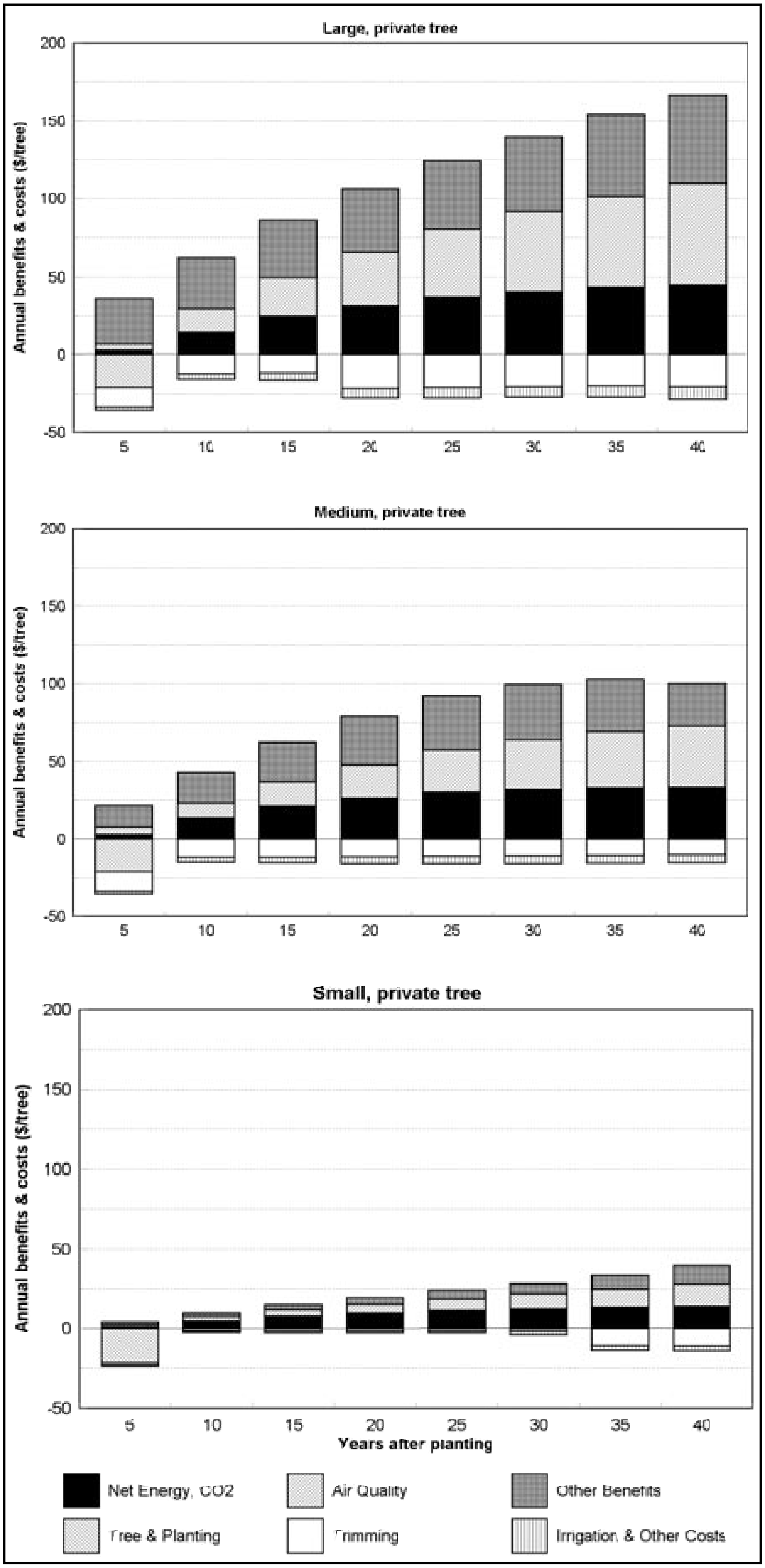
Benefits associated with atmospheric CO_2 reduction are substantial for the large and medium trees. Average annual net reductions range from 237-387 lb ($4-6) for the large tree and 92-261 lb ($1-4) for the medium tree. Trees opposite west-facing walls produce the greatest CO_2 reduction due to avoided power plant emissions associated with cooling savings. The release of CO_2 associated with tree care activities nearly offsets CO_2 sequestration by the small trees, and avoided power plant emissions are small because energy savings are small.

Hydrology benefits are modest for large and medium trees

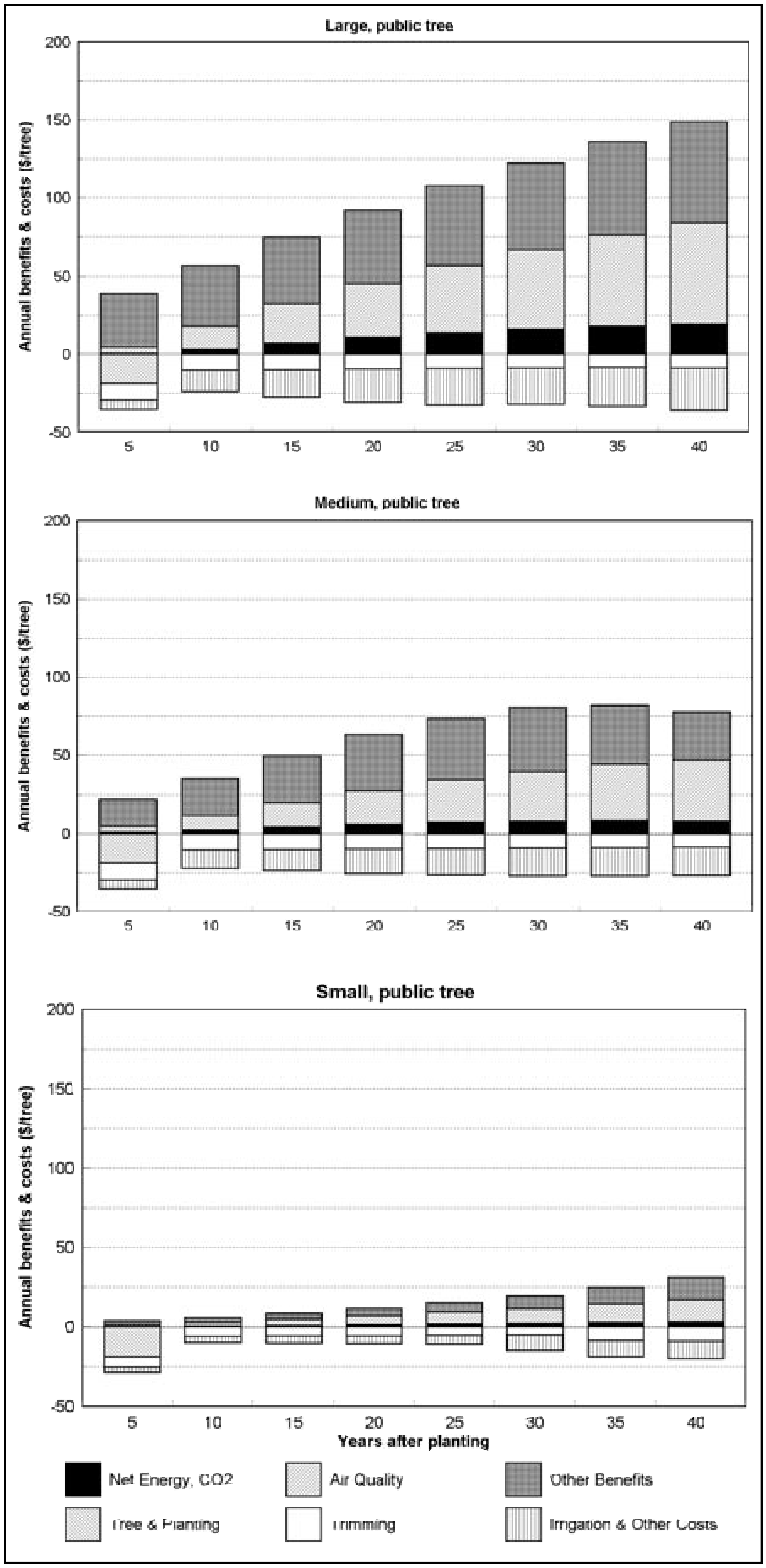
Average annual hydrology benefits are modest for the large and medium trees ($5-6), and minimal for the small tree. The Shamel ash intercepts 2,238 gal/year (8,471 l) on average with an implied value of $6. Approximately 67% of this value is attributed to the annual impact of runoff reduction on water quality and the remaining 33% is due to flood control during a 25-year storm event (265 gal). Average annual hydrology benefits ($5) are more important than energy savings ($3) for the medium, public tree (jacaranda). Its foliage intercepts 1,925 gal/year (7,286 l) of rainfall on average, nearly as much rainfall as intercepted by the larger Shamel ash. However, the ash is leafless during the rainy months of January and February.

Environmental benefits alone exceed costs

When totaled and averaged over the 40-year period, annual environmental benefits for large and medium public trees are $54 and $33, respectively. The value of environmental benefits alone exceed average annual costs for both types of trees. Adding the value of aesthetics and other benefits ($43 for large trees and $27 for medium trees) to these environmental benefits results in substantial net benefits ($97 for large trees and $60 for medium trees).



6. Residential trees. Estimated annual benefits and costs for a large (Shamel ash), medium (jacaranda), and small (crape myrtle) residential yard tree located west of the building. Costs are greatest during the initial establishment period while benefits increase with tree size.



7. Public street/park trees. Estimated annual benefits and costs for a large (Shamel ash), medium (jacaranda), and small (crape myrtle) public street/park tree.

3. How to Estimate Benefits and Costs for Trees in Your Community

In this chapter, we describe how benefit-cost information can be used for a specific project. A hypothetical problem serves as an example. As a municipal cost-cutting measure, the City of Buena Vista is planning to no longer require street tree planting with new development. Instead, developers will be required to plant yard trees. These yard trees will not receive care from municipal arborists, thereby reducing costs to the city. The community forester and local non-profit believe that although this policy will result in lower costs for tree care, the benefits "forgone" will exceed cost savings. The absence of street trees in new development will mean that benefits will not be received by residents and the community since there will be fewer trees to enhance neighborhood aesthetics, property values, air quality, water quality, and other aspects of the environment. What can the community forester and concerned citizens do to convince the city that it should continue to plant and maintain street trees?

The first step: calculate benefits and costs over 40 years

As a first step, the forester and local non-profit group decide to quantify the total cumulative benefits and costs over 40 years for a typical street tree planting of 100 trees in Buena Vista. Based on planting records this would include 50 large trees, 30 medium trees, and 20 small trees. Data in Appendix A are obtained for the calculations. However, three aspects of the Buena Vista urban and community forestry program are different than assumed in this guide:

❶ The price of electricity is $0.14/kWh, not the $0.12/kWh assumed in the Appendix,
❷ No funds are spent on pest and disease control,
❸ Planting costs are $215 per tree for City trees and $95 per tree for 15-gal trees.

Adjust for planting costs

Although the non-profit plants 15-gal trees and these account for 50% of the street trees planted in Buena Vista, all large trees are planted by the City in 24-inch boxes at a cost of $215 each.

Adjust for local electricity price

To calculate the dollar value of total benefits and costs for the 40-year period, the last column in Appendix A (40-Year Average) is multiplied by 40 years. Since this value is for one tree, it must be multiplied by the total number of trees planted in the respective large, medium, or small tree size classes. To adjust for higher electricity prices, we multiply electricity saved for a large public tree in the resource unit column by the Buena Vista price (56 kWh x $0.14 = $7.84). This value is multiplied by 40 years and 50 trees ($7.84 x 40 x 50 = $15,680) to obtain cumulative air conditioning savings for the project (Table 5). The same steps are followed for medium and small trees.

Adjust for other local costs

To adjust the cost figures, we eliminate a row for pest and disease control costs in Table 5. We multiply 50 large trees by the unit planting cost ($215) to obtain the adjusted cost for Buena Vista (50 x $215 = $10,750). The average annual 40-year costs for other items are multiplied by 40 years and the appropriate number of trees to compute total costs. These 40-year cost values are entered into Table 5.

Calculate cost savings and benefits forgone

Net benefits are calculated by subtracting total costs from total benefits for the large ($148,290), medium ($47,184), and small ($632) trees. The total net benefit for the 40-year period is $196,106 (total benefits – total costs), or $1,961 per tree ($196,106 per 100 trees) on average (Table 5). By not investing in street tree planting and maintenance the City saves $105,030 in total costs, but forgoes $301,136 in total benefits, for a net loss of potential benefits in the amount of $1,961 per tree. The analysis assumes 22.5% of the planted trees die. It does not account for the time value of money from a municipal capital investment perspective, but this could be done using the municipal discount rate. Also, for a more complete analysis, it is important to consider the extent to which benefits from increased yard tree plantings may offset the loss of street tree benefits.

Table 5. Estimated 40-year total benefits & costs for Buena Vista's street tree planting (100 trees).

	50 Large Trees		30 Medium Trees		20 Small Trees		100 Tree Total	
Benefits	Res units	$	Res units	$	Res units	$	Res units	$
Electricity (kWh)	112,000	15680	31,200	4,368	8,000	1,120	151,200	21,168
Natural Gas (kBtu)	146,000	880	40,800	240	10,400	64	197,200	1,184
Net Energy (kBtu)	1,256,000	14,000	352,800	3,924	90,400	1,008	1,699,200	18,932
Net CO_2 (lb)	550,000	8,260	188,400	2,820	19,200	288	757,600	11,3680
Air Pollution (lb)	8,000	73,860	2,400	27,732	800	5,544	11,200	107,136
Hydrology (gal)	4,476,000	11,400	2,310,000	5,616	85,600	168	6,871,600	17,184
Aesthetics/Other Benefits		86,680		32,532		4,952		124,164
Total Benefits		**$210,760**		**$77,232**		**$13,144**		**$301,136**
Costs		Public		Public		Public		Public
Tree & Planting		10,750		2,856		1,904		15,510
Pruning		18,340		11,472		5,584		35,396
Remove & Dispose		3,220		1,356		360		4,936
Infrastructure		1,760		744		192		2,696
Irrigation		8,180		4,380		1,448		14,008
Clean-Up		3,020		1,656		920		5,596
Liability & Legal		13,460		5,688		1,480		20,628
Admin & Other		3,740		1,896		624		6,260
Total Costs		**$62,470**		**$30,048**		**$12,512**		**$105,030**
Total Net Benefits		**$148,290**		**$47,184**		**$632**		**$196,106**

4. General Guidelines for Siting and Selecting Trees

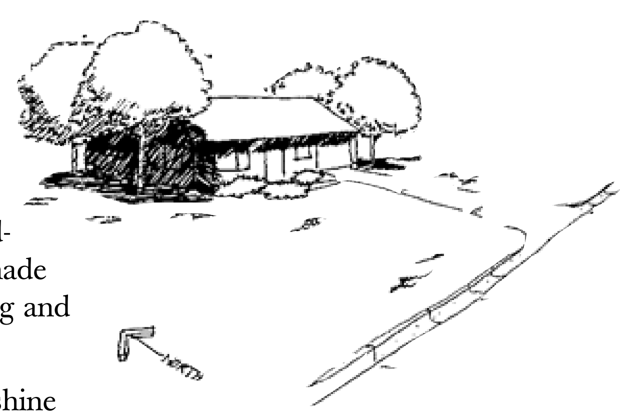
In this chapter, we present general guidelines to help you properly select and locate your trees. We consider both residential trees and trees in public places. Selecting a tree from the nursery that has a high probability of becoming a healthy, trouble-free mature tree is critical to a successful outcome. Therefore, select the very best stock at your nursery, and when necessary, reject nursery stock that does not meet industry standards (Little 2000).

Residential Yard Trees

Maximizing Energy Savings from Shading

Where should shade trees be planted?

The right tree in the right spot saves energy. In midsummer, the sun shines on the northeast and east sides of buildings in the morning, passes over the roof near midday, then shines on the west and northwest sides in the afternoon. Air conditioners work hardest during the afternoon when temperatures are highest and incoming sunshine is greatest. Therefore, the west and northwest sides of a home are the most important sides to shade. Sun shining through windows heats the home quickly during the morning.



8. Locate trees to shade west and east windows (from Sand, 1993).

Locate trees to shade windows on the west side of buildings. The east side is the second most important side to shade when considering the net impact of tree shade on cooling and heating costs (Figure 8).

Trees located to shade south walls can block winter sunshine and increase heating costs, because during winter the sun is lower in the sky and shines on the south side of homes. The warmth the sun provides is an asset, so do not plant evergreen trees that will block southern exposures and solar collectors.

Use solar friendly trees (listed in Chapter 6) to the south because the bare branches of these deciduous trees allow most sunlight to strike the building (some solar unfriendly deciduous trees can reduce sunlight striking the south side of buildings by 50%). To maximize summer shade and minimize winter shade, locate trees about 10-20 ft (3-6 m) south of the home. As trees grow taller, prune lower branches to allow more sun to reach the building if this will not weaken the tree's structure (Figure 9).

Roots, branches and buildings don't mix. Although the closer a tree is to the home the more shade it provides, the roots of trees that are too close can damage the foundation. Branches that impinge on the building can make it difficult to maintain exterior walls and windows. Keep trees at least 5-10 ft

9. Tree south of home before and after pruning. Lower branches were pruned up to increase heat gain from winter sun (from Sand 1993).

(1.5-3 m) from the home to avoid these conflicts but within 30-50 ft (9-15 m) to effectively shade windows and walls.

Patios, driveways and air conditioners love shade. Paved patios and driveways can become heat sinks that warm the home during the day. Shade trees can make them cooler and more comfortable spaces. Shading your air conditioner can reduce its energy use, but do not plant vegetation so close that it will obstruct the flow of air around the unit.

Power, sewer and water lines don't like trees. Keep trees away from overhead power lines and do not plant directly above underground water and sewer lines. Contact your local utility company before planting to determine where underground lines are located and which tree species will not grow into power lines.

Planting Windbreaks for Heating Savings

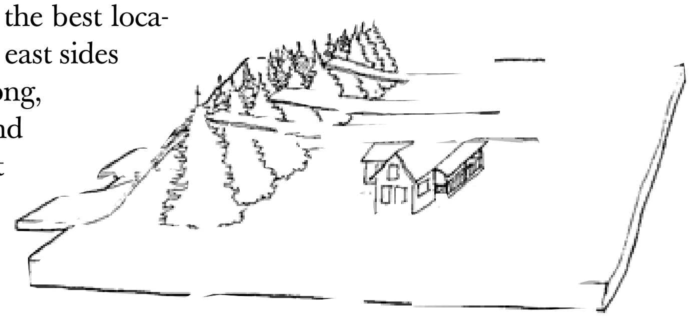
The winter heating season is relatively short in the Inland Empire, but windbreaks can reduce impacts of winter storms. Because of their size and porosity, trees are ideal wind filters. In situations where lot sizes are large enough to plant windbreaks additional savings can be obtained.

Locating windbreaks. Locate rows of trees perpendicular to the primary wind (Figure 10). Design the windbreak row to be longer than the building being sheltered because the wind speed increases at the edge of the windbreak. Ideally, the windbreak is planted upwind about 25-50 ft (7-15 m) from the building and consists of dense evergreens that will grow to twice the height of the building they shelter (Heisler 1986, Sand 1991). Avoid locating windbreaks that will block sunlight to south and east walls (Figure 11). Trees should be spaced close enough to form a dense screen, but not so close that they will block sunlight to each other, causing lower branches to self-prune. Most conifers can be spaced about 6 ft (2 m) on center. If there is room for two or more rows, then space rows 10-12 ft (3-4 m) apart.

Plant dense evergreens. Evergreens are preferred over deciduous trees for windbreaks because they provide better wind protection. The ideal windbreak tree is fast growing, visually dense, has strong branch attachments, and has stiff branches that do not self-prune. Trees that are among the best windbreak trees for Inland Empire communities include Incense cedar (*Calocedrus decurrens*) and Canary Island pine (*Pinus canariensis*).

Selecting Yard Trees to Maximize Benefits

The ideal shade tree has a fairly dense, round crown with limbs broad enough to partially shade the roof. Given the same placement, a large tree will provide more building shade than a small tree. Deciduous trees allow sun to shine through leafless branches in winter. Plant small trees where nearby buildings or power lines limit aboveground space. Columnar or upright trees are appropriate in narrow side yards. Because the best location for shade trees is relatively close to the west and east sides of buildings, the most suitable trees will be strong, resisting storm damage, disease, and pests (Sand 1994). Examples of trees not to select for placement near buildings include cottonwoods (*Populus fremontii*) because of their invasive roots, weak wood, and large size, and ginkgos (*Ginkgo biloba*) because of their sparse shade and slow growth.



10. Evergreens guide wind over the building (from Sand, 1993).

Picking the right tree. When selecting trees, match the tree's water requirements with those of surrounding plants. For instance, select low water-use species for planting in areas that receive little irrigation (Costello and Jones 2000, see WUCOLS list and Chapter 6). Also, match the tree's maintenance requirements with the amount of care and the type of use different areas in the landscape receive. For instance, tree species that drop fruit that can be a slip and fall problem should not be planted near paved areas that are frequently used by pedestrians. Check with your local landscape professional before selecting trees, to make sure that they are well suited to the site's soil and climatic conditions.

Trees in Public Places

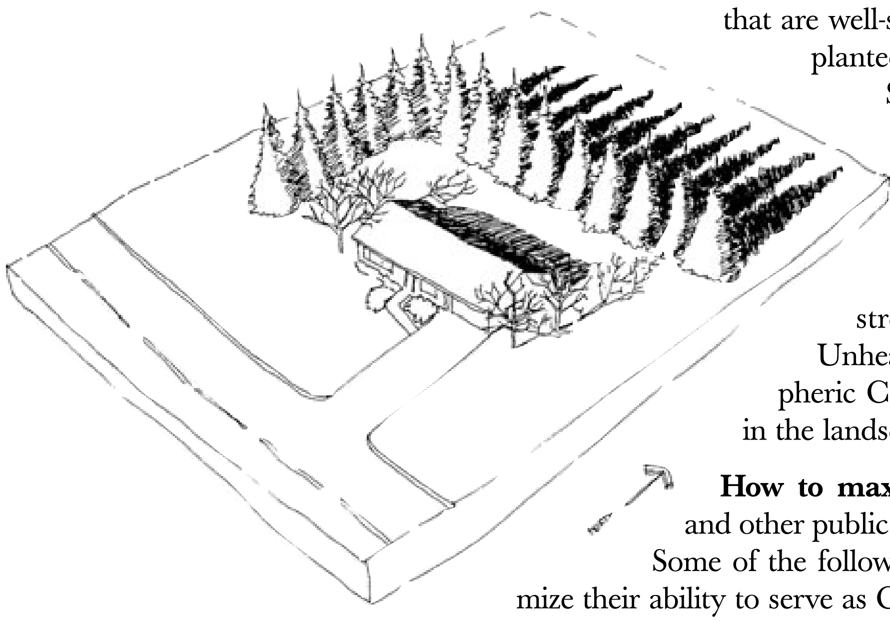
Locating and Selecting Trees to Maximize Climate Benefits

Large trees mean more shade

Locate trees in common areas, along streets, in parking lots, and commercial areas to maximize shade on paving and parked vehicles. Shade trees reduce heat that is stored or reflected by paved surfaces. By cooling streets and parking areas, they reduce emissions of evaporative hydrocarbons that are involved in smog formation from parked cars (Scott et al. 1998). Large trees can shade more area than smaller trees, but should be used only where space permits. Remember that a tree needs space for both branches and roots.

For CO_2 reduction, select trees well-suited to site

Because trees in common areas and other public places may not shelter buildings from sun and wind, CO_2 reductions are primarily due to sequestration. Fast-growing trees sequester more CO_2 initially than slow-growing trees, but this advantage can be lost if the fast-growing trees die at younger ages. Large growing trees have the capacity to store more CO_2 than do smaller growing

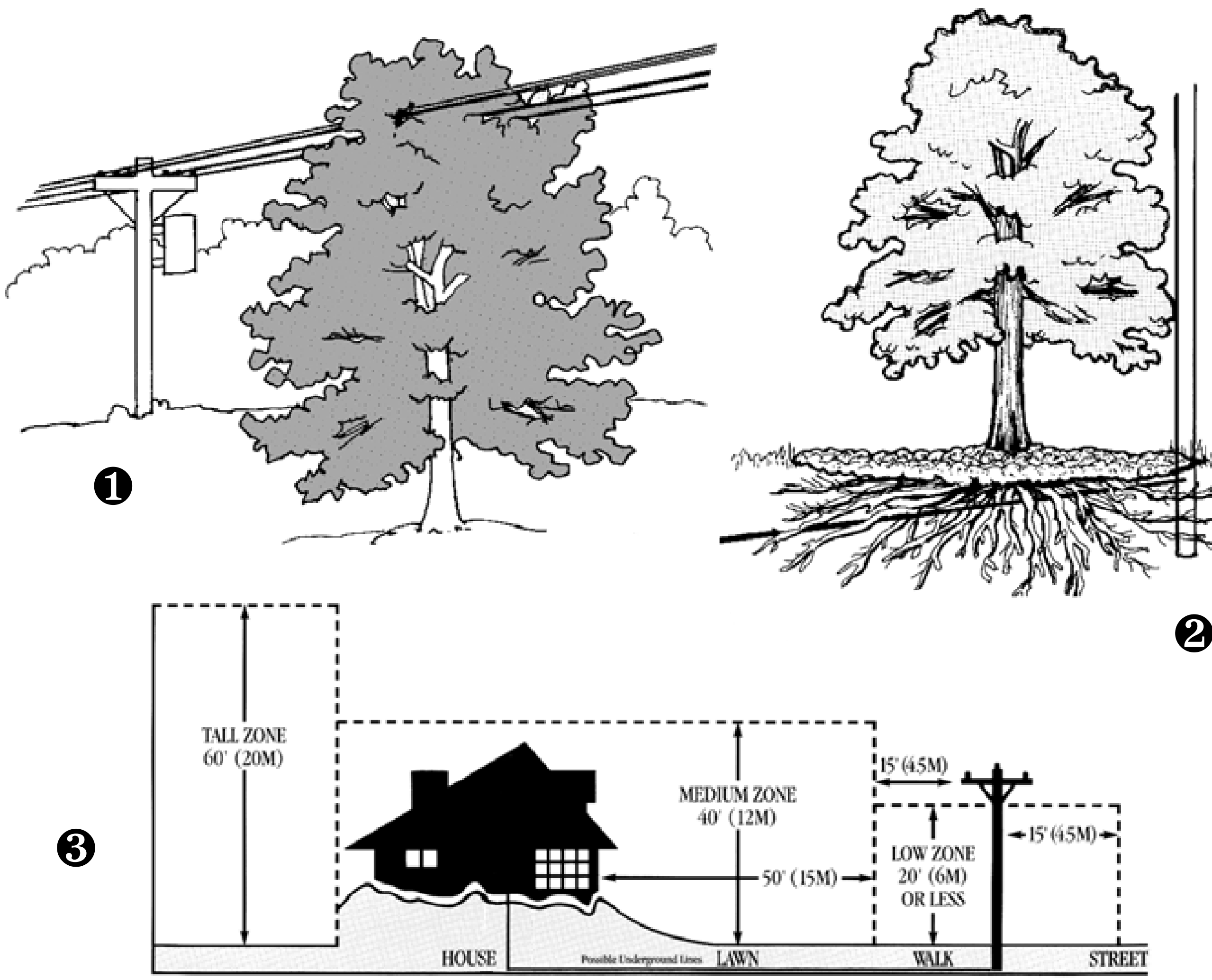


11. *Mid-winter shadows from a well-located windbreak and shade trees do not block solar radiation on the south-facing wall (from Sand 1993).*

trees. To maximize CO_2 sequestration, select tree species that are well-suited to the site where they will be planted. Use information in the Tree Selection List (see Chapter 6), and consult with your local landscape professional to select the right tree for your site. Trees that are not well-adapted will grow slowly, show symptoms of stress, or die at an early age. Unhealthy trees do little to reduce atmospheric CO_2, and can be unsightly liabilities in the landscape.

How to maximize trees as CO_2 sinks. Parks and other public landscapes serve multiple purposes. Some of the following guidelines may help you maximize their ability to serve as CO_2 sinks:

- Provide as much pervious surface as possible because soil and woody plants store CO_2.
- Maximize use of woody plants, especially trees, as they store more CO_2 than do herbaceous plants and grass.
- Increase tree stocking levels where feasible, and immediately replace dead trees to compensate for CO_2 lost through tree and stump removal.
- Create a diversity of habitats, with trees of different ages and species, to promote a continuous canopy cover.
- Select species that are adapted to local climate, soils, and other growing conditions. Adapted plants should thrive in the long run and consume relatively little CO_2 through maintenance.
- Group species with similar landscape maintenance requirements together and consider how irrigation, pruning, fertilization, weed, pest, and disease control can be minimized.
- Compost litter and apply it as mulch to reduce CO_2 release associated with irrigation and fertilization.
- Where feasible, reduce CO_2 released through landscape management by using push mowers (not gas or electric), hand saws (not chain saws), pruners (not gas/electric shears), rakes (not leaf blowers), and employing local landscape professionals who do not have to travel far to your site.
- Consider the project's life span when making species selection. Fast-growing species will sequester more CO_2 initially than slow-growing species, but may not live as long.



12. (❶, ❷) Know where power lines and other utility lines are before planting. ❸ Under power lines use only small-growing trees ("Low Zone"), and avoid planting directly above underground utilities. Larger trees may be planted where space permits ("Medium" and "Tall" zones) (from ISA 1992)

➢ Provide a suitable soil environment for the trees in plazas, parking lots, and other difficult sites to maximize initial CO_2 sequestration and longevity.

Pay attention to infrastructure. Contact your local utility company before planting to locate underground water, sewer, gas, and telecommunication lines. Note the location of power lines, streetlights, and traffic signs, and select tree species that will not conflict with these aspects of the city's infrastructure. Keep trees at least 30 ft (10 m) away from street intersections to ensure visibility. Avoid planting shallow rooting species near sidewalks, curbs, and paving. Tree roots can heave pavement if planted too close to sidewalks and patios. Generally, avoid planting within 3 ft (1 m) of pavement, and remember that trunk flare at the base of large trees can displace soil and paving for a considerable distance. Select only small-growing trees (<25 ft tall [8 m]) for locations under overhead power lines, and do not plant directly above underground water and sewer lines (Figure 12). Avoid locating trees where they will block illumination from street lights or views of street signs in parking lots, commercial areas, and along streets.

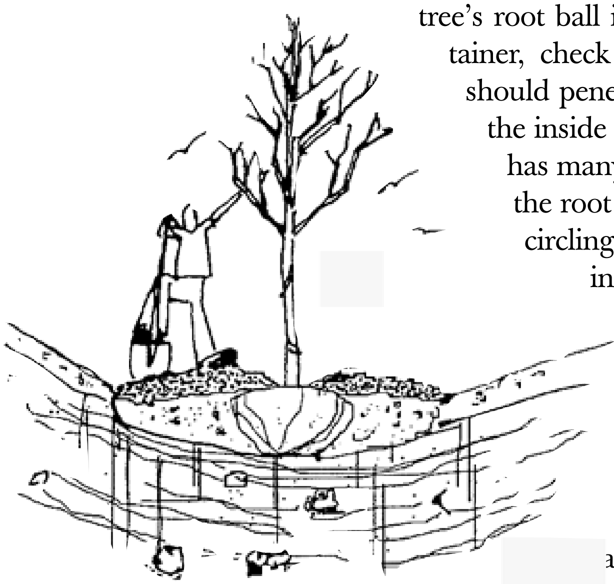
Match tree to site on case-by-case basis

Maintenance requirements and public safety issues influence the type of trees selected for public places. The ideal public tree is not susceptible to wind damage and branch drop, does not require frequent pruning, produces little litter, is deep-rooted, has few serious pest and disease problems, and tolerates a wide range of soil conditions, irrigation regimes, and air pollutants. Because relatively few trees have all these traits, it is important to match the tree species to planting site by determining what issues are most important on a case-by-case basis. For example, parking lot trees should be tolerant of hot, dry conditions, have strong branch attachments, and be resistant to attacks by pests that leave vehicles covered with sticky exudate. Consult the Tree Selection List in Chapter 6 and your local landscape professional for horticultural information on tree traits.

General Guidelines For Selecting, Planting and Establishing Healthy Trees For Long-Term Benefits

Root ball is critical to survival

Inspect your tree at the nursery or garden center before buying it to make sure that it is healthy and well formed. New guidelines for container-grown trees in California specify that the crown has not been headed and the trunk will remain vertical without a nursery stake (Little 2000). The health of the tree's root ball is critical to its ultimate survival. If the tree is in a container, check for matted roots by sliding off the container. Roots should penetrate to the edge of the root ball, but not densely circle the inside of the container or grow through drain holes. If the tree has many roots circling the around the outside of the root ball or the root ball is very hard it is said to be pot-bound. The mass of circling roots can act as a physical barrier to root penetration into the landscape soil after planting. Dense surface roots that circle the trunk may girdle the tree. Do not purchase pot-bound trees.



Another way to evaluate the quality of the tree is to gently move the trunk back and forth in the container. A good tree trunk bends and does not move in the soil, while a poor quality trunk bends little and pivots at or below the soil line. If it pivots and the soil loosens, it may not be very well anchored to the container soil.

13. Prepare a broad planting area and top it off with mulch and a berm to hold water (from Sand 1993).

Plant the tree in a quality hole. Dig the planting hole one inch shallower than the depth of the root ball so that the tree will not settle after it is watered in. The crown of the root ball should be slightly above ground level. Make the hole two to three times as wide as the container and roughen the sides of the hole to make it easier for roots to penetrate. Backfill with the native soil unless it is very sandy, in which case you may want to add composted organic matter such as peat moss or shredded bark (Figure 13).

Use the extra backfill to build a berm outside the root ball that is 6 inches (15 cm) high and 3 ft (1 m) in diameter. Soak the tree, and gently rock it to settle it in. Cover the basin with a 4-inch (10 cm) thick layer of mulch, but avoid placing mulch against the tree trunk. Water the new tree twice a week for the first month and weekly thereafter for the next couple growing seasons.

Don't forget about the tree

Inspect your tree several times a year, and contact a local landscape professional if problems develop. If your tree needed staking to keep it upright, remove the stake and ties as soon as the tree can hold itself up. Reapply mulch and irrigate the tree as needed. Prune the young tree to maintain a central leader and equally spaced scaffold branches. As the tree matures, have it pruned on a regular basis by a certified arborist. By keeping your tree healthy, you maximize its ability to reduce atmospheric CO_2 and provide other benefits. For additional information on tree planting, establishment and care, see *Principles and Practice of Planting Trees and Shrubs* (Watson and Himelick 1997), *Arboriculture* (Harris et al. 1999), and the video *Training Young Trees for Structure and Form* (Costello 2000).

5. Program Design and Implementation Guidelines

Your urban forest can become an important way to conserve energy, reduce atmospheric CO_2 and maximize other important benefits. In this chapter, we discuss issues to consider when starting a shade tree program. A checklist for designing and delivering a program is provided, as well as hints for increasing benefits and reducing overall costs.

Program Design And Delivery Checklist

Here is what to consider

A shade tree program directed towards reducing atmospheric CO_2 needs to be community-wide and collaborative. Fortunately, lessons learned from urban and community programs throughout the country can be applied to avoid pitfalls and promote success (McPherson et al. 1992). In this section, we provide a checklist to consider when initiating a shade tree program. For further information, short descriptions of successful shade tree programs are contained in the article "Utilities Grow Energy Savings" (Anderson 1995). Contact California ReLeaf for additional assistance.

Establish the Organizing Group

Most successful programs have a core group of people who provide the leadership needed to organize and plan specific planting and stewardship projects. Build this coalition with an eye toward forging important partnerships with local businesses, utility or energy organizations, politicians, service organizations, schools, individual volunteers, and agencies, and include individuals with expertise in the fields of planning, forestry, horticulture, design, and community organizing. A broad-based constituency and an inclusive process that involves people in decision-making are essential characteristics of a successful organizing group (Sand 1993).

Draw a "Road Map"

A "road map" provides a clear picture of where the program is headed and just as importantly, where it is not headed. Begin by establishing program goals and objectives. Some examples of program objectives include:

- Achieve a certain number of tree plantings per year.
- Achieve a certain percentage of future tree canopy cover based on current planting targets.
- Strategically locate trees to achieve a designated level of energy savings or CO_2 reductions per tree planted.
- Achieve a designated survival rate each year through an active stewardship program.
- Implement an outreach program to inform the public, local decision makers, and forestry and landscape professionals about potential benefits.

- ➢ Coordinate plantings on adjoining public and private properties to maximize mutual benefits and minimize conflicts with utilities, sidewalks, and other aspects of the infrastructure.
- ➢ Work with local decision-makers and developers to implement tree guidelines, ordinances, and incentives that reduce the number of trees removed or damaged during construction.
- ➢ For rural areas, coordinate with existing state and federal programs by piggybacking new funds with existing cost-share programs.
- ➢ Support research to quantify and validate benefits and costs from tree plantings.

Set Priorities

Once general goals and objectives are determined, set priorities for planting projects. Identify where genuine need exists and where there is a legitimate chance for success. For example, identify areas where the opportunities for shade tree planting are greatest and the interest is highest. Target these sites for planting. Concentrate on doing a few projects well to start. Take on additional campaigns after some successful projects have been established.

Send "Roots" into the Community

The social environment around a tree can be as important to its survival and well-being as the physical environment. Research shows that direct participation in tree planting is associated with greater satisfaction with tree and neighborhood than when trees are planted by city, developer, or volunteer groups without resident involvement (Sommer et al. 1994). Foster active participation in tree planting and stewardship by residents (Figure 14).

14. Direct participation in tree planting fosters increased satisfaction and a healthier urban forest.

Provide Timely, Hands-on Training and Assistance

Whether your program relies on volunteers or paid staff, selecting, placing, planting and establishing trees properly requires specialized knowledge and resources. Taking the time to provide hands-on experience pays off in the long run. Planting a tree is a fare more effective educational tool than reading a brochure or listening to a lecture about how to plant a tree.

Nurture Your Volunteers

Most successful tree programs depend on volunteers as the cornerstones of their efforts. Have a clear picture of how the talents and enthusiasm of volunteers can best be put to use. Pay people to do the routine work. Have volunteers do the inspirational work. Honor and reward your best volunteers.

Obtain High-Quality Nursery Stock

Don't put yourself in a hole by planting substandard trees. Identify sources of nursery stock who are growing trees according to the new "Specification Guidelines for Container-Grown Trees in California," and work with them to get the best quality available (Little 2000). If you are planting large numbers of trees and have time to order stock in advance of planting, contract for the trees to be grown to your specifications. For more information, see the *American Standard for Nursery Stock* (American Association of Nurserymen 1997).

Develop a List of Recommended Trees

Choosing trees for specific sites can be overwhelming unless the list is narrowed down to a limited number of species that will perform best. Enlist landscape professionals to identify species that thrive in local soils and climates. Tree lists may be subdivided by mature tree size (e.g., large, small), life form (e.g., deciduous, conifer), and type of site (e.g., under power lines, parking lots, narrow side yards).

15. The local media and corporate sponsors can be a real asset when you need to inform the public about your program.

Commit to Stewardship

Commitment is the key to a healthy urban forest (Lipkis and Lipkis 1990). After the tree-planting fervor subsides, community members need to be dedicated to the ongoing care of those trees and all that follow. Send out information on tree care to prompt program participants to water, mulch, prune, and inspect their trees. Establish a Shade Tree Hotline to dispense stewardship information. Select a sample of trees to track. Monitor their survival and growth, and use the findings to fine-tune your program. For example, the Sacramento Shade program discontinued planting species that were found to have the lowest survival and growth rates.

Use Self-Evaluation to Improve

After every project, ask staff and volunteers to fill out an evaluation form by noting what worked well, what didn't work, and what can be done to achieve better results. Use these evaluations to fine-tune your program on a continuous basis.

Educate the Public

Work with the local media to inform and involve the public in your program. Stimulate new linkages with the community by publicizing the program's goals and accomplishments.

Envision the Future

Share the big picture, and show people what a force for change they can be by working together (Figure 15).

How Long Does It Take?

There is a saying, "It takes 1,000 days to plant a tree." Tree planting is a simple act, but planning, training, selecting species, and mobilizing resources to provide ongoing care require considerable forethought. Successful shade tree programs will address all these issues before a single tree is planted.

Increasing Program Cost Effectiveness

What if the costs are too high?

What if the program you have designed is promising in terms of energy savings, volunteer participation, and ancillary benefits, but the cost per unit energy saved is too high? This section describes some steps to consider that may increase benefits and reduce costs, thereby increasing cost effectiveness.

Increase Energy Savings and Other Benefits

Work to increase survival rates

Active stewardship that increases the health and survival of recently planted trees is one strategy for increasing cost effectiveness. An evaluation of the Sacramento Shade program found that assumed tree survival rates had a substantial impact on projected benefits (Hildebrandt et al. 1996). Higher survival rates increase energy savings and reduce tree removal costs.

Target tree plantings with highest pay back

You can further increase energy benefits by targeting a higher percentage of trees for locations that produce the greatest energy savings, such as opposite west-facing walls and close to buildings. By customizing tree locations to increase numbers in high-yield sites, cooling savings can be boosted.

Reduce Program Costs

Reduce up-front and establishment costs

Cost effectiveness is influenced by program costs and benefits (Cost Effectiveness = Total Net Benefit / Total Program Cost). Cutting these costs is one strategy to increase cost effectiveness. A substantial percentage of total program costs occur during the first three years and are associated with tree planting (McPherson 1993). Some strategies to reduce these costs include:

- The use of trained volunteers,
- Smaller tree sizes,
- Follow-up care to increase tree survival and reduce replacement costs.

Pay attention to the site

Where growing conditions are likely to be favorable, such as yard or garden settings, it may be cost effective to use smaller, less expensive stock or bare root trees that reduce planting costs. However, in highly urbanized settings and sites subject to vandalism, large trees may survive the initial establishment period better than small trees.

Train volunteers to monitor tree health

Investing in the resources needed to promote tree establishment during the first five years after planting is usually worthwhile because, once trees are established, they have a high probability of continued survival. If your program has targeted trees on private property, then encourage residents to attend tree care workshops. Develop standards of "establishment success" for different types of tree species. Perform periodic inspections to alert residents to tree health problems, and reward those whose trees meet your program's establishment standards. Replace dead trees as soon as possible, and identify ways to improve survivability.

Prune early

A cadre of trained volunteers can easily maintain trees until they reach a height of about 20 ft (6 m) and limbs are too high to prune from the ground with pole pruners. By the time trees reach this size they are well-established. Pruning during this establishment period should result in a safer tree that will require less care in the long-term. Training young trees will provide a strong branching structure that requires less frequent thinning and shaping. Although organizing and training volunteers requires labor and resources, it is usually less costly than contracting the work. As trees grow larger, contracted pruning costs may increase on a per-tree basis. The frequency of pruning will influence these costs, since it takes longer to prune a tree that has not been pruned in 10 years than one that was pruned a few years ago. Although pruning frequency varies by species and location, a return frequency of about five years is usually sufficient (Miller 1997).

It all adds up

When evaluating the bottom line and whether trees pay, do not forget to consider benefits other than the energy savings, atmospheric CO_2 reductions, and other tangible benefits described in this guide. The magnitude of benefits related to employment opportunities, job training, community-building, and enhanced human health and well-being can be substantial. Moreover, these benefits extend beyond the site where trees are planted, furthering collaborative efforts to build better communities.

Sources of Technical Assistance

Alliance for Community Trees
2121 San Jacinto St., Suite 810
Dallas, TX 75201
☎(214) 953-1187 fax (214) 953-1986
www.treelink.org

American Forests
P.O. Box 2000
Washington, D.C. 20013
☎(202) 955-4500
www.americanforests.org

American Nursery and Landscape Association
1250 I St. NW, Suite 500
Washington, D.C. 20005
☎(202) 789-2900 fax (202) 789-1893
www.anla.org

American Public Power Association
2301 M St. NW
Washington, D.C. 20037
☎(202) 467-2900 fax (202) 467-2910
www.appanet.org

American Society of Consulting Arborists
15245 Shady Grove Rd., Suite 130
Rockville, MD 20850
☎(301) 947-0483 fax (301) 990-9771

American Society of Landscape Architects
636 Eye St. NW
Washington, D.C. 20001-3736
☎(202) 898-2444 fax (202) 898-1185
www.asla.org

California Association of Nurserymen
3947 Lennane Dr., Suite 150
Sacramento, CA 95834
☎(916) 928-3500 fax (916) 567-0505
www.can-online.org

California Landscape Contractors Association
2021 N St., Suite 300
Sacramento, CA 95814
☎(916) 448-CLCA fax (916) 446-7692
www.clca.org

California Department of Forestry and Fire Protection
Urban and Community Forestry
2524 Mulberry St.
Riverside, CA 92501
☎(909) 782-4140 fax (909) 782-4248
www.fire.ca.gov/ResourceManagement/UrbanForestry.asp

California Releaf
The Trust for Public Land
926 J St., Suite 201
Sacramento, CA 95814
☎(916) 557-1673 fax (916) 557-1675
www.tpl.org, then search for "California ReLeaf"

California Urban Forests Council
PMB #63, 2261 Market St.
San Francisco, CA 94114
☎(415) 647-4207 fax (415) 647-3903
email: caufc@home.com

Global Releaf for New Communities
American Forests
P.O. Box 2000
Washington, D.C. 20013
☎(202) 955-4500 fax (202) 955-4588
www.amfor.org/garden/global_releaf/gr_subhome.html

International Council for Local Environmental Initiatives
15 Shattuck Sq., Suite 215
Berkeley, CA 94704
☎(510) 540-8843 fax (510) 540-4787
www.iclei/org

International Society of Arboriculture, Western Chapter
235 Hollow Oak Dr.
Cohasset, CA 95973
☎(530) 892-1118 fax (530) 892-1006
www.wcisa.net

League of California Cities
1400 K St., 4th Floor
Sacramento, CA 95814
☎(916) 658-8200 fax (916) 658-8240
www.cacities.org

Local Government Commission
1414 K St., Suite 600
Sacramento, CA 95814-3966
☎(916) 448-1198 fax (916) 448-8246
www.lgc.org

National Arbor Day Foundation
100 Arbor Ave.
Nebraska City, NE 68410
☎(402) 474-5655 fax (402) 474-0820
www.arborday.org

National Arborists Association
P.O. Box 1094
Amherst, NH 03031
☎(603) 673-3311 fax (603) 672-2613
www.natlarb.com

National Association of State Foresters
444 N. Capitol St. NW, Suite 540
Washington, D.C. 20001
☎(504) 925-4500
www.stateforesters.org

National Association of Towns and Townships
National Center for Small Communities
444 North Capital St. NW, Suite 208
Washington, D.C. 20001
☎(202) 624-3550 fax (202) 624-3554
www.natat.org/natat

National Tree Trust
1120 G St. NW, Suite 770
Washington, D.C. 20005
☎(202) 628-8733 or (800) 846-8733 fax (202) 628-8735
www.nationaltreetrust.org

National Urban and Community Forestry Advisory Council
c/o Suzanne DelVillar
20628 Diane Dr.
Sonora, CA 95370
☎(209) 536-9201 fax (209) 536-9089
www.treelink.org/connect/orgs/nucfac/index.htm

National Wildlife Federation
8925 Leesburg Pike
Vienna, VA 22184
☎(800) 822-9919 fax (703) 790-4040
www.nwf.org/nwf

Phytosphere Research
1027 Davis St.
Vacaville, CA 95687
☎(707) 452-8735
www.phytosphere.com/treeord/Ordintro.htm
(tree ordinance information)

Society of American Foresters
5400 Grosvenor Ln.
Bethesda, MD 20814-2198
☎(301) 897-8720 fax (301) 897-3690
www.safnet.org

Society of Municipal Arborists
7000 Olive Blvd.
University City, MO 63130-2300
☎(314) 862-1711
www.urban-forestry.com

Street Tree Seminar, Inc.
P.O. Box 6415
Anaheim, CA 92816-6415
☎(714) 991-1900 fax (714) 956-3745
guidebook: *Street Trees Recommended for Southern California*

Tree Link Homepage
www.treelink.org

TreePeople
12601 Mulholland Dr.
Beverly Hills, CA 90210
☎(818) 753-4600 fax (818) 753-4625
www.treepeople.org

UC Cooperative Extension Los Angeles County
2 Coral Circle
Monterey Park, CA 91755
☎(323) 838-8330 fax (323) 838-7449
http://celosangeles.ucdavis.edu

UC Cooperative Extension Orange County
1045 Arlington Dr.
Costa Mesa, CA 92525
☎(714) 708-1606 fax (714) 708-2754
www.oc4h.org

UC Cooperative Extension Riverside County
21150 Box Springs Rd.
Moreno Valley, CA 92557-8708
☎(909) 683-6491 fax (909) 788-2615
email: ceriverside@ucdavis.edu

UC Cooperative Extension San Bernardino County
777 East Rialto Ave.
San Bernardino, CA 92415-0730
☎(909) 387-2171 fax (909) 387-3306
http://cesanbernardino.ucdavis.edu

UC Cooperative Extension San Diego County
5555 Overland Ave., Building 4
San Diego, CA 92123-1219
☎(858) 694-2845 fax (858) 694-2849
http://cesandiego.ucdavis.edu

UC Cooperative Extension Ventura County
669 County Square Dr. #100
Ventura, CA 93003-5401
☎(805) 645-1451 fax (805) 645-1474
http://ucceventura.xlrn.ucsb.edu

Urban Forest Ecosystems Institute
California Polytechnic State University
San Luis Obispo, CA 93407
☎(805) 756-5171 fax (805) 756-1402
www.ufei.calpoly.edu

USDA Forest Service / Urban and Community Forestry
1323 Cub Dr.
Vallejo, CA 94591
☎(707) 562-8737

USDA Forest Service / GreenLink
4600 Oak Grove Dr.
La Canada Flintridge, CA 91011
☎(818) 952-4935 fax (818) 790-5392
email: rretamoza@fs.fed.us

Western Center for Urban Forest Research and Education
USDA Forest Service, PSW
c/o University of California, Department of Environmental Horticulture
Davis, CA 95616-8587
☎(530) 752-7636 fax (530) 752-6634
http://wcufre.ucdavis.edu

6. Trees for Inland Empire Communities

In this chapter, we present information that will help you select the right tree for a particular location.

What is the geographic scope?

The non-desert interior valleys of Southern California comprise a widespread geographic area that includes Simi Valley, the San Fernando – San Gabriel Valleys, San Bernardino – Riverside, Moreno Valley, Perris, Hemet, Murrieta, Temecula, and Escondidio. Many of the communities located in the eastern and southern portions of this area are relatively young and capable of considerable development making proper tree species selection very important to their future appearance and livability.

What are the selection criteria?

The species list in Table 6 is limited because the primary emphasis for selection was based on species that:

❶ Have been well-tested or have proven, through objective documentation and long-term use, that they grow well in Sunset climate zones 18 through 21 (Brenzel, 1997).

❷ Are readily available through the wholesale nursery trade.

❸ Typically have no serious pest or excessive maintenance problems and do not produce large fruit.

❹ Provide energy conservation benefits by creating significant amounts of summer shade when planted individually.

For example, *Ligustrum lucidum* and palms are omitted, even though they grow well in these areas, because solitary trees of these species may not produce enough canopy cover and shade benefit relative to their expected maintenance costs. Species were also omitted if their ultimate height is expected to be less than 20 feet.

There is virtually no objective, quantifiable information on surface rooting, life span, minimum irrigation need, or specific pruning requirement for tree species, so these characteristics were not included, although reference may be made to these items in the “Comments” section in Table 6.

What information is included?

Tree species are listed alphabetically, and information regarding their size, leaf retention habit, growth rate, ozone forming potential, and best uses is included. The information also describes species’ characteristics related to energy conservation (leaf retention), air quality improvement (ozone-forming potential), and ability to avoid infrastructure conflicts (street tree and other use categories). It is important to note that a tree’s size, life span, growth, and rooting pattern are highly variable depending on the conditions and care it receives at the specific site where it grows. Therefore, the tree's actual performance can be very different from that described here. Use this information as a general guide and obtain more specific information from the references cited in the bibliography and from local landscape professionals. In preparing this information, the following important assumptions were made:

❶ Trees will be planted as 15-gallon container sized plants.

❷ Trees will be maintained and irrigated as needed until established and then receive about 60% to 80% of reference evapotranspiration.

Which trees are not listed?

There are hundreds of other tree species that merit use but do not have as extensive a track record as those appearing in the list. Some may have not been as widely grown for as long a time as those on the list, but based on limited observation or testing they possess attributes making them good choices for many situations. Other species may be excellent choices in very specific situations. Examples are *Cedrela sinensis, Chitalpa tashkentensis, Dombeya cacuminum, Michelia champaca*, and many palms. Readers are encouraged to use the reference materials cited in this chapter to identify additional species to plant in their communities. Diversifying the species palette beyond this list is highly desirable and recommended to minimize the impacts of future problems such as disease epidemics. A diverse urban forest can increase community attractiveness and expand the availability of well-adapted species.

How to match the tree to the site

Finding the best tree for a specific site takes time and study. Collecting information on conditions at the site is the first step. Consider the amount of below- and above-ground space, soil type and irrigation, microclimate, and the type of activities occurring around the tree that will influence its growth and management (e.g., mowing, parking, social events). In most cases, it is too expensive to alter site conditions by making them more suitable for a specific tree species. Instead, it is more practical to identify trees with characteristics that best match the existing site conditions, particularly those conditions that will be most limiting to growth.

Selecting best tree requires a compromise

There is no perfect tree. Selecting the best tree for a given site requires a compromise among various tree features, including: beautiful flowers and form, pest/disease resistance, growth rate, strong branch attachments, ozone-forming potential, litter production, pruning and training requirement, and other maintenance activities. Information in this chapter will assist in finding the best compromise possible. References used to develop the tree list include:

For more information

Benjamin, M. T. 1998. **Estimating the ozone-forming potential of urban trees and shrubs.** Atmos. Environ. 32(1): 53-68.

Brenzel, K. N. (ed.). 1997. **Sunset western garden book**. 6th ed. Menlo Park, CA: Sunset Books, Inc.

Hartin, J. S. and D. R. Pittenger. 1988. **Suggested landscape trees for the San Bernardino Valley**. San Bernardino: University of California Cooperative Extension publication.

Hodel, D. R. 1988. **Exceptional trees of Los Angeles**. Arcadia: California Arboretum Foundation.

Hodel, D. R. 1992. **Flowering trees for the southern California landscape**. Los Angeles: University of California Cooperative Extension publication.

Hodel, D. R. 1995. **Possible street trees for coastal southern California**. Los Angeles: University of California Cooperative Extension publication.

Hoyt, R. S. 1958. **Ornamental plants for subtropical regions**. Privately published.

Karlik, J. and A. M. Winer. In Press. **Measured isoprene emission rates of plants in California landscapes: comparison to estimates from taxonomic relationships**. Atmos. Environ.

Kourik, R. 2000. **The tree and shrub finder**. Newtown, CT: Taunton Press.

Maino, E. and F. Howard. 1955. **Ornamental trees: an illustrated guide to their selection and care**. Berkeley: University of California Press.

Mathias, M. E. 1982. **Flowering plants in the landscape**. Berkeley: University of California Press.

Street Tree Seminar. 2000. **Street trees recommended for Southern California**. 2nd ed. Anaheim: Street Tree Seminar, Inc.

Table 6. Trees for Inland Empire Communities.

Height: average ultimate height in feet for mature tree growing in these areas.
Spread: average ultimate spread in feet for mature tree growing in this area.
Type: **E** = evergreen; **SD** = semi-deciduous (very brief period without foliage); **D** = deciduous, generally solar friendly (blocks sun in summer, lets sun in during winter).
Growth Rate: years to mature size when planted from a 15-gal. container; **S** = slow, > 20 years; **M** = moderate, 10-20 years; **F** = fast, < 10 years.
Cultivars available: **Y** = yes, **N** = no
Ozone Forming Potential = potential for adversely affecting air quality if massive plantings occur: **L** = low,<1; **M** = medium, 1-10; **H** = high, >10 grams ozone per tree per day;
NDA = no data available.
Uses: **Y** = yes, **N** = no

- **Street Tree:** **S1** = 3 ft. or wider parkway or cutout; **S2** = 6 ft. or wider parkway or cutout; **S3** = 10 ft. or wider parkway or cutout; **N** = not suitable.
- **P/C** = park/commercial: ≥8,000 sq. ft. of planting area ;ultimate ht. >50 ft.
- **LR/C** = large residential/commercial: 4,000 - 8,000 sq. ft. of planting area; ultimate ht. 30 - 50 ft.
- **SR/C** = small residential/commercial: <4,000 sq. ft. of planting area; ultimate ht. 30 ft. or less.
- **P** = patio: **Y** = yes, **N** = no; very clean; ultimate ht. 20 - 30 ft.
- **VS/A** = vertical screen/accent: **Y** = yes, **N** = no; columnar, fits a narrow planting area.

Species	Height (feet)	Spread (feet)	E/SD/D	Growth Rate	Cultivars Available	Ozone Forming Potential	Uses: Street Tree	Uses: P/C	Uses: LR/C	Uses: SR/C	Uses: P	Uses: VS/A	Comments
Albizia julibrissin silk tree	25	40	D	F	Y	M	N	Y	Y	Y	Y	N	Attractive fern-like leaves; showy pink flowers in summer; cultivar 'Rosea' has darker pink flowers; may need early pruning to make single trunk.
Bauhinia variegata purple orchid tree	30	25	SD	M	Y	M	S2	Y	Y	Y	Y	N	Profuse, showy purple to pink flowers on mostly bare branches late-winter; bean pod fruits persist through summer, can be messy; needs early pruning to keep single trunk; cultivar 'Candida' has white flowers.
Brachychiton discolor white kurra jong	35	20	E	M	N	NDA	S2	Y	Y	Y	Y	N	Dark green, maple-like leaves; pinkish flowers in spring; good screen; yellow seed pods have irritating hairs; dense canopy; good shade.
Brachychiton acerifolius flame tree	40	20	SD	F	N	NDA	S2	Y	Y	Y	Y	Y	Handsome, glossy green, deeply lobed leaves; smooth greenish bark; showy red flowers early summer on mostly bare branches.

Height: average ultimate height in feet for mature tree growing in these areas.
Spread: average ultimate spread in feet for mature tree growing in this area.
Type: **E** = evergreen; **SD** = semi-deciduous (very brief period without foliage); **D** = deciduous, generally solar friendly (blocks sun in summer, lets sun in during winter).
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Species	Height (feet)	Spread (feet)	E/SD/D	Growth Rate	Cultivars Available	Ozone Forming Potential	Uses						Comments
							Street Tree	P/C	LR/C	SR/C	P	VS/A	
Callistemon citrinus lemon bottlebrush	20	15	E	F	Y	NDA	S1	Y	Y	Y	Y	Y	Showy, red, bottlebrush-like flowers in flushes throughout the year; good screen; flowers attract hummingbirds; cultivars selected for smaller size.
Calocedrus decurrens incense cedar	50	20	E	S	N	NDA	N	Y	Y	N	N	Y	Makes good screen, wind break; good formal specimen and vertical accent.
Calodendrum capense cape chestnut	30	30	SD	M	N	NDA	S2	Y	Y	Y	Y	N	Profuse, showy lilac flowers in early summer; peculiar, warty, shiny, black fruits.
Cassia excelsa crown of gold	30	30	D	M	N	NDA	S2	Y	Y	Y	Y	N	Profuse, showy, yellow flowers in late summer.
Cedrus atlantica atlas cedar	50	40	E	M	Y	NDA	S3	Y	Y	N	N	N	Bluish-green leaves; stiff branches; cultivar 'Glanca' is silver blue, 'Aurea'; has yellow tint, 'Pendula' has weeping branches.
Casuarina stricta drooping she-oak	35	20	E	F	N	NDA	S2	Y	Y	Y	N	N	Thin, jointed, green branches mimic pine needles; good street tree; airy, attractive silhouette.

Height: average ultimate height in feet for mature tree growing in these areas.
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Species	Height (feet)	Spread (feet)	E/SD/D	Growth Rate	Cultivars Available	Ozone Forming Potential	Uses: Street Tree	Uses: P/C	Uses: LR/C	Uses: SR/C	Uses: P	Uses: VS/A	Comments
Cedrus deodara deodar cedar	55	35	E	M	Y	NDA	S3	Y	Y	N	N	N	Nodding main leader and branch tips are characteristic; cultivar 'Aurea' has golden green leaves in summer.
Chionanthus retusus Chinese fringe tree	25	25	D	M	N	NDA	S1	Y	Y	Y	Y	N	Spectacular, profuse, white flowers in late spring; separate male/female trees, only females produce small olive-like fruits.
Cinnamomum camphora camphor tree	60	50	E	S	N	L	S3	Y	N	N	N	N	Strong, handsome, heavy structure; attractive showy leaves emerge pink to bronze; a regal tree; good large screen.
Cupaneopsis anacardioides carrot wood	40	40	E	S	N	H	S2	Y	Y	Y	Y	N	Glossy, leathery leaves; smooth gray bark; problem free except some trees produce heavy crop of dry, orange, leathery, marble-sized fruit.
Cupressus glabra Arizona cypress	35	20	E	M	Y	L	S2	Y	Y	Y	Y	Y	Leaf color varies from dark green to blue or silver-gray; reddish bark may be rough or smooth; cultivar 'Gareei' is silver-blue and makes good screen.
Eucalyptus camaldulensis red gum	60	50	E	M	N	H	S3	Y	N	N	N	N	Spreading crown; graceful weeping branches; handsome, smooth, peeling mottled bark.

Height: average ultimate height in feet for mature tree growing in these areas.
Spread: average ultimate spread in feet for mature tree growing in this area.
Type: **E** = evergreen; **SD** = semi-deciduous (very brief period without foliage); **D** = deciduous, generally solar friendly (blocks sun in summer, lets sun in during winter).
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SR/C = small residential/commercial: <4,000 sq. ft. of planting area; ultimate ht. 30 ft. or less.
P = patio: Y = yes, **N** = no; very clean; ultimate ht. 20 - 30 ft.
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Species	Height (feet)	Spread (feet)	E/SD/D	Growth Rate	Cultivars Available	Ozone Forming Potential	Uses						Comments
							Street Tree	P/C	LR/C	SR/C	P	VS/A	
Eucalyptus citriodora lemon-scented gum	60	40	E	M	N	H	S3	Y	Y	N	N	Y	Ultimate skyline tree; a designer's tree; slender, graceful, open habit; smooth, handsome white to pinkish peeling bark; casts limited shade.
Eucalyptus leucoxylon white ironbark	50	30	E	M	N	H	S3	Y	Y	N	N	N	Slender, open, upright habit with weeping branches; handsome, smooth whitish to mottled peeling bark; moderate shade producer.
Eucalyptus maculata spotted gum	50	35	E	M	N	H	S3	Y	Y	N	N	N	Graceful, strong habit; handsome grayish to yellowish, smooth peeling bark with red to violet patches.
Eucalyptus nicholii Nichol's willow-leaved peppermint	35	30	E	M	N	H	S2	Y	Y	Y	Y	N	Upright trunk with graceful weeping branches; narrow leaves, beautiful fine-textured tree.
Eucalyptus polyanthemos silver-dollar gum	50	30	E	M	N	H	S2	Y	Y	N	N	Y	Leaves distinctly gray; juvenile leaves markedly round, silver white; smooth bark, peeling, mottled; good large screen.
Eucalyptus rudis flooded gum	45	45	E	M	N	H	S3	Y	Y	N	N	N	Upright to spreading; often weeping habit; good large shade/street tree.

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Eucalyptus sideroxylon red ironbark	40	25	E	M	N	H	S2	Y	Y	Y	N	Y	Blue-green leaves are bronze in winter; pink flowers showy in winter; form usually upright, slender; weeping branch tips; deeply furrowed near black bark; good screen.
Eucalyptus torquata coral gum	25	10	E	F	N	H	S1	Y	Y	Y	Y	Y	Grayish leaves, showy coral red and yellow flowers throughout year; slender, upright habit; good screen.
Ficus macrophylla Moreton Bay fig	75	100	E	S	N	H	N	Y	N	N	N	N	Large dark green leaves; spectacular, buttressed trunk and large surface roots; massive tree but unsurpassed dramatic effect for large, open space.
Ficus microcarpa Indian laurel fig	40	45	E	M	Y	H	S3	Y	Y	N	N	N	Large, heavy, light gray trunk; dense crown; variety *nitida* more upright, glossy green leaves, more susceptible to thrips which may cause early leaf drop; cultivar 'Green Gem' is mostly unaffected by thrips; all make good large screens.
Ficus rubiginosa rusty leaf fig	40	35	E	M	Y	H	S3	Y	Y	N	N	N	Large, thick, leathery dark green leaves, rusty brown below; cultivars 'El Toro', 'Irvine' have very dark green leaves and 'Florida' lighter green leaves.

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Fraxinus angustifolia (F. oxycarpa) Raywood ash	30	30	D	M	N	L	S2	Y	Y	Y	Y	N	Round, compact, dense crown; purple-red fall color.
Fraxinus uhdei Shamel ash	50	35	SD	M	Y	L	S3	Y	Y	N	N	N	Cultivar 'Tomlinson' is best cultivar, grows smaller, deep green leaves; good screen.
Fraxinus velutina Arizona ash	30	30	D	M	Y	L	S2	Y	Y	Y	Y	N	Select cultivars for best quality; 'Modesto' has good golden fall color; 'Rio Grande' similar; good screen.
Geijera parviflora Australian willow	30	25	E	M	N	L	S2	Y	Y	Y	Y	N	Fine-textured, dense tree with symmetrical habit; perhaps cleanest, lowest maintenance tree; good screen.
Ginkgo biloba maidenhair tree	50	40	D	S	Y	L	S3	Y	Y	N	N	N	Handsome tree; great golden fall color; select only male cultivars, females produce obnoxious fruits; 'Autumn Gold' is upright, 'Fairmount' is pyramidal.
Grevillia robusta silk oak	50	30	E	F	N	NDA	N	Y	N	N	N	N	Showy golden orange flowers in spring; sporadic, heavy leaf drop; good screen or specimen.
Hymenosporum flavum sweetshade	30	15	E	S	N	L	S2	Y	Y	Y	Y	Y	Attractive glossy green leaves; profuse, showy white and yellowish, sweet/fragrant flowers in late spring; may need early training to get sturdy trunk.

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Koelreuteria bipinnata Chinese flame tree	30	30	D	M	N	H	S2	Y	Y	Y	Y	N	Dark green leaves; showy yellow flowers in late summer followed by showy salmon-pink pods; good form.
Lagerstromia indica crape myrtle	20	20	D	M	Y	L	S1	Y	Y	Y	Y	N	Showy summer flowers of various color depending on cultivar; handsome bark and branching characteristic in winter; fall color yellow to orange; select only mildew-resistant cultivars.
Liquidambar styraciflua sweet gum	50	20	D	S	Y	H	S2	Y	Y	N	N	Y	Handsome green foliage, dependable fall color of yellow, orange, red and burgundy; symmetrical pyramidal habit; select cultivars for uniform, dependable fall color and growing habit; fruits are spiny balls that need raking in winter.
Magnolia grandiflora southern magnolia	15-70	10-40	E	M	Y	M	S2/S3	Y	Y	Y	Y	N	Large glossy green leaves; showy flowers; numerous cultivars offer variety of sizes and shapes; produces dense shade.
Melaleuca linariifolia flaxleaf paperbark	30	25	E	M	N	H	S2	Y	Y	Y	Y	Y	Showy, white, papery, peeling bark; showy white flowers in summer; good screen.

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Michelia champaca michelia	30	15	E	M	N	NDA	S2	Y	Y	Y	Y	N	Large glossy leaves; pale orange flowers with great fragrance produced throughout the year.
Olea europaea olive	30	30	E	M	Y	L	S3	Y	Y	Y	Y	N	Select only fruitless cultivars such as 'Swan Hill', 'Wilson'; may need early pruning to make solitary trunk.
Parkinsonia aculeata palo verde	30	30	SD	F	N	M	N	Y	Y	Y	N	N	Greenish, thin bark; spiny twigs; showy yellow flowers spring/summer; needs training to make single trunk; continuous leaf drop; filtered shade.
Pinus canariensis Canary Island pine	70	30	E	M	N	L	S3	Y	Y	N	N	N	Upright, slender when young; round crown when mature; long, pendant needles; graceful tree.
Pinus halepensis Aleppo pine	50	40	E	M	N	L	N	Y	N	N	N	N	Rugged, attractive picturesque habit.
Pinus pinea Italian stone pine	60	50	E	M	N	L	S3	Y	N	N	N	N	Striking tree with age.
Pistacia chinensis Chinese pistache	30	25	D	M	N	M	S1	Y	Y	Y	Y	Y	Good fall color yellow, orange, red; irregular form when young.

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Pittosporum phyllyraeoides willow pittosporum	20	15	E	M	N	L	S1	Y	Y	Y	Y	Y	Fragrant yellow flowers in spring; weeping habit; excellent small tree.
Pittosporum rhombifolium Queensland pittosporum	25	15	E	M	N	L	N	Y	Y	Y	N	Y	Glossy green leaves; white flowers in spring; produces small sticky fruit.
Platanus acerifolia London plane tree	40	30	D	M	Y	M	S3	Y	Y	N	N	N	Cultivar 'Yardwood' resistant to powdery mildew, 'Bloodgood' resistant to anthracnose.
Platanus racemosa California sycamore	60	35	D	M	N	M	N	Y	N	N	N	N	Contorted, often multiple trunks often lean and are picturesque; attractive bark.
Podocarpus gracilior fern pine	60	45	E	M	N	L	S3	Y	Y	N	N	N	Very clean and pest free; may need pruning when young to develop strong trunk; dense canopy.
Podocarpus henkelii long-leaved yellow-wood	35	15	E	M	N	L	S2	Y	Y	Y	Y	Y	Erect, handsome habit with drooping leaves; may need pruning when young to develop strong trunk.

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Prunus cerasifera purple leaf or myrobalan plum	30	20	D	M	Y	L	S1	Y	Y	Y	Y	N	Reddish purple to dark purple foliage; showy pink flowers in winter; select cultivars 'Newport', 'Mt. St. Helens' to avoid fruit mess; cultivar 'Thundercloud' is best known but often produces many fruits.
Quercus agrifolia coast live oak	45	45	E	S	N	H	S3	Y	Y	N	N	N	Very handsome tree; avoid cultivating under canopy.
Quercus chrysolepis canyon live oak	45	35	E	S	N	H	S3	Y	Y	N	N	N	Leaves green above, whitish below; avoid cultivating under canopy.
Quercus douglasii blue oak	45	45	D	S	N	M	S3	Y	Y	N	N	N	Good orange, yellow fall color; remove lower branches to make street tree.
Quercus englemannii Engleman oak	50	60	E	S	N	H	S3	Y	N	N	N	N	Picturesque tree; remove lower branches to make street tree; avoid cultivating under canopy.
Quercus ilex holly oak	40	40	E	S	N	H	S2	Y	Y	N	N	N	Good street and residential shade tree; good screen.
Quercus kelloggii California black oak	50	40	D	S	N	H	S3	Y	Y	N	N	N	Deeply lobed leaves emerge pink then turn bright glossy green; attractive bark; avoid cultivating under canopy.

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Quercus lobata valley oak, California white oak	60	60	D	S	N	M	N	Y	N	N	N	N	California's mightiest oak; massive and picturesque; shades large area; avoid cultivating under canopy.
Quercus robur English oak	60	40	D	M	Y	H	N	Y	N	N	N	N	Select cultivars for special form; 'Skymaster' half as wide as tall, 'Fastigiata' narrow columnar, 'Westminster Globe' as wide as tall.
Quercus suber cork oak	50	40	E	S	N	H	S3	Y	N	N	N	N	Peculiar thick, corky bark; nice contrast between small textured leaves and massive bark; bark is subject to carving by vandals.
Quercus virginiana southern live oak	45	65	E	M	Y	H	N	Y	N	N	N	N	Leaves whitish below; very good in hot areas; cultivar 'Heritage' faster growth.
Quercus wizlizenii interior live oak	40	50	E	S	N	H	S3	Y	Y	N	N	N	Handsome tree for large park or lawn areas; avoid cultivating under canopy.
Rhus lancea African sumac	25	25	E	M	N	L	S1	Y	Y	Y	Y	N	Graceful, open habit; attractive rough bark; avoid female trees that produce messy fruit; may need pruning to attain single trunk.

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Sapium sebiferum Chinese tallow tree	40	30	D	F	N	NDA	S3	Y	Y	N	N	N	Exceptional fall color yellow to burgundy; dense canopy; needs pruning to make strong single trunk and to remove lower branches to make a street tree.
Schinus molle California pepper tree	40	40	E	F	N	L	N	Y	Y	N	N	N	Fern-like leaves and weeping habit; gnarled trunk; conspicuous small, hard red fruit attracts birds; messy due to frequent leaf and fruit drop; good thematic tree.
Syzygium paniculatum brush cherry	40	25	E	M	Y	M	N	Y	Y	N	N	N	Rich, glossy green leaves emerge bronze; showy, rose-purple fruit stains pavement; cultivar 'Monterey Bay' shows bronze new leaves for longer period; dense canopy.
Tabebuia impetiginosa pink trumpet tree	30	20	SD	F	N	M	S2	Y	Y	Y	Y	N	Spectacular pink flowers on briefly bare branches; good specimen in lawns.
Taxodium distichum bald cypress	50	30	D	M	N	M	N	Y	Y	N	N	N	Unusual deciduous conifer; reddish brown fall color; good used near ponds, lakes or as specimen.
Taxodium mucronatum Montezuma cypress	60	50	SD	M	N	M	N	Y	N	N	N	N	Graceful, fine-textured tree with weeping branches; good used near lakes and ponds, or as specimen.

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							Street Tree	P/C	LR/C	SR/C	P	VS/A	
Tipuana tipu tipu tree	45	45	D	F	N	M	S3	Y	Y	N	N	N	Showy yellow-orange flowers in June; wide-spreading flattened crown; tropical look; may need early pruning for form and structure.
Tristania conferta Brisbane box	35	30	E	M	Y	H	S2	Y	Y	Y	Y	Y	Smooth reddish brown bark peels; good all around tree; cultivar 'Variegata' has striking yellow leaf markings.
Ulmus parvifolia Chinese or evergreen elm	45	45	SD	F	Y	L	S2	Y	Y	N	N	N	Variable habit but usually makes handsome, graceful shade tree with spreading crown; bark patchy, attractive; cultivars 'Brea' (upright), 'Drake' (weeping), 'True Green' (more spreading) area evergreen; sometimes confused with *U. pumila* (Siberian elm) which is an inferior tree.
Zelkova serrata sawleaf zelkova	30	30	D	M	Y	L	S2	Y	Y	Y	Y	N	Good shade tree; moderate fall color yellow to purplish brown; resembles American elm; cultivars 'Halka' (faster growth), 'Green Vase', 'Village Green' offer uniform habit.

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8. Glossary of Terms

AFUE (Annual Fuel Utilization Efficiency): A measure of space heating equipment efficiency defined as the fraction of energy output/energy input.

Anthropogenic: Produced by humans.

Avoided Power Plant Emissions: Reduced emissions of CO_2 or other pollutants that result from reductions in building energy use due to the moderating effect of trees on climate. Reduced energy use for heating and cooling result in reduced demand for electrical energy, which translates into fewer emissions by power plants.

Biodiversity: The variety of life forms in a given area. Diversity can be categorized in terms of the number of species, the variety in the area's plant and animal communities, the genetic variability of the animals, or a combination of these elements.

Biogenic: Produced by living organisms.

BVOCs (Biogenic Volatile Organic Compounds): Hydrocarbon compounds from vegetation (e.g. isoprene, monoterpene) that exist in the ambient air and contribute to the formation of smog and/or may themselves be toxic.

Canopy: A layer or multiple layers of branches and foliage at the top or crown of a forest's trees.

Climate: The average weather (usually taken over a 30-year time period) for a particular region and time period. Climate is not the same as weather, but rather, it is the average pattern of weather for a particular region. Weather describes the short-term state of the atmosphere. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail storms, and other measures of the weather.

Climate Change (also referred to as “global climate change”): “Climate change” is sometimes used to refer to all forms of climatic inconsistency, but because the earth’s climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, “climate change” has been used synonymously with the term, “global warming”; scientists however, tend to use the term in the wider sense to also include natural changes in the climate.

Climate Effects: Impact on residential space heating and cooling (kg CO_2/tree/year) from trees located greater than approximately 15 m (50 ft) from a building due to associated reductions in wind speeds and summer air temperatures.

Crown: The branches and foliage at the top of a tree.

Cultivar (derived from "cultivated variety"): Denotes certain cultivated plants that are clearly distinguishable from others by any characteristic and that when reproduced (sexually or asexually) retain their distinguishing characters. In the United States, "variety" is often considered synonymous with "cultivar."

Deciduous: Trees or shrubs that lose their leaves every fall.

Diameter at Breast Height (dbh): Tree dbh is outside bark diameter at breast height. Breast height is defined as 4.5 feet (1.37m) above ground-line on the uphill side (where applicable) of the tree.

Emission Factor: A rate of CO_2, NO_2, SO_2 and PM_{10} output resulting from the consumption of electricity, natural gas or any other fuel source.

Evapotranspiration (ET): The total loss of water by evaporation from the soil surface and by transpiration from plants, from a given area, and during a specified period of time.

Evergreen: Trees or shrubs that are never entirely leafless. Evergreen trees may be broadleaved or coniferous (cone-bearing with needle-like leaves).

Fossil Fuel: A general term for combustible geologic deposits of carbon in reduced (organic) form and of biological origin, including coal, oil, natural gas, oil shales, and tar sands. A major concern is that they emit carbon dioxide into the atmosphere when burned, thus significantly contributing to the enhanced greenhouse effect.

Global Warming: An increase in the near surface temperature of the Earth. Global warming has occurred in the distant past as a result of natural influences, but the term is most often used to refer to the warming predicted to occur as a result of increased emissions of greenhouse gases.

Greenspace: Urban trees, forests, and associated vegetation in and around human settlements, ranging from small communities in rural settings to metropolitan regions.

Heat Sinks: Paving, buildings, and other built surfaces that store heat energy from the sun.

Hourly Pollutant Dry Deposition: Removal of gases from the atmosphere by direct transfer to and absorption of gases and particles by natural surfaces such as vegetation, soil, water or snow.

Interception: Amount of rainfall held on tree leaves and stem surfaces.

kBtu: A unit of work or energy, measured as 1,000 British thermal units. One kBtu is equivalent to 0.293 kWh.

kWh (Kilowatt-hour): A unit of work or energy, measured as one kilowatt (1,000 watts) of power expended for one hour. One kWh is equivalent to 3.412 kBtu.

Leaf Surface Area (LSA): Measurement of area of one side of leaf or leaves.

Leaf Area Index (LAI): Ratio of total leaf area to area under the drip line.

Mature Tree: A tree that has reached a desired size or age for its intended use. Size, age, or economic maturity varies depending on the species, location, growing conditions, and intended use.

Mature Tree Size: The approximate tree size 40 years after planting.

MBtu: A unit of work or energy, measured as 1,000,000 British thermal units. One MBtu is equivalent to 0.293 MWh.

Metric Tonne: A measure of weight (abbreviate "t") equal to 1,000,000 grams (1,000 kilograms) or 2,205 pounds.

MJ: A unit of work or energy, measured as 1,000,000 Joules.

Municipal Forester: A person who manages public street and/or park trees (municipal forestry programs) for the benefit of the community.

MWh (Megawatt-hour): A unit of work or energy, measured as one Megawatt (1,000,000 watts) of power expended for one hour. One MWh is equivalent to 3.412 Mbtu.

Nitrogen Oxides (Oxides of Nitrogen, NOx): A general term pertaining to compounds of nitric acid (NO), nitrogen dioxide (NO_2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes, and are major contributors to smog formation and acid deposition. NO_2 may result in numerous adverse health effects.

Ozone: A strong-smelling, pale blue, reactive toxic chemical gas consisting of three oxygen atoms. It is a product of the photochemical process involving the sun's energy. Ozone exists in the upper atmosphere ozone layer as well as at the earth's surface. Ozone at the earth's surface can cause numerous adverse health effects. It is a major component of smog.

Peak Cooling Demand: The single greatest amount of electricity required at any one time during the course of a year to meet space cooling requirements.

Peak Flow (or Peak Runoff): The maximum rate of runoff at a given point or from a given area, during a specific period.

Photosynthesis: The process in green plants of converting water and carbon dioxide into sugar with light energy; accompanied by the production of oxygen.

PM_{10} (Particulate Matter): Major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists. The size of the particles (10 microns or smaller, about 0.0004 inches or less) allows them to enter the air sacs (gas exchange region) deep in the lungs where they may get deposited and result in adverse health effects. PM_{10} also causes visibility reduction.

Riparian Habitats: Narrow strips of land bordering creeks, rivers, lakes, or other bodies of water.

SEER (Seasonal Energy Efficiency Ratio): Ratio of cooling output to power consumption; kBtuh output/kWh input as a fraction. It is the Btu of cooling output during its normal annual usage divided by the total electric energy input in watt-hours during the same period.

Sequestration: Annual net rate that a tree removes CO_2 from the atmosphere through the processes of photosynthesis and respiration (kg CO_2/tree/year).

Shade Coefficient: The percentage of light striking a tree crown that is transmitted through gaps in the crown.

Shade Effects: Impact on residential space heating and cooling (kg CO_2/tree/year) from trees located within approximately 15 m (50 ft) of a building (Near Trees) so as to directly shade the building.

Shade Tree Program: An organization that engages in activities such as tree planting and stewardship with the express intent of achieving energy savings and net atmospheric CO_2 reductions.

SO_2 (Sulfur Dioxide): A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use coal or oil high in sulfur content, can be major sources of SO_2. SO_2 and other sulfur oxides contribute to the problem of acid deposition.

Solar Friendly Trees: Trees that have characteristics that reduce blocking of winter sunlight. According to one numerical ranking system, these traits include open crowns during the winter heating season, early to drop leaves and late to leaf out, relatively small size, and a slow growth rate (Ames 1987).

Stem Flow: Amount of rainfall that travels down the tree trunk and onto the ground.

Throughfall: Amount of rainfall that falls directly to the surface below the tree crown or drips onto the surface from branches and leaves.

Transpiration: The loss of water vapor through the stomata of leaves.

Tree or Canopy Cover: The percent of a fixed area covered by the crown of an individual tree including small openings in the crown area.

Tree Litter: Fruit, leaves, twigs, and other debris shed by trees.

Tree-Related Emissions: Carbon dioxide releases that result from activities involved with growing, planting, and caring for program trees.

Tree Height: Total height of tree from base (at groundline) to tree top.

Tree Surface Saturation Storage (or Tree Surface Detention Storage): The volume of water required to fill the tree surface to its overflow level. This part of rainfall stored on the canopy surface does not contribute to surface runoff during and after a rainfall event.

Urban Heat Island: An "urban heat island" is an area in a city where summertime air temperatures are 3° to 8° F warmer than temperatures in the surrounding countryside. Urban areas are warmer for two reasons: ❶ they use dark construction materials which absorb solar energy, ❷ they have few trees, shrubs or other vegetation to provide shade and cool the air.

VOCs (Volatile Organic Compounds): Hydrocarbon compounds which exist in the ambient air. VOCs contribute to the formation of smog and/or may themselves be toxic. VOCs often have an odor. Some examples of VOCs are gasoline, alcohol, and the solvents used in paints.

Appendix A.

Estimated Benefits and Costs for a Large, Medium, and Small Tree for 40 Years after Planting

Data Tables

Information in this Appendix can be used to estimate benefits and costs associated with proposed or existing tree programs. The first three tables contain data for the large (Shamel ash, Table A1), medium (jacaranda, Table A2), and small (crape myrtle, Table A3) tree. Data are presented as annual values for each five-year interval. There are two columns for each five-year interval. In the first column, values describe resource units: the amount of air conditioning energy saved in kWh/yr/tree, air pollutant uptake in pounds/yr/tree, rainfall intercepted in gallons/yr/tree. These values reflect the assumption that 22.5% of all trees planted will die over 40 years. Energy and CO_2 benefits for residential yard trees (Private) are broken out by tree location to show how shading impacts vary among trees opposite west, south, and east facing building walls. In the row for Aesthetics and Other Benefits, the dollar value for Private trees replaces values in resource units since there is no resource unit for this type of benefit. For the remaining rows, the first column contains dollar values for Private trees.

The second column for each five-year interval contains dollar values obtained by multiplying resource units by local prices (kWh saved x $/kWh). In the Aesthetics and Other Benefits row and all subsequent rows, the dollar values are for a Public tree (street/park).

Costs for the Private and Public tree do not vary by location. Although Tree and Planting costs are assumed to occur initially at year 1, we divided this value by five years to derive an average annual cost for the first five-year period. All other costs, as well as benefits, are the estimated values for each year and not values averaged over five years.

Total Net Benefits are calculated by subtracting Total Costs from Total Benefits. Data are presented for a Private tree opposite west, south, and east facing walls, as well as the Public tree.

The last two columns in each table present 40-year average values. These numbers were calculated by dividing the total stream of annual costs and benefits (not shown in Tables A1-A3 due to lack of space) by 40 years.

Table A1. Data table for small tree (crape myrtle)

SMALL TREE Benefits	Year 5 Res units	Year 5 $	Year 10 Res units	Year 10 $	Year 15 Res units	Year 15 $	Year 20 Res units	Year 20 $	Year 25 Res units	Year 25 $	Year 30 Res units	Year 30 $	Year 35 Res units	Year 35 $	Year 40 Res units	Year 40 $	40 year average Res units	40 year average $
Cooling (kWh)																		
Private: West	11	1.30	48	5.63	74	8.68	90	10.61	102	12.07	109	12.85	115	13.55	118	13.93	83	$9.83
Private: South	5	0.54	20	2.37	32	3.80	41	4.80	47	5.61	52	6.11	55	6.55	58	6.82	39	$4.57
Prvate: East	6	0.68	25	2.98	40	4.70	50	5.88	58	6.80	62	7.36	66	7.84	69	8.13	47	$5.55
Public	0	0.04	2	0.28	5	0.65	9	1.05	12	1.44	15	1.76	17	2.03	19	2.23	10	$1.18
Heating (kBtu)																		
Private: West	-64	-0.38	-182	-1.08	-239	-1.43	-266	-1.59	-273	-1.62	-274	-1.63	-278	-1.65	-278	-1.66	-232	-$1.38
Private: South	-110	-0.66	-312	-1.86	-413	-2.46	-462	-2.75	-476	-2.84	-481	-2.87	-489	-2.91	-492	-2.93	-405	-$2.41
Prvate: East	-89	-0.53	-252	-1.50	-333	-1.98	-371	-2.21	-382	-2.28	-385	-2.29	-391	-2.33	-393	-2.34	-324	-$1.93
Public	0	0.00	3	0.02	7	0.04	12	0.07	16	0.10	20	0.12	23	0.13	25	0.15	13	$0.08
Net Energy (kBtu)																		
Private: West	45	0.91	294	4.54	496	7.26	632	9.03	749	10.45	814	11.22	870	11.90	901	12.28	600	$8.45
Private: South	-65	-0.12	-111	0.51	-92	1.34	-56	2.05	-2	2.77	36	3.25	65	3.63	85	3.89	-17	$2.16
Prvate: East	-32	0.15	0	1.48	65	2.72	126	3.66	194	4.53	238	5.07	273	5.51	296	5.79	145	$3.61
Public	4	0.05	27	0.30	62	0.69	101	1.12	138	1.53	169	1.88	194	2.16	213	2.37	113	$1.26
Net CO2 (lb)																		
Private: West	5	0.07	24	0.36	43	0.65	59	0.88	74	1.11	86	1.28	97	1.46	108	1.62	62	$0.93
Private: South	-8	-0.11	-20	-0.30	-20	-0.30	-15	-0.23	-6	-0.09	3	0.04	12	0.18	21	0.32	-4	-$0.06
Prvate: East	-4	-0.05	-7	-0.11	-2	-0.03	6	0.09	16	0.24	26	0.39	35	0.53	45	0.68	14	$0.22
Public	3	0.05	5	0.07	10	0.16	18	0.26	26	0.38	34	0.51	43	0.65	53	0.79	24	$0.36
Air Pollution (lb)																		
O3 uptake	0.052	0.65	0.089	1.11	0.134	1.68	0.189	2.36	0.255	3.19	0.333	4.16	0.425	5.31	0.531	6.63	0.25	$3.14
NO2 uptake+avoided	0.034	0.43	0.077	0.96	0.122	1.53	0.169	2.11	0.221	2.76	0.276	3.44	0.337	4.21	0.404	5.05	0.20	$2.56
SO2 uptake+avoided	0.006	0.03	0.026	0.12	0.041	0.19	0.052	0.24	0.061	0.28	0.067	0.31	0.072	0.33	0.076	0.35	0.05	$0.23
PM10 uptake+avoided	0.049	0.30	0.070	0.44	0.097	0.60	0.129	0.80	0.166	1.03	0.209	1.29	0.258	1.60	0.317	1.96	0.16	$1.00
VOC's avoided	-0.000	-0.00	0.000	0.00	0.001	0.01	0.001	0.01	0.001	0.01	0.002	0.01	0.002	0.01	0.002	0.02	0.00	$0.01
BVOC's released	-0.001	-0.00	-0.002	-0.00	-0.003	-0.01	-0.004	-0.01	-0.005	-0.01	-0.007	-0.01	-0.009	-0.02	-0.012	-0.02	-0.01	-$0.01
Avoided + net uptake	0.140	1.40	0.260	2.62	0.393	4.00	0.537	5.52	0.699	7.26	0.879	9.21	1.085	11.45	1.317	13.99	0.66	$6.93
Hydrology (gal)																		
Rainfall Interception	22	0.04	37	0.07	56	0.11	80	0.16	109	0.22	144	0.29	183	0.37	228	0.46	107	$0.21
Aesthetics and	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Other Benefits	$1.76	$2.07	$2.25	$2.65	$2.89	$3.41	$3.74	$4.40	$4.89	$5.76	$6.44	$7.59	$8.56	$10.08	$11.48	$13.53	$5.25	$6.19
Total Benefits	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Private: West	$4.19		$9.84		$14.91		$19.32		$23.92		$28.44		$33.73		$39.82		$21.77	
Private: South	$2.97		$5.16		$8.04		$11.24		$15.04		$19.22		$24.18		$30.13		$14.50	
Prvate: East	$3.30		$6.31		$9.70		$13.17		$17.14		$21.39		$26.41		$32.39		$16.23	
Public		$3.81		$5.71		$8.36		$11.47		$15.15		$19.48		$24.70		$31.13		$14.95
SMALL TREE	Year 5		Year 10		Year 15		Year 20		Year 25		Year 30		Year 35		Year 40		40 year average	
Costs ($/yr/tree)	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Tree & Planting	21.2	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$2.65	$2.38
Trimming	1.43	6.35	1.39	6.18	1.35	6.01	1.32	5.85	1.28	5.68	1.24	5.51	10.47	6.80	10.80	9.08	$3.53	$6.98
Remove & Dispose	0.38	0.38	0.26	0.26	0.33	0.33	0.41	0.41	0.50	0.50	0.58	0.58	0.68	0.68	0.77	0.77	$0.45	$0.45
Pest & Disease	0.12	0.12	0.16	0.16	0.20	0.20	0.24	0.24	0.28	0.28	0.32	0.32	0.36	0.36	0.42	0.42	$0.24	$0.24
Infrastructure	0.26	1.05	0.26	1.02	0.25	0.99	0.24	0.97	0.23	0.94	0.89	3.56	0.86	3.45	0.89	3.56	$0.45	$1.81
Irrigation	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.07	0.07	0.09	0.09	0.12	0.12	$0.05	$1.15
Clean-Up	0.12	0.80	0.16	1.20	0.20	1.51	0.24	1.82	0.28	2.12	0.32	2.43	0.36	2.73	0.43	3.22	$0.25	$1.85
Liability & Legal	0.11	0.45	0.11	0.44	0.11	0.43	0.10	0.42	0.10	0.41	0.39	1.54	0.37	1.49	0.39	1.54	$0.20	$0.78
Admin & Other	0.00	0.43	0.00	0.57	0.00	0.72	0.00	0.87	0.00	1.01	0.00	1.16	0.00	1.30	0.00	1.53	$0.00	$0.88
Total Costs	$23.63	$28.69	$2.35	$9.86	$2.47	$10.22	$2.59	$10.60	$2.72	$10.99	$3.81	$15.17	$13.20	$18.90	$13.82	$20.26	$7.82	$16.52
Total Net Benefits																		
Private: West	-$19		$7		$12		$17		$21		$25		$21		$26		$14	
Private: South	-$21		$3		$6		$9		$12		$15		$11		$16		$7	
Prvate: East	-$20		$4		$7		$11		$14		$18		$13		$19		$8	
Public		-$25		-$4		-$2		$1		$4		$4		$6		$11		-$2

Table A2. Data table for medium tree (jacaranda)

MEDIUM TREE Benefits	Year 5		Year 10		Year 15		Year 20		Year 25		Year 30		Year 35		Year 40		40 year average	
	Res units	$	Res units	$	Res units	$	Res units	$	Res units	$	Res units	$	Res units	$	Res units	$	Res units	$
Cooling (kWh)																		
Private: West	25	2.95	109	12.83	168	19.87	206	24.38	235	27.81	251	29.68	265	31.35	273	32.27	192	$22.64
Private: South	16	1.85	69	8.15	109	12.83	135	16.00	156	18.48	169	19.96	180	21.25	186	22.01	128	$15.07
Prvate: East	15	1.73	65	7.63	102	12.06	128	15.09	148	17.47	160	18.90	171	20.15	177	20.90	121	$14.24
Public	1	0.11	6	0.72	14	1.67	23	2.72	31	3.72	39	4.56	44	5.24	49	5.76	26	$3.06
Heating (kBtu)																		
Private: West	-110	-0.65	-308	-1.84	-403	-2.40	-445	-2.65	-452	-2.69	-451	-2.69	-454	-2.71	-453	-2.70	-385	-$2.29
Private: South	-322	-1.92	-913	-5.44	-1,210	-7.21	-1,355	-8.07	-1,397	-8.32	-1,412	-8.41	-1,436	-8.55	-1,444	-8.60	-1,186	-$7.07
Prvate: East	-195	-1.16	-550	-3.27	-725	-4.32	-808	-4.81	-829	-4.94	-835	-4.97	-846	-5.04	-849	-5.06	-705	-$4.20
Public	1	0.01	8	0.05	19	0.11	30	0.18	41	0.25	51	0.30	58	0.35	64	0.38	34	$0.20
Net Energy (kBtu)																		
Private: West	140	2.30	778	11.00	1,279	17.48	1,618	21.73	1,901	25.11	2,061	26.99	2,199	28.64	2,278	29.57	1,532	$20.35
Private: South	-165	-0.07	-224	2.70	-124	5.63	-1	7.93	168	10.16	278	11.55	362	12.69	419	13.41	89	$8.00
Prvate: East	-48	0.58	96	4.36	296	7.75	469	10.27	649	12.53	765	13.93	859	15.10	920	15.84	501	$10.04
Public	11	0.12	69	0.77	160	1.78	261	2.91	356	3.96	437	4.87	502	5.59	552	6.14	294	$3.27
Net CO2 (lb)																		
Private: West	56	0.84	173	2.59	269	4.04	326	4.90	352	5.28	342	5.13	310	4.65	261	3.91	261	$3.92
Private: South	19	0.28	54	0.80	104	1.56	137	2.05	150	2.25	134	2.01	97	1.45	45	0.67	92	$1.38
Prvate: East	35	0.52	98	1.47	162	2.43	202	3.03	217	3.26	202	3.04	166	2.50	115	1.73	150	$2.25
Public	47	0.71	116	1.74	176	2.65	213	3.19	221	3.32	203	3.05	165	2.48	113	1.70	157	$2.35
Air Pollution (lb)																		
O3 uptake	0.141	1.76	0.303	3.78	0.496	6.20	0.700	8.75	0.903	11.28	1.085	13.55	1.237	15.46	1.347	16.83	0.78	$9.70
NO2 uptake+avoided	0.113	1.42	0.288	3.60	0.480	6.00	0.667	8.34	0.848	10.60	1.002	12.52	1.130	14.12	1.222	15.26	0.72	$8.98
SO2 uptake+avoided	0.016	0.08	0.072	0.34	0.115	0.53	0.146	0.68	0.172	0.79	0.189	0.87	0.203	0.94	0.212	0.98	0.14	$0.65
PM10 uptake+avoided	0.157	0.97	0.287	1.78	0.431	2.67	0.574	3.56	0.708	4.39	0.825	5.11	0.917	5.68	0.982	6.09	0.61	$3.78
VOC's avoided	-0.000	-0.00	0.001	0.01	0.002	0.02	0.003	0.02	0.004	0.03	0.005	0.04	0.005	0.04	0.006	0.04	0.00	$0.02
BVOC's released	-0.002	-0.00	-0.004	-0.01	-0.008	-0.01	-0.011	-0.02	-0.016	-0.03	-0.020	-0.04	-0.025	-0.05	-0.028	-0.05	-0.01	-$0.03
Avoided + net uptake	0.427	4.23	0.947	9.50	1.517	15.40	2.080	21.33	2.619	27.06	3.085	32.06	3.468	36.19	3.740	39.15	2.24	$23.11
Hydrology (gal)																		
Rainfall Interception	281	0.72	563	1.47	952	2.46	1,427	3.64	1,998	4.99	2,673	6.51	3,460	8.19	4,047	9.45	1,925	$4.88
Aesthetics and	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Other Benefits	$13.70	$16.14	$18.46	$21.76	$23.27	$27.42	$27.26	$32.12	$29.44	$34.69	$28.90	$34.05	$25.06	$29.53	$17.99	$21.20	$23.01	$27.11
Total Benefits	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Private: West	$21.78		$43.02		$62.64		$78.84		$91.88		$99.58		$102.74		$100.07		$75.07	
Private: South	$18.86		$32.94		$48.32		$62.20		$73.90		$81.03		$83.59		$80.67		$60.19	
Prvate: East	$19.74		$35.26		$51.31		$65.52		$77.27		$84.43		$87.05		$84.15		$63.09	
Public		$21.92		$35.23		$49.71		$63.18		$74.02		$80.54		$81.99		$77.64		$60.53
MEDIUM TREE	Year 5		Year 10		Year 15		Year 20		Year 25		Year 30		Year 35		Year 40		40 year average	
Costs ($/yr/tree)	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Tree & Planting	21.2	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$2.65	$2.38
Trimming	12.44	10.45	11.87	10.18	11.78	9.90	11.45	9.63	11.13	9.35	10.80	9.08	10.47	8.80	10.14	8.53	$10.48	$9.56
Remove & Dispose	0.89	0.89	0.71	0.72	0.97	0.97	1.18	1.18	1.35	1.35	1.50	1.50	1.60	1.60	1.68	1.68	$1.13	$1.13
Pest & Disease	0.28	0.28	0.43	0.44	0.57	0.57	0.68	0.68	0.76	0.76	0.81	0.81	0.84	0.84	0.86	0.86	$0.62	$0.62
Infrastructure	0.26	1.05	1.00	3.99	0.97	3.88	1.10	4.42	1.07	4.29	1.04	4.16	1.01	4.04	0.98	3.91	$0.62	$3.65
Irrigation	0.06	0.06	0.11	0.11	0.18	0.18	0.26	0.26	0.35	0.35	0.43	0.43	0.49	0.49	0.54	0.54	$0.91	$1.38
Clean-Up	0.28	2.13	0.45	3.37	0.59	4.39	0.69	5.20	0.77	5.80	0.83	6.22	0.86	6.47	0.87	6.56	$0.28	$4.74
Liability & Legal	0.11	0.45	0.43	1.73	0.42	1.68	0.48	1.91	0.46	1.86	0.45	1.80	0.44	1.75	0.42	1.69	$0.63	$1.58
Admin & Other	0.00	1.02	0.00	1.61	0.00	2.09	0.00	2.47	0.00	2.76	0.00	2.96	0.00	3.08	0.00	3.12	$0.40	$2.26
Total Costs	$35.52	$35.33	$15.00	$22.15	$15.48	$23.67	$15.85	$25.74	$15.89	$26.52	$15.85	$26.96	$15.72	$27.08	$15.49	$26.89	$17.71	$27.30
Total Net Benefits																		
Private: West	-$14		$28		$47		$63		$76		$84		$87		$85		$57	
Private: South	-$17		$18		$33		$46		$58		$65		$68		$65		$42	
Prvate: East	-$16		$20		$36		$50		$61		$69		$71		$69		$45	
Public		-$13		$13		$26		$37		$47		$54		$55		$51		$33

Table A3. Data table for large tree (Shamel ash)

LARGE TREE Benefits/tree	Year 5 Res units	Year 5 $	Year 10 Res units	Year 10 $	Year 15 Res units	Year 15 $	Year 20 Res units	Year 20 $	Year 25 Res units	Year 25 $	Year 30 Res units	Year 30 $	Year 35 Res units	Year 35 $	Year 40 Res units	Year 40 $	40 year average Res units	40 year average $
Cooling (kWh)																		
Private: West	26	3.01	113	13.36	181	21.33	228	26.95	266	31.45	290	34.27	311	36.69	323	38.19	217	$25.66
Private: South	21	2.50	95	11.17	153	18.05	195	23.04	229	27.10	252	29.74	271	31.98	283	33.41	187	$22.12
Prvate: East	18	2.10	80	9.47	131	15.50	169	20.01	201	23.73	222	26.22	240	28.32	251	29.69	164	$19.38
Public	2	0.24	13	1.54	30	3.58	49	5.83	67	7.95	83	9.77	95	11.23	104	12.33	56	$6.56
Heating (kBtu)																		
Private: West	-85	-0.50	-231	-1.38	-291	-1.74	-309	-1.84	-299	-1.78	-286	-1.70	-278	-1.66	-269	-1.60	-256	-$1.53
Private: South	-326	-1.94	-918	-5.47	-1,207	-7.19	-1,341	-7.99	-1,371	-8.17	-1,376	-8.20	-1,392	-8.29	-1,394	-8.30	-1,166	-$6.94
Prvate: East	-196	-1.17	-549	-3.27	-715	-4.26	-786	-4.68	-795	-4.74	-790	-4.71	-793	-4.73	-790	-4.70	-677	-$4.03
Public	3	0.02	17	0.10	40	0.24	65	0.39	89	0.53	109	0.65	125	0.75	137	0.82	73	$0.44
Net Energy (kBtu)																		
Private: West	170	2.51	899	11.98	1,514	19.60	1,973	25.11	2,363	29.67	2,615	32.57	2,827	35.03	2,963	36.59	1,916	$24.13
Private: South	-114	0.56	27	5.70	321	10.86	609	15.06	923	18.94	1,141	21.54	1,314	23.68	1,434	25.10	707	$15.18
Prvate: East	-18	0.93	253	6.20	597	11.24	908	15.33	1,213	18.99	1,429	21.51	1,604	23.59	1,724	24.99	964	$15.35
Public	23	0.26	147	1.64	343	3.82	559	6.22	762	8.48	936	10.42	1,076	11.97	1,181	13.15	628	$7.00
Net CO2 (lb)																		
Private: West	25	0.37	177	2.66	321	4.82	422	6.33	492	7.38	534	8.00	558	8.37	569	8.53	387	$5.81
Private: South	-12	-0.17	68	1.01	172	2.59	252	3.79	313	4.70	351	5.27	371	5.56	380	5.69	237	$3.55
Prvate: East	3	0.04	103	1.55	217	3.26	302	4.53	363	5.44	400	6.01	421	6.31	430	6.45	280	$4.20
Public	14	0.21	114	1.71	220	3.31	299	4.49	352	5.28	386	5.79	404	6.06	412	6.17	275	$4.13
Air Pollution (lb)																		
O3 uptake	0.150	1.87	0.521	6.51	0.903	11.28	1.259	15.73	1.587	19.83	1.869	23.59	2.169	27.10	2.425	30.29	1.36	$17.02
NO2 uptake+avoided	0.109	1.36	0.419	5.24	0.732	9.15	1.016	12.69	1.275	15.92	1.500	18.74	1.706	21.31	1.886	23.56	1.08	$13.50
SO2 uptake+avoided	0.020	0.09	0.087	0.40	0.144	0.67	0.189	0.87	0.226	1.04	0.252	1.17	0.275	1.27	0.291	1.35	0.19	$0.86
PM10 uptake+avoided	0.144	0.89	0.422	2.62	0.666	4.13	0.875	5.42	1.053	6.53	1.214	7.52	1.356	8.41	1.490	9.24	0.90	$5.59
VOC's avoided	0.000	0.00	0.002	0.00	0.004	0.01	0.005	0.01	0.007	0.01	0.008	0.02	0.009	0.02	0.010	0.02	0.01	$0.01
BVOC's released	-0.004	-0.01	-0.010	-0.02	-0.017	-0.03	-0.024	-0.05	-0.032	-0.06	-0.041	-0.06	-0.050	-0.10	-0.059	-0.11	-0.03	-$0.06
Avoided + net uptake	0.419	4.21	1.441	14.75	2.432	25.20	3.319	34.68	4.116	43.28	4.822	50.96	5.465	58.01	6.042	64.34	3.51	$36.93
Hydrology (gal)																		
Rainfall Interception	356	0.87	723	1.95	1,097	3.05	1,641	4.45	2,237	5.92	3,021	7.73	3,959	9.81	4,872	11.85	2,238	$5.70
Aesthetics and	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Other Benefits	$28.12	$33.14	$31.18	$36.74	$33.43	$39.39	$35.66	$42.02	$37.93	$44.69	$40.24	$47.42	$42.61	$50.21	$45.03	$53.06	$36.77	$43.34
Total Benefits	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public
Private: West	$36.08		$62.52		$86.10		$106.23		$124.18		$139.51		$153.84		$166.33		$109.35	
Private: South	$33.58		$54.60		$75.12		$93.63		$110.77		$125.74		$139.68		$152.01		$98.14	
Prvate: East	$34.17		$55.63		$76.17		$94.64		$111.56		$126.45		$140.34		$152.65		$98.95	
Public		$38.68		$56.79		$74.76		$91.86		$107.66		$122.33		$136.07		$148.57		$97.09

LARGE TREE Costs ($/yr/tree)	Year 5 Private	Year 5 Public	Year 10 Private	Year 10 Public	Year 15 Private	Year 15 Public	Year 20 Private	Year 20 Public	Year 25 Private	Year 25 Public	Year 30 Private	Year 30 Public	Year 35 Private	Year 35 Public	Year 40 Private	Year 40 Public	40 year average Private	40 year average Public
Tree & Planting	21.20	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	$2.65	$2.38
Trimming	12.44	10.45	12.11	10.18	11.78	9.90	21.75	9.11	21.13	8.85	20.51	8.59	19.89	8.33	20.51	8.59	$16.11	$9.17
Remove & Dispose	0.90	0.90	0.92	0.92	1.32	1.32	1.66	1.66	1.96	1.96	2.22	2.22	2.47	2.47	2.69	2.69	$1.61	$1.61
Pest & Disease	0.28	0.28	0.56	0.56	0.78	0.78	0.95	0.95	1.09	1.09	1.21	1.21	1.30	1.30	1.46	1.46	$0.88	$0.88
Infrastructure	0.26	1.05	1.00	3.99	1.14	4.54	1.41	5.66	1.37	5.50	1.02	4.09	0.99	3.97	1.02	4.09	$1.02	$4.09
Irrigation	0.08	0.08	0.18	0.18	0.29	0.29	0.39	0.39	0.50	0.50	0.61	0.61	0.71	0.71	0.87	0.87	$0.41	$1.51
Clean-Up	0.29	2.17	0.57	4.31	0.80	5.98	0.97	7.31	1.12	8.38	1.23	9.26	1.33	9.96	1.50	11.21	$0.90	$6.73
Liability & Legal	0.11	0.45	0.43	1.73	0.49	1.97	0.61	2.45	0.60	2.38	0.44	1.77	0.43	1.72	0.44	1.77	$0.47	$1.87
Admin & Other	0.00	1.03	0.00	2.05	0.00	2.85	0.00	3.48	0.00	3.99	0.00	4.41	0.00	4.75	0.00	5.34	$0.00	$3.21
Total Costs	$35.56	$35.42	$15.78	$23.92	$16.59	$27.62	$27.76	$31.02	$27.77	$32.66	$27.25	$32.17	$27.12	$33.22	$28.50	$38.05	$24.04	$31.45
Total Net Benefits																		
Private: West	$1		$47		$70		$78		$96		$112		$127		$138		$85	
Private: South	-$2		$39		$59		$66		$83		$98		$113		$124		$74	
Prvate: East	-$1		$40		$60		$67		$84		$99		$113		$124		$75	
Public		$3		$33		$47		$61		$75		$90		$103		$113		$86

Appendix B.

Funding Opportunities for Urban Forestry in California

Compiled by
California ReLeaf
926 J St., Suite 201
Sacramento, CA 95814
☎ (916) 557-1673
fax (916) 557-1675
email: martha.ozonoff@tpl.org
www.tpl.org, “Local Programs”

SECTION 1. GRANT PROGRAMS DESIGNATED IN WHOLE OR IN PART FOR URBAN FORESTRY PROJECTS

American Forests/Global ReLeaf Forest Cost-Share Grants

Funds available: Not specified

Application deadline: January and July

Notification: March and September

Grant period: One year (multi-year projects are accepted)

Min/max award: No minimum/maximum
(previous grants range from $300 - $50,000)

Eligible applicants: Groups interested in tree-planting and forestry or riparian restoration programs

Description: Tree planting or environmental improvement projects that involve an organization and other public or private sector partners who are willing to partner with American Forests. The projects can be on public land or certain public-assisted private lands meeting special criteria. The planting area must be 20 acres or more and have been damaged by wildfire, hurricane, tornado, insects, disease, or misguided treatment by humans. Only projects where funding from regular programs or sources is not available qualify.

Contacts: American Forests (Attn: Heather Campbell)
P.O. Box 2000
Washington, DC 20013
☎(202) 955-4500 x204
www.amfor.org

Note: You can apply on line.

California ReLeaf Capacity-Building Grant Program

Funds available: Varies

Application deadline: Mid-October

Notification: Early-December

Grant period: Approximately one year from notification

Min/max award: Minimum $1,000; maximum $10,000

Eligible applicants: Citizen groups and city-affiliated volunteer entities (e.g., tree advisory boards, beautification commissions, etc.)

Description: This program assist new and emerging grassroots groups with tree-related projects and to provide capacity-building support for established urban forestry organizations. Project categories are: (1) Education and Public Awareness; (2) Tree-Care Programs; and (3) Volunteer Development and Support. (Tree planting is not the emphasis of this program and tree-stock purchase is limited to 20% of the grant request.)

Contact: California ReLeaf/The Trust for Public Land
P.O. Box 10856
Costa Mesa, CA 92627
☎(949) 642-0127

California ReLeaf Tree-Planting Grant Program

Funds available: Varies

Application deadline: Mid-September

Notification: Mid-October

Grant period: Approximately one year from notification.

Min/max award: Minimum $500; maximum $5,000

Eligible applicants: Citizen groups and city-affiliated volunteer entities (e.g., tree advisory boards, beautification commissions, etc.)

Description: Projects that plant large-crowning, environmentally tolerant trees on public property to provide shade and other benefits.

Contact: California ReLeaf/The Trust for Public Land
P.O. Box 10856
Costa Mesa, CA 92627
☎(949) 642-0127

Environmental Enhancement and Mitigation Program

Funds available: Varies

Application deadline: Mid-November

Notification: Not specified

Grant period: 12 months preferable, but up to 24 months possible

Min/max award: Maximum $250,000 (tentative)

Eligible applicants: Local, state, and federal governmental agencies, and incorporated nonprofit organizations

Description: Three categories of eligible projects, among them "highway landscaping and urban forestry." Projects must be designed to provide supplemental mitigation (over and above that required as part of the transportation project itself) for the environmental impacts of modified or new public transportation facilities. Projects need to be sited within the impacted area but do not have to be within or immediately adjacent to the facility.

Contact: EEMP Coordinator
State of California Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814
☎(916) 653-5656

International Society of Arboriculture Grant Program

Funds available: Not specified

Application deadline: May and November

Grant period: One to two years

Notification: Not specified

Min/max award: Maximums $5,000 and $20,000

Eligible applicants: Individuals privately or publicly employed in various fields, including arboriculture, urban forestry, horticulture, plant pathology, entomology, and soil science.

Description: Research projects that have the potential of benefiting the everyday work of arborists. Grants are not expected to cover all research costs, but rather provide seed money for projects that fall within one or more of the following research priority areas: ecological benefits of the urban forest; economic benefits of the urban forests; innovative tree-care techniques and practices; urban tree genetics; impact of the urban forest on energy consumption; and basic tree biology.

Contact: ISA Research Trust Grant Program
P.O. Box 3129
Champaign, IL 61826
☎(217) 355-9411
www.isa-arbor.com

National Tree Trust Growing Together Program

Funds available: Not specified

Application deadline: August

Notification: Within one month after receipt of application.

Grant period: September to June

Min/max award: Grant awards include grow containers, an activity guide and coloring book, guidelines, and a small per-student monetary subsidy for soil and seed.

Eligible applicants: Schools, incorporated nonprofit organizations, cities, counties, and townships

Description: A hands-on educational program that enables teachers and pre-kindergarten through 6th-grade school children to grow trees from seed in the classroom

Contact: National Tree Trust
1120 G St. NW, Suite 770
Washington, DC 20005
☎(800) 846-8733
www.nationaltreetrust.org

National Tree Trust Partnership Enhancement Monetary Grant Program

Funds available:	Not specified
Application deadline:	October
Notification:	December
Grant period:	Not specified
Min/max award:	Varies by project category
Eligible applicants:	Volunteer-based, incorporated nonprofit organizations that have been in existence for at least two years. Applicants must demonstrate that tree planting, maintenance, and education are components of the organization.

Description: Projects are selected in four categories: Tree Planting/ Maintenance; Education/Training; Overhead/Administration; and National/ Regional Program/Project.

Contact: National Tree Trust
1120 G St. NW, Suite 770
Washington, DC 20005
☎(800) 846-8733;
www.nationaltreetrust.org/PEPfacts.htm

National Urban and Community Forestry Advisory Council Challenge Cost-Share Grant Program

Funds available:	Varies, up to $1,000,000
Application deadline:	December (pre-proposal); April (full proposal)
Notification:	Mid-June
Grant period:	Two years
Min/max award:	No minimum or maximum
Eligible applicants:	Any non-federal organization can apply (individuals can not apply)

Description: Project categories vary from year to year. Recent categories have included: (1) Research and technology development to expand the understanding of the relationship between urban and community forestry resources and people; (2) Education, communication, and outreach to increase the knowledge of the public and/or targeted audiences about urban and community forests; and (3) Creative and innovative projects that support urban and community forestry ideas or messages, or projects that are national in scope, creative, innovative, and timely.

Contact: Suzanne M. del Villar
Executive Assistant to NUCFAC
20628 Diane Dr.
Sonora, CA 95370
☎(209) 536-9201

email delvr@lodelink.com
www.treelink.org/nucfac

Proposition 12 Grant Program

Funds available: Approximately $2,000,000

Application deadline: Spring and Summer

Min/max award: Maximum $50,000

Eligible applicants: Cities, counties, districts, and incorporated nonprofit organizations

Description: Projects that promote urban forestry through the planting and care of trees on public land. Funding can be used for general tree planting expenses and/or costs related to early tree care.

Contact: California Department of Forestry and Fire Protection
2524 Mulberry St.
Riverside, CA 92502
☎(909) 782-4140 x6125
email eric_older@fire.ca.gov

Grant application: www.ufei.calpoly.edu

SECTION 2. ENVIRONMENTAL EDUCATION GRANT PROGRAMS THAT OFFER POSSIBILITIES FOR URBAN FORESTRY PROJECTS

California Native Plant Society Educational Grants Program

Funds available: Not specified

Application deadline: September

Notification: December

Grant period: Generally one year

Min/max award: Not specified (average award is $700)

Eligible applicants: Varies by program (see description above)

Description: Four programs: (1) The Helen Sharsmith Grant for graduate and undergraduate students, and non-students, involved in research on California's native flora; (2) The Doc Burr Grant for graduate students conducting research that promotes conservation of California's native flora and vegetation; (3) The Hardman Native Plant Research Award for academic and applied botanical research on rare native plants and research leading to elimination of invasive exotic plants; (4) The G. Ledyard Stebbins Award for graduate students doing research in evolutionary botany.

Contact: Education Grants Committee
California Native Plant Society
1722 J St., Suite 17
Sacramento, CA 95814
☎(916) 447-2677

Captain Planet Foundation Grants

Funds available: Not specified

Application deadline: Applications may be submitted at any time during the year, but are only reviewed the last day of March, June, September, and December.

Notification: Within three months after the review date.

Grant period: Not specified

Min/max award: Minimum $250; maximum $2,500

Eligible applicants: All applicant organizations or sponsoring agencies must have 501 tax-exempt status.

Description: Supports hands-on environmental projects for children and young adults (elementary through high school), with a focus on innovative programs that empower youth to work individually and collectively to solve environmental problems in their neighborhoods and communities.

Contact: Captain Planet Foundation
One CNN Center
Box 105366
Atlanta, GA 30348
☎(404) 827-4130
www.turner.com/cpf

Constitutional Rights Foundation Robinson Mini-Grant Program

Funds available: Not specified

Application deadline: October

Notification: November

Grant period: Projects must be completed by June

Min/max award: No minimum; maximum $600.
Grants generally range from $300 to $600.

Eligible applicants: Elementary, middle, and high schools (grades K-12), and community-based organizations working with K-12 students.

Description: Approximately 30 mini-grants are awarded annually for K-12 service-learning projects designed to address community issues. Special consideration is given to projects that involve more than one community agency or group; demonstrate diversity among student participants (i.e., age, ability, gender, ethnicity); and provide matching funds or in-kind donations from community organizations.

Contact: Robinson Mini-Grant Program
c/o Constitutional Rights Foundation
601 South Kingsley Dr.
Los Angeles, CA 90005
☎(213) 316-2109 x109
www.crf-usa.org/network/robinap200.html

Environmental Protection Agency Environmental Education Grants

Funds available: Varies each year

Application deadline: Mid-November

Notification: Late spring

Grant period: One year

Min/max award: There are two funding categories at the regional level – grant requests up to $5,000 and grant requests between $5,000 and $25,000 – and one larger regional grant of up to $250,000 awarded by national headquarters.

Eligible applicants: Local, state, and tribal educational agencies; state environmental agencies, colleges and universities; nonprofit organizations; and non-commercial educational broadcasting entities.

Description: Projects that design, demonstrate, or disseminate environmental education practices, methods, or techniques. The goal of environmental education, according to the guidelines, is “to increase public awareness and knowledge about environmental issues, and to provide the public with the skills needed to make informed decisions and to take responsible actions.” The guidelines also state that environmental education “does not advocate a particular viewpoint or course of action.”

Contact: U.S. EPA-Environmental Education Grants
Office of Public Affairs
75 Hawthorne St.
San Francisco, CA 94105
☎(415) 744-1161

Project Learning Tree GreenWorks! Grants

Funds available: Amount varies from year to year.

Application deadline: September

Notification: December

Grant period: Not specified

Min/max award: A range of $200 to $1,000 per project is available. Applicants are encouraged to submit budgets showing the total cost of their project (not just the portion of funds applied for) in case extra funds are available for granting.

Eligible applicants: Formal and informal educators who have been trained through Project Learning Tree. Individuals applying must have a fiscal sponsor – a nonprofit organization, public agency, or other entity that can receive grant funds – and either establish or have in place a partnership to implement the project (e.g., school/PTA, school/local business, Girl Scout troop/local business, etc.)

Description: The GreenWorks! program provides Project Learning Tree educators with small grants to develop and implement environmental action projects with their students, such as graffiti paint overs, tree plantings, stream clean ups, and recycling projects.

Contact: Caroline Alston
GreenWorks! Grants
1111 19th St. NW, #780
Washington, DC 20036
☎(202) 463-2472
email caroline_alston@plt.org

SECTION 3. OTHER GRANT AND SUPPORT PROGRAMS THAT OFFER POSSIBILITIES FOR URBAN FORESTRY PROJECTS

California Horticultural Society Grant Program

Funds available: Amount varies each year (generally between $2,000 to $4,000)

Application deadline: Mid-June

Notification: Fall

Grant period: Not specified

Min/max award: Not specified (recent grants ranged from $500 - $1,000)

Eligible applicants: No restrictions (previous grant recipients include botanic gardens and individual researcher, students and faculty)

Description: Innovative educational, research, and plant-introduction projects that advance the knowledge and appreciation of ornamental horticulture in California.

Contact: Barbara Hopper
CHS Grants Committee
P.O. Box 783
Kenwood, CA 95452-0783
☎(800) 624-6633

California State Parks Foundation
Earth Day Restoration and Cleanup Grant Program

Funds available: Varies

Application deadline: Mid-November

Notification: December

Grant period: Projects must take place on Earth Day

Min/max award: No minimum; maximum is $2,000

Eligible applicants: State parks, schools, and environmental nonprofit organizations

Description: Projects taking place on Earth Day that enhance public spaces and that can be worked on collectively by community volunteers. Potential projects include tree plantings, trail or beach cleanups, development of recycling or composting programs, and habitat restoration.

Contact: California State Parks Foundation
Earth Day Grant Program
P.O. Box 548
Kentfield, CA 94914
☎(415) 258-9975

Department of Water Resources Urban Streams Restoration Program

Funds available: Varies

Application deadline: Spring and Fall

Min/max award: Minimum $2,000; maximum $200,000

Eligible applicants: Local public agencies, citizens' groups, and nonprofit organizations

Description: Projects that reduce flooding and erosion on urban streams and restore the natural value of streams. Previous projects have included creek cleanups, revegetation efforts, bioengineering bank stabilization projects, and acquisition of land critical for flood management. Projects may be as simple as a neighborhood stream cleanup day, or as complex as complete restoration of a stream to its original, natural state.

Contact: Department of Water Resources
Division of Planning and Local Assistance
Urban Streams Restoration Program
1020 Ninth St., Third Floor
Sacramento, CA 95814
☎(916) 327-1664 or (916) 327-1617
www.dpla.water.ca.gov/environment/habitat/stream/usrpbrochure.html

Earth Island Institute Brower Legacy Leaders Program

Funds available: Not specified

Application deadline: Spring and Summer

Notification: Not specified

Internship period: Three months

Min/max award: Up to $1,000 per month

Eligible applicants: Applicants must commit a minimum of 20 hours per week to the training and work program, have a high school diploma or GED, and have an interest in environmental issues.

Description: Paid internships designed to enhance environmental career development by giving interns a chance to earn money while gaining experience in the field. Interns may be trained in a variety of areas including research methods, campaign development, and coalition strategies.

Contact: Internship Coordinator, Earth Island Institute
300 Broadway, Suite 28
San Francisco, CA 94133
☎(415) 788-3666

Note: This program has two annual cycles.

Environmental Support Center Environmental Loan Fund

Funds available: Not specified

Application deadline: Quarterly

Notification: Not specified

Loan period: Repayment schedule is designed to meet individual circumstances

Min/max loan: Minimum $10,000; maximum $50,000

Eligible applicants: Local, regional, or state-level nonprofit organizations that devote a portion of their resources to environmental issues; have 501(c)3 status; have been in existence for at least three years; and have at least one paid full-time staff person or the equivalent (two part-time staff).

Description: The loan fund was established to provide low-interest loans to help grassroots environmental organizations diversify and increase their funding sources. Projects funded include membership development, workplace giving, start-up money needed to sell mission-related products or services, donor development, special events, and other long-term, income producing projects.

Contact: The Environmental Support Center
4420 Connecticut Ave., Suite 2
Washington, DC 20008-2301
☎(202) 966-9834
email loanfund@envsc.org
www.envsc.org

Environmental Support Center Training and Organizational Assistance Program

Funds available: Not specified (amount varies)

Application deadline: Applications accepted monthly

Notification: Within one month

Grant period: One year or less

Min/max award: Maximum $2,000 for Individual Assistance; maximum $3,500 for Coalition Building; none specified for Group Training, although typically no greater than $350 per group involved.

Eligible applicants: Local, regional, or state-level nonprofit organizations (incorporated or unincorporated) that devote a portion of their resources to environmental issues.

Description: Three categories of assistance: Individual Assistance (one organization); Group Training (a number of organizations); Coalition Building (a number of organizations). In each, the project focus must be on improving capabilities and effectiveness in areas such as planning, organizing, board development, computer skills, fundraising, communications, financial management, leadership development, and collaborative strategies. Funds can be used to subsidize the costs of consultants, trainers, workshops, and networking activities.

Contact: Environmental Support Center
4420 Connecticut Ave. NW, Suite 2
Washington, DC 20008-2301
☎(202) 966-9834
www.envsc.org

The Home Depot Environmental Grants Program

Funds available: Not specified

Application deadline: Continuous

Notification: Not specified

Grant period: Not specified

Min/max award: Not specified

Eligible applicants: Nonprofit organizations with 501(c)3 status

Description: Projects that involve "Team Depot" volunteers in the environmental focus areas of Forestry/Ecology; Clean-up/Recycling; Consumer Education; Sustainable/Green Building Practices; and Lead Poisoning Prevention. The Team Depot program provides employee volunteers for conservation programs, beautification efforts, and clean-up initiatives in local communities.

Contact: Manager, Environmental Programs
The Home Depot
2455 Paces Ferry Rd.
Atlanta, GA 30339-4024
☎(770) 433-8211
www.homedepot.com

National Fish and Wildlife Foundation Challenge Grants

Funds available: Not specified

Application deadline: Pre-proposals accepted continuously;
full proposals due July and December

Notification: Approximately three months from full-proposal deadline

Grant period: Not specified

Min/max award: None specified, but grants have ranged from $25,000 to $75,000 with some smaller grants and some over $150,000.

Eligible applicants: Local, state, and federal governmental agencies; educational institutions; and nonprofit organizations

Description: Conservation projects that address one or more of the following priorities with an emphasis on fish and wildlife: habitat protection and restoration on private lands; sustainable communities through conservation; conservation education.

Contact: National Fish and Wildlife Foundation
Southwest Region Office
28 2nd Street, 6th Floor
San Francisco, CA 94105
☎(415) 778-0999
www@nfwf.org

Target All-Around Scholarships for Students

Funds available: Varies

Application deadline: November

Notification: After February 15th

Min/max award: Five $10,000 and over 1,900 $1,000 scholarships will be awarded (two per Target store).

Eligible applicants: High school seniors, high school graduates, and current college students (age 24 and under). Applicants must enroll in a full-time undergraduate course of study at an accredited two-or four-year college, university, or vocational-technical school in the U.S.

Description: Scholarships to support well-rounded high school seniors and college students who are committed to community service, education, and family involvement. Awards are offered for institution costs and fees for full-time, post-secondary, undergraduate educational programs.

Contact: Program Manager, Target All-Around Scholarships
☎(800) 537-4180
www.target.com/schools/scholarships.html

SECTION 4. GRANTS LISTED IN THE JANUARY – JUNE 2000 EDITION OF URBAN FORESTRY FUNDING OPPORTUNITIES FOR CALIFORNIA (INCLUDED HERE FOR REFERENCE)

Environmental Quality Incentives Program
☎(530) 792-5646; www.ca.nrcs.usda.gov/eqip/index.html

Conservation Technology Support Program
email ctsp@ctsp.org; www.ctsp.org

Toyota Tapestry Grants for Teachers
☎(800) 807-9852; www.nsta.org/programs/toyota.htm

Great Valley Center LEGACI Grant Program
☎(209) 522-5103; www.greatvalley.org

Kodak American Greenways Awards Program
☎(703) 525-6300; www.conservationfund.org

Horticultural Research Institute Grant Program
☎(202) 789-5980 x3014; www.anla/research

ISA Hyland R. Johns Grant Program
☎(217) 355-9411; www.isa-arbor.com

Do Something Brick Award for Community Leadership
☎(212) 523-1175; email brick@dosomething.org

National Tree Trust Tree-Planting Grant Programs (Part 1)
☎(800) 846-8733; www.nationaltreetrust.org

Appendix C.
Local Government Programs and Ordinances

Requiring Shade Trees in New Developments:
Tree Preservation Ordinance, City of Redding

Requiring Shade Trees in Parking Lots:
Parking Lot Shading Guidelines and Master Parking Lot Tree List, City of Davis

Adopting a Tree Preservation Ordinance:
Trees and Construction: A Guide to Preservation, City of Redding

Adopting a Landscaping Ordinance to Encourage Energy Efficiency and Resource Conservation:
Sustainability in Landscaping Ordinance, City of Irvine

Using Tree Planting to Strengthen Communities and Increase Resident Involvement:
"Neighborhood Tree Project," City of Long Beach
"Cool Schools," LADWP and Los Angeles Unified School District

Municipal Utility Shade Tree Programs:
TreePower Brochure, Anaheim Public Utilities

The Inland Empire Isn't the Only Place Where California's Trees Are Growing!

The Local Government Commission and the Western Center for Urban Forest Research and Education, USDA Forest Service, Pacific Southwest Research Station, have also teamed up to produce versions of the *Tree Guidelines* for the San Joaquin Valley and Coastal Southern California.

And look for a Northern California guidebook in the future!

Who We Are: The Local Government Commission

The Local Government Commission is a non-profit, non-partisan membership organization of forward-thinking leaders that includes mayors, city councilmembers, and county supervisors, along with associate members drawn from local government staff and community leaders.

With almost 1,000 members, the LGC provides a diverse forum for exchanging ideas and inspiring local leaders to action. We provide practical, tested ideas and programs, technical assistance, networking, workshops, policy development, publications, and peer support that help foster a sustainable environment, strong economy, and social equity, as well as meaningful civic involvement.

The LGC serves cities and counties and is directed toward promoting cooperative efforts among all levels of government through such programs as land use planning for resource-efficient communities, energy efficiency and renewable energy, and waste and pollution prevention.

For more information about the LGC and its other publications:

☎(916) 448-1198 www.lgc.org

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