Investigating the Ability of Riparian Buffer Zones to Filter Nonpoint Pollution Sources

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Introduction

Riparian buffer zones are areas of natural vegetation surrounding streams, lakes, ponds, and other water sources. These riparian zones serve several essential ecological functions including stabilizing stream banks, filtering out pollutants, pathogens, and sediment from runoff water, and protecting aquatic environments from threats such as erosion and nonpoint source pollution. Other services of riparian zones include providing habitat for terrestrial macroinvertebrates, buffering stream temperatures, and maintaining biodiversity. Trapping sediment and pollution from runoff entering a body of water is one of the most beneficial qualities of riparian zones. However, there are many factors that can impact the pollutant removal effectiveness of a riparian buffer zone. These factors include the dimensions of the buffer zone, adjacent land uses, rainfall and water table characteristics, total pollutant load, surrounding field slope, the type/density of vegetation present, soil composition and structure, and the frequency and intensity of storm events. This experiment examined the impact of these characteristics on the pollution mitigation abilities of a riparian zone.

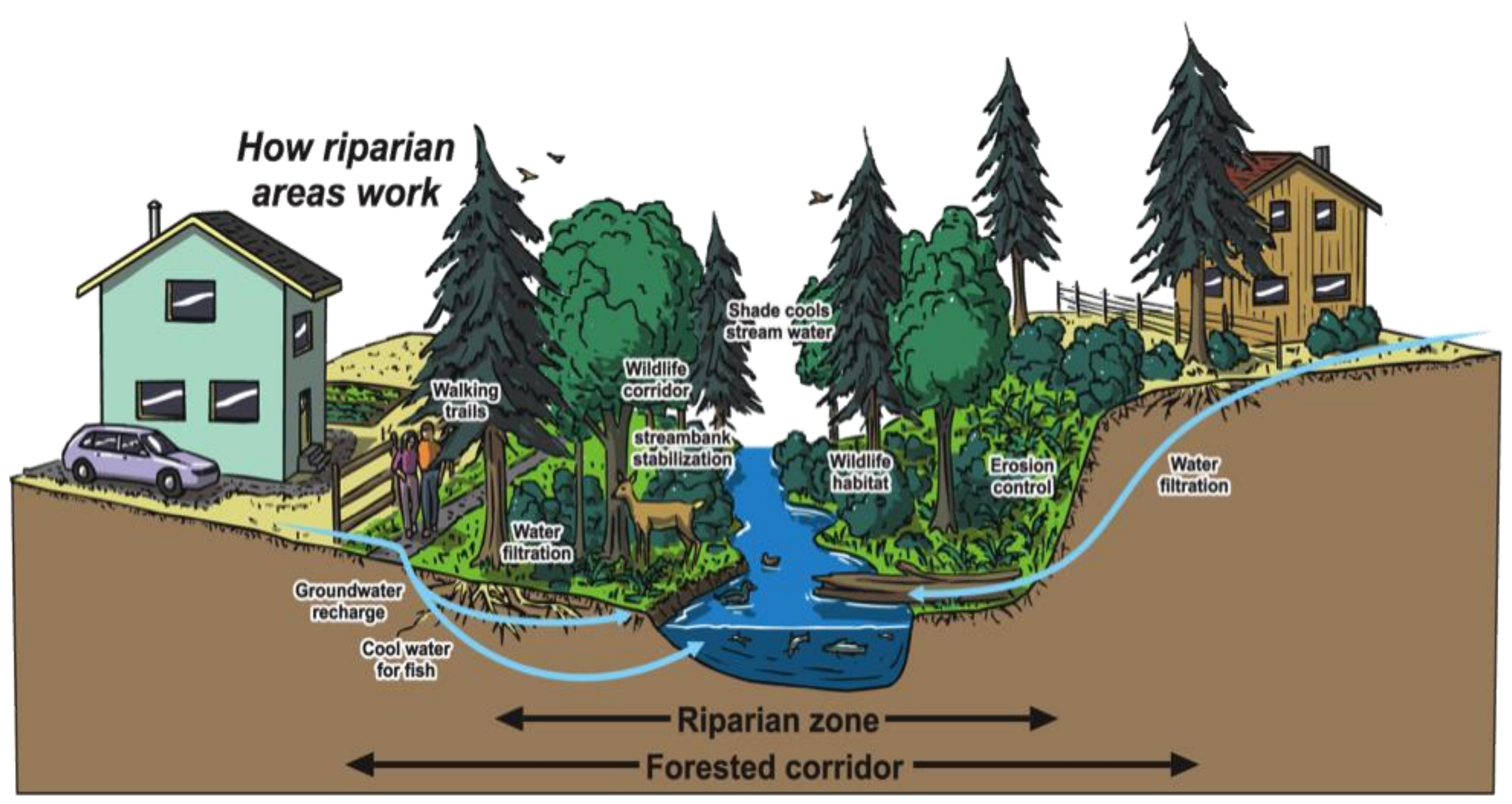

Image taken from the Regional District of Nanaimo

Materials and Methods

Two stream sections with different riparian buffers within Monastery Run (Latrobe, PA) were examined to determine how the presence and characteristics of a riparian zone impact pollutant introduction and transport. Geologic characteristics of the riparian buffer zones were expected to impact pollutant and sediment removal. A tracer dye (Rhodamine WT) and sodium nitrate ($NaNO_3$) were combined to simulate a runoff pollutant at two different riparian zones to determine how the riparian buffers impacted the time to detection, concentration, and residence time of these simulated pollutants. This solution was released in the riparian zone 1.5 meters from the streambank and 2 L of water was then added at a known rate to simulate a runoff event. A YSI 3160 Rhodamine WT probe was used to determine tracer dye concentrations downstream and an ion chromatograph (IC) was used to determine nitrate concentrations in the laboratory.

Results

The two study sites showed distinct differences in riparian zone composition, streambank slope, streambed material, and erosion processes. The upstream site contained much steeper stream banks. The upstream riparian buffer zone had slopes of 67 and 69 degrees, while the downstream site consisted of only 31 and 40-degree slopes. The downstream riparian buffer was also over twice as wide as the upstream buffer. The right upstream buffer consisted primarily of rock and wooded vegetation while the downstream riparian zones contained more vegetation and consisted of mainly oak trees and grasses.

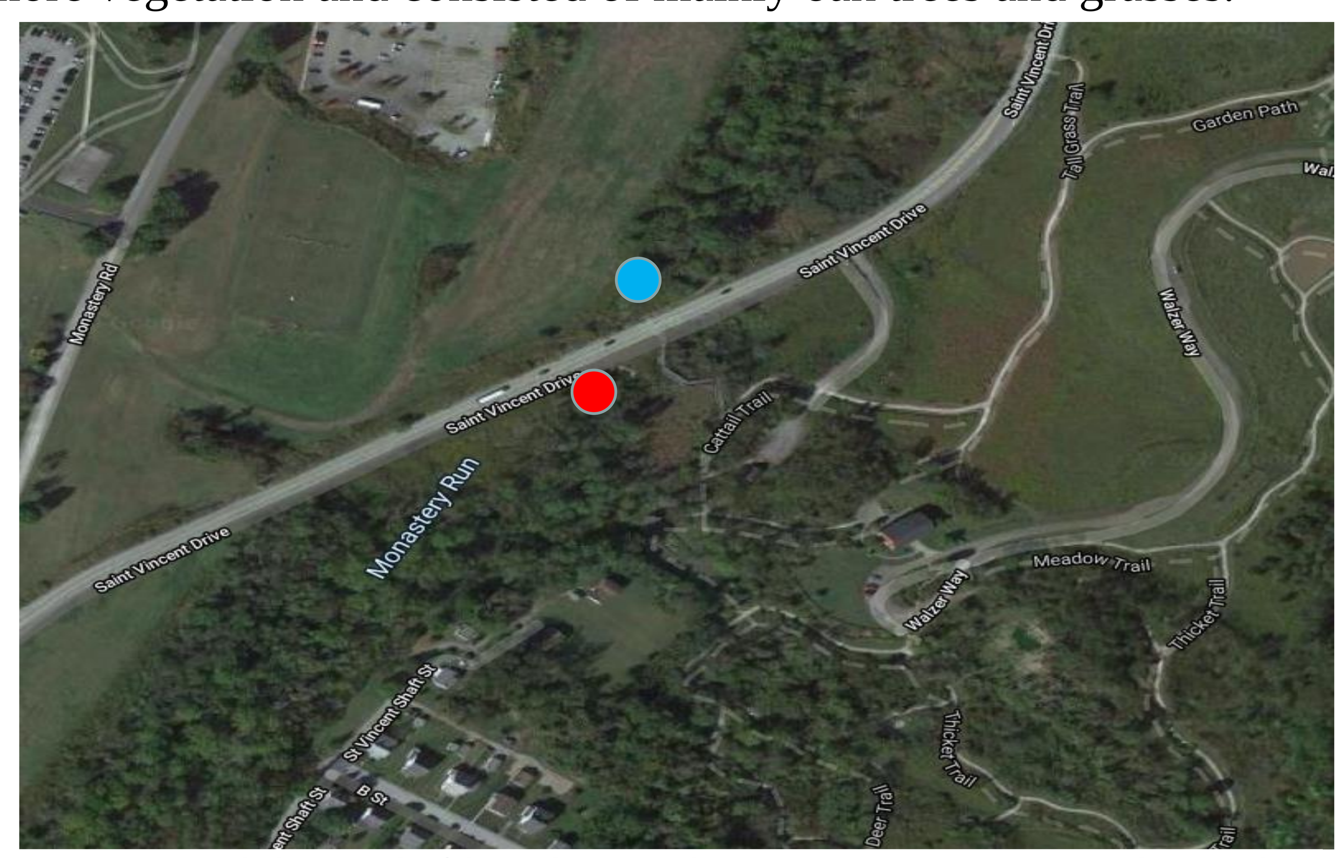

Figure 1: Aerial photograph of the study sites within Monastery Run (MR) in Latrobe, PA. Blue indicated the downstream site and red is the upstream study site. Parking Lot A of SVC can be seen at the top of the photo and Route 30 is just out of frame at the bottom of the photo.

Table 1: Breakdown of the results from the Rhodamine WT experiment at the four locations it was conducted. MRD-R is interpreted as Monastery Run downstream, right streambank and MRU-L is Monastery Run upstream, left streambank.

Site	Vegetation	Detection Time (min)	Max Concentration (µg/L)	Residence Time (min)
MRD-R	Forested	6.5	7.6	15
MRD-L	Forested	8	27.8	14
MRU-R	Unforested	5.5	16.4	24
MRU-L	Unforested	6	54.8	17

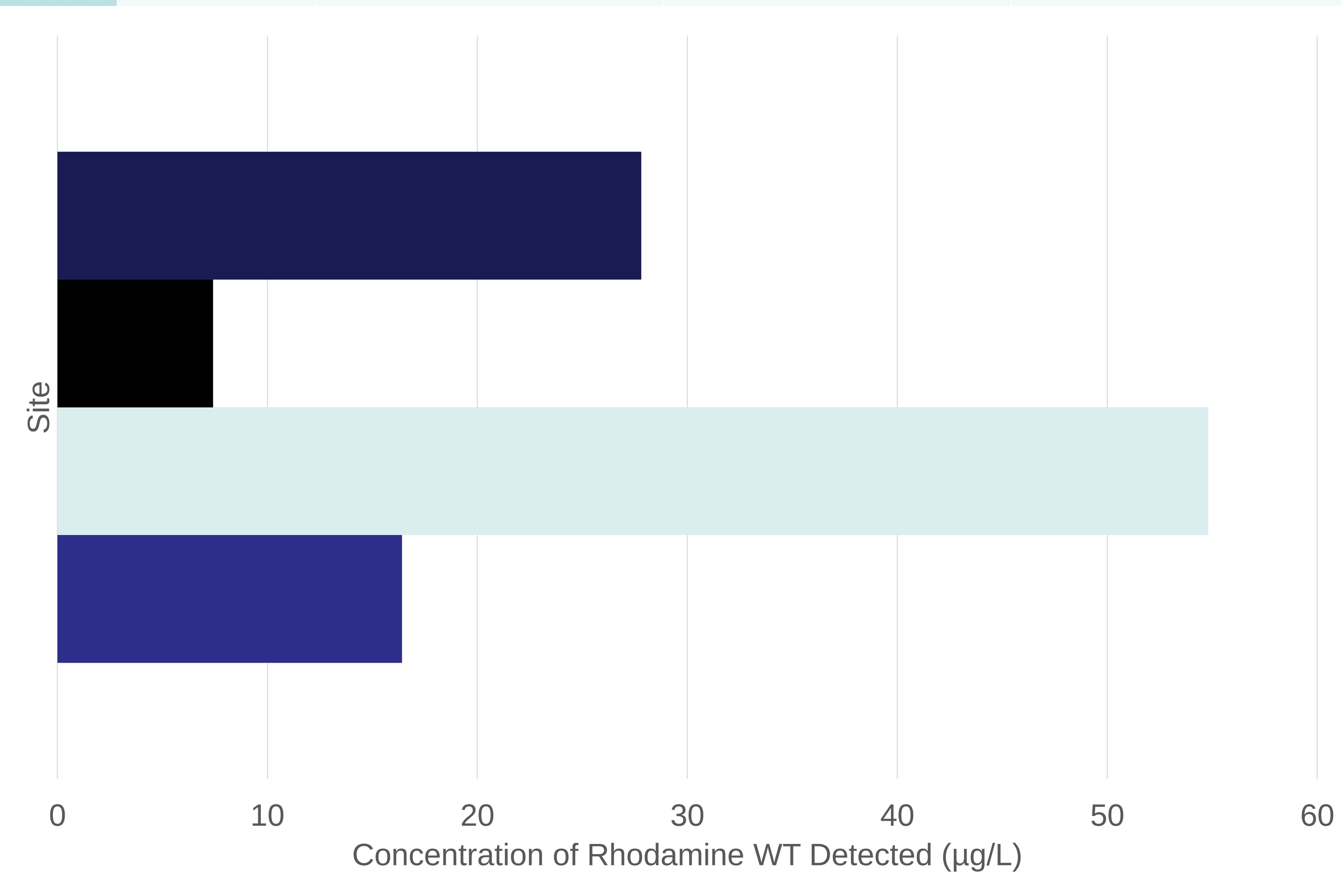

Figure 2: Graph depicting the total concentration of Rhodamine WT detected at the four experimental locations within Monastery Run.

Discussion

There were several differences in the pollution mitigation behavior of the two riparian zones that may be related to the variations in their characteristics. While the temperature differences between sites were not considered significant, the range of temperatures noted during these experiments may be of significant consequence to macroinvertebrate populations residing within the stream. The pH levels at both sites were slightly alkaline and are currently not a threat to the aquatic populations. Turbidity readings were consistently higher at the upstream site, indicating that the lack of vegetative cover is resulting in the erosion of stream banks at a greater rate than at areas of higher vegetated cover. The channel morphology of the two selected sites was similar, showing little variation in stream width, depth, and flow between the two sites. However, the channel characteristics showed significant differences in bank slope, riparian width, and vegetation cover. Two key differences were present between the data collected at the upstream and downstream sites for the Rhodamine WT and sodium nitrate experiments. These differences include how long it took for the experimental solution to be detected and the difference in the concentration of simulated pollutant present at each site. The longer time to detection and lower tracer concentrations at the downstream riparian buffer indicated superior pollution mitigation performance.

Conclusion

Overall, the concentration of simulated pollutants detected varied insignificantly between the unvegetated upstream and vegetated downstream sites. The higher concentration of Rhodamine WT and lower time to detection at the upstream site indicates a reduced ability of the riparian zone to remove pollutant loads and control erosion and sediment transport. The reduction in pollutant and sediment removal effectiveness in comparison to the downstream site was likely caused by a relative lack of vegetation, increased bank slope, and lower stream flows during the experiment. To better manage these riparian zones, it will be important to continue monitoring streamflow levels and patterns within this stream. Other management actions that could be taken to improve the current effectiveness of riparian zones within Monastery Run include the expansion of native vegetation, optimization of buffer zone width, and the introduction of bank stability and erosion control processes within the stream.

Bibliography

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