VEGETATIVE EFFECTS ON POND HEALTH AND STORMWATER RUNOFF

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INTRODUCTION

The presence of roads and other impervious surface require the usage of an MS4 program, or Municipal Separate Storm Sewer System, to manage stormwater runoff. This system is based off the amount of urbanized area in a township from the current Census and is implemented by the local government, with routine inspections and maintenance carried out by its engineering and public works department. The large surface area of impervious surface in communities, such as roads, roofs, and parking lots, allows no infiltration of rainwater, causing water volumes to buildup and enabling flooding. Just one inch of rainfall on a 40 x 70 feet roof for example, produces 1,743 gallons of water [1]. To control high volumes of water, Cranberry Township uses the MS4 program to send runoff directly into waterways through a collection of inlets, pipes, outfalls, and vegetated swales. A side effect of this efficient system is stormwater remains untreated, carrying toxins from roads or pesticides and fertilizers from farms or residential areas into major waterways. These toxins harm aquatic life; about 30% of PA's streams are impaired, meaning that they do not meet water quality standards for one or more pollutants [2]. Pollutants include nitrogen and phosphorus, two common components of fertilizers. In addition to toxins entering waterways, erosion of streams and transfer of sediment from MS4 systems have been a difficult and expensive problem to control. Sediment, small particles of rocks, minerals, sand, and organic matter, decrease pond depth as settlement occurs [3]. This damages aquatic life and benefits the breeding of mosquitos. In streams, the MS4 program accelerates erosion, often producing dirty and unclear water.

As communities continue to build new infrastructure, the need for improved stormwater planning and maintenance strategies become increasingly essential. Fortunately, the presence of certain vegetation can dramatically increase water infiltration, therefore preventing erosion and toxins from entering lakes and streams. Not only will following specific vegetative strategies help the environment, but the cost of dredging, the process of removing sediment from ponds, is decreased or otherwise eliminated entirely.

VEGETATION EFFECTS ON SOIL

Vegetation is extremely important for stormwater management since it promotes infiltration and prevents erosion. Infiltration of stormwater is a primary focus of the MS4 program due to its ability of removing toxins from the water and decreasing the amount of water entering waterways. A vegetated swale is a common and natural structure used for stormwater.

IMAGE 1 [4]

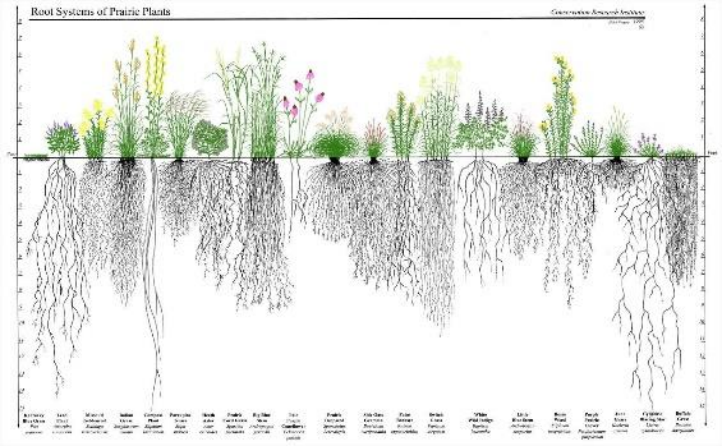
The vegetated swale above has a parabolic profile, allowing for stormwater conveyance and infiltration. Vegetated swales are the most natural stormwater technique since they do not require manmade materials to perform successfully.

In Image 1, the vegetation consists mostly of grasses. Though all plants increase infiltration, prairie grasses such as Indian grass, Kentucky Blue Grass, and Porcupine Grass, are the best vegetation for stormwater because of their deep and complex root systems. Roots allow infiltration, as they often increase the depth of the topsoil layer, which initially acts like a sponge at the beginning of a rainstorm. The deeper the roots, the deeper the topsoil layer, and the more rainwater absorbed into the ground. Root systems also absorb water, allowing for further absorption. During a rainstorm, root systems create more crevices and surface area for water to travel. Hence, the water is slowed, increasing the rate of sedimentation, which is the processes of settling or being deposited as sediment [5]. Swales often also contain rocks for this exact reason: to slow the water flow, increase surface area, and in turn, increase infiltration to keep waterways clean.

During a heavy rainstorm, the ground will eventually reach full saturation, a point at which the ground cannot absorb more water. When this occurs, the stormwater is conveyed into ponds and streams. Erosion, the process of transporting sediment from one location to another, can become a major problem without sufficient vegetation. The root systems of swale vegetation anchor the sediment, producing little to no erosion. According to the Hoffman Nursery of Green Infrastructure, some of the best grasses for erosion are *Muhlenbergia capillaris*, *Schizachyrium scoparium,* and *Sorghastrum nutans* species [6].

Though erosion preventive grasses are exceptional at holding dirt together, many cannot survive in vegetated swales due to their inconsistent wet and dry weather conditions. Consequently, grasses solely for erosion prevention are best on the banks of ponds or streams where weather patterns are consistent. There are a handful of hardy plants that can survive a wide range of weather patterns. These include the *Sorghastrum nutans*, also known as "Indian Steel", and the *Panicum virgatum* species [6].

IMAGE 2 [7]



enlarged image on page 8

In Image 2, several grasses and their root systems are shown. Indian Steel is the 4th from the left grass with roots reaching about 8.5 inches in depth.

Regarding pond health and maintenance, grasses are beneficial to have alongside the bank both of wet and dry ponds. The grasses will prevent sediment buildup, also known as sludge, on the edges and bottom of the pond. Sludge is harmful to aquatic life and creates a shallower, swampy environment in wet ponds and decrease volume capacity. In addition, if the sludge layer is too high, dredging may be required, an expensive process to complete. Hence, maintaining grass on the sides of a pond benefits both aquatic life and bank accounts.

For optimal erosion prevention, avoid cutting grass along pond banks. Cutting grass can remove too much leaf surface, starving the grass [8]. This

limits the ability for the roots to stabilize the pond bank, which prevents erosion. Since long grass can sometimes inhibit the enjoyableness of a pond, grass can be cut, but no more than one-third of the grass's total length should be cut at one time. Shorter grass will still help manage erosion, but to a lesser extent. Since no drastic change to the grass height should be performed, frequent maintenance is recommended for optimal visual appearance. The desire to reduce grass cutting frequency is usually the reason for cutting grass too short, but this maintenance strategy in effect may be most costly in the long term if the grass is damaged and cannot serve its purpose in the stormwater system.

NONNATIVE PLANTS AND THEIR ROLE IN POND HEALTH

A common nonnative plant found in stormwater systems is the cattail. Cattails are invasive species because of their ability to grow rapidly and overcome native plant species. Cattails can be seen overtaking stormwater wetlands, detention ponds, and are commonly found along pond banks. Though cattails are visually appealing and provide cover for some wildlife such as bullfrogs, the presence of cattails create additional issues, particularly for wet ponds. Firstly, cattails cannot grow in deep water, so their growth provides evidence of sediment buildup. Natural ponds should deepen quickly, reaching about 3-4 feet deep shortly from the shoreline [9]. Since cattails and sediment are linked, areas with cattails are much shallower than areas of a pond without cattails. These shallow areas provide perfect protection for mosquito larvae, since fish will not be able to access these areas [10]. Cattails undergo an annual reproductive growth cycle: they break down to the roots and regrow yearly. This quickens the eutrophication process of the pond and therefore the rate of sediment buildup [10]. Sediment buildup decreases the depth of the pond, allowing for sunlight to penetrate a greater pond percentage. This allows for algal blooms to take over much of the pond and lead to a lack of dissolved oxygen at night and a subsequent bloom crash. A bloom crash occurs when all dissolved oxygen is removed from the water of a pond, and overnight, fish and many other aquatic organisms are killed. This gives the pond a clear or black appearance the next day [11] Algal blooms are also caused if there are substantial amounts of nitrogen and phosphorous in the water.

IMAGE 3

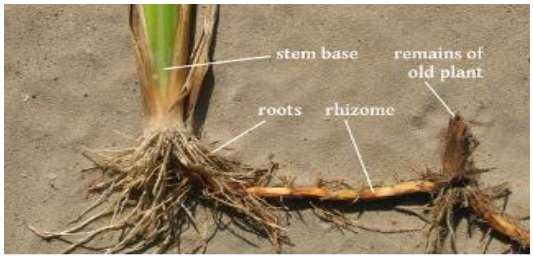
Image taken by Tim Schutzman in a residential area in Cranberry Township

In Image 3, the algae covering the pond signalizes sediment buildup.

Relating to stormwater management, many stormwater ponds have an outlet structure. The outlet structure allows for pond drainage if water levels get too high. Uncontrolled cattail growth can obstruct the outlet structure, increasing the risk of flooding. In addition, cattail growth can block access to ponds for recreational uses and grazing animals.

Cattails have extremely shallow roots, so their ability to lessen erosion is minimal. Consequently, they are unhelpful when placed around the outfall structure because they are ineffective at containing soil; it is more beneficial to let grasses grow there when possible.

IMAGE 4 [12]



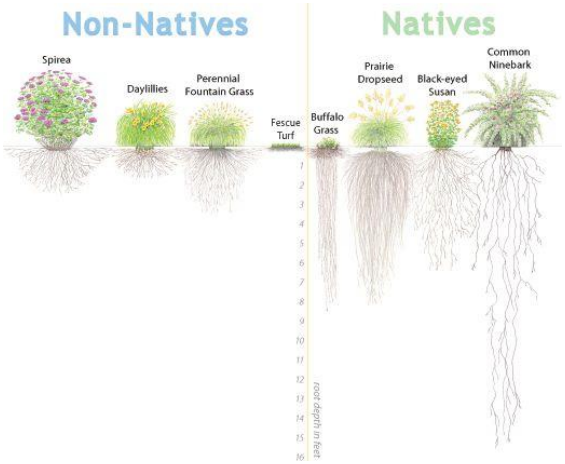
Root verses Rhizome

Image 4 shows the base of the cattail and its root system. Cattails most often reproduce with rhizomes, as shown in the image, which allow cattails to reproduce quickly and dominate a pond.

If cattails take away pond enjoyment and pond access or start making the pond comparable to a marsh, then the cattails are harming pond health and should be removed. However, many people like the appearance of cattails, so a controlled number of cattails in a pond is not an issue.

Other nonnative plants do not pose as big a problem as cattails, but still lessen the efficacy of the stormwater system when used alternatively to native plants. Nonnative vegetation tends to have shorter root systems than native plants, thus making them less effective in filtering toxins and allowing sedimentation.

IMAGE 5 [13]



The four native plants shown in Image 5: buffalo grass, prairie dropseed, black-eyed Susan, and common ninebark, compared to the four nonnative plants, show that native root systems are more extensive and deeper than the nonnative plants, creating a more efficacious stormwater system.

The nonnative plants in Image 5: Spirea, daylilies, perennial fountain grass, and fescue turf, are not harmful to the stormwater system and pond health like cattails but are not as competent as native species in terms of erosion control. Thus, when planting around ponds, vegetated swales, or any other stormwater structure, native species optimize stormwater systems.

INSPECTING A STORMWATER POND

When inspecting a stormwater pond, look for the outfall into the pond, outlet pipe, and the outlet structure. Both wet and dry ponds can have these structures. The outfall structure, a pipe or swale, brings stormwater into the pond. If the outfall structure is a pipe, the pipe will likely be composed of concrete, metal, or HDPE found along the bank of the pond. If no pipe is found, look for a swale. A swale is most often an earthen path for water to travel into the pond. Make sure that either your pipe or swale are free from major obstructions. As stated previously, it is good for swales to have vegetation and stone, but any major obstruction that blocks water significantly should be removed. Common obstructions of an outfall structure are branches or stones covering the opening or sediment buildup over the pipe. Also make sure that no strange colors, solids, or odors are entering the pond from the outfall.

IMAGE 6

Image taken by Jenna Sutton in a residential area in Cranberry Township

Image 6 shows an outfall in Cranberry Township with an HDPE (high density polyethylene) pipe and concrete endwall. The rocks outside the structure reduce erosion and decrease the force of water exiting the outfall.

After identifying the outfall structure, find the outlet structure. The outlet structure controls the release rate from the pond and is likely a square shaped concrete structure in the pond or could be shown as a spillway in the embankment. If the outlet is a spillway, then when water levels rise, water will leave the pond at one location, flowing over the embankment. If the embankment has a tree growing on it, remove the tree, for the embankment's stability could be impaired. If the embankment is unstable, it is important to repair the embankment to reduce the risk of a collapse. Make sure that the spillway or the outlet is not obstructed.

IMAGE 7 [13]

Image 7 shows both a spillway and outlet structure of a dry pond. The outlet structure is the block in the middle of the dry pond, with orifices to control the amount of water leaving the pond. The spillway is located on the top right of the image as a dip in the embankment.

Identify the outlet pipe. This pipe discharges the water from the outlet structure and is often located through the embankment towards a stream or a point of lower elevation from the pond. To locate the pipe, look at the pipe opening inside the outlet structure to determine the direction of the pipe. The outlet pipe may be made of concrete, HDPE, or metal, with an endwall. Inspect the outlet pipe the same as the outfall.

If the pond has a buildup of sediment in a wet pond, there are several red flags that should be heeded: abundance of cattails, thick sludge layer, high algae deposits, and dead fish or decreased number of fish. Oftentimes, sediment buildup is obvious since the pond does not look healthy or attractive. For dry ponds, too much sediment buildup will become apparent if the stormwater structures begin to get clogged with sediment or if the pond's volume capacity is too low and leads to overflowing of the embankment. For large buildups of sediment, consider dredging the pond. Dredging is the process of removing the sediment sludge layer at the bottom of the pond using mechanical excavation. Dredging revives wet ponds because the greater depth excludes cattails and prevents sunlight from reaching the bottom of the pond, thus preventing algal blooms. The amount of dissolved oxygen in the water will also increase, benefitting all aquatic life. In dry ponds, dredging will enable the stormwater system to function correctly. Although optimal pond health, appearance, and stormwater functionality can be obtained, dredging is a pricy process. Dredging is anywhere from $20,000 to $75,000 per acre due to the mobilization cost of excavation equipment, bathymetric and vegetation survey, perceived risks, and labor [14]. Therefore, it is important for homeowners to put money aside for dredging. Ponds typically

need to be dredged every 20 years, but this depends greatly on the quality of stormwater entering the pond during a rain event [9].

Improper vegetative strategies and lack of maintenance of ponds and swales can accelerate sediment buildup in ponds and waterways, harming both aquatic life and bottom lines. The correct maintenance and vegetative strategies can preserve the health of ponds and aquatic ecosystems. Native grasses and plants, as opposed to nonnative plants such as cattails, prevent erosion and toxins from entering waterways, as well as provide beauty, habitat, and food for animals who live in these ecosystems. Nevertheless, routine maintenance is part of all good systems, and Cranberry Township is committed to ensuring our public stormwater systems are optimized and our aquatic ecosystems remain healthy. The abundance of wildlife, such as frogs, turtles, fish, and birds, in stormwater service areas are living proof of Cranberry Township's commitment to excellence in stormwater management. To further preserve wildlife, homeowners are encouraged to follow these vegetative and maintenance strategies on their own private property.

WORKS CITED

[1] "Rain and Precipitation." USGS. Accessed 1 July 2021. https://www.usgs.gov/special-topic/water-science-school/science/rain-and-precipitation?qt-science_center_objects=0#qt-science_center_objects

[2]" What are sedimentary rocks?" USGS. Accessed 23 June 2021. https://www.usgs.gov/faqs/what-are-sedimentary-rocks-0?qt-news_science_products=0#qt-news_science_products

[3] "What are Stormwater Pollutants?" Penn State Extension. April 19, 2018. Accessed 23 June 2021. https://extension.psu.edu/what-are-stormwater-pollutants#:~:text=The%20nutrients%20nitrogen%20and%20phosphorus%20are%20the%20primary%20pollutants%20in%20stormwater.

[4] Construction Canada. Dec. 17, 2015. Accessed 23 June 2021. https://www.constructioncanada.net/code-blue-shifting-toward-water-efficiency-in-canada/trca_yorku_grass-swale_3/

[5] "Stormwater Pond Design, Construction, and Sedimentation." Clemson Cooperative Extension. Accessed 23 June 2021. https://www.clemson.edu/extension/water/stormwater-ponds/problem-solving/construct-repair-dredge/index.html

[6] "Plants for Green Infrastructure." Hoffman Nursery. Accessed 23 June 2021. https://hoffmannursery.com/assets/files/files/Hoffman_Nursery_Green_Infrastructure_Chart.pdf

[7] "Prairie roots." Driftless Prairies. June. 14, 2018. Accessed 1 July 2021. Prairie roots - Driftless Prairies: Native Ecosystems

[8] Ryczkowski, Angela. "Damage to Grass Cut too Short." Sfgate. Dec. 15, 2018. Accessed 23 June 2021. https://homeguides.sfgate.com/damage-grass-cut-short-44162.html

[9] "Pond Dredging—Why and When to Dredge my Pond." Magnolia Fisheries. Accessed 23 June 2021. https://magnoliafisheries.com/why-and-when-should-i-dredge-my-pond/

[10] "Cattails in ponds…good or bad?" Magnolia Fisheries. Accessed 23 June 2021. https://magnoliafisheries.com/cattails-good-or-bad/

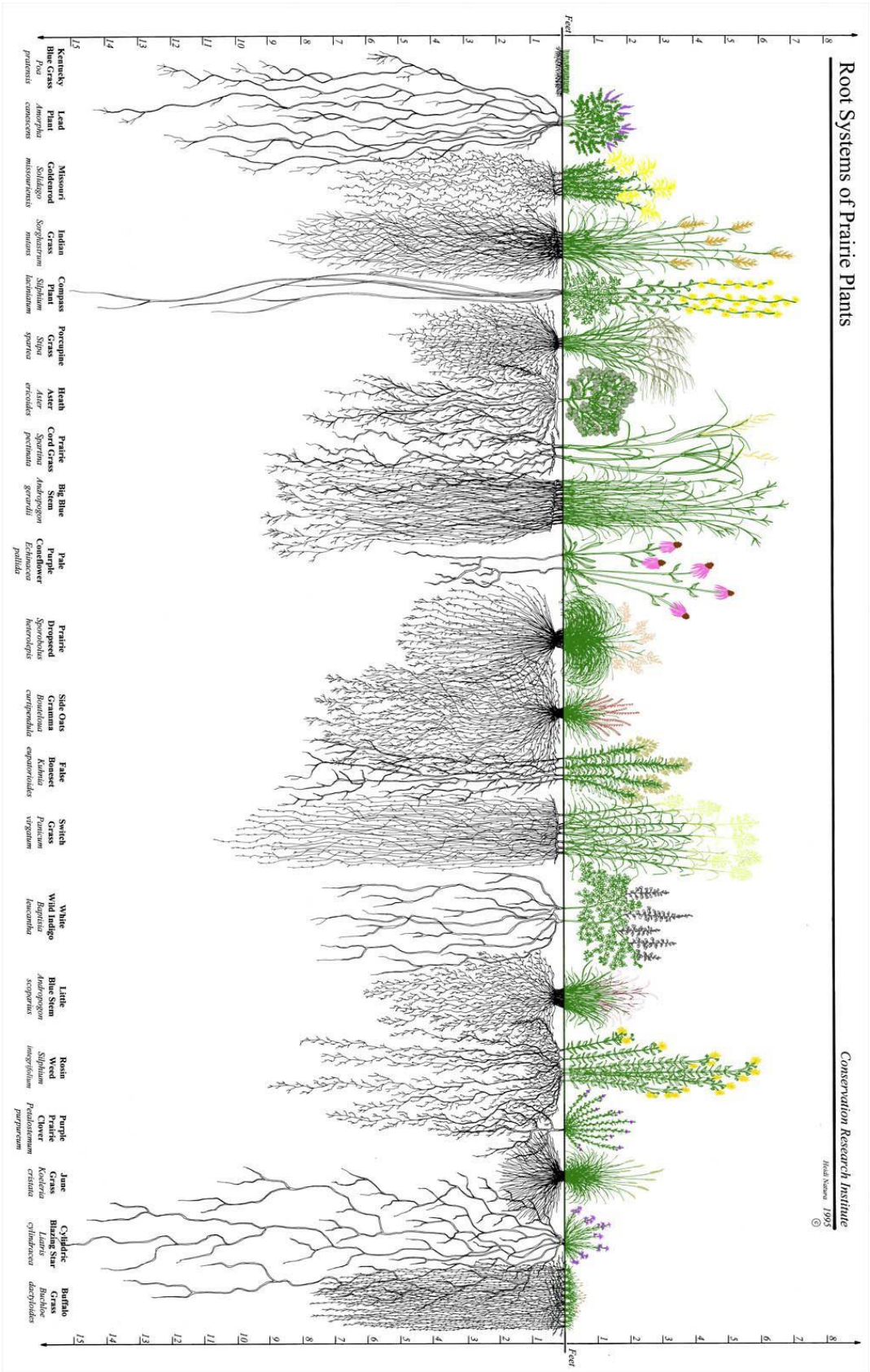
[11] Wurts, William. "Low Oxygen and Pond Aeration." Accessed 23 June 2021.

https://fisheries.tamu.edu/files/2019/02/lowoxygenandpondaeration.pdf

[12] “Cattails.” The Foraging Center. Accessed 23 June 2021. http://www.theforagingcenter.com/lesson_06.htm

[13] “What are native plants?” West Metro Water Alliance. Accessed 23 June 2021. http://www.westmetrowateralliance.org/native-plants.html

[14] “Alternative Dredging Techniques for Much Removal.” Clean-Flo. June 20, 2017. Accessed 2 July 2021. https://askinglot.com/how-much-does-pond-dredging-cost


Root Systems of Prairie Plants
Conservation Research Institute
Heidi Nomura 1993 ©
Feet
Kentucky Blue Grass Poa pratensis
Lead Plant Amorpha canescens
Missouri Goldenrod Solidago missouriensis
Indian Grass Sorghastrum nutans
Compass Plant Silphium laciniatum
Porcupine Grass Stipa spartea
Heath Aster Aster ericoides
Prairie Cord Grass Spartina pectinata
Big Blue Stem Andropogon gerardii
Pale Purple Coneflower Echinacea pallida
Prairie Dropseed Sporobolus heterolepis
Side Oats Gramma Bouteloua curtipendula
False Boneset Kuhnia eupatorioides
Switch Grass Panicum virgatum
White Wild Indigo Baptisia leucantha
Little Blue Stem Andropogon scoparius
Rosin Weed Silphium integrifolium
Purple Prairie Clover Petalostemum purpureum
June Grass Koeleria cristata
Cylindric Blazing Star Liatris cylindracea
Buffalo Grass Buchloe dactyloides