



Value of Hospital Admissions Avoided Due to Sulfur Dioxide Removed by Tree Cover

This EnviroAtlas community map illustrates the economic value (\$/yr) of annual reductions in hospital admissions due to sulfur dioxide (SO₂) removed by trees, summarized by census block group. The economic value is calculated using [willingness to pay](#) (WTP) estimates. These data are estimated using the U.S. EPA's Environmental Benefits Mapping and Analysis Program ([BenMAP](#)).

Why is it important to reduce hospital admissions?

Hospital admissions encompass all formal admissions to a hospital for inpatient, or overnight, care by a doctor's orders. In 2010, there were 35.1 million instances of hospital discharges from inpatient care in the United States, or 11.4 per 1,000 people.¹ Though hospital admissions enable individuals to receive necessary care, they also frequently pose an economic and psychological burden on patients. Nationally, hospital admissions accounted for 29% of total health care spending in the United States in 2009.²

Hospital admissions due to respiratory system illnesses were the third most costly cause of inpatient care in 2010 at 11% of total hospital costs.² This estimate excludes indirect costs, such as losses in productivity due to absenteeism. Short-term exposure to sulfur dioxide (SO₂) has been shown to increase bronchial reactivity (airway narrowing) and symptoms of asthma, especially during periods of increased respiration or exercise. Increased emergency room visits and hospital admissions for respiratory issues following exposure to SO₂ are additional risks for vulnerable populations.³ As SO₂ exposures can be elevated near busy roadways and industrial areas, people who spend time in or live near these areas, particularly the elderly, children, and those with asthma, may be more at risk than other groups.³

Trees help reduce the potential adverse health and environmental effects of SO₂ by removing it from the air. Gaseous air pollutants, like SO₂, are taken in primarily through the leaf stomata (pores), though some gases are removed by the plant surface.⁴ Absorbed gases are often converted within the leaf interior, making their removal more permanent than pollutants removed by plant surfaces. Healthy trees can remove significant amounts of air pollution in cities, where it is often concentrated.



Photo: Hospital room, D. Reid, National Cancer Institute

How can I use this information?

The map, Value of Hospital Admissions Avoided Due to Sulfur Dioxide Removed by Tree Cover (\$/yr), is one of six EnviroAtlas maps that illustrate the economic benefits of pollutants removed via tree cover by examining annual change in the incidence of a health outcome.

Used in conjunction with near-road and overall tree cover data available in EnviroAtlas, this map can highlight which areas are likely receiving the benefits of tree cover and which may lack natural buffers to common air pollutants. EnviroAtlas provides demographic data that may be overlaid to visualize the distribution of sensitive populations relative to the health benefits of tree cover. This map can also be used with urban planning and local health data to aid in current and future decision-making processes, such as land development, [public health](#) program implementation, or policy changes, which could involve changes in tree cover.

How were the data for this map created?

This data layer was derived from a high resolution community [land cover](#) map. The total amount of tree cover (m²) was determined for each census block group. The [i-Tree](#) pollution removal program was then run for each block group, assuming a [leaf area index](#) value of 4.9 and utilizing the closest hourly meteorological and pollution data. Percent of county tree cover that is evergreen was derived from the most current [NLCD](#) 30-m resolution [land cover](#) maps. Local leaf-on and leaf-off dates were used to vary canopy cover

daily based on the amount of tree cover classified as evergreen. Hourly estimates of pollution removal by trees were combined with atmospheric data to estimate annual percent air quality improvement due to pollution removal for several pollutants.⁴

Selected adverse health effects avoided due to tree cover were calculated using [BenMAP](#). The BenMAP model estimates health impacts and related costs or savings based on the local population and change in pollutant concentration. For EnviroAtlas, county-level multipliers of health impact per person per change in SO₂ were calculated and then applied to each block group. The final values incorporated the block-group changes in pollutant concentrations from i-Tree, and U.S. Census Bureau age distribution data reallocated from census tracts to each block group. The willingness to pay estimates were derived from health impact functions detailed in epidemiological studies described in the BenMAP Manual and accompanying appendices.⁵ For more information on these methods, see the layer's metadata or the publications below.

What are the limitations of these data?

Pollutant removal estimates are related to the use of [leaf area index](#) values that have been averaged from multiple study areas; specific values are unavailable for most communities. The relatively few existing weather stations and pollutant monitors are used to represent conditions across many block groups. Similarly, nearest atmospheric boundary layer height measurements and an assumption of a well-mixed boundary layer are used, but these may not reflect the local boundary layer. An additional limitation is the assumption that the age distribution for a census tract is mirrored in its block groups.

For more technical details about the limitations of these data, refer to the layer's metadata. EnviroAtlas data are estimates of the truth, founded on the best available science. These estimates reflect research on the relationships between tree canopy and SO₂, and SO₂ and hospital admissions. They do

Selected Publications

1. Centers for Disease Control and Prevention. 2014. [Hospital utilization](#). National Center for Health Statistics. Accessed January, 2015.
2. Agency for Healthcare Research and Quality. 2013. [Statistical brief #146: Costs for hospital stays in the United States, 2010](#). Accessed January, 2015.
3. US EPA. 2017. [Sulfur dioxide \(SO₂\) pollution](#). Office of Air and Radiation. Accessed February, 2018.
4. Nowak, D.J., D.E. Crane, and J.C. Stevens. 2006. [Air pollution removal by urban trees and shrubs in the United States](#). *Urban Forestry and Urban Greening* 4:115–123.
5. US EPA. 2015. [BenMAP Community Edition: User's Manual](#). Environmental Benefits Mapping and Analysis Program, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Nowak, D.J., S. Hirabayashi, A. Bodine, and E. Greenfield. 2014. [Tree and forest effects on air quality and human health in the United States](#). *Environmental Pollution* 193:119–129.

not consider hospital admissions due to pollen or other respiratory irritants generated by the trees themselves. Such effects vary widely with tree species and are not yet fully understood. It is advisable to consult with an arborist or urban forester on local tree planting decisions.

How can I access these data?

[EnviroAtlas](#) data can be viewed in the interactive map, accessed through web services, or downloaded. To find the EnviroAtlas 1-meter land cover grids created for each community, enter *land cover community* in the interactive map search box.

Where can I get more information?

To learn more about [i-Tree tools](#) and the [BenMAP](#) program and how they can be used to support research, planning, and policy efforts, visit their respective websites. There are numerous resources on the relationships among trees, ecosystem services, and human health and well-being; a selection of these resources is below. In-depth information on the relationships between trees and human health and well-being can be found in EPA's [Eco-Health Relationship Browser](#). For additional information on the data creation process, access the corresponding metadata found in the drop-down menu for each community map layer listed in the EnviroAtlas table of contents and click again on metadata at the bottom of the metadata summary page for more details. To ask specific questions about these data, please contact the [EnviroAtlas Team](#).

Acknowledgments

EnviroAtlas is a collaborative effort led by EPA. The data for this map were generated by Satoshi Hirabayashi and Allison Bodine, Davey Tree Expert Co., and David J. Nowak, USDA Forest Service. The fact sheet was written by David J. Nowak, USDA Forest Service, Pamela Barclay, EPA ORISE Fellow; Leah Yngve, EPA ASPPH Fellow; and Laura Jackson, EPA.