Journal of Environmental Protection, 2019, 10, 353-359
http://www.scirp.org/journal/jep
ISSN Online: 2152-2219
ISSN Print: 2152-2197

Ecological Restoration Zones within the Monkey River Area (Belize) Using Community Grown Nurseries to Produce Plants for Riparian Strips

Anna Koonce[1], Edward Bush[2]

[1]California Polytechnic State University, San Luis Obispo, USA
[2]Louisiana State University, AgCenter, Baton Rouge, LA, USA
Email: akoonce@calpoly.edu

How to cite this paper: Koonce, A. and Bush, E. (2019) Ecological Restoration Zones within the Monkey River Area (Belize) Using Community Grown Nurseries to Produce Plants for Riparian Strips. *Journal of Environmental Protection*, **10**, 353-359.
https://doi.org/10.4236/jep.2019.103020

Received: January 1, 2019
Accepted: March 3, 2019
Published: March 6, 2019

Abstract

Agricultural runoff near watersheds causes severe pollution of estuaries that can cause severe detrimental effects. The purpose of this experiment is to determine the most effective riparian strip combination to reduce offsite runoff and pollution. Three combinations of riparian strips were tested by simulating runoff in a greenhouse environment with drip irrigation. Results of elements in leaf tissues, effluent volume, and effluent element concentrations showed that the riparian strips with a combination of grass and trees was the most successful. If the detailed plan provided by this experiment for growing and planting a riparian strip near Monkey River is installed, then it can be concluded that the riparian strip will reduce nutrient runoff and help prevent erosion.

Keywords

Agricultural Runoff, Vegetated Buffer, Water Pollution, Fertilizer Pollution

1. Introduction

The Maya Mountain Marine-Area Transect (MMAT) is a one million-acre corridor recognized internationally for its integral part in the preservation of biodiversity and critical habitats. It connects the Maya Mountains to the Belize Barrier Reef in southern Belize, Central America. It is integral to protect this area containing 37% of the vegetation types found in Belize, seven protected areas, and is home to various endangered species. The Monkey River watershed is the largest and most heavily polluted of the 6 watersheds included in the MMAT. This pollution is due to extremely intense banana, mango, and citrus cultivation, timber extraction, and shrimp aquaculture [1]. The lifestyle of the people near the Monkey River watershed has created violent erosion that has washed away many of the homes, cemeteries, football fields, and places of work by the polluted area. The Monkey River Watershed Committee was formed to ask for funds to combat the erosion and to lobby for aid, but they still seek environmental engineers to best address the situation [2]. Research has proven that riparian strips have been successful in other areas [3].

The economy of Belize is based heavily upon agriculture, specifically labor-intensive agriculture [2]. Agriculture can cause severe erosion and land loss resulting in the reduction of living space for the people in the Monkey River community. The community has been forced to move due to sever land loss. [4]. The amount of soil eroded by water is controlled by runoff, soil erodibility, slope gradient and length, vegetation, and tillage practices. There are four main types of water erosion: sheet erosion, rill erosion, gully erosion, and bank erosion. These types of erosion are detrimental to farming as crops may not emerge or grow on land with large deposits of soil on top of them. They also accelerate bank erosion which creates a loss of the agricultural land itself. The different types of erosions can only be prevented by paying attention to the causes of each type of erosion. Proper tilling and cropping techniques can make farming efficient, while also conserving the land for years to come. Increasing awareness of soil erosion and how to conserve land can help to prevent further damage [5]. Research may provide a solution to this erosion issue by examining alternative ecological management methods to reduce land loss [4].

Over cultivation is a common cause to erosion. The overuse of agrochemicals on crop plants increase yield, but change soil composition. These chemicals increase the number of microorganisms that thrive in nitrate conditions. Because the balance of microorganisms is disturbed, harmful bacteria grow and thrive under stimulation while beneficial bacteria types typically suffer, also, when natural vegetation is burned to make room for agricultural fields, biodiversity, which keeps soil healthy, decreases. Clogged and polluted waterways are a consequence of pesticide and fertilizer runoff into a watershed. The runoff damages freshwater and the marina habitats that depend upon it as well as the human populations nearby [6].

Riparian buffers are a single or complex network of plant species used to filter nutrients and suspended solids typically near an aquatic habitat. If such strips are natural, they are made of an assortment of grasses and trees and can live in any habitat setting if maintained properly. Both the strips and their floodplains are an essential buffer for freshwater ecosystems as they protect against human impacts stemming from land use practices and land cover change [7]. The most common uses of riparian strips is to provide control for the surrounding environment, increase habitat diversity, modifying channel morphology, improving food webs or species richness, and protecting water sources from nonpoint source pollutants. The most common nonpoint source pollutants would be sediments and nutrients. Vegetation also removes different amounts of nitrogen and phosphorus through uptake depending on the types and amounts of plant species involved. Denitrification is an important process in the top layer of soil in a riparian strip. Within the first 15 feet of the riparian strip, most nitrate-nitrogen can be transformed into gaseous nitrogen which is much less harmful to the surrounding aquatic environment.

Many forested riparian strips have been instated and proven to be very useful in preventing pollution both on the surface and subsurface [8]. Their success was proven when each riparian strip showed significantly reduced nitrate concentrations in shallow ground water after the water flowed through the riparian strip. The strips were not only successful in this area, but also showed to reduce nitrate levels even when ground water moved very swiftly or at depths below the root zone. Those who established the riparian strips highly recommended their use wherever practical and claimed them to be effective in reducing nitrogen levels. If strips were removed, the land and water would change dramatically. Bank stability and the retention of nutrients and sediments decreased, the quality and quantity of organic matter in the freshwater system was altered, light penetration and water temperature increased, and the hydraulic balance between runoff and evapotranspiration became off-balance in the entire watershed [7].

2. Materials and Methods

In order to create a simulated riparian strip rain shelter, 16 11-gallon tubs were used with a hole drilled into the center of the bottom of each tub. A plastic netting was cut and glued around each hole to prevent large amounts of soil from leaking through the hole. Elevation devices created a terrace system between the tubs and four rows of tubs were connected using PVC pipes and plumbing glue. 160 gallons of soil was handmade and designed to simulate the Belize soil along the monkey river using mulch, sand, and small amounts of essential nutrients. Next, a watering system was installed that would dispense 5 gallons of water into each strip of four tubs daily using a drip system.

After researching various options of plant assortments as options to be included in a simulated riparian strip for the Monkey River area, it was determined that grass (*Cynodon dactylon*), mangroves (*Avicennia germinans*), and mahogany trees (*Swietenia macrophylla*) were the best options to be tested for pollution absorption. After this was determined, three planting plans for possible riparian strips were created and the respective plants were purchased and planted according to the planting plan into the tubs using the mixed soil. A fourth planting plan included a control strip which had no plants and was just the mixed soil. The rain shelter and the simulated riparian strips may be seen pictured in **Figure 1** and **Figure 2**.

Testing on the riparian strips centered around simulating fertilizer runoff and recording how each strip reacted. One day prior to fertilization, the water source would be turned off. The day of fertilization, 5 teaspoons of fertilizer would be

Figure 1. Simulated riparian strips top view.

Figure 2. Simulated riparian strips side view.

mixed per one gallon of water and each strip would receive 5 gallons of fertilized water.

One way data was collected was through water samples. The hole at the bottom of the last tub in each strip was connected to a tube that led to 5-gallon collection vessels. The vessel wore a lid to protect the water samples from evaporation. When water had finished running through each tub in a strip, 50 mL of water was sampled to be tested for its important element concentrations (Ca, Cl, Fe, Mg, Mn, NO_3^- K, NaCl, Na, S) and effluent pH. Also, three times a week the effluent volume of the strips was recorded based on how much water had not been absorbed by the strips and was present in the collection vessels.

Another way data was collected was through foliage samples. Prior to experimentation, leaf and grass samples were collected. These samples were dried and tested for element concentrations. At the end of experimentation, this procedure was repeated to measure nutrient uptake.

3. Results and Discussion

Sand riparian effluent pH, nitrogen, phosphorus, volume, and total salts were significantly greater than the grass riparian strips for all dependent variables. Sand was significantly greater than the grass and tree riparian strip and the tree alone for effluent nitrogen, and phosphorus. However, sand was only significantly different in the grass and tree riparian strips but was similar to grass and tree riparian strip for total salts. Sand had a greater effluent volume, nitrogen, and potassium.

In the foliage of the plants, grass had significantly lowest nitrogen, phosphorus and potassium followed by mangroves then trees. Grass had no significant difference with grass trees and grass but was significantly lower in potassium and phosphorus content than the strip with only grass trees. Grass has significantly lowest nitrogen in its foliage when compared to the grass trees and grass strip and the grass trees strip.

This research indicated that riparian strips were successful in preventing fertilizer runoff. Previous research also showed significantly reduced nitrate concentrations in shallow ground water after the water flowed through the riparian strip. These strips were not only successful in their area, but also showed to reduced nitrate levels even when ground water moved very swiftly or at depths below the root zone. Both results from previous experimentation and those produced by this study display that riparian strips are successful in preventing large amounts of pollution runoff [8]. Therefore, it can be inferred that if the riparian strip were to be planted along the Money River, results would most likely mirror those in previous research in that nitrate concentrations would be reduced on land and in water.

The Monkey River Area in Belize is a heavily polluted area that needs a solution to its erosion problem [1]. It appears that planting riparian strips would be a viable solution to this issue. Production of remediation trees and grasses is required for riparian strip effectiveness. The novel program called "The Coastal Roots Program" which teaches about plant biology and allows children in schools to plant different riparian strips along their eroding coastline would provide an excellent way to grow plants for riparian strips. This would increase education, economic benefit, decrease erosion, increase the river's balance, and provide habitat for endangered species such as the Red Macaw.

Future research applying riparian strips to be investigated within the Monkey River area is suggested by previous researchers (at 16.5562, −88.5468 in a 300' by 1000') to elucidate the effectiveness of riparian strips on the Monkey River [1] (**Figure 3**).

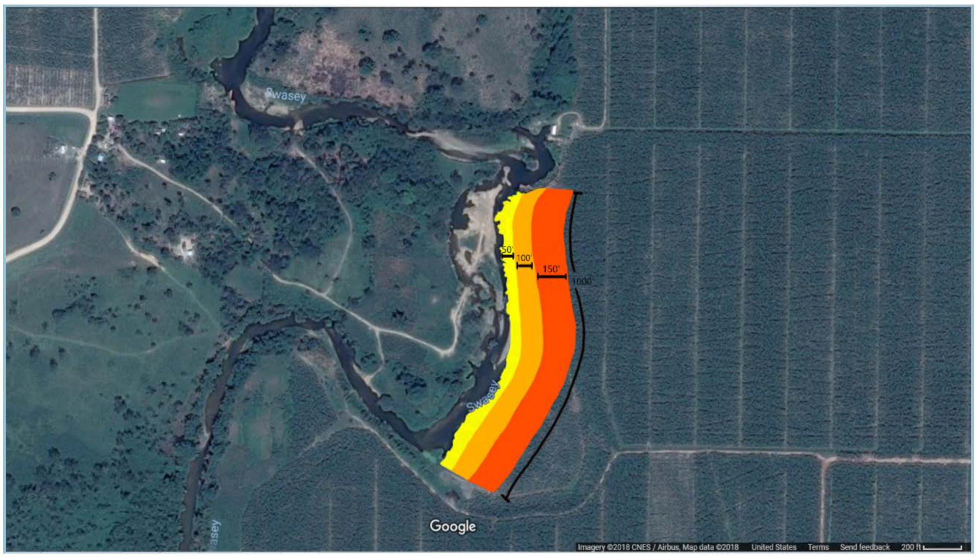

Figure 3. Suggested area of future riparian strip.

4. Conclusion

In conclusion, vegetated riparian strips were generally more effective at controlling fertilizer loss as compared to the sand control strip. Also, selecting native plants that can be used to establish these riparian strips and provide an ecosystem for wildlife is an effective way of remediating the Monkey River watershed's erosion and pollution issue. Finally, planting the Riparian Strip in a 300' × 100' area along the monkey river at 16.5562, −88.5468 would be the most effective way to stop runoff effects based off of prior experimentation pointing out pollution hotspots [1].

Application to Society

Monkey River is not the only polluted river that negatively affects nearby communities. If riparian strips are able to prevent polluting runoff from spreading to watersheds, then that area not only saves its own land for future generations, but it may also set an example to others of the usefulness of riparian strips. If other areas follow the Monkey River Community's lead, then countless amounts of land will be saved, habitat will be preserved, wildlife will be safer, and economic profit will be available to the surrounding communities. Also, timber lost through extraction will be replaced through foresting the area with riparian strips. Water quality is a huge factor in aquatic habitats, and by protecting such an important part of many ecosystems through riparian strips absorbing pollution, research may be able to provide a solution to the issue of erosion caused by timber extraction and agrochemical pollution.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Esselman, P.C. (2001) The Monkey River Baseline Study: Basic and Applied Research for Monitoring and Assessment in Southern Belize. University of Georgia, Athens. https://www.researchgate.net/publication/36219720_The_Monkey_River_baseline_study_basic_and_applied_research_for_monitoring_and_assessment_in_southern_Belize_electronic_resource

[2] Manzanero, M. (2017) Beachfront Erosion in Monkey River. https://ambergriscaye.com/forum/ubbthreads.php/topics/523815/beachfront-erosion-in-monkey-river.html

[3] Komor, S.C. and Magner, J.A. (1996) Nitrate in Groundwater and Water Sources Used by Riparian Trees in an Agricultural Watershed: A Chemical and Isotopic Investigation in Southern Minnesota. *Water Resources Research*, **32**, 1039-1050. https://doi.org/10.1029/95WR03815

[4] (2017) Monkey River. http://barebonestours.com/monkey-river

[5] Ritter, J.P. (2012) Soil Erosion—Causes and Effects. http://www.omafra.gov.on.ca/english/engineer/facts/12-053.htm

[6] Soil Erosion and Degradation. https://www.worldwildlife.org/threats/soil-erosion-and-degradation

[7] Allan, J.D. (2004) Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. *Annual Review of Ecology, Evolution and Systematics*, **35**, 257-284. https://doi.org/10.1146/annurev.ecolsys.35.120202.110122

[8] McCallie, G. (2016) North Carolina's Riparian Buffers: A Scientific Review (Rep.) NC: North Carolina Conservation Network. State of North Carolina Department of Environment and Natural Resources, 1-42. http://www.albemarlercd.org/uploads/2/1/7/6/21765280/riparian_buffer_report_2016.pdf