

### The Role of Trees & Forests in Healthy Watersheds *Managing Stormwater, Reducing Flooding, and Improving Water Quality*

**P**ennsylvania contains almost 83,000 miles of rivers and streams, ranging from small trickles to large rivers. These waterways are important because they provide water for people, farms, and industries; provide habitat for many kinds of wildlife and fish; and also provide us with great places to fish, swim, and boat.

As our landscape changes, it begins to have an impact on stream health. What we do on or to the land affects both the quantity (volume) and quality (pollutant levels) of the water in our streams and lakes. The land area through which any water moves, or drains, to reach a stream is called a watershed.

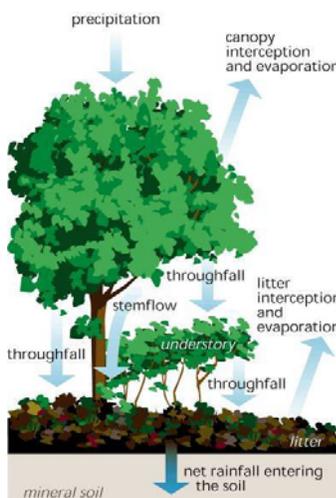
As we begin to remove forest canopy and replace it with roads, parking lots, driveways, homes, patios, pools (impervious surfaces) and even grass, we immediately have impact on watersheds and receiving streams (or lakes). With the increased amount of impervious surfaces, water runs off the land, traveling on the surface towards the streams. As this 'storm water runoff' travels to the streams it collects pollutants and increases speed. The changes to the landscape, not only increase the volume of water that goes to the stream, it also shortens the amount of time it takes the water to get to the stream. These increased or peak flows cause water to move quickly to the streams. This leads to flooding, stream bank erosion, widening of streams, sediment deposited in streams, a loss of fish habitat, and decline in water quality. In Pennsylvania there are over 12,200 miles of polluted streams and over 3,000 miles of streams that are impaired by storm water runoff.



#### **So how do we protect water quality and our streams as watersheds change?**

Trees and forests play an incredible role in reducing storm water in several ways and removing or filtering pollutants that would otherwise wind up in our waterways.

#### **Canopy Interception and Infiltration**



Forests filter and regulate the flow of water, in large part due to their leafy canopy that intercepts rainfall, slowing its fall to the ground and the forest floor, which acts like an enormous sponge, typically absorbing up to 18 inches of precipitation (depending on soil composition) before gradually releasing it to natural channels and recharging ground water. In a North Carolina Watershed study (Kays, 1980) the mean soil infiltration rate went from 12.4 in/hr to 4.4 in/hr when a site was converted from forest (duff layer on soils) to suburban turf. Other studies (Bharati et al. 2002) have found similar results when comparing hourly infiltration rates and soil bulk density of forested areas with crops and grazed pasture.

Average interception of rainfall by a forest canopy ranges from 10-40% depending on species, time of year, and precipitation rates per storm event. In urban and suburban settings a single deciduous tree can intercept from 500 to 760 gallons per year; and a mature evergreen can intercept more than 4,000 gallons per year. Even young, small trees help. In a recent Forest Service study a single small tree (callery pear) that was only 9 years old, was able to intercept 58 gallons of storm water from a ½ inch rain event (67% of the rain that fell within the canopy).

A study in the 1980's of Dayton, Ohio's existing tree canopy found that storm water runoff was reduced by 7% and could be increased to 12% through planting more trees. In a more recent UFORE Hydro study conducted by the USDA Forest Service of the Toby Creek Watershed (a suburban area of Wilkes-Barre), 54% tree canopy cover was able to reduce storm water runoff by 11%. One Forest Service Researcher has stated that planting large canopy trees over impervious surfaces, such as a parking lot or street has much greater impact on reducing storm water (up to 8 times greater) because it works to reduce peak flows in urban settings.



## Trees Consume Stormwater

Trees and forests absorb and use tremendous amounts of water for growth, thereby consuming storm water. A single mature oak tree can consume (transpire) over 40,000 gallons of water in a year. In Pennsylvania forests, an average of 24 inches of the annual 40 inches of rainfall is taken up by trees through evapotranspiration (movement of water from the ground through the tree and leaves, evaporating back into the environment). That evapotranspiration also serves to cool and modify surrounding summer temperatures. If the forest is removed or harvested, evaporation drops to 14 inches and stream flow increases to receive 26 inches of the annual 40 inches of precipitation. So, just the removal of forests can have an impact on streams in the watershed.

## Pollutant Removal and Phytoremediation

Plants, especially woody plants, are very good at removing nutrients (nitrates and phosphates) and contaminants (such as metals, pesticides, solvents, oils and hydrocarbons) from soil and water. These pollutants are either used for growth (nutrients) or are stored in wood. In one study, a single sugar maple growing roadside removed 60mg of cadmium, 140mg of chromium, 820mg of nickel, and 5200mg of lead in a single growing season (Coder, 1996). Studies in Maryland showed reductions of up to 88% of nitrate and 76% of phosphorus after agricultural runoff passed through a forest buffer.



In comparison, studies of residential lawns have shown overuse of chemical fertilizers (over 100 million tons applied to lawns annually) and synthetic pesticides (80 million pounds applied to lawns annually – 10 times the rate per acre used by farmers – Yale graduate study). Excess nutrients from lawns and agricultural fields is one of the largest sources of non-point pollutants that is impacting water quality in our streams, rivers, lakes and the Chesapeake Bay.

Parking lots, one of the fastest growing land uses, have become a major cause of water quality and stream degradation. Non-Point Source pollutants such as petroleum hydrocarbons, nitrates, and heavy metals (cadmium, copper, lead, and zinc) from brakes and rusting automobiles all wash into our water ways. Even a small rain storm (less than .5 inches) will cause 'first flush' – washing these pollutants into streams.



The runoff from one acre of paved parking generates the same amount of annual runoff as: 36 acres of forest; 20 acres of grassland; a 14 acre subdivision (2 acre lots); or a 10 acre subdivision (0.5 acre lots). One inch of rainfall on an acre of parking produces 27,000 gallons of stormwater. Large increases in stormwater volume reaching streams has caused major streambank erosion problems, down stream flooding, increased nutrient/sediment loads, and degraded aquatic habitat. The planting of trees in parking lots, especially in bio-

retention areas where stormwater flows, can have a positive impact on water quality and work to reduce flooding and stream impairment.

## Streamside or Riparian Forest Buffers



Planting and maintaining woody vegetation along streams provide a wealth of benefits and research at the Stroud Water Center and elsewhere have shown that stream health is dependent on the presence of woody vegetation along its banks. Riparian forest buffers filter sediment from streams during storm events; remove nitrogen and phosphorous leaching from adjacent land uses such as agriculture; provide stability to the bank (wood root systems); shade and modify stream temperatures, critical for habitat and pollution reduction; provide aquatic and wildlife habitat for many species; reduce stream velocity; and reduce down stream flooding.

Buffer widths vary from 50 feet, providing some bank stability to 250 feet, providing flood mitigation and wildlife habitat. Planting new buffers has become a state priority over the last 10 years, but regulations to protect existing buffers from removal do not exist. Some municipalities have adopted ordinances to protect riparian forest buffers, and model ordinances do exist (Montgomery County Planning).

Increased impervious surfaces and un-managed storm water continue to erode stream banks and fill streams with sediment. Streambank stabilization projects are costing taxpayers almost \$1million per mile and state and federal agencies can't afford or keep up with the increased number of streams needing restoration.

## Trees and Forests: a New BMP for Stormwater Management in Pennsylvania

Up until recently, stormwater management strategies have been focused on detaining large volumes of water in basins that had little to no effect on removing the pollutants in the stormwater. In December 2006, DEP unveiled the new Stormwater Management- Best Management Practices (BMP) Manual that works to protect water quality and to put stormwater back into the ground where it fell. One of the ten principles for new stormwater management is “preserve and utilize natural systems (soil, vegetation, etc)”.

Several of the Non-Structural BMPs include protecting/conserving existing forests and riparian areas, cluster or concentrate new construction to minimize site disturbance, use conservation subdivision design and low impact development techniques, minimize soil compaction and grading entire areas, re-vegetate and re-forest disturbed area using native species, and reduce impervious cover such as streets and parking lots.



Then there are Structural BMPs that are promoting infiltration of stormwater such as the development of rain gardens or bioretention areas where trees and vegetation play an active role consuming rain water and removing pollutants. Trees and vegetation are also being incorporated into newly designed or retrofitted stormwater basins to promote pollution and sediment removal. Other strategies include Green Roofs, rain barrels or cisterns, vegetated infiltration swales, constructed wetlands, and riparian buffer and floodplain restoration.

In older existing communities, increasing tree canopy cover along streets, in yards and in parking lots can have a positive impact on our watersheds. Planting large canopy trees (where growing space permits) provide the most benefit – 8 times that of small maturing trees, according to new USDA Forest Service research (Greg McPherson, Western Center for Urban Forest Research). A study in Oakland, California will be monitoring 1,800 newly planted trees for 40 years to determine if they will account for a 9 million gallon reduction in contaminated stormwater entering the San Francisco Bay.





The role of trees and forests in managing stormwater and protecting water quality is just beginning to be understood by some engineers, planners and community leaders. One of the most powerful statements that help support this came from the Chesapeake Bay Executive Council in 2006 and reads:

‘Forests are the most beneficial land use for protecting water quality, due to their ability to capture, filter, and retain water, as well as air pollution from the air. Forests are also essential to the provision of clean drinking water to over 10 million residents of the watershed and provide valuable ecological services and economic benefits including carbon sequestration, flood control, wildlife habitat, and forest products’.

## Watershed and Stormwater Resources

**Center for Watershed Protection** - [www.cwp.org](http://www.cwp.org)

(learn more about the impact of impervious surfaces and storm water on our streams and watersheds and access many downloadable publications).

**Urban Watershed Forestry Manuals** - <http://www.cwp.org/forestry/index.htm>

**Storm water Managers Resource Center** - <http://www.stormwatercenter.net/>  
(view slideshow, fact sheets and much more)

**USDA Forest Service Riparian Buffers** - [http://www.na.fs.fed.us/spfo/pubs/n\\_resource/buffer/cover.htm](http://www.na.fs.fed.us/spfo/pubs/n_resource/buffer/cover.htm)

**Stroud Water Research Center** - <http://www.stroudcenter.org/>  
(visit the Leaf Pack Network for Teachers)

**University Of Maryland Riparian Buffer** - <http://www.riparianbuffers.umd.edu/>

**Alliance for the Chesapeake Bay program** - <http://www.acb-online.org/pubs.cfm>

**Natural Stream Channel Design** - [http://www.nrcs.usda.gov/technical/stream\\_restoration/](http://www.nrcs.usda.gov/technical/stream_restoration/)

**Urban Stream Restoration** - <http://www.urbanstreamrestoration.com/index2.html>  
(a video tour of Ecological Restoration Techniques with Ann Riley)

**DEP's Watershed TV** – <http://www.greentreks.org/watershedstv/index.asp>  
(miniclips on storm water and other issues)

**Hubbard Brook Experimental Watershed** - <http://www.hubbardbrook.org/education/Introduction/Intro1.htm>

**Forest Service – Urban Forestry Research Center** – <http://www.fs.fed.us/psw/programs/cufr/research/water.shtml>

**Green Infrastructure Website** - <http://www.greeninfrastructure.net/>

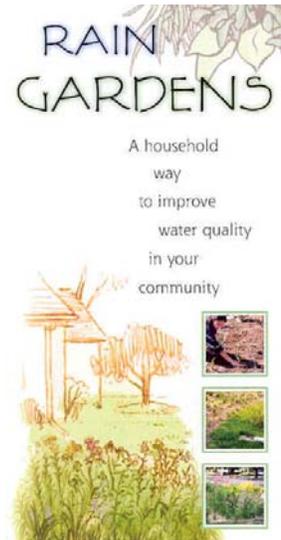
**Maryland's Storm water Website** - <http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/home/index.asp>

**Nonpoint Education of Municipal Officials (NEMO)** - <http://nemo.uconn.edu/>

**Alliance for the Chesapeake Bay** - <http://www.acb-online.org/>

**Storm water Journal** - <http://www.stormh2o.com/sw.html>

**Low Impact Development Techniques** - <http://www.lowimpactdevelopment.org/>



This publication was prepared by Vincent Cotrone, Urban Forester, Penn State School of Forest Resources

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