Sulfur Dioxide Removed Annually by Tree Cover

This EnviroAtlas community map estimates the total kilograms of sulfur dioxide removed annually by trees in each census block group.

Why is sulfur dioxide removal important?

Sulfur dioxide (SO_2) is a common air pollutant that belongs to the larger group of gases known as sulfur oxides (SOx). It is one of the six criteria pollutants regulated by EPA under the National Ambient Air Quality Standards (NAAQS). In the United States, approximately 2/3 of all SO_2 emissions come from the burning of fossil fuels such as coal, though natural sources such as volcanoes also release large amounts of SO_2.[1] Sulfur dioxide affects air and water quality and is linked to adverse respiratory health effects, such as increases in asthma symptoms. Trees are capable of removing SO_2 from the atmosphere, thus contributing to air and water quality and public health.

Sulfur dioxide, along with other air pollutants, can have significant effects on human health. Some of the human health problems that result from air pollution include aggravation of respiratory and cardiovascular diseases, decreased lung function, increased frequency and severity of respiratory symptoms (e.g., difficulty breathing and coughing) and increased susceptibility to respiratory infections.[2] People with pre-existing conditions such as heart disease, asthma and emphysema, as well as older adults and children, are at greater risk for air pollution-related health effects. Nationally, the number of people with asthma is growing, with about 1 in 12 people (25 million, 8% of U.S. population) having asthma in 2009, compared with 1 in 14 (about 20 million, or 7%) in 2001.[3]

In addition to its potential health effects, SO_2 also has environmental impacts. Sulfur dioxide is a major precursor to acid rain and contributes to the acidification of soils, lakes and streams.[2] This means that, when SO_2 gases in the atmosphere react with water, oxygen, and other chemicals, acidic compounds form that are then dispersed over varying distances and are deposited back to earth in wet or dry forms (wet deposition, dry deposition).[4] Thus, cleaner air also means fewer pollutants that can redeposit onto land and water bodies, degrading water quality.

Air pollution affects the climate by either absorbing or reflecting energy that can lead to climate warming or cooling, respectively. When released into the atmosphere, SO_2 is converted into sulfuric acid aerosols. These aerosols stay in the stratosphere for about two years, reflecting sunlight and reducing the amount of energy that reaches the lower atmosphere, thus cooling the atmosphere and the earth's surface.[5]


Photo: Coal-fired Powerplant, S. Greenwood

Trees help reduce the potential adverse health and environmental effects of SO_2 by removing it from the air. Gaseous air pollutants are taken in primarily through the leaf stomata (pores), though some gases are removed by the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces.[6] The removal of gaseous pollutants is more permanent than the removal of particulates because the gases are often absorbed and converted within the leaf interior. Healthy trees can remove significant amounts of air pollution in cities, where it is often concentrated.

How can I use this information?

The map, Sulfur Dioxide Removed Annually by Tree Cover, estimates the variation in the amount of air pollution removed by trees. These data could be used to explore the patterns of SO_2 removal by trees in communities that do not meet the standards set by the EPA's NAAQS. For compliant areas, the map can identify neighborhoods that potentially have higher SO_2 concentrations compared to other neighborhoods. Communities and researchers that have access to health data may be able to use this map and its underlying data to continue to research the relationships among trees, sulfur dioxide, and human health.

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How were these data created?

The data for this map are based on the land cover derived for each EnviroAtlas community and pollution removal models in i-Tree, a toolkit developed by the USDA Forest Service. The land cover data were created from aerial photography through remote sensing methods; tree cover was summarized as the percentage of each census block group. The i-Tree pollution removal module uses the tree cover data by block group, the closest hourly meteorological monitoring data for the community, and the closest pollution monitoring data. Additionally, the 2001 National Land Cover Dataset (NLCD) was used to determine the percent of these trees that were deciduous or evergreen. Local leaf-on and leaf-off dates were used to vary canopy cover daily based on the amount of tree cover classified as deciduous. Assuming a leaf area index value of 4.9, hourly estimates of pollution removal by trees were combined with atmospheric data to estimate hourly percent air quality improvement due to pollution removal for each pollutant.[7]

What are the limitations of these data?

All of the EnviroAtlas community maps that are based on land cover use remotely-sensed data. Remotely-sensed data in EnviroAtlas have been derived from imagery and have not been verified. These data are estimates and are inherently imperfect. This map also uses estimation methods for pollution removal. To accomplish this, average leaf area index values from urban areas were used. These averages may not accurately reflect local conditions, but since local values are not available, these are the best usable estimates. This limitation is not particularly significant because leaf area index values do not vary substantially and have a relatively small impact on the estimate. Additionally, this map uses weather and pollutant monitoring data to represent local conditions, though a city's average weather and pollutant conditions do not depict potential variability of conditions within the community.

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?

There are numerous resources where additional information on sulfur dioxide as an air pollutant can be found. A selection of these resources is listed below. For information on EPA air pollution rules, regulations, and monitoring programs, please visit the Agency's website. To learn more about i-Tree tools and how they can be used to support research, planning, and policy efforts, visit the i-Tree website. For more information on how air pollution and its removal may affect human health, visit the Clean Air section of the Eco-Health Relationship Browser. For additional information on the data creation process, access the metadata found in the layer list drop-down menu for map layers in the EnviroAtlas interactive map. To ask specific questions about these data, please contact the EnviroAtlas Team.

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Selected Publications

1. United States Environmental Protection Agency (EPA). 2012. Sulfur dioxide. Accessed October 2020.

2. United States Environmental Protection Agency (EPA). 2010. Our nation's air: Status and trends through 2016. Accessed October 2020.

3. Centers for Disease Control and Prevention (CDC). 2012. Asthma in the U.S: Growing every year. Accessed October 2020.

4. United States Environmental Protection Agency (EPA). 2012. Acid rain. Accessed October 2020.

5. Voiland, A. 2010. Aerosols: Tiny particles, big impact. National Aeronautics and Space Administration (NASA). Accessed October 2020.

6. Smith, W.H. 1990. *Air pollution and forests*. Springer-Verlag, New York. 618 p.

7. 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.