

Riparian Runoff Rivalry

Adapted from: An original Creek Connections activity.
Creek Connections, Box 10, Allegheny College, Meadville, Pennsylvania, 16335

Grade Level: Basic to advanced

Duration: 30 minutes

Setting: classroom

Summary: Students observe two demonstrations of how riparian forest buffers effectively reduce soil erosion and the amount of runoff entering waterways, decreasing sedimentation and turbidity levels therein.

Objectives: Students will be able to describe how riparian buffers reduce soil erosion and runoff as well as how these buffers remove and retain sediment. They will be able to explain why these functions are beneficial to the health of adjacent waterways.

Vocabulary: buffering, forested riparian buffers, turbidity, sedimentation, nonpoint source pollutants, Best Management Practices (BMPs)

Related Module Resources:

- “Riparian Buffer Basics” Fact Sheet
- Articles: “Riparian Forest Buffers: Protecting Streams with Nature,” [Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources](#)

Materials (Included in Module):

- Riparian Model
- 2 “Rain Cups”
- 2 cups for collecting water
- 1 spray bottle
- brown washable paint and brush
- 2 Riparian Plinko Boards
- bag of pennies
- Transparency data sheets

Additional Materials (NOT Included in Module):

- books to prop up models
- overhead projector and transparency marker

ACADEMIC STANDARDS: (ECOLOGY & ENVIRONMENT)

7th Grade

- 4.1.7.B. Understand the role of the watershed.
- Explain factors that affect water quality and flow through a watershed.
- 4.1.7.E. Describe the impact of watersheds and wetlands on people.
- Explain the impact of watersheds and wetlands in flood control, wildlife habitats and pollution abatement.

**NOTE: Riparian areas frequently contain wetlands or are considered to be wetlands.*

- 4.3.7.B. Describe how human actions affect the health of the environment.
- Identify land use practices and their relation to environmental health.
 - Identify residential and industrial sources of pollution and their effects on environmental health.
 - Explain the difference between point and nonpoint source pollution.
 - Explain how nonpoint source pollution can affect the water supply and air quality.
- 4.4.7.C. Explain agricultural systems’ use of natural and human resources.
- Define issues associated with food and fiber production.
- 4.8.7.C. Explain how human activities may affect local, regional and national environments.
- Explain how a particular human activity has changed the local area over the years.
- 4.8.7.D. Explain the importance of maintaining the natural resources at the local, state and national levels.
- Explain how human activities and natural events have affected ecosystems.
 - Explain how conservation practices have influenced ecosystems.

10th Grade

- 4.1.10.B. Explain the relationship among landforms, vegetation and the amount and speed of water.
- Explain how vegetation affects storm water runoff.
 - Explain how the speed of water and vegetation cover relates to erosion.
- 4.1.10.D. Describe the multiple functions of wetlands.
- Describe wetlands in terms of their effects (e. g., habitat, flood, buffer zones, prevention areas, nurseries, food production areas).
 - Explain how a wetland influences water quality, wildlife and water retention.
 - Analyze wetlands through their indicators (e. g., soils, plants, hydrology).
- 4.1.10.E. Identify and describe natural and human events on watersheds and wetlands.
- Identify the effects of humans and human events on watersheds.
- 4.3.10.B. Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices.
- Explain how human practices affect the quality of the water and soil.
- 4.8.10.C. Analyze how human activities may cause changes in an ecosystem.
- Analyze and evaluate changes in the environment that are the result of human activities.
 - Compare and contrast the environmental effects of different industrial strategies (e. g., energy generation, transportation, logging, mining, agriculture).

12th Grade

- 4.1.12.E. Evaluate the trade-offs, costs and benefits of conserving watersheds and wetlands.
- Evaluate the effects of human activities on watersheds and wetlands.

BACKGROUND:

Riparian zones are the land areas adjacent to waterways. When these areas contain forests, shrubs, grasses and other vegetation, they serve numerous important functions, many of which are related to protecting, or **buffering**, streams from the adverse

effects of adjacent land use. Some of the most vital services provided by **forested riparian buffers** to waterways are the reduction of soil erosion and runoff and the removal and retention of sediment. These functions help keep streams free of high **turbidity** levels (cloudiness of the water), and **sedimentation** (the filling in of waterways with soil, sand, and silt particles resulting from soil erosion.) According to two University of Illinois ecologists, “Sediment loading and deposition constitutes one of the most serious water-quality problems throughout the world.” Of all the **nonpoint source pollutants** (pollutants whose exact origin is difficult to discern because they are from a more widespread area), sediment causes the greatest problems.

One reason that sediment creates such serious water quality problems is because it is the most common and widespread non-point source pollutant. Sediment from eroded soil creates high turbidity in waterways. This cloudiness makes it difficult for aquatic predators to visually locate their prey. The suspended soil particles and other organic matter that make water turbid also clog fish gills and filter feeding apparatuses. Furthermore, suspended sediment reduces the penetration of sunlight, inhibiting the growth and reproduction of aquatic vegetation. Eventually, sedimentation occurs and those suspended particles are deposited on the bottom of waterways. Sedimentation is problematic for stream health because the silt and sand fill in the spaces between rocks, eliminating important macroinvertebrate and fish-spawning habitat. In addition, the settling sediment often smothers fish and macroinvertebrate eggs. Also, “increased stream sediment concentrations cause behavioral changes in fish and can result in migration, reduced reproduction and/or death of a species.” Moreover, excessive sedimentation can fill in stream channels, greatly increasing the risk of flooding. Runoff in and of itself is detrimental to stream health because in addition to carrying sediment and causing soil erosion, it also carries dissolved nutrients and nutrients attached to sediment, pesticides, and fertilizers to surface waters. Thus, by reducing the amount of runoff that enters waterways, riparian forest buffers also decrease the amount of pollutants that contaminate those waters.

Clearly, runoff, soil erosion and resultant increases in sedimentation and turbidity negatively affect stream health. However, riparian forest buffers, when left intact, effectively reduce runoff, soil erosion and the amount of sediment that enters waterways. How do riparian forest buffers do it? First of all, obstacle-filled (e.g., trees, shrubs, fallen logs, etc.) riparian zones slow the flow rate of runoff with heavy sediment loads. This reduced flow rate allows sediment to settle out of the runoff. The slowed runoff infiltrates (seeps into) the porous soils, vegetation, and leaf litter on riparian forest floors. These areas can soak up a lot of runoff and according to the Chesapeake Bay Program, “infiltration rates [in riparian forests are] 10-15 times higher than in grass turf and 40 times higher than in a plowed field.” That is, “forested buffers can take up water 15 times faster than pasture or cropland!” Riparian vegetation and trees further reduce the amount of soil erosion by breaking the fall of raindrops, decreasing their impact with the soil as well as raindrops’ soil eroding potential. In addition, vegetation roots stabilize streambanks and reduce erosion of these areas (Figure 1).

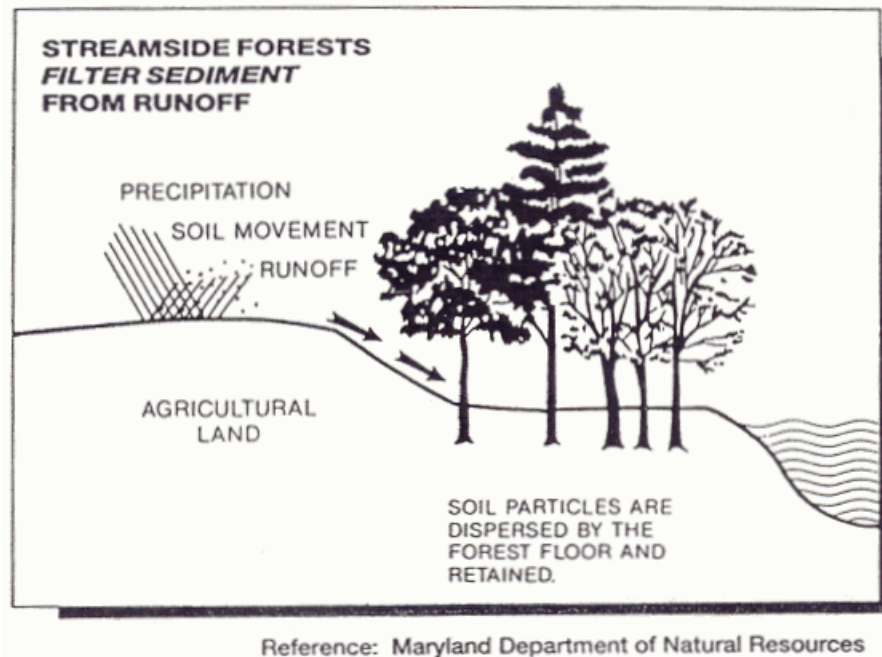


Figure 1

Unfortunately, the runoff, erosion and sedimentation reducing function of riparian forest buffers are often overlooked. Numerous human land use practices disturb the highly important and useful riparian areas and otherwise increase soil erosion. Anything that increases soil erosion contributes to an augmentation of runoff, turbidity levels and sedimentation. Agriculture is one of the biggest culprits when it comes to exacerbating soil erosion and disrupting riparian buffers. Both row crops and livestock grazing can be problematic. Row crops decrease infiltration and increase runoff. According to the USDA Forest Service, “cropland erosion accounts for about 38% of the approximately 1.5 billion tons of sediment that reach the nation’s waters each year” (Figure 2). Livestock grazing in cleared areas trample vegetation and erode streambanks adding huge quantities of sediment to waterways. In fact, “pasture and range erosion accounts for another 26%” of the sediment that washes into U.S. waterways (Figure 2). However, many farmers utilize **Best Management Practices (BMPs)**, which dramatically reduce the negative impacts of agriculture on the environment and waterways. Mining is another activity that can increase soil erosion. Some mining processes strip hillsides and riparian areas of vegetation. However, like farmers, many mining operations are employing new techniques to decrease the adverse effects of mining on the environment. Furthermore, clear-cutting of forests for timber exposes soil to increased erosion, much of which ends up in waterways. However, sustainable, less destructive forestry methods are being used more and more frequently. Roads and parking lots, urbanization, industry, housing development and other construction can also remove the protective vegetative cover of riparian zones that naturally reduce erosion and sedimentation.

Increasingly, municipalities are discovering that it makes economic as well as ecological sense to preserve and restore riparian forest buffers rather than destroy them in the name of development. For example, “retaining forest area and buffers has reduced storm water

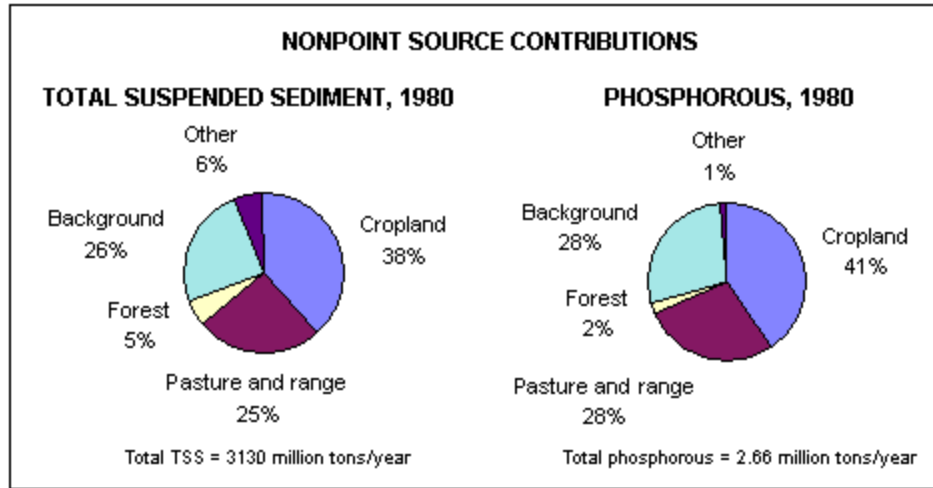


Figure 2

costs in Fairfax County, VA by \$57 million.” In Maryland, “it costs \$10-11.5 million annually to dredge and dispose sediments deposited into Baltimore Harbor to keep it navigable. Sediment produced by forest land is the lowest of all land uses.” If riparian forest buffers protected the riparian areas of the harbor and its tributaries, sediment deposition would not be nearly as problematic. Efforts to restore and preserve riparian areas throughout the country have increased in recent years.

When restoring riparian areas, landowners and ecologists seek to replicate the natural sediment filtering and erosion-reducing functions of riparian forest buffers by creating three-zoned streamside forests (Figure 3). Each of the three zones contributes to sediment and erosion control. Zone 1 is adjacent to the streambed. Ideally, Zone 1 consists of mature, undisturbed forest species. The roots of these trees hold soil in place and stabilize streambanks. The resultant decrease in soil erosion keeps sediment from washing into the waterway. Zone 2 is typically a managed forest from which trees, particularly hardwoods, can be harvested and sold to generate income and serve as an economic benefit to landowners who restore and manage their riparian areas. Vegetation and tree debris in this zone slow runoff and trap sediment in the runoff. Zone 2 can remove up to 80 percent of sediment from runoff! Zone 3 is typically composed of a grass filter strip. This strip also absorbs and slows runoff, allowing sediment to settle out. Runoff passing through grass strips is dispersed and distributed over a larger area, reducing the erosion caused by narrower, more concentrated flows. Zone 3 can remove over 50% of sediment from runoff!

References:

Alliance for the Chesapeake Bay and the DEP. Forest Buffer Toolkit: Replanting Pennsylvania’s Streamsides. Harrisburg, PA: DEP, 2000.

“Economics of Riparian Forest Buffers Fact Sheet.” Annapolis, MD: Chesapeake Bay Program, 2001.

Osborne, L.L. and D.A. Kovac. “Riparian vegetated buffer strips in water-quality restoration and stream management.” Freshwater Biology 29 (1993): 243-258.

Riparian Forest Buffers: Function and Design for Protection and Enhancement of WaterResources. USDA Forest Service. Forest Resources Management, Radnor, PA: 1992.

“Riparian Forest Buffers in the Chesapeake Bay Watershed Fact Sheet.” Annapolis, MD: Chesapeake Bay Program, 2001.

OVERVIEW:

The simple “Riparian Plinko” demonstration reveals how thumbtack “vegetation” in a riparian buffer slows and absorbs runoff and reduces the amount of penny “sediment-laden runoff” that reaches a waterway. The “Riparian Model” is a more life-like representation of a waterway at the bottom of a gentle slope. A riparian forest buffer flanks half of the waterway, and the other half is unprotected. Streams of water are applied to the model to simulate runoff and students observe how vegetation and the buffer slow and absorb runoff, filter out sediment, and help keep the stream clean.

PROCEDURE:

Teacher Preparation:

Riparian Plinko

1. Prop up the two Riparian Plinko boards side by side at equal angles of approximately 45 degrees or more at the front of the classroom.
2. Procure and set up an overhead projector with the transparency data sheet included in the module.

Riparian Model

1. Take the riparian model out of the container and turn the container over so that it lies lengthwise toward the students. Place the model crossways on top of the container so that both ends of the stream are hanging over the edge of the container. Next, place a plastic cup below each end of the stream. Then, place the lid of the container under the edge of the vegetated side to collect excess runoff.
2. Measure 600 mL of water into a large beaker. Add “sediment” to the water by mixing in brown washable paint to obtain the desired color. Some flakes of paint will not fully mix with the water. These flakes represent large sediments (e.g., trash, large clumps of soil) within runoff. Have two 50mL (or larger) graduated cylinders or beakers with pour spouts available for the demonstration.
3. Locate the 2 “Rain Cups” (plastic cups with holes poked in the bottom) and spray bottle and fill the spray bottle with water.
4. Procure and set up an overhead projector with the transparency data sheet included in the module.
5. Ensure that paper towels are readily available to clean up any spills or excess run-off.

Student Experiment or Activity:

Riparian Plinko

1. Generate a discussion of the importance of riparian buffers, particularly as they relate to slowing down and absorbing runoff and removing sediment from runoff. Be sure to mention why sediment in waterways is problematic.

2. Present the Riparian Plinko boards to the students and explain that the white foam boards represent hillsides with waterways at the bottom of them. The thumbtacks represent vegetation, particularly trees and shrubs. And the pennies represent sediment-laden runoff. Explain that they will be releasing the “sediment-laden runoff” down the two hillsides towards the waterways.
3. Ask the students where the sediment in the runoff might be coming from.
Agricultural fields, construction sites, deforested areas, etc.
4. Ask the students to compare and contrast the two “hillsides.” *They are both on the same angle, both have the same slope, they are the same length and both have waterways at the bottom, but they differ in the amount and location of vegetation.*
5. Explain to students that they will be measuring the number of seconds it takes for the first unit (penny) of sediment-laden runoff to reach the waterways at the bottoms of both hillsides. Ask the students to predict what will happen in the form of a hypothesis and record this hypothesis on the data sheet transparency as Hypothesis #1. For example, the first unit of sediment-laden runoff (penny) will reach the waterway at the bottom of the sparsely vegetated hillside more quickly than the runoff on the heavily vegetated hillside because there is less vegetation to slow and absorb the runoff on the less vegetated hillside. Also have the students make predictions about the amount of runoff that will reach each waterway. Have them express this prediction in the form of a hypothesis as well and record it as Hypothesis #2 on the data sheet transparency. For example, more sediment-laden runoff (pennies) will reach the waterway at the bottom of the sparsely vegetated hillside because there is less vegetation to trap it.
6. Select four student helpers and assign two of them to each Riparian Plinko board. Give a stopwatch to one of the helpers at each board. They will be measuring the time from when the runoff pennies are released to when the first penny reaches the waterway at the bottom of their respective Plinko boards. Have the other helper at each Riparian Plinko board equally space out 10 pennies above the “And They’re (Run)Off” foam board bars, making sure they line the bars up below the black indicator lines on the Plinko boards.
7. On your signal, have the students at both Riparian Plinko boards release the pennies and start their stopwatches.
8. Record the time from penny release to the arrival of the first penny at the waterway on the data sheet transparency under trial one. Also count and record the number of pennies that reached the waterway at the bottom of each hillside. Ask students if they observed anything else of significance and record this information under “Other Observations” on the data sheet.
9. Collect and realign the pennies and repeat steps 7 and 8 four more times so that you have done five total trials.

10. Have students calculate the average time it took the first penny to reach the waterways and the average number of pennies that reached the waterways for both hillsides and record these data under “average” on the data sheet transparency.

Riparian Model

1. Generate a discussion of the importance of riparian buffers, particularly as they relate to slowing down and absorbing runoff and removing sediment from runoff. Be sure to mention why sediment in waterways is problematic.
2. Present the Riparian Model to the class and explain that the well-vegetated side with a fence is a riparian buffer that has been created using Best Management Practices. The sparsely vegetated side with run-off and cows in the water is a poorly managed riparian area. Explain that they will be simulating the effect that these different land use practices have on runoff that if flowing down the hillsides towards the waterway by pouring water down each section of the model so that it flows towards the stream.
3. Ask the students where the sediment in the runoff might be coming from.
Agricultural fields, construction sites, deforested areas, etc.
3. Ask the students to compare and contrast the two “hillsides.” *They are both on the same angle, both have the same slope, they are the same length and both have waterways at the bottom, but they differ in the amount and location of vegetation and the placement of a protective fence to keep cows out of the waterway on the BMP section.*
4. Explain to students that they will be measuring the volume of runoff that each type of riparian area allows to enter the stream. The water that enters the stream will run into the cups positioned at the ends of the stream.
5. Ask the students to predict what will happen in the form of a hypothesis and record this hypothesis on the data sheet as Hypothesis #1. For example, more water will run into the stream when poured on to the poorly managed side of the riparian model because there is less vegetation to absorb the run-off than there is in the better managed side of the model.
6. Measure out 50 mL of brown water and have students decide which side of the model they would like to start with. Pour the 50 mL of brown water on the corresponding side of the model. Allow the water to run down the hillside until the water stops flowing, and then, pour any excess water that lies in the river into one of the cups at the end of the river by tilting it slightly towards that cup. Using only the two cups placed at the ends of the river, not the cup placed by the mark above the river, measure the volume of runoff that entered the stream. Record the measured volume on the data sheet transparency under the appropriate model side (BMP Riparian Buffer or Poorly Managed Riparian Area). Also ask the students if they made any observations while the water was flowing down the hillside. Note any differences

between the color of water poured on the model and the color of water collected from the stream. Record these observations in the "Other Observations" section of the data sheet transparency.

7. Dab the model dry with paper towels, being careful not to crush vegetation. Then, repeat the previous step for the other side of the model.
8. Repeat steps 6 and 7 at least four more times so that you will have done five total trials for each side of the model.
9. Once all trials are finished and recorded, have students compare and contrast their observations of each side of the model. Have students calculate the average volume of water that entered the stream on each side of the model and record these data under "average" on the data sheet transparency. Also, compare and contrast students' observations of each side of the model.
10. Note that a less quantitative version of this activity may be done by following a similar procedure without measuring the exact volumes of runoff left unabsorbed by either side of the model. You may choose to simulate rain by using the "Rain Cups" or spray bottle to apply water to the model instead of simply pouring water on the model using a cup or beaker.
11. PLEASE **LET THE RIPARIAN MODEL FULLY AIR DRY** BEFORE SEALING IT BACK IN ITS CONTAINER! If you fail to do so, mold will damage the model. THANK YOU FOR YOUR COMPLIANCE!

DISCUSSION:

Riparian Plinko

On average, how long did it take for the first penny to arrive at the waterways at the bottom of the heavily- and sparsely vegetated hillsides? Why did the average times differ? *Answers will vary.*

So, was our first hypothesis supported or rejected? *Answers will vary.* What does this tell us about the speed at which runoff moves over sparsely- and heavily vegetated land? *Runoff moves more slowly over heavily vegetated land because the vegetation serves as obstacles to slow down the runoff and soak it up.*

On average, how many units of sediment-laden runoff (pennies) reached the waterways at the bottom of the heavily- and sparsely-vegetated hillsides? *Answers will vary.* Why did the average number of pennies differ? *The trees and shrubs on the heavily vegetated hillside trapped more sediment.*

So, was our second hypothesis supported or rejected? *Answers will vary.* What does this tell us about the amount of sediment that reaches waterways at the bottom of sparsely- versus heavily vegetated hillsides? *Less sediment reaches waterways at the bottom of heavily vegetated hillsides.*

As a percentage of the sediment released down the hillside, how much was trapped by the vegetation? *Calculate the exact percentage based on your data. The literature claims that as much as 80% of sediment can be removed from runoff by riparian buffers.*

Riparian Model

On average, how much runoff entered the stream after passing through the well managed, heavily vegetated riparian buffer versus the poorly managed, sparsely vegetated riparian area? *Answers will vary.*

So, was our hypothesis supported or rejected? *Answers will vary.* What does this tell us about the amount of runoff that reaches waterways at the bottom of heavily- versus sparsely- vegetated hillsides? *The trees and shrubs on the heavily vegetated hillside trapped absorb more runoff and trap more sediment.*

Was there a difference in color between the water that was poured on the model and that which was collected in the cups? If so, was the color difference the same for both sides of the model? Why? *Ideally, the water collected after running through the riparian buffer should be cleared than the original water and cleared than that which was collected from the poorly managed side. The reason for the color change is that, in addition to absorbing runoff, the riparian buffer actually filtered out some of the sediment (brown paint) that was in the runoff.*

Why is stream fencing an important Best Management Practice? *Stream fencing keeps farm animals from eroding streambanks and from defecating in the stream, which adds nutrients and could lead to eutrophication.*

Both Demonstrations

How does the speed of the runoff relate to erosion? *The faster the speed of runoff, the more erosion.*

Where was most of the sediment on the heavily vegetated hillside trapped? *Answers will vary.*

What does the line of vegetation along the stream represent? *A streamside forest or riparian forest buffer.*

Other than trapping sediment and absorbing and slowing down runoff, what are some of the other benefits of riparian forest buffers? *See “Riparian Buffer Basics” Fact Sheet.*

Where does the sediment in runoff come from? What kinds of land use can increase the amount of sediment in runoff? *Agriculture, logging, construction, urban/suburban development, etc.*

Is sediment in runoff an example of point or non-point source pollution? *Non-point source pollution because it is difficult to pinpoint and comes from a widespread area.*

Why is sediment in waterways problematic?

See Background information.

What is sedimentation? *The filling in of waterways with soil, sand, and silt particles resulting from soil erosion.*

How can one reduce the amount of sediment entering waterways?

Preserve and restore riparian buffers! Use Best Management Practices and other more environmentally sensitive agriculture, logging, construction, and development techniques.

How does vegetation trap sediment?

See Background information.

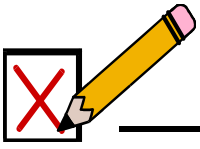
EVALUATION:

- Discussion questions above

EXTENSIONS AND MODIFICATIONS:

- Try positioning the Plinko boards at different angles to see if this affects the results of the experiment.
- If you have already done a unit on topographic maps and stream gradients, have students do stream gradients and make predictions about which waterways have more serious sediment issues based on the slope of the land and adjacent land use.
- Have students simulate runoff running over un- versus vegetated land by recording the amount of time it takes them to walk 50 meters in a straight line as opposed to the same distance but walking in a zigzag fashion.
- Make more Riparian Plinko boards of your own, varying the position and amount of vegetation, and perhaps mimicking the 3-Zone Riparian Buffer Model depicted in Figure 3.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

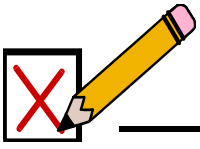


DATA SHEET : RIPARIAN PLINKO

HYPOTHESIS #1: _____

HYPOTHESIS #2: _____

Riparian Plinko Board	Trial	Time from release of pennies to the arrival of the first penny at the waterway (seconds)	# of pennies that reached the waterway	Other observations
Heavily vegetated hillside	1			
	2			
	3			
	4			
	5			
	Average			
////////////////////////////////////				
Sparsely vegetated hillside	1			
	2			
	3			
	4			
	5			
	Average			



DATA SHEET : RIPARIAN MODEL

Name _____ Date _____

HYPOTHESIS: _____

Riparian Model	Trial	Volume runoff that reached the waterway (mL)	Other observations
Best Management Practice Riparian Buffer	1		
	2		
	3		
	4		
	5		
	Average		
////////////////////////////////////			
Poorly Managed Riparian Area	1		
	2		
	3		
	4		
	5		
	Average		