Treenet Proceedings of the 3rd National Street Tree Symposium: 5th and 6th September 2002
ISBN 0-9775084-2-0

THE ECONOMIC VALUE OF TREES IN URBAN AREAS: ESTIMATING THE BENEFITS OF ADELAIDE'S STREET TREES

Phillip Killicoat, Eva Puzio & Randy Stringer - School of Economics and Centre for International Economic Studies, University of Adelaide

Introduction and Overview

As populations become increasingly urbanised, national governments to local councils are recognising that the trees that line our streets, fill our parks and shade our houses make up an urban forest. Urban forests provide multiple benefits that go far beyond adding an aesthetic beauty to our neighbourhoods**.** Trees in parts, streets and yards, conserve energy, reduce carbon dioxide in the atmosphere, improve air quality, reduce storm runoff, enhance the beauty of our communities by adding colour, texture, and form to our landscapes.

In addition, no matter where trees are located, they represent an interdependent part of complex ecosystems capable of providing a wide range of economic, social and environmental benefits. All these benefits should be considered when attempting to measure the economic, social and environmental benefits of our street trees. These benefits and services, however, are valued differently by different people and different groups in society. Local, regional, national and international interests in our urban trees and the resources they provide also differ greatly and tend to shift over time.

As interests shift and expectations conflict, difficult policy and management challenges are created, requiring innovative national, regional and local strategies that better integrate urban trees into community development efforts and balance economic, social and environmental needs among local, national, and even international interests. The emerging views of what urban trees are and what they contribute requires local governments to search for pragmatic management strategies that deal coherently with both the contributions of trees to urban development and to search for organisational structures to make better use of these contributions.

The roles of urban forestry in general, and street trees in particular (ie., the knowledge, concepts, institutions and practices through which multiple and competing demands for trees are managed), are changing as well. The changes are emerging as awareness grows of how local communities control and depend on trees and urban forests, prompting efforts to strengthen local stakes in urban forestry and street tree management, programs and activities.

Developing effective forestry strategies and policies involves an array of difficult choices. Some choices result in inefficient resource use because many essential benefits and services of street trees, such as aesthetic values, watershed protection, conservation, biological diversity and climate regulation are not priced. Markets with corresponding prices just do not exist for many important street tree services and benefits. The result is that street tree decisions are often biased because information is lacking.

An important message of this paper is that it is very difficult to address the total economic, social and environmental benefits of street trees because of the multiple roles and the competing interests. To some, street trees represent a nuisance, dropping their fruit, branches, and leaves, raising side walks or shading their 'heritage' roses. To others, street trees are a noise barrier and an air filter, adding value to their neighbourhood and their properties.

Urban forests as part of the development process

In general, Australia's forests need to be better recognised as an integral part of national and urban economies. Trees and forests contribute to urban development in many ways, including as natural capital, as production inputs and as environmental goods. Several factors help explain how urban trees contribute to Adelaide's development strategies.

First, urban trees are undergoing 'urbanization'. Urban trees are increasingly managed for their range of resource flows, their ability to support urban welfare, and their capacity to promote growth opportunities. Urban trees provide large albeit different ranges of goods and services for virtually all patterns of urban settlement and livelihood.

Second, urban development strategies are beginning to include the capital values of forests in policies and programs that modify tree stocks, qualities and distributions. Urban trees are more widely acknowledged as both *productive capital stocks* and as components of *public infrastructural systems.* As ecological analogs of industrial capacity and physical infrastructure, urban trees are entering the central equations of urban growth, often with new definitions of what trees are and do.

Advances in accounting practices make it possible to explicitly incorporate the capital value of trees as *productive stocks*, and to assess the effects of changes in them on productive capacity. Conventional accounting systems overstate national income in two ways. First, the accounts disregard depreciation of tree capital. Second, the costs of mitigating or offsetting the side effects of resource depletion (eg. electric power reducing contributions of urban trees) are not subtracted from national income. This sends the wrong message about the full contributions that urban tress make.

As *infrastructure,* street trees provide services that otherwise would require capital expenditures or reductions in human wellbeing. Urban trees cool cities, conserve energy, reduce runoff, and absorb pollutants, substituting for more conventional infrastructure that otherwise would be needed. Strategically placed trees can reduce home air conditioning needs by providing shade on buildings, houses and street pavements and side walks. Although the concept of urban forests as infrastructure is not yet widely held, the absence of trees clearly requires constructed infrastructure at a cost to other potential uses of scarce capital.

Third, urban trees represent productive assets that can be used as a means for attaining urban development objectives, including attracting new investment and growth. Community tree programs also encourage civic participation. For all of these reasons, urban forest politics and policies need to evolve out of a narrow sectoral prerogative to enter broader mainstream political interests involving highly diverse groups. The emergence of organisations like TREENET demonstrate how urban forests are gradually becoming topics of discussion among articulate groups of tree specialists, city dwellers, scientists and educators.

Estimating the benefits and costs of street trees in Adelaide

Estimating the financial, economic, social and environmental benefits and costs of Adelaide's street trees requires a detailed study well beyond the scope of this report. Nevertheless, inferences from other studies on the value of trees provide useful insights into the costs individuals, communities and taxpayers nation wide would be facing.

For example, the benefits trees provide for climate modification and energy conservation is crucial for South Australia residential and commercial offices. Some 95 percent of South Australia's population lives in urban forests and a major part of the state's electricity consumption is due to heating and cooling. The following examples from a range reports illustrate the economic value of these benefits to other communities[1].

Air temperature: reductions from 1 to 8 ºC can be expected due to the presence of tree cover. For instance, temperatures in a Davis, California neighbourhood were as much as 7 ºC cooler than recorded at the same time in a nearby unirrigated field[2].

***Wind speed**:* reductions in wind speed of up to 10 percent can be obtained by providing tree canopy. This may cause small increases in cooling load in some cases, somewhat larger reductions in heating load more than offset the increased cooling load.[3]

Building energy use for heating and cooling: Trees reduce building energy use by lowering temperatures and shading buildings during the summer, and blocking winds in winter Trees also increase energy use by shading buildings in winter, and may increase or decrease energy use by blocking summer breezes. Thus, proper tree placement near buildings is critical to achieve maximum building energy conservation benefits.

When building energy use is lowered, power plants pollutant emissions are lowered. Lower pollutant emissions generally improve air quality and lower nitrogen oxide emissions, particularly ground-level emissions, may lead to a local increase in ozone concentrations under certain conditions due to nitrogen oxide scavenging of ozone. The cumulative and interactive effects of trees on meteorology, pollution removal, and VOC and power plant emissions determine the overall impact of trees on air pollution.[4]

---

[1] This material is from Simpson, J.R. and E.G. McPherson. 1999. *Energy and air quality improvements through urban tree planting*. In: Proceedings of the Ninth National Urban Forest Conference, Sept. 3-11, Seattle, Washington, American Forests, In Press.

[2] Myrup, L.O., McGinn, C.E. and Flocchini, R.G., 1993: *An Analysis of Microclimatic Variation in a Suburban Environment*. Atmospheric Environment. 27B, 129-156.

[3] Heisler, G.M. 1990. Mean wind speed below building height in residential neighborhoods with different tree densities. ASHRAE Transactions. 95(Part 1):1389-1396. and Heisler, G.M. 1990. Mean wind speed below building height in residential neighborhoods with different tree densities. ASHRAE Transactions. 95(Part 1):1389-1396.

[4] David J. Nowak 1999, *The Effects Of Urban Trees On Air Quality* USDA Forest Service, Syracuse, NY.

Shade: Trees shading building surfaces reduce a major source of heat gain and hence air conditioning cooling load. Reduced solar heat gain in winter leads to small increases in heating load. Annual air conditioning savings from 3 trees, each 25-ft tall around a typical California residence, ranged from $23 in San Diego California to $83 in El Centro California[5].

A number of studies document the effects of urban trees on energy use and air quality[6]:

a)Direct shade from proposed planting of 11 million trees in the Los Angeles basin are predicted to result in $50 million reduction in annual air conditioning bills;

b)Cooling of air by these trees will save an additional $35 million annually;.

c)Cooler air temperatures reduce smog concentrations by 6%, resulting in an estimated savings of $180 million annually, assuming an offset commodity market existed for ozone;.

d)The total present value of these benefits for a single tree is $211 assuming a 20 year service life and 3% real discount rate;.

e)The cost of a tree planting program is estimated to be $35 per tree, resulting in a benefit-cost ratio of 6.0

Sacramento Shade [7]

a)From 1990 to 1996, over 200,000 trees were planted through Sacramento Shade, a partnership between the Sacramento Municipal Utility District (SMUD) and the Sacramento Tree Foundation.

b)Sacramento Shade has a benefit-cost ratio (BCR) of 1.1. This BCR includes benefits from direct shading only. If air temperature cooling effects are considered the BCR doubles to about 2.2.

Sacramento County[8]:

a)Each year about 1,300 GWh (1GWh = 1,000,000 kWh) of electrical energy is used for air conditioning in Sacramento County, at a retail cost of about $105 million.

b)The 6 million trees that comprise Sacramento's existing urban forest are responsible for annual savings of approximately 157 GWh of air conditioning electricity due to shading and cooling effects.[9]

---

[5] Simpson, J.R.; McPherson, E.G. 1996. *Estimating urban forest impacts on climate-mediated residential energy use.* In: Preprints of 12th Conference on Biometeorology and Aerobiology. Boston. American Meteorological Society. pp. 462-465.

[6] Ibid

[7] Simpson, J.R. and E.G. McPherson. 1998. Simulation of tree shade impacts on residential energy use for space conditioning in Sacramento. Atmospheric Environment: Urban Atmospheres, 32:69-74.

[8] McPherson, E.G. 1996. Urban forest landscapes, how greenery saves greenbacks. Wagner, C., ed. 1996 Annual Meeting Proceedings, American Society of Landscape Architects. Washington, DC. ASLA. pp. 27-29.

[9] Simpson, J.R.; McPherson, E.G. 1995. Impact Evaluation of the Sacramento Municipal Utility District's Shade Tree Program. Davis, CA. USDA Forest Service, Western Center for

c) Energy conservation stemming from trees saves Sacramento residents approximately $19.8 million each year.

d) The 6 million trees in Sacramento County absorb 1,457 m tons of air pollutants annually (ozone, nitrogen dioxide, particulate matter) with an implied value of $28.7 million.

e) Through energy conservation these trees reduce emissions of carbon dioxide from power plants, as well as directly remove atmospheric carbon dioxide during their growth process and store it as woody biomass. Approximately 238,000 m tons of CO2 are removed by the region's urban forest each year, with an estimated value of $3.3 million.[10]

f) These environmental benefits total approximately $8 per tree per year, and increase to about $90 once benefits such as increased property values, scenic beauty, wildlife habitat, community bonding, and recreation are added. Sacramento residents are estimated to spend about $5 to 10 per tree each year for watering, pruning, pest/disease control, and removal of dead trees. The Sacramento City Tree Services Division spends about $20 per tree to manage 150,000 street and park trees. Hence, initial research indicates that benefits are several times greater than costs. [11]

Removal of Air Pollutants:

Trees remove gaseous air pollution and some airborne particles. Some particles can be absorbed into the tree and others returned to the atmosphere (by rain back to the ground with leaf and twig fall). New York City trees removed an estimated 1,821 metric tons of air pollution at an estimated value to society of $9.5 million in 1994. The value in other U.S. cities included Atlanta (1,196 t; $6.5 million) and Baltimore (499 t; $2.7 million).

Large healthy trees greater than 77 cm in diameter remove approximately 70 times more air pollution annually (1.4 kg/yr) than small healthy trees less than 8 cm in diameter (0.02 kg/yr).[12] In urban areas with contiguous forest stands tree cover, short-term improvements in air quality (one hour) from pollution removal by trees were as

---

Urban Forest Research. 35p.

[10] McPherson, E.G. 1998. *Atmospheric carbon dioxide reduction by Sacramento's urban forest*. Journal of Arboriculture. 24(4): 215-223.

[11] McPherson, E.G.; Simpson, J.R.; Scott, K.I. In Press. *Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models*. Atmospheric Environment:Urban Atmospheres. McPherson, E.G. 1998. *The Sacramento Urban Forest Ecosystem Study: Urban Greenery Saving Greenbacks*. In: Kollin, C. ed. Cities by Nature's Design: Proceedings of the 8th National Urban Forest Conference. Washington, DC: American Forests: 170-173.

[12] Nowak, D.J. 1994d. Air pollution removal by Chicago's urban forest. In: McPherson, E.G, D.J. Nowak and R.A. Rowntree. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service General Technical Report NE-186. pp. 63-81.

high as 15% for ozone, 14% for sulfur dioxide, 13% for particulate matter, 8% for nitrogen dioxide, and 0.05% for carbon monoxide[13]

Trees serve multiple functions function as "nature's air conditioners" by cooling urban heat islands and shading buildings. As long as trees are growing, their rate of uptake of CO2 through photosynthesis is greater than their release of CO2 through respiration. Trees around buildings can reduce demand for heating and air conditioning, thereby reducing emissions associated with electric power production. Annual CO2 reductions achieved through shade tree programs could offset about .2 to 2% of annual emissions. Not only that, but tree planting and stewardship programs can provide many social, environmental, political and public benefits to utilities as well.

A study on Tree Guidelines for San Joaquin Valley Communities quantified benefits and costs of "green infrastructure" to increase awareness and investment in urban and community forests. The study found that average annual net benefits from large trees such as a London plane can be as much as 6 times greater than from small trees like crape myrtle (the most frequently planted street tree in California). Average annual net benefits (benefits -costs) for a small, medium, and large street tree were $1, $26, and $48, respectively. The Guidelines also describe optimal configurations of trees, recommend tree species for different situations, and identify sources of funding and technical assistance. In June we co-hosted with LGC a one-day workshop on "Strategies for Supporting and Funding the Urban Forest" to follow-up on interest generated by the Guidelines. We regard this publication-workshop format as a model to replicate in other regions as funding becomes available. What is the potential increase in tree plantings in Australia as a result of a carbon credit trading scheme?

The potential value of carbon credits

Uncertainty about the rules for international trading of carbon credits and the emission allowances, sequestration and the related uncertainties associated with forecasting the future to make the prediction of probable permit prices a difficult task. Some emission permit price predictions have arisen from studies that employ various mathematical models. The studies may tend to overstate the potential permit prices suggesting a range of permit price predictions, from $10/tonne to $50/tonne. Carbon credits would have to be below the permit price for them to be an attractive alternative strategy.

Cost-benefit study of Modesto California's urban tree management

A benefit-cost analysis of Modesto California municipal urban forest revealed that for every $1 spent on the 92,000 city-owned trees, residents received nearly $2 in benefits.[14] On average the city spends $29 per tree on management with residents receiving an estimated $55 a year in benefit: a net annual benefit of $26 per tree. The largest benefits are from air pollutant uptake, air conditioning energy savings, and aesthetics. The majority of the city's expenses (74 percent) are for mature tree care.

---

[13] Nowak, D.J. and Crane, D.E. In press. The Urban Forest Effects (UFORE) Model: quantifying urban forest structure and functions. In: Hansen, M. (Ed.) Second International Symposium: Integrated Tools for Natural Resources Inventories in the 21 st Century. USDA Forest Service General Technical Report.

[14] E. Gregory McPherson , *California Trees: Exploring Issues in Urban Forestry* 10(3): 5,9. 1999.

The study concludes that without continued program funding to maintain the health of these trees, the benefits they produce will be lost prematurely. Some 14 per cent of the current tree management budget is spent on sidewalk repair, current studies examining strategies for reducing sidewalk damage have potential to save residents a substantial amount. These strategies include: 1) directing tree roots away from paving such as propagating trees with vertical rooting patterns, 2) engineering designs that are less costly to repair, and 3) providing more space for tree roots through design and planning.

Table 1 summarises many tree benefits, including various estimates of the values associated with those benefits.[15]

Table 1 An overview of tree benefits: selected studies

Temperature and Energy Use
a)Community heat islands (3o to 10oF warmer than surrounding countryside) exist because of decreased wind, increased high density surfaces, and heat generated from human associated activities, all of which requires addition energy expenditures to off-set. Trees can be successfully used to mitigate heat islands.
b)Trees reduce temperatures by shading surfaces, dissipating heat through evaporation, and controlling air movement responsible for advected heat.
Shade
a)20oF lower temperature on a site from trees.
b) 35oF lower hard surface temperature under tree shade than in full summer sun.
c)27% decrease in summer cooling costs with trees.
d)75% cooling savings under deciduous trees.
e)50% cooling energy savings with trees. (1980) 20oF lower room temperatures in uninsulated house during summer from tree shade.
f)$242 savings per home per year in cooling costs with trees.
g)West wall shading is the best cooling cost savings component.
h)South side shade trees saved $38 per home per year.
i)10% energy savings when cooling equipment shaded (no air flow reduction).
j)12% increase in heating costs under evergreen canopy
k)15% heating energy savings with trees. (1980)
l)5% higher winter energy use under tree shade
m)$122 increase in annual heating costs with south and east wall shading off-set by $155 annual savings in cooling costs.
n)Crown form and amount of light passing through a tree can be adjusted by crown reduction and thinning.
o)Shade areas generated by trees are equivalent to $2.75 per square foot of value (1975 dollars).
Wind Control
a)50% wind speed reduction by shade trees yielded 7% reduction in heating energy in winter.
b)8% reduction in heating energy in home from deciduous trees although solar gain was reduced.
c)$50 per year decrease in heating costs from tree control of wind.
d)Trees block winter winds and reduces "chill factor."
e)Trees can reduce cold air infiltration and exchange in a house by maintaining a reduced wind or still area.
f)Trees can be planted to funnel or baffle wind away from areas -- both vertical and horizontal concentrations of foliage can modify air movement patterns.
g)Blockage of cooling breezes by trees increased by $75 per year cooling energy use.
Active Evaporation
a)65% of heat generated in full sunlight on a tree is dissipated by active evaporation from leaf

[15] Kim D. Coder *Identified Benefits of Community Trees and Forests*, The University Of Georgia Cooperative Extension Service Forest Resources Unit Publication, For96-39,University of Georgia, 1996.

surfaces.
b)17% reduction in building cooling by active evaporation by trees.
c)One acre of vegetation transpires as much as 1600 gallons of water on sunny summer days.
d)30% vegetation coverage will provide 66% as much cooling to a site as full vegetation coverage.
e)A one-fifth acre house lot with 30% vegetation cover dissipates as much heat as running two central air conditioners.

Pollution Reduction

a)Community forests cleanse the air by intercepting and slowing particulate materials causing them to fall out, and by absorbing pollutant gases on surfaces and through uptake onto inner leaf surfaces.
b)Pollutants partially controlled by trees include nitrogen oxides, sulfur dioxides, carbon monoxide, carbon dioxide (required for normal tree function), ozone, and small particulates less than 10 microns in size.
c)Removal of particulates amounts to 9% across deciduous trees and 13% across evergreen trees.
d)Pollen and mold spore, are part of a living system and produced in tree areas, but trees also sweep out of the air large amounts of these particulates.
e)In one urban park (212 ha), tree cover was found to remove daily 48 lbs particulates, 9 lbs nitrogen dioxide, 6 lbs sulfur dioxide, and ½ lbs carbon monoxide. ($136 per day value based upon pollution control technology).
f)60% reduction in street level particulates with trees.
g)One sugar maple (one foot in diameter) along a roadway removes in one growing season 60 mg cadmium, 140 mg chromium, 820 mg nickel and 5200mg lead from the environment.
h)Interior scape trees can remove organic pollutants from indoor air.

Carbon Dioxide Reduction

a)Approximately 800 million tons of carbon are currently stored in US community forests with 6.5 million tons per year increase in storage ($22 billion equivalent in control costs).
b)A single tree stores on average 13 pounds of carbon annually.
c)A community forest can store 2.6 tons of carbon per acre per year.

Hydrology

a)Development increases hard, non-evaporative surfaces and decreases soil infiltration -- increases water volume, velocity and pollution load of run-off -- increases water quality losses, erosion, and flooding.
b)Community tree and forest cover intercepts, slows, evaporates, and stores water through normal tree functions, soil surface protection, and soil area of biologically active surfaces.

Water Run-Off

a)7% of winter precipitation intercepted and evaporated by deciduous trees.
b)22% of winter precipitation intercepted and evaporated by evergreen trees.
c)18% of growing season precipitation intercepted and evaporated by all trees.
d)For every 5% of tree cover area added to a community, run-off is reduced by approximately 2%
e)7% volume reduction in six-hour storm flow by community tree canopies.
f)17% (11.3 million gallons) run-off reduction from a twelve-hour storm with tree canopies in a medium-sized city ($226,000 avoided run-off water control costs).

Water Quality / Erosion

a)Community trees and forests act as filters removing nutrients and sediments while increasing ground water recharge.
b)37,500 tons of sediment per square mile per year comes off of developing and developed

landscapes -- trees could reduce this value by 95% ($336,000 annual control cost savings with trees).
c)47% of surface pollutants are removed in first 15 minutes of storm -- this includes pesticides, fertilizers, and biologically derived materials and litter.
d)10,886 tons of soil saved annually with tree cover in a medium-sized city.

Glare Reduction

a)Trees help control light scattering, light intensity, and modifies predominant wavelengths on a site.
b)Trees block and reflect sunlight and artificial lights to minimize eye strain and frame lighted areas where needed for architectural emphasis, safety, and visibility.

Property Values -- Real Estate Comparisons

a)Community trees and forests provide a business generating, and a positive real estate transaction appearance and atmosphere.
b)Increased property values, increased tax revenues, increased income levels, faster real estate sales turn-over rates, shorter unoccupied periods, increased recruitment of buyers, increased jobs, increased worker productivity, and increased number of customers have all been linked to tree and landscape presence.
c)Tree amenity values are a part of real estate prices.
d)Clearing unimproved lots is costlier than properly preserving trees.
e)6% ($2,686) total property value in tree cover.
f)$9,500 higher sale values due to tree cover.
g)4% higher sale value with five trees in the front yard -- $257 per pine, $333 per hardwood, $336 per large tree, and $0 per small tree.
h)$2,675 increase in sale price when adjacent to tree green space as compared to similar houses 200 feet away from green space.
i)$4.20 decrease in residential sales price for every foot away from green space.
j)27% increase in development land values with trees present.
k)19% increase in property values with trees. (1971 & 1983)
l)27% increase in appraised land values with trees. (1973)
m)9% increase in property value for a single tree. (1981)
n)Values of single trees in perfect conditions and locations in the Southeast range up to $100,000.
o)$100 million is the value of community trees and forests in Savannah, GA.
p)$386 million is the value of community trees and forests in Oakland, CA (59% of this value is in residential trees).

Animal Habitats

a)Wildlife values are derived from aesthetic, recreation, and educational uses.
b)Lowest bird diversity is in areas of mowed lawn -- highest in area of large trees, greatest tree diversity, and brushy areas.
c)Highest native bird populations in areas of highest native plant populations.
d)Highly variable species attributes and needs must be identified to clearly determine tree and community tree and forest influences.
e)Trees are living systems that interact with other living things in sharing and recycling resources -- as such, trees are living centers where living thing congregate and are concentrated.
f)The annual ecological contribution of an average community tree is estimated at $270.

Aesthetic Preferences a)Conifers, large trees, low tree densities, closed tree canopies, distant views, and native species all had positive values in scenic quality. b)Large old street trees were found to be the most important indicator of attractiveness in a community. c)Increasing tree density (optimal 53 trees per acre) and decreasing understory density are associated with positive perceptions. d)Increasing levels of tree density can initiate feelings of fear and endangerment -- an optimum number of trees allows for visual distances and openness while blocking or screening developed areas. e)Species diversity as a distinct quantity was not important to scenic quality.
Visual Screening a)The most common use of trees for utilitarian purposes is screening undesirable and disturbing sight lines. b)Tree crown management and tree species selection can help completely or partially block vision lines that show human density problems, development activities, or commercial / residential interfaces.
Health a)Stressed individuals looking at slides of nature had reduced negative emotions and greater positive feelings than when looking at urban scenes without trees and other plants. b)Stressed individuals recuperate faster when viewing tree filled images. c)Hospital patients with natural views from their rooms had significantly shorter stays, less pain medicine required, and fewer post-operative complications. d)Psychiatric patients are more sociable and less stressed when green things are visible and immediately present.
Human Social Interactions a)People feel more comfortable and at ease when in shaded, open areas of trees as compared to areas of hardscapes and non-living things. b)People's preferences for locating areas of social interactions in calming, beautiful, and nature-dominated areas revolve around the presence of community trees and forests. c)Trees and people are psychologically linked by culture, socialization, and coadaptive history.
Recreation a)Contact with nature in many communities may be limited to local trees and green areas (for noticing natural cycles, seasons, sounds, animals, plants, etc.) Trees are critical in this context. b) $1.60 is the willing additional payment per visit for use of a tree covered park compared with a maintained lawn area.
Noise Abatement a)7db noise reduction per 100 feet of forest due to trees by reflecting and absorbing sound energy (solid walls decrease sound by 15 db) b)Trees provide "white noise," the noise of the leaves and branches in the wind and associated natural sounds, that masks other man-caused sounds.

Source: Kim D. Coder *Identified Benefits of Community Trees and Forests*, The University Of Georgia Cooperative Extension Service, Forest Resources Unit Publication, For96-39,University of Georgia, 1996.

Calculating the gross benefits of Adelaide's street trees

Quantifying the exact net value of Adelaide's street trees is beyond the scope of this paper. Instead the aim here to provide an overview of the kinds of benefits and costs that should be considered and estimates, especially for some of the benefits. The costs of street tree management will vary by council, so the responsible officials are best placed to quantify the costs per tree.

The core benefits street trees provide can be captured as follows:

B = E+A+C+H+P+F

Where

B = street tree annual benefits
E = annual price of energy savings (cooling and heating);
Q = annual price of air quality improvement(pollutant uptake and avoided power plant emissions);
C = annual price of carbon dioxide reductions;
H = annual price of stormwater runoff reductions;
P = annual price of property value and related benefits;
F = annual savings for reductions in repaving streets.

A suggested formula for estimating annual costs is:

C = M+T+R+D+I+S+L+A

Where

C = annual costs of street trees;
M = annual price of tree planting;
T = annual price for pruning;
R = annual price of tree removal;
D = annual price for pest and disease control;
I = annual price for repairing tree-damaged infrastructure;
S= annual price of litter and storm clean up;
L = annual insurance costs for street tree liability;
A = annual price for program administration.

Our assumptions include the following:

- The estimated number of street trees in Adelaide is 128,000 (based on 1927km of roadsides;
- If all Adelaide's street trees were removed summer temperatures would be from .5^{o}C to 2^{o}C warmer due to the heat island impact--lack of evapotranspiration and, most importantly, shade on paved streets and side walks;
- The average Adelaide household spends $193 on air conditioning due to heat (more than $80 million per year);

- Spending on air conditioning energy consumption would increase by $20 per household per year if street trees were removed or an increase in 57 million kWh power consumption;
- Difference in street tree growth rates, size, leaf area, and canopy are ignored and a typical medium sized tree is used for a typical tree;
- Street tree CO_2 sequestration is offset by CO_2 released but CO_2 is reduced due to reduced power consumption;
- Air Pollution (Ozone, NO_2, SO_2,PM_{10},VOCs, and BVOCs) are based on California data (city of Buena Vista);
- Power supply in Adelaide is 50 -50 gas and petroleum with .2299 grams carbon per kWh for petroleum and .1562 grams carbon per kWh for gas;
- Street trees contribute 1 percent to average house values (studies suggest 1 to 3 percent) and the average house is $145,000;
- Air quality price is based on average market value of pollution reduction credits in Southern California, USA;
- Our estimated residential energy use for summer cooling is given in the table below; we ignore commercial and industrial savings, but suggest additional savings of around 40 percent of total residential or $3.3 million or $25.6 per street tree;

	Average Input wattage (kW/h)	Mean Estimate Summer Use (Hours)	Total kWh	Price per kWh ($)	Air Cooling expenditure per household per year	Number of Households (1996)	Total power use (Mw)h
Ducted Refrigerative: reverse cycle	5	700	2800	0.1466	$410	83600	234080
Refrigerative: split system wall/window	2.1	700	1323	0.1466	$194	175560	232266
Ducted Evaporative	1.2	700	840	0.1466	$123	83600	70224
Ceiling Fans/Other	0.3	700	210	0.1466	$31	75240	15800

Sources: Paul Spicer: AGL; ABS Census 1996.

Gross annual Benefits from a typical Adelaide Street Trees

BENEFIT CATEGORY	Value
Energy Savings	$64.00
Air Quality	
CO_2 (reduced power output)	$1.00
Air Pollution	$34.50
Storm Water	$6.50
Aesthetics/others	$65.00
Repaving Savings	?
Estimated Gross Benefits	$171.00

Our estimate of gross benefits of a typical Adelaide street tree is $172. As the assumptions above suggest, other than energy savings these numbers are based on extrapolations from other studies in cities with similar climates to Adelaide. These estimates represent only a rough idea of the average annual benefit of a typical street tree in Adelaide. Without, adequate data on prices, tree numbers, and proper computer simulations the numbers only represent an initial 'guestimate'. Moreover, data is needed on how benefits (and costs) differ between tree varieties and tree sizes. However, the authors are confident that the gross benefits would actually be significantly higher if a proper study could be undertaken. The aim here is to provide this initial study to encourage others to confirm or contradict our findings.