U.S. Forest Service researcher Greg McPherson has been calculating the economic and ecological value of trees in cities decades before the term “ecosystem service” was in vogue.
Greg McPherson is quick to disclose that he really likes trees. But asked to explain why and the U.S. Forest Service researcher grasps for the right words.

“It’s definitely nothing quantitative,” he says. “It’s strictly emotional, spiritual. I don’t know … their grace and their beauty, the changing of the seasons, the habitat—just the fact that they provide so many different, wonderful things.”

There are two bits of irony here. First, McPherson makes his living as a scientist, not as a naturalist or artist (he did try his hand at landscape design once but discovered his skills were lacking).

Second, while McPherson may struggle to convey his appreciation for trees in words, he is a foremost expert at expressing their value in numbers. In fact, the urban forester was calculating the economic and ecological benefits of trees in cities decades before the term “ecosystem service” was in vogue. Starting with Chicago’s landmark urban forestry study, the Chicago Urban Forest Climate Project, in the 1990s, McPherson has helped dozens of communities inventory their trees, model ecosystem services like carbon storage, and convert the benefits into dollars and cents. He has examined trees’ ability to soak up air pollution, reduce the heat island effect, cut energy costs, intercept rainfall, and even protect paved surfaces. And he has done pioneering work on how the urban forest’s delivery of these services evolves as trees grow bigger with time.

It wasn’t always easy, especially early on. “I’ve kind of been fighting the battle within the Forest Service, which is traditionally focused on forests not cities,” says McPherson, who works at the agency’s Pacific Southwest Research Station in Davis, CA. “Taking the job in Chicago [with the Urban Forest Climate Project] was like going to Siberia, the gulag.” Likewise, when he co-founded the non-profit, tree-planting group Trees for Tucson 30 years ago in Arizona, McPherson felt something like the Dr. Seuss character, the Lorax. “The lone tree enthusiast, carrying the torch,” he says.

But he was recently invited back to Arizona to give a keynote talk; there’s a push now to grow the tree canopy of the entire Phoenix metro area, he explains. He also takes heart in the Obama administration’s mandate last October that federal decision-making take ecosystem services explicitly into account.

What really opened his eyes to the progress, though, was his role as a guest editor of the special section, “The Urban Forest and ecosystem services,” in the current issue of the Journal of Environmental Quality (JEQ; see http://bit.ly/1mUBArX).

McPherson jokes that he “doesn’t get out much now,” but the 40-some abstracts that he helped review brought the point home. In addition to roughly a dozen submitted by U.S. researchers, abstracts came in from all over, including Europe, Japan, Argentina, and Australia.

Nowadays, in other words, “there is a whole wide world of researchers doing a lot on the topic.”
of urban ecosystems, urban forests, and ecosystem services,” McPherson says. “I was impressed.”

**Groundbreaking Project Demonstrates the Power of Numbers**

With its concrete canyons and sprawling suburbs, the Chicago metropolitan area seems like an unlikely center of origin for today’s worldwide flourishing of urban forestry research. But Chicagoans have always loved their parks and tree-lined boulevards. And one of the city’s biggest tree huggers of all was its 54th mayor, Richard M. Daley.

Legend has it that shortly after taking office in 1989, Daley asked Chicago’s forestry division where all the elm trees had gone that he remembered from his youth. After learning they’d been felled by Dutch elm disease and that the agency was now mostly in the business of chopping down dead and dying trees, he ordered the planting of hundreds of thousands of new ones. But somewhere along the line, Daley saw that planting trees for love, or aesthetics, or their own sake, wasn’t enough. So, working with Illinois congressman Sidney Yates, he acquired federal funding for the Chicago Urban Forest Climate Project. The goal: to systematically quantify the ecosystem functions and value of the city’s burgeoning forest scape.

McPherson, in the meantime, had experienced his own epiphany about the power of numbers. After graduating from the University of Michigan, working in a tree nursery, and trying out landscape design, he did his first experiments on the economic impacts of trees and green space. He recalls one early study, in which he calculated the savings that accrued from building clusters of homes rather than sprawling developments. Not only did the clusters require less infrastructure and maintenance costs, he found, but the natural area that was retained also had value.

“And people listened,” McPherson says, with some awe still in his voice. “I remember being interviewed on the radio, which for me at the time was kind of a big deal. So it had a pretty profound impact in terms of me thinking that by quantifying this, I could get people’s attention.”

McPherson was subsequently recruited to work on the Chicago project, joining Rowan Rowntree, David Nowak, and other forestry researchers both inside and outside the Forest Service. The work the group carried out was groundbreaking for several reasons, McPherson says. First, it was the largest systematic inventory to date of a city forest, including the species composition, trees’ condition, their biomass and the extent of the canopy, and what all of this said about their management.

Second, the team developed models of forest functions, such as carbon sequestration and uptake of ozone and other air pollutants, linked these to the inventory, and “monetized the benefits,” McPherson says. And, finally—getting at the name “Chicago Urban Forest Climate Project”—weather stations were installed around Chicago to monitor the climate and calculate the effect of the forest canopy on wind speed, evapotranspiration, and other factors that influence energy and water use.

When the final numbers were crunched and reported in 1997, Chicago’s trees were estimated to remove more than 5.5 metric tons of airborne pollutants—an air-cleansing service worth $9.2 million. Planting just three trees around each building could also save an estimated $50 to $90 per dwelling in annual heating and cooling costs, thanks to increased shade and reduced wind speeds. The team concluded by stating that “the net present value of the services trees provide is estimated at $402 per planted tree”—or $38 million total in 1997 dollars.

The results both validated Mayor Daley’s ambitious tree-planting campaign in Chicago and spurred a flurry of urban forestry studies across the United States—one of which was McPherson’s own. After taking his position with the Forest Service in California, McPherson set about in 1998 to replicate much of the Chicago work in Sacramento.

A Growing, Maturing Scientific Discipline

The science of urban forestry has been growing and maturing ever since—perhaps not yet an imposing, old oak, but certainly no longer a sapling. At the same time, urban forestry’s 30 to 40 years as a scientific discipline is a blip compared with the practice of managing urban trees. Those

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Examining the Surface Water Storage Capacity of Trees

Green infrastructure systems for handling urban runoff naturally focus on soil and the roots of plants. But there is another green line of defense against stormwater, says U.S. Forest Service scientist Greg McPherson. “It’s kind of like a mini-sponge above the earth, which is the bigger, real sponge.” What he’s referring to are the aboveground surfaces of trees—their leaves, stems, and trunks—all of which also intercept rainwater and store it as a thin film until it evaporates or drips through to the ground.

In a paper (http://bit.ly/1PUXPXL) in the Journal of Environmental Quality special section, “The Urban Forest and Ecosystem Services,” McPherson and his colleague, hydrologist Qingfu Xiao, studied the “surface water storage capacity” of 20 common tree species in Davis, CA. Not only did the species differ threefold in the amount of water they could store, but this capacity also changed with the seasons and as leaf area increased as trees aged.

Although each tree can hold only a small amount of water in its crown, the idea is that many together could reduce and slow the flow of rainfall to the street and thus the burden on stormwater systems. This remains to be seen. “But if we’re going to be promoting tree planting as a green infrastructure strategy,” McPherson says, “we need to be able to quantify the effects that this interception has.”

The results may also extend beyond urban forestry to hydrological modeling overall, Xiao adds. For example, the information might be included along with other vegetation data in watershed models of water quantity and quality.

Surface water storage capacity is a dynamic process, McPherson explains. When it starts to rain, the tiny “reservoir” on each leaf surface begins filling, and if the rain stops before the storage capacity is reached, the water will eventually evaporate. But if the rain keeps up, “the leaf may tilt because of the weight of the water. It may start dripping,” he says. “Then as it loses the weight of that water, it [becomes] flat again and begins to store more.”

For this reason, conifers—which generally have stiff, bristle-like needles rather than flat, flexible leaves—tend to have a higher surface water storage capacity than their deciduous counterparts; that is, their needles hold more water before they start to drip. Not surprisingly, McPherson and Xiao also found that deciduous trees lose some storage capacity when they drop their leaves in the fall.

Based on this, they concluded that evergreen trees are best for intercepting rainfall in the Davis area and other Mediterranean regions, which get most of their precipitation in winter. But before these recommendations can be extended, not only do other species need to be studied, but the same species need to be examined in different areas. “It may well be that a hackberry in California performs differently than a hackberry in Illinois,” McPherson says.

He and Xiao also couldn’t determine how the surface water storage capacity of different species changes as trees age (other than by modeling the increase in leaf area over time). Older stem surfaces tend to be rougher and more furrowed than younger ones, for example—and thus possibly more absorbent. “So I think we’ve only seen the tip of the iceberg,” McPherson says. “It’s exciting. The implication is that a lot more work needs to be done.”
activities go back much further, points out University of Melbourne scientist Steven Livesley, another guest editor of the JEQ special section—to around the time people began settling in cities and towns in the first place.

So given all this history, what makes the subject timely today? While it’s true that general awareness has risen of the many ecosystem services that trees provide, Livesley says, what hasn’t kept pace is “the scientific understanding and evidence base through which city managers can justify the expense of urban tree management.” This is one reason why he wanted to pull together the special collection in JEQ. “The evidence we have as to the magnitude of these ecosystem benefits and how they operate needs to be consolidated and made available to help keep trees in our towns and cities,” he says.

The research assembled by him, McPherson, and Italian urban ecosystems scientist Carlos Calfapietra is diverse. One study from Granada, Spain, reported a method for designing the vegetation in city parks and green spaces to reduce Granada’s heavy loads of tree pollen and airborne allergens. Another, out of Livesley’s group in Australia, investigated how microclimate conditions created by street trees are influenced by street orientation (east-west versus north-south) and where on a street trees are planted. Calfapietra’s group in Italy examined ozone uptake by trees, including ways to boost ozone removal by selecting the right species. Still other papers looked at the capacity of trees to capture and treat stormwater, including one by McPherson and his colleague, Qingfu Xiao, which took an unusual approach to the question (see sidebar).

Like McPherson, Livesley is impressed by the scope of work happening in urban forestry today. But to maintain the momentum and meet future challenges posed by climate change, the field must become even more collaborative than in the past, he asserts—involving not just tree experts, but also water infrastructure engineers, urban hydrologists, urban planners, and soil scientists. With its wide readership, he adds, JEQ was a natural outlet for reaching these audiences. “Whether your city is in a high-rainfall, flood-risk climate, or a low-rainfall, hot-and-arid climate,” he says, “the nexus between the urban forest, green space, and catchment hydrology requires multi-disciplinary research.”

For his part, McPherson thinks one of the most exciting, new developments is that scientists are starting to look back—to Chicago, Baltimore, and elsewhere—with the aim of collecting a second round of data on those cities’ trees. “I started out by talking about Chicago as the first large-scale inventory of what was out there. Now, I think we’ve moved to monitoring: Going back to take repeated measurements so we can see how things are changing and using that information to better manage what we have,” McPherson says. “To me, that’s the evolution that’s occurred in urban forestry since the Chicago Urban Forest Climate Project.” It’s also, he believes, “the next frontier.”

As he continues contemplating the future, McPherson soon loops back in another way as well, to something that is at once less tangible and just as real: The impact of trees on the spirit and well-being of people. McPherson has never tried to measure these benefits himself, but he hasn’t really had to—having instinctively understood them his entire life. Now, it’s gratifying to see other scientists recognizing the same.

“Research on the effects of urban green space on human health—psychological, spiritual, physical—that’s just taking off and it’s very powerful.”

M. Fisher, Features Editor for ASA, CSSA, and SSSA