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Curriculum Units by Fellows of the National Initiative
2009 Volume VII: Energy, Climate, Environment

Teaching Ecology Principles through the Study of an Ecosystem

Curriculum Unit 09.07.08, published September 2009
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Overview

Originally this unit was designed to teach my students about the Chesapeake Bay. After all it is less than 90 miles away, yet the majority of my inner city students have never been there. The unit was going to be adaptable so it could fit other watersheds. Then through the course of writing it, something happened. I was using information about salt marshes in California to write about the Chesapeake Bay. I began to understand principles of ecology and ecosystems. Realizing that the principles are the same regardless of the ecosystem, I began to embed them throughout the unit. Now I have a unit that will not only empower my students to care about a watershed, but a unit to empower kids everywhere to become stewards of their our environment.

Objectives

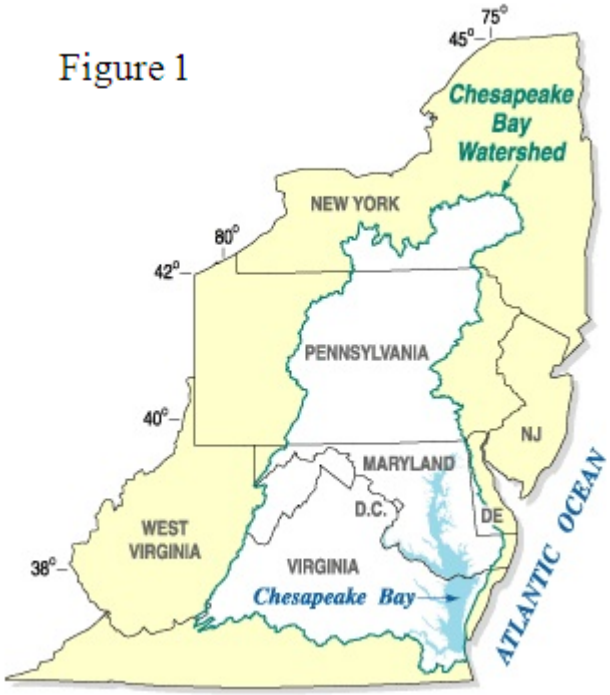
There are several main objectives that I want the students to learn from this unit. I would like them to understand what a watershed is and how a watershed works. It is also important for the students to understand that watersheds are systems. By the end of this unit the students will learn some basic principles of ecology. But, most importantly, I want the students to become stewards of the Chesapeake Bay and of nature in general.

This unit will cover many objectives across all content areas. It is designed to teach students the geographic regions of Virginia and how to use topographical maps. It will also incorporate graphing skills and writing skills. The focus of the unit is watersheds, but because a watershed is a system, students will also learn about ecosystems, natural resources, scientific investigation, animals and plants. While this unit is written for the Chesapeake Bay, an objective of mine is that this unit will be adapted and used to teach ecological principles in environments around the world.

Rationale

Importance of the Bay

The Chesapeake Bay is a remarkable waterway. Not only is it the largest estuary in North America, but also North America's most diverse. It is the home to more than 3,600 living species. The Chesapeake is also a temporary home for migratory birds. The bay is enormous and supports a wealth of wildlife. The Chesapeake Bay is an important natural resource upon which other living resources depend.



The Chesapeake Bay Watershed covers 64,000 square miles, including the bay and all of its tributaries. The Chesapeake Bay alone has about 8,000 miles of shoreline, and there are 11,684 miles of shoreline in the watershed. It spans out over six states: Virginia, Maryland, Pennsylvania, Delaware, New York, West Virginia, and the District of Columbia (Figure1). Thus, the idea of protecting the Chesapeake Bay is as vast as the bay itself.

My students live within the Chesapeake Bay watershed and their actions or inactions affect the bay everyday. It is difficult to see the impact one's actions have on a bay that is over a hundred miles away from home. However, changes need to be made quickly and need to continue into the future if the health of the bay is to be restored. By understanding the decline of the bay, the history of restoring the bay, and what students and teachers can do; I hope to foster an appreciation for nature and stewardship, no matter where your home is.

Decline of the Bay

When examining causes for decline in any ecosystem, it is helpful to categorize them as physical, biological or chemical in nature. Getting students to think in these terms will help build a strong foundation for ecology. The physical causes listed below include: fishing; and population growth and land use. Global warming; invasive species and marine disease; and endangered and threatened species would fall into the biological category. Pollution is primarily chemical, however, manure would have to be biological. As these issues are

taught to my students, I will work to develop their understanding and their ability to classify using these terms.

Pollution

Agriculture is the leading cause of pollution to waters throughout the country. Agricultural pollution comes from commercial fertilizers and animal waste. Animal agriculture accounts for about 50% of the total pollution load affecting the Chesapeake.

Poultry and dairy farms are the two main sources of pollution from animal agriculture reaching the Chesapeake Bay. The poultry industry that is primarily located on the Eastern Shore of Maryland and Virginia particularly plagues the bay. Perdue and Tyson both have plants on the Eastern Shore. Route 13 that extends the length of the Eastern Shore is dotted with "family run" poultry farms. Typically, these farms will have 5-6 chicken houses, containing approximately 40,000 chickens in each one. The manure may be shipped to a local farm and used as fertilizer, or it may accumulate in large piles and get into the runoff when it rains. The result, according to J. Charles Fox, senior adviser to the EPA's Chesapeake Bay cleanup program, is "the equivalent of medium-size cities in terms of the waste that is generated, that is virtually untreated, going into the Chesapeake Bay." [1]

The other 50% of agricultural pollution is due to traditional crop farming. The two main crops are wheat and corn. Nationwide, there has recently been a higher demand for corn in order to produce biofuel. The result for the Chesapeake Bay watershed is an increase in the acreage and production of corn, as well as, an increase in the use of fertilizers. On average, about 60% of all of the pollution entering the Chesapeake Bay comes from agriculture. The bottom line is that there is too much agriculture concentrated in one area. [2]

The other source of pollution is chemical. It enters the watershed from urban areas. Wastewater and power plants are two sources of chemical pollution entering the bay. In Maryland, 50 million gallons of effluent, liquid waste from industrial plants, enters the Patuxent River per day. Soon, the amount will increase to 80 million gallons per day. [3] The bay is also the recipient of pollution from beyond the watershed boundaries. Power plants in Ohio are responsible for the majority of the mercury in the watershed. The mercury gets into the atmosphere and is deposited into the bay. Unfortunately, bioaccumulation of chemical compounds, or the build-up over time, occurs and may take decades to disappear. These chemicals tend to linger in sediments. They also accumulate, in greater proportion, in organism higher on the food chain. Much of the pollution is a result of human impact and our use of land.

Population Growth and Land Use

There is a direct correlation between the changes in land use and the deterioration of the Chesapeake Bay. With more than 16 million people living within the Chesapeake Bay watershed, the amount of land being developed has vastly increased. Deforestation has taken place to make way for residential and commercial construction. The new construction removes landscaping that controls erosion and filters runoff. It is being replaced with concrete and other non-permeable surfaces. When the surface is permeable, water seeps into the ground and becomes a source of groundwater. This process helps the bay. However, when pavement sprawls across the surface, runoff increases, causing damage to the bay. So the harm caused by deforestation is two-fold.

The increase in runoff carries more nutrients, pollutants and sediments to the bay. Sediments are harmful to the bay for several reasons: they absorb high levels of toxic materials, reduce the water clarity and decrease

the water depth. This is especially harmful to the shallow waters of the Chesapeake Bay. Unfortunately, urban sprawl is not the only detrimental land use that has increased.

Over the years, farmland has also expanded. "Agriculture is by far the largest source of pollution to the Chesapeake Bay, and arguably the single biggest source of pollution to all of the waters in the country," states J. Charles Fox, senior adviser to the EPA's Chesapeake Bay Cleanup Program. [4] Agriculture is largely responsible for fertilizer and nutrients that enter the waterways. Currently, the nutrients entering the Chesapeake are the single most damaging factor. "The nitrogen load into the bay from six states is 360 million pounds, to be in balance according to Will Baker, president of CBF, the load should be no more than 150 million pounds per year." [5] We tend to think of nutrients as healthy, but too much is dangerous.

The influx of pollution is creating dead zones. A dead zone is an area with little or no oxygen. Dead zones form when too much nutrient pollution is in the water. The nutrients stimulate an algae bloom. Eventually, the algae die and sink to the bottom. Then it decomposes. During the process of decomposition, oxygen is consumed. The area becomes depleted of oxygen, and can no longer support life. Dead zones are increasing not only in the Chesapeake Bay, but also throughout the world. "The impact human beings are having on the watershed are tremendous, and in many ways irreversible." [6]

Toxic pollution presents another problem caused by human impact. Once toxins get into the sediment, it takes a very long time to eradicate the problem. The Allied Chemical Corporation in Hopewell, Virginia produced Kepone from 1966-1973. Kepone was a pesticide used to kill fire ants. Allied Chemical was dumping Kepone into the James River and it was accumulating in the sediments and in the fatty tissue of finfish. The cost of cleaning up the river was considered too high. So, instead commercial fishing in the James River was banned for ten years. Kepone can still be detected in fish found in the James River and is still underneath the sediments. It is estimated that Kepone will be present in the James River for one hundred years. [7] The cost of cleaning up contaminated areas and the long-term effects of toxic waste are troubling. The environment is not only battling chemicals that lay in sediments for decades, but also facing newer challenges, as well.

Global Warming

Global warming is a newer threat. Gas emissions are a main cause of global warming and this warming trend is increasing the air and water temperatures. The pollution created, in the United States and other parts of the Earth, is affecting the poles and the sea ice in the permafrost regions of the world. As the ice melts, it increases the amount of water in the Earth's seas. The increase in water results in higher seas. "The rising sea level is reducing coastal wetlands and mangroves, thus increasing the impact of coastal flooding in some areas". [8] This increase poses a greater threat particularly when large storms, such as hurricanes, brew in the sea. The surge from a storm can be catastrophic in low-lying areas. In 2005, we saw the devastating effects of Hurricane Katrina in New Orleans.

Sea level rise affects the Chesapeake and other bodies of water in several ways. As the water rises, the bay will become deeper. With deeper water, sunlight will be unable to penetrate and reach the submerged aquatic vegetation, or SAVs, that grow on the bottom of the bay. SAVs are grasses that provide habitat, breeding grounds, and food for living organisms. SAVs, like terrestrial plants produce oxygen. If the amount of oxygen is depleted, dead zones will increase and aquatic critters will die. Higher water levels also threaten to cover up barrier islands and bay marshes that are temporary homes and breeding grounds for more than 1 million migratory birds. [9] In 1990, the sea level rose 1.8 mm. The annual amount of rise has been gradually increasing. By 2000, the increase was 3mm. Three millimeters may not seem like much, but think about the

cumulative effect. In ten years, the sea level has risen over 20 millimeters, and it continues to rise at a faster rate each year.

Global warming also causes the air temperature to rise. It is expected that the air temperature will increase between 5 and 9 degrees Fahrenheit by the end of the 21 st century. [10] As the air temperature warms, so does the water. The rise in water temperature helps algae to bloom, creating dead zones. Warmer waters also increases the amount of salt the water can hold, or salinity. Saltier water holds less oxygen. Dead zones therefore increase in the summer, when the water temperature in the Chesapeake Bay is warmer.

Global warming is also responsible for increased amounts of precipitation in the winter and spring. The rain then causes more runoff, leading to nutrients, sediments, and pollution overloading the bay. Again, the overload leads to algae blooms that cause the formation of dead zones. The effects associated with global warming are not isolated. There is a ripple effect due to the interconnectedness of the world around us. The lack of oxygen in the water has a tremendous affect on plant and animal species. The lack of oxygen will impact the most sensitive organisms first. Then the ecosystem will begin to change and the changes will begin to accumulate similar to a snowball. The lack of oxygen will no longer affect only the sensitive species, but the entire ecosystem. Thus making these challenges daunting.

Invasive Species and Marine Disease

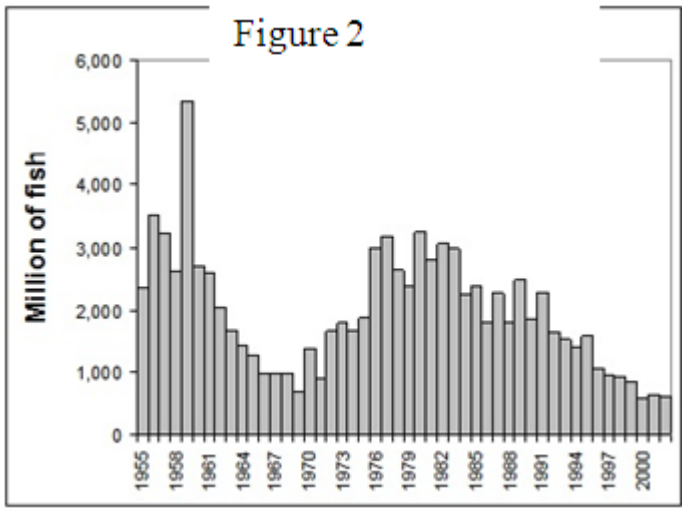
There are over 200 known invasive species in the Chesapeake Bay. An invasive species is a species that is not native to the area. So how did these "foreigners" get into the bay? Most of the invaders came with cargo ships from other parts of the world. Cargo ships suck up ocean water and store it in the hull, thus creating ballast. This provides stability. When the ships arrive in the Chesapeake, the ballast water is released into the bay. This water contains species, which get discharged into the bay at this time. If a species is to survive in its new environment, it must become part of the interconnected food web. It will secure a niche, or a specific role. If the newcomer is a predator it will pose a new threat to other organisms. Thus, decreasing the population of its prey. The invasive species will also become the prey for another organism. This changes the dynamics of the food web. Again, one small change spirals out of control and creates havoc throughout the ecosystem.

The oyster is an organism whose entire population was altered by "foreigners". Two parasitic invasive species, MSX and Dermo, have killed 90% of the oyster population. [11] In the 1940s, four million bushels of oysters were harvested annually. In the 1990s, only 40,000 bushels were harvested. [12] This example demonstrates a biological stressor, a parasite, which happens to also be an invasive species. An invasive species can be particularly dangerous when it is viral, bacterial, parasitic, or fungal in nature because the native species have not built up their immunity to them.

Aquatic species have an immune system in some ways similar to humans. If people get run down or stressed, they are more susceptible to sickness. When marine life becomes stressed or their immune system is compromised, they are more susceptible to disease. Biological stressors include viruses, fungus, parasites and bacteria. Poor water quality, pollution and toxins are chemical stressors for aquatic organisms. Diseases occur naturally, as with any population. Marine diseases become a concern when large numbers of a species are involved. Similarly, there is greater concern when a human illness becomes epidemic or pandemic. With the increase in runoff, water quality is decreasing thus increasing the susceptibility of organisms to disease. When one considers the overall decline that many species face due to pollution and water quality, the issue of disease becomes a larger concern.

When water quality, disease or other small changes occur in an ecosystem, the energy or the balance also changes. These small changes are called perturbations. There are human and non-human perturbations. An example of a human perturbation would be extra nitrogen going to the bay due to the use of fertilizer. A non-human perturbation would be a change in behavior by a species. These small disturbances can impact different species in different ways. For example, when too much nitrogen enters the Chesapeake Bay, the amount of dissolved oxygen is decreased. The lower level of oxygen is more harmful to finfish, which require higher levels of oxygen, than jellyfish. In this situation the jellyfish may inhabit the area with less oxygen. An increase in the number of jellyfish in the area impacts the prey of the jellyfish. Thus, changing the energy of the food web in this area. [13] The decrease in oxygen also changes the behavior of some species. If an organism is getting less oxygen, it may not be able to move as quickly or as often. This could affect the organism's ability to catch prey or to avoid capture by a predator. The impact of perturbations is difficult to predict. However, in order "to effectively conserve or restore native biodiversity in altered systems, one must consider impacts of multiple human disturbances, and the interactions between them." [14]

Fishing



An example of a human perturbation is fishing. This livelihood has been a part of the culture of the Chesapeake Bay for centuries. Commercial and residential fishing remove millions of pounds seafood each year. Fishing the bay is regulated with laws and moratoriums designed to regulate the population. However, because marine species live underwater, it is difficult to obtain an accurate assessment. Typically, the population density, or amount of species in a small area is determined. Using the density figure, populations are then estimated based on the range they inhabit. Knowing exactly where the species live is not as clear as with a terrestrial species. The combination of primitive surveillance and the desire to sustain an industry leads to over-fishing. Several species are over-fished in the bay to the point of threatening the survival of the species. In Figure 2, the population of menhaden is shown. This species is being taken out of the bay at a rate far greater than it can reproduce. The menhaden is not currently on the list of threatened or endangered, but there is an effort underway to add it to the list.

Endangered and Threatened Species

By examining the Chesapeake Bay ecosystem, basic principles of protecting species become evident. The four most common threats to species survival have already been mentioned as causes for the decline of the bay. They are: 1) resource use, 2) exotic species, 3) construction and 4) alteration of habitat dynamics." [15] When

trying to protect species, it is important to understand the threats. On average, most endangered or threatened species face four threats. This complicates the situation; and unfortunately a lack of understanding may hinder recovery efforts.

Pollution is more difficult to understand, but in cases where a single tractable threat is determined, the outcome will be more favorable. A single threat was the case with the bald eagle and the peregrine falcon. The threat, the powerful chemical DDT, was revealed in Rachel Carson's book, Silent Spring. Carson's work led to the ban of DDT. The eagle and the peregrine falcon are no longer on the verge of extinction. So, when a single threat is identified, understood and removed, the recovery for the species is much easier.

Effects on the Ecosystem

To understand the detrimental effects on the ecosystem, one must first have a clear understanding of an ecosystem. Long before the term global warming existed, a mathematician and demographer named Alfred James Lotka created the basis for a new science called "physical biology". Lotka was not an ecologist, but his work addressed many ecological problems. He viewed the earth as a single system, an energy transformer. He also discussed food webs, the water cycle, carbon dioxide, nitrogen and phosphorous cycles. Lotka's work led to the 1950s studies by Eugene P. Odum and Howard T. Odum. Their work created ecosystem ecology. [16] These early scientists had ideas ahead of their times.

An ecosystem is "the environment, both the living and the non-living environment, viewed in a way so that it all works together in a system." [17] With so many problems causing the decline of the bay, the effects on the ecosystem are widespread. The systematic nature of an ecosystem is like an intertwined web, where its problems are as interrelated and overlapping, as its effects.

By looking at several species, the impact on the bay will become clearer. Let's begin by looking at the effect on the oysters. "Four hundred years ago, oysters could filter the entire Chesapeake Bay in four or five days. Today's sparse oysters cannot filter the Bay's murky water in a year." [18] The oysters have declined primarily due to invasive species, over-harvesting and from sediments getting into the bay. Silt, or fine sediment, collects in the oysters' gills and also on the oyster reef. The accumulation of silt impedes an oyster's ability to filter water, and basically the oysters are smothered and then die. The loss of the oyster population affects the whole system. When the oyster population declines, so does a valuable filter for the bay. In the absence of these natural filters, the water is not as clear, and the lack of clarity affects the bay grasses. The bay grasses serve as a habitat and a breeding ground for aquatic organisms. Bay grasses also produce oxygen. Without oxygen, dead zones will result and habitats will be depleted. The effects could go on and on as the consequences trickle through the system.

The next species that will be examined is the menhaden. The menhaden are also called alewives. It is a schooling finfish in the herring family. Menhaden are stinky and oily; therefore menhaden are great bait, and are used for fish oil. Menhaden are also natural filters for the bay. A foot-long menhaden fish can filter 7 gallons of water per minute. This equates to 10,000 gallons of water a day. [19] The menhaden population has been declining due to over-fishing. The Omega Protein Corporation uses planes to locate schools of menhaden. Then two boats surround the school, catch them in a net, and suck them up a tube. Up to 300,000 fish may be removed through this process. Some uses of menhaden include fish oil, cosmetics and cat food. The loss of the menhaden represents the loss of another filter for the bay. Rockfish have relied on menhaden as food, but lately have been eating blue crabs instead. The change in diet has affected the health of the rockfish. So commercial menhaden fishing affects the menhaden, rockfish and crab population. As a filter, the

loss of the menhaden has larger implications for the bay and other organisms found within the bay.

The Chesapeake Bay is known for its blue crabs. This popular seafood is valued commercially. The harvesting of the blue crab has fluctuated over the years. Since 1980, the harvesting of blue crabs has been on the rise. It is speculated that the decline of commercial fishing for other species may be linked to the increased harvesting of crabs. Commercial fishermen, or watermen, need to make a living. It is estimated that 160 million pounds of crabs are harvested each year. This is split equally between commercial and recreational fishers. [20] Blue crabs are an important part of the ecosystem because they control the population of benthic, or bottom dwelling species. Blue crabs eat both living and dead organisms.

Blue crabs and watermen go hand in hand. Next, I will examine how the decline of the bay is impacting watermen. The term "watermen" refers to local residents who make their living fishing commercially. Watermen have been fishing the bay for generations. But, watermen are disappearing due to the decline of the bay, changes to laws, and the reduced profitability. The present generation is likely to be the last. The fact that the watermen are calling it quits speaks volumes for the condition and the future of the bay.

Another detriment of losing the watermen is that they understand the bay. They have spent their whole lives on the bay. Watermen have had to deal with frustrating laws that differ between Virginia and Maryland. The state line happens to run right through the Tangier Sound, which is part of the Chesapeake Bay. Most of the watermen live in Maryland and most of the crabs prefer the saltier water on the Virginia side. This became a problem in 1982, when Virginia passed a law, requiring residency to crab in Virginia. The Watermen's Association took the case all the way to the Federal District Court in Richmond, Virginia. The watermen won citing interstate commerce regulations. However, there are so many laws limiting everything from gear to the schedule changes due to holidays. In Maryland, a male crab must be at least 5 inches, but there is no limit on females. In Virginia, the male crab and immature, hard females must be 5 inches. All of the nuances and disparities between the laws make it challenging for the watermen to make a living. Unfortunately, watermen lack the financial resources to fight in political arenas. They are unable to make the necessary political changes to help their industry and the bay. For years watermen have been denied a voice, despite the fact that they hold the knowledge of the bay close to their hearts.

Attempts to Clean Up the Bay

History

The idea of protecting water resources from pollution is not a new. The earliest statute, "the 1888 Rivers and Harbors Act, said that it was illegal to pollute any waterway in the United States, and, that you had to pay a high penalty if you got caught." [21] The concept of protecting our water resources did not really take off until much later. In 1962, Rachel Carson's book, Silent Spring was published. Her work spoke about the dangers of pesticides. Then a series of environmental disasters including the oil spill in Santa Barbara and several rivers catching on fire brought attention to the environmental hazards of pollution. It was not until the 1970 that concern for pollution control problems in the United States emerged. In 1972, the use of DDT was banned in the United States. This was clearly an outcome of Carson's work.

In 1972, the Clean Water Act was passed. Through the years, it has been amended. The act was designed to regulate point source pollution. Dumping pollutants directly out of a pipe from a sewage plant, a power plant, or a factory is point source pollution. The main goal of this legislation was to make surface water (lakes, rivers, streams, wetlands, and coastal areas) safe for swimming and fishing.

The first Chesapeake Bay Agreement was enacted in 1983. The agreement was signed by the governors of the states of Virginia, Pennsylvania, and Maryland, the mayor of Washington, D.C., the chairman of the Chesapeake Bay Commission, and the administrator of the EPA. It was a statement recognizing the need to work together to improve and protect the bay and its living resources.

The second one, the 1987 Agreement, set forth 31 commitments to improve the health of the bay. A goal was set to reduce the amount of nitrogen and phosphorous entering the bay by 40% by 2000. This was the first time numeric goals were set with specific deadlines. Using specific numeric goals and deadlines is a strategy the Chesapeake Program continues to use.

The third, Chesapeake 2000, was signed by New York, Delaware and West Virginia in addition to the original group of signers. This new agreement states 105 commitments. It focuses on five areas: 1) living resources 2) habitat restoration 3) water quality 4) land use and 5) community engagement. The goals stated are to be met by 2010.

Despite these efforts to restore the bay, the 2008 State of the Bay reported a grade of a D. This is the tenth consecutive D based on these reports. The actual score was a 28 out of 100. The score of 100 represents the condition the bay was in when John Smith arrived. Since the bay could never be fully restored to that level, the top score is actually more like a 70. [22] While this report is discouraging, it has brought it to the forefront of policy makers. The plight of the Chesapeake even caught Barack Obama's attention. On May 12, 2009, he issued an executive order declaring the Chesapeake Bay a National Treasure. This distinction means that the federal government will oversee its protective and restorative efforts. New two-year milestones, an increased rate of progress, and hundreds of millions of dollars will be put toward restoring the bay. Hopefully, these efforts will show improvement on the next report card.

What Can We Do?

As teachers we have a tremendous influence on our students. Because the watershed is so large, people often do not recognize that their behavior in upstate New York or in the Shenandoah Valley of Virginia is impacting the Chesapeake Bay. If we can teach children about watersheds and how watersheds connect the living and nonliving world around them, then we can give them a foundation for ecology. We also need to teach them to get outside and bond with nature. Children, these days spend the majority of time inside, and typically do not explore the outside world around them. If we want to create stewards, we must first teach them to appreciate nature. "The protection of nature depends on more than the organizational strength of stewardship organizations; it also depends on the quality of the relationship between the young and nature - on how, or if, the young attach to nature." [23]

Nature in education is becoming a hot topic. Recently, Howard Gardner, who developed the theory of multiple intelligences in 1983, amended his list. He added naturalist intelligence. [24] I challenge you to get your students outside. Have them plant some native shrubs along a local river bank to make a riparian buffer, plant a garden on your schoolyard, or explore a nearby creek. A quote from Thomas Berry, a world- renowned cultural historian, is "Teaching children about the natural world should be treated as one of the most important events in their lives." [25]

We need to expose our children to nature and to knowledge about their environment. Then, we need to change their behavior. There are simple lifestyle changes and choices that can be made, from conserving water to using recyclable grocery bags instead of plastic. If many people make small changes, it will make a

big difference. Also, people need to think about the long-term effect of their choices and how the world around us works as a system. Change will not happen over night or from a few lessons in class. But, if children hear these messages from a young age and develop an appreciation for nature, then as adults, they may be concerned enough to make a difference.

Strategies

This unit is written for fourth grade students who live within the city limits of Richmond. In Richmond, many people like to vacation at "the Rivah". This term is not specific to any one river. It could mean the Rappahannock, the Pamunkey, or the Mattaponi to name a few. Some of my students are fortunate enough to travel to "the Rivah" or to Virginia Beach. However, others rarely escape the sweltering pavement of their Richmond neighborhood in the summertime. The experiences that my students bring to the classroom vary greatly. The unit I write, "Teaching Principles of Ecology Through the Study of an Ecosystem" will not only teach my students about the watershed, but also will develop young stewards of the bay. The unit will be designed to create a meaningful watershed experience. A meaningful watershed experience (MWE) has numerous components by definition. Some of the ones that stand out to me are that it is taught over an extended period of time, will include an outdoor experience, and will include an action project. This unit will focus on the Chesapeake, but could be adapted to fit any watershed.

This unit will be integrated with the fourth grade social studies curriculum and will also have art, math and language arts components. It will begin with a geography lesson introducing the students to the five regions of Virginia. The bordering states and bodies of water will be identified. Next, the main rivers beginning in the Blue Ridge Mountains and emptying into the Chesapeake Bay will be identified. The students will create a watershed model based on a map of Virginia. I am choosing to make the model as opposed to borrowing an Enviroscape® from the Department of Environmental Quality because the students will not only learn more, but will also remember more by constructing it. The students will learn how to read a topography map and how to properly scale the model. The map will be constructed using different colors of wax. Throughout the construction of the model, the students will learn the topography of each region. Then, the model will be used to examine the effects of pollution. One strategy that I will use to explore the effects of pollution comes from Project Wet®. The students will have to identify the agriculture, residential and commercial areas around the state. As they do, I will sprinkle different colors of Kool-Aid to represent different kinds of pollutants. Then a spray bottle will be used to spray water on the model. By using this strategy, the students will be able to see that even the pollutants in the Valley and Ridge Region enter waterways and collect in the Chesapeake Bay. The students will also see how the different areas are polluting the bay. By using different colors of Kool-Aid, the result is the same as mixing the wrong combination of paints, a brownish color that resembles mud.

The students will understand how land use has changed over time and will draw conclusions about the effect human impact has on the watershed. The strategy to teach this concept will be comparing and contrasting satellite images in small groups. The images will show the same location, but at different points in time. The students will also share their pictures and their observations. Then, the class will come together and draw conclusions about land and chemical use and its effects on the bay.

As we begin to learn specifically about the bay and the ecosystem of the bay, I will use a series of demonstrations to capture the students' attention. These will take about ten minutes and will teach the

student an important aspect in a visual hands-on way. One will demonstrate how an elodea, an aquatic plant, produces oxygen in water. Another one will demonstrate how oysters filter water. I will use two containers with the same amount of bay water. I will place an oyster in one container and the students will observe the changes in the water throughout the day. The third demonstration will show how different levels of salinity can cause currents, which stir up the sediment on the bottom of the bay. This will make the water cloudy and will lead to a discussion about water clarity and how it affects the sea grasses.

Once the students understand how a watershed works, the next area of focus will be ecosystems. By understanding both of these concepts, the students will be able to examine the impact pollution and global warming have on the Chesapeake Bay. The students will be asked to write a persuasive essay to convince others to care for our great natural resource, the Chesapeake Bay. Prior to drafting these essays, the class will brainstorm a list of ideas. Using a graphic organizer, we can sort the information into pros and cons. This strategy will not only help the students to organize their thoughts, but also to guide and model for the students who need more support.

Another strategy will be to write the Chesapeake Bay version of A River Ran Wild by Lynne Cherry. This children's book explores the history, destruction and restoration of the Nashua watershed (Massachusetts). This strategy will evoke higher level thinking skills and develop writing skills as the students synthesize the information they have learned.

The final phase of the unit will be to work on two action projects. First, the students will stencil storm drains in the neighborhood surrounding the school. The message will let residents know that whatever enters the storm drain goes to the Chesapeake Bay. The second action project will be to plant native plants at Reedy Creek. This will help to prevent erosion into the James River, a tributary of the Chesapeake Bay. These will be done much later in the year. The rationale for the delay is weather and also time. In order to stencil the storm drains the students need to write to the city to get permission. The students will also have to notify the residents of the project. This project is planned for the spring when the weather is warmer, which should be more conducive to painting. Through these projects, the students will understand that even children can make a difference and help save their local watershed.

Activities:

Activity 1: Watershed Model

This unit will begin with a mapping activity. Instead of making individual relief maps with salt dough, the class will make one larger map. While making this map, the students will learn how to read a topography map and how to make it to scale. For the purpose of combining social studies and science objectives, the map will include the Chesapeake Bay watershed and the state of Virginia.

The map will be constructed with non-permeable materials, so it can be used as a watershed model. The base will be a washing machine pan. These are available in many different sizes and shapes. The map outline will be traced onto the pan using an overhead projector. The water and land will be made of wax. Different colors of wax will be used to denote different geographic regions. The topography can be built up slowly using a layering technique. Students will be able to squeeze wax out of ketchup bottles to construct different landforms. Since the wax will be hot, special care will be taken when handling it. Small groups of students will

take turns making the map.

Once the map is constructed, it will be used as a watershed model. Different flavors of Kool-Aid® will be used to represent different types of pollution. The students will have to determine through instruction and research where different types of pollution occur. The students will sprinkle the pollution on the map. Then the rain will come. Spray bottles containing water will be used for the rain. The students will then observe what happens to the water and the pollution when it rains. The model will also be used for other simulations. The rise in sea level associated with global warming will also be simulated. The students would be able to observe the effects to different areas. The watershed model may be saved for use in subsequent years, or the model could be recreated each year. The pan and the wax may be used over and over again. This activity could be done with any geographic region or watershed in the world.

Activity 2: Compare/Contrast Land Use Photos

Students will compare and contrast photographs of the same land taken at different periods of time. By examining photographs, the students will determine how the area in the photograph has changed over time. My students will use photographs found on the website "watersheded.org". These are photos from Virginia. However, photographs of other areas should also be available by searching the Internet. First, we will compare two photographs together as a class. Then the students will work in small groups. The groups will share their findings. By compiling the changes of the class, the students will draw conclusions about the effects the changes have on the watershed.

Activity 3: Adaptation of A River Ran Wild, by Lynn Cherry

Using the book, A River Ran Wild, by Lynn Cherry, the students will look at the history of the Nashua River in Massachusetts. The book traces the story of the river prior to human civilization. It follows the history from the Native Americans, European settlers, an Industrial Revolution, a polluted river, and a community effort to clean up the waterway. The students will be placed into small groups and assigned focus pages from the story. Each group will be responsible for using knowledge learned in class and their own research to tell the history of the Chesapeake Bay. Then the students will work together writing and illustrating their own version of the story. The pages will eventually be combined into a class book.

Activity 4: Action Project: Helping the Local Effort

These two action projects are designed to teach my fourth grade students that they can make a difference in their own community. The first project will be to paint the storm drains in the neighborhood surrounding our school. The students will write a letter to the City of Richmond requesting permission to paint the storm drains. After receiving permission, notifying the neighbors, and ordering the necessary supplies, the students will be organized into groups with parent volunteers. The storm drains will be scraped and primed. Then the message used by the Chesapeake Bay Foundation will be stenciled on the storm drains to notify residents that anything put in the storm drain will go to Chesapeake Bay.

The second action project will be to plant native plants along the banks of the James River. The James River is located in Richmond, but feeds into the Chesapeake Bay. By planting native plants the students will create riparian buffers that will filter runoff before it enters into the watershed. The student council is willing to donate money to purchase plants for this project. However, grant money could be another source of funding for this project or a similar one in your area.

Daily Schedule Overview

Day 1

The concept of a watershed will be introduced beginning with the definition. Using a watershed map of Virginia, I will show the class the portion of the Chesapeake Bay watershed that is in Virginia. The four main rivers that flow into the Chesapeake will be identified. Students will complete a mapping activity identifying the Chesapeake Bay, the Atlantic Ocean, the Potomac River, Rappahannock River, York River and the James River.

Day 2:

The students will be instructed to take out two items from their desk (not sharp or breakable). The students will line up in single file. The front of the line will begin passing their items down the line. This will continue until the students at the end of the line are trying to hold all of the objects. The connection will be made to pollution and sediments flowing down the river and into the bay.

A map of Virginia will be projected with the overhead and students will take turns tracing the outline onto a washing machine pan. While this is taking place, the class will review Virginia geography. This is the first step in creating our watershed model.

Day 3:

The class will review the four main rivers and the definition of a watershed. A map of the entire Chesapeake Bay watershed will be projected using the overhead. While students trace it to the washing machine pan, the class will identify the other regions in the watershed including: New York, Pennsylvania, Delaware, West Virginia, Maryland, Virginia and the District of Columbia. The size of the watershed and the variety of species found in the watershed will be discussed.

Day 4:

Topography maps will be introduced to students, and the class will learn how to read them. Students will complete a mapping activity using a topography map. Small groups of students will add the five geographic regions of Virginia (coastal plain, piedmont, blue ridge mountains, valley and ridge, and Appalachian plateau) to the watershed model.

Day 5:

The class will review topographical maps. I will teach the class how to scale the topography map of Virginia to fit our model. The class will break into five small groups. Each group will be assigned a region to scale. Calculations will be shared and checked as a class. Then the class will assemble by the washing machine pan, the base of our watershed model. The group assigned to the coastal plain will spread the wax throughout the coastal plain region. I will teach the class how to do it, as the students observe.

Day 6:

The class will again break into groups. Each group will scale the topography of the areas outside of Virginia that are within the Chesapeake Bay watershed. Small groups will continue to create their assigned regions on the map.

Day 7 and Day 8:

The watershed model will be completed.

Day 9:

The watershed model will be used for watershed simulations. The teacher will introduce the students to the different industries in different regions. The students will determine what types of pollution could be produced in each area. The Kool-Aid activity will be conducted.

Day 10:

The land-use photo activity will be taught.

Day 11:

An experiment will be set up with two aquariums. Key concepts of scientific investigation will be taught through this experiment. Both will be filled with the same amount of bay water. An oyster will be added to one of the aquariums. The students will record observations throughout the day. Students will draw the conclusion that oysters clean the bay.

Day 12:

Students will review the experiment with the oyster. The students will be broken into small groups. Each group will be given an information packet about a species that lives in the bay. Each group will complete the species resume (questionnaire) and develop a poem, rap, song, or skit about their species. Each group will present to the class.

Day 13:

A science experiment will be set up using two aquariums and water. An elodea plant will be placed in one of the aquariums. The students again will review the key concepts of scientific investigation. Then the students will record their observations throughout the day. The conclusion is that the elodea plant produces bubbles or oxygen. I will introduce the class to submerged aquatic vegetation and to the benefits it provides the bay. Students will draw a picture to show one benefit of submerged aquatic vegetation.

Day 14:

The importance of aquatic vegetation will be reviewed. A demonstration will be performed. Begin with a rectangular Pyrex® pan. Place a thin layer of sand in the bottom and add about two inches of cool water. Allow the sand to settle. Then slowly pour in hot, saltwater with a drop of food coloring into the pan. The students will see currents swirling and stirring up the sand. This demonstrates how changes in salinity create currents, decrease water clarity and affect the amount of light reaching the aquatic vegetation.

Day 15:

The book, Why are the Ice Caps Melting? will be read aloud. Global warming and its affects on the bay will be discussed. Students will begin work on a flipbook about global warming.

Day 16:

The book, What's So Bad About Gasoline, will be read aloud and students will continue to add information to their flipbook.

Day 17:

Students will gather around the watershed model and conduct a simulation to determine the effect of the projected sea level rise on the Chesapeake Bay. Students will scale the sea level rise to fit our model. The effect of global warming on the bay will be discussed.

Day 18:

Pollution and its affects on the bay will be examined. Students will work in small groups to discover the affects of bioaccumulation on organisms. Students will use food coloring, sugar cubes and Jell-o to simulate the build-up of pollution in organisms.

Day 19:

Endangered and invasive species will be examined. The students will be broken into small groups and assigned an endangered or invasive species. Each group will read the information and become the experts on their species. Then the groups will be shuffled, forming new groups with one person from each original group. The students will record three facts and draw a picture for each species.

Day 20:

Students will learn about fishing in the Chesapeake Bay. A short video of menhaden fishing will be shown. Students will analyze species data by reading and interpreting bar graphs.

Day 21-24:

The book, A River Ran Wild, will be read aloud. The class will create a new version of the book.

Day 25:

The class book will be read aloud and we will discuss what we can do to help. We will discuss the action projects that will take place throughout the year. We also will discuss small changes that each student can make around their home and at school to help the bay.

During language arts, a persuasive essay will be written to convince others to take care of the bay.

Appendix A: Implementing District Standards

Virginia: Science 4.5

The student will investigate and understand how plants and animals in an ecosystem interact with one another and the nonliving environment. Key concepts include behavioral and structural adaptations; organization of communities; flow of energy through food webs; habitats and niches; life cycles; and influence of human activity on ecosystems.

This standard is addressed throughout the unit. All of the key concepts can be taught with this unit.

Virginia: Science 4.8

The student will investigate and understand important Virginia natural resource. Key concepts include: watershed and water resources; animals and plants; minerals, rocks, ores, and energy sources; and forests, soil, and land.

My unit covers most of standard 4.8. The unit does not address minerals, rocks, and ores.

Virginia: Science 4.1

The student will plan and conduct investigations in which

a) distinctions are made among observations, conclusions, inferences and predictions

b) hypotheses are formulated based on cause-and-effect relationships

c) variables that must be held constant in an experimental situation are defined

d) appropriate instruments are selected to measure linear distance, volume, mass, and

temperature

e) appropriate metric measures are used to collect, record, and report data

f) data are displayed using bar and basic line graphs

g) numerical data that are contradictory or unusual in experimental results are recognized h) predictions are made based on data from picture graphs, bar graphs, and basic line

graphs.

Standard 4.1 a, b and c are taught with the aquarium experiments. The graphs of species fulfill parts f and h.

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Endnotes

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