



We may sometimes take it for granted, but clean, fresh water is essential for life. In a number of ways, trees play an important role in protecting our water supplies. As storms increase in frequency and violence, and as sources of pollution grow with our population and consequent paving of surfaces, trees in both our urban and rural environments become ever more vital.

According to the Natural Resources Defense Council, 60% of the water delivered to American homes comes from waterways such as rivers, streams, and lakes. The U.S. Environmental Protection Agency warns that nearly half of the rivers and streams and more than one-third of our lakes are so polluted they are unfit for swimming, fishing, and drinking. The situation is getting worse, and the Council notes that by 2050 the global demand for freshwater is expected to be one-third greater than it is now.

Clearly, action is needed — now. Although the problem of water pollution is complex and the sources of the

pollution are many, planting and caring for trees is the one thing that is within reach of us all. The concepts behind how trees can help clean water are relatively simple. The canopy intercepts rain from storms and retains huge volumes of water that is slowly released into the atmosphere or to otherwise over-burdened municipal facilities such as drain pipes. This, along with simple landscape features such as street-side or backyard swales, can make a significant difference in the quantity and quality of water that reaches streams and rivers. The other contribution is roots. Roots can hold soil in place and take up chemicals such as fertilizers, forming an absorptive barrier between fields or urban developments and waterways.

In this issue, you will see the relation of trees and clean water. It is an issue that should concern every American and that can be addressed by individuals, tree boards, and city officials. It is a matter of protecting what might be considered our most important natural resource.



How Trees Help

It is no secret that trees freshen our air, cool our streets and homes, and provide other benefits of a practical and aesthetic nature. Perhaps what is less known and appreciated is their contribution to fresh water.

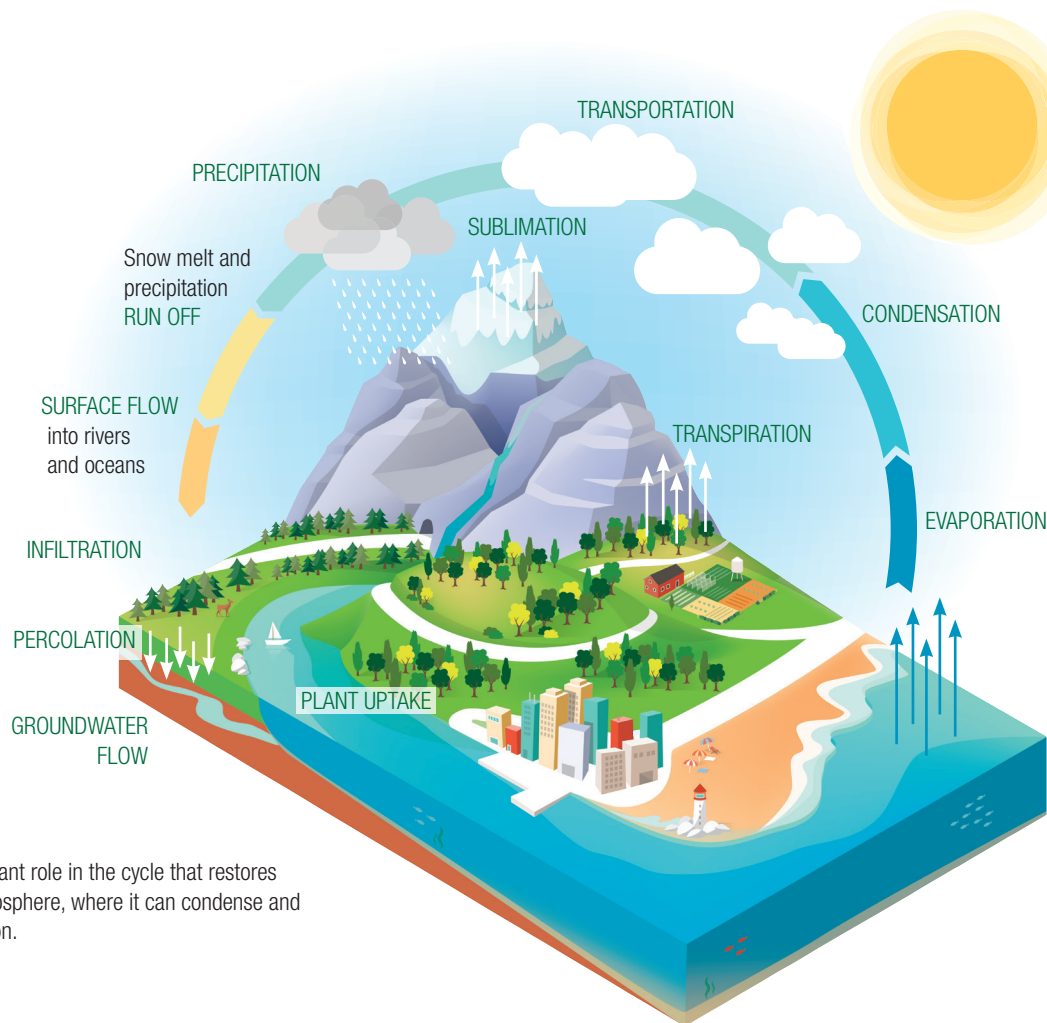
MAKING RAIN

“If the forest disappears, the sky-roof of the world will collapse; nature and man will perish together,” a Native American proverb warns. Other native wisdom includes the Hawaiian saying, “The rain follows the forest.” Scientists debate about the degree to which these concepts hold up, and it is apparent that geography plays a role, but the basic idea that there is an important relationship between trees and atmospheric moisture is sound.

Evapotranspiration is at the heart of the rain-making concept. The “evapo” part comes from rainwater evaporating from surfaces, including leaves, and returning moisture to the atmosphere. The rest of the word is from the phenomenon by which water is drawn from the soil by roots, raised to leaves, and released into the air. Scientists believe that up to 40% of precipitation is due to evapotranspiration from forests; that number can be even higher in summer. Urban trees contribute to that life-giving water cycle right along with their rural cousins.



Depending on species and time of year, water retained on leaves can be significant.



Trees play an important role in the cycle that restores moisture to the atmosphere, where it can condense and return as precipitation.

The Tree Canopy — Nature's Umbrella

Trees in our communities provide many services beyond the inherent beauty they lend to streets and properties. One of the most overlooked and under appreciated is their ability to reduce the volume of water rushing through gutters and pipes following a storm. This means less investment in expensive infrastructure and — importantly — cleaner water when the runoff reaches rivers and lakes.



Drop by drop, rainwater is stored on leaves of trees slowing, and reducing runoff. The collective effect of this simple action can make a huge difference in a community.

Have you ever stood under a tree that has served as an umbrella during a sudden downpour? Not a good idea when lightning is present, but otherwise the canopy offers welcome shelter.

The next time you experience the umbrella effect, consider the amazing service each tree provides to the quality of our environment. Aside from keeping you dry, the leaves and bark of a tree retain a huge amount of water, allowing some of it to evaporate and some to more slowly reach the ground. Depending on size and species, a single tree may store 100 gallons or more, at least until it reaches saturation after about 1 to 2 inches of rainfall. When multiplied by the number of trees in a community, this interception and redistribution can be significant. It is estimated that the urban forest can reduce annual runoff by 2–7%. This reduction can be converted into dollar savings due to the use of smaller drainage and artificial retention systems. When trees are combined with other natural landscaping, studies have shown that as much as 65% of storm runoff can be reduced in residential developments. In fact, sometimes even 100% of rainfall can be retained on site.

Through the collective action of leaves and the anchoring and absorbing effects of roots, trees also contribute to soil stabilization, cleaner water, and the recharge of groundwater that serves as the public water source for at least half of the people in the United States.

The ecoservices provided by trees can, to a large extent, be measured using the suite of computerized i-Tree tools. For example, using the i-Tree Eco program, the city of El Paso, Texas, found that its 1.2 million trees reduce 32.9 million cubic feet of stormwater, for a value of \$2.19 million in avoided costs.

RETAINING WHAT WE GET

Although community trees contribute to atmospheric moisture and help cool the hot summer air, their ability to help control stormwater is equally as important. “When it rains, it pours,” goes the old saying. And when this happens, it is important to reduce the quantity of water running into storm drains or cascading down streets and steep park areas. Trees tame stormwater by retaining huge quantities of water on their leaves and bark, making it available for evaporation or slowly releasing it into the soil. Trees also break the force of falling rain, preventing erosion. Fallen leaves even make a contribution by helping to make soil more spongy and absorbent. Together, not only does tree cover help harvest precipitation, it cleans our waterways by reducing the kind of fast runoff that picks up oils and landscape chemicals and deposits them as pollutants.

From an economic standpoint, the greater the tree canopy, the greater the retention of stormwater, and the less stress there is on sewer systems, catchment basins, and water treatment facilities. This attribute of trees can be measured, and its value to the community quantified.

Trees Tame Stormwater

RAIN REFRESHES THE LAND AND NOURISHES THE GREEN LANDSCAPE.

But as houses, stores, schools, roads, and parking lots spread and natural tree cover is lost, so is the absorbing effect of vegetation and soil. The welcome rain becomes costly stormwater runoff. Without the benefit of trees and vegetated infrastructure, waterways are polluted as oils, heavy metal particles, and other harmful substances are washed away. Fish and wildlife suffer, drinking water becomes expensive or impossible to reclaim, property values are reduced, and our living environment is degraded.

Trees make a difference, and every tree matters. It's never too late for municipalities, homeowners, businesses, and schools to plant abundant trees to retain more water on-site, enhance percolation into the soil, reduce the expense of pipes and treatment plants, and protect environmental quality.

FEW TREES

1 TREELESS PARKING LOTS are unsightly, add to stormwater runoff, and are a source of heat that is not only uncomfortable, but increases air pollution.

2 TREELESS STREETS deprive the community of social benefits and ecological services. Following storms, water rushes along the street sides.

3 ASPHALT PLAYGROUNDS are unnatural places for children to play, contributing to a disconnect with nature. The solid surface also prevents rain from slowly recharging groundwater, instead adding extra volume to runoff.

4 TREELESS HOMES AND YARDS reduce property values, increase energy costs, and allow rainfall to rush into gutters.

5 EROSION-PRONE RIVERS eat away at adjoining property, destroy fish habitat, and fill in reservoirs and waterways with silt.

6 COMPACTED LAWNS without trees are not only less appealing, they often can't soak up heavy rains fast enough. Excessive runoff flows across sidewalks and down driveways and streets.

7 OVERWHELMED SEWAGE SYSTEMS can lead to untreated sewage being swept into waterways. Upgrades are expensive, adding to local tax burdens.





LEAVES break the force of falling rain and reduce soil erosion.

PERVIOUS MATERIALS let rainwater enter the soil.

TREE ROOTS bind the soil and guard against erosion. They also take up quantities of water that would otherwise be added to runoff.

ABUNDANT TREES

- ① **WELL-LANDSCAPED PARKING LOTS** can be designed to slow storm runoff and beautify the community. They cool parked cars, reducing evaporated gasoline that contributes to air-polluting ozone. Tree shade also adds longevity to paved surfaces.
- ② **TREE-LINED STREETS** retain large volumes of rainfall, reducing and cleansing runoff. They also increase property values, encourage shopping and business, reduce air pollution, calm traffic, and lower noise levels.
- ③ **OUTDOOR CLASSROOMS** at schools can be combined with nearby community gardens and natural areas to serve as neighborhood parks. Their unpaved surfaces increase rainwater retention as they provide nature-rich play and learning spaces for children.
- ④ **SHADED HOMES AND TREE-FILLED YARDS** make urban life more pleasant and provide practical benefits such as lower heating and air conditioning costs and increased re-sale values. The tree canopy is also a major contributor to stormwater runoff reduction.
- ⑤ **RIPARIAN BUFFERS** consisting of trees and shrubs along waterways slow flood waters, reduce erosion, cool the water for fish, and filter harmful runoff from adjoining land.
- ⑥ **RAIN GARDENS** hold water on-site, reducing wasteful runoff and providing moisture for tree roots and flower beds. They also filter chemicals draining from walks, driveways, and streets.
- ⑦ **MANAGEABLE STORMWATER RUNOFF** results from abundant trees, multi-use catch basins and rain gardens, reduced impervious surfaces, and increased ground vegetation. The benefits are lower costs and a more liveable, sustainable environment.



More Ways that Trees Can Help

Whether standing alone to intercept rain or working in conjunction with water-retention facilities, trees can make significant contributions. Their benefits are practical and can save money for the community, but they also add beauty, and that counts, too.

VEGETATIVE SWALES

As impervious surfaces spread with the increase of paved roads, parking lots, driveways, and even former lawn areas, the use of swales is more important than ever. Their potential was well-demonstrated by the Center for Urban Forest Research in a Davis, California, parking lot. Using a control area for comparison and after 50 storm events and 22 inches of rain, the researchers credited the swale with reducing surface runoff by 89% and reducing pollutants by 95%.

While some communities require swales in new developments, the vegetated aspect is sometimes overlooked. Designing with plant materials appropriate to the climate and site is important, as is a plan for occasional maintenance, but the effort is most worthwhile. Not only can trees and other vegetation provide the benefits described throughout this bulletin, they add to the beauty of the area, help calm traffic, and offer the welcome cooling effect of shade in the summer. A swale with only rock or sod is depriving the neighborhood of a full return on its investment.



A streetside swale can be attractive as well as useful in retaining and cleaning stormwater runoff.

STORMWATER BASINS

A stormwater basin is similar to a swale but is generally not linear. Basins are often used in housing developments, especially if the streets and lots do not lend themselves to swales. Designs of basins vary widely. Some are simply concrete boxes that look like fenced, un-peopled swimming pools. They are often eyesores and reduce the space to a single use that contributes little else than the retention of water. On the other hand, stormwater basins can be built to serve as picnic grounds or free play areas during dry weather. Others appear as natural areas, providing open space, wildlife habitat, and a touch of beauty.

Fencing or hiding stormwater facilities out of view not only loses the opportunity to create an aesthetically pleasing site design, but also sends the message that stormwater is an attractive nuisance. While there are legitimate concerns for safety and liability, these concerns can usually be resolved with careful design consideration, such as specifying shallow facility depths with gentle side slopes.

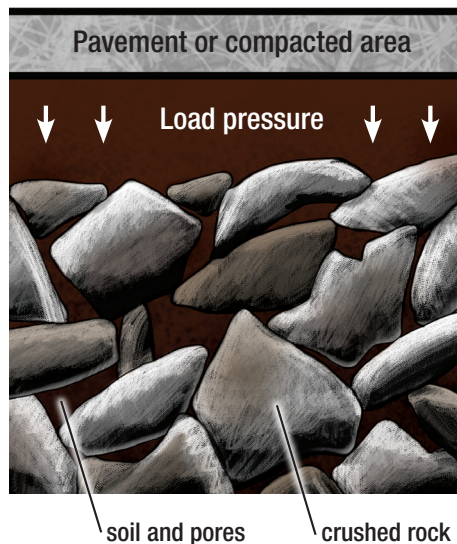
— *Portland Stormwater Management Manual*



Community policy can make the difference between ugly, single-use stormwater basins and those that provide not only function but open space, a refuge for wildlife, and a touch of beauty.

STRUCTURAL SOIL AND SILVA CELLS

One of the most significant urban forestry developments in recent decades has been the design and use of structural soil. Pioneered by Dr. Nina Bassuk at Cornell University, structural soil can be used beneath sidewalks and parking lots to provide both the strength needed for paving or compaction and a livable environment for tree roots.



In some cases, the use of structural soil can result in zero runoff from a site. Silva Cells, crate-like structures filled with soil, have much the same engineering attributes as structural soil and provide even more growing space for roots. Either way, the result is healthier, more robust urban trees and more water retained on-site.

There are several research-tested benefits provided by structural soil:

- It provides a reservoir for runoff that can then percolate deeper into the subsoil and eventually groundwater.
- It allows deeper, better root development. In turn, this means larger tree canopies, more intercepted precipitation, and more uptake by roots for transpiration.
- It can be used under paved areas where space for swales is not available.
- Normal amounts of surface pollutants are intercepted before reaching waterways. Immobilized contaminants can then be transformed by soil microbes or taken up by roots.
- Utilities can share the space.

Notes: Type of soil will affect infiltration. Where soils do not accommodate a reasonable rate of percolation, drain pipes may be necessary. Too much pooling of water will cause tree damage or death. Also, where limestone gravel is used in the structural soil mix, pH may become higher than in the native soil. In this case, plant species that can tolerate more alkaline soil.

TREE PITS

Even traditional tree pits can contribute to retaining stormwater runoff. If engineered for water to drain into the pits (sloping pavement, curbs with inlets, etc.), these are called "stormwater-capturing tree pits." Their usefulness is enhanced with greater soil volume and by connecting individual pits with trenches. Of course, as with structural soil, it is important for the subsoil to be able to receive percolating water, or a drain system is necessary to prevent drowning the root system.

RIPARIAN BUFFERS

Trees along the shores of lakes and the banks of rivers and streams are more than decorations. Not only do their canopies intercept some of the rain and reduce its impact, their roots anchor the soil and help take up leached chemicals before they reach the body of water. Shrubs in the riparian zone also help slow flood water. Where banks are washed away or heavily impacted, a range of bioengineering techniques are available using natural materials for restoration.



This riparian buffer in Story County, Iowa, offers a good example of using trees to protect water. The strip of trees and shrubs absorbs farm chemical runoff, helps cool the aquatic habitat, provides habitat for land mammals and birdlife, slows floodwaters, and prevents erosion.

Maryland Addresses the Water Issue



In 2012, the Maryland legislature passed a law mandating that the state's 10 largest communities establish a stormwater fee to be paid by their residents, businesses, and institutions. The stormwater fees are based on the amount of impervious area on a property from which rainwater must drain. Sidewalks, roofs, and concrete or asphalt driveways are examples. The fees provide funds for operating and improving the city's stormwater management system, with the ultimate goal of reducing flooding and erosion, and cleaning the waterways that drain into the treasured Baltimore and Chesapeake bays.

As explained by Bill Stack of the Center for Watershed Protection, Baltimore's stormwater travels through "an extensive, mostly underground, storm sewer system ... The system, like many systems around the country, was designed in the 19th century to drain stormwater, untreated, into rivers or streams in order to prevent the spread of infectious, water-borne disease. In the 1870s, the city built an elaborate underground stormwater conveyance system, and over the more than 140 years since, millions of tons of stormwater, sediment, and other pollutants have traveled,

untreated, through the pipes into streams, the harbor, and the Chesapeake Bay." Maryland's legislation, which is not without controversy, is a good example of how this situation is now being countered.

The Baltimore Department of Public Works makes a guide available to show residents how their fee is calculated. It also provides important ways to reduce the fee, including:

- Installing treatment features such as trees, rain gardens (and, presumably, swales) ... that treat runoff and decrease the quantity of stormwater entering the city's drainage system.
- Participating in organized volunteer activities like tree planting and trash cleanups that provide direct water quality benefits and increase awareness.

There are separate requirements and fee reduction opportunities for non-single family residential properties, faith organizations, and others.

STORMWATER RESOURCES AVAILABLE FOR EDUCATION

Visit arborday.org/stormwater to find an interactive version of this issue's centerspread. Move a lever across a scale from "Few Trees" to "Abundant Trees," and watch the urban landscape change dramatically; brief explanations pop up to highlight the importance of urban trees.

The poster is also available to download for use as a striking visual aid and is free for educational purposes.

MUCH MORE AT ARBORDAY.ORG

For more information about trees and stormwater as mentioned in this bulletin, please visit arborday.org/bulletins.

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