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Social and Cultural Shifts in the Wake of Climate Change

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Introduction

Global warming has been a subject of much debate for the past few decades and hardly anyone today can deny the reality of it. Most scientists agree that its origins are human induced but, not surprisingly industrialists and merchants in different fields deny the possibility of anthropogenic influence on the atmosphere's chemical structure, much less the conditions of climate and its effects on the world's biota. These people are inclined to argue that the climate has always changed on planet Earth. Other people, among whom I count myself, admit that although this is so, the episode that we are beginning to encounter had its origins, not with natural processes, but by human's zeal to resolve our problems with little regard to the consequences, and thus we have polluted the stratosphere in a most dangerous way.

My goal in writing this unit is for my fifth grade students to learn about the history of the Earth and the shifts that plants and animals have had to make to survive and reproduce. I want them to understand that humans are part of the natural world and that our species too, has had to make adjustments to some of the changes. Those changes have helped us improve our cultural development while others have caused the downfall of cultural groups of advanced civilizations.

Another purpose in writing this unit is to impress upon my students the interrelatedness of species with each other as well as with the abiotic factors in their ecosystems. Therefore we will look at the effects of global warming on different aspects of our lives: water availability, storm events, land usage, agriculture, and health.

Although the projections of the International Panel on Climate Change (IPCC) are regarding countries around the world I will analyze the coastal plains on the Gulf of Mexico for evidence of global warming effects already taking place. I will focus on the metropolitan area of Houston toward Galveston bay because it is where my students and I live. Furthermore, the eastern portion of the Houston Metropolitan area is where a large portion of the pollutants are released into the air causing many illnesses such as cancer, asthma, and other bronchial and pulmonary diseases.

The cities in the metropolitan area were built on coastal wetlands so they are at sea level and the aquifers that underlie them and part of the Gulf itself provide fresh water for agriculture as well as urban needs. But in the past those aquifers have been over exploited permitting not only salinization of the water but also causing a constant problem of land subsidence. Records show that between 1900 and 1990 Houston has subsided 9

feet. Subsidence and rising water levels do not presage a long future for this city. What is more, the increasing number of tropical storms, electrical storms, hurricanes and tornadoes that hit the region throughout the year cause numerous disruptions to the city's economic progress. Often the storms result in flooding that paralyzes transportation and perturb the accumulated toxic materials that lay on the ground from the industrial pollutants. The usual outcome of these episodes is an increase in disease and other health related issues.

Always a problem in the region; mosquitoes have also increased their numbers along with the diseases that they have habitually carried: malaria, yellow fever and dengue. This last one had always been confined to tropical regions but global warming is expanding those regions well into the coastal regions of Texas. Malaria has also found its way back to Houston and the United States where it had been eradicated in the mid forties. The poor, the very young and the aged are the most likely victims of these diseases even in cities like Houston because their families cannot always afford to air condition their houses. They spend a great deal of time out of doors. Unless they have ample access to fresh drinking water dehydration is another health issue that can result in diarrhea and often, death[1] .

I have intentions of integrating the concept of climate change and its effects, both present and past to my students' social studies, science and reading curricula. The social studies lessons will focus on social and cultural shifts in response to climate change as the one experienced from ~ AD 540 - 800 in which temperatures dropped as the result of a volcanic eruption; followed by a gentle warming period that lasted about five hundred years. The period that followed became increasingly colder as it progressed into the 1850s. During that last cooling episode humans made incredible strides to make their environments more habitable, inadvertently sowing the seeds that upon maturation are threatening the ocean's and earth's biodiversity along with the geomorphology of the earth itself. As I teach these aspects of human adaptations I would like my students to become aware that not all areas of the globe are affected identically during the episodes of climatic change, so that if one region is being subjected to heavy flooding events another might be going through quite the opposite: droughts and the subsequent aridity. In some areas the vegetation will expand its boundaries while in others fires and droughts will render a region barren. Any of these conditions will determine the growth of animal species and populations or their disappearance and extinction.

Understanding of these conditions will probably provide me with a logical scenario by which to explain the dynamics behind the European explorations and their meeting with the Amerindians. By discussing the past, drawing parallels with it and looking at the evidence of the warming trend that we are facing the students will be asked to forward ideas about cultural and social adaptations that the people in our area will be required to make in order to guarantee a future. Implicit in these projections will be their understanding of the situation not only from the social stance but, from the scientific one.

In brief, my goals in teaching these concepts are to create in my students an awareness of the integral part that humans have on their environment, the need to exercise forethought before physically, chemically or biologically altering the planet's ecosystems and to search for ways to respond to the realities threatening our civilization.

Historical Background on Climate Change

From ice cores taken from continental ice accumulations and isotopes from marine sediments scientists around the world have reconstructed a time line which indicates that the Earth has undergone a number of glacial and interglacial periods. The last major one occurred from about 120,000 to 11,500 years ago when the warming interglacial period called the Holocene began and in which we find ourselves. Interglacial - glacial cycles are caused by variations in the Earth's orbit through time in which the amount of solar radiation received by the Earth in each season is changed. The cycles seem to have a frequency of about 90,000 to 100,000 years[2] . Inter-glacial periods tend to occur during periods of long term changes in the Earth's orbit around the Sun (peaks in precession) as evinced in the Northern Hemisphere summer.

The data from the ice cores and marine sediments is especially helpful in reconstructing the changes that biotic factors were obligated to make in different parts of the Earth during the shifts in the cycles. Pollen from sediments in land based water basins such as bogs and lakes provide important correlations as they indicate the types of vegetation in a given region at a given time. Mosquitoes, their larvae or other small creatures trapped in the sediments add a dimension to the biota of the region and help formulate a picture of the prevailing conditions during the interglacial periods. They also help reconstruct the changes in habitats, ecosystems and biomes that took place as the cycle began to shift between and during glacial periods.

By using pollen analysis scientists have chronicled dramatic changes in the world's environment during the early part of the last major Ice age called the WÃ¼rm glaciation which lasted about 90,000 years. It is clear that Scandinavia and most of Britain were under ice during the height of the WÃ¼rm and that most of western and central Europe and Eurasia was open steppe-tundra.[3] Because the formation of ice caps draws large amounts of humidity toward them areas of shallower waters dried up exposing the earth beneath. Thus the Balkans were joined to Turkey, the Sahara was extremely arid, and snow levels on the world's mountains were hundreds of feet lower than today. The same phenomenon caused rain forests to shrink; the Southeast Asian mainland to be joined to the offshore islands; and only narrow straits separated the mainland from New Guinea and Australia formed a single landmass. Farther north Alaska and Siberia were joined by a low - lying land bridge called Beringia and most of Canada and the United States were covered with vast ice sheets, as far as Seattle, the Great Lakes, and Nova Scotia.

Throughout the Pleistocene (WÃ¼rm Glaciation) humans made dramatic changes in their lives and life styles. Homo sapiens from Northern Africa moved into Europe where some settled in the numerous caverns of southwestern Europe. There they remained and thrived, isolated from other human types for millennia. They are the well known Neanderthals. Elsewhere another type of human, the Cro-Magnon also known as modern man wandered through the Eurasian steppes following the herds for their skins and meat as well as gathering available plant foodstuff. These were resourceful people who made their shelters from available fallen trees when possible or from the ribs and skins of mastodons. There they could weather the severe winters. In a very simple way these people were modifying their mini-ecosystems. It is during the Pleistocene that one of the simplest and yet most important instruments - the needle was invented. This modest instrument permitted ice age people to sew together skins to keep the warmth close to the body. That along with their control of fire to keep their shelters warm and cook their food improved their lives considerably.[4]

It is evident that the better equipped groups of Cro Magnons wandered eastward toward the Pacific Ocean where they probably met with earlier wanderers. From there some went south as far as what would become

the Pacific Islands during the interglacial now called the Holocene. There is little material evidence of their passage into the area but, perhaps their hunting and fishing procurement instruments were made of hard woods and therefore, perishable. Other Cro-magnons must have walked northward where some settled and others, ever curious, or else following the herds crossed over into North America by way of the land bridge caused by the low sea levels of Beringia. This at least is the theory of the peopling of the Americas.

During the Pleistocene the southern part of Africa was undoubtedly cooler than it is now and the savannahs provided sufficient food for the small populations which developed there. Even if the people had wished to migrate northward they would have found a deadly impediment in the tropical forests: the tse-tse flies and malaria carrying mosquitoes which thrived unimpeded throughout the area. This barrier also kept the northern inhabitants from moving southward.

The warming period that began about 11,500 years ago caused ocean levels to rise separating previously connected lands like Alaska and Siberia, Asia's Mainland from the Indonesian Islands and Europe from Africa. Many animals became extinct because they could not adapt to the changes in temperature or vegetation. The mastodons, camelopids, and small equines disappeared completely from North America.[5] The Neanderthals, so well adapted to freezing weather were not equipped to make the change so they too, disappeared (there are other probable reasons for their extinction such as increasingly larger cranial vaults). On the other hand, since the climate was more moderate and dependable, modern man, but more likely woman was able to experiment with agriculture. As this new experiment improved the need to keep migrating became unnecessary and so settlements were established.

We are still in the Holocene and now we are talking about a new climatic change: one that is threatening the entire world. It is called global warming. On the streets and in cafés some people speak of it as simply the natural progression of the Earth's pattern of change. Other people insist that it is the end of life on the planet as predicted by the Maya hundreds of years ago. But climatologists and meteorologists, while not denying that natural climate change is taking place, feel that the natural process has been exacerbated and accelerated by human interference. They persuasively argue that pollution from industrial factories; cars' exhaust; oil refineries; deforestation and overpopulation have put undue amounts of carbon dioxide and other chemicals into the atmosphere: carbon dioxide which acts as a reflector of infrared radiation thereby keeping the heat from Earth from escaping into space. [6] The result is a rapid warming of the atmosphere around the world.

As mentioned above, cultural groups around the world have had to contend with climatic shifts such as changed rainfall patterns, longer cooling periods affecting planting seasons, shifted wind patterns, accessibility of fresh water and so forth. A brief study of a few cultures since the beginning of our era will suffice to make the point that climate change can impel or destroy civilizations, especially if it exacerbates lands that have already been overused. These civilizations are the Teotihuacans, the Mayas, the Cutah of the Mixtecs and the Medieval Europeans.

~250 BC	~500 AD	~600 AD	~900 AD	~1300 AD
Warm Trend	Cooling Trend	Cool Period	Warming	Cooling trend

Teotihuacan's Classical Period.	Teotihuacan population decrease and loss of power	Lowland Mayas intensify agriculture and building construction	Severe population decrease among lowland Mayas.	
			Mixtec Classic Period begins.	Decline of Salt producing Cutah in the Mixtec region.
Maya civilization Late Formative period draws to an end.			Rapid cultural and economic growth in Medieval Europe.	Storms and floods destroy and weaken Medieval civilization

Teotihuacan (250 BC - 500AD)

Toward the end of the last millennium before our era people in the Valley of Mexico began to aggregate in what would become the greatest city in the New World: Teotihuacan. It is not very clear what made this center a magnet but it is widely thought that the rulers had developed the proper resources, such as adequate supplies of food and water. Certainly there is ample evidence that the burgeoning city's population must have been supported by surrounding productive areas to the north which had broad areas of productive alluvial soils for adequate agriculture. Furthermore there is evidence of the tracts of drained fields called chinampas that extended through the lower Teotihuacan valley from the city down to the lake.

On the western edge of the lake there were a number of smaller settlements with a relatively larger one called today Cuicuilco. It was slightly north of the volcano Xitle which had increasingly threatened to erupt. One day, the date is not certain; it finally erupted covering all of Cuicuilco in ashes and lava.[7] Those people who were able to escape the destruction aggregated to Teotihuacan. By the beginning of our era Teotihuacan's population density had reached 100,000, and covered an area of 20 sq. km.

Transecting the city was the famous street of the dead headed by the pyramid of the Moon and flanked by the pyramid to the Sun with other minor pyramids, palaces and platforms. All of these buildings were coated with stucco and then painted. Stucco is made by rendering limestone into a powder by dehydrating it. Once in powder form it is mixed with water and, depending on the desired quality, quantities of honey. The mixture is then spread over the chosen surface. When dry a second coating and perhaps third is desirable. This provides not only a smooth surface to the building walls but also a great deal of permeability from rain water. Floors, walls, ceilings, walk ways, plaza surfaces and most impressively, complete pyramids were thus coated.

Large amounts of energy are required to produce lime for the stucco. This was achieved by subjecting the limestone to high degrees of heat from the burning of trees constantly during a few days and nights. To get an idea of the environmental damage that this had in the long run I will mention what a man who coats walls with stucco told me during one of my investigations. Twenty to thirty large limestones are required to produce about 25kgs of lime and will coat an area of 9 sq. meters. The amount of wood needed to produce the 25kgs of lime is roughly about 1 meter high by fifteen meters length. With the continued and growing demand for stuccoing of buildings the regions to the north increasingly became quite devoid of vegetation.

During the late Formative and certainly through the first four hundred years of the Classic period the rulers of Teotihuacan had established contact with communities as far away as Copan to the south east in present day Honduras and as far north as, perhaps Arizona. At first they traded in bulk obsidian from nearby volcanoes, but later with finely knapped blades for different usages for gold, feathers, cocoa, rubber, cotton, fruits, jade

and many other sundry desirable objects. As their influence grew, so did the city.

Artisans from distant places aggregated to turn raw materials into precious objects to trade for more goods. Their products made excellent trade items along with the famous Thin Orange ceramics which can be found in all the places under Teotihuacan influence.

As the vegetation surrounding the area made the production of lime and ceramics more difficult the Teotihuacans solved their problem by outsourcing. They had people who lived in areas with similar soil composition make them for them. This created a rather lose type of controlling bonds with rising cultural groups of the Mixtecan, Zapotecan and Mayan regions which for the most part functioned to the satisfaction of all.

The Classic period terminated about AD 500 with the deliberate burning of buildings along the Street of the Dead by the city's inhabitants. It is not certain what caused the uprising but if we consider the ecological collision course that they were on it certainly is possible that the failure of the rulers to provide access to sufficient food and comfortable conditions could be to blame. Furthermore there are naturally stressful conditions which affect both poor and rich in large, closely packed urbanized centers: scarcity of certain kinds of food, of water, and exposure to an overabundance of garbage and sewage.

Both Rebecca Storey and Linda Manzanilla have done studies of skeletal remains in different barrios of Teotihuacan and have concluded that for the period in question the population was quite susceptible to parasites and malnutrition. In addition Storey's studies on the remains of the population found in Tlajinga, the poorest barrio there indicate signs of chronic infection and under nutrition.[8]

These environmental and demographic trends may have been part of a much larger pattern of a cooling trend probably caused by the eruption around AD530 to 590 of a volcano preceding the present one called Krakatoa. The eruption plunged the world into a kind of nuclear winter for years (Keys 1999). It has been noticed that colder climatic spells are characteristically associated with drought, and any drought affecting the Central Highlands would have made many marginal areas like the Teotihuacan Valley especially vulnerable to desertification.

Some people - about 20,000 or 30,000 remained in Teotihuacan after the uprising while others abandoned it, migrating to various points in Mesoamerica. Some went to the Gulf coast, others to the Mixteca, the Zapotec area and to the peninsula of Yucatan among the Maya. Everywhere they went they established themselves among the elite and exercised artistic and cultural influence over the receiving groups.

Mayas (600 AD - 900AD)

Perhaps the most talked about civilization of the New World are the Mayas who seem to evoke a feeling of mystery among laymen. They too, like the other cultural groups, had to contend with changing climate after having severely damaged their environment in the tropical forests of the lowland Petén area their magnificent cities, palaces and ceremonial centers were abandoned around the 10th century to be retaken by the natural vegetation and hidden from sight until the early 19th century.

Toward the end of the Formative period most of the southeastern portion of Mexico all of Guatemala, Salvador and Honduras had a number of urban centers governed by different types of rulers. The people in these centers were aware of the existence of communities to the north, west and south of each other because of extensive trade routes. From the Maya lands sea shells, jaguar skins; feathers from exotic birds, jade, cocoa

and other products were traded with merchants from the Mexican highlands while these carried with them obsidian, mica, precious stones, and salt among other goods. Pottery from many places was greatly admired and of course the Maya elite wanted pottery from the Mixteca or Teotihuacan, the Mixteca elites wanted Orange Thin and Maya pottery and so forth. The acquisition of these status symbols was certain to increase the sense of importance of the owner.

Agriculture, in these marshlands was attained by elevating the soils in the chinampa style draining the water into canals for other purposes. [9] At first the rich soils produced excellent quality food which sufficed for the growing number of people. But as cities grew they encroached upon the rainforest which had to be cut down to make room for all the new buildings. The hunting grounds retreated with the forests and agricultural fields were pushed into less fertile regions.

The vain glory of the Mayas was their pyramids and houses which were also covered with plaster upon which fantastic murals would be painted. For the convenience of the population the floors in the plazas of the ceremonial centers were also paved with cobbles coated with plaster. Every fifty two years, as happened in all Mesoamerica the pyramids had to be killed and rebuilt more gloriously and beautiful than the one before. As the new building had to be built over the previous one it of course had to be larger.

The amount of deforestation that occurred during the Classic period can only be guessed at but one thing is certain. As the rainforest canopy disappeared and the agricultural fields which had been pushed into lands with poor quality soils became overused making the products harvested less nutritional than was desirable. Without the canopy the soils were evaporated rapidly throwing the mineral contents out of balance. This silent and invisible threat was exacerbated by the changing climate which began to warm again. Thus, toward the end of the Classic period, from the 9th to the 10th centuries we find that at the great Classic centers, one by one, there is a cessation of commemorative stelae and buildings begin to fall into disrepair. The skeletal remains of members of the nobility buried in the palaces and pyramids evince signs of tuberculosis and acute anemia, undoubtedly due to malnutrition.[10]

It is interesting to note that untreated advanced anemia can have severely negative effects on the reproductive ability of the infirm. In most cases it can cause infertility but, in those cases when a child is engendered, it is likely to be lost due to the mother's weakened state. In addition to this grim situation those children who are born frequently have severe mental disabilities because of improper oxygenation caused by iron deficiency in the blood system.

Into this scenario the next global warming trend began. The lands of the Peten, already damaged and deforested were further evaporated and made useless to sustain the Mayan lifestyles. The population slid dramatically in the region from about 1,000,000 to a scarce 10,000. The people who remained turned to hunting and gathering for their survival.

Cutah in the Mixteca: (900 AD- 1300 AD)

Nestled in the sierra of Zapotitlan in the most southeastern point in the state of Puebla in Mexico is the salt producing community of Zapotitlan, previously called Cutah. The area is a semiarid desert with xerophilous vegetation, a fairly large aquifer of saline water and a relatively small underground deposit of freshwater, the result of volcanism. It is in this austere environment that the relatively small group of people (Popolocas?) settled on the mountain top of the Cutah hill sometime in the Formative period and began to produce salt by evaporation from shallow spots where water accumulated.

In the beginning the salt must have been traded for corn and other food stuff that could complement diets based on diverse cacti, for textiles and other wanted products. With time the hilltop settlement and became a citadel with rulers that controlled the production and distribution of salt far into the Oaxaca region to the southeast, and as far away as present day Michoacan.

Cutah's rulers expanded their sphere of influence and control to surrounding hills where different members of the nobility moved to better control the production in their charge. As demand for salt grew so did production. It became necessary to dig wells in search of salt water and to terrace the hills to provide flat 3 x 3 x .10 m evaporation pans near salt water wells.[11]

Each pan had to be impermeable because it takes about three months for the water to completely evaporate. I don't really know who discovered how to make plaster (stucco) in Mesoamerica but it is evident that in this area coating the evaporating pans with stucco was common practice at a fairly early stage of cultural development. Salt then was the natural resource that gave vitality to Cutah, whose nobility intermarried with those of other polities within the Mixtecan region.

Through commerce they also came in contact with merchants from Teotihuacan who, during their diaspora, settled in the area; not as conquerors but as guests. As such they brought with them knowledge of the production of fine pottery. Although pottery vessels had been made in the area for many centuries they were of nice, but unremarkable quality. The quality required by the Teotihuacan merchants was much finer and refined. For those in the population who were not dedicated to salt production in provided another form of business.

From the 7th century Cutah and the polities in the Tehuacan Valley reached their Classic period becoming part of a lose Mixtecan hegemony with interdependencies and political demands that extended from Cholula to different places on the pacific coast and far into Oaxaca.

Sometime during the 13th century the salt water began to be inaccessible in many wells, the needed vegetation to produce the energy required for rendering lime and cooking pottery could only be found at great distances and the supply of salt could not meet the demands. Toward the end of that century the overlord of Cutah and his family were not only deposed but, killed by a stronger polity called Teozacoalco. But, if they had thought that they could revive the salt production they had to wait a long time because the world wide climatic change referred to as the Little Ice Age had only just begun.[12]

In Europe this period began with heavy and continuous rainfall gathered over the Atlantic Ocean. In the arid highlands of Mexico it began with humidity being carried away from the continent toward northern Europe by the North Atlantic Oscillation. The result was a long period of desertification that obligated the abandonment of Cutah by the majority of the people. We have no reports regarding famines or diseases but, a large number of people began to seek shelter in the mountain caves closer to the Tehuacan Valley floor. There the production of salt continued but at a much more humble scale until the arrival of the Spaniards who helped to revive it sometime in the 18th century.

Medieval Europe (800AD - 1300 AD)

The period in history referred to as the medieval period is often considered to have begun about the time of Charlemagne in today's France. It was a time in which the general climate was warming and stabilizing enough to warrant dependable agricultural pursuits. Many of the warlords began to put down their arms and

to invest in land, agriculture and animal husbandry. Religious communities such as the Cistercians cleared large expanses of land on which they built their monasteries. Through hard work and planning they brought the land to life producing wheat, barley, oats, and various legumes.

In order to make the land fertile and productive they diverted the water from streams to make ponds where fish could live and be captured easily; keep vegetable gardens humid; and irrigate the agricultural fields when necessary. The water from the streams also provided the energy to make the water wheels and thereby grind the grain that had been harvested.

The peasantry in the vicinity learned new agricultural strategies and began to use machinery that the monks had learned about from Asian merchants. The iron plow and iron tipped spades were two of their principal contributions to Europe. Another imported idea that made agriculture easier was the harness for horses to be able to pull the plow and facilitate the farmers' work. Lands were also cleared for pasturage of large numbers of sheep for the wool industry and cattle for dairy products.

But the greatest achievement of the medieval period was, without doubt, the churches and cathedrals that the monks ordered built for the glory of God and the saints. These magnificent offerings to God were made in ever greater and higher dimensions with increasing complexity and luxury. Their constructions required workmen of all kinds, from stone cutters, masons, glass makers, designers, masons and architects. Farther away the stone had to be quarried and transported either by land or, preferably by boat or rafts. Either way there was a large demand on trees as boats and carts were made of wood.[13]

The frames for the buildings themselves were made of wood as were the ladders and other structures for construction. As buildings took on greater and greater dimensions the size and length of the logs also grew. The demand for wood kept growing.

There were some unsuccessful experiments with iron as a replacement for the increasingly scarce long wooden beams that had to be used to span the widths of the naves in the churches. To be sure, iron had been in use since before the Romans however it had been almost exclusively used for armor and weapons. Now it was being used to construct buildings, to make, and to improve agricultural tools. The demand for iron products required the felling of trees to stoke the fires for the foundries. [14]

The production of glass for the fantastic stained glass windows that we admire so much in the gothic churches and cathedrals also required large amounts of energy for their making.

Towns and cities sprouted everywhere and the dwellings, shops, taverns and inns in them were made of wood. Bridges spanning the waterways that connected roads leading to the towns were also made of wood. Homes were kept warm with wood and food was prepared with wood. Wood was a natural resource that seemed inexhaustible.

By the mid 13th century the resources had been greatly depleted; so much so that to meet the demands they had to be imported from Finland and parts of Western Russia.

About this time there began a climatic shift that was punctuated by severe storms with large amounts of rainfall that damaged the crops triggering episodes of famine throughout Europe. The wet conditions were such that landed gentry had to abandon the prospect of agriculture along with their peasants. Even the grazing animals such as sheep and cattle were affected by the wet soils as their hooves. As the wet years progressed fewer crops were brought in, granaries were emptied to the point that people were reduced to

grinding nut shells to provide themselves with some sort of food.

The lack of adequate nutrition greatly debilitated the health of the weaker members of society. Into this weakened scenario the virulent virus commonly called the Black Death entered in the second quarter of the 14th century killing 3 out of every 5 people. Most of the philosophical, scientific, mathematical and astronomical advances were abandoned as the survivors went about the business of living as well as they could.

Global Warming (2000 AD - ?)

I have just reviewed the rise and fall of a few civilizations which damaged their environments so greatly that when the climate changed their people were unable to sustain their life styles and were forced to make dramatic changes in order to survive. These are but a few examples of what has happened around the globe at different periods during the past two thousand years. It seems clear that climatic change is a natural event for which we must always be prepared to make the appropriate social and cultural changes. But, this would not be likely to happen because the change, except in the case of volcanic actions, is usually gradual and therefore, imperceptible.

A great difference from the examples above is the climate change taking place today. One big difference is the speed and intensity at which this global warming is occurring and that it is undoubtedly anthropogenic. Before the Industrial Revolution in the second quarter of the nineteenth century the levels of carbon dioxide in the atmosphere had remained at a regular constant throughout the history of the planet. But the Industrial Revolution hailed a period of wealth in which material goods would become more available to many people around the world. Those goods would be made in factories where machines would change the raw materials into new products. The machines would be powered by burning coal - a carbon based mineral. Greater access to new products created greater wants perceived as needs. As time progressed industrialists' dependence on coal shifted to a somewhat cleaner source of energy: petroleum. Both of these energy sources require burning so great amounts of carbon dioxide and methane are released into the air in quantities never before seen. In addition, for millions of years carbon dioxide and methane from dead animals and vegetation have accumulated and been trapped in the sediments beneath the glaciers in the north and south poles. As the polar ice caps melt, so do the frozen gases within them. These gases are released into the already dense air thus adding more pollution into the stratosphere. In turn they contribute to an increase in temperatures which accelerate the melt down the ice caps.

Houston: A present day case study

The meltdown of the polar caps is causing sea levels to rise in different parts of the world at a speed that is obligating governments to find ways to solve problems such as salinization of aquifers which provide the necessary fresh water for everyday living and procurement of food in the form of agriculture. In the Gulf Coast of Mexico, from western Louisiana to Matagorda in Texas the Chicot Aquifer is becoming rapidly salinated. This aquifer which underlies the city of Houston on the eastern side is also underlain by the Evangeline Aquifer which in turn is underlain by the Jasper Aquifer. The last two recharge and discharge to Houston's northwest, while the Chicot discharges to Houston's east. The three aquifers are separated from one another by layers of clay lenses which, while wet, are impermeable but could collapse if the lenses should dehydrate.

Studies of the pollution in the Houston area have been made on a rather frequent basis in the hopes of persuading the responsible industries to make favorable changes someday. Most of these studies indicate that airborne air-chemistry measurements throughout a calm day will show high concentrations of ethylene,

propylene, and nitrogen oxides indicating that the source of the pollution in the ozone rich air is primarily industrial: from the facilities along the Ship Channel and the western shore of Galveston Bay. [15]

One such study reveals that Houston's air pollution does not always readily dissipate. There are times when meteorological conditions help to concentrate it near the ground trapping a mass of unmoving air over the city. In *A Bad Air Day in Houston* Banta and his team wrote that one day in August of 2000 the air was rife with ethylene, propylene, and nitrogen oxides. The pollution formed a "spectacular" wall of ozone reaching more than 1Â½ km. high, with very high concentrations of 200 ppb occupying much of the volume that did not move until early afternoon when a slight westerly breeze began to move it out to sea at 1 km per hour. By mid afternoon a sea breeze moving at 2 km per hour began to blow toward the oncoming pollution which made it uplift. Late that night both the westerly and the easterly winds converged lofting the pollutants high over the entire coastal zone toward Beaumont, Port Arthur and inland to Austin and San Antonio; a distance of about 200 miles[16] . As the breeze carried the pollutants inland it was undoubtedly dropping some on to pasture lands and agricultural fields, affecting the quality of the nutrients that the fauna, including ourselves is consuming.

In addition to the contaminants carried across the landscape by the breeze are those captured in the fresh water features such as lakes, rivers and streams where they were deposited from air borne pollutants from tailpipes, smoke stack emissions and excess nutrients from farm fertilizers and animal wastes. It would seem that there is no place within a radius of two hundred miles of a city that is safe from contaminants.

Farm lands and agricultural fields in east Texas are increasingly depending on fresh water to irrigate the crops of sugar cane, cotton, citrus fruits, rice, soybeans, and hay because of frequent episodes of drought. But, over the past decades increased urbanization, industrialization and intensified agriculture have reduced the quantity and quality of watersheds to the point that the practice might soon be unsustainable[17] .

This scenario is compounded by the need for fresh water which is used in private homes for sundry purposes but mostly to provide the thermoelectric power required by the petrochemical industries. Fresh water is likely to become increasingly scarce as sea levels rise. The Chicot and Evangeline aquifers, to the east and north east of Houston have already begun to become salinated and the city mayors of the metropolitan area have asked for advice from the Trans-Texas Water Program to propose desalination procedures. After conducting the survey the Texas Water Program authorities advised that they be left as they are because pumping the brackish waters out of either the Chicot or the lower Evangeline would very likely result in subsidence which is already a great problem in the region. They pointed to the records which show that between 1900 and 1995 more than nine feet of ground have subsided in the region. What is more, they warn that excessive pumping such as was done in 1998 further subsidence of one or two feet will undoubtedly occur in the vicinity of Houston Ship Channel by 2030. The San Jacinto Monument which commemorates the victory of the â€˜Texicans' over the Mexicans is next to the Ship Channel and has already suffered the impacts of subsidence with some of the monument park land already under water and the monument itself at a tilt as a result of subsidence.[18]

An added consideration to the practicality of desalinization processes is the conundrum of where to dispose of the salt removed. It cannot be released into the sea because it would upset the chemical balance of the water and risk the survival of species. Kept on land posits another problems such as leaching into the freshwater sources. Fisheries, another important source of income for Texas, are already vulnerable to water quality declines in coastal areas because of the contaminants that threaten to kill fish or to make them unfit for human consumption. Increases of salinity would definitely upset the chemical balance of the water and risk the survival of various species of fish and shrimp that spend the early part of their life cycles in the brackish

waters of the coastal marshlands.

Subsidence and salinization of aquifers are only two of the problems threatening the Houston area. There is also the issue of ill health among most Houstonians, especially those living in the eastern portion of the city where people suffer from allergies, pulmonary difficulties resulting in asthma, pneumonia and bronchitis. This is not surprising because it is to the east, along the Ship Channel and the western shore of Galveston Bay where most of the petrochemical industrial plants, power plants and refineries are established. Every one of them belches different amounts of ethylene, propylene, and nitrogen oxides into the air on a fairly constant basis.

Still, not all of the health issues are the direct result of industrial emissions, but they are compounded by them. For example; in this humid area air pollution can be aggravated by a small increase in temperature causing a drastic rise in the heat index which in turn provokes asthma. This is especially noticeable among the poor and minority children who do not have adequate access to air conditioning. As it is, asthma among preschoolers 3 - 5 years of age rose by 160% in the United States between the years 1980 and 1994.[19]

Houston's warm weather has always come with large numbers of mosquitoes and fleas. During the nineteenth century yellow fever was a yearly calamity that culled out large numbers of people every year and died out when the temperatures began to descend into the lower 60s in September. After World War I mosquitoes were identified as the vectors of this scourge and great steps were taken to eradicate them or at the least, avoid them. But, in spite of all efforts the disease was never totally conquered; medical advances just made it curable.

A dilemma that we now have in Houston is that temperatures inferior to 61Âº F are less and less frequent. On the contrary, warm to hot is beginning to be the norm here. That means that the environment is just right for insect carrying diseases to pullulate straining the health care system with an increasing number of cases of encephalitis, West Nile virus, malaria and Lyme disease. In addition as tropical weather has expanded into the area, dengue, a tropical disease caused by mosquitoes has begun to appear in the Houston area.

Another heat related problem that will soon affect the health care system is diarrhea from dehydration. This frequent health assailant is worst among the elderly and very young. While at this time it is not yet a great problem here, the bacteria that causes diarrhea does spread mostly through unclean water and food it has the potential to be one, especially as supplies become contaminated by high rainfall, flooding or conversely, drought.

This particular coastal area has always been prone to flooding and many attempts have been made to control the waters that flow southeastward from the Great Plains into the Gulf of Mexico. In the late 50s and early 60s the rivers were dammed in various places creating recreational lakes such as Conroe, Livingston and Houston. Bayous which crisscross the city capturing the excess moisture have been extended and deepened. Undoubtedly these controls have prevented greater flooding. Nevertheless, flooding occurs in Houston a number of times each year. Whenever it floods the toxics from air pollution that have lain on the ground get stirred around and replaced elsewhere in the city or else into the waterways. This of course affects the health of all animals since the particulates in the air contain seven types of carcinogens - diesel particulate matter, 1,3-butadiene, formaldehyde, acrolein, chlorine, and hexamethylene diisocyanate. [20]

Conclusion

The following ancient Spanish saying of probable Arabic origin comes to mind as sound advice: "*Cuando las barbas de tu vecino veas trasquilar; pon las tuyas a remojar*". Roughly translated, this says "When you notice that your neighbor's beard is being shorn, start to soak yours". What if anything, have we learned from lost social groups? Have we learned to recognize the signs in the landscape of subtle changes in our environment that we have degraded or modified for our economic well being and taking the proper, logical steps toward rehabilitating the coastal plains or are we simply looking for more ways to control nature.

Here in Houston we are still making projections to increase the population, expand the urban areas, improve industrial complexes and dredge the Ship Channel to deepen it and make it more comfortable for ocean vessels. This in spite of all the evidence that the industries in the vicinity of the channel have polluted the air and water with different carcinogens during the past hundred years and must have settled at the bottom of the Gulf of Mexico. To dredge the bottom would dislodge them and threaten the lives of all creatures in the ecosystem including that of humans.

It seems that we are caught up in a spiral that demands benefits to the economy - as if it were an insatiable god - at the expense of the health of the citizenry. Much like the Maya elite who were unwilling or unable to make adequate changes to their life styles in order to relieve their stressed fragile ecosystem we see that our governor and industrialists follow in their footsteps.

Looking at the catastrophic effects that climate change has had upon damaged environments in the past and the resulting impact upon the most culturally rich populations, one wonders what awaits us.

Lesson Plans

This coming year I will be teaching science and social studies to fifth graders and my intentions are to awaken in them the realization that everything on this planet is connected to something else and that what affects one factor will undoubtedly have an effect of equal magnitude elsewhere. With this in mind and after the standardized testing period is over in late April I will be able to implement all of the lessons derived from this curriculum unit. It will be a good time to review many scientific concepts and truly integrate them into an interrelated whole.

Lesson I

I will remind the students that the Earth spins at a tilt of 23.5 degrees perpendicular to the ecliptic. As I remind them I will be spinning a world globe a foot away from a light source. Then, while still spinning I will ask the group to tell me what they can deduce from this fact.

I am certain that after a short while someone will venture to suggest that the sun is shining most directly upon the equatorial latitudes and that there is probably a greater quantity of evaporation taking place there. After agreeing with the student I will ask how that would affect the islands in the tropical zones. They of course will suggest greater amounts of humidity and perhaps rainfall.

At this point I need to have them focus again on the movement of the globe and show them how its movement disturbs the air in the troposphere. In addition we will discuss how warm air rises and cool air undercuts it. This will serve to introduce to the students the idea of how the winds will then be dispersed.

Their text book has a very good chapter on coriolis effects on wind currents and therefore, rainfall and wind patterns. I will have the students draw arrows on their individual world maps indicating the prevailing wind directions in different latitudes. Once they have grasped the idea I will ask them to make a relationship between wind coming in from large bodies of water over land and that which comes from land over more land. I expect them to realize that the wind will be moving along air heavy with moisture from the oceans and dropping it over land. The further it travels over land the air will have less moisture to move along so the rainfall will be less frequent or intense farther inland.

Since the purpose of this lesson is to connect the Earth's tilt, solar radiation and climate change, I will have to posit to them the question about what would happen if the Earth tilted just one degree: to... say 24.5. After a brief discussion I would ask them to spin the globe at just a bit more tilted an angle in front of the light source. I am hoping that they will be able to perceive the difference in location receiving the direct light rays. That of course, will be the new equator.

Then I will hand them another set of individual world maps and have them draw the new equator and redraw the wind patterns of the previous lesson. They will undoubtedly see that the rain and wind patterns will have shifted slightly to the south and hopefully realize the probable effects to the biosphere.

After a while of discussion I will assign to the students a short essay in which they will write about the effects that the tilt of the Earth has upon the climates around the planet. They will be expected to complement their work with convincing illustrations of specific biomes and their place on the Earth.

Lesson II

In the first lesson the fifth graders learned about the effects that a shift in the tilt of the Earth can have upon its global climates. In this one I intend for them to learn that other factors can also affect the stability of climates around the planet, so I will introduce them to the effects that a major volcanic eruption can have.

I will begin this lesson by telling the students the story about Xitle's eruption and subsequent destruction of Cuicuilco in the highlands of Mexico millennia ago, the migration of its survivors and the aggregation to Teotihuacan. Availing myself of slides of maps and pictures of Teotihuacan I will show the students some of the murals within the palaces, Teotihuacan pottery and the geographic extension of its people's influence. As I show the power point I will explain to them the diverse ways in which the Teotihuacanos went modifying the landscape and the resources that they used: the diversion of the water, the raised soils, the production of lime and the deforestation that all of this required.

Then I will tell them about how a major volcanic eruption half way around the world about the year 500 AD caused a three hundred year cooling period around the world. The students will be asked to consider how the world wide cooling period will have affected the lives of the Teotihuacanos.

After this, the students will be directed to consider the changes that the cooling period would have on the local vegetation, the fauna, the rainfall, and the water ways; and, finally to consider the impact of the changes upon the lives of the cultural group.

To finalize this unit I will tell them another story: one that speaks of the southbound migrations that great numbers of Teotihuacans had to make; and of their efforts to merge with the hosting groups; of the barely habitable lands left behind and of what became of their great civilization.

Lesson III

This is probably an excellent time to discuss how after the cooling period came a warm trend sometime during the 9th century and the positive effects that this had upon the development of various civilizations, but I will focus on conditions that led to the development of Europe's Medieval period.

Before the students begin this unit we will discuss how the same cold period that forced the Teotihuacans southward also affected the Nordic peoples and their desire to find food and sustenance. We call these people Vikings.

The students will consider how latitude can affect the way in which people react to the prevailing climatic conditions. They will compare the strategies that the Vikings used to cope with the frigid climate and the ones to which the Teotihuacans resorted.

But before we can proceed it will be necessary for students to learn about the Vikings; who they were; and what the ecosystem in which they lived was like. They will learn about the natural resources available to them and the population's strategies to procure their food, shelter, and safety.

Lesson IV

Since the purpose of these lessons has been to teach about the shifts that social and cultural groups have to make in response to climate changes the students will begin to learn about the warming trend that began during the 9th century. They will become aware of how the longer and warmer periods permitted greater opportunities to plant and harvest different foods, to put aside sufficient grain for the next planting season and to practice the animal husbandry that would provide the necessary meat and milk products.

These improved conditions allowed the population in general to enjoy better health and to dedicate their free time to interests beyond survival: industry, commerce, construction, contemplation, and study. In order to better explain these changes I will show the students pictures of villages, convents, churches, cathedrals, universities, and even hospitals built during the height of the Medieval Period.

Inclusive in this lesson will be a stress on the modifications to the landscape that these people made. The students will realize that all of the improvements were made to enhance their lifestyles as well as the general economy. They did not realize that they were sowing the seeds of their own destruction when the climate would change again in the late 13th century.

Activities for this lesson will include research into: rock quarrying, iron smelting, construction of buildings, forest management, sheep herding, weaving of wool, boat and land transportation; all of them activities of the high medieval period. The research papers will be expected to reflect sound investigation into the subject and a clear understanding of how careless pursuit of progress can affect a civilization. The research papers will be shared with the other students with the intention of bringing about thoughtful discussions with their peers.

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