Reduction in Median Load of Copper Due to Tree Cover

This EnviroAtlas community map estimates the annual reduction in kilograms of median copper load measured 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 copper load reduction important?

Urban stormwater runoff is a major source of untreated heavy metals (such as copper, cadmium, cobalt, nickel, lead, and zinc) in streams and lakes near developed areas. Major sources of copper in urban environments include building materials (roofing, treated wood, and water pipes), vehicles (engine, tire, and brake pad wear, gasoline, and tailpipe emissions), asphalt, concrete, and pesticides.[1] Metals are bound to soil and transported with sediments in runoff or dissolved directly in water. Though natural vegetative cover can filter out metals from urban stormwater runoff, urban lawns, golf courses, and parks can also contribute copper accumulated in the soil from fertilizers and pesticides.[2]

Aquatic animals, including fish, crustaceans, and aquatic insects, are more susceptible to copper toxicity than are terrestrial mammals. Fish exposed to excess copper experience fraying of gills, changes in internal salt balance, and loss of sense of smell. The loss of sense of smell in fish may interfere with their foraging, predation avoidance, reproduction, and homing navigation.[3]

In addition to degrading water quality, polluted stormwater runoff affects the hydrology and channel structure of local waterways as well as recreational opportunities, public health, 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 metals concentrations in urban streams often occur soon after major storms because of this pulse of pollutants into streams.[1]

Urban tree cover can benefit communities by reducing the influx of heavy metals into local waterbodies. Trees in an urban setting intercept rain water, slow the passage of stormwater to drains, and filter out nutrients and pollutants. Toxic substances in organic pollutants may be modified by

Photo: J.M. Pease, NIH

microorganisms in the soil into less harmful forms and made available for plant growth.[4]

This EnviroAtlas map helps to visualize the varying relationships among impervious surfaces, tree cover, and estimates of potential annual reduction in median copper load. Estimates of potential copper reduction are lower in city center areas with higher impervious surface area and higher in suburban and rural areas having more tree cover. The copper reduction data layer can serve as an important planning tool for mitigating copper toxicity in receiving waterbodies.

How can I use this information?

The map, Reduction in Median Load of Copper due to Trees, illustrates the potential reduction of pollutants in stormwater runoff due to filtration by urban trees. Users can compare the estimated reductions in median annual copper 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

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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 reduction in annual median copper 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 of copper load.

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 copper 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.

Acknowledgments

The data for this map were generated by David Nowak, USDA Forest Service, and Tian Zhou, Bangshuai Han, and Ted Endreny, State University of New York. The fact sheet was created by David Nowak, USDA Forest Service, and Sandra Bryce, Innovate!, Inc.

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. Boulanger, B., and N. Nikolaidis. 2003. Mobility and aquatic toxicity of copper in an urban watershed. *Journal of the American Water Resources Association* 39(2):325–336.

3. Sandahl, J.F., D.H. Baldwin, J.J. Jenkins, and N.L. Scholz. 2007. A sensory system at the interface between urban stormwater runoff and salmon survival. *Environmental Science and Technology* 41(8):2998–3004.

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.