Reduction in Mean Load of Soluble Phosphorus Due to Tree Cover

This EnviroAtlas community map estimates the annual reduction in kilograms of the mean load of soluble phosphorus in urban stormwater runoff due to filtration by trees within each census block group. The estimates were produced using the i-Tree Hydro analysis tool developed by the USDA Forest Service.

Why is soluble phosphorus load reduction important?

Urban stormwater runoff is a major source of untreated nutrients entering streams and lakes near developed areas. Sources of phosphorus in urban stormwater runoff include lawn and garden fertilizers, pet waste, leaking septic tanks, vehicle exhaust, construction runoff, and detergents.[1] Phosphorus from aerial and terrestrial sources accumulates on urban land and pavement until runoff from a precipitation event carries pollutants into stormwater drains and directly to local waterbodies. The highest phosphorus pollutant loadings in urban runoff originate from impervious surfaces (e.g., construction sites, commercial and industrial properties, high density residential areas, and freeways).[2] Excess phosphorus in urban runoff contributes excess nutrients to waterbodies, creating algal blooms and overabundant aquatic plant growth (eutrophication). The breakdown of decomposing aquatic plants can create an oxygen deficit that negatively affects the health and productivity of aquatic animal species. Low oxygen levels also promote microbial activity that releases additional phosphorus from bottom sediments, further fueling the eutrophication cycle.[3]

Phosphorus is chemically active in water, where it forms various organic and inorganic phosphates. The soluble-phosphorus water-quality test measures total phosphorus in a filtered water sample, separating soluble phosphorus from particulate phosphorus. However, because of its high turnover rate, the quantity of soluble phosphorus in a waterbody is constantly changing. A phosphorus test to track the full impact of eutrophication measures the sum of both soluble and particulate phosphorus.[3]

In addition to degrading water quality, polluted stormwater runoff affects the hydrology and channel structure of local waterways as well as recreational opportunities, community aesthetics, and sense of well-being for local residents.[1] The proportions of tree cover relative to impervious surfaces in community neighborhoods influence the quantity and speed of urban stormwater runoff entering nearby waterways.

Impervious surfaces greatly increase peak runoff magnitude following precipitation events.[4] Increased nutrient concentrations in urban streams often occur soon after major storms because of this pulse of pollutants into streams.[2]

Urban tree cover can benefit communities by reducing the influx of nutrients into local waterbodies. Trees in retention basins or riparian buffers are capable of filtering significant quantities of phosphorus (30–80%) from stormwater runoff, depending on area, slope, and the volume and velocity of runoff.[4]

This EnviroAtlas map helps to visualize the varying relationships among impervious surfaces, tree cover, and estimates of potential annual reduction in mean soluble phosphorus load. Estimates of potential nutrient 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 nutrients in waterbodies.

How can I use this information?

The map, Reduction in Mean Load of Soluble Phosphorus Due to Tree Cover, illustrates the potential reduction of pollutants in stormwater runoff from filtration by urban trees. Users can compare the estimated annual reductions in mean soluble phosphorus 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

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other interested users can identify the 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 from 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 soluble phosphorus load due to trees, national mean 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 phosphorus 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.

3. Correll, D.L. 1998. The role of phosphorus in the eutrophication of receiving waters: A review. *Journal of Environmental Quality* 27:261–266.

4. Nowak, D.J., J. Wang, and T. Endreny. 2007. Chapter 4: Environmental and economic benefits of preserving forests within urban areas: air and water quality. Pages 28–47 *in* de Brun, C.T.F. (ed.), The economic benefits of land conservation. The Trust for Public Land, San Francisco, California.

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