Reduction in Median Load of Total Suspended Solids [TSS] Due to Tree Cover

This EnviroAtlas community map estimates the annual reduction in kilograms of the median load of total suspended solids (TSS) in urban stormwater runoff due to filtration by trees within each census block group. Estimates were produced with the i-Tree Hydro analysis tool developed by the USDA Forest Service.

Why is total suspended solids reduction important?

Urban stormwater runoff is a major source of total suspended solids (or TSS) entering streams and lakes near developed areas. Sources of TSS in urban runoff include soil from pavement, overland flow, and landfills; airborne dust and chemical compounds; organic debris; and sewage.[1,2] TSS from aerial and terrestrial sources accumulates on urban land and pavement until runoff from precipitation carries the pollutants into stormwater drains and directly to local waterbodies. The highest TSS loadings originate from construction sites (a typical load is 6000 lbs/acre/year) and impervious surfaces (e.g., commercial properties, freeways, and industrial sites [at ≤ 1000 lbs/acre/year]).[2] Sediment particles also carry molecules of nutrients, pesticides, heavy metals, and volatile chemicals such as petroleum products, which may be released by disturbance or microbial activity.[3]

Impervious surfaces greatly increase peak runoff velocity and magnitude following precipitation events.[3] Increased TSS loadings in urban streams often occur soon after major storms because of this pulse of pollutants.[2] High velocity stormwater runoff affects the hydrology and channel structure of local waterbodies as it flows into them from stormwater drains, eroding stream banks to deliver additional sediment.

Sedimentation can have serious long-term effects on aquatic biota, either through direct species elimination or relative changes in community composition. Suspended solids reduce water clarity and light penetration, smother or retard the growth of beneficial aquatic plant life, and bury gravel or cobble habitats in stream and lake beds that are essential for the sustainability of aquatic insects and fish spawning sites.[2,4] Fish are directly affected by sedimentation through the loss of habitat and insect prey, clogging and abrasion of gills and skin, and loss of productivity and species diversity. Only the most tolerant species survive chronically high TSS.


Photo: Construction sediment runoff. Eric Vance, EPA

Besides degrading water quality, polluted stormwater runoff affects recreational opportunities, community aesthetics, and sense of well-being for local residents.[1] Urban tree cover can benefit communities by reducing the influx of total suspended solids. The proportions of tree cover relative to impervious surfaces in community neighborhoods influence the quantity and speed of urban stormwater runoff entering nearby waterbodies. Trees planted along roadways, in retention basins, or riparian buffers intercept runoff, slow the passage of stormwater to drains, and filter significant quantities of sediment. Studies have shown that sediment removal by trees ranges from 60–90% depending on buffer area, slope, and volume and velocity of runoff.[4] Toxic substances adhering to sediment particles may be modified into less harmful forms by microorganisms in the soil and made available to plants.

This EnviroAtlas map helps to visualize the varying relationships among impervious surfaces, tree cover, and estimates of potential annual reduction in total suspended solids. Estimates of potential TSS reductions are lower in city centers with higher impervious surface area and higher in suburban and rural areas with more tree cover. This data layer can serve as an important planning tool for mitigating excess suspended solids in waterbodies.

How can I use this information?

The map, Reduction in Median Load of Total Suspended Solids, illustrates potential the reduction of pollutants in

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stormwater runoff due to filtration by urban trees. Users can compare the estimated annual reductions in median TSS load among community census block groups. This layer can be combined with other community ecosystem service layers in EnviroAtlas (e.g., air pollution removal, carbon storage and sequestration, and air temperature effects) to calculate the magnitude of multiple ecosystem services contributed by trees within a given area. Using this surface water runoff information, planners and other interested users can identify community neighborhoods and block groups with the highest proportion of impervious surfaces, where additional tree planting might improve the retention and filtration of runoff following heavy precipitation. Users might also overlay National Hydrography Dataset (NHD) flowline data (available in Supplemental Data) to explore where tree planting would have the greatest return in terms of improving water quality in nearby waterbodies.

How were the data for this map created?

This data layer was derived from a high resolution tree and impervious cover map provided by the US EPA for selected communities. To estimate the effect of changes in tree and impervious cover on runoff, the i-Tree Hydro model was run to simulate cover change effects on a local or nearby watershed. The model was calibrated using hourly stream flow conditions and run numerous times to produce estimates in changes in runoff due to changes in tree and impervious cover. To estimate the block group effect, the runoff outputs of the watershed were determined for each possible combination of tree cover (0-100%) and impervious cover (0-100%), giving a total of 10,201 possible responses (101 x 101). For each block group, each percent tree cover and percent impervious cover combination was matched to the watershed hydrologic response output for that combination (actual streamflow data). The hydrologic response outputs were calculated as either percent change or absolute change in units of kg of pollutant per square meter of land area. These per square meter values were multiplied by the square meters of land area in the block group to estimate the tree effects at the block group level.

To estimate the annual reduction in median TSS load due to trees, national median event-mean-concentration (EMC) values (measured as a mass of pollutant per unit volume of water [mg/l]) were multiplied by the volume of runoff to determine estimated changes in kg/year.

What are the limitations of these data?

To generate the data for this map, modeled results for a local or nearby watershed were transformed into runoff results for all of the census block groups in the community. Trees within each block group were assumed to have a similar hydrologic effect as trees within the modeled watershed. In addition, national water quality EMC values were substituted for actual local concentration values of runoff, which are unknown. Finally, the model is more illustrative of the effects of changes in cover than it is predictive of actual stream pollutant load.

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. The land cover maps created for each community are available under Supplemental Maps: Raster: Biophysical Data in the interactive map table of contents.

Where can I get more information?

A selection of resources related to sediment and urban runoff is listed below. For additional information on the data creation process, access the 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 this data layer, please contact the EnviroAtlas Team.

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Selected Publications

1. The National Academy of Sciences. 2009. Urban stormwater management in the United States: 2009. Report prepared by the Committee on Reducing Stormwater Discharge Contributions to Water Pollution, National Academies Press, Washington, D.C.

2. Strassler, E., J. Pritts, and K. Strellec. 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices, EPA-821-R-99-012, U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

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4. Newcombe, C.P., and D.D. Macdonald. 1991. Effects of suspended sediments on aquatic ecosystems. *North American Journal of Fisheries Management* 11(1):72–82.