United States Department of Agriculture
Forest Service
Pacific Southwest Research Station

Center for Urban Forest Research
c/o Dept. of Environmental Horticulture
University of California
Davis, CA 95616-8587
(530) 752-5897, (530) 752-6634 fax
e-mail: egmcpherson@ucdavis.edu

BENEFIT-COST ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PROGRAM

E. Gregory McPherson, Ph.D.
James R. Simpson, Ph.D.
USDA Forest Service
Center for Urban Forest Research
c/o Department of Environmental Horticulture
Davis, CA 95616
(530) 752-5897
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Purpose

The purpose of this analysis is to quantify benefits and costs associated with the proposed "Trees for a Green LA" shade tree planting program developed by the Los Angeles Department of Water and Power (LADWP) and delivered through the Los Angeles Conservation Corps (LACC).

Assumptions

We assume that 200,000 trees (5 gal) are planted in fall 2001 at a unit cost of $40. In reality, these trees will be planted over two years. Our assumption simplifies the analysis without compromising its accuracy. The 30-year stream of benefits associated with air conditioning savings are calculated assuming:

• 70% of the trees planted survive after 30 years,
• 95% are planted in single family residential yards and 5% in parks and open space where trees do not shade buildings,
• 60% are planted in inland areas, where cooling loads and air conditioner saturations are greater than in coastal areas, where the remaining 40% are assumed to be planted,
• and residential plantings are evenly distributed to shade the east, south, and west sides of homes.

The present value of energy benefits are calculated assuming constant avoided costs ($0.04/kWh) and rates for inflation (2.5%) and discounting (5.8%). The present value of other benefits and costs produced by program trees are estimated using readily available information for trees planted in coastal and inland valley communities. These ancillary benefits include atmospheric carbon dioxide reductions, air pollutant uptake by trees as well as pollutants released by trees and equipment used to maintain trees, stormwater runoff reduction due to canopy interception of rainfall, and aesthetic benefits.

Results

The present value of all benefits is $140 million, while costs total $8 million (see Table 2, page 3, Benefit-Cost Analysis Summary). The program's discounted net present value is $132 million (benefits - costs). The benefit-cost ratio (BCR) is 17.5 assuming a 5.8% discount rate and 2.5% inflation rate for all benefits. For each dollar spent on the program, approximately $17.50 is returned as avoided costs for energy supply and air pollution control, as well as other benefits produced by trees (e.g., stormwater runoff reduction, increased property value and scenic quality, improved human health and well-being).

Value of Energy Conservation Benefits

If only energy conservation benefits for cooling are considered, the present value of benefits is $11.4 million and the net present value is $3.37 million. The BCR is 1.4, indicating a return of $1.40 on each $1 invested. Over the 30-year period, all trees are estimated to reduce cooling energy use by 485 GWh. The average annual savings is 16,172 MWh/year, or 81 kWh per tree planted. Because LADWP has excess capacity there is no value assigned to avoided peak cooling demand due to program trees. Although winter shade from bare branches can increase space heating costs, this penalty is assumed to be offset by reduced heating costs associated with wind speed reductions and lower rates of air infiltration.

Value of Atmospheric Carbon Dioxide Reduction Benefits

Atmospheric carbon dioxide reduction is expected to total 870,282 tons. Average annual reduction is 29,009 tons/year or 290 lb per tree planted. The present value of this benefit is $1 million. Residential yard trees account for 95% of the trees planted, but are responsible for 96% of the CO_2 reduction benefits and 98% of the energy benefits because they produce savings from shade on buildings.

Value of Air Quality Benefits

Benefits related to air quality improvements account for 66% ($92 million) of total benefits. This finding reflects the relatively high trading price for emission reduction credits during 2000 in the South Coast Air Basin, as well as the effectiveness of trees for pollutant removal. Assuming 30% of the trees die over the 30-year period, the program is estimated to reduce by nitrogen dioxide (NO_2) by 5,204 tons, ozone (O_3) by 1,906 tons, particulate matter (PM_{10}) by 1,869 tons, sulfur dioxide (SO_2) by 460 tons, carbon monoxide (CO) by 101 tons. The total present value of benefits is greatest for reductions of O_3 ($40 million), NO_2 ($30 million), and PM_{10} ($21 million).

Hydrocarbons (HC) released into the air naturally by "low-emitting" trees and by chain saws and chippers used to maintain trees are involved in smog formation. Approximately 1,018 tons of HCs are estimated to be released over the 30-year period. The discounted cost of HCs released is $2.9 million.

Value of Aesthetic and Other Benefits

The present value of aesthetic and other benefits is $27.3 million or about 20% of total benefits. This amount reflects the contribution of trees to property value and is based on research that found large front yard trees increase the sales price of residential properties by about 1%. An average sales price of $199,000 is assumed for the LADWP service area.

Value of Stormwater Runoff Reduction Benefits

Stormwater runoff reduction due to program trees is estimated to total 9.2 million Ccf (hundred cubic feet) during the 30-year period. The average annual reduction is about 1,500 gal per tree planted. The present value of benefits is $8.6 million, largely due to benefits associated with improved water quality rather than local flood control.

Limitations

This analysis does not account for the variety of trees planted, energy efficiencies associated with different building construction, and local climatic factors that influence space conditioning energy use in the Los Angeles area. It applies the same growth and mortality rates to all trees, when variation can be expected across sites and throughout the region. Projected energy savings and carbon dioxide sequestration rates are based on a limited set of single family residential simulations that do not bound the range of conditions expected in Los Angeles. In particular, there is much uncertainty associated with estimates of energy savings from climate effects.

Because of the many simplifying assumptions, extrapolations, and general lack of research concerning urban trees and their impacts on climate and air quality, these results are preliminary in nature. Estimates of pollutant deposition are first-order approximations that do not consider geographic differences in tree cover and pollutant concentrations or local meteorological effects. Uptake rates are based on data collected over rural forests, not cities.

Finally, it should be noted that estimating the value of aesthetic and other benefits is fraught with uncertainty, since there is virtually no local data to adjust study results from other regions of the U.S.

Appendix A: Modeling Procedures and Assumptions

This analysis assumes planting of 200,000 trees, with 190,000 located in residential yards and 10,000 in parks or other open space where they will not shade buildings. Although trees will be planted over two years, we assume all are planted in fall 2001 and that 70% of the originally planted trees survive the 30-year analysis period. The annual mortality rate is 2% during the first five years, since losses are usually greatest during the establishment period. A 1% annual mortality rate is assumed for the remaining 25 years. All costs ($40/tree, 5-gal) are incurred at the project outset, while benefits extend for 30 years, from 2002 to 2031. Benefits are derived from previous studies for two species of large-growing trees: a camphor *(Cinnamomum camphora*) in coastal Southern California and Shamel ash (*Fraxinus uhdei*) in inland valley areas (McPherson et al. 2000, 2001). In those studies, street tree growth rates and dimensions were measured in Santa Monica and Claremont. Hourly computer simulations were used to calculate benefits from these tree species as they "grew" for 40 years after planting. Many of the procedures and assumptions involved in these calculations are described in the following sections.

Air Conditioning Energy Savings

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 trees at 3 tree-building distances following methods outlined by Simpson and McPherson (1996, 1999). The inland Shamel ash is leafless Dec.- Jan and has a visual density of 80% during summer and 37% during winter. The coastal camphor is evergreen, with a visual density of 80% all year. Simulation results for each tree were averaged over distance and weighted by occurrence of Sacramento Shade 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 and we assume trees will be evenly distributed among these three orientations and between coastal and inland sites. Based on data from Sacramento Shade, we assume that 23% of program trees will shade neighboring homes, resulting in cooling savings equal to about 15% of that found for participant homes. Our results for park trees assume that they do not provide shading benefits.

In addition to localized shade effects, 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 cooling 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) is estimated to be 40%. Canopy cover is calculated to increase by 24% for large trees on maturity based on an effective lot size (actual lot size plus a portion of adjacent streets and other rights-of-way) of 8,000 ft^2 (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 park and yard trees.

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 Los Angeles communities. This house is a two story, stucco, slab-on-grade building with a conditioned floor area of 2,070 ft^2 (192 m^2), window area (double-glazing) of 325 ft^2 (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 LAX for coastal trees and Riverside for inland trees.

Simulated annual cooling savings for 30-year old coastal yard trees ranged from 154-181 kWh/tree and was 98 kWh for the park tree. In the warmer inland climate, yard tree savings ranged from 325-418 kWh/tree and park trees saved 135 kWh/tree. These values were adjusted downward to account for air conditioner saturations and relative unit energy consumption of room air conditioning and evaporative cooling (California Energy Commission [CEC] 2001). Weighted saturations were 16.6% and 59.1% for the coastal and inland zones, respectively. This adjustment, along with the 15% adjustment to account for shade on neighboring buildings, resulted in average annual savings of $140 kWh/ yard tree and 51 kWh/ park tree at 30 years after planting (45-ft tall tree). Annual benefits were linked to tree height growth as a percentage of mature height at 30 years, since height is related to the amount of shade and evapotranspirational cooling a tree produces (Simpson.

The dollar value of energy savings is based on a long-term average avoided cost of $0.04 per kWh (Personal communication, Randy Howard, Manager of Commercial Services, LADWP). This analysis assumes that trees will not have a net benefit or cost on space heating. The heating cost associated with reduced winter solar access is assumed to be offset by the benefit of reduced wind speeds and heat loss via air infiltration.

Atmospheric Carbon Dioxide Reduction

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 the respective CO_2 emission factors for electricity (Table 1). Emissions factors for electricity (U.S. EPA 1995) are weighted by the fuel mix for Los Angeles Department of Water and Power (48% natural gas, 28% coal, and 28% other, the latter assumed to have no emissions, CEC 1994). The value of CO_2 reductions (Table 1) is based on limited trading of reduction credits (Cantor Fitzgerald Environmental Brokerage Services 2001). The values for all other pollutants are based on costs associated with 168 emission reduction transactions in the South Coast Air Basin during 2000 (California Air Resources Board 2001)

Table 1. Emissions factors for electricity generation and implied values for CO_2 and criteria air pollutants

	Electricity lbs/kWh	Implied value $/ton
CO_2	0.9956	2¶
NO_2	0.0023	39,342 †
SO_2	0.0017	14,076 †
PM_{10}	0.00017	21,148 †
VOC's	0.00017	5,399 †

† California Air Resources Board 2001
¶ Cantor Fitzgerald Environmental Brokerage Services 2001

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 growth data for the coastal camphor and inland Shamel ash. Biomass equations for camphor (Pillsbury et al. 1998) and Modesto ash (*Fraxinus velutina* 'Modesto') were used, the later substituted since equations were lacking for Shamel ash. 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

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. 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.

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 (VOC's) and nitrogen dioxide (NO_2), both precursors of ozone (O_3) formation, as well as carbon monoxide (CO), 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 LADWP emission factors for electricity, with the value of emissions savings (Table 1) based on the price of emission reduction credits for the South Coast Air Quality Management District.

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) were obtained from the California Air Resources Board. 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 the coastal and inland sites were obtained from the California Department of Water Resources.

Annual emissions of biogenic volatile organic compounds (BVOC) were estimated for the low-emitting camphor and Shamel ash using the algorithms of Guenther et al. (1991, 1993). Annual emissions were simulated during the growing season over 15 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 species were based upon values reported in the literature (Benjamin et al. 1996). Both 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 both 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 Santa Monica and Claremont. The amount of foliar biomass present for each year of the simulated tree's life was unique for each species.

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).

Rainfall Interception By Tree Canopies and Stormwater Runoff Reduction

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 3 trees) values influence the amount of projected throughfall. Hourly meteorological and rainfall data from the California Irrigation Management Information System (CIMIS) are used for this simulation. A more complete description of the interception model can be found in Xiao et al. (1998).

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.

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 1) determining the value of individual trees on a property, 2) the need to extrapolate results from studies done years ago in the east and south to California, and 3) the need to extrapolate results from front yard trees on residential properties to trees in other locations (e.g., back yards and parks).

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 a Los Angeles resident would gain from sale of residential property with a large tree. The sales price of residential properties within the LADWP service area varies widely by location. For example, 2000 median home prices ranged from $125,000 in South Los Angeles to $650,000 in West Los Angeles (California Association of Realtors 2000). In 2000 the median home price for 8 communities in the LADWP service area was $199,000 (California Association of Realtors 2000). The value of a large tree (45-ft tall, 40 years old) that adds about 1% to the sales price of such a home is $1,755.

To calculate the base value for a large tree on private residential property we assume that a 40-year old camphor or Shamel ash tree in the front yard will increase the property's sales price by $1,755. 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. We assume that the average annual aesthetic benefit for a yard and park tree is \$0.16 / ft^2 of leaf area (\$1.72 / 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.

Program Costs and Benefits

The program cost is \$40 per tree planted, or \$8 million assuming 200,000 trees are planted in fall 2001. This \$40 value includes costs of the trees, stakes, mulch, and follow-up care, monitoring, program administration, educational services, and media relations. Residents who receive trees will be responsible for planting, subsequent tree care, and related expenditures (irrigation, pruning, and removal). Because these are not LADWP program costs they are not included in this analysis. Since the entire expenditure occurs at the outset, there is no future stream of costs to discount and the present value of costs is \$8 million.

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 cooling energy savings
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 stream of benefits occurs over a 30-year period, from 2002-2031. Prices of benefits are increased annually assuming a 2.5% inflation rate. Future benefits are discounted to the present using a 5.8% interest rate (Personal communication, Randy Howard, Manager of Commercial Services, LADWP).

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ECONOMIC ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PLANTING PROGRAM - Table 1, Page 1

BENEFITS IN RESOURCE UNITS (TOTAL AND PER TREE)

Tree Numbers:	% of total	Number	Mortality	
Yard Trees:	95.00%	190,000	Year 1-5:	2.00%
Park Only Trees:	5.00%	10,000	Year 6-30:	1.00%
		200,000	Survival:	70.31%

Avoided kWh:	$0.040
Avoided kW:	$0.00
Trees Planted:	200,000
Discount Rate:	5.80%
Inflation Rate:	2.50%

Yr	Tree Height (ft)	% Mature Tree Ht	Tree Numbers	Yard kWh/tree	Park kWh/tree	Total Savings - All trees Yard kWh	Park kWh	Total Electric Savings kWh	Yard Avoided CO2 lb/tree	Park Avoid CO2 lb/tree	Seq CO2 lb/tree	CO2 Released lb/tree	Total Yard CO2 (lb)	Total Park CO2 (lb)	Total CO2 (lb)	PM10 lb/tree	Total PM10 (lb)
2001/0	5.0	0.23	200,000	0	0	0	0	0	0	0	0	(31)	(5,890,000)	(310,000)	(6,200,000)	0.00	0
2002/1	7.1	0.29	196,000	40	14	7,481,206	141,691	7,622,897	40	14	117	(3)	28,229,475	1,234,814	29,464,289	0.07	13,771
2003/2	9.2	0.34	192,080	48	17	8,727,300	165,291	8,892,591	48	17	139	(4)	32,583,654	1,422,182	34,005,836	0.11	21,229
2004/3	11.3	0.39	188,238	55	20	9,817,919	185,947	10,003,865	55	20	160	(4)	36,300,188	1,581,206	37,881,394	0.15	28,962
2005/4	13.3	0.44	184,474	61	22	10,772,410	204,024	10,976,434	61	22	179	(5)	39,460,332	1,715,512	41,175,844	0.20	36,757
2006/5	15.3	0.48	180,784	68	24	11,606,425	219,820	11,826,245	67	24	196	(5)	42,130,329	1,828,062	43,958,391	0.25	44,495
2007/6	17.4	0.52	178,976	73	26	12,458,922	235,966	12,694,888	73	26	213	(6)	46,225,088	2,014,980	48,240,068	0.29	52,641
2008/7	19.3	0.56	177,187	79	28	13,229,505	250,561	13,480,065	78	28	228	(6)	48,872,495	2,128,469	51,000,964	0.34	60,780
2009/8	21.3	0.60	175,415	84	30	13,925,490	263,742	14,189,232	83	30	243	(7)	51,221,507	2,228,755	53,450,262	0.39	68,885
2010/9	23.2	0.63	173,661	88	32	14,553,329	275,633	14,828,962	88	32	256	(7)	53,298,501	2,317,010	55,615,512	0.44	76,940
2011/10	25.0	0.66	171,924	93	33	15,118,763	286,342	15,405,105	92	33	269	(7)	55,127,001	2,394,280	57,521,281	0.49	84,930
2012/11	26.8	0.69	170,205	97	35	15,626,944	295,967	15,922,911	96	35	281	(8)	56,728,135	2,461,504	59,189,639	0.55	92,849
2013/12	28.5	0.72	168,503	100	36	16,082,523	304,595	16,387,118	100	36	292	(8)	58,120,991	2,519,531	60,640,521	0.60	100,690
2014/13	30.2	0.74	166,818	104	37	16,489,715	312,308	16,802,022	104	37	302	(8)	59,322,885	2,569,129	61,892,015	0.65	108,450
2015/14	31.8	0.77	165,149	107	39	16,852,356	319,176	17,171,532	107	38	312	(9)	60,349,587	2,611,002	62,960,589	0.70	116,126
2016/15	33.3	0.79	163,498	111	40	17,173,952	325,267	17,499,218	110	40	321	(9)	61,215,495	2,645,789	63,861,283	0.76	123,717
2017/16	34.7	0.81	161,863	114	41	17,457,707	330,641	17,788,348	113	41	330	(9)	61,933,789	2,674,075	64,607,864	0.81	131,221
2018/17	36.1	0.83	160,244	116	42	17,706,563	335,354	18,041,917	116	42	338	(9)	62,516,555	2,696,400	65,212,954	0.87	138,637
2019/18	37.3	0.85	158,642	119	43	17,923,223	339,457	18,262,680	118	43	346	(10)	62,974,896	2,713,255	65,688,151	0.92	145,966
2020/19	38.5	0.86	157,055	121	44	18,110,172	342,998	18,453,170	121	43	353	(10)	63,319,024	2,725,096	66,044,120	0.98	153,207
2021/20	39.6	0.88	155,485	124	45	18,269,702	346,020	18,615,721	123	44	359	(10)	63,558,343	2,732,341	66,290,684	1.03	160,361
2022/21	40.6	0.90	153,930	126	45	18,403,925	348,562	18,752,487	125	45	366	(10)	63,701,522	2,735,374	66,436,896	1.09	167,428
2023/22	41.5	0.91	152,391	128	46	18,514,794	350,662	18,865,455	127	46	372	(10)	63,756,558	2,734,552	66,491,110	1.14	174,409
2024/23	42.3	0.92	150,867	130	47	18,604,109	352,353	18,956,462	129	47	377	(10)	63,730,832	2,730,202	66,461,034	1.20	181,303
2025/24	43.0	0.94	149,358	132	47	18,673,538	353,668	19,027,206	131	47	382	(11)	63,631,164	2,722,627	66,353,791	1.26	188,111
2026/25	43.6	0.95	147,865	133	48	18,724,622	354,636	19,079,258	133	48	387	(11)	63,463,854	2,712,108	66,175,962	1.32	194,834
2027/26	44.1	0.96	146,386	135	49	18,758,790	355,283	19,114,072	134	48	392	(11)	63,234,730	2,698,903	65,933,633	1.38	201,473
2028/27	44.5	0.97	144,922	136	49	18,777,362	355,634	19,132,996	136	49	396	(11)	62,949,180	2,683,251	65,632,431	1.44	208,028
2029/28	44.8	0.98	143,473	138	50	18,781,563	355,714	19,137,277	137	49	400	(11)	62,612,189	2,665,373	65,277,562	1.50	214,500
2030/29	44.9	0.99	142,038	139	50	18,772,529	355,543	19,128,072	139	50	404	(11)	62,228,369	2,645,475	64,873,844	1.56	220,889
2031/30	45.0	1.00	140,618	140	51	18,751,311	355,141	19,106,452	140	50	408	(11)	61,801,989	2,623,746	64,425,735	1.62	227,196
	30-yr Loss:		29.69%	3,138	1,129	476,146,668	9,017,996	485,164,663	3,124	1,125	9,527	(284)	1,668,708,657	71,855,003	1,740,563,660	25.61	3,738,787

Assumptions:

1) 30 year analysis from 2002 - 2031.
2) All trees planted in fall 2001 with benefits accruing in 2002, at an average cost of $40/tree as shown, which includes education, administration, media, and follow-up care and monitoring, in addition to planting. Long-term tree maintenance is assumed to be by residents and trained volunteers, with no cost to LADWP.
3) Assume "typical" tree is 5-ft tall when planted (5-gal).
4) Assume energy benefits are linked to tree growth as percentage of mature height and other benefits to leaf area growth based on measured data for camphor and Shamel ash trees.
5) Adjustments to benefits based on tree mortality assume 30% of the planted trees die.
6) Assume 95% of trees are in residential Yards, are evenly distributed to east, south, and west of buildings, and provide benefits from direct shade and cooler summer air temperatures, 5% are in Parks or other open space and provide climate benefit only. AC savings assume 60% of trees are Inland and 40% are Coastal and adjusted using weighted AC saturations for each area (17% Coastal, 59% Inland).
7) Assume impacts of trees on heating are offsetting with no net cost or benefit (block winter solar access but reduce wind speeds/infiltration).
8) Assume nominal discount rate of 5.8%, inflation rate of 2.5% (applies to energy and other benefits), and 30-year constant avoided energy cost of $0.04/kWh.

ECONOMIC ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PLANTING PROGRAM - Table 1, Page 2

(continued)

CO2:	$2
PM10:	$21,148
Ozone:	$39,342
NO2:	$39,342
SO2:	$14,076
CO:	$3,765
ROC or Hydrocarbons:	$5,399
Stormwater Runoff Reduction ($/gal):	$0.0018
Aesthetics and other benefits ($/sq ft leaf area):	$0.1596

Notes: See Table 2, page 2

Yr	Ozone lb/tree	Total Ozone (lb)	NO2 lb/tree	Total NO2 (lb)	SO2 lb/tree	Total SO2 (lb)	CO lb/tree	Total CO (lb)	Tree BVOC lb/tree	Tree Care HC Out lb/tree	Total HC Out lb/tree	Total HC Release (lb)	Runoff Reduction gal/tree	Total Runoff Reduction (gal)	Other Benefits LA change (sf	Total Other Benefits LA change (sf)
2001/0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	0.00	0	0	0	0	0
2002/1	0.07	14,038	0.05	10,526	0.02	3,388	0.00	743	-0.02	-0.02	-0.04	(7,501)	129	25,370,554	11	2,077,572
2003/2	0.11	21,640	0.08	16,227	0.03	5,223	0.01	1,146	-0.03	-0.03	-0.06	(11,562)	204	39,109,776	31	5,898,684
2004/3	0.16	29,523	0.12	22,138	0.04	7,125	0.01	1,563	-0.04	-0.04	-0.08	(15,775)	283	53,357,360	42	7,814,021
2005/4	0.20	37,469	0.15	28,096	0.05	9,043	0.01	1,984	-0.06	-0.05	-0.11	(20,020)	367	67,717,633	47	8,754,458
2006/5	0.25	45,357	0.19	34,011	0.06	10,947	0.01	2,402	-0.07	-0.06	-0.13	(24,235)	453	81,973,481	51	9,235,697
2007/6	0.30	53,660	0.22	40,237	0.07	12,951	0.02	2,842	-0.08	-0.08	-0.16	(28,671)	542	96,979,724	54	9,576,779
2008/7	0.35	61,957	0.26	46,458	0.08	14,953	0.02	3,281	-0.10	-0.09	-0.19	(33,104)	632	111,974,356	55	9,789,122
2009/8	0.40	70,220	0.30	52,654	0.10	16,947	0.02	3,719	-0.11	-0.10	-0.21	(37,519)	723	126,907,370	57	9,924,436
2010/9	0.45	78,430	0.34	58,811	0.11	18,929	0.02	4,153	-0.13	-0.12	-0.24	(41,906)	816	141,745,637	58	10,011,258
2011/10	0.50	86,575	0.38	64,918	0.12	20,895	0.03	4,585	-0.14	-0.13	-0.27	(46,258)	910	156,466,669	59	10,066,649
2012/11	0.56	94,648	0.42	70,971	0.13	22,843	0.03	5,012	-0.16	-0.14	-0.30	(50,571)	1,005	171,055,346	59	10,100,878
2013/12	0.61	102,641	0.46	76,965	0.15	24,772	0.03	5,436	-0.17	-0.16	-0.33	(54,842)	1,101	185,501,414	60	10,120,411
2014/13	0.66	110,551	0.50	82,897	0.16	26,681	0.04	5,854	-0.19	-0.17	-0.35	(59,068)	1,198	199,797,658	61	10,129,726
2015/14	0.72	118,376	0.54	88,764	0.17	28,570	0.04	6,269	-0.20	-0.18	-0.38	(63,249)	1,295	213,939,206	61	10,131,782
2016/15	0.77	126,113	0.58	94,566	0.19	30,437	0.04	6,679	-0.22	-0.20	-0.41	(67,383)	1,394	227,923,117	62	10,128,419
2017/16	0.83	133,763	0.62	100,302	0.20	32,283	0.04	7,084	-0.23	-0.21	-0.44	(71,470)	1,494	241,747,308	63	10,121,061
2018/17	0.88	141,323	0.66	105,971	0.21	34,108	0.05	7,484	-0.25	-0.22	-0.47	(75,509)	1,594	255,410,706	63	10,110,888
2019/18	0.94	148,794	0.70	111,573	0.23	35,911	0.05	7,880	-0.26	-0.24	-0.50	(79,501)	1,695	268,912,932	64	10,098,421
2020/19	0.99	156,175	0.75	117,108	0.24	37,693	0.05	8,271	-0.28	-0.25	-0.53	(83,445)	1,797	282,253,477	64	10,084,279
2021/20	1.05	163,468	0.79	122,576	0.25	39,453	0.06	8,657	-0.29	-0.27	-0.56	(87,342)	1,900	295,433,461	65	10,068,891
2022/21	1.11	170,672	0.83	127,978	0.27	41,191	0.06	9,038	-0.31	-0.28	-0.59	(91,191)	2,004	308,452,910	65	10,052,174
2023/22	1.17	177,787	0.87	133,314	0.28	42,909	0.06	9,415	-0.33	-0.30	-0.62	(94,993)	2,108	321,312,663	66	10,035,144
2024/23	1.23	184,815	0.92	138,583	0.30	44,605	0.06	9,787	-0.34	-0.31	-0.65	(98,748)	2,214	334,013,561	66	10,017,125
2025/24	1.28	191,755	0.96	143,787	0.31	46,280	0.07	10,155	-0.36	-0.33	-0.69	(102,456)	2,320	346,556,707	67	9,998,624
2026/25	1.34	198,609	1.01	148,926	0.32	47,934	0.07	10,518	-0.38	-0.34	-0.72	(106,118)	2,428	358,942,951	67	9,979,650
2027/26	1.40	205,376	1.05	154,001	0.34	49,567	0.07	10,876	-0.39	-0.36	-0.75	(109,734)	2,536	371,173,641	68	9,960,371
2028/27	1.46	212,058	1.10	159,011	0.35	51,180	0.08	11,230	-0.41	-0.37	-0.78	(113,304)	2,645	383,249,869	69	9,940,636
2029/28	1.52	218,655	1.14	163,958	0.37	52,772	0.08	11,579	-0.43	-0.39	-0.81	(116,829)	2,754	395,172,482	69	9,920,762
2030/29	1.59	225,168	1.19	168,842	0.38	54,344	0.08	11,924	-0.44	-0.40	-0.85	(120,308)	2,865	406,943,290	70	9,900,598
2031/30	1.65	231,597	1.24	173,663	0.40	55,896	0.09	12,265	-0.46	-0.42	-0.88	(123,744)	2,977	418,562,886	70	9,879,996
	26.21	3,811,217	19.25	10,407,883	6.03	919,829	1.38	201,830	-7.32	-6.68	-13.12	(2,036,351)	47,360	6,887,958,145	1,762	283,928,511

Energy Benefits w/ No Mortality - based on Tree Guidelines data for 30 yr old trees (Coastal Camphor and Inland Shamel ash)
Residential energy simulations asume energy efficient (Title-24 compliant) 2,070 sf residence, and used weather data from LAX and Riverside:
Saturation adjustment is weighted to account for different Unit Energy Consumptions by AC type, assumes trees evenly split by region, and shade on adjacent homes reduces AC use by 15%.

Yr 30 AC Savi Large Tree	East Shade kWh/tree	South Shade kWh/tree	West Shade kWh/tree	Climate kWh/tree	Yard Avg kWh/tree	Yard w/ SAT Adjust	Park Avg kWh/tree	Park w/ SAT Adjust
Coastal	54	83	83	98	171	83	98	41
Inland	190	230	283	135	369	179	135	57
Wtg Avg.	135	171	203	120	290	140	120	51

Weighted Saturation Adjustments - based on CEC residential consumption forecast data for LADWP

	CAC Sat (%)	Avg UEC kWh	Room AC Sat (%)	Avg UEC kWh	Room AC % UEC/CAC	Evap AC Sat (%)	Avg UEC kWh	Evap AC % UEC/CAC	Weighted Saturation
Coastal	11.60%	750	20.20%	169.7	22.63%	2.40%	146.7	19.56%	16.64%
Inland	46.10%	1593	24.00%	594.8	37.34%	11.00%	587.8	36.90%	59.12%
Avg.									42.13%

ECONOMIC ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PLANTING PROGRAM - Table 2, Page 1

BENEFITS IN DOLLARS (TOTAL AND PER TREE)

Tree Numbers:	% of total	Number		Mortality
Yard Trees:	95.00%	190,000	Year 1-5:	2.00%
Park Only Trees:	5.00%	10,000	Year 6-30:	1.00%
		200,000	Survival:	70.31%

Avoided kWh:	$0.040
Avoided kW:	$0.000
Trees Planted:	200,000
Discount Rate:	5.80%
Inflation Rate:	2.50%

Yr	Tree Height (ft)	% Mature Tree Ht	Tree Numbers	Yard kWh $/tree	Park kWh $/tree	Total Savings - All trees Yard kWh Tot $	Park kWh Tot $	Total Electric Sa kWh Tot $	Yard Avoid CO2 $/tree	Park Avoid CO2 $/tree	Seq CO2 $/tree	CO2 Released $/tree	Total Yard CO2 ($)	Total Park CO2 ($)	Total CO2 ($)	PM10 $/tree	Total PM10 ($)
2001/0	5.0	0.23	200,000	0	0	0	0	0	0	0	0	-0.03	(5,890)	(310)	(6,200)	0.00	0
2002/1	7.1	0.29	196,000	1.61	0.58	299,248	5,668	304,916	0.04	0.01	0.12	-0.00	28,229	1,235	29,464	0.74	145,616
2003/2	9.2	0.34	192,080	1.96	0.71	357,819	6,777	364,596	0.05	0.02	0.14	-0.00	33,398	1,458	34,856	1.20	230,085
2004/3	11.3	0.39	188,238	2.31	0.83	412,598	7,814	420,412	0.06	0.02	0.17	-0.00	38,138	1,661	39,799	1.71	321,752
2005/4	13.3	0.44	184,474	2.65	0.95	464,028	8,788	472,817	0.07	0.02	0.19	-0.01	42,494	1,847	44,342	2.27	418,555
2006/5	15.3	0.48	180,784	2.98	1.07	512,453	9,706	522,158	0.07	0.03	0.22	-0.01	46,504	2,018	48,522	2.87	519,336
2007/6	17.4	0.52	178,976	3.32	1.19	563,845	10,679	574,524	0.08	0.03	0.24	-0.01	52,299	2,280	54,579	3.52	629,767
2008/7	19.3	0.56	177,187	3.65	1.31	613,687	11,623	625,310	0.09	0.03	0.26	-0.01	56,677	2,468	59,145	4.21	745,318
2009/8	21.3	0.60	175,415	3.97	1.43	662,121	12,540	674,662	0.10	0.04	0.29	-0.01	60,886	2,649	63,536	4.94	865,832
2010/9	23.2	0.63	173,661	4.30	1.55	709,273	13,433	722,706	0.11	0.04	0.31	-0.01	64,939	2,823	67,762	5.71	991,243
2011/10	25.0	0.66	171,924	4.62	1.66	755,251	14,304	769,555	0.12	0.04	0.34	-0.01	68,846	2,990	71,836	6.52	1,121,544
2012/11	26.8	0.69	170,205	4.95	1.78	800,152	15,155	815,307	0.12	0.04	0.36	-0.01	72,617	3,151	75,768	7.38	1,256,767
2013/12	28.5	0.72	168,503	5.27	1.90	844,067	15,986	860,053	0.13	0.05	0.38	-0.01	76,260	3,306	79,566	8.29	1,396,977
2014/13	30.2	0.74	166,818	5.60	2.01	887,073	16,801	903,874	0.14	0.05	0.41	-0.01	79,783	3,455	83,238	9.25	1,542,256
2015/14	31.8	0.77	165,149	5.92	2.13	929,246	17,599	946,846	0.15	0.05	0.43	-0.01	83,193	3,599	86,792	10.25	1,692,701
2016/15	33.3	0.79	163,498	6.25	2.25	970,654	18,384	989,037	0.16	0.06	0.45	-0.01	86,496	3,738	90,234	11.31	1,848,426
2017/16	34.7	0.81	161,863	6.58	2.37	1,011,359	19,155	1,030,513	0.16	0.06	0.48	-0.01	89,699	3,873	93,571	12.42	2,009,552
2018/17	36.1	0.83	160,244	6.91	2.49	1,051,420	19,913	1,071,333	0.17	0.06	0.50	-0.01	92,806	4,003	96,809	13.58	2,176,208
2019/18	37.3	0.85	158,642	7.24	2.60	1,090,892	20,661	1,111,553	0.18	0.06	0.53	-0.01	95,824	4,129	99,952	14.80	2,348,535
2020/19	38.5	0.86	157,055	7.57	2.72	1,129,828	21,398	1,151,226	0.19	0.07	0.55	-0.02	98,756	4,250	103,006	16.09	2,526,669
2021/20	39.6	0.88	155,485	7.91	2.85	1,168,274	22,127	1,190,401	0.20	0.07	0.57	-0.02	101,608	4,368	105,976	17.43	2,710,770
2022/21	40.6	0.90	153,930	8.25	2.97	1,206,279	22,846	1,229,125	0.21	0.07	0.60	-0.02	104,382	4,482	108,865	18.85	2,900,987
2023/22	41.5	0.91	152,391	8.59	3.09	1,243,884	23,559	1,267,443	0.21	0.08	0.62	-0.02	107,084	4,593	111,677	20.33	3,097,480
2024/23	42.3	0.92	150,867	8.94	3.22	1,281,132	24,264	1,305,396	0.22	0.08	0.65	-0.02	109,717	4,700	114,417	21.88	3,300,416
2025/24	43.0	0.94	149,358	9.29	3.34	1,318,061	24,963	1,343,024	0.23	0.08	0.67	-0.02	112,284	4,804	117,089	23.50	3,509,965
2026/25	43.6	0.95	147,865	9.64	3.47	1,354,708	25,658	1,380,366	0.24	0.09	0.70	-0.02	114,789	4,905	119,694	25.20	3,726,299
2027/26	44.1	0.96	146,386	10.00	3.60	1,391,110	26,347	1,417,457	0.25	0.09	0.73	-0.02	117,234	5,004	122,237	26.98	3,949,602
2028/27	44.5	0.97	144,922	10.37	3.73	1,427,299	27,032	1,454,332	0.26	0.09	0.75	-0.02	119,622	5,099	124,721	28.84	4,180,056
2029/28	44.8	0.98	143,473	10.74	3.86	1,463,309	27,714	1,491,024	0.27	0.10	0.78	-0.02	121,956	5,192	127,148	30.79	4,417,846
2030/29	44.9	0.99	142,038	11.11	4.00	1,499,170	28,394	1,527,564	0.28	0.10	0.81	-0.02	124,239	5,282	129,520	32.83	4,663,175
2031/30	45.0	1.00	140,618	11.49	4.13	1,534,913	29,071	1,563,983	0.29	0.10	0.83	-0.02	126,472	5,369	131,841	34.96	4,916,232
		30-yr Loss:	29.69%	193.98	69.80	28,953,155	548,359	29,501,514	4.83	1.74	14.09	-0.42	2,521,341	108,422	2,629,763	418.64	64,159,966

Assumptions:

1) 30 year analysis from 2002 - 2031.
2) All trees planted in fall 2001 with benefits accruing in 2002, at an average cost of $40/tree as shown, which includes education, administration, media, and follow-up care and monitoring, in addition to planting. Long-term tree maintenance is assumed to be by residents and trained volunteers, with no cost to LADWP.
3) Assume "typical" tree is 5-ft tall when planted (5-gal).
4) Assume energy benefits are linked to tree growth as percentage of mature height and other benefits to leaf area growth based on measured data for camphor and Shamel ash trees.
5) Adjustments to benefits based on tree mortality assume 30% of the planted trees die.
6) Assume 95% of trees are in residential Yards, are evenly distributed to east, south, and west of buildings, and provide benefits from direct shade and cooler summer air temperatures, 5% are in Parks or other open space and provide climate benefit only. AC savings assume 60% of trees are Inland and 40% are Coastal and adjusted using weighted AC saturations for each area (17% Coastal, 59% Inland).
7) Assume impacts of trees on heating are offsetting with no net cost or benefit (block winter solar access but reduce wind speeds/infiltration).
8) Assume nominal discount rate of 5.8%, inflation rate of 2.5% (applies to energy and other benefits), and 30-year constant avoided energy cost of $0.04/kWh.

ECONOMIC ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PLANTING PROGRAM - Table 2, Page 2

(continued)

Implied Value for Air Pollutants ($/ton)
- CO_2: $2
- PM10: $21,148
- Ozone: $39,342
- NO_2: $39,342
- SO_2: $14,076
- CO: $3,765
- ROC or Hydrocarbons: $5,399
- Stormwater Runoff Reduction ($/gal): $0.0018
- Aesthetics and other benefits ($/sq ft leaf area): $0.1596

1) Implied values are weighted averages for emission reduction credits traded during 2000 in the South Coast Air Basin (from Calif ARB web-site).
2) Pollutant uptake values from "Tree Guidelines for Inland Empire and Coastal SC Communities" and avoided emissions from CEC emission rates for LADWP.
3) Hydrocarbon (HC) emissions from trees (BVOC) are for a "low emitter" species such as zelkova and crape myrtle.
4) Chain saw and chipper HC emissions based on data from Sacramento Tree Services: assume time to prune and chip 18-inch tree is 30 & 15 mins., 50% load, standard 30 cc chain saw (2 HP), 4-stroke (65 HP) chipper, trees pruned every other year. HC emissions reduced 5% annually due to new standards.
5) CO_2 avoided assumes emission factor of 1 lb/kWh for LADWP, CO_2 sequestered is average for coastal Camphor and Inland Shamel ash from Tree Guidelines, CO_2 released based on survey data from nurseries, non-profits, and municipal forestry programs.
6) Stormwater runoff reduction due to canopy interception of rainfall: water quality benefit based on annual interception after first one-tenth inch has fallen (3,000 gal) priced at cost to treat sanitary wastewater, flood control based on interception for 25-year event (250 gal) priced at current flood control spending $500,000/sq mile.
7) Aesthetics assume front yard tree adds 1% to sales price of home, median sales price $199,000, adjusted downward assuming 75% backyard trees.

Yr	Ozone $/tree	Total Ozone ($)	NO2 $/tree	Total NO2 ($)	SO2 $/tree	Total SO2 ($)	CO $/tree	Total CO ($)	Tree BVOC $/tree	Tree Care HC Out $/tree	Total HC Out $/tree	Total HC Out ($)	Total Benefits Pollutants ($)	Runoff Reduction $/tree	Total Runoff Reduction ($)	Aesthetic Benefits $/tree	Total Aesthetic Benefits ($)
2001/0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0.00	0.00	0	0	0	0	0	0
2002/1	1.41	276,140	1.06	207,063	0.12	23,845	0.01	1,399	-0.05	-0.05	-0.10	(20,248)	633,816	0.30	59,334	1.69	331,585
2003/2	2.27	436,324	1.70	327,177	0.20	37,677	0.01	2,211	-0.09	-0.08	-0.17	(31,993)	1,001,481	0.49	93,752	5.02	964,979
2004/3	3.24	610,157	2.43	457,525	0.28	52,688	0.02	3,092	-0.12	-0.11	-0.24	(44,739)	1,400,475	0.70	131,104	6.96	1,310,271
2005/4	4.30	793,730	3.23	595,177	0.37	68,539	0.02	4,023	-0.16	-0.15	-0.32	(58,199)	1,821,825	0.92	170,548	8.16	1,504,665
2006/5	5.45	984,846	4.08	738,485	0.47	85,042	0.03	4,991	-0.21	-0.19	-0.40	(72,213)	2,260,488	1.17	211,612	9.00	1,627,062
2007/6	6.67	1,194,263	5.00	895,516	0.58	103,126	0.03	6,052	-0.26	-0.23	-0.49	(87,568)	2,741,155	1.43	256,609	9.66	1,729,330
2008/7	7.98	1,413,388	5.98	1,059,826	0.69	122,047	0.04	7,163	-0.31	-0.28	-0.58	(103,635)	3,244,106	1.71	303,692	10.23	1,811,865
2009/8	9.36	1,641,926	7.02	1,231,195	0.81	141,782	0.05	8,321	-0.36	-0.33	-0.69	(120,392)	3,768,662	2.01	352,798	10.73	1,882,833
2010/9	10.82	1,879,750	8.12	1,409,527	0.93	162,318	0.05	9,526	-0.41	-0.38	-0.79	(137,831)	4,314,535	2.33	403,899	11.21	1,946,788
2011/10	12.37	2,126,847	9.28	1,594,812	1.07	183,655	0.06	10,779	-0.47	-0.43	-0.91	(155,949)	4,881,687	2.66	456,992	11.67	2,006,498
2012/11	14.00	2,383,279	10.50	1,787,097	1.21	205,798	0.07	12,078	-0.54	-0.49	-1.03	(174,751)	5,470,268	3.01	512,091	12.12	2,063,653
2013/12	15.72	2,649,167	11.79	1,986,473	1.36	228,758	0.08	13,426	-0.60	-0.55	-1.15	(194,247)	6,080,553	3.38	569,222	12.58	2,119,335
2014/13	17.53	2,924,666	13.15	2,193,056	1.51	252,547	0.09	14,822	-0.67	-0.61	-1.29	(214,448)	6,712,899	3.77	628,419	13.03	2,174,318
2015/14	19.44	3,209,964	14.57	2,406,986	1.68	277,183	0.10	16,268	-0.74	-0.68	-1.43	(235,367)	7,367,734	4.18	689,720	13.50	2,229,128
2016/15	21.44	3,505,275	16.08	2,628,424	1.85	302,683	0.11	17,765	-0.82	-0.75	-1.57	(257,021)	8,045,552	4.61	753,173	13.97	2,284,098
2017/16	23.54	3,810,827	17.65	2,857,541	2.03	329,068	0.12	19,313	-0.90	-0.82	-1.73	(279,425)	8,746,876	5.06	818,826	14.45	2,339,500
2018/17	25.75	4,126,867	19.31	3,094,524	2.22	356,358	0.13	20,915	-0.99	-0.90	-1.89	(302,598)	9,472,275	5.53	886,734	14.95	2,395,577
2019/18	28.07	4,453,659	21.05	3,339,568	2.42	384,577	0.14	22,571	-1.08	-0.98	-2.06	(326,560)	10,222,350	6.03	956,951	15.46	2,452,439
2020/19	30.51	4,791,466	22.88	3,592,872	2.63	413,747	0.15	24,283	-1.17	-1.07	-2.24	(351,329)	10,997,709	6.56	1,029,535	15.98	2,510,229
2021/20	33.06	5,140,587	24.79	3,854,660	2.85	443,894	0.17	26,052	-1.27	-1.16	-2.42	(376,928)	11,799,034	7.10	1,104,550	16.52	2,569,059
2022/21	35.74	5,501,305	26.80	4,125,144	3.09	475,042	0.18	27,880	-1.37	-1.25	-2.62	(403,378)	12,626,981	7.68	1,182,057	17.08	2,628,913
2023/22	38.55	5,873,927	28.90	4,404,554	3.33	507,218	0.20	29,769	-1.48	-1.35	-2.83	(430,700)	13,482,249	8.28	1,262,122	17.65	2,690,071
2024/23	41.49	6,258,766	31.11	4,693,124	3.58	540,449	0.21	31,719	-1.59	-1.45	-3.04	(458,918)	14,365,557	8.91	1,344,811	18.24	2,752,372
2025/24	44.56	6,656,145	33.42	4,991,098	3.85	574,763	0.23	33,733	-1.71	-1.56	-3.27	(488,055)	15,277,650	9.58	1,430,196	18.85	2,815,971
2026/25	47.79	7,066,393	35.83	5,298,722	4.13	610,189	0.24	35,812	-1.83	-1.67	-3.50	(518,136)	16,219,278	10.27	1,518,345	19.48	2,880,892
2027/26	51.17	7,489,853	38.37	5,616,253	4.42	646,755	0.26	37,958	-1.96	-1.79	-3.75	(549,186)	17,191,236	10.99	1,609,333	20.13	2,947,210
2028/27	54.70	7,926,876	41.01	5,943,954	4.72	684,492	0.28	40,173	-2.10	-1.91	-4.01	(581,230)	18,194,321	11.75	1,703,236	20.80	3,014,905
2029/28	58.39	8,377,812	43.79	6,282,087	5.04	723,431	0.30	42,458	-2.24	-2.04	-4.28	(614,294)	19,229,341	12.55	1,800,128	21.50	3,084,099
2030/29	62.26	8,843,042	46.68	6,630,939	5.38	763,604	0.32	44,816	-2.39	-2.18	-4.57	(648,407)	20,297,168	13.38	1,900,091	22.21	3,154,777
2031/30	66.30	9,322,929	49.71	6,990,782	5.73	805,042	0.34	47,248	-2.54	-2.32	-4.86	(683,594)	21,398,639	14.25	2,003,203	22.95	3,226,917
	793.89	121,670,176	595.30	91,234,163	68.55	10,506,317	4.02	616,617	-30.43	-27.78	-58.21	(8,921,340)	279,265,898	170.58	26,143,084	425.81	67,449,340

Energy Benefits w/ No Mortality - based on Tree Guidelines data for 30 yr old trees (Coastal Camphor and Inland Shamel ash)

Residential energy simulations asume energy efficient (Title-24 compliant) 2,070 sf residence, and used weather data from LAX and Riverside:

Saturation adjustment is weighted to account for different Unit Energy Consumptions by AC type, assumes trees evenly split by region, and shade on adjacent homes reduces AC use by 15%.

Yr 30 AC Savings Large Tree	East Shade kWh/tree	South Shade kWh/tree	West Shade kWh/tree	Climate kWh/tree	Yard Avg kWh/tree	Yard w/ SAT Adjust	Park Avg kWh/tree	Park w/ SAT Adjust
Coastal	54	83	83	98	171	83	98	41
Inland	190	230	283	135	369	179	135	57
Wtg Avg.	135	171	203	120	290	**140**	120	**51**

Weighted Saturation Adjustments - based on CEC residential consumption forecast data for LADWP

	CAC Sat (%)	Avg UEC kWh	Room AC Sat (%)	Avg UEC kWh	Room AC % UEC/CAC	Evap AC Sat (%)	Avg UEC kWh	Evap AC % UEC/CAC	Weighted Saturation
Coastal	11.60%	750	20.20%	170	22.63%	2.40%	147	19.56%	16.64%
Inland	46.10%	1,593	24.00%	595	37.34%	11.00%	588	36.90%	59.12%
Avg.									42.13%

ECONOMIC ANALYSIS OF LADWP'S "TREES FOR A GREEN LA" SHADE TREE PLANTING PROGRAM - Table 2, Page 3

(continued)

P Value Energy Benefits ($)	P Value of CO2 Benefits ($)	P Value Pollutant Benefits ($)	P Value Runoff Benefits ($)	P Value Aesthetic Benefits ($)	P Value of Total Benefits ($)	Yr
0	(6,200)	0	0	0	(6,200)	2001/0
288,200	27,849	599,070	56,081	313,408	1,284,608	2002/1
325,717	31,139	894,687	83,755	862,078	2,197,376	2003/2
354,992	33,606	1,182,547	110,702	1,106,380	2,788,227	2004/3
377,355	35,389	1,453,999	136,114	1,200,873	3,203,730	2005/4
393,889	36,602	1,705,194	159,629	1,227,371	3,522,686	2006/5
409,632	38,915	1,954,428	182,961	1,233,002	3,818,938	2007/6
421,401	39,859	2,186,228	204,661	1,221,030	4,073,178	2008/7
429,735	40,470	2,400,501	224,720	1,199,296	4,294,722	2009/8
435,102	40,796	2,597,544	243,165	1,172,054	4,488,661	2010/9
437,908	40,878	2,777,879	260,047	1,141,779	4,658,490	2011/10
438,509	40,751	2,942,160	275,426	1,109,927	4,806,774	2012/11
437,217	40,448	3,091,114	289,370	1,077,387	4,935,536	2013/12
434,304	39,995	3,225,495	301,950	1,044,743	5,046,488	2014/13
430,011	39,417	3,346,067	313,237	1,012,362	5,141,094	2015/14
424,549	38,734	3,453,590	323,303	980,460	5,220,635	2016/15
418,103	37,964	3,548,806	332,216	949,188	5,286,277	2017/16
410,836	37,124	3,632,436	340,045	918,658	5,339,099	2018/17
402,892	36,229	3,705,175	346,855	888,907	5,380,056	2019/18
394,396	35,289	3,767,684	352,706	859,975	5,410,051	2020/19
385,461	34,316	3,820,613	357,661	831,880	5,429,931	2021/20
376,181	33,319	3,864,564	361,776	804,595	5,440,434	2022/21
366,643	32,306	3,900,117	365,104	778,178	5,442,348	2023/22
356,921	31,284	3,927,825	367,698	752,552	5,436,280	2024/23
347,079	30,259	3,948,213	369,606	727,733	5,422,890	2025/24
337,173	29,237	3,961,775	370,876	703,696	5,402,757	2026/25
327,252	28,221	3,968,988	371,551	680,430	5,376,443	2027/26
317,359	27,216	3,970,295	371,674	657,901	5,344,445	2028/27
307,529	26,225	3,966,119	371,283	636,106	5,307,261	2029/28
297,793	25,250	3,956,864	370,416	615,013	5,265,336	2030/29
288,179	24,293	3,942,903	369,109	594,590	5,219,075	2031/30
11,372,318	1,027,178	91,692,880	8,583,700	27,301,551	139,977,627	
					139,977,627	check

BENEFIT-COST ANALYSIS SUMMARY

Summary of Program Costs

Type	Number	Avg $/tree	Total Cost
Yard Trees:	190,000	$40	$7,600,000
Park Trees:	10,000	$40	$400,000
Total Trees	200,000	$40	$8,000,000

Summary of Program Benefits

Type	PV Benefits Yard Trees	PV Benefits Park Trees	PV Benefits All Trees
Energy:	$11,160,935	$211,383	$11,372,318
CO2:	$984,710	$42,467	$1,027,178
Air Pollution:	$87,108,236	$4,584,644	$91,692,880
Stormwater:	$8,154,515	$429,185	$8,583,700
Aesthetics:	$25,936,474	$1,365,078	$27,301,551
TOTAL:	$133,344,870	$6,632,757	$139,977,627

Net Present Value (Benefits -Costs):

Yard Trees:	$125,744,870
Park Trees:	$6,232,757
Total Trees:	$131,977,627

Benefit to Cost Ratio (Benefits/Costs): 17.5

Benefit to Cost Ratio (Energy Only): 1.4

Estimated Annual Savings (All Trees):

Average Energy:	16,172	MWh / yr
Average CO2:	29,009	ton / yr

Estimated Annual Savings (Per Tree Planted):

Average Energy:	81	kWh / yr
Average CO2:	290	lb / yr

Total Benefits Per Tree Planted (30 Years)

Benefit Type	Res Unit/Tree	PV Benefits/Tree
Energy (kWh)	2,426	$56.86
CO2 (lb)	8,703	$5.14
Air Pollutants (lb)	85	$458.46
Stormwater (gal)	34,440	$42.92
Aesthetics	na	$136.51
Total		$699.89
Average PV Benefits Per Year Per Tree Planted:		$23.33