Reduction in Mean Load of Nitrites and Nitrates Due to Tree Cover

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

Why is nitrite and nitrate load reduction important?

Urban stormwater runoff is a major source of untreated nutrients entering streams and lakes near developed areas. Sources of nitrite (NO_2) and nitrate (NO_3) in urban stormwater runoff include lawn and garden fertilizers, pet waste, leaking septic tanks, and aerially-deposited nitrogen from powerplant emissions and vehicle exhaust.[1] Nitrogen from aerial and terrestrial sources accumulates on urban roads and parking lots until runoff from a precipitation event carries pollutants into stormwater drains and directly to local waterbodies. The highest nitrite and nitrate pollutant loadings originate from impervious surfaces (e.g., commercial properties, parking lots, and freeways).[2] Excess nitrogen 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.

Though nitrites are not common in stormwater runoff, nitrates can be transformed into nitrites if ingested in drinking water and may affect human health; infants less than 6 months old are susceptible to blue baby syndrome if they drink formula made from water contaminated with nitrites.[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]

Photo: J.M. Pease, NIH

Urban tree cover can benefit communities by reducing the influx of nutrients into local waterbodies. Trees planted along roadways, in parking lots, retention basins, or riparian buffers are capable of filtering significant quantities of nitrates from stormwater runoff. Trees also enable denitrification, a process where bacteria in saturated soil transform dissolved nitrates into gaseous nitrogen compounds that escape to the atmosphere. [4]

This EnviroAtlas map helps to visualize the varying relationships among impervious surfaces, tree cover, and estimates of potential annual reduction in mean nitrite and nitrate 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 Nitrites and Nitrates Due to Tree Cover, illustrates the potential reduction of pollutants in stormwater runoff due to filtration by urban trees. Users can compare the estimated annual reductions in mean nitrite and nitrate 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 readily 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 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 mean nitrite and nitrate 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 nitrogen compounds 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. U.S. Environmental Protection Agency. Frequently asked questions about nitrate and drinking water. Accessed December, 2015.

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.

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. *Environmental Management* 28(2):255–266.