GreenKids Audubon Naturalist Society
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Enviroscape® Model: Exploring Watersheds and Riparian Forests

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Students will learn about watersheds and pollutants using a model of a landscape. They will observe what happens when it rains in a landscape with and without riparian buffers.

OBJECTIVES

- To reinforce the concept of watersheds and how water flows over a watershed.
- To learn about and identify pervious and impervious surfaces in a landscape.
- To discuss different types of pollutants in a landscape and how they may be carried by runoff into waterways.
- To learn about riparian buffers and understand how riparian buffers may help protect waterways by slowing the flow of runoff and filtering pollutants.
- To learn about point source and non-point source pollution.
- To understand that models are used as representations for things or processes in the real world. To set up and perform experiments using models.

SUPPLIES

The EnviroScape™ model, an instruction booklet and the supplies for the lesson are in a large carrying case. Check for the following supplies:

- Model-sized buildings, bridges, vehicles, animals, golf course flag
- Clay for berms, and to secure the animals and golf course flag to the model
- Sponges and trees
- Drain plug for the bay and a plastic container to empty the runoff from the bay
- Shakers with different colored powders to represent soil, fertilizer and pesticides (check the supply of powders – tea, Kool-Aid, lemonade, etc.)
- Container for liquid "sludge" for the factory (check the supply of chocolate powder for making sludge)
- Bits of paper to represent litter.
- Spray bottles (2 or 3, filled with water)
- Large piece of green fabric
- Rags and a bucket (to hold water) for cleaning the model
- 1 Assessment Worksheet for each class

PRE-ACTIVITY

- This activity is not easy to move between classrooms, so if you are teaching the lesson in consecutive time slots arrange to teach it in one classroom.
- Spread out the large piece of green fabric and set the EnviroScape on the fabric. This is useful if you are working on the floor. The fabric can be used to set boundaries and give you space to work. Students will be instructed to sit beyond the edges of the fabric.
- Set up the model with the buildings, vehicles, animals, golf course flag and bridges. Set aside the, containers with powders and sludge, spray bottles filled with water, and sponges with the trees. Make sure the drain hole for the bay is plugged!

INTRODUCTION

- **Pre-Assessment** – Explain that students will learn about watersheds and types of pollution that threaten water quality. Ask students to name forms of point source and non-point source pollution. Write their answers on the assessment worksheet at the end of the lesson plan. Write any examples they offer, regardless of whether they are correct.
- Have the students gather around 3 sides of the model (you will sit or stand behind the side opposite the bay). Students will sit or stand depending on if you are working on the floor or on a table. Ask the teacher to help you arrange students so everyone can see the model. (No one should be sitting or standing on the piece of green fabric.)

DISCUSSION

For this lesson, we will be talking about issues related to a watershed and what happens when it rains.

- **Model**: We will be working with a model. A model is a **representation** of what may happen in the real world. It is a useful way to study processes in nature.
    - Have students look at the model and describe what they see. Ask if the model looks like their neighborhood. What are the similarities and differences?
- **Pervious and impervious surfaces**. Pervious surfaces will absorb water; impervious surfaces do not absorb water.
    - Have student identify pervious and impervious surfaces on the model.
- **Sources of Water Pollution:** We will show some things that people do that contribute to water pollution using powders.
    - **Sediments**: People do things that disturb or loosen the **soil** (loose soil is called **sediment** when it enters the water). Ask a student to explain where soil might be disturbed and where there might be loose soil in the model (construction site and farm). Hand the shaker with a brown powder to the student and have him/her pour powder in places he/she is describing. Have 1 or 2 more students do the same.
    - **Fertilizers:** People put fertilizers on the landscape. Fertilizers provide nutrients for plants. Ask a student to explain where fertilizers may be used in the model (golf course, farm and yards). Hand the shaker with a red powder to the student and have him/her pour powder in places he/she is describing. Have 1 or 2 more students do the same.
    - **Pesticides**: People spread pesticides to kill animals they think are harmful (often called "pests", e.g., insects and rodents). Do pesticides only kill the animals that people are trying to kill? No, a pesticide can't tell the difference between a "harmful" animal and a "beneficial" animal. Hand the shaker with a yellow powder to the student and have him/her pour powder in places he/she is describing (farm, yards). Have 1 or 2 more students do the same.
    - **Sludge**: People build and run factories which may create waste products like **sludge**. Sludge can contain toxic chemicals and bacteria. Hand the container with the brown liquid to a student and have him/her pour sludge on the roof of the factory. Ask students what they see happening.
    - **Litter**: Ask students to name ways that trash ends up in the water. Have students put litter (bits of paper) along the sides of roads.
    - **Manure**: With the help of a student, have the cows leave manure (using sludge bottle) near the stream in the cow field.
- **Watershed:** Ask: What is a watershed? A watershed is the entire region that water flows over as it drains into a particular body of water such as the Chesapeake Bay. The watershed is named after that body of water. Think of the model as part of the Chesapeake Bay Watershed.

- Ask: What direction does water run or flow? Water runs down (downhill).
- **Rain on the watershed**: Hold up the spray bottles and ask students what they think these represent. Clouds! Ask the teacher to select 2 students to be "clouds." Tell the "clouds" that water must only be sprayed down and toward the model. Before they begin, also tell them that they have been given a job and can be fired if they don't do the job as instructed!
- **Ask the students to make it rain**. Have the students spray water all over the model.
- **Runoff:** As it rains, ask what is happening. Rainwater runs along the surface of the land – this is runoff. Soil that is loose or has been disturbed is carried into waterways by the runoff. Excess fertilizer (what is not absorbed by plants) is carried into waterways. Pesticides are carried into waterways by runoff. What is happening to the manure during a rainstorm? It may be carried into waterways. Where is the litter going?
- **Stop the rainstorm.** How does the water in the Chesapeake Bay look? What are some ways that the pollution is affecting water quality? How do you think the fish and underwater plants are doing? What do you think about this bay as a source of drinking water for people? Some effects of pollution:
  - **Why are fertilizers a problem for the bay**? Fertilizers are plant foods. The problem is that when a lot of fertilizer is washed into the bay in a very short period of time (from yards/farms), the chemicals may cause an algal bloom. Algae absorb the nutrients and quickly grow, reproduce and die. When algae die, they are decomposed by bacteria. Bacteria use up oxygen in the water in the process. Do fish and other aquatic animals need oxygen? YES! The area with the rapidly-dying algae becomes a dead zone or an area without oxygen. Animals that cannot escape from the dead zone may suffocate and die. Algal blooms are a natural process, but human activities have increased their frequency.
  - **Why is manure bad for the bay**? Manure is high in nutrients and contains bacteria. When a lot of manure enters a stream/bay, it can result in fish kills and problems associated with algal blooms. The bacteria in manure can make streams, rivers and bays unhealthy places for people to play and swim.
  - **Why are pesticides a problem for the bay**? Pesticides can potentially sicken or kill aquatic animals, such as aquatic insects and fish.
  - **Why is litter bad for the bay**? Litter is ugly, but also:
    - Plastic litter can harm animals that eat it (sea birds and sea turtles are common victims)
    - Pieces of glass and other sharp objects can injure people and wildlife
    - Some forms of litter may contain toxic chemicals that harm wildlife/plants
    - Plastic containers can trap small animals
    - Fishing lines, ropes, nets can ensnare aquatic animals and kill those that aren't able to escape.
- **Non-point Source Pollution.** Tell the students they are scientists responsible for testing water quality in the bay. They take a water sample and find pesticides and fertilizers in the sample. Ask if anyone can tell you **EXACTLY** where the pesticides and fertilizers came from (you want students to try to point to only 1 place on the model). **They can point to many places but not to the exact place because these pollutants could have come from many different sources**. These are examples of **non-point source** pollution. What are other examples on the model? Litter and sediment (loose soil).

- **Point Source Pollution.** What if they found sludge in the water sample? Can they tell you **EXACTLY** where the sludge came from? Yes, the factory. Have them point to where it came from. This is an example of **point source** pollution. (For this model, manure would be a second type of point source pollution since there is only one farm. In an agricultural community, it would be a non-point source. This would be true of other pollutants as well; they may be non-point sources or point sources depending on the landscape and situation.)

- Which is easier to control, **non-point source or point source** pollution? Point source pollution is easier to control because its source is easily identifiable. If you had to write a ticket for polluting, you can write a ticket to the factory for its point-source pollution…sludge.

CLEAN AND RESET THE MODEL

- Tell the students we will clean the model and set it up again. (Pull the plug in the bay and drain the water into a plastic container – **DO NOT PULL THE PLUG UNLESS YOU'VE PLACED A CONTAINER UNDER THE MODEL!** Use the spray bottles and rags to clean the model.)
- As you are cleaning and resetting the model, ask students to give you some ideas of actions that can be taken to protect the bay.

We can reduce the impacts of fertilizers, pesticides, litter, sediment and manure using the following techniques…

…BUT FIRST, let's learn about riparian buffers. Riparian buffers are made up of plants that grow between waterways and human developments. The plants help slow and reduce the flow of runoff into the streams. Plant roots absorb water and nutrients. Soil absorbs water and filters out (traps) pollutants as the water seeps down through the soil.

We will use several techniques to create riparian buffers throughout the model. Explain the techniques and let students do the work, with assistance as needed.

Use clay to create a wide **berm** that protects the bay from farm fertilizer/pesticide-laden stormwater runoff. Plant trees in the berm. A berm is a mound of earth that is used to control stormwater runoff. Berms have many functions, including: • being a barrier to water flow • absorbing runoff • directing water flow towards a bioretention area such as a rain garden	
Berms can be constructed within the field for the same purposes as above. Such practices are becoming more common-place because reducing erosion and providing habitat for pollinators benefits the farmer as well as the waterways. Have students add loose soil to the farm field.	

Reduce the amount of pesticides and fertilizers used.

Many farmers are now using less fertilizers by:

- Spreading manure at appropriate times in place of chemical fertilizers.
- Testing soil so fertilizers are used only as needed

Some farms do not use pesticides, or only use them as necessary.

Have students sprinkle fertilizers and pesticides in the landscape, but use less than before.

Stop erosion on the hill.

Have students plant trees along the hill to prevent excessive erosion.

Before the next rainstorm, sprinkle little to no loose soil on the hill.

Create a community bioretention garden.

Bioretention gardens are designed to collect and slow stormwater runoff and treat it (remove pollutants) by the actions of vegetation – plants absorb water resulting in infiltration into soils and evaporation (as opposed to all the water running off into natural waterways). Another positive side effect of bioretention gardens is that they provide habitat for wildlife, such as birds and insects.

* Note that a real rain garden would actually be within a depression.

Construct a berm between the road and the home.

Next, place sponges, with trees, between the homes and the berm.

Farmers can reduce the impact of livestock on a stream by erecting a fence.

To absorb manure-laden runoff from the field, plant shrubs/trees along a berm located between the fence and the stream to create a riparian buffer.

Add sponges with vegetation to model a bioretention swale between the roads.	
Construct a berm to prevent the flow of sediment out of construction site. In MD construction companies must prevent sediment-laden runoff; usually by constructing silt fences, compost berms or sediment control basins. Add loose soil to the construction site.	
Sludge. Two options: 1) Sludge can be collected (do not add it) and used to fertilize farms (some types of manufacturing result in nutrient-rich sludge that can be safely applied to farms as fertilizer). 2) Turn the building so the outflow pipe doesn't point directly into the stream and place a sponge with trees at the end of the outflow pipe to filter the pollutants. Have the students choose an option.	
Bioretention swales and trees. Have students plant trees or create vegetated swales along the roads in areas that they think will provide a buffering effect. **The trees are somewhat delicate so do not hand them to the students until they are ready to put the trees on the model.**	

- If you are short on time, you can focus your runoff control measures on a particular area, such as just the farm or in constructing a neighborhood rain garden and bio-retention swales.

- **Rain on the watershed.** Once the buffers and pollution-reduction techniques are completed, ask the teacher to select 2 students to be "clouds." Remind the "clouds" that they have been given a job and can be fired if they don't do the job as instructed! Have the students spray water all over the model.
- As it rains, have students discuss what is happening. How does this compare to what happened before?
- **Stop the rainstorm.** How does the water in the Bay look? Better, worse or the same?
- Pick up a few "buffers" (sponges) that seemed to be well-placed to slow runoff. Squeeze the sponges out into the bay and **talk about how they did as buffers**. Pick up others that may not have been well-placed. Ask for suggestions about what changes students would make (in terms of the placement of buffers) if we were to set up the model again.

POST-ASSESSMENT

Return to the assessment worksheet. Ask students to list forms of point and non-point source pollution, based on what they learned during the activity.

- Examples of non-point source pollutants: fertilizers, pesticides, herbicides, sediments, litter, oil and other chemicals that may have been spilled on roadways, manure (depending on the type of community), chemical deicers (used on roads, parking lots, driveways, sidewalks, etc.).
- Examples of point source pollutants: pollutants from factories, manure (depending on the type of community), oil spills, outflow from wastewater treatment plants, chemicals used in mining operations, sediments from an area where trees were clearcut.

  * Note: students may argue that certain pollutants could be in both categories. What is important is that they can explain their reasoning.

EXTENSION ACTIVITIES

- Many concepts from the EnviroScape lesson can be reinforced by teaching the lesson with "We All Live Downstream." A class would do both activities in 1 hour. Plan 30-minutes for each lesson. If you are able to work with another teacher, each of you will teach 1 activity, working with 1 class for 30-minutes and the other class for the next 30-minutes.

NOTES AND ADDITIONAL INFORMATION

"Manure's Impact on Rivers, Streams and the Chesapeake Bay: Keeping Manure Out of the Water": A Report by the Chesapeake Bay Foundation, July 28, 2004.
http://www.cbf.org/Document.Doc?id=137

'Keep America Beautiful' is a good source for more information about problems with litter and preventing litter.
www.kab.org

The Chesapeake Bay Foundation has excellent on-line resources about the effects of excessive fertilizers on the bay. Follow the links to the Bay Resources/Fact Sheets index to view a variety of reports on this issue.
www.cbf.org

From a publication of the **Savannah River Ecology Laboratory**, Ecotoxicology Master Lesson 23 January 04, Activity 5, "Ecotoxicology: Watersheds and Pollutants" (found on the Clean Water Campaign website), http://www.cleanwatercampaign.com/files/ecotox-master-lesson.pdf

"Watersheds are drainage basins (areas of land) where surface water runs off of and drains into common collection sites such as creeks, streams, rivers, ponds, lakes, and oceans. Watersheds also include areas where surface water has seeped underground and become groundwater. Watersheds are separated from each other by landforms, such as mountains or ridgelines. Water falling on either side of the divide drains into different watersheds and collections sites.

Water in the form of precipitation falls to the earth and travels over natural and man-made surfaces before it ends up in larger bodies of water as runoff. One way to get students to understand the concept of a watershed is to have them pay attention to what is going on outside their classroom on a rainy day. Surface runoff flows over a schoolyard on its way to collection sites. Which way is the water "running?" Point out puddles and explain how the land around it is like a mini-drainage basin or mini-watershed and how the puddle is considered the collection site. When the puddles overflow or the soil becomes saturated, then the water is released to "runoff" further down the watershed. Have students look for materials that were left behind by the flowing water. Twigs, leaves, oil, trash, soil, and other items may be found. Surface water leaving the school grounds may carry similar materials with it as it goes to a larger collection site in the watershed, combining with water and materials from other drainage basins.

Even though some materials may decompose, settle out, or be filtered by the soil, there will still be some materials that continue to travel long distances downstream. Some materials will nourish aquatic plants and animals, but other substances can be highly toxic. These pollutants or contaminants can harm humans and animals that drink the water, or aquatic life that lives in creeks, rivers, ponds, and oceans.

Most students know that the water flowing out of their faucets has been treated, unless they live in a house that uses a well. Almost every city in the U.S. has some kind of wastewater treatment plant. Drinking water standards are set to ensure that water is potable. The water is sampled and tested for contaminants on a regular basis. Water quality standards are established based on the assumption that water with concentrations of organic or inorganic compounds above a certain limit might cause health problems to humans and other living things.

Once contaminants are discovered, how does one go about finding the source of the problem so that it can be fixed? It is often very difficult to pinpoint the exact entry point of common chemicals such as pesticides and fertilizers into a watershed. Contaminants that are difficult to trace to one location, or "point," are classified as non-point source pollutants. Contaminants that are easy to trace, such as sewage from a broken sewer pipe at a school or a chemical from a discharge pipe from a factory, can be categorized as point source pollutants.

Once a contaminant is found it is important to determine the amount present in the ecosystem and whether or not it will pose an immediate danger or a long-term threat. Water quality standards have been established for hundreds of chemicals and scientists like ecotoxicologists measure and report air, water, and soil contaminants in parts per million, parts per billion and parts per trillion. Although these numbers may seem like extremely small concentrations, many chemicals are so toxic that they can cause health problems at even very low levels. An interesting fact is that people can smell petroleum and petroleum products in water at concentrations as low as 10 parts per billion!"

EnviroScapes® Assessment

School _____ **Class** _____ **Date** _____

Pre-Assessment	
Sources of Point Source Pollution	Sources of Non-point Source Pollution
Post-Assessment	
Sources of Point Source Pollution	Sources of Non-point Source Pollution