PNW
Pacific Northwest Research Station

Science FINDINGS

issue one hundred twenty six / september 2010

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"Science affects the way we think together."
Lewis Thomas

CALCULATING THE GREEN IN GREEN: WHAT'S AN URBAN TREE WORTH?

Rhonda Mazza

Street trees can increase a home's sale price, reduce its time on the market, and reduce summer electricity use—all while providing clean air, sequestering carbon, and moderating storm runoff.

"The trees in the streets are old trees used to living with people, family-trees that remember your grandfather's name."
—Stephen Vincent Benét, *John Brown's Body,* Book 4

Most people would probably rather look out their windows at stately maples, elms, and dogwoods than at gray concrete and asphalt. The ancient bond between humans and trees is expressed in a modern city dweller's intuition that trees add value to an urban landscape.

And so they do, but how much? Neighborhood and yard trees are not market commodities, so there is no simple, agreed-upon basis for calculating their value, comparing it to that of other urban-planning priorities such as keeping development costs low, or weighing benefits of trees against their costs.

Two recent studies by Geoffrey Donovan, an economist and research forester at the Pacific Northwest (PNW) Research Station, and David Butry, an economist with the National Institute of Standards and Technology, yielded specific dollar values for street and neighborhood trees in Portland, Oregon, and for yard trees that provide summer shade in Sacramento, California. This research is important to city governments, communities, and environmental organizations because it helps them make a case for publicly funded "green infrastructure," that supports many environmental and social amenities.

For nearly 30 years, Forest Service scientists and their collaborators have been exploring the economic links between urban trees and a suite of environmental and social amenities, including cleaner air, moderated storm runoff, sequestering of atmospheric carbon dioxide (CO_2), higher property values, reduced energy consumption, and improved human health.

IN SUMMARY

For urban dwellers, trees soften a city's hard edges and surfaces, shade homes and streets, enhance neighborhood beauty, filter the air, mitigate storm runoff, and absorb carbon dioxide. Trees may even reduce crime and improve human health. However, these benefits have not been well quantified, making it difficult for urban planners and property owners to weigh their costs and benefits or assess tree cover against competing land uses.

New research from the Pacific Northwest (PNW) Research Station demonstrates that street trees increase home prices in Portland, Oregon, that shade trees reduce household energy use in Sacramento, California, and that these effects can be measured and expressed in dollars.

A study led by economist Geoffrey Donovan, research forester with the PNW Research Station, determined that trees planted on the south and west sides of Sacramento houses reduced summertime electricity bills by an average of $25.16. In a second study in Portland, Donovan's team found that street trees growing in front of or near a house added an average $8,870 to its sale price and reduced its time on the market by nearly 2 days. These economic benefits spilled over to neighboring properties: a neighborhood tree growing along the public right-of-way added an average of $12,828 to the combined value of all the houses within 100 feet.

This research has produced practical tools for managers and planners, such as STRATUM, a benefit-calculation model developed by researchers at the Pacific Southwest Research Station and the University of California at Davis. The model estimates the value of amenities like urban trees and green spaces, basing its calculations on findings like those of Donovan and Butry. The New York City Parks Department used STRATUM to determine that the nearly 600,000 street trees in its five boroughs provide an annual benefit of $122 million—more than five times the cost of maintaining them.

Research on valuation of urban trees is useful also to companies looking to document their environmental performance. For several years now, the National Football League (NFL) has been working with host cities to reduce the environmental impact of the Super Bowl by (among other things) planting trees. In 2008, the NFL began using a software tool called i-Tree, developed by the Forest Service and the Davey Tree Expert Co., to assess how much carbon the trees would remove from the air, along with measures of other environmental benefits.

KEY FINDINGS

- The presence of street trees increased the sale prices of houses in east Portland neighborhoods by an average of $8,870 and reduced time on the market by an average of 1.7 days.
- A tree in front of a house increased the house's sale price by an average of $7,130. The tree's benefits spilled over to houses within a 100-foot radius, increasing their combined value by $12,828.
- Citywide, street trees add $1.1 billion to Portland's property value, or $45 million a year. Annual maintenance costs of $4.6 million are a small fraction of the trees' value and are mostly borne by property owners.
- Shade trees growing on the west and south sides of Sacramento houses lower summertime electricity use by reducing the need for air conditioning. The combined west- and south-side tree cover reduced summertime electricity bills by an average of $25.16.

The new Donovan-Butry studies address significant gaps in the literature, updating and refining the body of knowledge that powers models like STRATUM and i-Tree. "We're providing the next pieces of the puzzle," says Donovan. Few previous studies have examined the effects of urban trees on the housing market, and none has focused on street trees—those growing along public rights-of-way, such as parking strips or grassy medians—or on the effects of tree attributes (crown size or deciduous vs. conifer type, for example) on the housing market.

PORTLAND: STREET TREES AND PROPERTY VALUES

Donovan, who lives in the moderately tree-covered Mount Tabor neighborhood of Portland, was of course aware that "there is a profound difference between neighborhoods with trees and neighborhoods without." Indeed, in Portland at least, the bigger trees tend to be in the pricier neighborhoods. "But I thought there must be more to it than that," Donovan says.

In an earlier project, Donovan had used an economists' tool called hedonic price valuation to study the effects of wildfire risk on a housing market. Then, he says "My program manager made some passing remark about urban forestry being a topic of the future. I realized I could apply the same methods to urban forestry."

Hedonic price valuation is an economist's tool for breaking down the value of a market-traded commodity—such as a house—into its nonmarket-traded attributes and calculating the value of each. For example, a three-bedroom house usually costs more than a two-bedroom house. What is the value of

Rhonda Mazza

Researchers determined that Portland's street trees produce $45 million in annual benefits. This far exceeds the trees' annual maintenance costs, which are estimated at $4.6 million.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208

Send new subscriptions and change of address information to:
pnw_pnwpubs@fs.fed.us

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Science Findings is online at: http://www.fs.fed.us/pnw/publications/scifi.shtml

USDA United States Department of Agriculture

Forest Service

Evan Schneider

About 55 percent of potential planting spaces in Portland do not have trees, estimates the Bureau of Environmental Services. An initiative is underway to plant 50,000 street trees by July 2013.

that third bedroom? The researcher works from actual house sale prices to calculate these component values, which include not only the house's attributes but also environmental qualities. "The hedonic method is what economists call a revealed-preference model," Donovan explains, "because it's based on real market transactions. Using it, we were able to show that a tree adds value to a house just as a third bedroom does."

In summer 2007, he and colleague Butry hired two data collectors to take detailed measurements on 3,479 single-family houses on Portland's east side that had sold in the previous 10 months. They counted and measured the street trees at each site and noted their type (flowering, fruiting, deciduous without flowers or fruits, or coniferous) and condition. They also recorded data about the property's physical environment, such as pavement condition and proximity to an arterial street. They augmented these data with sales records of each property, including attributes of the house (square footage, number of bedrooms, type of heat, presence of a fireplace, etc.) and of the neighborhood (ZIP code, school district, distance from downtown, etc.).

A key component of the hedonic method is multiple regression, a powerful statistical tool that helps researchers tease apart a tangle of variables and measure the relative importance of each one. To use it correctly, the researcher must discern which variables are likely to be important. An obviously important variable in this study was socioeconomic status of the neighborhood. Because households sharing a ZIP code tend to be similar in socioeconomic status, ZIP code is a fairly reliable indicator of how wealthy a neighborhood is. Without it, the analysis would have been confounded by the fact that older, taller trees are disproportionately found in wealthier neighborhoods where houses sell for more than those in less affluent neighborhoods.

"If we had not included ZIP code as a variable," says Donovan, "the height of the trees would have become important—in fact, too important." Multiple regression, in short, enabled the researchers to be confident that the increased sale price of a house was in fact attributable to the presence of street trees, and not to the wealth of the neighborhood, the features of the house, or some other factor.

Donovan and Butry found that, on average, street trees added $8,870 to a house's sale price—the equivalent of adding 129 finished square feet—and decreased the house's time on the market by 1.7 days. They also found that a single tree raised the value of multiple houses. A tree with an average canopy of 312 square feet—a good-sized bigleaf maple, for example—added an average $7,130 in value to the house it fronted, plus additional value to neighboring houses. "Only about one-third of the total benefit goes to the homeowner with the tree in front," says Donovan. "The rest spreads to neighbors within 100 feet." Such a tree added an average combined value of $12,828 to the 7.6 houses lying within that radius.

Extrapolating to the entire city, the researchers determined that Portland's street trees have a capital value of $1.1 billion, which translates to $45 million in benefits annually. And if street trees increase property-tax revenues as much as they increase house prices, they account for $15.3 million in revenue to local governments. Street trees, in short, provide benefits far exceeding their annual maintenance costs, which are estimated at $4.6 million.

Property owners pay most of these costs, which means they subsidize a benefit that goes to everyone. This is an example of what economists call an externality—something that one party enjoys and another party pays for. The importance of this detail becomes readily apparent when trying to gauge the motivations and likely behaviors of homeowners. "As long as homeowners bear most of the cost," Donovan explains, "they will likely under-invest in street trees."

The city of Portland wants to plant 33,000 yard trees and 50,000 street trees by July 2013 as part of its 5-year, $50 million Grey to Green initiative. Grey to Green plants trees along streets and in other public spaces, and its Treebate program offers a utility-bill credit to homeowners who plant trees in their yards. "Our data say that 45 percent of our urban street areas are stocked," says Jennifer Karps of the city's Bureau of Environmental Services, which administers the program. "That means 55 percent of potential planting spaces in Portland don't have trees in them."

Grey to Green's main objective is to use green infrastructure to manage stormwater more effectively. But if trees also increase property values, with obvious benefits to the city's tax coffers, then Portland might do well, say the researchers, to increase its investment.

SACRAMENTO: SHADE SAVES ENERGY AND MONEY

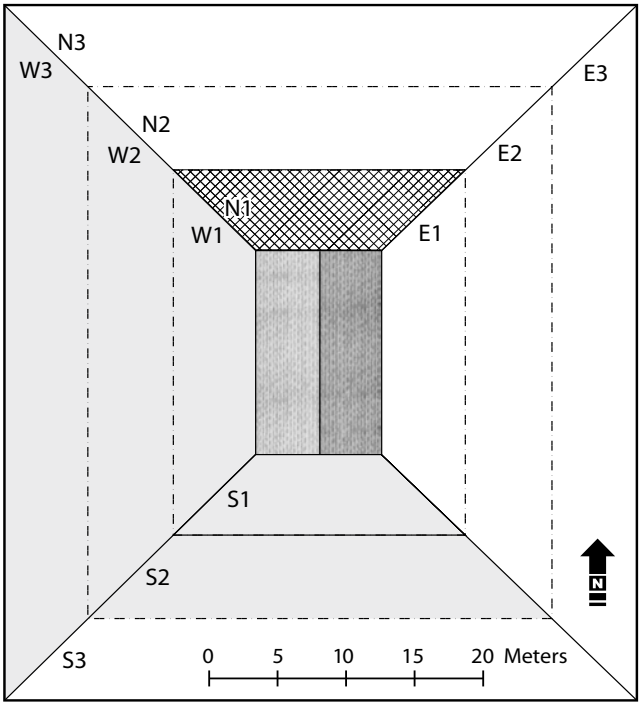
A tree's shade on a hot summer afternoon is a welcome oasis. As with Portland's street trees, Sacramento's shade trees add value to homes in many ways, not least by reducing the need for summer air conditioning.

For 20 years, Sacramento Municipal Utility District (SMUD) has been giving free shade trees to homeowners who agree to plant and care for them. Since 1990, the utility and its customers have planted nearly half a million trees. The program is carried out by the local nonprofit Sacramento Tree Foundation, which delivers the trees and helps homeowners site them strategically to maximize direct shading. SMUD keeps detailed electronic records for each tree planted—address, distance from the house, orientation to the house, species, and other information.

Sacramento Municipal Utility District

The Sacramento Municipal Utility District has been giving free shade trees to homeowners for 20 years with the goal of reducing summer energy use.

Donovan and Butry analyzed SMUD's tree-planting information along with its monthly billing data. They also examined aerial photographs of crowns of trees on the sampled properties. They determined that shade trees on the west and south sides of a house reduced summertime electricity use, whereas trees on the east had no effect. "This makes sense," says Donovan, "because east-side trees cast morning shadows on the house, before most people feel the need for air conditioning."



Tree canopy cover in the west and south quadrants (grey area) decreased a household's summer electricity use, whereas canopy cover in the north quadrant (crosshatched area) increased summer electricity use.

They were surprised to find that north-side trees not only didn't reduce energy consumption, they were correlated with increased summertime electricity use. "Perhaps trees close to a house reduce the cooling effect of wind, slow the release of heat at night, or cause more lighting to be used in the house," the researchers explained in issue 41 (2009) of *Energy and Buildings*. "This may be true of trees in all four quadrants, but in the east quadrant, the positive and negative effects of trees on energy use cancel out, and in the south and west quadrants, the energy saving effects of trees predominate."

On average, households with trees on the west and south sides reduced their summertime bills by $25.16, compared to houses with no trees. (Those with north-side trees had an average summertime increase of $7.48.) Although not a huge savings per household, these savings add up quickly in a city of nearly half a million people. And each kilowatt saved means less fossil fuel burned and less CO_2 released into the air.

The Donovan-Butry study confirmed findings from SMUD's earlier experimental and modeling studies—namely, that they really do decrease residential summer energy consumption. It also validated SMUD's current effort to reorganize its pricing structure. One curious finding was that, while both south- and west-side trees saved money for SMUD's customers, only the west-side trees saved money for SMUD. This proved to be an artifact of a disconnect between SMUD's retail pricing structure and the daily fluctuation in wholesale power prices. (Power purchased at 6 p.m. costs SMUD more than six times as much as power purchased at 4 a.m.) The SMUD is in the process of changing its retail pricing and will be installing new metering equipment that will charge customers more for power consumed during heavy-use afternoon hours. This change, mandated by the state legislature, aims to encourage more efficient energy use.

TREES WORK

Cities and environmental organizations have put the Donovan-Butry findings to immediate use. "This study is the first to document the energy-saving efficacy of trees directly, not just by modeling," says Jacobe Caditz of the Sacramento Tree Foundation. "One thing we've been asking ourselves for a long time is, Are tree-planting programs effective in reducing energy use? The answer is clearly, Yes, they are."

In Portland, the findings are helping persuade homeowners to participate in the city's

Sacramento Shade

Placing a dollar value on the benefits of urban trees can help persuade people to invest in their urban forest.

LAND MANAGEMENT IMPLICATIONS

- In assuming most maintenance costs, property owners subsidize the value increase that trees bring to neighboring homes and to the city as a whole. Homeowners are unlikely to plant enough trees on their own to maximize Portland's potential. The high benefit-cost ratio of the city's urban trees suggests that increased public investment would likely justify the cost.
- Trees on the west and south sides of Sacramento houses are optimal for reducing summertime electricity use, but because of a difference between wholesale and retail pricing structures, the city's electric utility benefits financially only from west-side trees. Changing the pricing structure, an effort now in progress, will increase fiscal benefits to the utility.
- Because trees provide a suite of benefits to neighborhoods and cities, it may be appropriate for governments to consider trees community assets and adopt incentives and regulations for homeowners and developers that increase their presence and enhance their value.

tree-planting programs. "We have teams of canvassers going door to door," says Whitney Dorer of Friends of Trees, a local nonprofit partnering with the city in its Grey to Green initiative. "Having studies like Geof Donovan's helps us put a number on something that's hard to describe. For a lot of people, it's really about the economic benefits, the property values. It sinks in when we can show them the numbers."

The study is also getting the attention of urban planners. In the Portland suburb of Tigard, the urban-forestry component of the city's draft comprehensive plan was challenged by a local homebuilder's association. In the next draft, city planner John Floyd beefed up the rationale for urban forests by citing the Donovan-Butry study along with other economic data. "We're using Dr. Donovan's work to defend our decision to adopt policies specific to trees," says Floyd. Tigard's urban forester, Todd Prager, adds, "Geof's research is valuable because it's local and because it's the most current information out there on the economic value [of trees] to real estate."

Sacramento Shade

A volunteer spreads mulch around a recently planted tree.

Finally, the findings help make the case to taxpayers and property owners that cities have a legitimate public interest in cultivating, nurturing, and protecting their trees. "A lot of people don't understand why we are looking to regulate trees, beyond aesthetics," says John Floyd. "When you're talking about air quality or water quality, or a good healthy urban canopy, you're talking about a somewhat abstract concept. Dr. Donovan's work helps place a dollar value on that healthy urban canopy. Dollars are something anyone can understand."

"If a tree dies, plant another in its place."
—Carl Linnaeus

WRITER'S PROFILE

Gail Wells is a science writer based in Corvallis, Oregon. She is the author of The Tillamook: A Created Forest Comes of Age *(2nd ed. 2004) and coauthor of* Lewis and Clark Meet Oregon's Forests: Lessons from Dynamic Nature *(2001).*

FOR FURTHER READING

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WEB RESOURCES

i-Tree—tools for assessing and managing community forests: http://www.itreetools.org/

Center for urban forest resources: http://www.fs.fed.us/psw/programs/cufr/stratum.shtml

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