US FOREST SERVICE NORTHERN RESEARCH STATION

Research *Review*

NO. 26 | APRIL 2015

Trees Improve Human Health and Well-Being in Many Ways

With more than half the U.S. and world's populations now residing in cities, urban forests and their benefits have become more valuable than ever. Common sense tells us that trees are good for us—their beauty can inspire us, and their shade keeps us cooler. But urban trees do more; they provide benefits that are called ecosystem services, which include the obvious ones such as cooling the air, and other, less noticeable ones, such as providing oxygen, intercepting ultraviolet (UV) light, absorbing rainfall, storing carbon, and reducing air pollution. Knowing this, many city and national planning and action groups work to maintain, improve, and enlarge the urban forest. Although it's easy to say that "more trees" are better than "few trees," that is not enough for managers, planners, and advocates. They need accurate information, facts, and numbers to justify and improve their programs.

The Forest Service's Northern Research Station (NRS) has scientists in a 20-state area from Maine to Maryland, Minnesota to Missouri, studying many aspects of trees and forests. This area is home to 23 percent of U.S forests and 40 percent of the total U.S. population. As urban/suburban populations have increased in numbers and residents have become more concerned about quality of life, urban forestry research is now a science whose time has come. Forest Service Research and Development has 10 research scientists and numerous technicians studying urban forestry and ecosystem services in the Northeast and Midwest.

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Photo by U.S. Forest Service.

Some trees and green areas can increase neighborhood social cohesion. thinkstock.com

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URBAN AND SUBURBAN TREES HAVE DIRECT BENEFITS FOR RESIDENTS

Backyards and parks with trees seem to satisfy a deep need in the human psyche, perhaps because they are similar to the landscape where the human species originated. Street trees too are valued for the beauty and coolness they bring to neighborhoods. But trees can do so much more. On the psychological front:

- Trees and nature relieve what is sometimes called "nature-deficit disorder," the malaise caused by excessive time and focus indoors, particularly when there are no views of the outdoors through windows. Studies of students and hospital patients show improved learning and healing in rooms with a view of nature.
- Some trees and green areas can increase neighborhood social cohesion and reduce crime.
- Some trees produce allergenic pollens and messy fruit, but smart management picks the best species to enhance the positive and reduce costs.

On the biochemical, physiological, and physical fronts:

- Trees release oxygen (O_2) and store considerable amounts of carbon (C) in their wood.
- Tree leaves intercept sunshine and UV rays. Transpiration and shade cool the air.
- Tree leaves absorb lower-atmospheric ozone (O_3) and other pollutants.
- Leaf surfaces intercept and trap small-particle pollution; some is washed off onto ground surfaces, some is caught up in leaf surface waxes.

The production of oxygen and storage of carbon are direct benefits of photosynthesis. But the UV rays and pollutants that are intercepted have direct ties to human health. Some ultraviolet rays in sunshine can cause skin cancers and cataracts; high temperatures can bring on heat stroke. Small particles, ozone, and other pollutants worsen chronic respiratory diseases such as asthma, bronchitis, emphysema, and chronic pulmonary obstructive disease (COPD) and can bring on acute cardiac and pulmonary incidents, possibly leading to premature death. These problems affect about 1 in 7 Americans middle-aged or older according to a new study from the National Center for Health Statistics at the Centers for Disease Control and Prevention.

NORTHERN RESEARCH STATION SCIENTISTS QUANTIFY THE TREE-HEALTH CONNECTION

In the first broad-scale estimate of air pollution removal by trees nationwide, U.S. Forest Service scientists and collaborators calculated that trees are saving more than 850 human lives a year and preventing 670,000 incidences of acute respiratory symptoms. The study by Dave Nowak and Eric Greenfield of the U.S. Forest Service's Northern Research Station and Satoshi Hirabayashi and Allison Bodine of the Davey Institute is a first in that it directly links the removal of air pollution with improved human health effects and associated health values. The scientists found that pollution removal is substantially higher in rural than in urban areas, but that the effects on human health

and monetary savings are substantially greater in urban than in rural areas. The study considered four pollutants for which the U.S. EPA has established air quality standards: nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter less than 2.5 microns ($PM_{2.5}$) in aerodynamic diameter. In the United States, about 130,000 $PM_{2.5}$-related deaths and 4,700 ozone-related deaths in 2005 were attributed to air pollution. Using computer simulation i-Tree and BenMAP with local environmental data, they found that trees and forests in the conterminous United States removed 17.4 million tonnes (t) of air pollution in 2010 (range: 9.0 to 23.2 million t), with human health effects valued at $6.8 billion dollars (range: $1.5 to 13.0 billion). Although pollution removal by trees equated to an average air quality improvement of less than 1 percent, these effects illustrate that planting urban trees does not just beautify the city but provides beneficial ecosystem services, making cities healthier for human inhabitants.

Assessments of canopy cover using aerial or satellite images are used to determine amount and distribution of tree cover, potential planting space and other cover types. Photo by U.S. Forest Service.

Forests are the lungs of our land, purifying the air and giving fresh strength to our people.

Franklin D. Roosevelt

i-Tree — www.itreetools.org

From cities in the northeastern and midwestern United States to cities all over the world, the i-Tree software suite developed by the U.S. Forest Service's Northern Research Station and several partners is helping communities get to know and value their trees. These tools help communities to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services and values that trees provide. Since the release of the i-Tree tools in August 2006, numerous communities, nonprofit organizations, consultants, government organizations, volunteers, and students have used i-Tree to report on individual trees, parcels, neighborhoods, cities, and even entire states. By understanding the local, tangible ecosystem services that trees provide, i-Tree users can link urban forest management activities with improving environmental quality and livable communities.

Initially, i-Tree creators expected interest in the software to be limited to city foresters in the United States. However, with continual updates and expanded capabilities, the software has attracted new users, including teachers, researchers, nongovernment organizations, and consultants. Most of i-Tree's 30,000-plus users are in the United States, but the software is now widely used all over the world, in such diverse places as Brazil, India, Russia and Australia, and over 100 countries in between.

i-Tree is developed, supported and distributed through a consortium of partners including the U.S. Forest Service, Davey Tree Expert Company, Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry.

"The partnership among all of the groups, along with feedback from user groups, has been fantastic," said Nowak. "It has led to new ideas, tools and expanded usage and impacts across the globe."

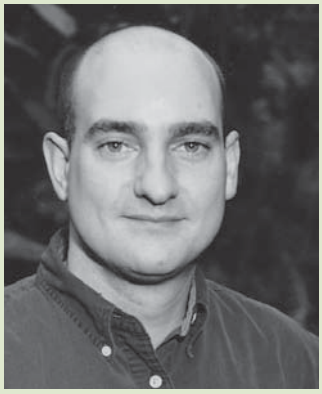
View of Morgantown, WV, from the Monongahela River.
Photo by Anne Cumming, U.S. Forest Service.

Scientific papers are important, but not the most useful end product to help managers. It's essential to use the science behind those papers to develop tools that people can use to design better landscapes and improve their quality of life.

Dave Nowak,
U.S. Forest Service
Northern Research Station

BIOGRAPHIES

David J. Nowak is a research forester and project leader of the "Urban Forests, Environmental Quality, and Human Health" research unit in Syracuse, New York. He received his PhD from the University of California, Berkeley, in 1991, and his MS and BS from the State University of New York, College of Environmental Science and Forestry, in Syracuse. Dave helps lead the development of free software tools—for example, iTree (www.itreetools.org)—that assess urban forest structure, functions, and values to help manage and design landscapes to improve environmental quality and human health. The models have been used in cities around the globe. One of his program goals is to integrate urban forest ecosystem services—for example, air quality improvement—within various environmental regulations such as the Clean Air Act. Tools are also being developed to aid in management and planning decisions to sustain urban forest health and services. His long-term monitoring research is investigating how and why urban forests change through time so that better management plans can be developed to sustain this important resource.



Eric Greenfield, a forester, also works in the "Urban Forests, Environmental Quality, and Human Health" research unit. He received his PhD from the SUNY College of Environmental Science and Forestry, in 2005; an MA from the SUNY Rockefeller College of Public Affairs and Policy, Albany, in 1996; and his BA from SUNY Harpur College, Binghamton, in 1990. Eric has worked with Dave Nowak on a series of publications about urban and community forests of the various U.S. regions.

RESOURCES AND REFERENCES

Web Resources:

Alliance for Community Trees: www.actrees.org

American Lung Association: www.lung.org

Atlantic Magazine articles:
www.theatlantic.com/health/archive/2014/07/trees-good/375129/
www.theatlantic.com/health/archive/2013/01/when-trees-die-people-die/267322/

Casey Trees: caseytrees.org

Centers for Disease Control and Prevention:
www.cdc.gov/nchs/data/databriefs/db180.pdf

Cornell University, Urban Horticultural Institute (planting suggestions):
woodyplants.cals.cornell.edu/urbantrees

National Heart, Lung, and Blood Institute:
www.nhlbi.nih.gov/health/resources/lung

National Institute of Environmental Health Sciences:
www.niehs.nih.gov/health/assets/docs_p_z/respiratory_disease_508.pdf

USDA Forest Service: www.fs.fed.us/ecosystemservices/

USDA FS, Northern Research Station:
www.nrs.fs.fed.us/units/urban

i-Tree:
www.itreetools.org/resources/content/guide_to_assessing_urban_forests_nrs_inf_24_13.pdf

World Health Organization, urban populations:
www.who.int/gho/urban_health/en/

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Delfino RJ, Wu J, Tjoa T, Gullesserian SK, Nickerson B, Gillen DL.2014. **Asthma morbidity and ambient air pollution: effect modification by residential traffic-related air pollution.** Epidemiology Jan25(1): 48-57. www.ncbi.nlm.nih.gov/pubmed/24240657

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Kondo MC, Low SC, Henning J, Branas CC. 2015. **The impact of green stormwater infrastructure installation on surrounding health and safety.** American Journal of Public Health 105(3): e114-e121. www.nrs.fs.fed.us/pubs/47686

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Tallis M, Taylor G, Sinnett D, Freer-Smith P. 2011. **Estimating the removal of atmospheric particulate pollution by the urban tree canopy of London, under current and future environments.** Landscape and Urban Planning103 (2): 129. DOI: 10.1016/j.landurbplan.2011.07.003.

BenMAP — www2.epa.gov/benmap

BenMAP-CE is an open-source computer program from the U.S. Environmental Protection Agency that calculates the number and economic value of air pollution-related deaths and illnesses. The software incorporates a database that includes many of the concentration-response relationships, population files, and health and economic data needed to quantify these impacts.

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NRS Research Review is published quarterly by the Communications and Science Delivery Group of the Northern Research Station (NRS), U.S. Forest Service. As part of the Nation's largest forestry research organization, NRS serves the Northeast and Midwest and beyond, providing the latest research on current problems and issues affecting forests and the people who depend on them. Our research themes are (1) Forest Disturbance Processes, (2) Urban Natural Resources Stewardship, (3) Sustaining Forests, (4) Providing Clean Air and Water, and (5) Natural Resources Inventory and Monitoring.

There are 111 NRS scientists working at 20 field offices, 24 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota.

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