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Our Mission: Save Planet Earth

Curriculum Unit 93.05.03
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INTRODUCTION

The purpose of this environmental unit is for students at the fourth to sixth grade levels, working in cooperative groups, to research several key environmental problems and brainstorm possible solutions after intense investigation. My students ' "mission " will begin in the Amazon Basin of South America Here the "scientists " will research the devastating effects that deforestation and global warming have on the rain forest's ecosystem. After analyzing data and developing theories for preserving the rain forests, our "scientists" will travel to Yaldez, Alaska, to evaluate clean-up techniques after the March 1989 Exxon spill that poured eleven million gallons of toxic, crude oil into Prince William Sound. After experimenting with various clean-up techniques, our research group will reach its final destination, the Antarctic Ocean to determine the effects that chlorofluorocarbons (CFCs) and halons have on our depleting ozone layer. Noticed back in 1969, the ozone hole is now approximately nine million square miles large. These harmful rays cause skin cancer, destroy crops, stunt the growth of plankton, and create many other health problems. After completing this "leg" of their journey, our group travels back home where they will organize all of their data into an extensive report which they will present to fellow "scientists". Each student (aka-scientist) will be assigned an area of specialty to focus on during the expedition. One student, for example, will serve as the group's leader and oversee the entire research process. Another student will be the group's geologist focusing on the geological aspects of the issues involved. The meteorologist will study the effects that weather has on the environment. A fourth student, acting as the group's biologist, will work closely with the last student who is an environmentalist. All students must gather data from their respective f elds and then report back to the group on a regular basis. The intended length of this unit is approximately three months. One month will be spent studying each environmental issue. It is expected that students will use multimedia resources such as books, videos, cassettes, encyclopedias, magazines, and other periodicals in addition to science texts. Some initial lessons will be taught by the teacher in a whole group atmosphere. However, the majority of the work will be completed by the separate research groups. Therefore, it is anticipated that no two groups will study the same information or produce the same results. Our mission to save planet Earth is about to begin. Get your passports, your scientific journals. and we're ready to go!!!

TROPICAL RAINFOREST

Tropical rain forests are complex habitats that occupy four million square miles of the wettest land in the world. Tropical rain forests flourish in South America, Africa, Asia, Australia, Central America, and even in the United States (Hawaii). Although rain forests account for only 7% of Earth's land surface, more than half of all living things reside there. As one of the most diversely populated places on Earth, one would assume that we are doing everything we can to protect and preserve this unique ecosystem. On the contrary, an estimated 71 million acres are being destroyed each year. That breaks down to one acre every second! At this rate, there will be very little left by the year 2035. The destruction is so enormous that planes at an airport in La Paz (5,000 feet up in the Andes) have been grounded due to dense smoke. Already half of Earth's tropical forests have been burned, bulldozed, and obliterated. Tropical deforestation eliminates 17,000 species of plants and animals each year. Sadly, most of these species have yet to be identified and studied. Since all species of life are connected by a complex network, what happens to the rain forest does ultimately affect everyone else on Earth. Scientists divide the area between the Tropic of Cancer and the Tropic of Capricorn into three broad categories: 1) tropical dry forest 2) tropical moist forest 3) true tropical rain forest

In this unit, I will be referring mainly to true tropical rainforests unless otherwise noted. True tropical rainforests receive 160-400" of rain annually with temperatures averaging 80°F. In comparison, New York City receives an average of 43" of rain each year. Tropical rain forests contain valuable hardwoods, various food products, and vital medications, not to mention the millions of plant and animal species. More species of plant grow in the Panamanian rain forests than in all of Europe. 1,500 bird species (16% of all bird species) live in the Indonesian rain forests alone. A single acre of tropical rain forest supports 60-80 tree species compared to the United State's richest temperate forests at 25 species per acre.

Tropical Rainforest II

Seventy percent of the 3,000 cancer-fighting plants exist in the rain forest. For these reasons and many, many others, we must take steps to save the rain forests. Tropical rainforest vegetation grows in distinct and unique layers. The top layer, the emergent layer, towers above all the other trees and plants at 110-160 feet. Emergents endure high temperatures, low humidity, and strong winds. Many of these trees have thick buttresses which help support shallow-rooted trees. Buttresses are woody flanges that radiate from the bases of some tall tropical forest trees. (Taken from Ranger Rick's Nature Scope)

(figure available in print form)

The next layer is the canopy. This is the most luxuriant layer at a height of 65-100 feet. Acting like a giant sun and rain umbrella, it allows only 2-5% of sunlight to reach the forest floor. Orchids, bromeliads, vines, and many of the plants and creatures in the rainforest call the canopy their home. The understory consists of small saplings, bushes, and shrubs that grow between 15-50 feet. Many of the understory's trees have large leaves which help plants absorb as much sunlight as possible. Life at the bottom is called the forest floor. Here plant growth is limited because of the different growing conditions as compared to the top layers. On the forest floor, the air is very still, humidity is almost always 70%, and the temperature remains quite constant. Contrary to popular belief, the forest floor is actually spacious. The rainforests are often referred to as jungles. Etymologists have traced the word "jungle" to the ancient Sanskrit word "jangala" meaning "thick, impenetrable vegetation. " People probably first used the word when traveling by boat to explore these areas. From the river banks, the rainforests do appear to have thick vegetation.

Tropical Rainforest III

However, once inside the forests, explorers realized that the forest floor was actually open and uncluttered. As with all habitats, the animals in the rainforests are faced with constant challenges. Many rainforest animals carve their own niche by living in one particular layer. Still others roam from layer to layer in search of food and shelter. Mammals are the largest animals in size that live in the rainforest. Elephants, deers, tapirs, wild pigs, ocelots, jaguars, leopards, lemurs, anteaters, orangutans, okapis, sloths, monkeys, gibbons, tarsiers, gorillas, bats, and chimpanzees are among mammals found throughout the world's rainforests. The most eye-catching and colorful animals, however, belong to the bird family. Toucans, macaws, hornbills, Birds of Paradise, hummingbirds, and harpy eagles are just a few of the 2,600 bird species found in rainforests. When speaking of the largest group in number, though, the insects win hands down. Estimates are that 80 million different species reside in the rainforest. Rainforests contain an astonishing array of climbing plants, vines, mosses, and ferns. Of the 12,000 species of fern identified worldwide, 11,000 are tropical. Some vines can grow as thick as your body and some leaves can reach six feet in length ! Most tropical plants actually grow on other plants and never touch the ground. These "air plants" are called epiphytes. They derive all their water and nutrients either from the air or from materials caught in the trees far above the floor. Approximately 28,000 species of epiphytes have been identified around the world. Orchids, bromeliads, ferns, and mosses are the best known epiphytes. Unlike epiphytes, climbing vines are rooted in the ground. Some sprout on the forest floor and grow upwards while others germinate in the canopy and grow down to the forest floor. Rainforest plants have self-protective adaptations to get rid of pests. Some plants produce distasteful and poisonous chemicals in their leaves. Others have sharp spines and prickles to keep animals away. Some of the most amazing adaptations, however, involve the intricate relationships between plants and animals. The best illustration of this partnership is pollination. The majority of plants depend on animals for pollination. Insects, bats, and birds are the most common pollinators. Of these, bats are the most important; contributing up to 95% of the seed dispersal that leads to forest regeneration.

Tropical Rainforest IV

Plants and animals are not the only inhabitants of the rainforest. Approximately 140 million people live in the rainforest. However, these indigenous tribes are disappearing forever. Their physical and cultural heritage, having existed for thousands of years, is in jeopardy. Within the last century, 87 separate Brazilian tribes have been exterminated. A particularly sad story is that of the Penan tribespeople in Malaysia. A decade ago, the government gave logging companies the right to clear the rainforests. Logging has already caused river pollution, widespread siltation, and destroyed the Penans' food supply. With their traditions on the verge of obliteration, the Penan must now live in government built shacks suffering from malnutrition and disease. The Penan have fought back by blockading the logging roads but the government has retaliated by arresting these people. Current estimates say that the Malaysian rainforest will be completely destroyed in just seven years. As French scientist Charles Marie de la Condamine discovered in the mid-1700s when he saw native Amazonian people extracting rubber from a tree, there is a wealth of knowledge in these tribespeople. Scientists are urgently working to learn as much as they can from the indigenous tribes' shamans before they all die out. In fact, the field of ethnobotany has gained popularity in recent years. Ethnobotany is the study of how indigenous people use local plants. Many of the rainforests' products were introduced to scientists by indigenous people. These products have affected us in many positive ways; some have saved lives. The rainforest truly is a medicine cabinet for the world. The estimated value of these natural medicines was $51 billion just four years ago. Rosy periwinkle, for example, combats leukemia in children, Hodgkin's disease, breast cancer, and cervical cancer. Quinine, derived from the cinchona tree, is effective against Malaria, a disease which kills millions. Many of the crops, which in the United States are considered domestic, actually originated in the rainforests. Only 2% of the United States' crop production is from native species. Rice, coffee,

tea, chocolate, lemons, oranges, bananas, pineapples, coconuts, mangoes, chicle (chewing gum), vanilla, and various nuts all found their way to us via the tropics. Many of these crops have developed natural defenses from insects and other damage. A majority of the citrus fruits are now cultivated and harvested in other parts of the world. Tropical plants can enhance the quality of domestic crops through hybridization.

Tropical Rainforest V

Industrial benefits from the rainforest include rubber trees and copaiba trees. Since up to 40% of all bus and car tires are made of natural rubber, rubber exports are worth more than $3 billion annually to rainforest countries. Another advantage of rubber is that it is a renewable resource; it can be tapped without destroying a tree. Copaiba trees produce a sap used to fuel diesel engines. Rainforests help our weather by absorbing solar energy, affecting wind and rainfall patterns worldwide, preventing global warming (also referred to as the “greenhouse effect”), reducing erosion, and providing natural buffers against coastal flooding. Rainforests receive almost half of all the rain that falls on land. The forests absorb this rain and eventually release it into rivers and streams. Once the trees are cut, however, rivers swell with muddy sediment after rains and shrink during dry spells. Therefore, there are either floods or drought. Soil erosion also increases. It can take 1,000 years for topsoil to develop, yet only ten years to disintegrate. Rainforests provide a natural defense against hurricanes, typhoons, and cyclones. Tropical forests absorb most of these storms’ ferocious winds saving lives and lowering damage amounts. Each year tropical storms kill approximately 20,000 people and cause more than $8 billion in damage. If there were no rainforests, both figures would skyrocket. Deforestation of the rainforests is the result of social, political, and economic problems. Most of this tropical land is found in poor Third World countries who view the forest as a valuable resource to be sold for profit. By selling timber, for example, some countries can build much needed hospitals and schools. This, however, does not take into account long-term ecological impacts. Deforestation rates have nearly doubled in the last ten years. Cattle ranching has destroyed more rainforest in Central America than any other activity. There is a huge market for cheap beef in the United States and other Western countries. Much of this beef comes from cattle raised in South American and Central American rainforests. In 1988, the United States imported almost 50,000 tons of beef worth more than $1 billion. Land cleared from rainforests only supports cattle for 3-7 years before the land deteriorates and ranchers move onto other areas. Ironically, a typical four ounce hamburger represents the destruction of 1,000 pounds of living matter. This includes one tree, fifty saplings, and thousands of insects and animals. Cattle ranching in the rainforests would lose much of its appeal if it weren’t for the subsidized loans of governments and world banks. Tropical Rainforest VI

Inter-American Bank and World Bank have promoted rainforest ranching by loaning almost $4 billion to ranchers in the 1970s. To meet the demand for mahogany, teak meranti, and ebony, at least eleven million acres are logged each year. Since these hardwoods take hundreds of years to mature, they cannot be readily replaced. Although only the oldest and largest trees are supposed to be felled, more than half of the forest may be damaged by the time all of the work is finished. Tropical hardwoods are especially valuable because of their beauty, durability, and resistance to insect damage. Industrial countries buy over eighteen times more hardwood today than they did fifty years ago. A lack of local political control has allowed overcutting in many forests. Studies show that logging can result in the loss of valuable economic revenues in the areas of tourism, food products, and fisheries. Increased sedimentation of many rivers threatens fish populations downstream. Alternatives to typical clear-cutting practices, such as selective logging and small-patch clear-cutting can lead to sustainable timber harvesting. Unfortunately, neither practice is widely used. According to the International Tropical Timber Organization (ITTO), such efforts have had “negligible” success. Continuing at the current pace, high profits from commercial logging will be short-lived. Presently, the tropical timber trade produces $6 billion per year. However, by the year 2000, that figure will drop to only $2 billion because of shrinking

supplies and poor logging management. In many countries, slash-and-burn agriculture is a leading cause of tropical deforestation. Slash-and-burn agriculture is a farming method in which patches of tropical rainforest are cut and then burned to clear the land for crops. For the first few years, crops do quite well due to the nutrients in the soil and ashes. But eventually, the soil wears out and the plot is usually abandoned. On a small scale, slash-and-burn agriculture is sustainable but only if the land is given time to regenerate itself. Unfortunately, this is often not the case and the land does not recover. It is imperative that the rainforests be saved because the trees and plants help to keep the air around us clean. They use water, sunlight, and air to make food. Plants and trees make use of carbon dioxide and produce oxygen, which helps everyone breathe. When the rainforests are burnt down or destroyed, the trees stop using carbon dioxide and instead, produce more CO_2 which pollutes our atmosphere.

RAINFOREST GLOSSARY

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bromeliads—tropical plants in the pineapple family that often grow on the trunks and branches of trees.
buttresses—woody flanges that radiate from the bases of tall tropical trees which help support shallow-rooted trees.
deforestation—the destruction of a forest.
epiphyte—a plant that grows on other plants.
ethnobotany—the study of how people use plants.
extinction—when the last member of an animal or plant species dies out.
indigenous—referring to tribal peoples, such as American Indians, who lived in an area before Europeans arrived.
shaman—a tribal priest/doctor who has great knowledge of the medicinal qualities of native plants.
sustainable development—development that uses natural resources in an efficient way and without destroying the basis of their productivity.
tropical rainforest—an evergreen forest located at low elevations in regions between the Tropics of Cancer and Capricorn. It is characterized by abundant rainfall and a warm, humid climate year-round.

(figure available in print form)

OIL SPILLS IN OUR OCEANS

After studying the Amazonian rainforest extensively, our scientists have arrived at their next destination- Valdez, Alaska. Here, our group will research the long-term effects of the March 23,1989, Exxon Valdez oil spill.

(figure available in print form)

We, in North America, are fortunate in having more fresh water, more fertile soils, and more resources than any other continent. Unfortunately, it is true that the oceans are "our sinks" for much of the waste that we, as a planet, produce. As Jacques Cousteau, famous oceanographer, has stated, "the very survival of the human species depends upon the maintenance of an ocean clean and alive, spreading all around the world. The ocean is our planet's life belt. " Effects on ecosystems by oil spills depend on various factors which include: the type of oil, amount of the spill, times of the year, weather conditions, average water temperature, ocean and tidal currents, and the distance of release from the shore.

Immediately following a spill, low-boiling hydrocarbons such as benzene and toluene cause the sudden death of shellfish and many fish in their larval forms. Other chemicals remain on the surface that adhere to sea otters, birds, rocks, and other objects. This "coat" of oil destroys the animals' natural insulation and buoyancy. Most ultimately die from loss of body heat or drown. Heavy oil components that sink to the ocean floor have the most devastating effects on marine life. They kill crabs, oysters, clams, mussels, and completely alter all food chains. Generally, marine life can recuperate within three years of such accidents, but cold, polar waters take longer for recovery. It is generally accepted that the heavier the oil, the less toxic it is. While scientists theorize that oceans are strong and resilient, the toxification of the water is closely connected to other pollutants that threaten Earth's biodiversity. As John Cairns, a marine ecologist, states, "should an entire ocean be damaged, the time required for recovery staggers the imagination." Oil spills have been with us for quite a while in our history. Reports of oil damage date back to the Civil War. Back in 1912, the New York Zoological Society reported that it could not use local harbor water for its aquarium tanks because oil contamination was killing specimens.

Oil Spills II

Tanker accidents account for only 10-15% of the yearly release of oil into our oceans, but these spills have disastrous impacts on coastal regions. Nearly 50% of released oil comes from runoff and dumping of waste oil by cities. While our researchers will be studying the worst oil spill in U. S. waters, the largest accident ever took place in 1983 when the tanker Castillow de Bellver caught fire and dumped 78.5 million gallons into the waters off of Capetown, South Africa.

Since 1973, the actual number of accidents per year has decreased due to better training, and improved safety measures. However, this relaxed attitude toward standards by oil companies led to disasters such as the Exxon Valdez. Some 10,000 spills occurred in the year alone following the Exxon accident. At least three of those were in the million-gallon range. Since these smaller spills occur all of the time, the constant toxic pressure on coastal ecosystems is tremendous when accompanied by the occasional huge spill. Estimates are that anywhere from 1-10 million tons of oil are spilled each year into our oceans.

The fate of spilled oil depends on the nature of the crude. Number 6 heavy crude barely floats and is

extremely viscous. Number 4, which is light crude, and Number 2 heating oil are lighter and less viscous, therefore spreading more easily across the oceans surface. These lighter oils contain more aromatic hydrocarbons and lower boiling alkanes. The low boilers induce anesthesia and narcosis among fish and invertebrates.(Taken from The Environment by Gerald Leinwand)

(figure available in print form)
Valdez, Alaska, is one of the busiest seaports in the state. Since the Alaskan pipeline opened in 1977, some 9,000 tankers have made the trip to the West Coast without any major accidents.

Oil Spills III

Much oil is pumped through an 800 mile pipeline that ends in Valdez. In Valdez, it is stored in huge storage tanks until the super tankers can take it to refineries. At the refineries, oil is made into gasoline, chemicals, plastics, and other products.

In the early 1970s, conservationists predicted there would be a large spill so they urged politicians to transport oil via a pipeline to reduce potential damage. The oil companies won by a 50-49 vote in the United States Senate. Since 70% of the worlds oil output travels by sea, it is quite apparent why the conservationists were concerned about the oceans future.

The 1989 spill, which covered some 4,000 miles of shoreline, killed hundreds of thousands of marine birds and thousands of sea otters and fish. Large, but indeterminable amounts of seals, sea lions, porpoises, dolphins, and whales are presumed dead as well. Human clean-up crews were also exposed to health risks by the toxic chemicals. Tar is fed upon by marine turtles and, accompanied by plastic garbage in the water, is a major cause of their decreasing numbers. Finally, bald eagles and other birds may also be affected indirectly through the toxins built throughout the food chain. The final toll, however, will never be known because many of the animals sank.

The area of the spill is known as Alaskas Emerald Jewel -Prince William Sound. The eleven million gallons of thick, toxic crude oil cost nearly $2 billion to clean up, making it one of the costliest spills ever. What is especially sad is that this major tragedy could have been avoided, or at the very least, controlled. Most of the clean-up measures were not effective. In hindsight, it would have cost Exxon only $22.4 million to have a second, protective hull built. The ultimate irony is that the captain of the Exxon Valdez was drunk on duty according to blood tests. His automobile drivers license was revoked due to his alcohol problems yet Exxon still let him take charge of a super tanker more than three football fields in length.

While Exxons corporate greed was a major factor in the tragedy, we as consumers must also share some of the blame. Our careless and wasteful habits have created such large demands for domestic oil. Ironically, oil carelessly dumped by consumers (from automobile, lawn, and recreational equipment) is equal in volume to twenty or more spills by the Exxon Valdez on an annual basis. The argument has been made that the Exxon Valdez was an accident, whereas our own oil spills are done with reckless intent.

Oil Spills IV

Although various clean-up techniques have been attempted, these efforts remove only a fraction of the oil at best. Skimmers and booms are used to contain and scoop up the oil. Skimmers are most effective when used on well-confined spills in relatively calm waters. Booms, on the other hand, are similar to large floating corrals. Oil-absorbing materials such as hay or plastic shavings are thrown on the spill to make it easier to pick up. Sometimes, soaps and detergents are added to reduce surface tension of the oil. The use of fire as a clean-up

technique was tried back in 1967 in England but it was not very successful. Bioremediation is a fairly new idea that utilizes oil-eating bacteria to change the oil into a fatty-acid compound that is eventually decomposed by marine organisms.

During the Exxon Valdez spill, a method was attempted that actually turned out to be more destructive in the long run. The clean-up crews tried to wash the oil from the beach by using powerful streams of hot water. The ultimate effect was that this cooked marine organisms in 65øc water. Since oil spills will continue to occur, as seen recently in the Shetland Islands, solutions to this problem will come from future generations.

It is important to mention that oil spills are not the only threat to our oceans. Sewage, industrial waste, insecticides, herbicides, natural runoff, and constant polluting all account for the problems. In 1988, everyone can remember beaches along the eastern U.S. closing due to contamination from medical wastes. Every individual can do his/her part to keep our oceans clean. By conserving oil, recycling, being informed consumers, writing letters to politicians, and car pooling, we can all improve the quality of our oceans. After all, were not called the Blue Planet for nothing!

As David Bulloch aptly states in his book, The Wasted Ocean, We simply do not comprehend the extent to which we have stretched the resiliency of nature, nor do we recognize that nature, bent under these new and strange stresses, is losing its elasticity. Experience has yet to teach us that neither the private ownership of land nor the use of common water conveys the right to spoil them. Land, water, and wildlife are not artifacts along the course of civilization. They are its roots.

Our scientists have concluded the second leg of their journey. They will gather all of their data from Valdez, Alaska, and have a final report upon their return to Connecticut. Our scientific group will also present methods to stop the contamination of our oceans and various techniques to effectively clean-up oil spills.

OZONE DEPLETION

As early as 1969, scientists noticed that the ozone layer was breaking down. Ozone (03) is a pungent and poisonous gas which floats some fifteen miles above the earths surface by shielding all living things from the suns ultraviolet light. This hole in the ozone layer, which was approximately nine million square miles large just last year, is about the size of North America. If more of the suns harmful rays reach the earth, this can lead to crop destruction, slow plankton growth, skin cancer, and other health problems including cataracts or even blindness. Our true awareness of the ozone depletion problem began in 1974 when University of California chemists F. Sherwood Rowland and Mario Molina discovered that chlorofluorocarbons (CFCs) could rise slowly to the upper atmosphere and destroy earths fragile ozone shield.CFCs were used in the manufacture of air conditioners, refrigerators, fast food containers, aerosol spray cans, and other products. The 1973 production of CFCs was at a rate of one million tons per year.

During their research, Molina concluded that each chlorine atom from CFCs collides with an ozone molecule. While ordinary oxygen molecules have two atoms, ozone is made of three oxygen atoms and is very unstable. Ozone will tend to give up one of its oxygen atoms to other gases and turn back into oxygen. In brief, the breakdown of CFCs by sunlight would set off a catalytic chain reaction in which one chlorine atom could eat up 100,000 molecules of ozone, turning them into impotent oxygen molecules.

Derived from the Greek work ozein which means to smell, ozone at the ground level gives off an acrid odor. The ozone layer is really only an eighth of an inch thick. For every 1% decrease in the ozone layer, cases of nonmelanoma skin cancer are expected to increase 5-6%. Since some CFCs take one hundred years to decompose in the atmosphere, we will live with the consequences of CFCs for another 100-150 years at least. As Vice-President Al Gore stated, While we have hardly begun to make the dramatic changes that will be necessary, it is a revolutionary step for society to recognize the problem at all.

Reactions to Molina and Rowlands 1974 discovery was minimal at best. Du Pont, the worlds largest CFC manufacturer, discredited their findings and refused to initially acknowledge the ozone problem as a serious threat to the environment.

Ozone Depletion II

Molina and Rowlands discovery would spell bad news for CFC manufacturers. More than three hundred aerosol spray products were on the market—everything from deodorants, perfumes, air fresheners, to insect sprays, lubricants, and automobile products. In 1974, it was an $8 billion business which employed more than 200,000 people.

The history of the chlorofluorocarbon is an interesting one indeed. CFCs were discovered in 1928 by Du Pont chemist Thomas Midgley,Jr. A colleague had told Midgley that the refrigeration industry needed to improve. At that time, ammonia or sulfur dioxide was used but they were not very effective. The new refrigerant must be nonflammable, nontoxic, and stable. After much experimentation, Midgley created the compound fluorocarbon. Freon was the trademark name that Du Pont gave to its new class of fluorocarbon chemicals. Freons F-11 and F-12 were the most widely used in the 1930s and now it turns out that they are the most dangerous to the ozone. Other health threats associated with the use of aerosols and CFCs include the risk of cardiac arrest when CFCs are in high concentrations. In smaller doses, they could cause changes in normal heart rhythms. Although the nations policymakers were aware of the CFC threats, it would take them the next fifteen years before any serious action would occur. American consumers did not waffle on the issue, however. The CFC-ozone theory generated more letters to politicians than any issue since Vietnam. About half of the people surveyed said they had already stopped using aerosol products. In 1984, Rowland expressed frustration and disgust that ten years after their revelation, nothing was still being done about the problem.

Unfortunately, this means that if there is a disaster in the making in the stratosphere, we are probably not going to avoid it, Rowland warned. Sadly, Rowland would be proven correct just months later when the British Antarctic Survey released data showing that the ozone hole was increasing over the South Pole. Scientist Joe Farman and his research assistants had been studying at Halley Bay, Antarctica, since 1957. Since they had spent twenty-five years there, the results of their findings had credibility. Having used the old ground-based Dobson spectrophotometers to read ultraviolet light that reached earth, however, Farman doubted his own results at first and requested brand new equipment. Nevertheless, the new equipment confirmed the previous data. The ozone had actually begun to decrease back in 1977. The Nimbus 7 satellite took ozone readings from 600 miles above the earths surface. The Antarctic ozone hole suddenly appeared before our eyes

Ozone Depletion III

Instead of congratulating the scientists on their discovery, many people criticized them for having not released their findings sooner.

One possible explanation for the 1983 ozone decrease was the volcanic eruption of El Chichon in Mexico in

April 1982. Rowland theorized that the massive amounts of sulfuric acid spewn into the atmosphere could react with chlorine nitrate and cause ozone loss. Rowland and other researchers debated over this theory. After experimenting with chlorine nitrate, hydrogen chloride, and water, the group concluded that the volcano could have created some ozone depletion.

However, vehement arguments as to what was causing the ozone hole arose from the entire scientific community. A popular theory called the dynamicists theory suggested that air movement was the cause of the hole. A third theory, called the odd nitrogen theory, suggested that the solar cycle was the cause of abnormal ozone fluctuation.

In a 1985 report by NASA, statistics showed that if CFC emissions continued at 1980 rates, the ozone would decrease 4.9 to 9.4% by the next century. Even if the Antarctic hole was linked to CFCs, regulations of non aerosol uses would be difficult to control. In the 1970s, consumers had a vote and they chose to protest aerosol products. Now,however, it is harder to walk into an automobile dealership and request a car with an air conditioner free of fluorocarbon-12.

In June 1986, a series of hearings and meetings were scheduled in Washington. Both sides of the issue brought out their toughest tactics. Environmentalists and scientists testified that the greenhouse effect was a cause for concern. According to the EPA, changes in climate could cause the extinction of some species. Crops in semiarid regions would die. The number of 100øf + days would increase from 3 to 20 in Omaha, Nebraska, for example. Sea-level increases of 2-12 feet by the year 2100 could easily flood coastal cities such as New Orleans. Protecting wetlands, beaches, and even drinking water would be impossible. Just protecting our countrys east coast could cost an estimated $10-100 billion. Traces of CFC contributed to the greenhouse effect at rates comparable to carbon dioxide.

Other shocking reports stated that ultraviolet radiation could reduce seed quality, lower a species resistance to pests and diseases, damage aquatic systems, and destroy fisheries. A 25% loss in ozone would result in a 35% loss of phytoplankton, the main food source for many marine animals..

Ozone Depletion IV

Humans, too, would be greatly affected by this increased exposure to W. Ultraviolet light it could damage DNA, perhaps harming the humans immune system. Cases of skin cancer, cataracts, and visual aging would also increase. It is not yet evident whether the behavior of ozone above the Antarctic is an early warning of future changes in global ozone or whether it will always be confined to the Antarctic because of special geophysical conditions that exist there, stated NASAs Bob Watson. Antarctica is the coldest place on Earth. With the most unfriendly environment on the planet, the thirteen American scientists who set out on the first official ozone expedition in August 1986 had alot to deal with besides the weather conditions. Lead by chemist Susan Solomon, the group organized the trip in less than five months; a major accomplishment given the tasks ahead. Although much of the public wanted the group, called NOZE I (National Ozone Expedition), to come back with all of the answers, scientists realistically didnt expect them to generate much on this first outing.

Surprisingly, the instruments were performing well enough to gather solid data. In Antarctica, its a challenge to do anything. Temperatures often reach -90 F By the end of the expedition, they had gathered strong evidence to prove that chemicals were causing the rapid ozone depletion. Solomon discovered high levels of chlorine dioxide which implicated CFCs. Satellite data showed that ozone was being depleted in a huge region to at least 45 south latitude (the Southern tips of South America and Australia).

A larger and more detailed expedition was needed in 1987 to accurately solidify the chemical theory. The $10 million project would hopefully resolve many of the uncertainties from NOZE I.

On September 1 6,1986, the Alliance for Responsible CFC Policy held a press conference announcing that it would encourage the limit on the growth of CFCs. Replacing CFCs in refrigerators, air conditioners, and solvents would be much more difficult than the substitutes of aerosol sprays. The three main chemicals that needed to be replaced were: CFC-11 (used in making polyurethane foam); CFC-12 (used in refrigeration,air conditioning, and foam blowing); and CFC-113 (used as a solvent in the electronics industry). On September 14,1987, the Montreal Protocol was signed by 43 nations. The 43 countries agreed to a freeze on consumption and production of CFCs at 1986 levels by 1990; a 20% reduction by January 1,1994, and an additionalcut of 30% by January 1,1999. The Protocol stated that all nations would meet again to eventually eliminate ozone-destroying chemicals.

LESSON ONE

Pack Your Bags: Were on Our Way!

Objective:
To familiarize students with the three geographical locations of their journey: Brazil, Alaska, and the South Pole. To create an understanding of mileage, costs, time zones, and governmental restrictions while traveling to these destinations.

Materials:
Atlases, travel guides, passports,travelers checks, a scientific journal for logging information.

Lesson:
Each scientific group will obtain their passports (by making them) and create a list of items they will need for their three month long trip. Next, they will use maps and atlases to research mileage to each destination. By contacting travel agencies, they will learn approximate costs of each plane flight. They will next budget how much money they will need to bring and then buy enough travelers checks. After obtaining all of their necessary documents and items, the group is ready to depart for the first stop of their expedition: Brazilian rainforest in South America!

LESSON TWO

Rainforest Menagerie

Objective:
To classify various rainforest animals into their appropriate invertebrate and vertebrate groups. To understand the characteristics and features of each group and distinguish amongst them.

Materials:

Various pictures of rainforest animals from old magazines or photocopies.

Lesson:
Rested after the long flight, our scientists waste no time in exploring the rainforest. They have spent several days and nights examining and observing the many species of animals located throughout the forests layers. After taking hundreds of pictures and countless notes, they are all gathered back at their lab to study the pictures and research their data. For example, our scientists will put all vertebrates into their appropriate category: fish, reptile, amphibian, bird, or mammal. They will then analyze various survival techniques, unique adaptations, unusual body appendages, and symbiotic relationships in the rainforest. The majority of their work will be with the invertebrates, though. With millions of species of insects alone, our scientists will be very busy classifying these animals.

LESSON Three

Cleaning up Valdez, Alaska!

Objective:
To experiment with various clean-up techniques of an oil spill. To analyze which methods are the most effective and which are the least productive.

Materials:
a baking pan, cooking oil, baking soda, dish washing liquid, paper towels, a sponge, cold water.

Lesson:
Our scientists have explored the Prince William Sound area and have now returned to their research lab with various oil specimens. They will attempt to clean the oil from a small confined area so that they might eventually try these techniques on the open waters. First, they will add enough water to a pan to fill it halfway. Then they will add the oil that they collected. Next they will begin their various clean-up techniques such as baking soda, dish washing liquid, skimming the surface with paper towels and soaking the oil with a sponge. The group will record their findings and determine which method was the most effective. Some questions they might ask themselves are: Did any method leave an additional residue on the water?, Did any of these methods create additional harm to marine life?, or Which method would best be attempted on larger areas?

LESSON FOUR

Weather Watching in Antarctica!

Objective:
To experiment with various weather watching instruments. To analyze how weather affects how lives and what it is capable of doing to our planet.

Materials:
thermometer, anemometer, rain gauge, barometer, almanac, atlas, and chart for recording data.

Lesson:
Our scientists are preparing for their trip to Antarctica. While there, they will study the weather intensely, analyzing what affects weather might have on the ozone problem. Prior to their departure, the group will test their meteorological instruments to verify that everything is working properly. For two weeks, our group will check the air temperature, wind speed, wind direction, air pressure, precipitation amounts, and general weather conditions each day. Keeping all of their data on charts, the group will determine the mean temperatures and other averages using their math skills. Knowing that their equipment works properly, our scientists will now use almanacs and other resources to determine average temperatures in Antarctica for the time of the year that they are traveling there. As a final step in this lesson, the scientists will compare and contrast weather conditions in Antarctica with those here in Connecticut. Our group will hypothesize on what effects the weather might have on the depleting ozone layer and possible solutions to this environmental problem. Several groups may want to share their findings with each other to see any similarities or differences.

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