Pacific Southwest Research Station
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Science **Perspectives**

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Greener Cities

Center for Urban Forest Research

Trees line a residential city street, providing valuable ecosystem services and other benefits.

A software tool called i-Tree gives cities a means to conduct inexpensive surveys of urban trees and assess the value of their numerous benefits.

U.S. Forest Service Software Package Helps Cities Manage Their Urban Treescape

Urban forests don't get the recognition that natural forests do. They don't encompass sweeping vistas and magnificent views and they don't provide critical habitat to endangered species. Nevertheless, they are vital. More than 90 percent of all Californians live, work, and play in urban forests. Trees in the urban landscape provide vital ecosystem services, including reducing rainwater runoff, cooling urban heat islands, shading nearby buildings, and controlling air pollution.

In fact, urban trees are the ultimate managed forests. To maximize ecological, economical and social benefits, cities need to identify potential planting locations as well as make decisions about what species of trees to use to maximize services and minimize expenses, such as pruning and removal of problem trees.

Unfortunately, many cities find it difficult to manage their treescape because it is expensive to inventory and update urban tree records. Typically, a municipality must hire surveyors who charge $3 to $5 a tree. A city with 25,000 trees might pay $100,000 for a starting inventory and that's a tough sell to city budget planners.

To address these issues, a public/private partnership of scientists and urban foresters has developed a software suite called **i-Tree** (http://www.itreetools.org/), which integrates inventory, analysis, and forecasting tools into one package. Partners include Forest Service Research and Development, Forest Service State and Private Forestry, the Davey Tree Expert Company, the National Arbor Day Foundation, and the Society of Municipal Arborists. The partnership is also providing i-Tree training, marketing, and technical support.

Cities can use i-Tree to conduct inexpensive surveys that estimate the extent of canopy cover and the approximate economic value trees provide, including storm-water control, energy savings, air pollution control, carbon storage, and increases in property value.

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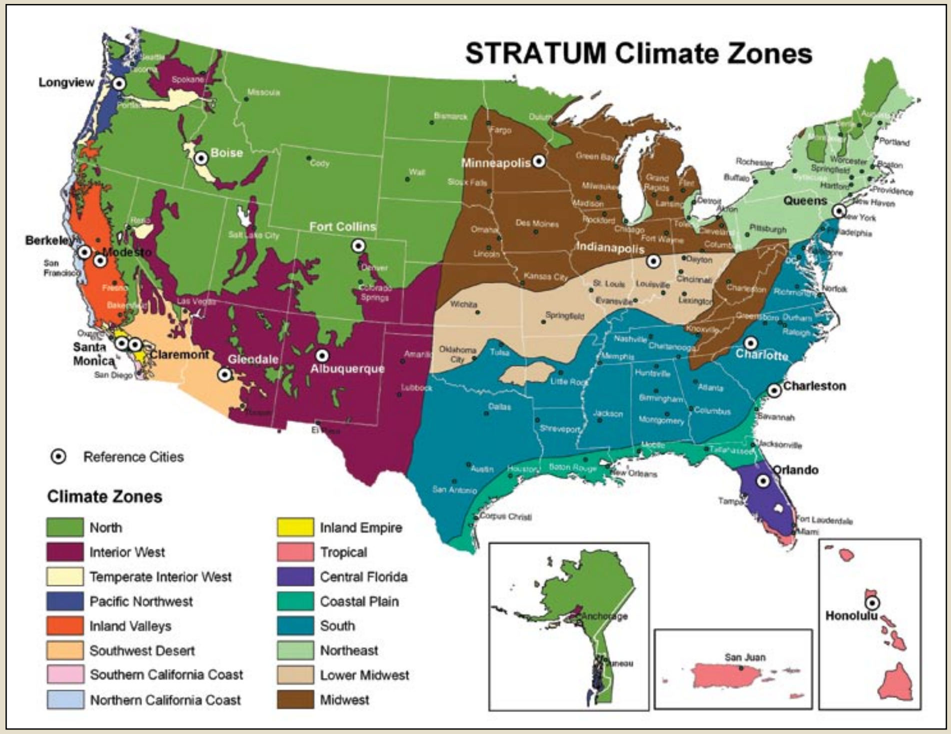
From Research…
…to Management

Research: In September of 2006, Los Angeles Mayor Antonio Villaraigosa announced a plan to plant 1 million trees in the city. Using geographic information systems and satellite images of the city, researchers conducted a canopy analysis and found that about 11 million trees cover about 21 percent of Los Angeles.

Management: The canopy analysis identified gaps in canopy coverage that helped motivate citizens. "A map that comes from satellite imagery compiled by the U.S. Forest Service carries a lot of weight," says George Gonzalez. "Every time I did a presentation I would get gasps from the community because they realized that they really did live in a low canopy area. I may have told them that previously, but it didn't resonate the way it did when I could show them a map. It really helped us get buy-in from stakeholders in areas with low canopy."

Research: U.S. Forest Service researchers used image processing software to mask the areas with existing trees, buildings, paved surfaces, and areas covered by water. The software then identified potential sites where trees could be planted.

Management: The analysis identified 2.5 million potential locations for tree planting. The researchers used reference city data for California coastal (Santa Monica) and inland (Claremont) areas to estimate that over 35 years, 1 million additional trees would provide an economic benefit of $1.3 to $2.0 billion, or $50 to $60 annually for each tree planted. The plan calls for one million trees to be planted by 2016. More than 130,000 trees have been planted so far.

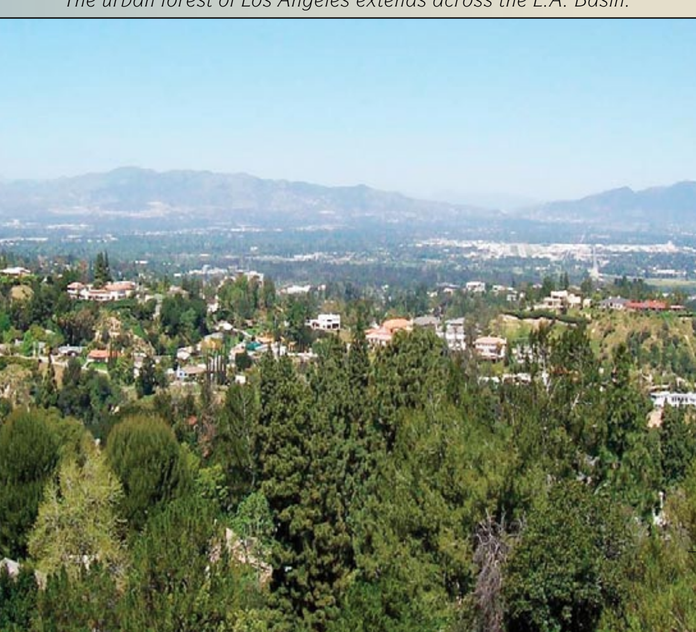


The 16 climate regions for STRATUM.

STRATUM Helps Cities Model Costs and Benefits of Urban Forests

I-Tree STRATUM (**Street Tree Assessment Tool for Urban Forest Managers**) is a useful tool for determining the current status of municipal forests because it can be applied by any city using regionally based tree size data and growth curves. Although more accurate benefit results could be obtained using locally based tree growth curves, the cost of more than $100,000 per city to survey 800 trees and analyze growth data is often prohibitive.

The urban forest of Los Angeles extends across the L.A. Basin.



George Gonzalez, Chief Forester, City of Los Angeles

To address that, Greg McPherson and colleagues at the Pacific Southwest Research Station's Center for Urban Forest Research have created a cheaper alternative by dividing the Nation into 16 climatic zones and conducting in-depth analyses for a reference city in each zone. The reference city research entails extensive data collection on 30 to 60 trees from each of the predominant 20 tree species. Researchers sample leaf biomass, collect data on tree care expenditures, compile environmental data for modeling tree benefits, and determine appropriate monetary values for tree benefits. In summer 2008 the Center for Urban Forest Research completed the last reference city, Orlando, Florida, and is applying their approach with scientists in Lisbon, Portugal, and Padua, Italy. Their reference city research has four outcomes:

- Regional tree guides
- i-Tree STRATUM regional database for use by any city
- Municipal Forest Resource Assessments (MFRAs) using STRATUM
- *Trees in Our City* PowerPoint® presentations

The 14 regional tree guides (a total of 16 are scheduled) extend applicability of the reference city research to all cities in a climate zone. "The idea was to be a little more expansive in terms of the audience, to provide a tool that other cities in the climate region can use to estimate the future benefits and costs of tree planting projects that they might be considering," says McPherson.

Each regional guide contains tables that can be used to make cost/benefit estimates, as well as examples on how to adjust the reference data to match a specific community. The guides offer advice on where to place trees to maximize their cost effectiveness, and also which tree species are likely to have the fewest conflicts with power lines, sidewalks, and buildings. The regional guides are designed to help cities estimate the future benefits of a tree planting.

STRATUM on the other hand, provides a snapshot of a city's current canopy cover. It also estimates annual costs and benefits. The program accepts data from a sample or full inventory of a city's trees. Then, it generates an estimate of the annual aesthetic and environmental benefits, including energy conservation, air quality improvement, carbon dioxide reduction, stormwater control, and property value increases.

Midwest Center for Urban and Community Forestry

In St. Paul, Minnesota, trees around the capitol were labeled with price tags indicating the value of benefits they had provided to the residents of the city.

STRATUM incorporates information on management costs, as well as regional data on building construction, energy use, and air pollution concentrations. It can produce various reports that include comparisons of canopy cover in different neighborhoods, conflicts with power lines and sidewalks, and the performance of individual tree species.

In five cities, STRATUM demonstrated that cities gained $1.37 to $3.09 in benefits for every dollar invested in tree management.

Municipal Forest Resource Assessments (MFRAs) are produced using STRATUM and provide a much more in-depth look at a city's urban forest. They estimate the energy conservation, air quality, stormwater runoff control, and property value increases conferred by trees. Reports include management recommendations regarding species to plant, optimal pruning cycles, and tree removal and replacement programs. They also present strategies to reduce conflicts between trees, sidewalks, and power lines, and techniques to ensure space for trees in new developments.

In New York City, the MFRA produced dramatic results. Street trees there are providing $5.60 in benefits for every $1 spent on tree planting and care. In 2005, the city's parks and recreation department began a major street tree inventory, and wanted to be able to run the inventory results through STRATUM to quantify the benefits of these trees.

As it turned out, McPherson was still completing work on the reference cities for the regional guide project, and he hadn't completed a reference city for the Northeast region where New York City is located. "He was kind enough to put it on the front burner and suggested a portion of New York City as a reference city… He and his scientists looked at Queens and realized that it was representative," Watt recalls. "So while we conducted our street tree inventory, Greg led a reference city study."

This study resulted in publication of the New York City Municipal Forest Resource Analysis. The STRATUM analysis found that street trees annually produced $122 million in benefits to New York City, including improved air quality, rainwater uptake, and increased property values. That monetary value helped planners show that tree benefits can offset their anticipated costs. "It was a

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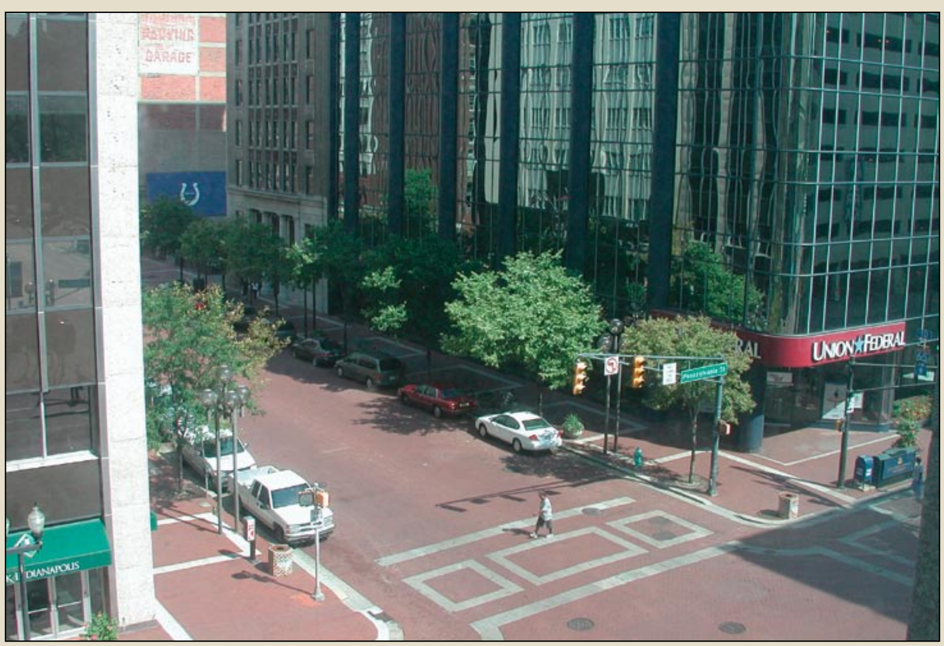
Center for Urban Forest Research

Old trees shade historic New York City brownstones.



Center for Urban Forest Research

Young city trees will eventually pay big returns to residents and visitors in downtown Indianapolis.

A Conversation with Greg McPherson

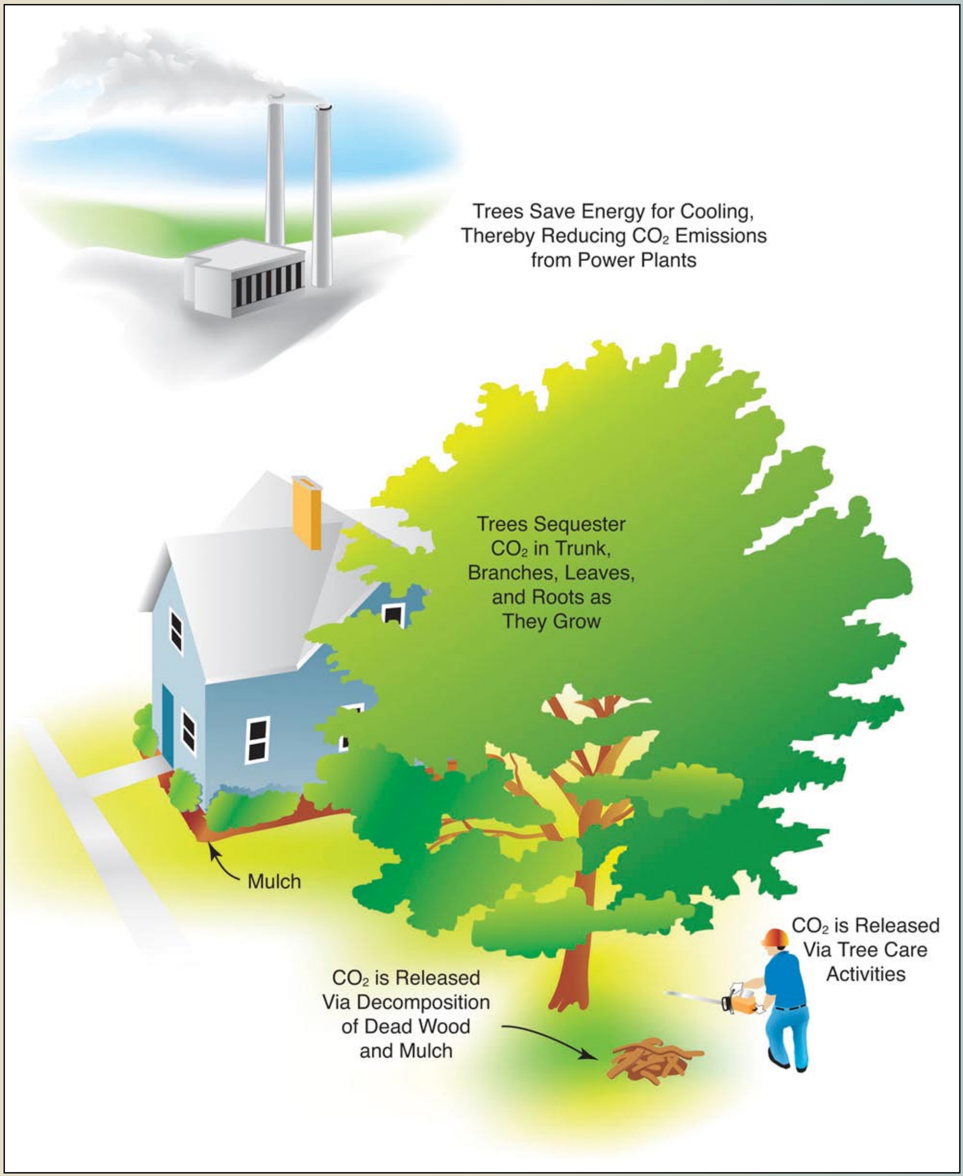
Q ***Describe how i-Tree STRATUM works.***

It calculates the annual dollar value of the benefits that trees are producing, based on measurements of individual trees. If our numerical models tell us that a European ash tree that is 4.5 inches in diameter at chest height will provide 100 kilowatt hours of energy savings in a year and that the inventory for a city has 1,000 European ash trees that are 3 to 6 inches in diameter, then we'd multiply that 1,000 trees by 100 kilowatt hours to get air conditioning savings. That's the idea.

Q ***Trees provide important services such as controlling stormwater and reducing air pollution. How do these processes work?***

Trees act as miniature reservoirs. Their leaves and branches soak up and store rainwater, which reduces the initial runoff and postpones the peak volume of runoff water following a storm. Some of the water that soaks into the soil is later released to the atmosphere through transpiration from the leaves. The canopy also shields soil from the impact of the rain droplets, reducing erosion.

Within the soil, tree roots also have an important effect on the soil. Their growth and decomposition can increase the soil moisture storage capacity and the rate at which the soil absorbs water.



Trees sequester CO_2 as they grow and indirectly reduce CO_2 emissions from power plants through energy conservation. At the same time, CO_2 is released through decomposition and tree care activities that involve fossil-fuel consumption. (Drawing by Mike Thomas.)

Air quality improvement occurs through several mechanisms. Leaf surfaces absorb gaseous pollutants, such as ozone, nitrogen oxides, and sulfur dioxide, some of which the tree may use as nutrients. They also act as a sort of air filter, intercepting particulates such as smoke, ash, pollen, and dust. Trees improve air quality indirectly by reducing building air conditioning use, which leads to reduced electricity use and less pollutants emitted from power plants.

Some pollutants wash off trees during rainfall, while others—including heavy metals—are absorbed via the soil. The ultimate fate of the pollutants depends on the type of pollutant, species of tree, and disposition of removed leaves and woody biomass. Some pollutants are sequestered for a long time, while others, such as particles on leaves, fall and make their way into the surrounding soil or receiving water bodies via stormwater runoff.

Q ***What about greenhouse gases?***

Trees can help out in several ways. They sequester carbon dioxide in the form of woody biomass, and they reduce energy consumption and power plant emissions by shielding buildings in the summer months. Removed wood can be used as fuel for biopower plants, thereby displacing fossil-fuel power plant emissions. Also, some removed urban tree wood can be utilized for wood products. Of course, greenhouse gases are released by motor vehicles and equipment used to maintain trees in the urban forest.

Scientist Profile

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Carmen Alvarez

Greg McPherson received his undergraduate degree at the University of Michigan in 1975 and then went to work for a nursery and landscape design company in suburban Detroit. He received an associate's degree in landscape and nursery management at Michigan State University. His interests shifted to design, so he went to Utah State University in 1977 to get a master's degree in landscape architecture, but he discovered that landscape design wasn't a good fit. "I found out I wasn't a very good designer, but I saw the power in quantifying things and the value of that, so I decided to get a Ph.D. in urban forestry," McPherson recalls.

He went on to earn a Ph.D. in urban forestry at the State University of New York-Syracuse and eventually went to work at the University of Arizona's renewable natural resources program, where he taught landscape architecture and urban forestry. In 1991, his mentor at Syracuse, Rowan Rowntree, received funding to conduct a 3-year study called the Chicago Urban Forest Climate Project (CUFCP). McPherson agreed to lead the study, which became widely recognized as the Nation's most comprehensive study of urban forest structure and function. Other researchers adopted approaches developed by the CUFCP team, and study personnel became increasingly sought after for participation in similar types of studies. At the conclusion of the study, Rowntree established the urban forest research program at the Pacific Southwest Research Station's Center for Urban Forest Research and hired McPherson to become its director.

McPherson developed his interest in urban forestry as his career evolved. "I was always interested in plants, particularly trees, beginning with my work at the nursery," he says. "When I did my master's thesis on the effects of tree shade on energy use in buildings, I became interested in trees and energy conservation and buildings. So I decided to either go into architecture or urban forestry, and I felt like I had more interest in forestry and trees than I did in the buildings and their design and architecture."

McPherson chairs the International Society of Arboriculture's Science and Research Committee. In 2000, he received the society's L.C. Chadwick Award for Arboricultural Research. ■

Urban Treescape *(from cover)*

Despite the fact that many cities have taken advantage of this resource and convinced some policymakers to make major investments in urban forests (see STRATUM story on page 2), officials in many cities still haven't fully bought into the value of trees, says George Gonzalez, who is chief forester for the City of Los Angeles and also serves on a committee of the American Public Works Association. "It hasn't seeped into their decisionmaking yet, but I'm optimistic that at some point it will," he says. "Certainly the community starts to see trees differently. As urban foresters, we've known for a long time that trees have a higher value than just aesthetics, but i-Tree helps us articulate that argument."

Fiona Watt, who is chief of forestry and horticulture at the New York City Department of Parks and Recreation, agrees with that assessment. "Before the Forest Service's work on quantifying the values of trees, trees were more of a feel-good issue than anything else, and the resources allocated to tree planting and maintenance really waxed and waned with the level of public advocacy," she says. "The scientific work over the last decade has really helped everyone articulate that trees can be viewed as very productive infrastructure. Seeing trees in that way makes people value them more."

To help convince policymakers, local advocates can use PowerPoint® presentations developed by the i-Tree research team. Each presentation can be customized with regional data and photographs. ■

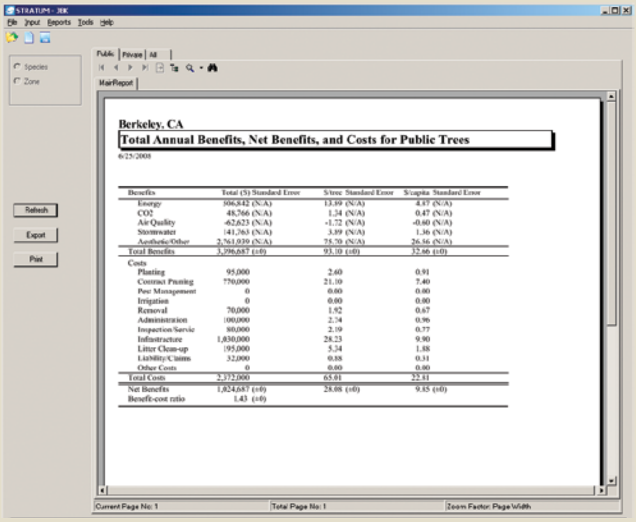
STRATUM *(from page 3)*

way for policymakers to have some perspective about the real costs and benefits of trees," says Watt.

In April 2007, New York City Mayor Michael Bloomberg outlined a plan for creating a sustainable city in which trees figured prominently. The STRATUM results provided Watt and her colleagues with information for Mayor Bloomberg's sustainability planning staff. "It really formed the basis of our policy discussions, and as it turns out, trees are one of the environmental cornerstones of that (sustainable city) plan," says Watt.

Mayor Bloomberg's plan calls for planting a street tree in just about every site that can accommodate one, and the expectations are that the trees will bring health benefits as well as environmental improvements. For example, air pollution is a major problem in New York, and the city has high rates of asthma that might be improved by more trees. "Mayor Bloomberg is looking at trees as an environmental good that we can bring to neighborhoods in need, both neighborhoods with low canopy coverage and neighborhoods with higher public health burdens," says Watt.

The sustainable city plan includes a number of other elements, including creating new forests on 2,000 acres of city park land and construction of 800 new street gardens, with trees and shrubs planted in triangular patches near intersections. It calls for an impressive $380 million in new funds for urban forestry efforts over the next 10 years, including reforestation, neighborhood tree planting, and street garden construction. Additional funds have been allocated to increase staffing to care for all the new trees. ■



Berkeley, CA

Total Annual Benefits, Net Benefits, and Costs for Public Trees

6/25/2008

Benefits	Total ($) Standard Error	$/tree Standard Error	$/capita Standard Error
Energy	306,842 (N/A)	13.39 (N/A)	4.47 (N/A)
CO2	48,766 (N/A)	1.34 (N/A)	0.47 (N/A)
Air Quality	-62,623 (N/A)	-1.72 (N/A)	-0.60 (N/A)
Stormwater	141,763 (N/A)	3.89 (N/A)	1.36 (N/A)
Aesthetic/Other	2,761,939 (N/A)	75.70 (N/A)	26.56 (N/A)
Total Benefits	3,396,687 (±0)	93.10 (±0)	32.66 (±0)
Costs			
Planting	95,000	2.60	0.91
Contract Pruning	770,000	21.10	7.40
Pest Management	0	0.00	0.00
Irrigation	0	0.00	0.00
Removal	70,000	1.92	0.67
Administration	100,000	2.74	0.96
Inspection/Servic	80,000	2.19	0.77
Infrastructure	1,030,000	28.23	9.90
Litter Clean-up	195,000	5.34	1.88
Liability/Claims	32,000	0.88	0.31
Other Costs	0	0.00	0.00
Total Costs	2,372,000	65.01	22.81
Net Benefits	1,024,687 (±0)	28.08 (±0)	9.85 (±0)
Benefit-cost ratio	1.43 (±0)		

A STRATUM report shows total annual benefits, costs, and net benefits of the Berkeley, California, municipal forest.

What's Next

Ongoing projects include an effort to quantify carbon storage by street trees in Chattanooga, Tennessee, and a statewide project in Indiana using i-Tree STRATUM to inventory and determine the costs and benefits of municipal forests.

The Street Tree Simulator (STS) will extend STRATUM's snapshot-in-time capability to predict how management decisions will affect the future health and functionality of the community forest. One of its modules estimates the budget required to maximize the services generated by the trees in a 5- to 10-year planning period. Another uses a constrained budget estimate to prioritize expenditures. The Street Tree Simulator runs a model that follows the growth and death of trees, and predicts the effects of changes in pruning cycles on the health of trees and the ecosystem services they provide. In short, STS allows community foresters to predict how current funding decisions are likely to impact the future of the urban forest. ■

Writer's Profile: Jim Kling is a science writer based in Bellingham, Washington. His work has appeared in *Science* magazine, *Scientific American*, *Technology Review*, and other publications. Ecology is often an important theme in his science fiction stories, which he has published in *Nature*.

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For Further Reading

Dwyer, J.F.; McPherson, E.G.; Schroeder, H.W.; Rowntree, R.A. 1992. **Assessing the benefits and costs of the urban forest**. Journal of Arboriculture. 18(5): 227–234.

Maco, S.E.; McPherson, E.G. 2003. **A practical approach to assessing structure, function, and value of street tree populations in small communities.** Journal of Arboriculture. 29(2): 84–97.

McPherson, E.G. 1992. **Accounting for benefits and costs of urban greenspace**. Landscape and Urban Planning. 22: 41–51.

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

McPherson, E.G.; Nowak, D.; Heisler, G.; Grimmond, S.; Souch, C.; Grant, R.; Rowntree, R. 1997. **Quantifying urban forest structure, function, and value: The Chicago Urban Forest Climate Project**. Urban Ecosystems. 1: 49-61.

McPherson, E.G.; Simpson, J.R. 2002. **A comparison of municipal forest benefits and costs in Modesto and Santa Monica, California, U.S.A.** Urban Forestry & Urban Greening. 161–174.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Xiao, Q. 2005. **Municipal forest benefits and costs in five U.S. cities.** Journal of Forestry. 103(8): 411–416.

McPherson, E.G. 2007. **Benefit-based tree valuation.** Arboriculture & Urban Forestry. 33(1): 1–11.

McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. 2007. **Northeast Community Tree Guide: Benefits, Costs, and Strategic Planting.** Gen. Tech. Rep. PSW-GTR-202. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 95 p.

McPherson, E.G.; Simpson, J.R.; Xiao, Q.; Wu, C. 2008. **Los Angeles 1-Million Tree Canopy Cover Assessment. Gen. Tech. Rep.** PSW-GTR-207. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 52 p.

Scott, K.I.; McPherson, E.G.; Simpson, J.R. 1998. **Air pollutant uptake by Sacramento's urban forest**. Journal of Arboriculture. 24(4): 224–234.

Simpson, J.R.; McPherson, E.G. 1998. **Simulation of tree shade impacts on residential energy use for space conditioning in Sacramento**. Atmospheric Environment: Urban Atmospheres. 32(1): 69–74.

Xiao, Q.; McPherson, E.G.; Simpson, J.R.; Ustin, S.L. 1998. **Rainfall interception by Sacramento's urban forest**. Journal of Arboriculture. 24(4): 235–244.

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