NEW ADVANCES IN QUANTIFYING THE ENVIRONMENTAL BENEFITS OF TREES

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ABSTRACT: The urban forest provides environmental services that are often unpriced and underappreciated. This paper summarizes the latest research and technology tools developed to help managers optimize these benefits.

Urban Forest Benefit-Cost Analysis

The Center has refined a theoretical approach for greenspace accounting and conducted research quantifying urban forest benefits and costs. Findings are included in commercial products such as CityGreen, American Forest's GIS-based program. Benefit Cost Analysis (BCA) results, as well as modeling tools have been eagerly adopted by professionals and volunteers.

The two-year Modesto Municipal Urban Forest BCA was the first in-depth analysis of annual costs and benefits associated with a municipal street and park tree population (McPherson et al. 1999). It answered the question; Do the accrued benefits from Modesto's urban forest justify an annual municipal budget of over $2 million? The Modesto study extended previous work by: 1) focusing on the street and park tree population, 2) accounting for all management costs, 3) using locally derived dimensional/leaf area data for common tree species to project their future annual benefits and costs, and 4) creating a new BCA modeling system that functions at the species-level.

This study was influential in Modesto. It not only helped City Council members decide to retain existing funding for the tree program in the face of overall budget cuts, but spurred formation of the new non-profit Modesto Tree Foundation through a $25,000 investment by the local electric utility and city. The Foundation is increasing participation by schools, residents, and businesses in tree planting and stewardship. Similar BCA studies are nearly complete for Santa Monica, Claremont, and Longview, WA.

Tree Guidelines for California Communities

The Center has developed a series of Tree Guideline publications for different California regions that extend municipal benefit-cost data described above to other communities in the region, plus add new information on benefits and costs of trees in residential landscapes (McPherson et al. 1999, 2000, 2001). The Guidelines also present information on program design and implementation, optimal configurations of trees, tree species for different situations, techniques for successful establishment of new trees, and sources of funding and technical assistance. Guidelines are being developed for other regions in the West.

The Guidelines inform decision makers in local communities. For instance, in testimony before the San Diego City Council, People for Trees cited results from the guidelines showing that investing in urban forests reaps significant rewards and significant cost savings to the City through the reduction of crisis management. In addition, sequestration of harmful air pollutants, watershed management, along with other testimonies, led the City to fund an additional $500,000 toward tree care. These are the first significant monies for shade trees in over 30 years!

Urban Tree Biometrics

Our research has developed new knowledge concerning the dimensions, leaf area, and annual growth of trees in California cities. Because accurate estimates of tree growth and leaf area are fundamental to accurate modeling of many urban forest functions (i.e., rainfall and particulate interception, evapotranspiration, shading) this knowledge has strengthened the scientific underpinnings for analysis of urban forest function and value.

Rainfall Interception

This research developed new knowledge in three areas: 1) a method for measuring rainfall interception by open grown trees (Xiao et al. 2000a) 2) a one-dimensional model of urban forest interception (Xiao et al. 1998), and 3) a three-dimensional interception model for open-grown trees (Xiao et al. 2000b). The measurement technique overcomes important limitations of other approaches used in forests and in the open (e.g., adhesion to sheeting, losses due to

splashing or debris blocking gutter, low temporal resolution). This research has generated new knowledge about the interception process for open- grown trees that makes it possible to more accurately estimate impacts of urban forests on stormwater runoff and flooding. Current research is quantifying the surface detention storage capacities of common tree species (foliage, stems, and bole) and modeling the amount of rainfall intercepted annually or during specific events by different tree species, at different ages and sizes, in different bioregions. This information will help urban foresters select trees to optimize stormwater runoff reduction.

Expenditures Associated With Hardscape Damage Caused By Tree Roots

Although trees provide a host of environmental, social, economic, and aesthetic benefits, the wrong tree in the wrong location can be costly. Conflicts between tree root growth and hardscape can result in repair costs, as well as other costs that have not been widely studied. The magnitudes of these other costs were not known until our research began to document them (McPherson 2000). For example, recent findings point out the importance of expenditures other than repair costs, such as trip and fall payments/legal staff (14%) and tree removal and replacement (10%).

In cooperation with Drs. David Burger and Larry Costello the Center co-sponsored a symposium to identify strategies for reducing conflicts between tree roots and infrastructure (Costello et al. 2001). A more detailed Compendium of strategies will be available in 2002. Dr. Burger is evaluating the ability of seedlings of several species to produce downward as opposed to horizontal growing roots. Current lab and field experiments are determining if deep rooting characteristics persist under conditions of vegetative propagation.

Urban Forest Effects on Building Energy Use

Drs. Simpson and McPherson have conducted six studies funded by electric utilities to quantify the potential of tree shade for reducing building energy use in their service areas. Findings were used to:

- *evaluate cost-effectiveness of tree planting programs for reducing peak generating and distribution requirements,*
- *develop incentives for energy-efficient landscaping around new construction,*
- *inform development of pilot shade tree programs and public education materials.*

Two studies done under contract with the Sacramento Municipal Utility District (SMUD) related to Sacramento Shade, their shade tree program delivered by the Sacramento Tree Foundation (STF). Using recommendations and data from both studies, SMUD and STF revised program goals and guidelines. Among the important program changes that resulted from our research were:

- *a minimum spacing between trees was established,*
- *a maximum number of trees per site was established,*
- *new tree siting guidelines based on cost-effectiveness were adopted,*
- *program performance measurement changed from number of trees planted to total program load impacts and cost-effectiveness.*

Two benefit-cost analyses for the Los Angeles Department of Water and Power have helped justify funding for Cools Schools, a $3 million/year schoolyard greening program that started in 1998 and Trees for a Green LA, a $4 million/year residential shade tree program begun in 2001.

Atmospheric Carbon Dioxide Reductions Through Urban Forestry

This project developed look-up tables for 11 regions of the U.S. that incorporate information from the Center's previous studies (e.g., tree locations, species mixes, and growth) with computer simulations of tree impacts on building energy use and avoided CO_2 emissions from power plants (McPherson and Simpson 1999). The approach provides users with a step-by-step process to calculate annual CO_2 reductions over a 40-year planning horizon. Also, the publication contains a review of literature on the subject of urban forestry and climate change, as well as general guidelines for shade tree program design and implementation. State of the art information on selecting and locating trees to maximize their energy saving and CO_2 sequestration potential are included.

During development it was used by Boulder City, NV to estimate the extent to which CO_2 reductions through tree planting would offset emissions from a new power plant. In 1999 the City received $1 million from the utility and has embarked on a shade tree program. Also, the Guidelines were used to assist city officials, local

planners, and landscape architects locate, select, plant, and steward trees to meet targeted CO_2 emission reductions in Chula Vista, CA.

Sacramento Urban Forest Ecosystem Study (SUFES)

This research extended the scientific scope of comprehensive regional urban forest analysis. It influenced local policy and management by providing science-based information on the state of the urban forest and the ecological services it provides. For instance, the neighborhood-sampling units used in SUFES are now management units with targeted goals for tree planting and tree canopy cover. The SUFESs regional approach is the cornerstone of the STF State of the Urban Forest Report, which advocates regional urban forest planning and management. Study findings were published as two special issues in the Journal of Arboriculture (1998, Nos. 2 and 4) and cited in the Alliance for Community Trees 2001 congressional testimony on the Forest Service's 2002 budget proposal.

Conclusion

Studies at the Center for Urban Forest Research are:

- *Providing objective, reliable, and accurate science-based information on urban forest benefits and costs for policy-making and management.*
- *Measuring and modeling of urban forest effects on fluxes of energy, water, and materials in urban ecosystems.*
- *Developing new analytical techniques and knowledge concerning growth, dimensions, biomass, and leaf area of urban trees.*
- *Producing an integrated suite of technology transfer products that link state of the art science with the needs of targeted sets of users.*

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AIR QUALITY, ENERGY, AND THE URBAN HEAT ISLAND

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