



Science

FINDINGS

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

Plant a Tree and Save a Life? The Value of Planting More Trees in Urban Areas



Volunteers plant a tree in Portland, Oregon. In an urban setting, trees can improve the aesthetics of a neighborhood; they are also associated with improving the public health outcomes of residents. Photo courtesy of Friends of Trees.

"I am myself and what is around me, and if I do not save it, it shall not save me."

—José Ortega y Gasset, Spanish philosopher

The nonprofit organization Friends of Trees can measure its accomplishments in trees. Rain or shine, work parties of volunteers and paid staff meet from November through March to plant trees in the Portland-

Vancouver-Salem and Eugene-Springfield metropolitan areas. Over the past 35 years, they have planted more than 900,000 trees and native shrubs.

"He plants trees to benefit another generation," wrote Caecilius Statius, a Roman poet who lived 220–166 BCE. Yet that's not entirely accurate. In an urban setting, planted trees provide public health benefits to both the

IN SUMMARY

Exposure to urban trees is associated with improved public health outcomes, including healthier infant birth weights, fewer symptoms of attention-deficit hyperactivity disorder, and decreased cardiovascular mortality. Conversely, tree loss is linked to increased rates of cardiovascular disease and higher mortality. Could this mean that trees save lives?

Using 30 years of tree planting data generated by Friends of Trees, a nonprofit organization that has planted trees throughout Portland, Oregon, researchers with the USDA Forest Service's Pacific Northwest Research Station and colleagues modeled the impact of tree planting on nonaccidental mortality in Portland's 140 census tracts.

The analyses revealed that an increase in the number of trees was associated with lower rates of cardiovascular and nonaccidental mortality. This lower rate of nonaccidental mortality has economic ramifications. Based upon the U.S. Environmental Protection Agency's value of a statistical life (\$10.7 million), planting a single urban tree in each of Portland's 140 census tracts is associated with \$14.2 million in reduced mortality. Furthermore, as the trees matured, the health benefits increased.

The team also found that a commonly used vegetation greenness index derived from satellite imagery to describe the exposure of people to trees and plants may not be sensitive enough to consistently detect small changes in vegetation over time. Instead, tree characteristics observed from the ground more accurately capture what people experience while moving through the urban environment.

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generation doing the planting and the generation who will sit in the shade. These benefits may include healthier infant birth weights, reduced symptoms of attention-deficit hyperactivity disorder (ADHD), and decreased mortality from cardiovascular disease. And when trees are planted on public property, the primary focus of Friends of Trees' efforts, all the residents who walk by these trees or view them through their windows reap the benefits.

Of these associated health benefits, there was one missing from the literature that Geoffrey Donovan, a research forester with the USDA Forest Service, Pacific Northwest Research Station, wanted to explore. In 2013, he was the lead author on the journal article "The

Relationship Between Trees and Human Health: Evidence from the Spread of the Emerald Ash Borer." That article reported how the loss of trees to emerald ash borer resulted in increased rates of cardiovascular disease and higher mortality for the residents living in the impacted neighborhoods.

"It was an interesting finding, and I always wondered if the opposite was true," Donovan says. "If you kill trees, there's an increase in human mortality. What if you plant trees—is there a decrease in mortality?"

Phrased another way, does planting trees save lives?

Exploring Tree Planting and Mortality Links

For several years, Donovan couldn't make traction in pursuing this question. He knew where to access the mortality data and the demographic data, but the tree planting data remained elusive. In what he describes as a "coincidental conversation" with Whitney Dorer, who at that time worked for Friends of Trees, Donovan learned of the dataset he sought. "They mentioned they had planted 50,000 trees over 30 years," he says. "I couldn't believe it. It's so amazing this organization would keep these records."

Donovan reached out to researchers with whom he had worked on previous tree-related public health studies to form a research team. This included Demetrios Gatzliolis, a research forester with the Pacific Northwest Research Station; Jeffrey Prestemon, a forest economics project leader with the Southern Research Station; and Yvonne Michael, a professor of epidemiology with Drexel University Dornsife School of Public Health.

Upon hearing of the tree-planting dataset, Gatzliolis admits being skeptical of its usability. "My experience with other types

of data created by nonprofits and citizen scientists is that they are passionate about their work, but they do not necessarily abide by the scientific method," explains Gatzliolis. "The data have a lot of inaccuracies. Thankfully this group was very meticulous in recording the address of where the tree was planted, which for our type of analysis is what we needed."

Next came sourcing the other data for the model. Oregon Health Authority provided the human mortality data between 2006 and 2019 for Portland's 140 U.S. census tracts. (Whereas neighborhood boundaries may change over time, census tracts established by the U.S. Census Bureau remain relatively permanent and have a population between 1,200 and 8,000 people.)

Donovan and the team focused specifically on four causes of death: cardiovascular, chronic lower respiratory, accidental, and nonaccidental (all mortality minus accidental). Because demographics, such as age, income, and education, are drivers of mortality, the team used data from the U.S. Census's American Community Survey collected between 2007 and 2018 to control for these factors.

Earlier research has shown that mature trees may provide greater health benefits than small trees. So, to capture the effects of mature trees, the team divided the trees planted in the preceding 15 years into three tree-age sets: 1 to 5, 6 to 10, and 11 to 15 years.

The team developed and ran multiple models to test their hypothesis and the robustness of their findings. Even when the analyses appeared to validate that there was an association of trees with the nonaccidental mortality rate, they would tweak the model and run it again to see if there was another explanation.

*Trees planted by Friends of Trees in 2008, 2014, and 2020. Scientists found that as trees matured, the positive benefits to human health increased.
USDA Forest Service photos by Geoffrey Donovan.*



“One of our challenges was making sure we accounted for all the other factors, confounding factors, that would affect human mortality,” explains Prestemon. “People die for many reasons. Some are systematic, which we can usually account for in a statistical model, and some are idiosyncratic and random, which are invisible to the analyst.”

Additionally, “we needed to think about ways to control for factors that may be explaining the association other than the trees,” Michael adds. “Is there something else that is really causing this relationship that we’re seeing?”

One relationship stood out. Fifteen years following the planting of 1,638 trees (the mean annual number of trees planted), there was a significant reduction in cardiovascular mortality and nonaccidental mortality.

The impact of trees on human mortality grew bigger as the trees matured. Donovan says he was a little surprised at the strength of the relationship but “it was consistent with our broad hypothesis of how trees and health are related.”

Michael recalls that she and Donovan thoroughly interrogated the data to find other explanations for the associations. They conducted additional sensitivity analyses to challenge their possible biases of expecting to find an association.

“It is important to not let yourself off the hook too easily,” Donovan says. “You’ve got to really poke and prod [the model] and make sure that the relationship works in the way you think it should.”

The increase in trees did not affect accidental mortality, which the researchers expected, because there’s no plausible way that tree planting could result in more accidental deaths. However, the relationship still needed to be tested to confirm that a relationship did not exist.

Return on Investment

To complement the finding that trees are associated with reducing human mortality, the team looked at the economics of tree planting and value of human life. “Sometimes in environmental economics you’re forced to convert human outcomes into dollars,” Prestemon says. “We convert mortality into dollar values, which can make some people uncomfortable, but it’s necessary if you want to make economic comparisons.”

Unlike trees in a natural setting that can survive without human intervention, urban trees require maintenance throughout their lifespan. Saplings require regular watering, especially during the summer. Mature trees require pruning and possibly continued

KEY FINDINGS

- Residents in neighborhoods with more newly planted trees in Portland, Oregon, experienced lower rates of cardiovascular and nonaccidental mortality over 15 years. Specifically, planting 1,638 trees (the mean number planted annually by the nonprofit organization Friends of Trees) was associated with 15.6 fewer deaths per year.
- The increase in neighborhood trees was not significantly associated with accidental mortality.
- The health benefits of tree planting far exceed the costs. Using the U.S. Environmental Protection Agency’s value of a statistical life (\$10.7 million), the estimated benefit-cost ratio of tree planting by Friends of Trees is 1,727:1.
- As trees aged and grew, the association between tree planting and mortality increased in both magnitude and significance, meaning that the impact of trees on human mortality grew stronger as the trees matured.



One of more than 50,000 trees planted by Friends of Trees over 30 years. Meticulous data on the location of each tree facilitated a study on urban trees and human health. Photo courtesy of Friends of Trees.

watering. All this maintenance involves investment, both capital and labor. The research team estimated that maintaining one tree per tract, 140 total, would cost \$2,716 to \$13,720 annually. However, people living longer also results in a societal economic value. The Environmental Protection Agency assigns a person's lifetime or statistical value at \$10.7 million. That one extra tree in each of the 140 tracts would generate a total sum of annual benefits of \$14.2 million—an estimated benefit-cost ratio of 1,727:1.

Increasing Urban Greenness

This is an observational study, cautions Donovan, and does not establish a causal relationship between trees and reduced mortality. Also, the study was conducted in an urban environment; the observations might not be applicable in rural communities. However, the finding that trees can reduce nonaccidental mortality is useful for policy makers, city officials, and even residents who want to improve the health outcomes within their neighborhood, especially neighborhoods that currently have fewer trees.

“We are a part of a growing body of literature that’s showing consistent benefits using different methods, measures, and study designs,” explains Michael. “While we can’t point to this relationship as exactly being causal, it certainly points to a consistent positive association.”



A sapling in Portland, Oregon. Maintaining urban trees requires capital and labor, but the benefits to human health exceed the costs by an estimated ratio of 1,727:1. USDA Forest Service photo by Geoffrey Donovan.

LAND MANAGEMENT IMPLICATIONS

- Tree planting may be a cost-effective way of reducing premature human mortality.
- Larger trees appear to have a greater effect on human health than smaller trees. This underlines the importance of retaining mature tree canopy as well as planting new trees.
- Disadvantaged neighborhoods, which tend to be less green, may also be less healthy. Prioritizing tree planting efforts in these neighborhoods could improve health outcomes and quality of life for residents.
- Use of tree planting data instead of values from the normalized difference vegetation index can better assess the amount of green space in a community.



Planting a tree in Portland, Oregon. Photo courtesy of Friends of Trees.

Selecting the Right Tools for the Job

Many studies that explore the association between trees and human health use the normalized difference vegetation index (NDVI), which is a vegetation greenness index derived from satellite imagery. “NDVI is very attractive to use because it’s free and available for the entire world, at regular intervals” says Demetrios Gatzliolis, a research forester with the USDA Forest Service Pacific Northwest Research Station.

In the natural environment, NDVI is an invaluable tool. In the urban environment, however, the NDVI value captures vegetation greenness but not necessarily how people experience that greenness. In a separate study, the research team calculated the NDVI value of an American elm tree that was the first tree enrolled in Portland’s heritage tree program. When walking down SW 10th Avenue, one’s eye is immediately drawn to the expansive tree crown that covers a significant portion of the sidewalk and street. The image pixel that contains this tree had a NDVI value of 0.37095.

When looking at other areas of Portland with the same NDVI value and what people saw while walking through the neighborhood, there was not a similar stately tree, but rather one or more trees, sometimes mature, sometimes not, and sidewalks and driveways bordering lawns. “A satellite doesn’t know exactly where within an image pixel sunlight is reflected from so it computes the average,” explains Gatzliolis. “The presence of a lot

of grass, healthy grass, increases the NDVI even when nonvegetative objects are also present, and makes it approximately the same as if the whole pixel was covered by trees.”

For the tree planting study, the researchers used the mean NDVI value for each census tract as a variable in their model. The vegetation greenness value did not indicate a significant association with nonaccidental mortality.

“It was obvious that the changes in NDVI were so small they appeared not to have occurred at all, when in reality there were trees that have been planted and are growing,” Gatzliolis says. “NDVI is not sensitive enough to pick up changes that occur from vegetation that changes slowly.”

But this may change in the future because technology is constantly improving.

“We now have microsatellites the size of a loaf of bread that take high resolution images daily, as opposed to [once every] two weeks,” he explains. “I expect within a decade the information we’re using from satellites to compute NDVI and other metrics would be available at a much finer resolution. When that happens, some of these resolution limitations will go away.”

Until then, tree planting data will be the preferred data source to document the greenness that people experience in their neighborhoods.



Featured in the study: a 154-year-old American elm (*Ulmus americana*) in downtown Portland, Oregon. Photo courtesy of Stuart White.

For Yashar Vasef, executive director of Friends of Trees, he was “super excited” when Donovan shared the results that demonstrated the value of the nonprofit’s mission. “Having that science behind our ask to funders and sharing with community why trees are important, it’s everything,” he says. “As forestry practitioners, we really tend to focus on the trees themselves and doing that work but having this compelling background elevates the work we do.”

Learning that mature trees have the strongest association with reducing mortality, Vasef says, they are now prioritizing tree establishment. “We have programs that we’ve always run for pruning young trees and watering after they’re planted,” he explains. “But this speaks to a broader more collective effort that we all need to engage in to make sure these trees survive, mature, and provide that astounding public health benefit.”

“Deep down, at the molecular heart of life, the trees and we are essentially identical.”

—Carl Sagan

For Further Reading

Donovan, G.H.; Prestemon, J.P.; Gatzliolis, D. [et al.]. 2022. The association between tree planting and mortality: a natural experiment and cost-benefit analysis. *Environment International*. 170(8): 107609. <https://www.fs.usda.gov/research/treesearch/65639>.

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Scientist Profiles



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