Reflection and Experimentation: Tools for Dispelling Misconceptions

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As a teacher of science in the inner city, I am increasingly appalled at the misinformation that youngsters have learned and that they consider truth. For instance, the following assertions were made by bright-eyed fifth graders: that mice eat only cheese; that honey, as everyone in that age group knows, is what bears eat; that all bats are "rabies carrying vampires" and all mosquitoes are bloodsucking, disease carrying creatures; and that any plants not bought in a nursery are weeds and are possibly poisonous. The result of these misconceptions is both a fear of nature and the idea that we are justified in destroying it. In this unit, "Reflection and Experimentation," I clarify these and other misrepresentations by improving the students' awareness of our surroundings and their ability to intelligently question the information they receive.

An additional area of concern that I address is the cynicism regarding the natural world that students have developed in response to documentaries, the Internet, and commercially prepared microscope slides. As an example of the last, following a presentation of microorganisms from commercially prepared slides, I asked the students to discuss and analyze what they had just learned. I was shocked when I overheard them arguing about the authenticity of the samples. This made me realize that fifth graders are already sagacious enough to know that any information can be altered to fit a desired point of view. As a result of this experience, I have the students make their own slide samples from the classroom aquaria, from the plants, or from any other materials that are readily available. The benefits of this approach are that I can cover more than one curriculum objective at a time, and the students can honestly discover the factual wonders of nature and reality.

Ours is a very old school whose campus has various gardens and wooded areas that provide us with excellent opportunities to observe and study all varieties of plants and animals. Several of the live oaks are so mature they are mini habitats in themselves, where mosses, lichens, and ferns grow freely. On quiet days, we can hear woodpeckers drilling away in pursuit of something to eat; squirrels rushing around gathering, eating, or hiding acorns; and swallows flying in and out of the canopy in search of food to eat. During a simple walk around the grounds, the teacher can draw the students' attention to a particular scientific concept being studied, regardless of its specific nature.

The fifth-grade curriculum expects a very broad view of the Alaskan Tundra, the Sonora Desert and the Great Plains. Unfortunately, the gardens are insufficient to cover anything greater than a few urban habitats; however, by focusing on the Houston/Galveston wetland ecosystem as a pivotal point, we can make comparisons of land formations, natural resources, tidal effects, plant and animal adaptations, food availability, energy pyramids, and animal behaviors, including those of humans, and

relate them back to the broader curriculum. Furthermore, while the basic unit and lesson plans can be covered in a few weeks, the information contained therein can and will be reinforced continually throughout the school year and beyond.

This unit's activities are focused on directly observing, recording, measuring, analyzing, conjecturing, hypothesizing, and proving. Other activities include research, compilation of data, scale model building, and information sharing (i.e. always questioning through dialog). This is not to say that we will not explore topics outside of the units' basic framework; on the contrary, should a learning situation come up that is not part of the objective at hand, we will turn our interest to it. A perfect example of this flexibility occurred recently in class, while we were covering a unit on the planetary system. A student near the saltwater aquarium interrupted the class to tell us that one of the hermit crabs was trying to change shells. We stopped the lesson and went over to quietly observe it. It was a wonderful experience for all of us! The children were very moved to actually see such an event happen. The crab's transfer made the students realize the vulnerability of the tiny creature in a world where even its own kind can be its predator and its survival depends upon speed and determination. The situation lent itself to a discussion about adaptations and behaviors, whether learned or inherited. Quite a bit of time passed before the planetary system was addressed again! Having constant access to natural surroundings gives students and teachers tangible evidence of scientific affirmations regarding plant life, animal behavior, as well as processes of erosion and deposition. It validates the information given by teachers, seems to lodge that information more firmly in the students' memories, and appears to give them the necessary assurance to try higher level learning skills and seek out information well beyond the school's curricula.

As mentioned above, fifth graders are expected to understand that there are various types of ecosystems. It is always interesting to them that Houston forms part of a very important and misunderstood ecosystem—a wetland. As the year progresses, they will discover the reasons for the many bayous that crisscross the city. They will also learn the reason why some animals, including alligators, can be naturally found in them. It is necessary for them to become acquainted with the basic geologic composition of the area, its geographic location, climatic conditions, and a brief history of the city.

The estuarine lands on which Houston is nestled are marshy and boggy. That is because of the constant humidity provided by the Brazos, San Jacinto, and Trinity Rivers, which are not easily drained on account of the large substrate of clay that underlies them (Moulton and Jacob 3). A number of natural drainage features called bayous cross the city from the west toward the ship channel and the ocean. They are streams with slow-moving water captured from inland surface drainage, seepage, runoff, floodwaters, and now, human waste (*Bayous* 13, 15). As the city has grown, its inhabitants have either taken advantage of the bayous or covered them up to make way for intended construction. An example is Harris Bayou, which until 1912 ran through the property that was donated for Rice University (see Figure 3). Some bayous have been altered to

divert waters toward larger bayous or otherwise modified to accommodate some urban need. Some bayous with slow moving waters, which are mostly supplied with sewage effluent from the Houston area, have their waters pass through water treatment plants (such as the West University Treatment Plant) before continuing their course to the ocean.

Bayous are natural habitats to many species of fish, turtles, herons, and skimmers. During dry periods, the waters in these features barely move. At these times, green algae thrive, the mosquito population flourishes, and fish all but perish due to the elevated nitrate concentrations and lowered dissolved oxygen (*Bayous* 13). At other times of the year, depending on climatic conditions in Western or Northern Texas, the San Jacinto and the Brazos Rivers overflow their banks, and flood the areas near them (Cronin and Wilson 1-2, Kennedy 10). At times, the floods cause damage and distress; however, most of the time they improve the soils with their rich nutritious silts (Mills 99). Unfortunately, their capacity is limited, and frequently they overflow and flood the areas near them, as proven during Tropical Storm Allison two years ago. At these times, the fauna and flora are badly damaged, but, when conditions normalize, they return to the bayous and the cycles begin anew.

Though inconvenient, these episodes give us the opportunity to explain our particular land formation, prevailing weather conditions, and specific fauna and flora to students. They also give us an occasion to discuss the constraints surrounding engineers, architects, and other people involved in housing and land development might have (*Bayous* 1-18). Admittedly, we are discussing human impact on the ecosystem; however, humans are also animals who seek to modify and alter their environment as a way to adjust to it (Farrar). It has happened for millennia, and I dare say will continue to happen. The goal is to seriously consider the ecological environment in which we live before we decide to modify it. This consideration will determine the likelihood of long-term success for all flora and fauna, including humans.

Figure 1—Coastal Plains showing Beaumont Clay Stratum (Moulton)

Selected textbooks provide an age-appropriate, coherent science source for the students to read and comprehend either in English or Spanish. Therefore, I always prepare my lesson plans based on these books. An additional advantage to using the textbooks is that they have wonderful ideas upon which I can and do expand. That being said, however, I do not rely solely on the textbook. I also derive ideas from professional

improvement seminars I have attended; including the materials given out at such seminars. Magazines, newspapers, books, storybooks, anecdotes, and my attempted drawings on the chalkboard also form part of my teaching methods.

Now, a brief natural history of Houston will introduce some of the ideas that are explained in the lessons to follow.

BRIEF HISTORY OF HOUSTON

Among the stories I tell the students are excerpts from Houston's history. I have two main reasons for this practice. One is to clarify some of the misconceptions that we in the region have that mankind has prevailed over nature through the use of science. The other is to acquaint them with the geologic and climatic realities of the coastal plains of eastern Texas; the adaptations that humans have made to live here; and the impact their presence has had on the flora and fauna. My long-term goal is for the students to realize the effect that urbanization has had upon the ecosystem and be prepared to contribute in the region's future with reasoned, analyzed, and well considered decisions.

The city of Houston was founded on this location for political reasons rather for its desirability as a place where humans could settle comfortably. Houston lies in the floodplains of three navigable rivers that transport water from northwestern Texas and Oklahoma to the Gulf of Mexico: the Trinity, the San Jacinto, and the Brazos. Underlying most of the coastal plains is a thick substrate called Beaumont Clay, which impedes the free and rapid drainage of surface waters. There is ample evidence that as the ice from the glaciers of the last Ice Age melted and water levels rose, these coastal margins were greatly reduced, and the gulf expanded. The perpetually moist lands between rivers, called estuaries, are rich in fauna and flora. Most places estuaries are ideal places for human habitation, but not the Texas coastal plains. That is because the clay substrate keeps the water from draining adequately; therefore, the lands here are marshy bogs that are always waterlogged and mosquito infested. So why did anyone decide to stay here?

The first written information we have regarding the area is from the 16th-century Spanish explorer, Nuño Cabeza de Vaca. He recorded that although many of his crew survived the hurricane and consequent shipwreck off the coast of Florida, what was left of his crew either died or became insane from the unbearable heat and slapping at the millions of mosquitoes that bit and worried them. In the end he and two other survivors tried to escape the region by following the coastline westward in and hopes of finding their way home to Mexico City. As they reached the area now known as Galveston/Houston, they noticed that they met one of the few populations they had so far seen. But these humans did not appear to have permanent settlements. In fact, they were hunters and gatherers foraying into the area who called themselves the Karankawa. Their skins were covered with a foul-smelling substance that seemed to protect them from the mosquitoes. (Cabeza de Vaca 72-73) When asked, the natives told the three explorers that the substance was buffalo fat and shared it with them.

The small group was taken in by the Karankawas, with whom they lived for a spell, very possibly as hostages. While among them Cabeza de Vaca recorded everything he noticed: plants, animals and cultural activities. Notable among these was that the Karankawas seldom visited or stayed in the coastal wetlands due to their inhospitable nature.

Upon his eventual return to Mexico City, Cabeza de Vaca had the lands chartered and declared part of New Spain. Soon the crown was offering land grants to anyone who would want to help colonize the area. However, there were few takers. The overbearing heat, the mosquitoes, and the unpredictable behavior of the Indian populations made the coastal wetlands an undesirable place to live. In fact it remained basically uninhabited by either Native Americans or by Europeans throughout the Colonial period. Furthermore, the entire coastal plains, from Florida to Tampico, Mexico and beyond, soon became known as places of death where mortal enemies – extreme heat, yellow fever, malaria, and cholera – abounded.

Apparently, mosquitoes picked up yellow fever and malaria from the explorers and became vectors of these diseases. So it was that throughout the entire period of colonial rule there was a constant decrease in indigenous populations and very little increase in that of Europeans. Yet the conditions did not keep Spain's enemies from making incursions into its territories (Navarro Garcia 400). Garrisons were established on many of the sand bars for terra firma. The best known is Galveston, which helped to keep the enemy away.

Toward the end of the 18th century, there was a general feeling of discontent in New Spain because the United States was increasing its territorial boundaries. The crown suspected the efforts to expand might include the province of Texas. (Fuentes Mares 494-495) So, it increased its efforts to entice settlers to populate the province of Texas. (Navarro Garcia 17-33) They struck a deal with Stephen F. Austin to broker its offer of land grants to Europeans under the condition that the grantees would embrace Catholicism, abide by Spanish rule, and speak Spanish.

Austin promoted the project in Prussia, where famine and war were making life very difficult for many. (Lucas Alamán 230) Soon boatloads of German settlers began to arrive at the shores of Galveston, where they received their grants after passing inspection. Then, the settlers proceeded up to Arroyo del Cíbolo – later known as Buffalo Bayou – where they debarked. But the uninviting surroundings, with their intense heat, profusion of sickness, large numbers of mosquitoes and alligators, and generally miserable conditions soon convinced the would-be settlers to move farther inland in search of better conditions to either claim or redeem their grants. Still, some hardy souls did stay on. They established small plantations and tiny settlements along the coast, where they endeavored to plant sugar cane, cotton, or rice.

Events overseas were affecting Spanish rule in the Americas. Most important among these was Napoleon's removal of the Spanish king and substitution of his brother Joseph for him. The *novohispanas* who had heard the winds of freedom and liberty from France and then United States began to consider more seriously a separation from Spain, especially if the mother country was now under French rule. The insurgents declared independence in September of 1810 and fought the crown for 11 very long, bitter years.

In the end they won the war and called the new country Mexico. But governance was not easy. During the years of war many areas had been neglected. Among them was the province of Texas. There the void was filled by numerous illegal immigrants from the United States in search of free land without any perceivable laws to hinder their desires. As the war dragged on and the new country established itself, the immigrants came to consider themselves owners of the land. They were loath to follow any laws to which they had not agreed.

In 1835, they declared their independence from Mexico and took up arms. After a series of battles in different parts of Texas; the Mexican and Texian armies met at San Jacinto. There, where the *Arroyo del Cíbolo* meets the Gulf of Mexico, the Texians defeated the Mexican troops, and Texas became a country of its own.

Among the Spanish laws that the Anglo settlers on the coastlands had ignored during the Mexican War of Independence was Spain's anti-slavery laws of 1810, later upheld by Mexico. Many plantation owners had imported slaves from African and Haiti to work in their fields. Once Texas became part of the Union, the plantation owners continued to resist ordinary laws. In 1847, for example, the United States forbade the importation of slaves, arguing that there already was a large enough African population to meet labor demands. A few unscrupulous plantation owners continued to import slaves for trade, pretending that they had been born on their plantations.

Without for a minute approving of bondage as an economical working setup, I can see that the importation of people of African stock made perfect sense. The native populations of Sub Saharan Africa seemed to be more resistant to the heat than either the Native Americans or the Europeans. Furthermore, they did not seem susceptible to malaria or yellow fever – two of the dreadful epidemics that struck the coastlands yearly. Their sturdy traits made them desirable as workers on the plantations in the Gulf coast and Atlantic seaboard areas.

It was not until the third quarter of the 20th century that we learned that millennia ago, a cell mutated in most African coastal people. The invisible mutation protected them against the malarial fevers that prevailed in the region. No one really knew why those populations were resistant to the infirmity until modern scientists began to serious use insecticides in an effort to eradicate mosquitoes in many coastal areas of the world. Then, many people of African descent began to manifest a life-threatening problem with

anemia, an anemia caused by the sickle cell. Rendered useless in the absence of malarial threat, the cell works against its host (Brown and McInhorn 87-117, Buford 9).

Europeans did not have the same type of protection – at least not against tropical diseases. Great numbers of settlers and visitors here died within a few years. In spite of great efforts to populate the region from the second half of the 16th century onward, in 1910 Harris County had only a population of 115,693 (Farrar). Research into the causes for the slow population growth can be found in documents that belong to the Catholic Church. Priests recorded the baptisms, marriages, and deaths they officiated. These records indicate that by mid-summer people, suffered diarrheas, fevers, chills, and vomiting, which all too often resulted in death. Neither the people nor the doctors knew what caused the disease. There was a great deal of speculation and just as many efforts to control its spread, all to no avail. Among the efforts to control the contamination, people burned down a house where there had been death. Less extreme were the burning of bed clothing and personal effects. Another effort was to keep a bucket of burning tar at the entrance of a house.

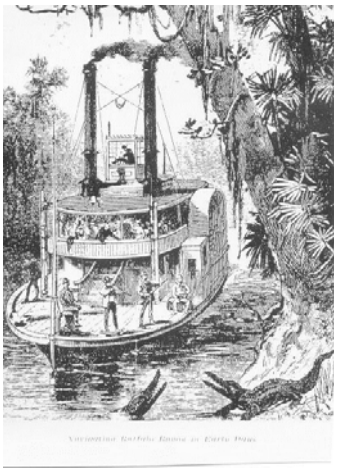

Figure 2—Nineteenth century lithograph of Buffalo Bayou

Houses were continually being destroyed and rebuilt; a phenomenon that continues to this day. Houstonians have an almost paranoid attitude toward old buildings. Anyhow, the constant building and improving altered the natural habitats of a great many organisms as the land itself was modified to meet the population's needs. In 1926 Farrar quoted an unnamed source who, in 1837, described Buffalo Bayou as follows:

> Its banks are high and lined with the Cypress knee which shoots up along the edge of the water. In passing over this singular body of water, which is confined; with few exceptions to precipitous banks on either side, covered with massive timber whose rich dense foliage throws a melancholy, somber shade over its dark and sluggish waters. Throughout its whole extent it bears a strong resemblance to a canal. (Farrar)

Farrar included a lithographic picture (Figure 2) of that early view of Buffalo bayou. It includes plants that we now only see in natural reserves such as High Island. These are; palmettos, cypress knees, Spanish moss and different types of ferns. Also present in the picture are alligators. Buffalo Bayou was not only the largest and deepest of the bayous in the area with White Oak, Brays,' Sims,' Vince's, and Greens Bayous augmenting its waters; but also an arm of the Gulf of Mexico and subject to a 1–2 inch tidal swelling at the 'head of Main Street" (Farrar). Buffalo Bayou's size and its tributary bayous were the factors that Houstonians took into account when they decided to bring the ship channel closer to Allen's Landing in an effort to improve maritime trade.

Historical Modifications to the Landscape

According to Farrar procedures to make the Port of Houston began in 1904 when Captain Charles Crotty of the United States Engineering Department began to dredge Buffalo Bayou and expand its banks considerably. Not surprisingly this effort displaced many people from their lands; along with them, animal and plant wildlife changed dramatically. Gone from Houston were the "flocks of marsh birds, snipes, plovers killdeers and curlews, mud hens and phalaropes – and even herons, ibises, stilts and flamingoes" (roseate spoon bills?) that Selle claimed had abounded (Selle 6). He added that "As the village expanded into a city, the great trees disappeared. Deprived of their shady retreats, some of the birds became shy and others avoided the patch of houses and bare strips of land where there was so much noise" (6). It is reasonable to assume that other forms of fauna such as alligators, deer, porcupines, various snakes, and beavers were also displaced.

In 1912, W. Waldo drew a map, which he called *Sketch Showing Relative Locations of Houston, Rice Institute and Westmoreland Farms. also Drainage between Harris and Brays Bayous*. It places the proposed Rice Institute near the junction of Main Street and Bellaire Boulevard. Over the HB&T Railroad track and a Bayou called Harris. The interesting detail here is that south of both features he has the symbols and words "natural divide," with arrows toward Harris Bayou. It appears that the waters tended to drain north into the Harris Bayou. On the southern side of the divide, the arrows indicate the waters draining into Brays Bayou. An artificial divide is mentioned south of the natural divide under Bellaire Boulevard. Was Harris Bayou covered or detoured to make way for the Rice University Campus? Was the venture completely successful? Where would the waters draining into it go? This and other modifications of Houston's natural landscape have had positive and negative effects. The intense flooding of the Medical Center during Tropical Storm Allison can probably be partially attributed to the loss of Harris Bayou.

During the 1930s, there were severe flooding episodes in the area, so different points west of Buffalo Bayou were dammed in an effort to contain both drainage and underground waters into reservoirs and lakes and control floods. These reservoirs would also contain sufficient water for periods of drought. The Addicks Reservoir in Aldine, the Barker Reservoir north of Alief, and our own Lake Houston appeared on the geographical map for the first time. An added benefit from the new water features was that they attracted all manner of natural wetlands' wildlife that had previously been displaced, restoring in part the lost ecosystem.

In the 1950s the picture changed, and there was a severe drought in northwestern Texas, making the Brazos, San Jacinto and Trinity rivers flow at very low levels (Cronin and Wilson 1). In fact, they flowed so low that farmers on the flood plains had to begin searching for water to irrigate their lands and sustain their farming pursuits. By 1964,

they had dug more than 1,100 irrigation wells in the Brazos River alluvium plains near Richmond (Cronin and Wilson 2).

It seems that since the early settlement people dumped their waste into the bayous, causing them to be foul smelling, disgusting, illness infested streams. "In 1945 the U.S. Health Service found enough raw sewage in Brays Bayou (then on the outskirts of Houston) to equal that produced by a town of 54,000 people" (*Bayous* 15). *Bayous: Recycling an Urban Resource* quotes Frank J. Metyko, an investigator hired by the county, as declaring that "Buffalo Bayou water was 80% sewage" (15). Efforts to treat the waste before entering the bayou system have since been made all over town and seem to have relieved the pollution problems. Nevertheless, some days, near the West University Water Treatment Plant on South Braeswood, the air is not very pleasant at all. This is especially true in the summer after a short dry spell.

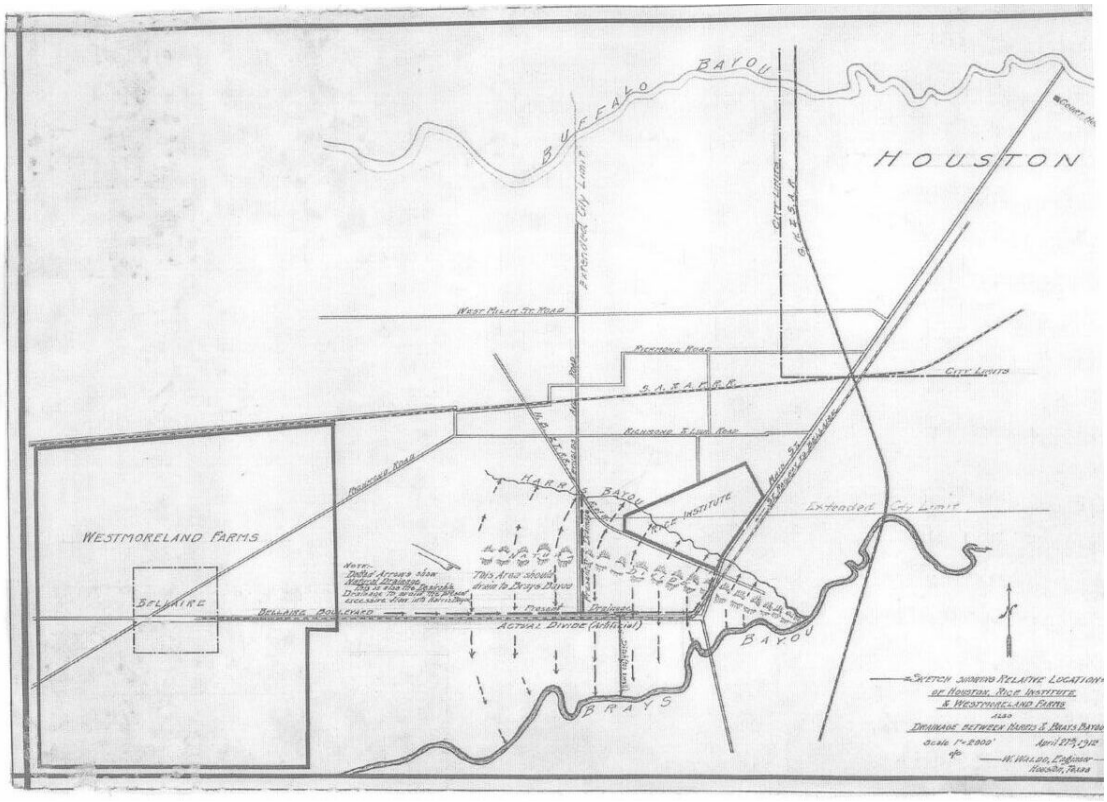

Figure 3—Map shows Harris Bayou passing through the future Rice Institute (Waldo).

Houston, although a city with a university, some hospitals, a zoo, and some parks, remained relatively small until the early 1960s, when a new discovery made it truly habitable: air conditioning. In 1960, there were only two highways in Houston: the Southwest freeway (59) and the Gulf Freeway (45). Sharpstown was being traced, Hobby was the only airport, the town of Sugarland was well separated from Houston city

limits, and everything south of Bellaire was open field. It should not be surprising, then, that the polluted waters of Brays Bayou should not have received the city's full attention until the city limits reached it and a water treatment plant was installed near its banks on North Braeswood.

With air conditioning Houstonians solved many problems ranging from shoes, pictures, and carpeting growing mold; to cockroaches of different sizes in the house; to diverse diseases related to dehydration. With air conditioning, the city could fumigate without fear of killing the population that used to sleep with the windows open for cross ventilation. Houstonians became dramatically dependent on electricity, and people socially isolated themselves to stay out of the heat.

From the written record left by settlers and passers-by, it is clear that although the hot and humid ecosystem in this region was home to a large amount of diverse fauna and flora, it was not healthy for humans. But the human species is extremely persistent. If humans could not adapt to the region, they would modify it to meet their needs. For the time being it appears to everyone but the very observant or those in hydrological or geological professions as though humans have won the battle against nature.

This brief history is the kind of story that I find motivates discussion and dispute among my students. The point is that many forces work together over time to create our world. Next, we will explore how to investigate.

RECOVERING A NATURAL HISTORY: SIMULATION OF LAND FORMS

Among the objectives to be covered toward the end of the school year is for students understand that land formations and features take a very long time to form. The processes by which they are made are so slow that the changes taking place are imperceptible. This concept is very hard for young people to grasp. For that reason, at the beginning of the school year, the students and I make a model of an estuary with constant water drainage that will be used throughout the year, regardless of the objective being studied.

This model is a fundamental tool for Lesson One, but it has use outside of that lesson plan; thus, the model is described independent of the particular lesson plan. The students will observe the model frequently and record the conditions they see. Creating our estuary at the beginning of the school year will ensure the natural maturation required in our discussions of ecosystems. As the year progresses and the students begin to study earth sciences, they will be able to review their notes and images and realize that their land formation has undergone changes that make it radically different from what it was at the beginning. This will serve as proof that land formations are the result of destructive as well as constructive forces that are constantly, implacably, and imperceptibly at work.

Another reason for making the model is to help learners understand a little more clearly the effects that drastic modifications to an ecosystem will have. During the year, we will try different ways to improve nature's domain (the simulated land form) and observe the results. My purpose in doing this is to make them aware that there are results to all our decisions so that when they become adults they will consider possible positive and negative effects with a more realistic view than their predecessors did.

I borrowed the following idea from another lesson plan and then modified it considerably to meet my classroom needs (Great Explorations in Math and Science). To create our estuary, we will use three kitty litter trays. Small holes will be bored into the angled end wall, the floor close to the end wall, and the floor of one of the trays. The second tray will have a larger hole bored into the floor close to the end wall. The third one will remain intact. From there, we will cover the bottom of the first tray with a one-centimeter layer of gravel, followed by a layer of sand and a layer of clay. We will add one layer of diatomaceous earth before placing a two-inch thick block of wood under the tray to force the layers toward the end opposite the holes.

We will then place that in the one without any holes. We will let it protrude just enough to capture the water that will seep out of the tray with the hole in the bottom. The tray with the hole in it will be placed near the edge of the shelf above on top of tongue depressors intended to create a slight slope

When the layers have shifted in the first tray, it will be turned around and repositioned on two-inch blocks under the end with the soils. With time, the seepage from the first tray will begin to form a deltaic fan in the second tray.

Figure 4—Model of wetlands.

After all of these steps have been accomplished, a spring from which the rivers carry water into the estuary will be created. For this, I usually make a mound from an upside down, gallon size ice cream container placed at the end of the first tray. On it, and hanging over the edge of the tray, I lay an angled plastic container with a tiny hole in it to represent a spring dripping into our river. The water in the plastic container will have to be replenished once or twice a week.

As the weeks progress, the dripping water will begin to bore a hole in the soil; rivulets will appear; and water will have accumulated at the far end of the tray. Soon the soils will have shifted, and water seepage will be evident.

LESSON PLANS

Lesson One – Changing Climatic Conditions

At some point, I will cease to fill the bottle with water and will simply declare it a time of drought. The purpose of this lesson is to teach the students about water being stored underground, about climatic changes, and a bit about physics. After a couple of weeks of drought, the students will notice that, although the surface of the model is dry, there appears to be some humidity underneath and that it continues to be so for a long period of time.

As the "drought' continues, I plan to have my students read a very touching book called the *Hummingbirds' Gift*, a Mexican myth about a lovely town in a fertile valley watered by a river which runs dry as a result of drought. Afterwards, we will discuss the importance of water as a source of life. I will then ask the students if they can think of ways to find water. Because many of the students are either first or second generation immigrants from very arid areas of Mexico much like the one in the story, I will not be surprised if one or two students have an anecdote to share with us about how "back home someone had to look for water in the ground."

Taking advantage of the moment I will turn the conversation towards our model and ask the students to suggest ways in which we could get water from our model. Their assignment will be to formulate workable ideas and designs to put to the test the following day. If the students fail to suggest a well, I will suggest it as a solution. For this, I will have a student introduce a short drinking straw far into the soils. He or she will put the glass part of an eye dropper into the straw, effectively cutting off air supply and creating a vacuum. As the student presses and releases the rubber bowl, a suction will result. At first, nothing will happen; however, as time passes, a clump of mud will begin to rise up the straw, and finally, clear water will begin to flow.

At this time, the students will hopefully realize that water does indeed get stored within the soil below the surface. This type of discovery validates the stories and activities that our students' elders have told them about their country, and occasionally

even provides an explanation of why they left it. An additional benefit of this validation is that it allows the students to view their kin with increased respect.

Lesson Two – Introspective Analysis of Ecosystems Mishandled

Bat Eradication

To impress upon the students the importance of considering the ecosystem carefully before making alterations, I resort to 'storytelling' mode and tell them stories about decisions made by mankind that have backfired. For example, during a recent discussion of bats, I told them how the Gulf coastal wetlands have always had incredible amounts of mosquitoes and how uncomfortable they make life for everyone. I further explained how people have always searched for the means to destroy them by trying different types of insecticides and pesticides, with varying degrees of success. As Houston grew in the 1970s, those efforts were accelerated. At the same time, biologists were reporting that bat populations around the world were decreasing. No one was very concerned because, at that time, bats were being given a bad reputation through "a highly sensationalized rabies scare that began to frighten the public . . . into extreme intolerance of bats . . . This hysteria became highly profitable for the pest control and public health industries and was difficult to stop" (*Bat Conservation at a Crossroads*). Bats, which were never considered one of nature's prettier species, were all but exterminated. Concurrently, pesticides began to affect fauna and flora in negative ways never before seen. After much research, when human ill health and economic concerns were linked to the pesticides, people began to recollect that bats are among nature's most effective controlling agents of mosquito populations. Therefore, in 1982, the Bat Conservation International Organization was founded. Its members began to reverse the misperceptions of bats and arranged to bring colonies of them back to Houston area (*Bat Conservation*).

By the time I finish the story, the students realize that there is a moral to it: that we must consider all of the factors in an ecosystem and accept that we are only a part of it before we make permanent alterations to it for our comfort. If, by telling this story or in some other way, I can influence students to be aware of their surroundings and understand how biotic and abiotic factors function to sustain life, they will be less likely to wantonly or carelessly destroy it when they step into the world.

Before revealing my interpretation of the story and its moral, the students will asked to share their ideas. We will record and discuss these ideas and then compare them to the theme I suggest.

Filling the Wetlands

Another story that I have for the students is a very recent one. It is the about the "waste lands" toward Galveston. These areas are places where people threw away their old tires along with different materials and waste chemical substances that they happened to consider noxious. Some people even sold their claims to those lands to real estate

developers who thought about "improving" the wetlands – for that is what they were – by filling them in and building upon the fill. While I tell them the real story of a Baytown elite subdivision designed in the late 1970s, I will fill in our model of the wetlands with soils and rocks. Then, I will have the students help me place parking lots (manipulatives from the math department) and buildings made of tinker toys on the newly filled area. Naturally the water from our spring will keep dripping in. As it does, the students will notice that water is coming in faster than it goes out and that the areas surrounding the buildings and parking lots are flooding. After a few hours, the waters will overtake the bases of the buildings. A few days later, some of the buildings will be tilting into the water. We will discuss ways in which the buildings and parking lots could have been better anchored, and I will allow the students to try the proposals.

"But," I will tell the students, "flooded buildings and destroyed parking areas were only part of the story. While the wetlands were being "improved" for economic remuneration by the realtor companies, other aspects of the economy were being badly affected. Principal among them were the shrimping, fishing, refrigeration, and restaurant industries. It was not immediately obvious what was causing the shrimpers and fishermen to return from the sea with decreased amounts of shrimp and red fish. For years they had made a very acceptable living catching them and selling them, but now the quantities caught were hardly worth the effort. The price of shrimp rose above all reason, and red fish were put on the endangered species list.

As the students are listening to the rest of the Baytown story, I will sketch a profile of the wetlands and trawling ships at high seas. I will include emergent plants and comment that a female red fish will lay up to 50 million eggs at high seas. These simply float on the surface and are carried toward land by the waves. During this trajectory, millions are devoured by predators or never hatch. Those that do hatch, however, live on plankton until they reach the calm waters of the wetlands, where they nestle among the plants. There, they will live and grow for about three years until they are old enough to go out to sea and mate, never to return. The wetland environments, so rich in biota and calm waters, are excellent nurseries for the hatchlings and juveniles of many species, including red fish and shrimp.

By the time I have concluded my drawing, the students will understand that building houses and highways over the nursery sites not only affect the faunal population in dramatic ways, but also the economy that so drives us. It does not take fifth grade students long to realize that foresight and forethought were lacking when decisions related to land use were made.

This presentation will be followed with some exercises from *The Gulf of Mexico: A Special Place*, a Galveston Bay workbook that discusses wetland environments. One of its worksheets personifies the Galveston Houston Wetlands and the Everglades in Florida. The workbook represents the ecosystems as cousins writing to a similar relative in Louisiana and telling him about the human interventions they have suffered. They

mention how they have been so altered that the plants and animals that lived with them are either dead or struggling to survive. They continue their letters with comments about how those modifications are affecting those very humans effecting them both in their living comforts and their economy.

After a general discussion in which we compare and contrast the Everglades and the Galveston/Houston wetland ecosystems, I will assign research papers on animals that live in or off of the wetlands. The students will be informed that the information must tie in with the food chain and the energy pyramid to be acceptable. Furthermore, they will be expected to honestly investigate any efforts being made to correct the damages caused through thoughtlessness. As an example I point out to them that Dow Chemical, responsible for much of the ecological disaster in the Galveston/Houston region, is not only cleaning up its previous mistakes, but also doing research into ecological preservation. It has built a very large hatchery for red fish in League City where other wetland fish are protected as they are observed and studied.

As the students learn, however, making repairs is much more costly in all manner of lives as well as money. Their homework for the next 50 or 60 years will be to think about the effects their decisions will have on the ecosystem before they decide to modify it or allow anyone else to do so.

Lesson Three – Humanity and Nature: Examination of Waterborne Disease, Introduction to Epidemiology

A few months ago, I had a professional development course at the Houston Museum of Natural Science in which they taught us a very interesting activity. It is about a cholera outbreak in London in 1854. Provided with a map of the area, students read the facts, read clues, and then try to identify the cause of the outbreak. Finally, they read about cholera and read some historical data about that particular epidemic.

I am in the process of making a similar activity for my students. My version will be about a yellow fever outbreak in a fictitious place similar to Houston in 1867. There will be bayous, creeks, and ditches. As in the Houston of that period, there will be rice, cotton, and sugar cane fields nearby. A railroad track will traverse the fields near the mills and slaughterhouse to load and unload goods as well as people.

The larger of the two main bayous has been named Wilkes. Although it is navigable for 10 or 15 miles eastward, it is not very deep – only three or four feet during normal conditions. The barges that travel its length also carry rice, sugar, or cotton down toward the ocean to be loaded on to larger freighters. Wealthier families have built their town homes on the elegant Hauffer Avenue running parallel Wilkes Bayou. Their homes look across the bayou toward the miles of fields dotted with rice, cotton, or sugar cane crops.

Main Street begins at a point where Wilkes and Settemont Bayou converge into the ocean. This is a perfect landing place for the small freighters that seek harbor here to

pick up and leave trade goods. Beside the bank, the post office, general store and other buildings necessary for a town there are two taverns complete with breweries, biergartens, and inns. These are popular places for travelers and town citizens to congregate and visit. One of them, Beuringer's, is on Main Street and Lovett Avenue. The other one, Schulte's, is an earthier location facing Settemont Bayou in the warehouse district of town; it caters principally to the mill workers, railroad personnel, and sailors. Across the street from Beuringers is Dr. Meadow's house.

On Lovett, across from Dr. Meadow's house, is a nice park called Hauffer Park. A few ditches and streams run through it sometimes. They empty into the large ditch that has been made at the far end of Hauffer Park to drain it and other lands. It runs along Travis Street in a southerly direction and empties into Wilkes Bayou.

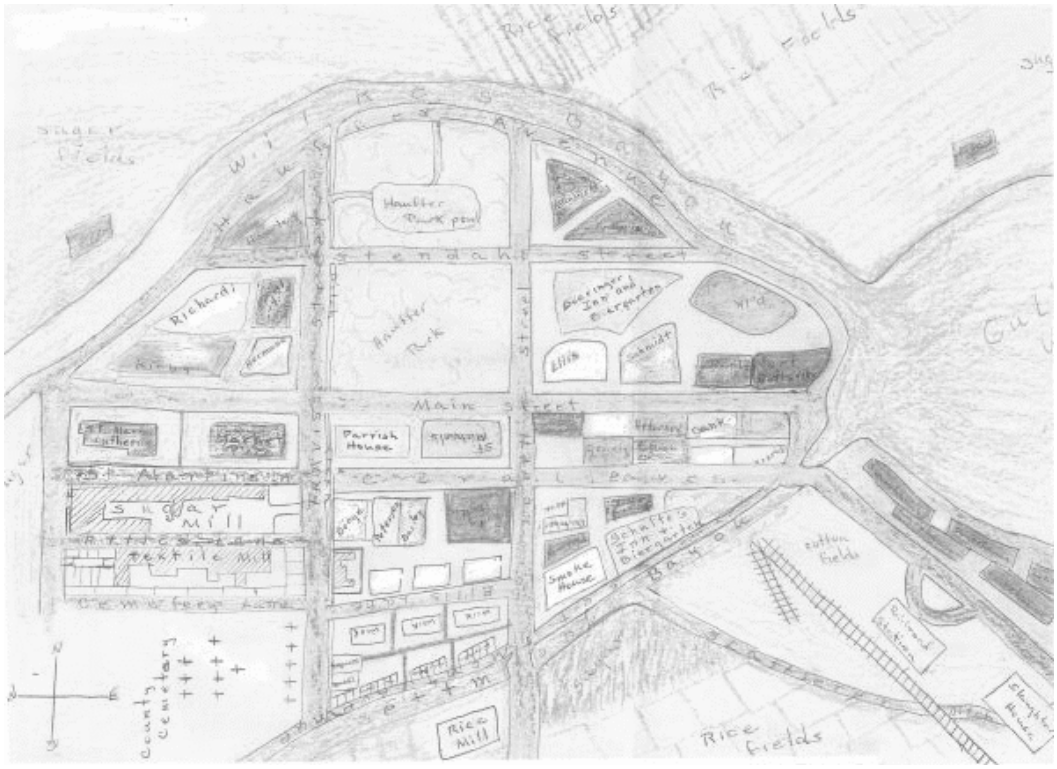

Figure 5—Map of the imaginary Birimia.

The spring of 1867 was rather dry in the northwestern part of the state, so the rivers and bayous were running at very low levels. Although the ditches had some water, they were moving very slowly. In some places, the water was standing. Summer was hot and sultry with only occasional showers to cool the population. Most people wanted to stay in the shade, but had trouble with the mosquitoes that also wanted escape from the intense sun. Evenings would have been slightly better were it not for the swarms of mosquitoes that came out at dusk and tortured any warm-blooded creature in their path.

Those people not in the Biergartens sit on their porches and enjoy the slight breeze that blows in from the gulf. The children make their beds on a corner of the porch where they hope to spend a cool night listening to the frogs, crickets, owls, and even bats.

Life seems good until news arrives in late July that Ellie Jean Polk has come down with the dreaded fever that usually strikes about this time of year. Soon, the number of ill and death rises to the tens in a single day, and by September the death toll for the year reaches 885 citizens, not including the numerous visitors and drifters present in the town.

The priests and ministers in St. Michael's Catholic Church and St. Martin's Lutheran Church are finding it difficult to preside over the burials of so many people. Dr. Meadows cannot visit all of the sick, and there is a general feeling of distress and helplessness among the people. Some burn their houses down to contain what they perceive as contamination. Some families, like the Sellers, who have country homes, leave the city or send their healthy children there to escape the dreaded disease. Often to no avail as was the case with the six Ellis children who were sent to their grandparents' home near the rice mill. All, except Bob, died.

The students will try to piece all of this information from the facts and clues cards. Hopefully they will apply what knowledge they have of the Houston Galveston wetland environment to reach the conclusion that mosquitoes might have something to do with the disease's outbreak. When they have had a good try at resolving the mystery, they will receive a passage to read about yellow fever and Walter Reed's 1901 discovery of its causes. Documentaries on viruses and other articles should complement the information acquired. Their first-hand knowledge and understanding of the bayous and wetlands as natural habitats for much wildlife including mosquitoes as well as the summer heat in Houston help them make the necessary connections. Follow-up literature for this lesson will include "Fever" by Laurie Halse Anderson, a book on a yellow fever epidemic in Philadelphia in 1793. After the mystery is solved, I will also ask the students to offer simple behavioral changes that the human population could have undergone circa 1860 to reduce the impact of the epidemic.

Both the yellow fever mystery and the one on cholera will reinforce the students' understanding of social studies, agriculture, commerce, economy, and transportation. At the same time, they will practice using maps and learning about medical conditions and discoveries; discoveries that made a difference in the attitudes toward dreaded annual diseases; toward sanitation; toward the ecosystem and how to live with it.

Furthermore, as Houston appears to have a viable permanent reservoir of mosquito-borne disease (mostly St. Louis and West Nile encephalitis), this exercise will reinforce the need to weigh public health considerations in planning daily activities.

CONCLUSION

As the year has progressed I have had the opportunity to implement some of the lessons proposed in this unit. It has been gratifying to notice how eagerly and willing fifth graders were to reflect upon and experiment with their natural surroundings. As they did so, they shed many of their misconceptions – along with their fears and prejudices – and replaced them with caution and respect. Along with increased knowledge of the earth, the students have come to understand, to some extent, how tropical storms and hurricanes are formed and what they represent for entire regions. Instead of viewing their effects as catastrophes, students have begun to understand that storms and the ensuing floods enrich the soils and thus bring great benefits for us in the way of better and more nutritious crops. Throughout the year, the students have observed, touched, studied, and analyzed many of the biotic factors of our environment. They have learned to admire many of them while developing true affection for others. As students have gone from one building to another, it has been a pleasure to observe them stopping to discuss some plant or animal they have just noticed. It was gratifying for me that at the beginning of spring some of the students began to ask for permission to help in the gardens. The gardener on staff was delighted with the extra help, and the children learned that the activity required a great deal of work and attention. In spite of that they continued to be interested in helping.

It has been my interest to teach the students to recognize different types of animals, to read about them, and to observe their behaviors whenever possible, but I have purposely not encouraged making pets of them. My reasons are to encourage them to allow other creatures to be free, natural, and independent of us humans. This perspective, of course, does not preclude assisting a fellow creature in distress. It only means allowing it to be free. Among the benefit to this outlook is that the students can observe habitats and their inhabitants as they really are. As the students observe without participation, they will learn that each of these creatures resolves its problems in very practical ways. If the students truly observe, they will realize that they too can resolve their problems in very reasonable ways. I feel that it is important that children learn to respect the animals' decisions without feeling that they need to improve upon them.

As the fifth graders have learned about plants and the invaluable importance they have upon all faunal life, they have gained knowledge about the other forms of life that make up the environments in which we live: protists and fungi. In addition, they become keenly aware that without the specific abiotic factors that we have on this planet, those life forms will simply not be.

The students have also realized that the biotic/abiotic interaction is closely connected to specific geographic areas of the world and that the natural biota are well adapted to the resulting conditions. From discussions and studies of prior times the young scientists have understood that often human events have forced some changes in the habitats of other biota with devastating results for some life forms and wonderful for other species.

However, I have been quick to impress upon them there are some changes to ecosystems that have nothing to do with human intervention. It is important for them to realize and accept that there are forces in nature much greater than our humanity, such as reduced or excessive water availability, tornadoes, hurricanes and earthquakes. Any of these changes can force most regional species to migrate, readapt or perish. In this ligh,t recent discoveries on planet Mars have given students much to think and conjecture about. Their questions, worded differently are: Whence the carbon dioxide? What happened to the water? If Mars ever contained life forms, what happened to them?

Having constant access to the natural surroundings afforded by our school's various gardens and wooded areas gives the students and me tangible evidence of scientific affirmations regarding plant life, animal behavior, and erosion and the depositional processes. With the help of our model of wetlands, and by observing it during the course of the year, students have gotten a clear idea of how slow and implacable some processes are and how they can be explained and understood through physics. Furthermore, contact with the natural world around them has given them a vivid and clear idea of habitats and of the repercussions of mismanaging ecosystems without considering the niches that each species has. With the support of stories, myths and historical recounts, the students have begun to appreciate the natural world around them and to recognize the role that modern humans can and should play in their specific ecosystems.

Throughout this unit, my concern has been to address ways in which to dispel misconceptions among the fifth graders. I have resorted to practical and real experiences to imbue the students with the necessary knowledge. They have also begun to learn how to reason through deduction, a talent that they can apply when they read, research, discuss, and analyze any new information that they encounter. It is also a talent that must be used when attempting new feats in order to consider all possible outcomes. In the event that students are negative, teachers should study the possible ways to counterbalance or avoid them. It is important that the students seriously realize that just because something can be done does not necessarily mean that the outcome will be exactly that which was hoped for, as seen in the above-mentioned examples of the mosquitoes and bats. I sincerely believe that we must teach children to realize that there are inevitable reactions to actions that may not be pleasant to contemplate but should still be considered. As teachers, we must reintroduce, include, and emphasize deductive reasoning as part of the scientific curriculum.

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