Developing an Educational Module on the Impacts of Climate Change on Puerto Rico and its Inhabitants

An Interactive Qualifying Project (IQP) to be submitted to the Faculty of Worcester Polytechnic Institute (WPI) in partial fulfillment of the requirements for the degree of Bachelor of Science

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Abstract

Small islands like the island of Puerto Rico are susceptible to the negative effects of anthropogenic climate change. Because of this, it is important that climate change education is developed and implemented on the island so that the population, especially its youth, can adequately adapt to climate change. The goal of this project was to develop effective lessons that could be used to teach middle school students in Río Grande, Puerto Rico about the immediate and long-term effects of climate change. These lessons were designed to be relevant to the students by providing evidence and examples of climate change in the island of Puerto Rico. Through the use of interviews with experts on climate change, members of environmental education initiatives, and teachers, we were able to determine what material to incorporate into our lessons and how to best deliver it. To analyze the effectiveness of our lessons we tested our lesson on a ninth grade class and utilized a pre-test and a post-test as a method of evaluation. These tests asked questions based on the learning objectives covered in the lessons, and were then compared using statistical analysis. The analysis showed a significant increase in understanding climate change based on the information provided in the lessons. Additional evaluations suggested that the lessons required further development to incite a greater increase of student knowledge on climate change. We revised the lessons, and recommend that they be tested further and in different settings. Additionally, we developed supplemental lesson outlines to deepen student understanding of climate change topics that are relevant to Puerto Rico. We recommend that these outlines be further developed and tested so that they may encourage climate change education and help pave the way to having a more environmentally conscientious Puerto Rican youth.

“Education is the most powerful weapon
we have to change the world.”

-Nelson Mandela

Executive Summary

Background

Throughout the world, it is apparent that anthropogenic climate change is having more and more adverse effects on the environment and on society as a whole. These effects are varied, and can range from the destruction of coral reefs and other marine ecosystems to increased instances of water-associated diseases such as malaria, cholera, dengue, and viral encephalitis (Boelee et al., 2012; McMichael et al, 2006). In the Caribbean, the effects of climate change are more tangible and observable, as the region is comprised of small islands, which will be impacted by even the most minute effects of climate change, when compared to a large-scale continental region of the world. Specifically, the Caribbean will face rising sea levels, coastal erosion, habitat shifts, and changing precipitation patterns (Nurse et al., 2014).

In Puerto Rico, these effects are already apparent, and include, among others, the loss of coastal regions and changes in precipitation. The island's various ecosystems are all vulnerable to the impacts of anthropogenic climate change. El Yunque National Forest (EYNF) is one such ecosystem that is currently experiencing the effects of climate change, such as erosion, habitat shifts, and species endangerment. As a result, the island has seen the development of several initiatives and legislative changes to combat this issue. One of the most imperative aspects of this devlopement is the education of the public on the causes and effects of climate change. It is especially imperative that the Puerto Rican youth are educated, as they are the future decision makers of the island. Through education, effective adaptations to climate change can be made by the public, which can allow for a more sustainable lifestyle and, ideally, the prevention of more severe effects of climate change.

Methodology and Results

<u>The goal of this project was to develop an educational module for middle school students of Río Grande, Puerto Rico, which is a city just outside of El Yunque National Forest.</u> This educational module was intended as the first step towards the development of a climate change curriculum to be administered by our sponsor, the United States Forest Service (USFS). This curriculum would be able to be used by teachers and other environmental education groups, and would include material that focused in particular on the region. To achieve this project goal, our team developed the following project objectives:

1. Identify the main concepts and concerns with respect to climate change in Puerto Rico.
2. Determine the best way to educate middle school students in Río Grande
3. Create an educational module for the area and our targeted students
4. Evaluate the effectiveness of our developed learning unit and revise as necessary.

Our sponsor selected a local middle school for our team to use as a resource for our last three objectives. This school, the Carmen L. Feliciano Carreras del Sector Palmer Middle School, is a Spanish language middle school serving grades seven through nine, and is just ten minutes from El Yunque, in the city of Río Grande. More specifically, we were paired with a ninth-grade class in this school. The entire class was also a participant of an environmental youth initiative known as 4-H. The school integrates extracurricular activities with electives instead of having them after school. Therefore, the class participated in the 4-H organization primarily as an integration with their visual arts elective. As members of 4-H, the class often took field trips to El Yunque, and had already formed a strong relationship with our sponsor.

This first objective was to identify what concepts and concerns that experts in various fields related to climate change were aware of. Thes experts included technicians and managers associated with the USFS, professors at the University of Puerto Rico, as well as participants in various environmental education initiatives. Through interviews with these people we were able to determine what the content of our lessons should be and what kinds of activities and topics had been successful in similar initiatives. We received a general consensus from these interviews that the Puerto Rican public was generally unaware of, and lack of concern about, climate change. This was inclusive of the youth that our lessons were to be geared towards. As such, we were frequently advised to make our lessons introductory, to start the process of emerging students into the topic of climate change, but also relatable by providing local examples in order to drive the point home and emphasize the importance of the topic in a manner that would make the students care.

To understand exactly how we would develop our lesson plans, we went to the school in which we would be testing the lessons to learn more about the classroom structure of the school itself. We met objective 2 in two parts: classroom observations and teacher interviews. In our classroom observations, we noted that lectures were conducted in Spanish, but classroom materials, such as activities and informative posters, were often in English. We took this to denote that there was at least some understanding of and exposure to English amongst the students, allowing us to implement the use of graphs and figures in English as needed in our lessons. We also observed that the time in class was a mixture of lecture and interactive group/class activities, which gave us the flexibility to include both in our lesson.

We interviewed three teachers to further our understanding of the school's academic structure. These interviewees consisted of a mathematics teacher, a general science teacher, and a visual arts teacher. We received a wide variety of information that helped guide our lesson plan development. This included how typical classes were structured in the school, how the teachers plan their lessons, and the integration of climate change and the environment into the class material.

Once we understood what topics we were going to include in our lessons, as well as how to execute them, we began the development of our educational module (objective 3). We utilized background research on creating a curriculum and general pedagogy in the development of our lesson plans. We first created 7 learning objectives that we intended to be achieved by our two lessons, such as "Students will be able to identify sources of CO_2 emissions." We created activities, homework assignments, discussion questions and diagrams to address these learning objectives. In the first lesson, we covered topics such as the greenhouse effect, the different greenhouse gases, the relationship between carbon dioxide emissions and global temperatures, the carbon cycle, and sources of carbon dioxide emissions. The impacts of climate change such as rising sea levels, changes in precipitation patterns, and changing conditions for plants and animals were discussed in detail in our second lesson. We developed a PowerPoint presentation in order to display the graphs and diagrams of our lesson. In addition, we created student worksheets that included these same diagrams and graphs for students to complete and materials for the activities of our lesson. In order to make our lesson easier to use, we wrote an instructor's guide to teaching each facet of our lessons with extensive explanations of the many complex concepts that were incorporated in our lesson. Lastly, we translated all the written components of our lesson to Spanish to increase the usability of our lesson.

Once the lessons were developed, we proceeded to administer our pilot lessons to the 4-H class of students at the Carmen Feliciano Carreras Middle School and test its effectiveness

(Objective 4). We administered our pre-test, post-test, and lessons over the course of three days. On the first day, we delivered a pre-test to the 4-H students, as well as distributed a student questionnaire to the four other classes of ninth graders. On the second and last day, we delivered lesson one and lesson two to the students, respectively. Immediately following lesson two, we delivered the post-test. The comparison of the pre-test and post-test results for each student can be seen below.

Student #	Number of questions correct (Pre-test)	Numbers of questions correct (Post-test)
1	3	9
2	8	7
4	2	1
5	5	8
6	5	9
7	4	5
10	5	8
11	5	5
13	7	6
14	3	6
16	8	9
17	5	8
18	6	7

Using the data from the pre- and post-tests, we performed a paired samples t-test within subjects statistical analysis to determine whether our pilot lessons were effective. This test worked under the assumption that there would be no increases in test scores between the pre- and post-tests, also known as the null hypothesis. The application of the paired samples t-test within subjects showed a statistically reliable difference between the mean number of the pre-test (mean = 5.08, sd = 1.85) and the post-test (mean = 6.69, sd = 2.25, t= =2.63, df=12, p = .022, α = .05). Because the p-value was less than or equal to .05, we were able to reject the null hypothesis, and definitively conclude that our pilot lessons were effective in increasing the students' climate change knowledge at the 5% significance level.

After the formal testing of our lessons, we completed a process of revisions on the lessons we administered. These revisions were largely based upon the changes in score of the students on each learning objective, from the pre- to post-test. In order to obtain a breakdown in student learning by objective from the pre- to post-test, we calculated the mean number of students that answered each question correctly. Then, we grouped together questions of the same learning objective and determined a rough average score for each objective. We informally compared these scores and decided upon which learning objectives needed to be addressed by revisions. Additional edits were also made according to the suggestions of the teacher of the 4-H class. After these major revisions were applied, we developed 4 additional lesson outlines that briefly explained different topics and activities that could be used to provide a more complete learning unit on climate change in Puerto Rico. To accompany the additional lesson outlines, we created a bibliography of different activities that detailed various supplemental activities, their sources, and where one could utilize them within the context of our learning unit.

Recommendations

Our overarching recommendation to those looking to expand upon this project would be to continue the development and testing of our learning unit. Particularly, we recommend that any future iteration of the project conduct validity and reliability tests on their pre- and post-tests, as these analyses can definitively state whether these tests are an appropriate representation of the learning objectives. Upon further expansion and testing, we believe our learning unit can become an extremely useful educational resource for teaching anthropogenic climate change, and how it specifically affects Puerto Rico and its inhabitants.

Acknowledgements

It has been an honor to work on this project and to be a part of the movement to preserve the landscape, environment, and future of Puerto Rico through the education of youth on the topic of climate change. We would like to thank our sponsor, the United States Forest Service (USFS) for providing us with the opportunity to work on this project, as well as our liaisons Pedro Ríos and Felipe Cano, both of the USFS, for the resources and time they've put into making this project a success**.** Additionally, we would like to thank Worcester Polytechnic Institute (WPI) for the opportunity to complete our Interactive Qualifying Project (IQP) in the Puerto Rico project site, and our academic advisors, Professors Tina-Marie Ranalli and Lauren Mathews, for their continued guidance and support throughout the course of this project. Thank you to Professor Stephen McCauley for his guidance in constructing our project proposal during the preparation phase of this project. We would like to thank the USFS technicians Benjamin Fuentes and Bruce Drapeau for providing transportation to and from El Yunque, as well as to the school in which we tested our learning unit.

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1. Introduction

Climate change is the modification of the Earth's climate resulting from changes in the atmosphere as well as interactions between the atmosphere and other factors within the Earth's system (Cusbasch et al., 2013). This change in climate can range from local seasonal changes to a global shift in weather patterns. While it is a natural occurrence, since the latter years of the Industrial Revolution (1820-1840) the planet has seen unusually dramatic changes in its climate as a direct result of human activity. Human influenced (anthropogenic) climate change, including high emissions of greenhouse gasses into the atmosphere and deforestation, has resulted primarily in an increase in the Earth's temperature by 0.9°C in the span of twenty years. This form of climate change, known as anthropogenic warming or global warming, coupled with natural climate change has had and continues to have undesirable effects all over the world (Cusbasch et al., 2013).

Though climate change is considered a global issue, the effects it has on different ecosystems and biomes are extremely varied. For example, in northern Canada there was a 20% decrease in the polar bear population between the years of 1987 and 2004. This decrease has been correlated to decreases in the amount of time that sea-ice is present in the habitat, one of the effects of climate change. This results in longer fasting periods for the polar bears on land and inadequate fat reserves for them to live off of as they fast (Guardia et al., 2013). Furthermore, in sub-Saharan Africa, there has been a trend towards decreases in the precipitation of the area since 1970. Additionally, there has been a doubled rate of rain runoff which, coupled with increasingly variable levels of precipitation, has resulted in more severe floods (Boelee et al., 2012). This high variability of rainfall in the area is predicted to become even more variable with climate change. Therefore, wet seasons and dry seasons will become more extreme, which will lead to millions of people experiencing increased water stress during dry seasons by the year 2020. One product of this stress is the increase of water-associated disease burdens (Boelee et al., 2012) including viral diseases such as malaria, cholera, and viral encephalitis (McMichael et al, 2006).

Likewise, tropical rainforests throughout the world have also been affected by climate change. These forests are important natural regulators of the planet's atmosphere, as they are partially responsible for the removal of carbon dioxide (CO_2) from the atmosphere (Ricker, 2007). They are a great source of biodiversity and pharmaceutical treatments, such as the rosy periwinkle of Madagascar, which is used today as a part of cancer therapy (Curry, 2012). Higher concentrations of CO_2 combined with higher average temperatures and changed precipitation patterns alter the behavior of plants in a tropical rainforest by changing photosynthesis and respiration rates. Such changes in tropical rainforest vegetation are concerning, considering their key role in regulating the essential carbon, water, and nutrient cycles of the forest (Ostendorf et al., 2001).

Similar to other tropical rainforests around the world, El Yunque National Forest, in the Commonwealth of Puerto Rico, is currently experiencing changes due to shifts in the climate of the area (Billmire et al., 2008). Throughout the island of Puerto Rico the average minimum temperatures have risen over recent years at rates higher than typical global warming trends. The effects of this are especially noticeable in El Yunque, where the rain patterns of the region have changed, resulting in more drastic dry and wet seasons, as well as a trend towards a drying of the forest. If these trends continue, the result could be a complete change to many components of the forest including the local extinction of several indigenous plants and animals (Billmire et al., 2008).

Unified global cooperation to mitigate the effects of climate change has thus far been unsuccessful (Rao, 2014); instead, the efforts of individual governments, non-governmental organizations (NGOs), and communities have shifted to adapting to climate change. These efforts include government regulations and objectives (Swedish Environmental Protection Agency, 2012; United Nations Environmental Programme, n.d.), agricultural adaptation (Yulandhika & Nugrahanti, 2014), community engagement, and education. Educating community members, especially youth, on climate change is a particularly useful method of communicating the importance of adaptation to climate change, since education can encourage support for policy changes (Yulandhika & Nugrahanti, 2014) and unify communities to adapt to climate change as a whole (Cano, personal communication, 2014). As the effects of climate change in Puerto Rico continue to manifest themselves, the need for climate change education will become greater. While there have been initiatives to develop effective educational materials on this issue, the lack of environmental literacy of youth in the area, as well as their families, continues to be problematic (Cano, personal communication, 2014).

Our goal was to develop an effective education module that can be used to teach middle school students in the city of Río Grande, just outside of El Yunque National Forest, about the immediate and long-term impacts of climate change. In order to achieve our project goal, there were several objectives that must be reached. We first identified the main concerns of local environmental experts, in relation to climate change. We also identified how the education system is structured in middle schools in Río Grande. We acquired this information through the use of classroom observations and interviews with teachers. By doing this, we ascertained the best ways to educate local students on climate change. Using the information gathered, as well as applying various principles of pedagogy, we developed a learning unit to be used by the USFS to be distributed to teachers as they see fit. In addition, we delievered two lessons of our module to a 4-H class in the Carmen Feliciano Middle School in Río Grande. By conducting pre- and post-tests we developed for those two lessons, we evaluated the effectiveness of our learning unit. This information was used to modify our educational module to increase its effectiveness. These steps helped us pave the way towards preparing a more environmentally conscientious youth for the future effects of climate change.

2 Background

2.1 Introduction

The area that is currently designated as El Yunque National Forest has been an important area in Puerto Rico for hundreds of years, and adds a fundamental depth to the culture and history of Puerto Rico. To understand the importance of climate change literacy in the area today, it is vital that one understands the history of the forest, as well as how climate change may adversely affect it and its surrounding communities. By understanding climate change education and education as a whole, one is able to convey the importance of these topics in a manner that can result in a positive change for the forest. In this chapter, we intend to enrich the understanding of this project by providing in-depth information about the history of El Yunque National Forest, climate change in the world and in Puerto Rico, and various aspects of education including climate change education, STEM education, pedagogy, and curriculum development.

2.2 El Yunque

El Yunque National Forest has been viewed as an important area of unique nature and of nature conservation since prior to the arrival of the Spanish to the New World. The Taíno Indians, who were the indigenous people of Puerto Rico, viewed the land that is now known as El Yunque to be sacred. It was believed that the supreme god Yucahú lived in the forest, and that the forest's waters had religious properties (Luquillo LTER, 2014). Even after the Spanish colonized the Americas and the Taíno no longer had a presence on the island, the forest was still viewed as an important region on the island of Puerto Rico. When Puerto Rico was still considered a colony under Spanish Rule, the forest was proclaimed by the Spanish king as a forest reserve, one of the earliest existing reserves of the Western Hemisphere, to be regulated by the Spanish Forest Service (United States Department of Agriculture, 2013).

When the island was acquired by the United States following the Spanish-American War (April, 1898 – August, 1898), the American government made efforts to maintain the forest, the names of its various geographic landmarks, and its status as a forest reserve as it was under the Spanish Crown. The forest reserve was renamed as the "Luquillo Forest Reserve", and several initiatives were recommended to ensure that the forest remained intact for the conservation of both the ecological and economic feasibility of the region. In 1904, during one of the first American analyses of the forest, tropical forest expert and university professor John C. Gifford

(1905) stated that the forest lands should be maintained and protected to prevent an otherwise disastrous end to the forest. In this same analysis however, Gifford encouraged using the forest as a source of lumber to be used and sold, which eventually led to dramatic deforestation.

During the Great Depression, El Yunque, like much of the United States, was affected by the New Deal programs enacted by President Franklin D. Roosevelt (mid 1930s) to lift the country out of its economic state. Here, the Civilian Conservation Corps - also known as The CCC or “Las Tres C” in Spanish - planted a large variety of trees to restore and reforest El Yunque (United States Department of Agriculture, 2013). The help of the CCC revitalized the forest, replacing many of the lost trees for newer ones. During this time, the group was proactive in identifying trees that were older and could be used for lumber, allowing the younger trees to grow and reforest El Yunque. The CCC also developed roads, trails, and facilities, some of which are still used today, to make the forest accessible to the public (United States Department of Agriculture, 2013).

It was originally thought that El Yunque contained very little animal life. In 1904, Gifford commented in his analysis of the forest that there was minimal animal life present during his observations (Gifford, 1905). However, the wide variety of trees planted by the CCC sparked an interest in the biodiversity contained within El Yunque. Starting in the 1940s, research was conducted to understand and catalogue these many tree types, as well as the forest’s natural reforestation patterns. As the years progressed this research segued into observation of both the flora and fauna found in El Yunque. Since then, several native animal species have been found in the forest, including the Elfin Woods Warbler (*Setophaga angelae*), the Puerto Rican boa (*Epicrates inornatus*), several species of coquí frogs , and the endangered Puerto Rican parrot (*Amazona vittata*) (United States Department of Agriculture, 2013). Additionally, ancient petroglyphs made by the Taíno Indians, as well as 50 types of orchid flowers, have been discovered in the forest (Luquillo LTER, 2014).

Puerto Rican Boa (Photo: El Yunque National Forest Archive); Orchid Found in El Yunque (Photo: Princesa Cloutier); Taino Petroglyph (Photo: Rex Cauldwell)

El Yunque is an incredible source of biodiversity for the island of Puerto Rico with its many species of flora and fauna. It serves as a window to the history of the island, and even as a home to animals that are iconic to the Puerto Rican identity, like the coquí. The existence of El Yunque preserves part of the rich history and beauty of the island, yet the present and future impacts of climate change may have significant negative consequences for the forest.

2.3 Climate Change

By definition, climate change refers to the cyclic variations of climate conditions throughout Earth's history. The phenomenon of climate change is one that has been occurring naturally for hundreds of millions of years. Indeed, in just the past 650,000 years there have been seven distinct periods of glacial ingress and egress, meaning that the Earth goes through phases of global warming followed by glacial periods (Cusbasch et al., 2013). The problem that currently faces society in relation to climate change is not that it is occurring, but rather the alarming rate at which climate change is happening.

2.3.1 The Tropical Rainforest Biome

El Yunque National Forest (18°19' N) is an example of the tropical rainforest biome. It is located in an equatorial region of the world (28°N to 28°S), like most other tropical rainforest biomes. Heavy rainfalls are characteristic of the tropical rainforest and can range from roughly 100 to 180 inches per year (Holzman, 2008). The estimated average precipitation in El Yunque is 120 inches per year. However, El Yunque National Forest contains various forest types that have extremely varied precipitation levels ranging from 50 inches per year in low elevation to 250 inches per year on the mountain peaks (USDA, 2014). This rain is known to be orographic, or dependent on the interactions between trade winds and mountain ranges. In El Yunque, precipitation is a product of humid air from the Atlantic Ocean rising when it encounters the Luquillo Mountain Range, then condensing into water (USDA, 2013).

Tropical rainforests are also known for their wealth of biodiversity in both flora and fauna. It is believed that 50% of the Earth's biodiversity is encompassed within the tropical rainforest biome, despite only covering approximately 7% of the Earth's terrestrial landmass (Holzman, 2008). In El Yunque National Forest, many endangered species that contribute toward Puerto Rico's unique biological identity can be found, including the Puerto Rican parrot (*Amazona vittata*), Puerto Rican boa (*Epicrates inornatus*), Puerto Rican helmet orchid

(*Cranichis ricartii*), Elfin-woods warbler (*Dendroica angelae*), as well as the lowland coquí (*Eleutherodactylus juanariveroi)* (U.S. Fish & Wildlife Service, 2014). For this reason, these species are inherently important as endemic to the island.

One of the environmental services that tropical rainforests provide is being a natural carbon sink, removing carbon dioxide (CO_2) from the air and converting it to biomass and releasing oxygen (O_2). This is a particular aspect of the photosynthetic process, which is imperative to life on Earth, as it replenishes the oxygen supplies necessary for the respiration systems of all organisms, including humans (Ostendorf, 2001). Being defined as a carbon sink is inclusive of containing a high concentration of terrestrial carbon. This means that the forest converts atmospheric carbons (particularly carbon dioxide) and converts it to biomass through the process of photosynthesis. Since all living beings contain carbon, tropical rainforests are abundant in surface carbons.

2.3.2 Causes of Climate Change in Tropical Rainforests

There are many mechanisms that contribute to climate change, both anthropogenic and natural. Whether natural or anthropogenic climate change, there are certain biological, geological, and chemical cycles involved that are important to understand, such as the carbon, nitrogen, and water cycles. Due to the complexities involved in each of these cycles, this section will have a particular focus on those processes that are relevant to the tropical rainforest biome. Specifically, tropical rainforests are affected most by changes in greenhouse gas (GHG) concentrations, increased temperature and its related consequences, as well as human activities.

Greenhouse Gases:

In establishing a basic background in the science behind climate change, it is important to know details about greenhouse gases and how they relate to climate change. Greenhouse gases are a collection of gases including carbon dioxide, methane (CH_4), nitrous oxide (NO_2), Ozone (O_3), and various fluorocarbons (CFCs, HFCs, PFCs), that trap infrared heat from the sun's rays in the Earth's atmosphere (Hartmann et al., 2013), as can be seen in Figure 1.

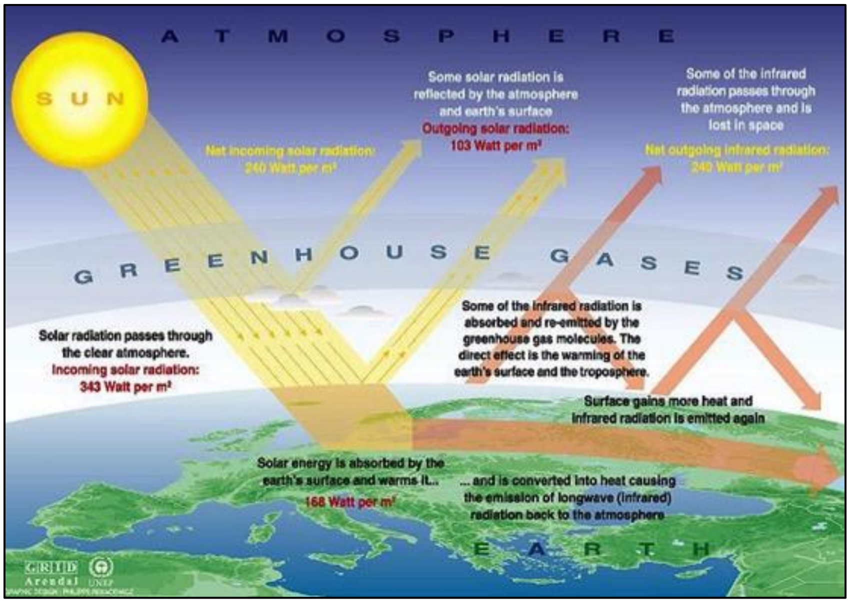


Figure 1: Diagram of the Greenhouse Effect (GRID Arendal & UNIP).
This diagram depicts how energy is emitted by the Sun and trapped in the Earth's troposphere via. the greenhouse effect.

This trapping of heat can lead to increased air temperatures as well as increased average water temperature in oceans and lakes (Hartmann et al., 2013). Many of the gases that are categorized as greenhouse gases are vital to natural Earth processes. Ozone, for example, serves the purpose of protecting life on Earth from harmful amounts of ultraviolet radiation. However, this can only occur when ozone is located in the stratospheric layer of the atmosphere. When in the troposphere, ozone acts like any other greenhouse gases and no longer reflects radiation (Ciais et al., 2013).

Many other GHGs are similar to ozone in the aspect of being both helpful and harmful to the environment. Methane, for example, has both advantages and disadvantages, with advantages including being used as a component of natural gas fuel. Methane is also naturally produced as a product of digestive processes (Hartmann et al., 2013). As outlined above, carbon is a central element in the tropical rainforest and is imperative to its proper functioning. However, atmospheric carbon in excess can trap heat within the troposphere and lead to increases in global mean temperature. Likewise, nitrous oxides are environmentally beneficial toward creating fertile soil compositions, especially when applied to the process of nitrogen fixation. Similar to carbon, excess atmospheric nitrogen has minimal purposes outside of trapping infrared heat in the troposphere.

A History of Anthropogenic Climate Change:

The issue of rapid climate change is one rooted firmly in anthropogenic, or man-made, causes. Today's rates of global warming are certainly the highest they have been in hundreds of thousands of years, and perhaps the highest in the Earth's history (EPA, 2014a). Substantiating this claim are multiple environmental reports stating mean global temperatures have increased anywhere from 0.3 to 0.9 degrees Celsius within the last hundred years alone, with this trend becoming more drastic in recent decades (Cusbasch et al., 2013). Furthermore, many of these reports contain data supporting the inference that the rate of modern climate change can be largely attributed to human activities, such the emission of greenhouse gases (Cusbasch et al., 2013). For example, Figure 2 below, created by the National Oceanic and Atmospheric Administration (NOAA), depicts the positive correlation between increasing concentrations of atmospheric CO_2 and increasing global temperatures from 1880 to 2010 (NOAA, 2014).

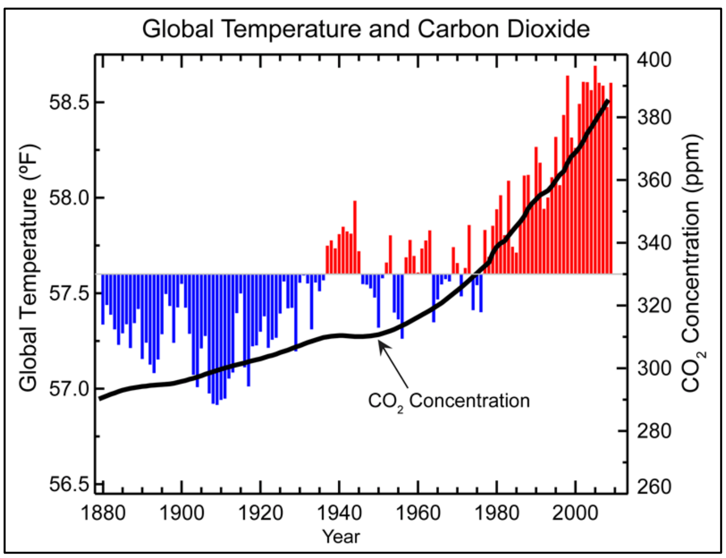


Figure 2: Comparison of Global Temperature and Carbon Dioxide Concentrations Over Time (NOAA, 2014). This graph depicts the concentration of atmospheric CO_2 (ppm) and the average global temperature over the past century.

Furthermore, it is projected that median annual surface temperature in the Caribbean could increase by 1.2 to 2.3 degrees Celsius by 2100 when compared to a 1986-2005 baseline. This prediction uses an assumption of a moderate-low emission scenario, or a scenario where CO_2 emissions continue to increase at a rate slightly lower than the current rate (Nurse et al., 2014). The shaded blue portions in Figure 3 show this projection.

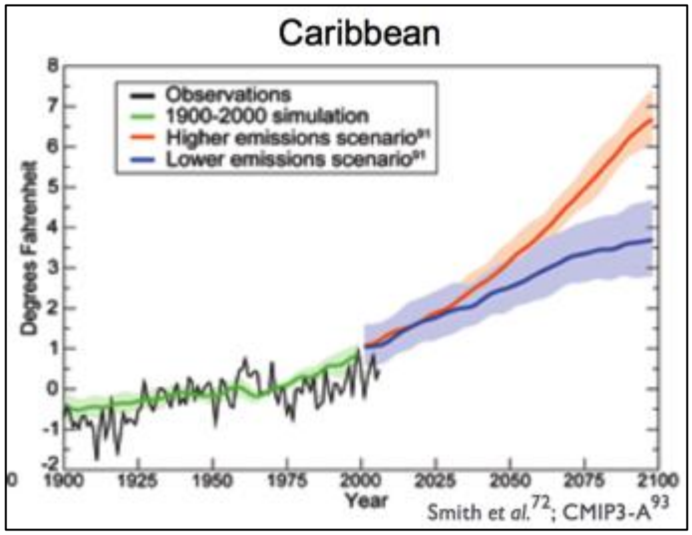


Figure 3: Projected Global Temperature in the Caribbean From 1900 to 2100 Based on Two Emission Scenarios (From Karl et al. (2010) using data from Smith et al. (2008) and CMIP-3A (1993)

Overall, many of the observable aspects of climate change can be attributed to anthropogenic causes. Such phenomena include increased variability in global climate, as well as changes in precipitation. Though scientific studies and scholarly works, such as reports by the Intergovernmental Panel on Climate Change (IPCC), confirm with high confidence the existence of rapid man-made climate change (Cusbasch et al., 2013; EPA, 2014a; NOAA, 2014), it is still controversial. Currently, there is skepticism stating that modern climate change is nothing more than a natural cycle (RFF, 2011), as has occurred throughout the Earth's history. Though natural factors may be a part of current climate change, the current rate has been greatly exacerbated by human activities (National Association of Geoscience Teachers, 2013). These activies are largely varied and include the burning of fossil fuels (CO_2), trash incineration (NO_X), bulvine fecal matter (CH_4), and the use of aerosol products (F-Gases). Further substantiating this claim, the Environmental Protection Agency gathered data from Antarctic ice cores to document the concentrations of atmospheric CO_2 over the past 800,000 years. The data indicated that atmospheric carbon fluctuated naturally between 180 and 300 parts per million (ppm) over this time period (EPA, 2014a). However, the data collected over the past century have shown an increase in atmospheric carbon concentration levels from 290 ppm to 388 ppm (NOAA, 2014). This rapid increase is almost entirely due to the burning of large amounts of fossil fuels by humans (EPA, 2014a).

Another such human activity that exacerbates climate change is deforestation (Ciais et al., 2013). This is particularly pertinent in El Yunque, as the forest experienced deforestation in the early years of United States acquisition. Deforestation is a term that encompasses the clearing of trees, either by selective cutting of trees or non-selective clear cutting (National Geographic, 2014b). Deforestation is complex due to the ways that it connects to the carbon and nitrogen cycles. Carbon that would normally be used in photosynthetic processes would, after deforestation, become excess atmospheric carbon. In terms of nitrogen, the presence of varied flora helps ensure a nitrogen-rich and fertile soil structure. However, when deforestation strips away the trees as well as the surrounding soils, nitrogen gas (N_2) is allowed to escape the soils, interact with oxygen (O_2) and form nitrous oxides (NO_x), which are a group of greenhouse gases. Therefore, deforestation contributes to an increase in atmospheric greenhouse gases (Ciais et al., 2013).

2.3.3 Effects of Climate Change in Tropical Rainforests

The effects of climate change can be wide and varied when observed on a global scale, but for the purposes of this project only those effects that are directly relevant to tropical rainforests will be examined. The most observable effect of modern climate change is an increased global mean temperature. The effects of increased global temperatures are two-fold, as increased temperature leads to variability in regional precipitation patterns and changes in sea level. Examples of possible effects of these increased temperatures include rises in sea level and the increased acidification of the world's oceans (Ciais et al., 2013). Human activities also have an extremely pronounced effect on global climate, including contributions to increased global temperatures as well as introducing the pollutants involved in acid rain into the environment.

Changes in Precipitation Patterns:

One of the key components of climate change that will affect tropical rainforests is change in precipitation patterns (Nurse et al., 2014). In the Caribbean, it is predicted that rainfall amounts will decrease over the coming century by anywhere from five to twenty percent based on low and high emission

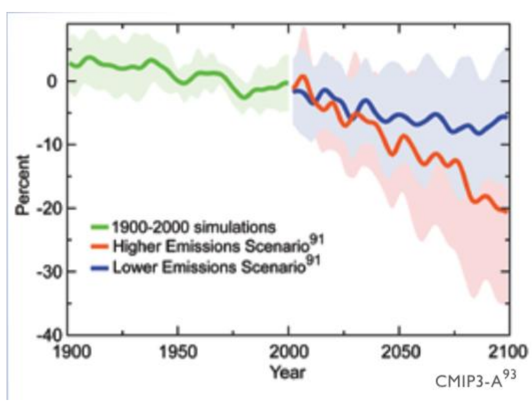


Figure 4: Projected Pricipitation Patterns in the Caribbean from 1900 to 2100 Based On Two Emission Scenarios (From Karl et al. (2010) using data from CMIP-3A (1993)

scenarios, respectively, as shown in Figure 4 above. This figure depicts two simulations of the decreases in precipitation, relative to the precitation levels of the year 2000, that the Caribbean may face throughout the 21st century. This decrease is partly due to an increase in evaporation rates caused by a warmer atmosphere. Though the levels of water vapor in the atmosphere would increase, a warmer atmosphere would also lead to lower condensation rates, inhibiting the formation of clouds. With less cloud formation, more water vapor would remain trapped in the atmosphere, where it would act as a greenhouse gas and further contribute to climate change.

Accompanying this decrease in precipitation, climate change experts expect the Caribbean to also experience greater seasonal variability in precipitation. This unpredictability in rainfall will negatively affect Puerto Rico in particular, due to the presence of extremely sensitive ecosystems, such as the elfin forest type, that require specific amounts of precipitation. Variability in precipitation in Puerto Rico will have a noticeable effect on its inhabitants, as there will be higher likelihoods of drought in the dry season and excessive flooding in the wet season. Due to the gradual warming of the Earth, recent data have shown an increase in the severity of both the rainy and dry seasons of tropical rainforests. In other words, while it may rain more in the wet season, interspersed rain in the dry season will be much less frequent. This is a major issue to humans living in such habitats because it can increase the likelihood of water shortages during the dry season (Nurse et al., 2014).

Acidification of Water:

An additional element of climate change that can have serious consequences on the water cycle is the acidification of water. This includes the acidification of oceans as well as higher acid concentrations in rainwater. Acid rain occurs when sulfur dioxide (SO_2) in the air reacts with water vapor to form sulfate salts as well as sulfuric acids that fall down to the earth as rain (McGouldrick et al., 2011). Air pollution that particularly emits high amounts of sulfur dioxide into the air contributes to the formation of acid rain (EPA, 2014c). This phenomenon can be devastating toward tropical forest biomes, as it has the potential to strip soils of its nutrients and turn lakes and streams so acidic that they are uninhabitable for wildlife (National Geographic, 2014a; Nurse et al., 2014).

Acid rain must be taken into account when discussing climate change in El Yunque, as it poses a clear potential threat to aquatic life. Many native species can only withstand certain amounts of acidty within their habitats without causing some degree of harm to the animal itself (EPA, 2012). Some specific tolences for the pH levels that various aquatic species can tolerate can be found in Figure 5. As defined in chemistry, pH is the measurement of an aqueous solution's acidity or basicity. When describing the pH of a solution, the pH scale must be used. The pH scale is used to simplify complicated chemical measurements by assigning a value of 1 through 14 to a solution, with 1 indicating an extremely acidic solution, 7 corresponding to a chemically neutral solution, and 14 indicating an extremely basic solution (Ophardt, 2003). This same corrosive effect also occurs on the flora of the tropical rainforest. Acid rain can greatly degrade many of the various layers of foliage in El Yunque. When this is paired with heavy rainfall, a multi-tier problem persists of the rain harming fauna, corroding flora, and hastening potential erosion in the various watersheds of El Yunque (Nurse et al., 2014).

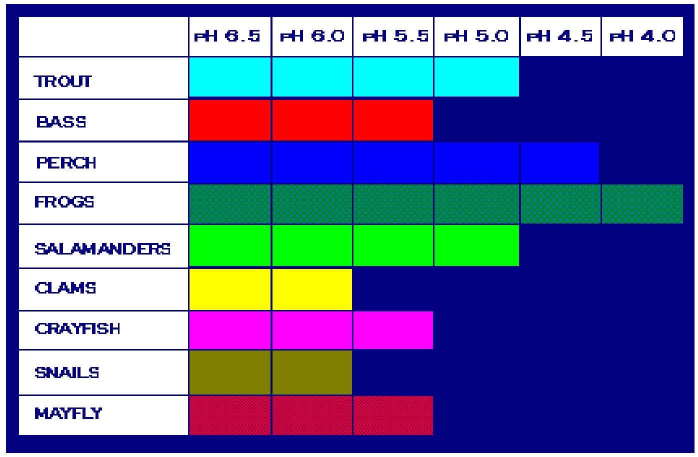
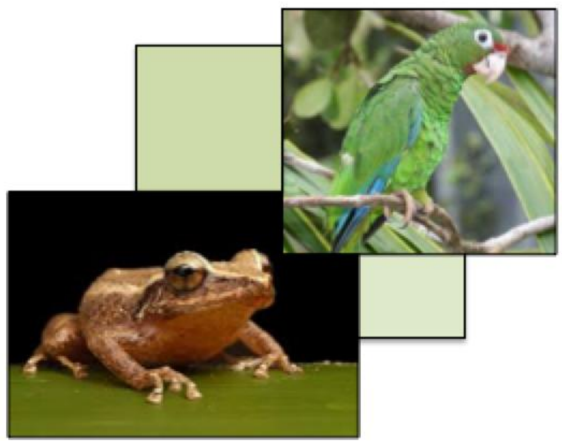


Figure 5: The maximum pH levels that can be tolerated by these aquatic animals (EPA, 2012)

An effect of climate change that is also relevant to Puerto Rico is the acidification of large bodies of water (Nurse et al., 2014). This is due largely to increases in atmospheric CO_2 concentrations, as this can cause these bodies of water to dissolve more carbon, or act as a sink of atmospheric CO_2. For example, when oceans absorb atmospheric carbon dioxide, a chemical reaction to create carbonic acid commences. This chemical reaction involves absorbed CO_2 reacting with oceanic H_2O to form carbonic acid (H_2CO_3). As the ocean absorbs more carbon dioxide, the overall pH level of the ocean will decrease and become more acidic ($pH<7$). A pH under 7 can be extremely harmful to aquatic ecosystems, such as coral reefs, that are located along Puerto Rico's coasts (Nurse et al., 2014).

Biodiversity:

The island's previous degradations are important in understanding El Yunque's current environmental state. Due to expansive clear-cutting for farming during the island's initial European contact, many native animal species lost their primary habitats and became formally endangered (USDA-FS, 2013; U.S. Fish & Wildlife Service, 2014). Even after large tracts of El Yunque became protected land, invasive species better suited for the changing climate took over primary habitats in the forest as opposed to the native species. A specific example can be found in the story of the Puerto Rican parrot, which used to thrive before the arrival of Columbus in 1493, but currently only has about 50 wild individuals of the species, due to rapid deforestation and competition from invasive species (USDA-FS, 2013).



Puerto Rican Parrot (above) and Common Coquí (below): Photos courtesy of El Yunque National Forest Archive

The phenomenon of invasive species taking over areas originally inhabited by endemic species is something that will become more common as climate change continues to progress. In general, non-native "alien" flora will be better adapted for the new extremes in precipitation, as they will not be suffocated by the increasing amounts of rainfall in the wet season. Just the opposite would be seen in the fauna of the island, as the native species would not be well adapted to the lack of precipitation in the dry season (Holzman, 2008).

Another phenomenon that is beginning to occur due to climate change in El Yunque National Forest is habitat shift. Habitat shift occurs when environmental conditions change, causing entire populations of flora and fauna to change location. This is presently being observed in El Yunque, where habitats are shifting upward in elevation due to changes in global temperature and precipitation patterns (Felipe Cano, personal communication, 2014). Habitat shift greatly affects the fauna in El Yunque, as much of the endemic wildlife (species exclusive to Puerto Rico) that resides there live in habitats that are in critical danger of disappearing or shifting upwards in elevation. One species that is currently experiencing habitat shift is the elfin-woods warbler. This species is currently seeing the disappearance of its prime habitat, the elfin forest, and being forced to relocate to habitats that it is not well suited for. This is a trend that has been noted by USFS species managers in El Yunque National Forest. Should current climate change trends continue, the elfin-woods warbler would eventually completely disappear from Puerto Rico (Felipe Cano, personal communication, 2014). Similar patterns have also been observed for other species that are endemic such as the Puerto Rican parrot.

Elfin-woods Warbler: Photo Courtesy of El Yunque National Forest Archive

2.4 Climate Change Initiatives in Puerto Rico

In recent decades, professionals, legislators, and social movements have showed a marked interest in climate change initiatives throughout the island of Puerto Rico. These efforts have already positively changed the environmental situation of Puerto Rico in significant ways. As they continue, the result will continue to positively impact the entire island from an ecological and industrial standpoint. In the 1930s, more than 94% of Puerto Rico was deforested (Guerrero, 2014; Nieves & Ruiz, 2010) as a product of agricultural expansion on the island (Zou et al., 1995). The rise of environmental and climate change awareness, as well as spontaneous reforestation as a result of the abandonment of the agricultural industry (Rudel et al., 2000), has helped guide the island toward obtaining forest cover greater than 60% (Guerrero, 2014).

Tract of Deforested Land Near San Juan, Puerto Rico: Photo Courtesy of

Many previously established environmental groups in Puerto Rico have started to refocus their efforts in the past few decades to combat the rising issues stemming from global climate change. The Department of Natural and Environmental Resources (DRNA), for example, has been a functioning department in the Puerto Rican government since the 1970s. It has served to manage and develop Puerto Rico's natural resources while conserving and protecting the environment of the island (DRNA, 1993). In the 1990s, the department became much more active in its environmental conservation and protection programs, as evident from the numerous laws they have administered during this past decade (2000-2010) (DRNA, 2012). The department went so far as to restructure itself in 1993, so that its five new components and one pre-existing component may better address the shifting needs of the island. As a department, they placed more emphasis on the island's conservation (DRNA, 1993). Many other environmental groups have either followed suit and shifted their objectives to being more environmentally conscientious, or have been created, in response to anthropogenic climate change. This can be inferred from how the timing of these shifts and emergences coincided with the occurrence of the United Nations Earth Summit that was hosted in Rio de Janeiro, Brazil in 1992 (United Nations, 1997). At this concefernce, it was agreed upon that the countries of the world needed to begin finding solutions to reduce negative human impact to the Earth. A particular group that has recently shifted their objectives is the International Institute of Tropical Forestry (IITF). This institute, a program of the USFS that is stationed in Puerto Rico, has conducted research in El Yunque and its surrounding areas since the late 1930s. Previously, the institute focused its research on forestry, forest inventory, endangered species, and similar topics. In recent years, however, it has turned its focus toward understanding forest ecology, climate change, and the human impact on the environment (IITF, 2014). Likewise, organizations such as the Caribbean Landscape Conservation Cooperative (CLCC) and programs such as the Environmental Sciences program of the University of Puerto Rico have been established in response to a continued and growing need for impactful climate change initiatives and awareness (CLCC, 2014; UPR College of Natural Sciences, 2014).

The USFS, and its personnel in El Yunque National Forest, are also actively shifting their focus toward becomming more aware of climate change and climate change initiatives. Every fifteen years, the Forest Service is required to revise their management plan. The rationale behind this mandated restructuring is to ensure that the USFS is addressing relevant and poignant problems that the forest is actively encountering. For the past year and a half, they have been developing the latest management plan (Frederico Cintron-Moscoso, see Appendix B). This plan is described in a document that lists the standards, guidelines, and tools that must be followed for any and all activities that occur in the forest (Frederico Cintron-Moscoso, see Appendix B). For this new plan, forest managers are consulting a variety of groups, including environmental educators, biologists, and ecologists. This "model forest" management plan is geared towards working with communities neighboring El Yunque to develop a more sustainable and economically beneficial collaboration between human and forest activities (Ríos, personal communication, 2014). Some of the proposed actions of this new plan include the planning, development, and participation in agroforestry initiatives, using adaptive management to plan the production of resources, renovation of exhibitions in its visitor center, El Portal, and education (Edgardo Gonzales, see Appendix B). Education is an especially important aspect to the proposed management plan, as it has the potential to influence the next generation of Puerto Ricans to make more environmentally conscientious decisions to preserve the island for generations to come.

2.5 Education

The future decisions concerning our environment will be made by today's students. Therefore, it is critical that the concepts of climate change be communicated effectively to adolescents (UNESCO, 2010). In order to make these decisions, future generations must have a basic understanding of climate science and its many components. The best way to prepare today's students is through education (UNESCO, 2010). To develop a climate change curriculum, one must first understand pedagogy – the study of education – and how to create and assess a curriculum. In addition, one must have knowledge about the topic of climate change as well as the geographic and educational area in which they are trying to educate.

2.5.1 Pedagogy

According to the Department of Education at Aarhus University (2014), pedagogy is defined as the process of creating a supportive environment in which learning can thrive and impact the lives of the students in a meaningful way. It encompasses the science, art and craft of teaching. In order to teach effectively, one should be creative, skillful, and interdisciplinary in one's approach to teaching. Thus, a critical component of an effective approach to education is to combine these elements of creativity with relevant, fact-based research (Smith, 2012).

Pedagogical theory has helped change the way education has been conceptualized over the past century in the United States and around the world. In the United States, education was developed and expanded so that it may be applicable to many groups of people, such as women, African-Americans, and Catholics (Franklin et al., 1991). Despite being more inclusive, traditional education methods continued to be prevalent (Franklin et al., 1991). It was not until the Civil Rights era (1954 – 1968) and the Vietnam War era (1955-1975) that these methods evolved. This evolution occurred partly in response to the rapidly advancing mechanical technologies of the time, and partly in response to the demand for universal human rights, including the demand for equal public education amongst people of various backgrounds (Gamble & Kinsler, 2001) as well as the numerous student protests and riots across the country that demanded improved, sophisticated education (Stephen McCauley, personal communication, 2014). In this time, students realized that they had the power to influence society, including how they were educated. Most prominent among the protests in the US were the Berkley riots of the 1960s, which sought larger social reform. Particularly, students were seeking to incite societal reform using the ideologies of the free speech and anti-war movements, as well as the women's rights movement (Gales, 1966).

These riots were not limited to the United States, as France also experienced numerous protests at this time, one such example being the May 1968 student protests. These protests sought to change the notion of traditional institutions, and replace these infrastructures with new, progressive ones (Erlanger, 2008). Since then, education has been progressing to be more inclusive of not only different groups of people, but also different individual learning styles and more interactive, hands-on curricula (Mazurek & Winzer, 2006; Egan, 1992).

Student Protests at University of California, Berkeley (above): Photo Courtesy of The Berkeley Lab; Parisian Student Revolt Against Teacher Repression, May 1968 (below): Photo Courtesy of Serge Hambourg

The ideological basis behind pedagogy is to create an environment of support and mutual respect between student and educator in order for education to flourish (University of Tasmania, 2014b). Education is a personal experience; therefore, it is important that formal education incorporate the student's experiences and thoughts into the class. This allows the student to form a meaningful connection to the material being presented, resulting in the potential for better retention of the subject matter (University of Tasmania, 2014a). In order to bring learning to life, an effective curriculum often includes new experiences for the students, reflection on their past experiences, and ways to take action and change their own lives, while accounting for the stages of mental development of each student (University of Tasmania, 2014a, b). According to the Teaching and Learning Research Programme (2009), effective pedagogy should prepare students for life by equipping them with the skills to be better citizens, while also setting standards of quality and expertise and providing a supportive environment. Additionally, it must expand on their prior education, assess knowledge only for the purpose of advancing student learning, engage students to actively participate and independently choose to learn, provide students with independent and social opportunities to learn, and allow students to learn in an informal setting (Teaching and Learning Research Programme, 2009).

2.5.2 Creating and Assessing a Curriculum

In order to develop a curriculum, one must determine what will be taught, the persons whom will be taught, and how they will be taught. In particular, one should consider the issue(s) or problem(s) that has brought about the need for this curriculum to be created as well as the needs of the learners. From there, learning objectives should be determined in addition to the methods and relevant information needed to meet those objectives. Lastly, there should be a way to evaluate the curriculum in order to gauge its effectiveness. All of these steps are crucial when developing environmental education curricula that often cover extremely broad and complex topics (Natural Resources Management and Environment Department, 2014).

The important steps in creating a curriculum include planning, determining the content and methods, implementation, and evaluation (Natural Resources Management and Environment Department, 2014). In the planning stage, the scope of the curriculum and the needs of the class are determined. Assessing the needs of the students can be done through focus groups, observations of the learning environment, or by knowledge, attitude, and practice surveys. From these assessments, one can prioritize the needs of the students and identify the characteristics of the class. When determining the content and methods of the curriculum, one must define the intended outcomes of the curriculum and transform these outcomes into learning objectives for the curriculum. In addition, one must determine methods that will accomplish those objectives which may consist of activities and lessons. Once the methods and the content of the curriculum are created, it can be implemented by presenting it to the target audience. Following the completion of the curriculum, its effectiveness should be evaluated. There are two types of evaluation: formative, which provides feedback during the process, and summative, which determines the impact of the curriculum after it is completed. From these evaluations, the curriculum can be revised and re-tested if necessary to improve its effectiveness (Natural Resources Management and Environment Department, 2014).

In order to make a curriculum that will engage students and help them better understand the concepts, it is important to use creative activities and learning techniques that actively engage students. In a Stanford University study researchers found a positive correlation between levels of student engagement in the classroom and learning (Carroll et al., 2010). Furthermore, this finding is supported by scholarly works that emphasize the need to utilize active teaching techniques as opposed to passive techniques (Egan, 1992). Table 1 below lists and describes creative learning techniques that can be used.

Table 1: Creative Learning Techniques (Iowa State University, 2014)

Creative Learning Technique	Definition
Assumption	The class makes a list of assumptions about a topic and then each assumption is analyzed.
Brain sketching	In small groups, students are given a problem or concept. Each student independently sketches something relating to the concept or question and passes it to the next person in their group. The student then expands on the sketch or is inspired to make a new one.
Brainstorming	The class comes up with ideas and thoughts about a topic. These ideas can be ridiculous at first and then changed to be useful.
Concept Mapping	The class is given a focus question in which they must create a list of key concepts (the most general at the top and the more specific at the bottom of the list). From there, the class will create a graphic of the hierarchical organization of the concepts, linking the concepts together.

DO IT	**D**efine the problem Be **Open** to many solutions **I**dentify the best solution **T**ransform it into an action
Fishbone Diagram	The class is given a problem, and must come up with its causes. This creates a diagram in which the causes are branches to the problem. For each branch, sub causes can be determined.
Laddering	The class is given an idea and they must determine the category it belongs to (ladder up) and find examples of the idea (ladder down).
Mystery Spot	The class is given a mystery that they must solve. The story evolves as the students investigate.
Questioning Activity	The class is given a topic and is tasked with coming up with 100 questions.
Random Action	The class is given a random noun and is asked to determine its attributes and associations.
Reverse Brainstorming	The class is given a list of ideas and is asked particular questions about each idea.
Role-playing	Each student assumes the role of someone affected by a particular issue.
Slip Writing	Each student is given small pieces of paper and the class is given a question. Each student must write down an idea about the question on each one of their slips.
Storyboarding	The class is given a set of topic cards and will create categories or general points for each topic card. Specific points will be created for each category or general point. These cards will be displayed on a cork board or a similar apparatus.

Though it is important to engage students while educating, some studies have claimed that students actually prefer to utilize a mixture of both lectures and activities in the classroom. One such study conducted by Brawer et al. (2012), used a qualitative questionnaire and quantitative survey to assess whether students like the use of lectures as an educational technique. This study was conducted on medical and dental students in their first year graduate school. The researchers of the study found that students thought lecture was an important aspect of the learning process. Some specific reasons provided by students for preferring the utilization of lectures included the focus and emphasis that a lecturer can provide. Also, students liked that a lecture could be a multisensory experience where one could write, hear and see the information being presented (Brawer et al., 2012).

Developing a Lesson Plan

A curriculum encompasses several different lessons. For each lesson, a plan can be developed, which is the road map for an educator that is determined by the learning objectives of the lesson. The objectives should be ranked and the objectives that are essential should be determined in addition to those that can be omitted if time runs out (Milkova, 2014). This type of curriculum design is known as backward design or backward mapping, which puts an emphasis on student learning objectives (Wiggins & McTighe, 2005). When implementing a backward design approach towards developing a curriculum, it is imperative that the learning objectives be clearly defined by the educator. The learning objectives are crucial in determining the types of teaching methods that an educator should use in individual lessons of a curriculum, as well as providing a very focused goal for each lesson (Wiggins & McTighe, 2005).

First, a creative introduction should be developed in order to engage students in the concept as well as gauge the students' previous knowledge of the subject (Milkova, 2014). Next, the specific activities should be planned which can include real-life examples, analogies, and visuals. It is important to determine the amount of time each activity will take, factoring in time for explanation and discussion. In addition, one should plan ways in which to check for the student's understanding of the topic, such as asking questions specific to the lesson. Lastly, a conclusion should be created that summarizes the topics discussed and previews the next lesson. In planning a lesson, one should make sure to have a realistic timeline in mind and anticipate what problems or questions students may have (Milkova, 2014).

In addition, an important component of a lesson plan is being able to assess how effective it is. Two types of lesson assessment include formative and summative assessment, which provide feedback during and after the development process, respectively (Carnegie Mellon University, 2014a). When using formative assessment, an educator can get a more immediate feedback through use of inquiry during the lesson process. An example of formative assessment would include having students create concept maps about the contents of the lesson. This feedback can then be applied before the delivery of the lesson is completed. Ways to apply formative assessment during an ongoing lesson include conducting further discussion on topics that are not well understood by students and readjusting the time frame of a lesson based upon students' receptiveness to certain topics. When summative development is used, an educator administers a proposed lesson in its entirety, and then seeks feedback through the use of a high-stakes assessment. In terms of a single lesson, summative feedback is applied only after the lesson is administered to students. Examples of summative assessment can include exams, homework, or even projects (Carnegie Mellon University, 2014b).

Pre- and Post-testing

Pre- and post-tests measure the learning during a class by comparing what the student knew before to what they know after. The pre-test determines the starting point for the curriculum and determines what topics need to be emphasized and what can be omitted. The post-test determines what students learned and the appropriateness of the learning objectives. In addition, the post-test establishes who needs extra help on the subject as well as what should be changed in the curriculum to best reflect learning objectives. Pre-tests should be administered at the beginning of the class following the introduction of the subject matter, while a post-test should be administered directly after the class as well as at later date. The importance of conducting both of these tests is to gauge the immediate effectiveness of the curriculum as measured by the first post-test as well as the long-term retention of the material as measured by the second post-test. The tests should be focused on the objectives of the curriculum and can include multiple choice and short answer questions. Once the pre- and post-tests are compared, the strengths and weaknesses of the student's knowledge can be determined. The curriculum can then be revised based on the established weaknesses (Boston University School of Medicine, 2013).

When developing pre- and post-tests, it is advantageous to have these tests be isomorphic, or of similar form, to each other (Gormally et al., 2012). By utilizing nearly identical pre- and post-tests, data gathered from these tests can be directly compared. Additionally, this allows educators to more easily identify which learning objectives were well addressed in a curriculum, as well as those that were not. In a study conducted by Gormally et al. (2012), pre- and post-tests comprised of entirely multiple-choice questions were utilized to assess science literacy skills in university undergraduates after the completion of a basic life science course. The pre- and post-test they used contained 28 multiple-choice questions that were rigorously scrutinized by both expert biology educators and undergraduate students. After addressing any imperfections, the questions were categorized in accordance to the learning objective or skill it addressed. In doing this, the researchers were able to directly compare the answers to the questions in both tests and determine whether the completion of a life science course increased students' scientific literacy skills. In this study, significant positive learning gains were reported for the class. Gains were also reported across a majority of learning objectives, with some objectives having larger learning gains than others (Gormally et al., 2012).

It is also possible to use isomorphic pre-and post-tests that are comprised entirely of short answer questions. This can have the advantage of making students think critically about the questions, and synthesize more detailed responses from recalled knowledge. This type of test structure was utilized by Brownell et al. (2013) in a study on the ways that students think about and approach experimental design in biology courses. In this study the pre- and post-tests that were used were completely isomorphic, and utilized a single Expanded Education Data Analysis Tool (E-EDAT) prompt, or open-ended question, that asked students to design a scientific experiment to determine the effects of ginseng. Each student in the class had to complete two activities, designated as the "design" activity and the "analyze" activity. These activies served as the lesson that was being tested in this study. Both the "design" and "analyze" activity pertained to a theoretical experiment about the growth rates of poppy plants. A detailed answer key was provided for the E-EDAT pre- and post-test, which explicitly outlined the responses that would be awarded full credit for each facet of the question. As well, the answer key included responses that would be awarded partial credit and the grading breakdown for each of these answers. After the pre- and post-tests were graded, various means of statistical analysis were applied to determine whether students experienced learning gains. The overall findings showed that introductory biology students were more likely to experience significant learning gains when compared to advanced biology students. The two tests also helped identify areas where introductory students had the most misconceptions (Brownell et al., 2013).

2.5.3 STEM Education

STEM education stands for science, technology, engineering, and mathematics education. The problems facing STEM education in the US include student underperformance, gaps in instructional practices, lack of theory development, and a limited system of standards (Saxton et al., 2013). Numerous scholarly works about STEM education bring to light the low quality methods often used in teaching this subject area. One core issue is a dependence on textbooks as the sole learning tool in the classroom. In addition, many teachers tend to adopt a strictly oratory lecture style of teaching, which does not actively engage students (Saxton et al., 2013). In order to fix these issues, there needs to be a common and regulated system of STEM education standards for secondary education that take advantage of innovative and progressive pedagogical approaches. This system would facilitate effective learning by emphasizing conceptual knowledge of STEM content and higher-order thinking about those concepts. In addition, a regulated system would benefit the individual student by expanding on individual academic backgrounds and providing motivation for further learning.

There is strong evidence to indicate that the implementation of standardized STEM education can be particularly effective in communicating material to students. In a recent study, specialists in elementary science education were brought into a school district to test a more involved and hands-on science curriculum which deliberately adhered to the national standard (National Academy of Sciences, 2000) in fourth, fifth, and sixth grade classes (Schwartz et al., 2000). This district was observed in conjunction with a nearby, comparable school district. The default teaching program in the district, like many school districts across the country, did not follow the national standard set in place. Instead, science was taught in a traditional manner with textbook readings and context-free and content-free activities. After both respective curricula were administered, students were asked to take a test as part of the experiment. The test used was designed specifically for this study and was based upon the recommended national standards provided by the United States Department of Education. The results of the study indicated that students in the classes taught by the elementary science specialists showed 96 percent proficiency in STEM subject area for fourth and fifth grades and 89 percent proficiency for sixth grade, compared to 9 percent, 74 percent, and 50 percent proficiency for fourth, fifth, and sixth grades respectively in the comparison district. These numbers suggest the effectiveness and need for a more universal and regulated STEM curriculum, as well as the need to incorporate hands-on learning into STEM curricula (Schwartz et al., 2000).

In order to achieve an effective STEM curriculum, teachers must employ teaching techniques firmly based in current pedagogical theory such as understanding their students' thinking. This includes students' prior knowledge, misconceptions, difficulties, and development levels. In addition, teachers of STEM disciplines should attempt to use strategies such as engaging students in inquiry, guiding dialogue, and integrating technology. Some instructional practices that teachers can employ include active engagement, facilitating discussion, formative assessments, and using activities that are relevant to students' lives (Saxton et al., 2013).

2.5.4 Climate Change Education

There are many challenges to communicating climate change effectively. Climate change denial is one such challenge that remains to this day (National Center for Science Education, 2012). Resistance to its education is also prevalent, however, teachers must be willing to defend the importance of teaching climate change. Currently, many people, especially students, have misconceptions about climate change. For example, people may believe that the Earth actually moves closer to the sun during the summer, that air is simply empty space above the Earth and has no function, that CO_2 cannot impact climate change, and that climate change is just long-term weather and cannot be predicted (National Center for Science Education, 2012).

To effectively educate students about climate change, it is important to understand and correct such misconceptions, and to not draw too much attention to them thereafter so as to not reinforce them (National Center for Science Education, 2012). The evidence about climate change should be presented by teachers in order to convey to their students that climate change is a relevant issue in today's society and that it is becoming more severe. However, the fact that our planet is drastically changing, though not necessarily for the better, can be disturbing and students may find the subject upsetting. For that reason, it is important in climate change education to stress that, while there are long-term solutions, no single action we take will completely stop climate change from happening in the short-term. Furthermore, it is imperative that climate change education teaches ways to adapt to the changing climate (National Center for Science Education, 2012).

To educate students about climate change in a balanced way, a curriculum should raise climate change literacy while also discouraging a feeling of hopelessness (National Center for Science Education, 2012). The main topics that are important to teach in a climate change curriculum include an explanation of how greenhouse gases trap infrared rays in our atmosphere, causing global temperatures to rise, as well as the emphasis that climate is different from weather. As a multifaceted subject, climate change should be integrated in all science classes including physics, biology, chemistry, and geology. Climate change can also be incorporated in other subjects such as social studies, geography, and art. Involving current global decisions about climate change into the curriculum can help students connect what they are learning to the real world. Teachers should explore climate change in all areas of the world, and should keep their data up to date as they teach it. However, it is also important to make climate change relevant by providing students with local examples of climate change (National Center for Science Education, 2012).

There are many resources for climate change education in existence online and in books. Readings, maps, simulations, science projects, experiments, field trips, graphics, websites, television programs, and movies can all be utilized (National Research Council, 2010). The National Oceanic and Atmospheric Association (NOAA) and the American Association for the Advancement of Science Project 2061, for example, developed literature called *Climate Literacy: The Essential Principles of Climate Science* that outlines eight key aspects of climate change education to be integrated into national education standards, as seen in Table 2.

Table 2: Eight key aspects of climate change education (National Research Council, 2010)

	Climate Change Principles
1	The Sun is the primary source of energy for Earth's climate system
2	Climate is regulated by complex interactions among components of the Earth system.
3	Life on Earth depends on, is shaped by, and affects climate.
4	Climate varies over space and time through both natural and man-made processes.
5	Our understanding of the climate system is improved through observations, theoretical studies, and modeling
6	Human activities are impacting the climate system.
7	Climate change will have consequences for the Earth system and human lives.
8	Humans can take actions to reduce climate change and its impacts.

These principles are important to discuss with students in order to enhance their basic understanding of climate change. In an effort to bring climate change education outside the classroom, one can visit science centers, museums, parks, and zoos (National Center for Science Education, 2012). It is essential that climate change includes a human aspect such as lectures from local scientists, documentaries, or narratives on climate change. The National Science Foundation funded a cognitive research project, *Visualizing Earth*, proving the effectiveness of letting students see images of Earth and how life on Earth is connected to the land, water, and atmosphere by giving the changing climate tangibility towards which they can feel empathy (National Research Council, 2010; Egan, 1992). There are several other initiatives in the US for climate change education including: NASA's Global Climate Change Education, NOAA's Environmental Literacy, NSF's Informal Science Education, USFS's Educator Resources and the Department of Energy's Global Change Education Program (National Research Council, 2010). In addition, the Climate Literacy and Energy Awareness Network is a great tool to use for activities, videos, visualizations, tips, and interactive concept maps on climate change (National Center for Science Education, 2012).

2.5.5 Education in Puerto Rico

In Puerto Rico, education is free for all children between the ages of six and sixteen, with one third of its annual budget spent on education (Wagenheim, 2014). Puerto Rico offers a variety of schooling options, including 1460 public schools and 764 private schools (Studylands, 2014). These schools typically focus on a broad range of subjects including history, English language, mathematics, physical education, and many science courses (Studylands, 2014).

Despite the variety of education in Puerto Rico, the education is not of the highest quality (Casiano Communications, 2014). While most children complete at least 8 years of education, only 50% of Puerto Ricans over the age of 25 have a high school diploma and only one-seventh of the total population pursues a Bachelor's degree (Wagenheim, 2014). 85% of Puerto Rico's public schools take part in improvement programs because of their poor academic performance on standardized tests (Casiano Communications, 2014).

Middle Schools

Middle school is compulsory in Puerto Rico and consists of students in grades 7 through 9 or typically ages 12 through 15 (Studylands, 2014). Students can fulfill this education at both private and public institutions. Topics of study include language arts, English, mathematics, world and Puerto Rican history, geography, health science, life science, earth science, biology, art, physical education, and health. Typically in middle schools in Puerto Rico, students change classrooms and teachers for each area of study (Studylands, 2014).

Types of Schooling

Generally public schools in Puerto Rico can be divided into the two overarching categories of rural and urban schools. Rural schools provide 4 years of primary education and then a pre-vocational program. The urban school curricula consist of studies of agriculture, some economics, health and physical education, Spanish, English and manual training (Puerto Rico Department of Education, 2014). There is not an adequate amount of educational facilities for all students in both urban and rural schools (Wagenheim, 2014). As a result, homeschooling is a popular option for education on the island. There are several homeschooling organizations, including Puerto Rico Protection and Advocacy Agency, Escuela en el Hogar Nuevos Horizontes, Grupo Area Metro de Educadores en el Hogar, North Area Christian Homeschoolers, and The Caribbean Center of Home Education Resources (ED Anywhere, 2012). Homeschool programs are typically not funded by the government and therefore have no regulations, teacher qualification requirements, or standardized testing (HSLDA, 2014). Ironically, this lack of regulation proves to be beneficial, as homeschooling students tend to test better than students enrolled in public and private schools.

3. Methodology

Our goal was to develop an effective educational module that can be used to teach middle-school students in the city of Río Grande, Puerto Rico, about the immediate and long-term impacts of climate change. We worked on this project in collaboration with the United States Forest Service in Puerto Rico from October 2014 to December 2014. Based on interviews with regional and local experts on climate change and teachers, questionnaires given to students, and observations of classroom settings, we developed a learning unit to address the current need for climate change literacy in the community. This unit included two lessons and a homework assignment. Provided with each lesson were student materials and an instructor guide. The intent of making this guide was to provide the teachers with sufficient knowledge to teach the concepts presented in each lesson.

In order to fulfill our goal, we developed the following objectives:

1. Identify the main concepts and concerns with respect to climate change in Puerto Rico.
2. Determine the best way to educate middle school students in Río Grande
3. Create an educational module for the area and our targeted students
4. Evaluate the effectiveness of our developed learning unit and revise as necessary.

These objectives will be addressed in the subsequent sections.

Objective 1

Identify the main concepts and concerns with respect to climate change in Puerto Rico.

For this project, the USFS's particular interest was to create an educational module that focuses on the aspects of climate change that are affecting El Yunque National Forest, as well as Puerto Rico in its entirety. In order to create the most relevant learning unit on climate change possible, we had to gain knowledge about the forest and the island.

We conducted interviews with local experts to determine the current state of climate change impacts in the region. This group of experts was identified by the USFS, and included, amongst others, members of the DRNA and the University of Puerto Rico. We asked these experts about their observations of climate change and the effects that they foresee in the future as a result of these observations (see Appendix A). Our aim was to determine the most important effects of climate change that are impacting the island of Puerto Rico. These interviews expanded upon our previous climate change research by providing more specific information about the observed impacts of climate change in Puerto Rico, as well as helping us to identify the misconceptions that Puerto Ricans have about climate change. In addition, the data gained during these interviews helped us to determine what topics are most relevant to include in a learning unit involving adaptation to local climate change impacts. This was done by identifying common topics in the interviews and by directly asking what topics the interviewees thought were important to include in a learning unit about climate change. We used a coding system to evaluate and quantify the information gathered from these interviews. The system included identifying phrases and terminology that were common throughout the interviews. These phrases were then placed into three categories: climate change, environmental education techniques, and public opinion. Example topics that we found in our interviews included “outside of their reality”, “loss of coastal resources”, and “relatable/personal”. These topics would be categorized into the public opinion, climate change, and environmental education techniques, respectively.

The topics that appeared most often throughout the interviews were the topics that influenced what was discussed in our learning unit. Lastly, we further researched topics that had yet to be covered in our background research in order to develop our learning unit. In addition, we asked our interviewees about what studies they had done or observed as well as what resources and literature they could provide that was relevant to Puerto Rico. After receiving these resources, we incorporated what we learned into our background research and learning unit.

Objective 2

Determine the best way to educate middle school students in Río Grande.

In order to identify the best ways to educate middle school students in Río Grande, we conducted interviews with local educators. From these interviews, we gained knowledge about the teaching styles of local educators as well as their familiarity with teaching topics related to climate change to students (see Appendix A). The techniques that were found to overlap between the responses of the interviewed teachers and our background research, as well as techniques found in modern pedagogy, were the techniques that we intended to incorporate into our learning unit.

By identifying the education styles used in the area, our intention was to make the learning unit as relatable and as easily integrated as possible while introducing a new topic to the students. This helped us to develop a learning unit that is suitable for the average Puerto Rican middle school, in order for it to be used as a potential resource for these and other teachers in

Puerto Rico. From our interviews with educators, we gained an insight to the educational styles and structures in place in the school. After these interviews, we observed classroom settings to acquire a first-hand view of these educational styles. This helped guide the process of creating a learning unit that can be easily integrated into the current learning environment. In order to better integrate this learning unit into varied learning environments, we felt it necessary to create an instructor's guide that incorporated detail on both the subjects of the lesson as well as how those subjects are presented. This ensured that teachers that do not ordinarily employ modern pedagogical techniques could easily include our lesson plans into their own curricula. This guide would also be informative for teachers that do use active learning techniques, as it would provide crucial background information on climate change and its related topics.

Objective 3

Create an educational module for the area and our targeted students.

Our selection process for determining what subjects to include in our lessons was based upon the results from our expert interviews and our background research. Our lessons targeted the topics that were deemed important by the experts and that we felt would serve well as an introductory course to climate change. From interviews with teachers we determined the best ways to present these concepts. The concepts identified above were translated into specific learning objectives for our lesson plans (see Appendices E and F). These objectives were the intended learning outcomes of our lessons. Based on these, we created activities, diagrams, and discussion questions to address each objective within two 50-minute lessons. In addition to these lessons, we created a homework assignment designed so that both the students and their family members would find them informative. Lastly, we translated all written components of both lessons into Spanish so that it would be more accessable for Puerto Rican students. In order to ensure that crucial activities could be completed as desired in an allotted time, we tested them on a group of three fellow WPI students. We then applied the feedback received from this preliminary testing of the proposed activity as necessary.

While we were only able to test two lessons, as per the request of our sponsor, we developed complementary lesson outlines that can be further expanded upon in future iterations of this project. In addition, we created a few field activities intended to show the immediate impacts of climate change in the students' locality. The components of our lessons and the homework assignment, as well as instructions on how to present these materials, were combined to create a deliverable to be accessed both in person and online.

Objective 4

Evaluate the effectiveness of our learning unit and revise as necessary.

We assessed the effectiveness of these lessons by administering them to a class of 24 students, aged 14 to 15 years old. Prior to this pilot test, we developed a pre-test to determine what the students know of and understand about climate change. This pre-test gauged the students' preexisting knowledge about the learning objectives that we desired to address in our lessons. The test was comprised of 12 multiple choice questions, with questions allocated to each learning objective, and was distributed the day before the presentation of the first lesson. Immediately after the execution of our second lesson, we administered a post-test to the students. In developing our post-test, we used the same questions used in our pre-test, but the order was changed, since using an identical set of tests could skew our comparisons, as the students could easily remember the questions of the pre-test and not genuinely answer the post-test questions (Gormally et al., 2012). These post-tests also included qualitative questions such as "did you enjoy the past two lessons?" (see Appendix G) that gauged the students' opinions of the lessons.

During our project development process, we created our resources under the assumption that our pilot tests would be taught by a non-science teacher. It was for this reason that we created a detailed instructor's guide, so that any teacher could easily include our lessons into their classrooms. However, due to unforeseeable circumstances we had to step in at the last minute and teach both of our pilot lessons ourselves. Additionally, the timing of when we were going to administer our lessons differed from what we had initially planned, resulting in a single day gap in between the two lessons. These circumstance also lead to us conducting these lessons at different locations. Lastly, the amount of time we had for the first lesson was miscommunicated due in part to the presence of a language barrier. All of these complications we faced forced us to alter certain parts of our methodology.

The results of the pre-test and post-test data were compared to examine whether an increase in knowledge about climate change occurred. To determine this, we performed a paired samples t-test (a within-subjects test comparing each student's change in score) using the program, Statistical Package for the Social Sciences (SPSS). We based our analysis on the null hypothesis (h_0) that there would be no changes between the pre- and post-test, and an alternate hypothesis (h_1) that there would be increases in the scores between the pre- and post-test. We took each individual's tests and graded the pre-test and post-test as a pair. Each question was weighted equally, and a numerical score was determined for each test. The change in test scores between the pre-test and the post-test was determined, and the percent change between these two scores was generated. The percent changes from pre- to post-test of each student were analyzed to evaluate the overall effectiveness of the lessons. For this testing, we defined the term "effective" to correspond to a p-value of less than .05.

Additionally, percent changes were determined for each learning objective, first individually and then as a whole class. We compared the results of how well each learning objective was addressed by calculating the change in correct student responces on each objective's corresponding questions between the pre- and post-test, and made observational inferences based upon the data. Based on the learning objectives that showed the least improvement from the two tests, we revised the learning unit to cover the learning objective in a different and potentially more effective way. In addition, we distributed student questionnaires to four other classes of students of the same grade level in the same school. To statistically compare the pre-test scores of the students we planned to test our lessons on with the questionnaire data of the other ninth grade classes, we decided to utilize an independent samples t-test. The rationale behind conducting this test was to ensure that our testing class was not significantly different from the other ninth grade classes in terms of test scores and, moreover, knowledge about climate change. This provided us with additional information on how to prioritize the other revisions to our lessons. Furthermore, lesson outlines on additional climate change topics were created, taking into account the gaps in knowledge of the ninth grade, as a whole. These lesson outlines, as well as the revised pilot-test lessons, were provided to our sponsor. The results of our lesson evaluation and the topics determined from expert interviews about climate change (Objective 1) were used to create these additional lessons.

4. Results and Discussion

Objective 1

To best understand the most pressing issues of climate change facing Río Grande, we interviewed several local environmental specialists with knowledge of climate change as well as participants of environmental education initiatives. Our interviewees consisted of professors at the University of Puerto Rico, forest managers in El Yunque National Forest, and DRNA employees.We asked these experts about their observations of climate change and its potential effects, public perception of climate change, adaptation, and effective means of communicating change to students. Throughout our interviews there was a consensus that rain patterns have changed in the area over recent years, that the public is generally unaware of and unconcerned about climate change, and that, to adapt to climate change, there needs to be an effort towards local, relatable education.

To determine what information was most relevant in our interviews, we first recorded and transcribed each interview. We critically read each transcription, and completed a process of thorough coding based upon three predetermined categories: climate change, environmental education techniques, and public perception. We recorded the topics discussed in each interview in a table that organized these topics into columns corresponding to each categories. We then compared our interview tables to identify any repeating topics. We calculated the number of times each of these topics appeared in an interview, and presented the results in a bar graph. Only the topics that were discussed at length in at least two interviews were included in the bar graph.

For our interviews with climate change experts, we noticed that changing rain patterns were mentioned in 7 out of these 8 interviews. Additionally, we saw that rising sea levels, rising temperatures, and effects on endemic species were mentioned in these interviews. In the interviews with specialists who were also participants in environmental education initiatives, we chose to expand our focus to include topics such as how these experts were trying to raise public awareness of climate change and how effective and efficient these initiatives were. There was a consensus amongst the interviewees that the Puerto Rican public knows very little about climate change and is, on the whole, unconcerned about it. The reasons for this perception range from a lack of understanding to the denial of this rather large and overwhelming topic. Overall, our interviewees expressed a feeling of genuine concern for the future of the island because of this lack of awareness.

It was apparent from these interviews that climate change is an issue of pressing concern in Puerto Rico, and one that the general public is virtually unaware of (see Appendix B). The island is currently experiencing many of the effects of climate change typical of a tropical island. These include changing precipitation patterns, increased median temperatures across the island, ecosystem degradation, and rising sea levels (Nurse et al., 2014). These topics were frequently mentioned by our interviewees, as seen in Figure 6**Error! Reference source not found.** below, which measures the number of interviews in which this topic was discussed at length. Further explanations of each of these topic headings is provided in Table 3.

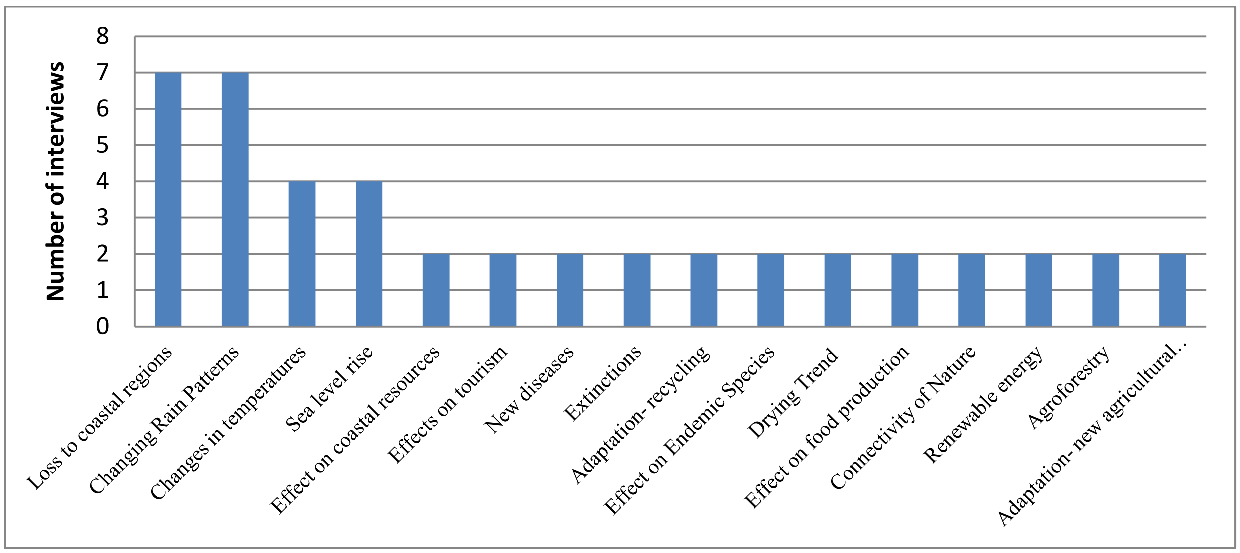


Figure 6: Topics of Interest - Climate Change

Table 3: Explainations of the Identified Climate Change Topic

Climate Change Topic	Meaning
Loss to coastal regions	Discussions referring to the disappearance of the coasts due to rising sea levels
Changing Rain Patterns	Discussions about how climate change will cause changes in precipitation due to the increase in atmospheric temperatures
Changes in temperatures	Discussions about how temperatures will be altered due to climate change
Sea level rise	Discussions about how climate change contributes to rising sea levels

Effect on coastal resources	Discussions on how sea level rise will effect resources on the coast
Effects on tourism	Discussions on how the effects of climate change, such as sea level rise and changes in precipitation patterns, can impact the tourism industry
New diseases	Discussions about how new diseases can arise because of changes in precipitation patterns and in temperatures
Extinctions	Discussions on how animal extinction in an area can occur due to the species' inability to adapt to changing climate conditions conditions
Adaptations	Discussions about adapting to climate change, in general
Effect on Endemic Species	Discussions about how changing precipitation patterns and temperatures can affect species only found in Puerto Rico
Drying Trend	Discussions about how the island may be experiencing a drying climate due to climate change
Effect on food production	Discussions on how food production can be affected by changing precipitation patterns, rising temperatures, and other affects of climate change
Connectivity of Nature	Discussions about the how all of nature is connected and therefore climate change is a problem that can affect every aspect of nature
Renewable energy	Discussions about how the use of renewable energy sources can help mitigate climate change
Agroforestry	Discussions about the use of agroforestry, or farming in forests, as a way to adapt to climate change
Adaptation- new agricultural practices	Discussions about adapating to climate change in reference to utilizing new agricultural techniques in order to improve food production as the climate changes

Changes in precipitation have already had a visible effect on the island (Filipe Cano, personal communication, 2014). Previously, the island's rain patterns followed a steady trend over the course of a year based upon the wet and dry seasons. Since the 90s, however, these rain patterns have begun to fluctuate drastically, and are now able to be represented graphically by spikes and troughs. This indicates that in place of a steady rain trend, the island is now seeing extreme weather, with very dry and very wet periods. This in turn gives way to very rainy wet-seasons and very arid dry-seasons (Filipe Cano, personal communication, 2014). This past summer, the island experienced an example of such weather extremes with a several-month-long drought, followed by floods (Isabel Rivera, personal communication, 2014). The results of this small period of time alone included huge financial losses, as well as burdens on several industries such as the coffee industry and farming (Univision PR, 2014). It can be inferred from this incident alone that the island's rain patterns have an enormous effect on many parts of the island, and the continuation of current precipitation changes may have devastating effects on the island as a whole.

Puerto Rico is experiencing changes in its wildlife in response to climate change as well (Filipe Cano, personal communication, 2014). The changing rain patterns and increased temperatures are having an effect on the island's many ecosystems by shifting its nature in response to these changes. As a result, the animals in these ecosystems have begun to inhabit different ecosystems so that they may have a better quality habitat. This leads to an increase in competition for resources, which has the potential to lead to other changes in the area. One such example is the potential increase in tropical diseases, which are now able to survive in areas they previously did not exist in, as a result of the changing ecosystems. Already there is an increase of instances of Dengue and Chikungunya cases in Puerto Rico at higher rates and in locations where these diseases did not exist in the past (Filipe Cano, personal communication, 2014).

Climate change in Puerto Rico also has an effect on the island's land use. As an island, Puerto Rico is very susceptible to changes in its coastline. As sea levels around the world rise, the island suffers from a loss of land via its coastline. Not only does this result in less land, there is also a loss of beach tourism – a particularly viable industry on the island (Isabela Perez, personal communication, 2014; Marcela Canon, personal communication, 2014).

Despite the many negative impacts that climate change could have, there is the potential for it to be beneficial for the world. Provided that the world changes some of its habits on both microscopic (individual) and macroscopic (governmental) levels, there is the possibility for economic shifts that may open up opportunities for islands like Puerto Rico (Ashley Perez and Eduardo Agostini, personal communication, 2014). One of the biggest contributors to this shift would be the use of renewable energy. In an island like Puerto Rico, the use of fossil fuels is extremely costly due to the need to import them, which in turn burns even more fossil fuels. A shift toward renewable energy would reduce the need for such importation. For example, a solar megawatt farm could save five million gallons of gas from being burnt over the course of twenty-five years. Because Puerto Rico is very sunny by virtue of its climate, it most likely would have the ability to sustain its own energy market. The recycling industry also has the potential to have an enormous, positive financial impact on the world economy. In an area like Puerto Rico where there is currently an excess of trash, the possibility for such an economy could help relieve the island of its trash burden and provide it with another form of income (Ashley Perez and Eduardo Agostini, personal communication, 2014). An awareness of the positive impacts of climate change is useful, as it could allow for a more receptive audience to an otherwise daunting topic.

Objective 2

After conducting interviews described in Objective 1, we began to meet our second objective of understanding the school system in Puerto Rico, more specifically in the school we worked in. We observed several classes during the course of a school day and interviewed teachers to get a sense of the school and a typical day in their classroom. By doing this, we were able to have a deeper understanding of the school and the students for whom we would be customizing our learning unit.

We interviewed three teachers in the Carmen L. Feliciano Carreras del Sector Palmer Middle School in Río Grande, Puerto Rico. These teachers, a math teacher, a visual arts teacher, and a science teacher, all taught primarily, if not exclusively, ninth grade students – the demographic for whom our learning unit is to be designed. From the interviews, we were able to learn that the school offers classes in English, Spanish, mathematics, science, and more to its students, as well as elective classes such as physical education, visual arts, and music (Amabel Soto, personal communication, 2014). Classes are typically about forty minutes in length and consist of at least twenty-one students. The classes that we observed were all classes taught by the teachers that we interviewed. Lectures began with instruction on that day's material, followed by some sort of group work or class-wide activity until the period ended. Some of these classes also incorporated technology into the lesson, such as with interactive learning tools on an iPad or the use of Google Earth.

The progressive tools and styles implemented in the school were not unique to one single classroom, and not even to the school itself. From our interviews, we learned that such methods have been suggested throughout the island as part of the latest revisions to its academic requirements (Departamento de Educación de Puerto Rico, 2014; Marganese Sanjunto, personal communication, 2014). These revisions included, among other things, the use of problem-based learning and other student-centered pedagogical techniques (Departamento de Educación de Puerto Rico, 2014). We also learned that among the curriculum changes were new requirements for students to be taught climate change in science and in other classes (Marganese Sanjunto, personal communication, 2014). This school year was the first iteration of the new curriculum, and climate change was taught in the first few weeks of the semester. The material covered was an introduction to the topic, meaning it was not especially in depth and did not include many details about the effects of climate change on Puerto Rico. According to the science teacher that we interviewed, the material that was covered was still enough to bring an awareness of climate change to the students, and they expressed concern and outrage for the current state that the planet is in and is headed towards (Marganese Sanjunto, personal communication, 2014). Due to these findings, we determined that our learning unit pre-test and post-test would most likely reflect some sort of effect of this curricular change, as we would be testing the learning unit on students that have recently had an exposure to the topic. However, because the learning unit was intended to be introductory, while also including some aspects that focused on Puerto Rico, we kept our learning unit design ideas the same. Because the learning unit was intended to be designed for students who had never had an exposure to climate change, the results of our pre-test had the potential to be higher than anticipated.

Our interviews also informed us about other aspects of the school. In particular, we learned about the school's involvement with large-scale projects and its participation in field trips. This knowledge was fundamental to the development of our learning unit, as we originally intended to include a field activity in it. We also were considering large-scale projects as part of our learning unit development for later iterations of this project. In our interviews we learned that field trips were often used to supplement class material. At this school, the definition of a field trip included outdoor activities on school grounds as well as activities off of the school grounds. When asked, teachers reported that they found using field trips to be particularly effective at emphasizing class material and engaging students. These teachers felt that, by exiting the classroom, students were able to have more mental stimulation simply from being outside of the classroom setting, and that field activities provided resources that teachers could not always provide in a classroom. This ultimately would result in a deeper, multi-layered understanding of the topic being taught and its many applications in the outside world. The teachers in the school also reported often incorporating large-scale projects into their curriculum to further student understanding. One such project was conducted by Amabel Soto (2014), wherein students applied the topics learned in their math classes to a recycling project. Using trash barrels of a certain size, students applied basic geometry to calculate how many recyclables can be placed into the barrel, allowing them to not only put their acquired knowledge to a real-world situation but also to see how efficient the barrel is at containing the recyclables before it is brought to a recycling center.

We also conducted interviews with members of various environmental education initiatives to help us establish various education techniques in conjunction with the information provided by the Carmen L. Feliciano Middle School teachers. Many of these initiatives that interviewees were involved in involved a youth outreach component, such as the following youth initiatives: Children’s Tropical Forest, Sierra Club, and Project Learning Tree. From the questions that we asked our interviewees, we determined some of the ways in which we may structure our lessons. One of the most important aspects that were recommended to us was to make our lesson relatable to students. In this way, they would have a better point of reference from which to understand the subject matter. By having a relatable lesson, the students would also be able to find the material more relevant to their lives, allowing for the potential for them to be more concerned with the issue (see Figure 6). In previous environmental education initiatives many topics had not been particularly relevant to Puerto Rican students and were as a result not very effective (Carolyn Krupp, personal communication, 2014). We were also advised to try incorporating outdoor activities and field trips to make the material more tangible and to stimulate the students’ interest. Due to the age, grade-level, and lack of exposure to the topic of climate change, we were instructed to keep the lesson superficial and introductory so that the students would be able to understand the material. Figure 7 below depicts the other recommendations we received. The graph measures how many interviews mentioned the same education technique at length. These techniques were determined using the same general process of coding the interview trancripts as outlined in Objective 1. However, for the teacher interviews specifically, we separated the information into education techniques, environmental education, and specifics of Puerto Rican education.

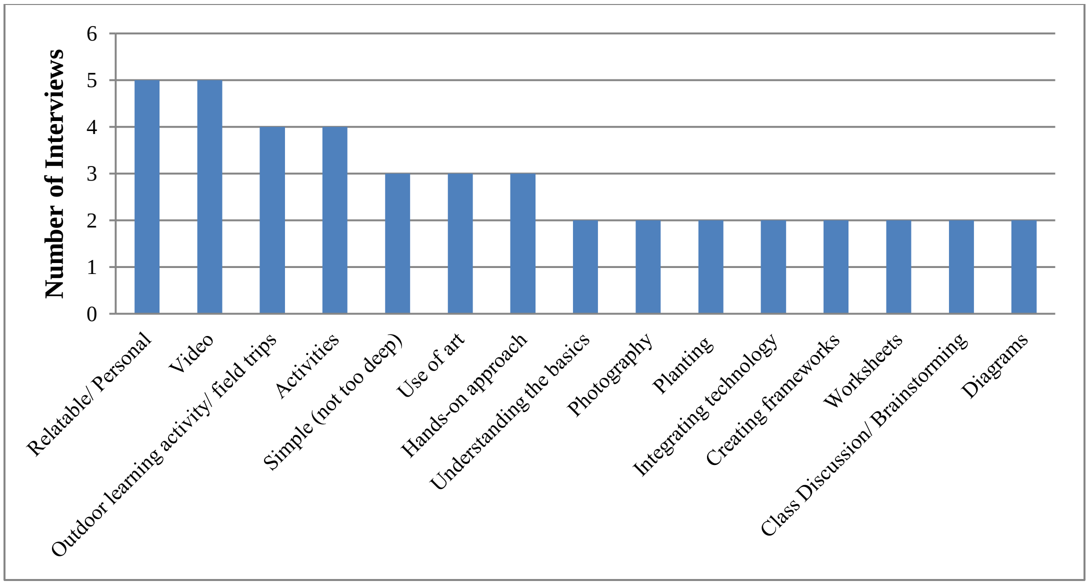


Figure 7: Education Techniques Discussed in Interviews
This graph shows the various techniques discussed in our interviews. This included utilizing tools such as videos and worksheets, as well as suggestions such as making the lesson relatable/persobnable.

Overall, the observations of the classes and the classrooms at the Carmen Feliciano Carreras Middle School gave way to a better understanding of the possibilities available while developing our learning unit. We found that though the classes were taught in Spanish, many tools presented to the students were in English. This included informational wall posters and interactive, online activities. By having this mixture of languages, we were able to use more tools in the development of our learning unit, as we had more English-based tools that were at our disposal. Most of the classrooms we saw also had an integration of technology, which again opened a range of possibilities for learning unit development. The availability of technology both in the classroom and in the student use of personal cell-phones allowed us to be able to realistically include slide-shows, videos, and/or technology based homework assignments in the construction of our learning unit. Our learning unit construction also included classroom activities to allow for a more hands-on approach to the topic. By including classroom activities in conjunction with lectures, this mixed approach to our learning unit would be easily integrated into Puerto Rican schools, as this format mirrors the formats seen in the classrooms that we observed as well as those described in the island's latest curriculum guideline (Departamento de Educación de Puerto Rico, 2014).

Objective 3

As the data from the first two objectives were gathered, we began to develop our climate change learning unit. First, we developed seven learning objectives to be covered in the two lessons, as seen in Table 4. These objectives were based on the topics that were deemed important by our experts in addition to the topics we found in our research on climate change education. However, we wanted our lesson to be an introduction to climate change, as requested by our sponsor and as reiterated by the interviewees. Therefore, in our first lesson we began with discussing the causes of climate change and the processes involved. Then we presented the specific effects of climate change that are impacting Puerto Rico.

Table 4: Learning Objectives For Our Two Developed Lessons About Climate Change

Learning Objective	Students will be able to…
1	Identify an evidence of climate change, focusing on the relationship between CO_2 concentrations and atmospheric temperature.
2	Describe the greenhouse effect and identify the gases involved in it.
3	Describe how carbon enters the atmosphere as depicted by the carbon cycle.
4	Identify sources of CO2 emissions.
5	Identify the predicted impacts of a warmer atmosphere on the earth, focusing on the water cycle and oceans.
6	Determine the impacts of climate change on animals and plants in El Yunque, focusing on the impacts of rising temperature and changing precipitation patterns.
7	Determine the impacts of climate change on humans, especially how changing precipitation patterns, rising sea levels, and changing animal and plant habitats affect humans

We developed a PowerPoint presentation to display material and guide activities. This presentation addressed each learning objective using graphs, discussion questions, and activities. Such graphs and diagrams from the first lesson included a diagram of the greenhouse effect, a pie-chart depicting the different percentages of each greenhouse gas in the atmosphere, and a diagram of the carbon cycle, a pie-

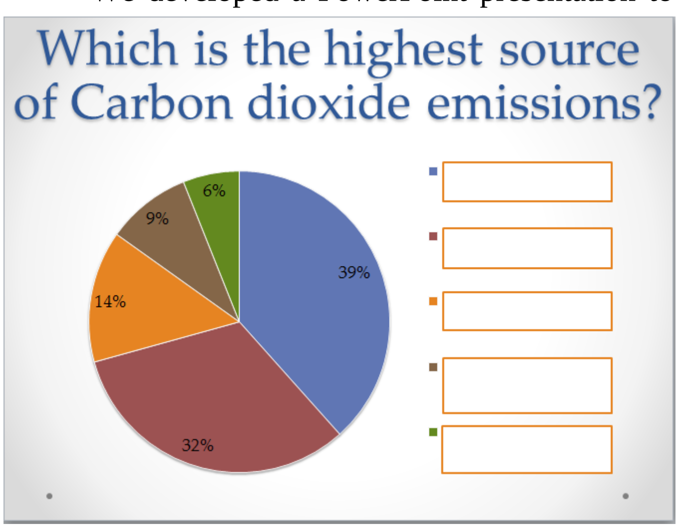


Figure 8: Activity from Lesson 1 (see Appendix uviwelyb)

chart of the sources of CO_2 emissions (Figure 8). Each of these graphs was doctored to not include specific information in order for the student to supply said information. A student worksheet was created that exhibited these graphics and allowed for students to fill-in the appropriate information as the lesson progressed. These graphics were either found or created based upon data provided by various government agencies. The activities involved in lesson 1 included having the students create graphs depicting changes in global temperature and carbon emissions over time and a version of the classic board game Pictionary, in which the students had to draw sources of carbon emissions.

In our second lesson, discussion questions and other graphics included a diagram depicting the water cycle and a graph displaying the change in ocean temperature over time were utilized. Additionally, we developed an activity in which students placed endemic animals and plants on an illustration of a mountain in El Yunque and shifted their elevation on the mountain based on hypothetical scenarios in which the precipitation levels or temperature changed. We developed this activity based on a conversation we had with Filipe Cano (see Appendix B) where we discussed how climate change contributes to habitat shift. We created a worksheet to accompany this activity that included the pictures of the animals and plants, the picture on the mountain in El Yunque, graphs depicting the required conditions of the animals, plants, and forests, and detailed instructions on how to complete the activity. This activity is intended to encourage students to think critically about how changing temperatures and precipitation patterns due to climate change can affect the wildlife of El Yunque. In order to ensure that this activity would work the way we intended, we tested the activity on a group of college students. In this testing, we gave three students a rough draft of our habitat activity and they were allotted twenty-five minutes to complete it. They were able to complete the four scenarios by moving the animals and plants to different elevations. In that time, they were able to complete the discussion questions and provide detailed responses. However, the fact that they could not move the different forests types provided confusion. Therefore, we created labels of each forest type that could be moved in elevation when the temperature and precipitation ranges changed.

In addition to this PowerPoint presentation, we created worksheets for the activities and an instructor's guide that provided instructions for teachers on how to present each part of the lesson. It also included additional information on each aspect of the lesson in case the teacher had never taught climate change before. This instructional guide explained each of the concepts addressed in our lessons in order to provide a deeper understanding of what we are asking them to teach, with the use of supplemental diagrams. Figure 9 below is an example of a page in this instructor's guide.

Slide 4: Which greenhouse gas has the greatest emissions?

Estimated time: 5 minutes

Purpose: Defines the different greenhouse gasses (Objective 2).

Ask the students what they believe is the greenhouse gas with the highest emissions and then reveal the answer. Next, ask what they believe is the second greenhouse gas with the highest emissions and then reveal the answer. Continue in this manner, until all four of the greenhouse gases are revealed. Have students fill out their own graph as it is discussed. The answers include CO_2 (carbon dioxide), CH_4 (methane), NO_x (nitrous oxides), F-gases (Fluorocarbons).

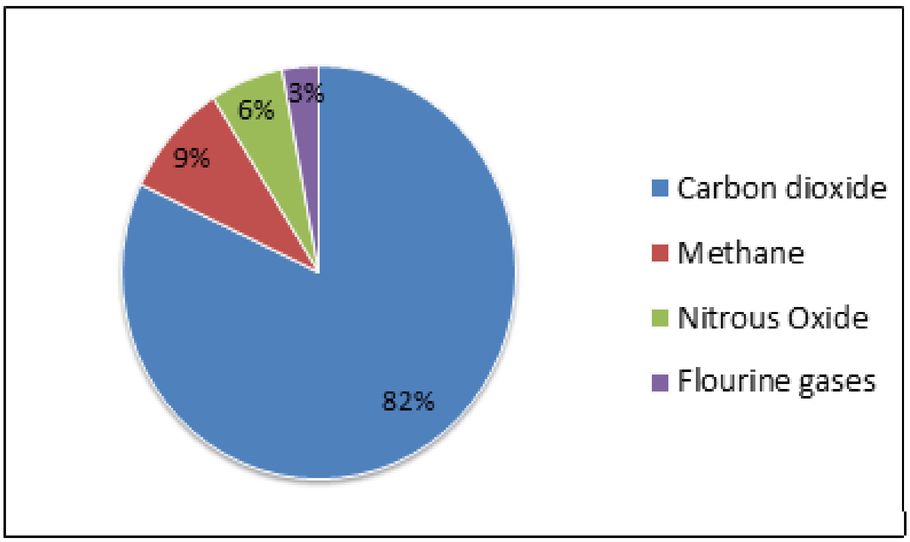


Figure 86: Relative percentage of greenhouse gases in terms of greenhouse gas emission levels (Environmental Protection Agency)

Explain that these gases are not necessarily bad for the environment. Carbon dioxide is only an issue because it is currently present in the highest amounts recorded in the Earth's history. It is for this reason that the remainder of the lesson will focus on the effects of carbon dioxide concentrations on mean global temperature.

Figure 9: Excerpt from our Instructor's Guide

Objective 4

To understand the effectiveness of our developed lesson plan, we went to the Carmen Feliciano Carreras Middle School to test the individual lessons. We were paired with a class of ninth grade students at the school (designated as class 9-2) that was also involved in a 4-H club through the University of Puerto Rico, Río Piedras. The class groups at the school were separated by their chosen elective courses; in the case of the class that we worked with, the students were all taking a visual arts elective. This elective art class was integrated with 4-H through the environmental education program known as Casa del Árbol, a project that focused on developing tree propagation, planting, and transplanting, as well as nursery management and maintenance skills in 4-H members. The class therefore was very involved with El Yunque and they frequented the forest for various school field trips, such as a large-scale photojournalism project. There were a total of 24 students in the class who participated in our lessons; there were 16 girls and 8 boys in the group.

To evaluate the effectiveness of our lesson plans on this class, we gave each student a pre-test on the material to be covered in the lessons. This pre-test was designed to evaluate their understanding of these topics before participation in our lessons. Each question in the pre-test was geared to address one of the seven learning objectives for the lessons, and they all contained information that was to be covered in the lesson. a sample of a question on this test can be seen below.

1. Which of the following is not a greenhouse gas? (Objective 2)
    a. Carbon dioxide
    b. Propane
    c. Methane

Additionally, we handed out questionnaires (which contained the same questions as the pre-test) to the entire ninth grade to be able to obtain a comparison of the results of the pre-test for the 4-H class and determine if the additional exposure to climate change topics that the 4-H classes received would correspond to significantly better pre-test scores. These contained demographic questions such as age and gender. To distribute these questionnaires, we asked the ninth grade math teacher, Amabel Soto, to administer them to all of her classes, with the exception of the 4-H class. We asked that she only give students ten minutes to complete the questionnaire and work individually, so as to best simulate the condition that were present when the 4-H class received the pre-test.

The lessons were developed with the intent of being administered on two consecutive days by a professional teacher. However, due to unforeseen circumstances, our team had to deliver the lessons ourselves with little time to prepare. Furthermore, there were last-minute schedule and

location changes. We had to deliver the two lessons with a day in between them, and the post-test on the day of the second lesson as opposed to a day after. These factors could affect our lessons' effectiveness. Firstly, our team members have no formal training in teaching, leading to the possibility that various points in the lesson could have been delivered more effectively had we been professional teachers. We were also limited in part due to a language barrier. Though for the most part, the students were able to understand English, they were more comfortable speaking Spanish. Meanwhile, for the most part, we could understand Spanish and had moderate to high proficiency in the language, but there was still an occasional confusion between both parties. In an attempt to minimize confusion, we translated all written material involved in our lessons, including the pre- and post-tests. Despite this, we still received questions concerning the meaning of certain technical terms, such as "correlation". Overall, we found that the ten minutes given to complete these test was reasonable, as students did not seem to have any difficulty completing the test in this time. It is important to note that most student utilized the full ten minutes to complete the pre-test.

Table 5: Paired Data for the 12-Question Pre- and Post-Tests

Student #	Number of questions correct (Pre-test)	Numbers of questions correct (Post-test)
1	3	9
2	8	7
4	2	1
5	5	8
6	5	9
7	4	5
10	5	8
11	5	5
13	7	6
14	3	6
16	8	9
17	5	8
18	6	7

In order to determine whether our lessons were effective, our team utilized SPSS and performed a paired samples t-test within subjects. For the purposes of this test, we defined "effective" as an increase of statistically significant magnitude from the pre- to the post-test. We also worked under a null hypothesis (h_0) that the pre- and post-test scores would not have any mean change and, therefore, that the lessons would not be effective. Due to absences of students for either the administration of the pre-test, post-test, or lesson one, we could only consider the paired data of thirteen (n=13) students. The accompanying table (Table 5) shows scores for pre- and post-test for each student, which a full pair of data was obtained. In scoring the tests we wre not blind, however any bias that could be introduced by knowing which test was being graded was eliminated by the use of a set answer key. The average score on the pre test was 5.08 out of 12 and the average score on the post-test was 6.69 out of 12.

Table 6: Mean Number on Correct Responses by Objective (Entire Class)

	Mean number correct (Pre-test)	Mean number correct (Post-test)
Learning Objective 1	4	6
Learning Objective 2	5.5	8.5
Learning Objective 3	7	6
Learning Objective 4	4.5	9
Learning Objective 5	7	7
Learning Objective 6	4	5.5
Learning Objective 7	7.5	7

To attempt to identify any variability in effectiveness by learning objective, we designed each test question to correspond to specific learning objectives, and tabulated the mean number of correct responses for each learning objective in the pre- and the post-tests (see Table 6). Due to the class' environmental exposure through 4-H, as well as the entire ninth grade having recently taken a climate change unit in their science class (Marganese Sanjunto, personal communication, 2014), we were aware of the potential for skewed data analysis as we evaluated our lessons. For this reason, we thought it was extremely important to compare the 19 pre-test results of class 9-2 to the questionnaire results of classes 9-3, 9-4, 9-5, and 9-6. We received a total of 89 completed questionnaires from among those classes. A one-way between subject ANOVA was conducted to compare the effect of different classes of students on the number of questions that students correctly answered on a pre-test in the 9-2 (4-H), 9-3, 9-4, 9-5, 9-6 class conditions. There was a significant effect of different classes of students on the number of questions that students correctly answered on a pre-test at the $p<.05$ level for the three conditions [$F(4,103) = 5.693$, $p = .000$].The descriptive statistics of this data, determined through the use of the ANOVA test, are provided in Table 7 below.

Table 7: Descriptive Statistics of Initial Student performance on 12 Pre-test Questions

Class	Number of Students	Mean number of correct answers	Standard Deviation	Minimum number of correct answers	Maximum number of correct answers	Variance
9-2 (4-H)	19	4.31	2.02	2.00	8.00	4.08
9-3	21	3.05	1.43	1.00	5.00	2.04
9-4	24	4.24	1.97	0.00	7.00	3.88
9-5	23	2.24	1.67	0.00	5.00	2.79
9-6	21	3.57	1.63	1.00	7.00	2.66

While the ANOVA test did determine that there were significant differences in test score between all classes, it did not state which classes were significantly different from each other. A plot of the mean pre-test scores for all ninth grade classes can be seen below in Figure 10.

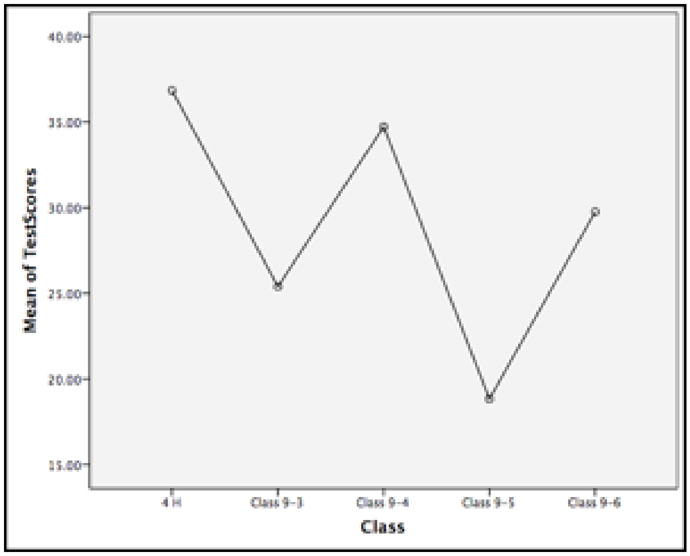


Figure 10: Plot of Mean Test Scors for Each Ninth Grade Class as Determined by an ANOVA test

In order to determine which class's test scores, if any, were significantly different when compared to the 4-H class test scores, we decided to use an additional statistical analysis, known as an independent-sample t-test, for each class. Like the ANOVA test, the independent samples t-test utilized a null hypothesis of no difference in test scores between classes. An independent-samples t-test was conducted to compare the number of questions that students correctly answered on a pre-test in the 9-2 (4-H) class and 9-3 class conditions. There was a significant difference in the score for the 9-2 (4-H) class (mean = 4.42, sd = 1.92) and 9-3 class (mean = 3.05, sd = 1.43) conditions; $t(38)=2.58$, $p = .014$). This p-value of less than .05 indicated the the difference between test scores in classes 9-2 and 9-3 were of a statistically significant magnitude. Next, an independent-samples t-test was conducted to compare the number of questions that students correctly answered on a pre-test in the 9-2 class and 9-4 class conditions. There was not a significant difference in the score for the 9-2 class (mean = 4.42, sd = 1.92) and 9-4 class (mean = 4.04, sd = 1.80) conditions; $t(40)=.66$, $p = .515$). In this case, the tests for students in the 9-2 and 9-4 classes showed a difference in test scores that was insignificant in magnitude. Then, an independent-samples t-test was conducted to compare the number of questions that students correctly answered on a pre-test in the 9-2 class and 9-5 class conditions. There was a significant difference in the score for the 9-2 class (mean = 4.42, sd = 1.92) and 9-5 class (mean = 2.26, sd = 1.66) conditions; $t(40)=3.91$, $p = .000$). Of all the classes we compared the 4-H students to, the difference in test score between these two classes had the greatest statistical significance. Lastly, an independent-samples t-test was conducted to compare the number of questions that students correctly answered on a pre-test in the 9-2 class and 9-6 class conditions.

There was not a significant difference in the score for the 9-2 class (mean = 4.42, sd = 1.92) and 9-6 class (mean = 3.57, sd = 1.63) conditions; $t(38)=1.51$, $p = .139$). The results of this analysis, similar to the previous analysis of classes 9-2 and 9-4, showed that the difference in test scores between these two classes was not statistically significant. Because we were only able to reject the null hypothesis for the analyses comparing 9-2 with 9-3 and 9-2 with 9-5, we concluded that, although the 4-H student had increased prior exposure to climate change topics, their test scores were not significantly greater than ninth grade classes who had not had this increased exposure.

Based on the data in Table 7, we determined that there was no statistically signifigant difference between the overall mean class scores of the 4-H group, which we used for testing, and other classes of ninth grade students in the Carmen Feliciano Carreras Middle School. We were not able to definitively determine whether the 4-H class' recent exposure to a climate change curriculum provided a skew, as there was no pre-test data from before that curriculum to compare our pre-test with. However, the theoretical score that a student should get on this exam if they were to randomly guess the answer for each question would be a 3 out of 12, as this test comprised of multiple-choice question with four responces each. Having determined that the 4-H class did not display a significantly greater pre-existing knowledge of climate change, we further analyzed the output of the statistical analysis of our pre- and post-test.

During this analysis, we adopted a null hypothesis predicting no changes students' test scores, and an alternative hypothesis (h_1) predicting that our lessons would be effective in increasing the students' test scores. The application of the paired samples t-test within subjects showed a statistically reliable difference between the mean number of the Pre-Test (mean = 5.08, sd = 1.85) and the Post-Test (mean = 6.69, sd = 2.25, t= =2.63, df=12, $p = .022$, $\alpha = .05$. Because the p-value was less than or equal to .05, we were able to reject the null hypothesis, and definitively conclude that our pilot lessons were effective in increasing the students' climate change knowledge at the 5% significance level.

While we were able to statistically demonstrate that our lessons, as a pair, were effective, we did note that learning objectives 3 and 7 experienced a small negative change in the number of student who answered their corresponding questions correctly (Table 6). Additionally, we observed that learning objective 5 experienced no change in the average number of students who answered the corresponding questions correctly. Therefore, we targeted these objectives as the focus of our revisions. Our revisions will also incorporate the recommendations from the teacher of class 9-2, in order to make our instructor guide more useful for teachers. An additional factor that we would like to note is that we did not test the validity of the questions presented in our pre- and post-tests due to a lack of resources, and this may have affected the results of these tests.

Additionally, we coded the answers to the qualitative answers on the post-tests. These answers revealed, overwhelmingly, that students enjoyed our lessons. When asked specifically what they liked about the lessons, the students stated that they liked the interactive form of the lessons, the student-focused activities, and the dynamics of working in groups. Furthermore, fifteen out of the eighteen students present for the post-test reported that the lessons further inspired them to want to learn more about climate change. This finding implies that our lesson was successful from a qualitative standpoint, since the lessons were well received by the students.

In the testing of our lesson, there were various factors that may have affected the results of our lesson administration. One key factor that may have affected the outcome of our lesson administration was not strictly following our instructor's guide. During our lessons, we omitted some examples while teaching certain topics in the lessons, and this did have a noticeable effect on some of the questions on our post-test. One question in particular that we believe suffered because of these omissions is provided below:

6. Which is not an environmental effect of warmer oceans? (Objective 5)
    a. Rising sea levels
    b. Coral reef changes
    c. Changed chemical compositions
    d. Increased waves

Student response for this question from pre- to post-test did not greatly differ . This may be attributed to the omission of the example of changed chemical composition as an effect of a warmer atmosphere. Similarly, we were forced to omit the Pictionary activity from the delivery of the first lesson and replace it with a brief verbal description about sources of carbon emissions. These factors, though unpredictable in nature, could have contributed toward whether the lessons were effective.

Lastly, we found that the questions corresponding to the learning objectives of lesson one experienced much larger increases than the questions corresponding to the learning objectives of lesson two. This observation points out a critical flaw in the testing structure that we employed. Specifically, we tested the lessons as a pair. Since lesson one was administered two days before the distribution of the post-test and had a pre-homework and homework accompany it, students were given a chance to both absorb the information in the classroom and think about the content of that day's lesson. On the other hand, the second lesson was taught directly before administering the post-test, without any opportunity afterward for the students to think about the material covered in the lesson. Since lesson two was largely comprised of an interactive group activity, it was imperative that students be given the proper time to critically think about the information presented to them in the lesson. However, due to scheduling difficulties, this was not a possibility. Overall, though our lessons proved to be statistically and qualitatively effective in teaching students about climate change, there were many variables that may have affected these results that were, ultimately, out of our control.

Based on the results from our pre- and post-tests, we established that we needed to revise the portion of our lessons that addressed learning objectives 3 and 7. In order to address these concerns, at least in part, we decided to omit learning objective 7 (which states that students will be able to identify the impacts of climate change on humans) in the revised version of lesson 2. We believe that the lack of understanding could be attributed to the fact that there was not adequate time to address this learning objective in the fifty minutes of lesson 2. Instead of lengthening the duration of our lesson, we decided to not address that specific learning objective. Therefore, we recommend creating an additional lesson that mainly focuses on the impacts of climate change on humans (see Recommendations).

In order to address our concern with learning objective 3, we decided to simplify the diagram of the carbon cycle. The students seemed to have difficulty with completing the activity, which required students to use a list of terms to correctly complete the carbon cycle diagram, due to the overabundance of terms that needed to be placed. We kept the original diagram however; we required them to place less of the terms on the diagram. Therefore, some of the steps of the cycle were already were provided on the diagram, such as ocean uptake, root respiration, organic carbon, and decay organisms. Based on our observations of students completing this activity, we noticed that these specific terms were particularly hard for the students to place in the correct location because the terms themselves were either vague or more complicated to comprehend. Additionally, we increased the estimated time of the activity to allow the teacher to completely review and explain each step of the carbon cycle.

In addition, we observed through teaching the lessons ourselves that the layout of our instructor's guide could be revised to be more intuitive. At times, we found that the use of long paragraphs to describe each activity and aspect of the lesson were hard to follow, especially while teaching the lesson. Therefore, we decided to format the instructor's guide in a way that more clearly organizes what the teachers need to ask or explain to the students and then, separately, provide additional information that will aid their own understanding of the topics. We also adjusted the estimated times for each aspect of the two lessons to be more realistic and reflect what happened when we taught each lesson. Minor edits were made throughout the lesson correcting grammatical errors as well as making the lesson more intuitive for the students. For example, we added an answer bank (like we had for the carbon cycle) to two diagrams in order to help the students fill in the diagram more accurately (see Appendicies N and O). Some of the edits for making the lesson more intuitive to the students were provided by the visual arts teacher, Stephanie Santos, as she observed the administration of our lessons. For further reading, the revised lessons, in their entirety, can be found in Apendices N through Q.

5. Recommendations

We would like to highly encourage additional testing of our lesson plans. A major component of this testing process would be to apply formal validity and reliability analyses to the questions on our pre- and post-tests, as is often done in studies that involve using written tests (Gormally et al., 2012; Brownell et al., 2013). Conducting these types of rigorous analyses would be crucial in any further testing (Phelan, 2006). First, a validity analysis would determine whether each question truly measures the learning objective it corresponds to. Second, a reliability analysis would determine with what consistency our questions measure each learning objective (Phelan, 2006). After performing this set of analyses, we would recommend applying any necessary changes to the pre-and post-test that would increase both validity and reliability. Our lessons should be tested upon a classroom of students who have had no previous exposure to climate change topics in an academic setting. This type of testing condition could help isolate whether our climate change lessons are effective on students who have not studied climate change, as well as on students who have studied climate change. We encourage the administration of an additional post-test one month after the lessons are taught to be able to analyze the long-term retention of the content present in each lesson.

Lastly, we recommend the continued revision and expansion of our developed lessons and lesson outlines, as we believe the six proposed lessons in our unit, which integrate both scientific content and personal experiences, have the potential to be an excellent introduction to the complexities of climate change that. To supplement our revised lessons, we developed outlines for additional lessons that could be used in a classroom setting to provide more knowledge about climate change to students (see Appendix R). These outlines contain the desired learning objectives and topics of interest for each lesson, as well as potential activities that encourage a hands-on understanding of these topics. The subject material for these lessons was determined by analyzing the topics mentioned in the interviews conducted in Objective 1 (See Figure 6). One of the most frequently discussed topics of climate change by our interviewees was the effect that climate change would have on various bodies of water and the water cycle. We therefore decided to develop our first supplemental lesson outline to address this topic in more depth, focusing on the aspects of climate change that resulted in effects on water. This included rising sea levels, coastal erosion, changing precipitation patters and the consequences of each of these aspects on Puerto Rico. Adaptation was another frequently discussed topic, a specific example being adaptation through recycling. Accordingly, our next lesson outline focused more closely on the impacts of climate change on humans, as well as ways to mitigate and adapt to these changes. The fifth lesson was built off of this topic and focused exclusively on recycling. Here, we were able to propose a variety of lesson activities, including art using recycled materials. Seeing as art was a frequently discussed education technique (See Figure 7) in our environmental education interviews from Objective 2, we decided that it would be best to incorporate art into one of the supplemental lesson outlines that we provided. Following this was a final lesson that focused on the more societal impacts that climate change would have on Puerto Rico, food. Here, we suggested material that focuses on the environmental impacts that Puerto Rico's large volume of food importation has, as well as ways to lower these impacts, thus encouraging self-sustainability and the potential mitigation of climate change effects.

We believe that these lessons will start to lay down the framework for an effective climate change unit that is relevant to youth in Puerto Rico. To make these lessons even more accesable, we suggest that they be designed in a simple and straight-forward manner so that students of the target age group may best understand the material. By following these recommendations, we believe that our project can become an extremely useful and informative tool for teachers in Puerto Rico when discussing climate change in their classrooms. After being fully expanded, this completed learning unit could have a large impact upon students in Puerto Rico by introducing many essential facets of anthropogenic climate change in an active and engaging manner.


CLFC

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Appendix A: Interview and Questionnaire Questions

Interview Questions

Qualitative Data

To whom it will apply: experts on climate change, educators

Climate change experts

1. What is your area of expertise?
2. What organization(s) are you a part of or involved in?
    a. What environmental education initiatives have you been a part of? (*If Applicable*)
3. Where on the island have you focused your studies? (*If Applicable*)
4. What studies have been done in the Caribbean on climate change? In Puerto Rico? If so, can you explain the findings?
    a. Is there any available literature about these findings that we can have a copy of? (*If Applicable*)
5. What are the main issues and impacts of climate change that you have observed in Puerto Rico?
6. What are ways to adapt to these changes (that are feasible)?
7. What forms of adaptation have you seen? (Ex: water harvesting)
    a. What kinds of problems arose from these, if any?
8. What are the main socioeconomic consequences of climate change? (Ex: industries, culture, etc.)
9. What about climate change is the public unaware of?
    a. Which of these topics do you feel is most important to know?
    b. Why is not being informed about these topics especially concerning?
10. In order to develop a lesson that covered a good majority of climate change concepts, what topics of climate change do you feel are important to incorporate into the lesson?

Educators

1. What subject do you teach?
2. What subjects are available at the school where you work?
3. How long have you been teaching?
4. What age/grade level do you teach?
5. What language do you normally teach in?
6. Could you describe what a typical day in your classroom is like?
7. What educational tools and styles do you use to teach a topic?
    a. (Classroom activities, problem based learning, readings, visuals, homework, outdoor activities, etc)
    b. **When teaching a science course, what educational tools/styles do you find most effective?** (To be used in special situations, like teachers who teach multiple topics)
8. Is climate change taught in any way in the school where you work? If so, to what capacity?
    a. Have you ever taught climate change before?
    b. What were the results of teaching climate change? What about it was successful/unsuccessful? (*If Applicable*)
9. To what extent have you taught environmental science in a formal classroom setting?
    a. To what extent have you taught environmental science in a club, student group, or informal setting?
10. What problems do you typically face when teaching a new topic?
11. How do you develop your curriculum and lesson plans?
12. Do you ever have any challenges with planning and executing class activities, field trips, etc.?
    a. If so, could you please describe the challenges you encounter?
13. Are you open to using field trips to supplement a classroom topic?
    a. What types of field trips have your school done with classes in the past?
    b. What defines a field trip at the school you work in?
        i. Outside the classroom on school grounds? Off school property? etc.
14. Are you open to doing a large-scale school project? Ex: School-wide project, activity, etc.
    a. What kinds of projects do you think are feasible?
    b. Have you ever done a large-scale school project? Ex: Grade-wide artwork? (*If Applicable*)
    c. Do you think there are any benefits/disadvantages to doing a project like this?
15. How do you deal with teaching controversial subject material? (*If Applicable*)

Español

1. ¿Cuál tema usted enseña?
2. ¿Cuáles temas se ofrecen en la escuela donde usted trabaja?
3. ¿Por cuánto tiempo ha estado enseñando?
4. ¿Cuál edad/grado de estudiantes enseña?
5. ¿En cuál idioma enseña?
6. ¿Usted puede describir un día típico en su clase?
7. ¿Cuáles herramientas y estilos de educación usted use para enseñar una tema?
    a. Por ejemplo, actividades de clase, tareas, actividades fuera de la clase, lecturas, visuales, etc.
    b. **¿Cuándo usted enseña una clase de ciencias, cuales herramientas/estilos de educación son los más eficaces?**
8. ¿Se enseñan cambio climático en su escuela? ¿Cómo?
    a. ¿Ha ensañado cambio climático?
    b. ¿Qué fue la resulta de enseñar cambio climático? ¿Tuvo éxito? ¿Cómo?
9. ¿Hasta qué punto la ciencia del medio ambiente han enseñado en un ambiente formal en el aula?
    a. ¿Hasta qué punto la ciencia del medio ambiente han enseñado en un club, grupo estudiantil, etc.?
10. ¿Cuáles problemas usted encuentra cuando se enseña una tema nueva?
11. ¿Cómo desarrolla sus currículos y planes de lección?
12. ¿A veces tiene desafíos con la planificación y ejecución de las actividades de clases, viajes de estudio, etc.?
    a. Si es así, ¿podría describir los desafíos que usted encuentra?
13. ¿Estás abierto a la utilización de salidas de campo para complementar un tema aula?
    a. ¿Qué tipos de salidas de campo han hecho su escuela con clases en el pasado?
    b. ¿Qué es lo que define a un viaje de estudios en la escuela donde se trabaja?
        i. Por ejemplo, ¿es definido como salir del edificio, salir del campus de la escuela, etc.?
14. ¿Está dispuesto a hacer un proyecto de la escuela a gran escala? Como una actividad, un mural, un jardín, etc.
    a. ¿Cuales tipos de proyectos usted piensa son practícales?
    b. ¿Ha hecho un proyecto a gran escala en el pasado?
    c. ¿Usted piensa que hay beneficios/desventajas de hacer un proyecto como eso?
15. ¿Cómo lidiar con la enseñanza de material de tema controvertido?

Appendix B: Interview Transcripts

Climate Change and Climate Change Education Expert Interviews:

The following interviewees were selected for us by our sponsor and were deemed to have significant knowledge and expertise in climate change topics and/or environmental education initiatives.

Interview 1: Filipe Cano

Wildlife and fishery manager, United States Forest Service – El Yunque National Forest
Date & Time: November 5, 2014; 11 a.m.

Emma (E):…And you don't mind us recording you, right?

Filipe Cano (C): No, I don't.

E: Okay.

Princesa (P): So, the first question we really wanted to ask was what your area of expertise was?

FC: Okay. My area of expertise is in the management of wildlife and fishery species here in El Yunque, so I manage the program. That's basically a lot of monitoring any management activities that we do with our species. I'm usually the one in charge and leading that effort.

P: So if there's a species you want to preserve is that something you would -

FC: Yeah. I'd probably be leading that with the resources we had: providing objectives, standards, guidelines to technicians and probably to other cooperators and federal agencies or other state agencies to work together and to work on that particular species concern.

P: Well, we were also wondering if you were involved in any organizations? In particular, any environmental organizations or environmental initiatives?

FC: You mean societies? Professional societies?

P: Yes, or really any especially that goes out to the public.

E: So, environmental education initiatives.

Michael (M): Any types of grassroots types of organizations? Those kinds of things.

FC: Oh! I started, like three years ago, an agroforestry initiative. This is sort of outside of the forest so I don't have much authority. I work with partners, private landowners, so that they can, because there's a lot of agriculture to the east and to the south of us, and I wanted to have wildlife habitat be a priority for them. So, I work with NRCS (that's the Natural Resource Conservation Service), and then the farms service agency, and the Puerto Rico Agricultural extension agent to work with many of our landowner neighbors to try to have more emphasis on more ecofriendly use of their land. The products – the agricultural products - that they produce, either livestock or vegetation or fruits to be a little bit more, again, ecofriendly so that it provides healthy habitats for wildlife that they can off forest and back onto the forest. Okay? Then, like, a year and a half ago I started a children's education effort. It's called the

Children's Forest. This is the forest service initiative and so what we've done here is we received funding to work with four NGOs – Nongovernmental Organizations – surrounding the forest and the theme is climate change. Then, the second requirement is the use of art so, instead of it being a classroom where you lecture students, the NGO's have to come up with an art project and then that way learn what climate change is to these children and what, if possible, can they do to counteract the effects of that.

P: Why use art?

FC: People are much more interactive with art than they are with listening to a lecture. You know, if you go to any sort of professional symposium, after a while people just get tired and bored! But, with something you do with your hands, especially with children, they love doing things with their hands and seeing something fun come out of it, and so they learn at the same time. So, humans have this tendency to be much more connected if they have something of an ownership in it, and so the art is that ownership.

P: Do you do any specific kinds of arts? So for an example, do you use recycled materials or do you focus maybe on drawing and painting? Or, is it kind of scattered?

FC: It's scattered. It all depends on the NGO partners. We have one NGO group in the urban areas. They're coming up with these huge steel structures in the form of bees and then they put flowers in that structure so that it's a living structure, knowing that bees are affected by climate change. So, that's one NGO. Another NGO is doing the use of video making a small movie, I guess, of how habitat in El Yunque and off to the east in relation to climate change and students are making a movie out of that. The third NGO is creating long term photography projects, so they are going to different plots and taking photos. This is mostly on the forest, and they are using trees – the planting of trees – as that project. Then, the fourth NGO is making an interactive social map, so kids are actually creating an interactive GIS map and they are looking into – and this is also in an urban estuary – creating a map that really makes sense to kids, and social components that relate to kids. So, those are the four projects.

E: That definitely has a lot to do with our project that we are working on. Do you have any pictures from those that we could take a look at so we could use it as inspiration for our educational module?

FC: Yeah. I do! Each group was supposed to have a proposal and they have all turned it in. Some of them have pictures.

E: Okay! Is there any way you could send that to use?

FC: Yeah, I can send to Princesa, I guess? I have your email? Okay, so I'll send it to her. I'll need to write that down!

P: okay! So, regarding your personal work, where do you – I'm guessing you focus your studies here in el Yunque? Or do you do anywhere else on the island?

FC: I do other places because of the need of the wildlife species, for example the parrot. We work with Fish and Wildlife service and the Department of Puerto Rican Natural Resources out in places in Mayaguas, which is out west, and Arecebo. Those are locations where the parrot is really doing really well so we help out also in other parts of Puerto Rico. I also do a little bit of international projects, mostly in Africa, Central America, northern South America, and that's it!

P: What kinds of projects are those? Are those in environmental?

FC: Yeah. I was a planner in the Forest Service so in Africa they needed a planner with background with natural resources, so I helped them out with that. In Central and South America it was based upon expertise with wildlife issues.

E: So, on the topic of climate change, what studies that you know of have been done either in the Caribbean or in Puerto Rico? If you could please expand on that.

FC: Oh, yeah. Lots and Lots! You're very lucky because this is a central node for climate change studies. USDA has actually created a hub with all those studies, and they call it the climate change hub and it's on the internet, USDA, and you'll find a lot of the research that our research station – that's the International Institute of Tropical Forestry - they've done. Then there's the University of Puerto Rico. They have elevation stations where they're measuring change in temperature and rain patterns so that all affects the water quantity that is collected on the forest and flows off. Also, a lot of nutrient cycling like Nitrogen, Phosphorus, Sulfur, Calcium, Carbon. Studies that have occurred here, and you will find them in that hub.

P: what are the main impacts and issues of climate change that you may have observed in the area or in El Yunque? Puerto Rico overall?

FC: The first thing would be, in regards to wildlife, what's called behavioral adaptation that's where –. Imagine yourself where you would live on the coast back in Massachusetts and say the sea level rises twenty feet. Say you live very close to the water. Obviously you're going to have to change, so you change by the sense of, you know, moving more inland and maybe your lifestyle will change because not only you but a mass amount of people are gonna have to move inland so there's going to be change in people competing for resources, so things might get not as safe and it's the same thing with wildlife. So if you have a species that have occurred in one habitat, let's say through climate change, whether it's through change in rain patterns or change in temperature, it reduces the quality of the habitat. Well, that species now either has to go to other locations and compete with what's already there. So, that's sort of like, what are the interactions of the wildlife species? Are there going to be new diseases that'll come out based from these interactions? What is the type of potential for sustained population viability for these species? So those are basically it, those three things.

P: Have you observed any other effects of climate change?

FC: Yes, I'd say one in particular species is the elfin-woods warbler. This is a bird that was discovered here in the 1970's. A black and white little bird. It was called elfin-woods warbler because the Elfin Woods are up in a high elevation. Now, we are starting to see them in lower elevations. We don't know why. We don't know if this is because of climate change or perhaps another factor we just haven't figured out. So that's a type of behavioral adaptation. They moved from these high elevations to low elevations, so that's one particular species.

P: If I'm remembering correctly, in previous conversations with you, you might've mentioned something about rain pattern – weather pattern – changes? Could you maybe elaborate on that?

FC: Yeah. I would probably say in the past you would be able to see a type of trend that occurs with the water gauges that IITF researchers have out there. Much of the pattern that you would look, prior to the

1990's, the rain pattern would look more of a sloping downward, but once the 90's occurred then it sort of did this unique spike and then it drops. Up and down. That's what researchers are finding now, so one of the hypothesis is that with changing rain patterns where we could probably see a more steady trend, we're going to be seeing the extremes. Think of it like a pendulum, no longer is it going to be weather or patterns like this moving in a natural oscillation. Now we're thinking, "Very dry. Very wet. Very dry. Very wet."

P: Now, is that within the course of a year, or a couple years? Like, that pattern.

FC: That one was particular – I believe that one was a thirty-year trend of this all of a sudden shifts. Prior to that it was all the way back to the 1920's. You know, that it would be a steady trend.

P: So, within a year are you seeing that, say, there's a five-year block of a lot of rain and another five-year block with no so much rain? Or, is it more that within one year you'll have a lot of rain suddenly and then no rain?

FC: No rain. Yeah.

P: Within one year?

FC: Yeah. That's what we're looking at.

P: So, what kind of effects would you think that might have on the forest, maybe in terms of the animals or even the plants or anything like that?

FC: I guess the best way to explain that would be to think of the mountain itself, and think of it in four sections. Each section is a vegetation type. So, if you have drier conditions - and that's what the theory is, that the Caribbean region will become much drier – those that are on the top are adapted for wet conditions. So, if we have less rain, hotter temperatures, that upper quarter will basically disappear because the three below that will shift up. So that's why the Elfin-woodlands warbler that would occur up on the very top, they're moving down into one of these lower quarters of the mountain. So, that's basically what you'll see more of what's called a habitat shift. And so, with that, you have population effects. We just finished coming out of what's called a genetic bottleneck with the Puerto Rican parrot so we may be seeing, perhaps, another genetic bottleneck with, perhaps, the Elfin-woods warbler. It's a good example. Humans sort of experienced that in the past also and with humans it's all just speculating but it's, sort of, more geneticists looking at what sort of seems to be humans did have in a some type of response to genetic bottlenecking. So, think of it that way, as if you have a small group of humans but even then conditions were right for you to expand throughout the globe and you have all this diversity. Now, if we can keep those species safe so that they can make it through their bottleneck and try to make it so that there's preferred habitat afterwards, then they'll explode and take care of themselves.

P: So, with the disappearance of animals in that top quarter you were mentioning, what kind of effect would that have on the forest as a whole or even the entire island, if you can?

FC: That would affect food webs. That would affect certain nutrient cycling. That would affect, perhaps, extinctions. It's all based off of mutualistic relationships, communal relationships among all these individual members of the ecosystems. So that's what you would see – something like that. So, who know?! It's all speculation, but until it happens and scientists can confirm it, then we have something we can hang our hat on.

P: What about what it would have as an effect on people?

FC: On people? It's all speculation, but the biggest thing that people would see be and increase in tropical diseases. Think about it up in the continental U.S. All of a sudden we're seeing west-Nile virus – west-Nile fever – well those are actually sub-tropical diseases and no they're occurring in temperate zones. That tells you that temperature has somewhat fluctuated on a very minuscule scale, that those particular virus can now occur in, say, corn belt USA. You know? That's not a subtropical, but it's changed so much that that's what you see. That's why here in Puerto Rico, you probably saw in the airport, Chikungunya and Dengue.

P: wasn't Dengue already common here though? Or was it not so?

FC: No, it was not common. That was because of globalization. It was brought in, most likely, from South America and then it was brought in here. Now, here at the high elevations you won't see much Dengue, but in the coastal regions, and that's just as temperature and conditions changes, that's when you'll start seeing people – even other people up in the mountains getting Dengue and all these interesting tropical diseases. Even though we're in the tropics the elevations, especially high elevations, are not characteristic of a tropical wet zone, just a tropical high zone, so it's a little bit different. It's a little bit cooler and just a few degrees make a difference.

E: Is there any effects you see in industry or culture or anything like that?

FC: In regards to climate change?

E: Yeah.

FC: Maybe societal cohesion. That's probably the only thing, because if you get change and then say you have refugees, then you'll see a lot of refugees due to coastal flooding. That is probably what I'd say is the biggest stress for social fabric. You know, keeping order, having structure. So it's a classic nut-to-soup sort of scenario. That'd be the biggest concern: loss of that structure.

P: As there continues to be changes in the forest and in the weather and everything, especially on an island, do you know of any ways people can adapt to them and even possibly mitigate these effects?

FC: Yeah. I think in the Children's Forest, we call it the Children's *Tropical* Forest, effort, one of the things we've sort of found out is that focus on pollinators .You know, bees and native pollinators, butterflies, stuff like that. One of the results that came from the agroforestry is we're establishing beehives – controlled beehives – in the forest so that the community can have honey – organic honey – and we can get extra pollinators throughout the forest. So, one of those things would probably be improving local habitats for growth of vegetation. The vegetation we're talking about is vegetables, fruit trees, stuff like that which also helps out wildlife. So, since I'm only focusing on wildlife – obviously there are other social components. Obviously there is population control; it's the big elephant in the room, but that's out of my scope. But that would probably be the big thing for the most part: sort of would the improving your local habitat, wherever you're at, whether it's a river or riparian or land. Try to reduce heat island effects. These are urban areas. If you have to have urban areas, plant trees so that it reduces the temperature and then probably practice recycling habits. I know we consume a lot and we're sort of encouraged to consume a lot and that sort of a –. It's something that'll take a generation to really address, but if you keep recycling and try and keep the young generation asking, "do you really need to consume that much?" That's probably a good way to go.

P: What about climate change do you feel the public in general is not very aware of?

FC: I'd probably say the whole thing! Yeah, and we're in another meeting with developing the forest plan and we're finding that out. It's very complex, very scary, and who really wants to deal with that - a scary, complex boogieman? So people just try to shy away, so with the Children's Tropical Forest we tried to bite-size small steps and working with the youth for the most part.

P: So how have you been able to figure out that most people don't really know anything about it? Did you just – I don't know – I guess, how did you find that out?

FC: Well, two things. The first thing would be the general response of people when you talk about climate change. It's really a big thing to wrap your mind around. Then, the second thing is just sort of getting – gauging the public's response to many of these, you know, news articles or newspaper items that come out. People maybe sit there and shake their heads; it's just too big for me to do anything about it. You know, that kind of deal. So, that's how I sort of know that. Nothing official. No scientific study or anything to back me up on that, but that's how it is.

E: So our project is going to be working with a ninth grade 4-H club, and we're creating a lesson plan for them about climate change. Are there any particular topics that you think are important for youth to know concerning climate change and any activities, since I know that you worked a lot with teaching youth about climate change, that are particularly effective?

FC: Well, I'd probably have to say… topics?

E: Yeah, the topics.

FC: Well climate change is its own sort of topic.

P: More of the subtopics. The specifics. Greenhouse gases, water levels –

FC: For a curriculum?

P: Yeah, especially for the first few lessons as we really try and introduce it.

FC: Okay. I see what you're saying.

E: We have one lesson [to test] so we want to make sure we have everything that's really important in there –

P: - and for our supplemental lessons afterward.

FC: That's always been my weak point. I'm not much of an instructor like a teacher who develops a curriculum, and you'll talk to [Edgardo] next. He's on the Children's Tropical Forest and he helps me out with those particular items because, especially when it comes to Department of Education, there's curriculum requirements that's necessary and for the Children's Tropical Forest we're making a smartphone app. An application for android or iPhone and the public or the very kids themselves can access this curriculum and actually glean information from it. For public teachers, if they come here we no longer have resources to act as a host to public schools, so they can use that app as a virtual host once they come here and learn about climate change. But, that's a question that's really hard for me to answer. I don't know teaching theories or teaching tools.

P: It doesn't have to be a tool so much as if you just had to –. If you knew that you only had -. Because we only have one lesson that we present to them and then we hope to develop a couple lessons afterwards just to kind of present to the USFS as well as our personal advisors from our school, we wanted to know what kind of main topics would be really essential to getting a kick-start for developing a curriculum. So, in the first lesson what would be something that would help get information out about some general things that really tie to El Yunque and to Puerto Rico? Did that make sense?

FC: Yeah. You're thinking of a lesson plan and so you're coming up with -. In your lesson plan is broken down by component activities and so your first component activity would probably be, I'm assuming, "what is climate change?" I'd probably start from there. You know, what is climate? You know, what is weather? I would use a lot of analogies. A very good one that I saw on television was the analogy of the man walking with a dog on a beach. You see a man who walks in a parallel to the ocean and he has his dog, and his dog is going left to right, left to right. What was a very good analogy was weather is that dog that goes left and right; he doesn't stay in one particular pattern parallel to the ocean like the guy walking on the beach. We'll that guy walking on the beach is climate because climate doesn't change as quick as weather, so something fun that kids can designate, because they'll go outside and say, "Oh! It's a sunny day! What do you mean: 'climate change is occurring?'" While another kid will come up and say, "Oh, my God! It's raining cats and dogs! This must be climate change!" And so you have to designate those first with definitions. What is weather? What is climate? That's where that particular component, I would start off with. Anything else?

E: Since we only have an hour to do this lesson, how in depth would you suggest going into greenhouse gases? I know that's a major component to causing climate change, so how in depth do you suggest going into that with youth?

FC: With youth you don't want to go too deep because you'll lose them really quick. Try to make it into something that challenges their mind. Probably when you were in ninth grade, if you started immediately quoting data or studies then you've already lost them form the get go. You want something that's contemporary. Something that relates to them, like what's the technological mode or fashion nowadays. Try to have a very superficial introduction of greenhouse gases to kids like 'where does greenhouse gases come from?' You know, that kind of deal. Can somebody show me? They probably wouldn't be able to tell you since they probably would say, "I don't even know what it is. What am I doing here?" Those kind of things. That's where you educate them. You know, carbon monoxide. What else? You've got natural sources like volcanoes then you've got manmade like cars, automobiles, smokestacks, those kind of stuff. That's where I'd keep it very, probably, piques their interest. They'll be like, "Didn't think about that." That kind of stuff.

P: If you were to pick a topic that you found to be the most, out of all those subtopics of climate change, if you were to pick one or two that were the most pressing to El Yunque, what would they be?

FC: I'd say that's easy. I'd say basically the danger that wildlife would be in from climate change. Not only to our birds, but also to our coquís. Those are our tree frogs. People know one of the icons of Puerto Rico is the Puerto Rican parrot and then for El Yunque also there's the parrot and also coquís, the little tree frogs and here on the forest we have eleven species of coquís. One of the things that I think kids would definitely look interested in is, you know, a coquí in their hands since we did something like that with river shrimps and kids are just taking pictures. They wanted to hold them. Once you have something in your hands then you see the click. You see the connection and they're like, they understand now because, I guess, us humans, unless we have something in our hands we don't understand it. Then it becomes no longer an abstract. Take them out of that abstract realm and into hard, 'This is it, this is what it is'. That'd probably be the trick.

P: And the things that affect those wildlife would be climate change - changing temperatures, changing weather patterns - all that is tied?

FC: Yeah. How it affects habitat quality. Focus it on – Yeah it's pretty cool, I think. Is there anything, like, initiatives like that happening up in Massachusetts? You're all from Massachusetts?

E & P: Yeah.

M: I'm from New York.

FC: New York, huh? So, the New England Area.

E: Yeah, there's this park called the Audobon Park where they have camps and stuff where they do stuff like that and they talk about wildlife and changing habitats and things like that.

P: I think Boy and Girl Scouts do something like that.

E: Yes. Definitely camps do it.

M: State parks do.

FC: Yes, some state parks here do that too. That's a good format to follow. In the states – I used to live in Arizona – they had a really good one too where it's communicating to different groups of the public and they've really done a good job. I think the States seem to be at least trying to do – certain states – try to include that so a lot of education.

P: I think it depends on the state. Like California and Washington. I think those kinds of states really would try and push for that. I don't particularly notice anything in Massachusetts not being someone who's a Girl Scout or a Boy Scout.

E: I remember having Earth Science in the sixth grade and they did a lot about climate change. It really depends on what school district you go to.

P: For me, earth science was geology.

E: For mine, they had two years of earth science, so one was more geology based and the other one was more climate change and that sort of stuff.

P: I did have a geography class.

FC: In Massachusetts?

P: Yeah, My school was a charter school, but we did have a bit of global warming type of education in my class, but the teacher really made it more doom and gloom, we're all going to die…

FC: You probably don't want to do that!

E: We watched *The Inconvenient Truth*.

FC: It does wake you up. Don't get me wrong. But, sometimes you can overkill on the doom and gloom. You guys have got to be optimistic and then try to stress that we've still got a chance to do something.

P: Definitely with the research we've done I've personally noticed that there is hope.

M: Do you think that is a better option: to more so stress the optimistic approach to teaching climate change than trying to do the scare tactic?

FC: Yeah. I would probably do that. I would just let the science do it since science is not positive or negative, it's just – it is science. You know? This is what it is. It's up to humans to think of it as good news or bad news, but once you have the science there – you can just go to the climate change hub - you'll be able to glean off a whole bunch of publications and then, I imagine, also in the Forest Service we also have, I think it's called Nature Watch. Nature Watch has some examples of types of curriculums that can use that type of data into. So what I need to do is send you an email with all of the proposals from the NGOs.

M: Lastly, you don't mind having your name in our report for transcriptions purposes?

FC: Yes, no problem. Once you're federal you don't have any say since it's all public funding, so go ahead.

M: I think that we are all set.

E: Thank you very much.

Interview 2: Edgardo Gonzalez

Research Associate at Centro para la Conservación del Paisaje
Date & Time: November 5, 2014; 1 p.m.

Emma (E): Do you mind if we have a transcript of this interview in our paper that we're doing?

Edgardo Gonzalez (EG): No problem

E: 'kay…let me just pull up the questions real quick

Princesa (P): So our first question to ask was what your area of expertise was?

EG: The main area of expertise is forestry, and then I also have a background in biology and natural resource management

P: Okay. Um, so do you participate in any organizations, like environmental organizations or environmental education initiatives?

EG: Well I used to work in the government, in the Department of Natural Resources. And in there my main work was with the unity in charge of the state forest. So in there there were a lot of different initiatives involving education at different levels, you know? So that I was related with. Right now I'm working with, uh, as a private consultant, and I have a project with the Centro Para Conservacion del Paisaje – that's the organization that right now its working also with El Yunque in the management plan. So there, just right now, I'm working with a project that have a – basically an education focus and its just to start the development of uh, there is a program in the forest service that is called Children's Forest, so we will directing that to what we're gonna call Children's Tropical Forest. And uh, the idea will be to develop educational alternatives with different groups that are associated with tropical forests, not necessarily inside El Yunque. And I'm working that with Felipe [Cano] right now. With that initiative we're working with, uh, four different groups that are developing initiatives – educational initiatives. When I took – basically right now with uh, an art experience with the students, and also direct it to the main theme of climate change.

E: So where have you focused your studies on the island? Like in El Yunque or all over –

EG: All over. Basically, yeah, when I was working in the Department of Natural Resources, they're all over, you know, from the east to the north to the south to the different islands in one island so I have been general with all the different systems around the island.

E: Now, do you know of any or have you maybe worked on any studies involving climate change in the Caribbean or in Puerto Rico?

EG: Well, uh, I participate through the Department of Natural Resources to – with the climate change initiative that was in contact with the Coastal Zone management program, and in there with the development of the documents that has been already produced as part of those initiatives and I'm part of the committee in there basically working with the Area of Natural Resources and Biology. They develop different alternative in there – I don't know if you are gonna talk with Ernesto Diaz, but Ernesto Diaz is the director of Coastal Zone Management Program. And, uh, he's basically leading that initiative in the agency right now. So that has been my main contact with the theme, other than secondary activities that are more related probably with a particular project or an educational alternative.

E: What, have you noticed, would be the main issues and impacts of climate change?

EG: In Puerto Rico?

E: In Puerto Rico, yeah.

EG: The main issues I think is basically, right now I think probably it's because how the thing has been developed, is in the coastal areas and the changes in the dynamics of some of the coastal zones in Puerto Rico. And connected to that is probably the issue that the infrastructure of the island that is associated with some of those areas. For example, the main power supply of the company that provides electricity in Puerto Rico is located in coastal areas. So from there the changes in the dynamics of the coastal areas and the loss of coastal resources of coastal areas – or beach areas – I think is the main problem right now. Because of my background I am also probably say that there are other issues that people might not be connecting with that. For example, with some agricultural products there has been some of the pests that have been affecting some of the areas, there has been some changes in the pattern of rain that we're receiving in the area, and those things are affecting some agricultural products. Probably people are not connecting them with this issue. But, and probably we need further study to establish that there is a specific connection, but at least you start to see some of those things that are…at last in my experience or my feeling are connected with climate change. But I think the main thing will be the coastal changes that we have right now, the impact of those changes in the coastal areas, and the loss of some coastal zones because of the changes in patterns that we're having in Puerto Rico.

E: Now, when we talked to Felipe Cano earlier today he talked a lot about precipitation changes due to climate change. Can you expand on that, or have you noticed anything concerning that?

EG: Well, it's an issue that is in discussion right now, so I think that there're more people that are interested to know or to understand it a little bit better. It's a thing that is not that easy to understand. Probably in some of the educational activities that I have been involved, it has been interesting how the students or the participants understand what they understand as climate change. And then we start to present some other examples and people start to connect a little bit better, and then they're more able to present examples. So I think that in terms of perception, uh, yes at that level. In terms of perception in other levels like agencies, I think that it's not that dramatic, you know? I think that after some of the words that Ernesto developed as part of that initiative of climate change through the Department of Natural Resources and the Coastal Zone Management Program, because there were some products that people can read, and there was also an initiative to send those documents to the different agencies. Now we start to see a little bit more responses from agencies. But in general I would say yes there has been a change in that perspective and trying to understand a little bit more.

E: What are ways to adapt to these changes in climate, that you know of?

EG: Well, adaptation. I think that the main thing, that, uh, at least my experience with the climate change initiative in there, is to maintain a certain aspect of monitoring these changes, and then to start to develop an initiative in that area of adaptation. For example, in terms of construction there might some need to review some of the alternatives of some of the uses of the coastal areas. That might take some time, it might take a little more energy from other agencies, like the planning board for example. And redefining some of these zones in a different way. I think the main thing will be adaptation in terms of construction in those areas. In terms of other activities like agricultural activities, I think it will be more to continue a monitoring strategy, and to see the responses of the main crops that have been used here in Puerto Rico. So some of these changes, you know, changes in the pattern of rain distribution, changes in pest management in some of the species, and start to develop new practices. I see a response in there. I think probably the adaptation process will probably have to go by phases and by demonstration projects, you know? See how this work in this specific area, and then try to use that as an educational alternative so – and they need to apply them, you know? So I think the main thing will be construction in the coastal area, reevaluation of the available infrastructure of those areas to start to identify some changes, and probably monitoring areas in terms of crops and agricultural activities, to evaluate demonstration projects that might be needed to protect some of these crops.

P: Um, by coastal sounds, what do you –

EG: Zones. The coastal zone areas.

P: Zones! Okay, I'm sorry!

EG: Yeah, coastal zones.

P: Okay

EG: And, uh, there is a technical definition from the Coastal Zone management program that established a certain distance. In there, according – my background is more in science so I use the "coastal plane", so you know, anything in there, I don't go as much as in distance. For me, coastal resources might include even, you know, the wet lands, and different areas that get more inside the areas, probably that are outside the consideration of the Coastal Zone Management Program. So when I refer to coastal zones in there will be what is more in those areas in the coastal parts of Puerto Rico, but not limiting only to the have coast with the ocean or the sea level.

E: So going back to ways to adapt to climate change, has there been any adaptation to climate change already? Like any programs and such, that you've seen?

EG: Not that I can talk about it. My only connection will be that initiative of the documents produced by the Coastal Zone Management Program that were sent to the different agencies in Puerto Rico, and there was a request that the agencies must evaluate the documents in terms of their infrastructure and present alternatives of adaptations. I cannot tell you that there has been that product, but I think – I know – that that initiative was done at the beginning of last year. And, uh, I think probably by mid or late last year the document was sent to the different agencies. And as far as I know there were certain workshops with the agency for the discussion of the documents because, again, it was, uh, there was some gaps in the information and some of the agencies were not that clear on how to use those documents. So in there my recommendation will be to talk with Ernesto. And I don't know if he's in your list of interviews.

P: I think he's not actually…

E: No he's not, what's his name again Ernesto –

EG: Ernesto Diaz

E: Okay

Michael (M): Yeah, I have it in here

P: Oh, you do?

M: Yup!

EG: If you're gonna be visiting the symposium, he's probably gonna be there.

P: The one tomorrow?

E: Yeah…

EG: Yeah. So I can, uh, arrange that you can meet with Ernesto. So, Ernesto and in that initiative that's the only one that I think will be more related to that. There have been some remediative things more than adaptation things. Probably in some coastal areas because of erosion problems, but I don't see that as adaptation process, you know, right now, it's more of – it's for protection of infrastructure in some of the areas. So those will be the ones that I can recall. But I can arrange it. If I saw Ernesto and I saw you both days in the symposium one of the days I can point out that to him so that you can make an interview with him, because I think it will be important.

P: For, uh, you mentioned something about erosion. Would you say that maybe – not would you say – um…do you think that climate change as it effects the coastal regions, would that have an impact on erosion?

EG: Yeah

P: Would it make it more pronounced? I know that the weather patterns are changing and that I guess overall the island is becoming drier –

EG: It will depend. When I talk there on erosion I'm talking about coastal erosion basically. The pattern of rain in other areas, um, I have to see. There might be some changes in some of the areas in terms of patterns of rain and erosion inside the island, but what I'm referring to right now is more coastal erosion problems. An initiative that has been done to protect some coastal resources, basically infrastructure, houses, roads, in some of these areas. So I don't see it more as adaptation its more as a, uh, you know, as they don't got any more options than to try to do something to try to protect those –

M: Like more of an immediate solution as opposed to a long-term one?

EG: Yeah

E: So what are some of the main consequences of climate change that affect people? Like culture or anything like that? Or industries, I guess? That you find –

EG: Well, here, again, the issue of infrastructure I think will be critical, you know? There are a lot of infrastructure that is associated in areas – in coastal areas in Puerto Rico. And, uh, just to give you an example of the electrical companies, you know, are there in coastal areas and basically that will affect everybody. I think in most of the areas, even the airport is an area that is very close to coastal areas and that's, um, one of the main influences, uh, here in Puerto Rico in terms of companies like tourism. So those are the big ones that I think it would be affecting. If we get down to the residents or people, uh, probably the fishermen in coastal areas and towns like that are dependent to the activities, I would say, with coastal resources that, uh, again we're talking about like Fajardo in the east, that, uh, a lot of people visit them because of the coastal resources they have in there and because it's an area that has a connection to the islands of Vieques and Culebra that are to the east, and there's a lot of tourism activities in those areas. Uh, there there would be probably an impact of the type of activities and people that live in those areas. Other areas like Guanica that's in the southern part of the island that is part of the – part of Puerto Rico – and Cabo Rojo in the southwestern part of the island again there might be some communities in there that have some tradition in terms of, uh, weekend residents, for example, for people and as an area for tourism that might be impacted with some of these changes. And again, uh, people that just provide recreational activities, you know, fishermen that takes you in their boat to some of the different islands that are outside here in those areas in Cabo Rojo like Cayo Ratones, those are recreational areas in there that might be affected, that might need to be some changes in there and that will affect some of the probably secondary economic resources in some of these areas.

P: You mention Cabo Rojo as well as areas – what was the other one?

EG: Guanica

P: How do you spell that?

EG: Guanica. G-U-A-N-I-C-A, and it's in the southern part, just a little bit after Ponce.

P: Oh, okay.

E: So what about climate change is the public in Puerto Rico unaware of?

EG: Could you provide me a scale there? Very? Almost? None?

P: On a scale of Complete Ignorance to, uh, Expert-Forest-Service-Been-Teaching-and-Learning-This-For-Hundreds-of-Years –

EG: And I go from zero to ten in there I…below five – probably a three. People have hearing about it, people have, uh, some – might have some general concept about it – uh, not really a big concern I would say in [the] general public. It's more like, uh, you see it in the movies or in some of the documentaries that you might see but they don't see it in their backyard. There might be in some of the coastal areas people that have a little bit more concern that have seen some of these changes, but again, you know, less than five if you go on a scale zero to ten in there.

P: Why would you say that that is? What makes that sort of not known? Is it just people don't know, or don't pay attention –

EG: Well, education. There has been a little bit of disconnection, you know, "it will not happen to us". Uh, and basically because they don't have received enough education or educational alternative of the problem, you know I think. So, they also see it as on a scale of time, they don't see it as an immediate impact to their daily life activities. So they might not be *that* concerned about it. You know those I think would be the main areas, you know, in relation because of this connection because of information or education, and because of the scale of time that they see it, and probably there might be a little bit of, you know, responsibilities in the way that some of the educational programs present that, you know? That they put it further in the scale of time, and I think those will be the main reasons, you know? It's not an issue that it's over the table, in some of the discussions. I think the initiative of the Coastal Zone Management Program is starting to bring it to the table of discussion and integrating agencies and municipalities, and those kinds of things will probably start to grow up more in the concerns of the people.

E: So our project is to create a lesson about climate change for a ninth grade classroom in Río Grande. So what do you think are the main topics about climate change that should be emphasized?

EG: Well, understand it – understand it probably from the basic, you know? And, uh, as simple as possible, and how it will affect a student at that level. I think from there, how it will affect the family of that student. And from there how it will affect the community where the family of the student is living. And there, growing in scales, you know? Different areas, and there will be some of the problems in terms of the island of Puerto Rico. But I think it will probably be important to try to show them and understand it at their personal level. And I think also in terms of education, I think it would be important to show some of the alternatives that people might have, you know? And in some educational activities that I have been doing, for example I try to show them how the trees work in relation of capturing CO_2 and how it's important, how they are working all the day, basically doing that type of work and we are not seeing work, and we're doing a very simple experiment, where as part of the talk that I – that we produce – or the activity – we select a tree that is in the zone and we put a plastic bag, basically, over one of the branches getting most of the leaves in there, and we just close it in there. And we go back to the talk and we say "this is to see how the tree is gonna be working as we are doing the activity there". And there we just present the function of the trees and all the cycles that are associated and how the trees are producing, like, water by transpiration and how that is part of the system of how they fix carbon and other things. So we go back out there and the plastic bag is full of water, basically from transpiration and there they see, you know, how the tree has been working. And then I say "well, look at all the trees we have in here". So that might be an alternative that you can do and bring up the importance of the vegetation in this problem. And then I try to explain how in general some other initiatives have been working – depends on the level of the students more than that. But for example I get to the point of the Carbon Credits if we're talking with university students, and how that has been an economic alternative in other areas, you know? But I think it will be important, in terms of education, to let them know how that might affect them personally, their family, where they live, and then the island. I think that will be my recommendation.

E: So I'm all set. Do you guys have any other questions?

P: I don't believe so.

E: Thank you very much for meeting with us.

Interview 3: Caroline Krupp

Public Affairs Officer, United States Forest Service – El Yunque
Date & Time: November 5, 2014; 3 p.m.

Emma (E): Do you mind if we record you?

Caroline Krupp (CK): Sure. No, that is no problem. Go ahead.

E: Thank you

Princesa (P): So the first question we wanted to ask, was about what your area of expertise was? Kind of like what you do, what you focus on.

CK: Ah, okay. I sort of do everything. I've been here a long time. I've been working here at the Forest Service in Puerto Rico for probably even close to twenty years. So I've done many different things. That's the thing. My background was in, actually my area of education and I guess interest where it started all along was in Natural Resource Management, Recreation Management and Conservation Education. So and I've tended to always work, at least started in what they had Public Affairs and Communications. Here in Puerto Rico I worked in that capacity as well as with the Institute of Tropical Forestry years ago. I worked with the visitor's center, El Portal, where I worked with the managing the center and working with recreation and interpretive and education programs and I worked for about ten years with the permitting program here which is a variety of uses from filming, recreation, tour operators, events, research permits, communications like telecommunications, water, utilities, probably other things I can't think of right now and even worked with the lands and the land acquisition programs. Then, just recently, within the last probably about two years, I went back to communications and then shortly thereafter they put with the focus on planning initiatives, so the forest plan revision. So I have been sort of working on a little bit of everything. I go in circles. So, my background is all those things mostly related to say recreation, communications, outreach, education. That's where I am.

P: Okay. Going off of the education, have you been a part of, sort of, education -environmental education - initiatives of any kind?

CK: Yes. I mean, the past I worked with that so probably earlier on I was more hands on with that like, worked a lot with, this was back when I was actually working in Colorado more, where I did, you know, teacher training. I worked with Project Learning Tree at the time, which still exists. And so, that's the type of work I was doing with education and now, I am getting, I can explain some of the history of the education here on the forest. I think that's one thing I can possibly help provide today, sort of, at least from my perspective, where we've been, where we are, and now that's wide open where we are going. So I think we had a vision for the forest, and now its changing a little bit because of the planning initiative and so we are seeing maybe ourselves moving in a different direction, which is being defined. But, as far as my background working specifically with education I'm not a curriculum developer, probably it's been mostly support messages, conservation messages, seeing that we align our programs with our interpretative things, with the conservation and education messages with hands on delivery, so being in the schools, working with department of education, leading um classes and doing that type of thing. I haven't been doing a lot of that. It's more in the context of the plans, structure, where we want to go, vision and strategy.

P: You say that you kind of know the background of what is going on in the forest. Can you kind of elaborate on that please?

CK: Yeah! What I was doing some of the looking into like where we've been and I would say, and again everything is sort of focused on the planning revision, because I have been working so much with that, but in a way that is the foundation of where we are and where we've been and where we need to go in the future. So it still needs to support that, but back when we did the planning, before we did the plan back when in the early nineties, is when the vision or the idea for the El Portal visitor's center, the rainforest center, was really getting the energy and the synergy behind it to become the project that it is today. There was a lot of interest in the whole forest management because of deforestation that was happening particularly in, no different parts of the world, but I think they had a big summit. I think it was in Brazil. The timing of all that really helped the forest get the momentum for getting the support to back the visitor's center in Puerto Rico. So the themes of the time that were designed for the visitor's center were based on the tropical forestry, tropical forest management and the significance of the tropical forest, and since El Yunque is the tropical forest - the only tropical rainforest in the national forest system we had that unique role because of the you know having the international institute of tropical forestry here - they had a lot presence in tropical forest research and management. The project had the architecture, the idea of it being more, to tell a story of the tropical forest, why they are significant is really the focus of El Portal. We had a staff of probably eight to ten people at that time who were just there and provided a lot of hands on activities for students coming to the rainforest. People would come to the rainforest and have a guide to take them out to the forest and talk about some of it.

P: that was called rent-a-ranger, right?

CK: Yeah. That was for schools that – schools were encouraged to come by reservation where we could have people available and they would there to take groups out on the forest. It tended to be on one particular area in the forest, at the palm Colorado recreation area, using that trail and those areas around there. It was by reservation and they were active with the staff to do that with a lot of the interpretive themes supporting the educational themes. One of the things I see with the forest service is there is a lot going on with conservation education, but it's a big agency. It's very broad and it's not necessarily specific to a particular location and so here, a lot of the work they did at the time was based on either language translation – things were coming out in English that they had to translate to Spanish – and the other was the different species and ecosystems that are shown in the woodsy owl and the smoky bear educational materials wasn't really resonating with kids here. It's like when you've got deer and species that you're not finding in Puerto Rico as –

P: the mascots?

CK: exactly! As the mascots or even in the educational material. It just wasn't the same, so it was a lot of effort to try to information and provide it through education and interpretation more specific to Puerto Rico. The Puerto Rican parrot, species that are found here, their vegetation, so they created this lot of brochures and information about that. They got the webpage up and running at about that time so there is a lot of information there that hasn't been updated as much as it should be, so it's the foundation of what has been there since, probably, the 1990s, still supports where it is today. There's lots of good information buried in there, but it hasn't been made – they haven't taken it to the current generation. It's the foundation there but it's not necessarily in a format that's as visually exciting or connecting as well.

Basically, the other thing they did specific to education was – there were some funds that became available – the woman who was leading that program, her name is Blanca Luis – she's retired, but she's still around Puerto Rico and sometime you might want to talk to her – she took the project learning tree concept and basically developed this, I can get you guys a copy of this too. This was when we were Bosque Nacional del Caribe, so 1990s again when that information is all being generated and in turn conservation Ed was really integrated. So, this is the baul de actividades para bosques tropicales. She basically took the idea and concepts of how Project Learning tree was set up – interdisciplinary – and then taking activities that were in lesson plans and, this had accompanied with it materials that supported the work.

Michael (M): Is that only in Spanish?

CK: I think it is. I don't know if we ever had an English version of this, I think we only have it in Spanish. That was basically the audience that we were trying to out reach to at the time. She had workshops and was working with the Department of Education in Puerto Rico, so there was a team of people helping to develop these. An interdisciplinary team that worked together to develop these lesson plans and educational indicators and academics and scientists and managers came up with this, and then they were able to put on workshops. Teachers, through the department of education sponsored two-day workshop, they put it here in the forest and let them stay at the camp and it was two days of getting immersed in this. Teachers got the materials and the idea was for tem to go back to their schools or sphere of influence and to help put more training or workshops on.

M: And this was information just specifically on the rainforest and how rainforests work?

CK: Pretty much that and specifics to El Yunque, but it could have other environmental issues related to water and watersheds that could be applicable to other parts of the island, but it was really specific to Puerto Rico to El Yunque, to students here.

P: That's just a pamphlet for teachers to teach the teachers or is it lesson plans?

CK: lesson plans to teach the students.

P: Do you know how effective the workshops were and if they would convey things to the teachers?

CK: that's a good question. I would have to look into some of the background on that. I know they were pretty well attended, but they only lasted about two to three years because funding and changes within the structure of being able to put them on. Probably because the project didn't last more than a five-year period, so for me to say how effective they were in terms of numbers of people and the outreach beyond that, I don't know if we know. I'm sure Blanca, when she was here, did some monitoring of that, but I don't know where that is, but it could be – there are some things talked about in this [pamphlet] because back in 2009 – well, let me finish on this one. Basically, a lot of people still were talking about the workshops and knowing that we were doing that. That made the connection that we were doing this at one time but we're not doing it anymore. So we're hearing that as we go out for the communities around here with the plan, and we're hearing from people, "you used to put on workshops", and yes, we did. We sort of lost the continuity of this. We lost the staffing and we also lost the continuity of the project. But, we have some good materials that, probably, are dated like some of our stuff, but some are not. I don't know if there's anything in here that talks about climate change. I sort of doubt it since it wasn't in the conversation as much back when this was prepared in the late 90s. But, in 2009, they did an interpretive education and conservation master plan, and this one is in English and I think it's on our webpage too.

P: Yes. I feel like we have that as a reference.

CK: I can send you the link.

M: Yes, that would be helpful.

CK: The interpretive education and conservation master plan for El Yunque in 2009. This is sort of like "this is where we've been, here's where we are now. What are the new messages, where do we want to go? I know that, in looking at this, we won't have the staffing we had before. Although I think that even in here sometimes there are things that I'm not sure that we would necessarily implement because of the same reasons. Climate change became another topic that we wanted to start providing more messages about and outreach. Another was cultural and historic resource that people could come and get a pretty background. I have information available about the ecological environment, but not so much about what the forest means to the culture in a cultural and historic context. It's there, but there were opportunities to do more. I think some of the other things that this talked about was that we have El Portal, we are using El Portal, and when I read this I believe there was 8,000 students at they time that they were saying that were being served every year by coming to El Yunque, so that gives you an idea of how much. I think there are records to see how many students over time we've been working with. I would say that that was an average that we work with 8,000 students were coming and taken on ranger tours, and then how many other people are we outreaching to. That's something that I don't know if they were even able to address with this. That's something that we need to get to. The next wave of planning has come along and now I think we're at a point again that when we go out to the communities and ask, "what's the vision of the forest as we plan and look into the future." people in the communities around the forest, what are they – what's important to them? One of the issues that we hear a lot is the role of the forest being more involved in education. That can be formal education by working with students in schools, to just education about conservation and conservation ethics with working more with the communities and working more with partnerships. To me, education is not just schools and children. That's a big part of it, but it's also just working with everyone societally, that there's a higher level of understanding and conservation and the importance of resources. Things like ecological services were something that we weren't talking about back then, but we're talking about more now. What's the value of some of the resources that we have in the forest and why is it important to conserve them, and what would happen is we don't have them?

P: So, as students who are making a curriculum, or starting a curriculum to educate more about climate change, What would you say is something that we could – that is almost essential to put into that curriculum so that we can kind of meet those needs for students and for the community overall.

CK: That's a really good question. The issue with climate change is that it's a fairly new topic and it's – I think there's a lot of good information out there. It's pretty technical for the most part, but there's a lot of curriculum guides out there that you can use. . I'm sure you've been looking into what's available. For me, I'm not really clear right now with how that would look – I don't have a good idea of what exactly a climate change curriculum for this forest or this area would look like right now. But I know it needs – some of the things that it would need to talk about is the big picture, what is happening globally related to climate change, and how is it affecting things everywhere. I think that's the thing about climate change is it's a big issue. Then maybe what are some of the things we've seen that have changed and how can we show it's changed more locally and even region-wide. I think it's important to talk about the Caribbean and the tropics and what would be the effects of climate change happening here that students and the public would see and notice. Then, if we could bring it to a level where it resonates with what's going on in your background that provides a more hands-on approach of looking at and monitoring the change or doing some sort of activity that helps students be involved in measuring or seeing or observing what these changes are starting, to look at things differently in connection with what might be happening now and how it could be connected to climate change.

P: One of the parts of our curriculum is to actually have a sort of class activity or field activity. Could you maybe go into a little more of a specific example that you think would be effective of either one that would involve observation or measuring or whatever?

CK: I don't know. I don't really have that as well thought out. It isn't an area that I've been – I'm just starting to get involved in this. Really, we don't have somebody right now who's involved in climate change discussions at kind of a planning level, but I'm not really involved in working with students and kids and teachers. One of the things I think would be helpful is, and this is just an idea I had, and I don't know enough about what you are doing – if the curriculum you are working on is specific to a place, or is broader.

(*Emma briefly explains the goals and objectives of our project*)

M: It's designed to be able to be used by other students, going forward, and obviously under some revisions, but it is definitely designed that it doesn't have to be a 4-H group to understand it, and it should be able to educate any student at the ninth grade level.

CK: Okay. But it would be specific to, say, Puerto Rico?

M: Yeah. This group is just who we're testing it on.

CK: Testing, good! I think at least one thing is that - again, specific things in the classroom, I don't know. I couldn't give – I just haven't done enough with that type of teaching or those types of experiences. Outside, that's where I am connected more with – the outdoor learning opportunities – and I think talking with the biologist on some of the things we talk about is the impacts on, we've seen impacts on -. Things we can easily see are we're having more – the rain events or weather patterns are sort of changing. We seem to have more intense rains and our temperatures are fluctuating. Some of the times that are more traditionally wetter times May not be as distinguished as it used to be. It was a little bit more seasonal and it used to be heavier rains, but now it's fluctuating. What affect does that have in your backyard? What are you seeing there's a road that washed away back in May. Can you directly tie that to climate change? Maybe. Maybe not, but there might be some things that are more rainy or steep slopes. Soils could wash away and this effects the water and soil quality. What are some of the things you might have changed that would've – of course, these are ninth graders, so their history of seeing things is a little bit less than someone like me who's a little bit older. What's a good connector here is the water and watersheds, and that's the one thing that, as we would go out to students and teachers around the forest. Not everyone can get out to El Yunque to do a curriculum or a placed activity, but could we be using more of the watersheds that flow from El Yunque that probably go by most of the communities, or many of the schools nearby to try and start to make those connections. I think that's a really important point that we start showing that El Yunque isn't just this isolated place, but that it's connected to you [people who live around it], the water, and to the ocean, so that there's these connectivities occurring within some of the things happening to vegetation. I know there are some things that are changing – where you're finding species and the types of species you're finding and then also some of the effects on wildlife. Those are things that are being studied, but exactly how – I see that those things have changed, but when you're that young maybe you don't see that, but you want them to realize climate change does exist out there and how to be more observant of it. Exactly what those activities are, I don't know. You guys have any good ideas?

E: We have some. We're still brainstorming. We're just trying to come up with what's going to be more effective for Puerto Rico and El Yunque. Learning more about the forest is helping us come up with ideas.

P: especially, as you mentioned, the watersheds. Using the fact that it can be applied to Puerto Rico overall with all the different watersheds is pretty helpful because it might give us sort of a path to follow.

CK: We did a project a couple of years ago. It was called FOCCUs: Forest, Oceans, Climate Change, and Us. It was a forest service project and there was an artist. His group, Wylan Foundation, worked with it and they were part of the with the national level projects where they did them all over the country, and we were one of the forests that they picked because of our proximity to the ocean. Very few, Washington state, California, maybe Alaska, I don't know on the east coast where, Florida may've had one, but the tie was, obviously having the connector. The important one is water. They had an art component too, where we had the museo del arte contemporanio and the artists from there who were aiding with them and talking about visually expressing some of the changes or what they're concerned about. Doing it about why these resources are important to protect and the impacts that climate change could have in the future, but then to be drawing and painting – in this case they painted these big murals – and they put them up in the museum. It was a connector, because what we were able to do with the schools that we sponsored around the forest was we took them into the forest where they could have waters and learn about what was going on within the forest, and then they followed to points along the way down to the estuary and to the ocean so they could follow a river to see how it changed and what was going on to that river as it went down the stream. I don't think too many people have those connections, and I think that's very important. We have a place where we can do it in a fairly close distance and so that's why I keep thinking the rivers and the watersheds, and students getting more exposed to that in their backyards could be a good connector to tie these two. You can't always get everyone up here and its even harder, but if there's something that they can do that can, kind of, create that link between the mountains and the oceans and what's happening in between and how much what they do or what happens in there. Even kids like saying, "wow, I've seen more pollution" or, "I found this area and there was trash there that wasn't there before." I'm seeing a lot more people – you know, things that they can observe is maybe a good decision, is a part of how we can change these policies to protect the ecosystems.

P: So, within our first introductory lesson about climate change and what it is, and to get them more aware, would you say that introducing the water cycle and watersheds, how they're important and how they can be affected – would you say that should be something that would be effective in that first lesson, to really drive home the point home?

CK: I think it could help. Yeah. I mean, there might be other ideas too, but that's just one that I think is a good connector here. This is a rainforest with lots of water and watersheds, all the plants and animals depend on and all have a relationship with here. So, it seems like a big part of it. It's like something that you see goes down to the ocean and there's this connection there that we have there that I think is a good example. I don't know, for example – I'm working more on planning and strategic planning level than doing lesson plans for kids, at all. I don't know if down there, if people are working with interpretation in our forest. Victor Juevos and Cynthia Winfred have been working with all the climate changes or have any more specific stuff. I know in the interpretive area that we need to get done some key messages, whether they come up with specific interpretive or conservation Ed activities. I don't know. I don't have a whole lot of activities-based examples to give or provide to you. I'm anxious to see what you guys come up with, though.

P: So are we.

CK: And, the other thing is - it's a topic of discussion. Have you found some links with – EPA has been doing things on conservation Ed. I know the forest service does with the baul, though not necessarily on climate change education. I few times I've sat in and watched them. The kids, teaching kids, training kids, kid speakers, kids talking to kids – where it was basically high school students that put on this program, and they were talking about the effects of climate change to other students. I think that they were talking to middle schoolers. These kids who were high school age put the whole thing together and they were talking to students about climate change and why it is important and what the effects are or may be.

M: was that in Puerto Rico?

CK: no. It was somewhere in the states. I think in the national office – Washington office – I think it was somewhere in the DC area. If I'm not mistaken, somewhere in the North East that they were working on these seminars. If you need, I can get links to that to you.

P: We'd appreciate that.

CK: Yes, like I said, I'm more at the planning stage than the strategic side of it. I'm not so much of the implementer. I can talk about that, not the one who goes out there and talks and is going to the schools and giving the talks. It doesn't mean I wouldn't want to in the future, but I just haven't been where I've been, but we've had staffers doing that.

P: So, My reading isn't always perfect. Is this – I feel like this isn't – but I want to say activity owl?

CK: Baul would be like the trunk – trunk of activities – because what this came with. This was the activity guide and then there were all these other things that you could do like these little – use this package of whatever! They could create these little games or activities that related, so you needed these materials. Everything came in this little trunk. So when they would come, they could come in and actually make reservations to use the trunks. Say, if there was a teacher who wanted to do this in their school, they would come and use the activity guide or some of the activities and then the materials that corresponded with it. Sort of like the package deal, but it was very physical that you had to come here and pick up this trunk and take it to your school and so, with technology now. Did you talk to Filipe Cano a little bit? Definitely better on the biology, better on the what's going on with climate change. Some things he's seen. He's definitely studied that more than I have, but the idea right now is – he probably talked about the Children's Forest component, which the 4-H group is part of that, so I don't know how that connects with the other project, but I think that it's wonderful because hopefully we'll have a good curriculum ideas and activities that can then be incorporated into that. The idea is – we've been struggling a little bit with conservation education. What can we deliver that we don't have? The publics expecting us to do a lot. That's how I feel when asked, "what do you do?" I was throwing out thing praying more specific things are going to help you, but – you know hearing it. What I'm seeing is there's a lot of people doing thins out there that may not be specific to climate change, but conservation education. We need to help find ways to support that because we need to be somehow connected to those efforts and provide support by working together when we build our capacity to affect kids in the area. So, instead of us trying to figure out how are we going to take on climate change, how can we help find and build capacity if it's not just us trying to do it but others. That's one part of the conservation effort in education, not the whole thing. I don't think – let me finish the whole children's tropical forestry thing first. Basically, we still have the visitor center and we use it and still get people going there, but you don't have the hands-on people to meet and greet and take groups out there anymore. We're' down to one interpreter one day a week to meet whoever shows up, so it's not what we were offering ten years ago. Can we use technology? Can we get teachers and students using their iPhones or whatever to connect more through the exhibits and to use technology when they're in the forest here, but make it for when they get out of the forest, you see? It's always been that they have to come here, but we're working on some conservation messages outside the forest. I don't know, since I don't work with the Department of Education, is if there is a conservation education curriculum? Is there one? What requirements do they have? Really, is anything going on? That's where I'm coming into this area with what we can do from that perspective. I don't know what's going on in the bigger picture surrounding Puerto Rico. That's where Edgardo Gonzalez was talking with your group, and I know he's working with DRNA. They've been working with this idea of project learning tree and having the standard curriculum translated into Spanish and sort of using that, so it would be different from this form, and they have climate change information, specific activities, which would help to create. Look at Project Learning Tree if you haven't already and see if they have climate change specific activities. Because that's probably what's being translated into Spanish that the Institute gets its funding for state and private forestry. Conservation is more important with them to see if they can get it more integrated into our life. So, for me, I think it would be to get kids – what we were doing before was great but – another project which was called More Kids in the Woods, where the remaining interpreter and conservation staff had to go out to about six schools around the forest in a year. They would go to the class and then the students would go to El Yunque and they would take them on an interpretive tour of the forest, so they were doing in school and getting out into the forest. We were doing that up until three years ago and that was good. As much as specific activities, I would have to look into – I need to do some homework and send some links, but those were some of the contacts that – the other thing is that there are a lot of little groups. Here people tend to be more grassroots and go for – I know of several groups that are working within the estuary back in San Juan. CCP, Edgardo's NGO, they're working on Río Espiritu Santo. they're working with some other student groups. It's like these, they're great efforts, but it just seems overall not clear who's responsible for conservation Ed and climate change initiatives.

M: There's no unifying force.

CK: That's what I don't sense. Maybe it's through DNR, maybe the Department of Education, I don't really know enough about the curriculums to say. Yeah. That's where I am. I wish I could give you more specific things.

E: That's fine! That's why we're here. I think that is all we had to ask. Thank you for helping us.

Interview 4: Federico Cintron-Moscoso

Applied anthropologist, University of Puerto Rico, Rio Piedras, Department of Sociology and Anthropology
Date & Time: November 6, 2014; 11:45 a.m.

Emma (E): Do you mind if we record this?

Frederico Cintron-Moscoso (FCM): Yes.

E: Okay. And we're gonna put the transcript in our paper.

FCM: uh-huh.

Princesa (P): So first we would like to kind of ask what your area of expertise was? Or what you've focused on in your work?

FCM: In general?

P: mm-hm!

FCM: I'm an applied anthropologist. For the last say four years I've been working on environmental education issues. Before that my main area of work is anthropology of education. So I've done work in participatory action research with youth in the US and Puerto Rico. And so, what I'm doing now is trying to combine that work and participation – student participation –into the management and protection of natural resources. So right now I'm the principle coordinator for the participation campaign of the revision of the forest management plan for El Yunque. That's what I'm doing right now.

P: The forest management plan is…its just to kind of restructure how the resources are distributed or something with the forest or…?

FCM: That's kind of like the framework all the programs and activities that the administrators do on a daily basis. So every 15 years they have to revise the plan.

P: Okay.

FCM: So what they've been doing now for the last year and a half is going through that process of looking at the previous one and then changing it to create a new one. Yeah. But the plan is just a document and what it does is that if the guidelines, the standards, all the tools for then different entities – it doesn't have to be only the forest service but it could be also a group of the community that then suggests a specific project s and initiatives and they will have to fit the new plan and the guidelines that are set up there.

P: During our research we found your dissertation or something, it was about Puerto Rico and encouraging youth I believe to get more involved in environmental initiatives and environmental education?

E: *Articulating social change in Puerto Rico*?

FCM: Yes.

P: Could you maybe go into a little bit into detail about that and a little about what the goal was for that paper and what you were trying to –

FCM: What I was trying to accomplish with the dissertation? Sure. Like I said, my main focus is on working with youth and doing participatory action research in general. So the dissertation was actually to look at a youth group that was working – a youth led group because that was one of the things that I wanted to look at. It was not only – there's many groups that are formed by organizations or by adults – but what I wanted to see was a group that they have come together themselves and have an agenda and they have a plan to work and do activism. So I found this wonderful group here in Puerto Rico and what they were doing is they design a curriculum – an environmental education curriculum – for elementary schools – public elementary schools. And they started when they were in 11th grade and it was a great story and I wanted to document it biographically and then to go for that year to follow them throughout the process of how they organize as an organization and what are their networks and try to look at it as from an ecological theory – an ecological perspective – and try to understand the group in a broader context. So one of the key findings was to see how they relate to other components. For example the Department of Education which they were intervening on how schools run basically. But also the environmental movement. And it was interesting to see how – well many things. So how the group was able to serve as a link between the environmental movement and the public schools in Puerto Rico, because one of the critics to the public education is that they don't really teach environmental education. They're not taking over that responsibility. So how can that happen, how can we promote that? And the other critic to the environmental movement is that, you know, you work outside schools, so how can we start communicating both towards that goal? And I found that this one particular group was doing that. And that the fact that they were young was one of the main factors for them to be able to access the school. So the other problem is that public schools are very restrictive in terms of who can go there and give workshops and do all these kind of things without a permit and things like that. Well this group was doing it with no problem they just go, they just talk to the principles and the principles were like "ah yeah sounds good, when do you start?" And I was like "woah so how does that happen?" And it was mainly because they were youth, and they were seen as nonthreatening to a school system. And because of that they were like "yeah take this group of kids" and they would go in school gardens and they're still around. So my thesis was trying to document that process and trying to understand better the whole relationship. And then on the other side most of the youth that created it came from the environmental movement directly. So they for example were trained by the Sierra club on activism lobbying and that kind of stuff, and that's how they decided to come back with this idea. So that was part of it. The other part of it was that there is a lot of discussion in the literature about how do you move people from knowledge to action? And there's no concrete answer on how that happens, so we don't know how someone suddenly becomes a pro-environmental person and kind of start behaving that way. And one of these things that I found in the group was that some of the members were actually – so before they joined the group they wouldn't even think about the environment. They didn't care. But because of personal relationships with the other members they found it interesting and start participating. And through their participation in the group and through going to the schools, they actually start getting more aware of the importance of behaving in favor of the environment. And that was very important because caring for the education was what motivated people to join the group; it wasn't caring for the environment. And that was actually a very interesting thing. So I would say half of the members at that point when you asked them "so why did you join?" it's like "well because I want to make a change in education". Not because they wanted to make a change in the environment. So it's fascinating that through the process of participating they then got very, very aware of why it was important to be a part of the group. So that's kind of a short summary of what the dissertation was about.

P: Would you say that environmental groups like that are more effective? So a student-led group, would you find that to be more effective than, say adults from a forest group coming and educating children?

FCM: It's a challenging question. It wasn't meant to evaluate their work necessarily, or to compare, but there're definitely some elements that they, you know that allowed them to do that. The fact that they were younger definitely, students can maybe relate more to them? But that's not necessarily the case in every case because then each school's like "we leave that one with that group who'd come to teach", then it's like free time! You know? It's not part of the school. So that transgression of what are the limits and what are the schools saying on that change, and it's difficult to see, to evaluate if that's really the best way of doing it. And then you compare that, for example, with teachers, who are adults, and are teaching environmental education in their schools on their own and are very successful. So I don't necessarily think that because they were younger that they were more effective, but because they were maybe from outside the school they were more effective. So the kids were more interested, the new thing, the new people that were coming in.

Michael (M): Oh, Shiny Object Syndrome.

FCM: Haha, Yeah. And they would bring, that's the third thing or fourth thing in the dissertation, is that that group is important because they channel resources into the school. So you have a poor [? 12:00] school system and you have these people that are bringing a lot of resources. Not only knowledge but new methodologies for teaching those topics, and literally materials and resources to do that. So then in a sense that makes them an asset to the schools.

P: Why do you think climate and environmental education groups, initiatives, why do you find those to be important for youth, for communities, for Puerto Rico overall?

FCM: Well, we need to live with the environment and I think that as a society we need to learn how to do that and sustain our way. And in order to do that we need to understand the environment, we need to understand what we believe the environment is. I think that some of the presentations today are trying to get at that. How historically, as a society, we have made decisions and now we have to reflect on those decisions and say "well, do we want to continue with that, or is it time for a change?" And I think that process of reflection is part of the import teachings of environmental education. So to me, environmental education is not only about knowledge about the environment and our attitudes about the environment, but we need to identify criteria for people to be able to make decisions about the future. And that is the way I see the importance, and you know I'm also an anthropologist so I'm trained and I've studied different cultures and their relationships to the environment and learned that its important throughout the history of humanity it has been the decisions and the way that the people have related to the things around them. So for me it's like a no-brainer. As an anthropologist I should say.

P: So for our project because we're doing something with developing a new curriculum if you were to give any suggestions to something that we could do to make it more effective or really drive home the importance of climate change and how to be aware of it, how to adapt to it, what would you say is something to stress, especially within the first couple of lessons?

FCM: Well for your team the first thing I would suggest is to look into materials that have been created and adapted for Puerto Rico. So there's probably a library of documents that have been prepared by different people. I think the way to connect is by making it local and relevant, and that's key. Part of that history that I was talking about is that most of the curricula that has been developed for Puerto Rico has been brought from outside and the examples and the references do not reflect the reality of children who are going to be listening to that, who are gonna be trying to learn all of that unless, you know if you don't engage them at that level it doesn't matter that you told them that its urgent, that its gonna happen, that its already here. You know that doesn't matter, and you have to show that right when there's some information that is coming out now from the environmental natural resources about things that are already happening, I think it will be key to show those examples in Puerto Rico. Now one challenge is where do you teach these things? One of the things that we saw with that in my dissertation is that sometimes you talk to the children about things they have never seen. So part of the issue is that public schools, especially in urban areas, doesn't really encourage seeing, experiencing nature, and their surroundings. So you're like "oh, we're losing the coast because of erosion". What coast? What beach? You know, I don't know what beach? So you know, things like that, it's kind of like part of what we tried to do with that group and the group that we're working with now is that we create lessons that beyond in the school, the classroom, are beyond the classroom. Just part of learning about global warming is understanding, for example, is understanding that you live in a globe. You know? It's bigger than just the classroom. It's bigger than just your household. And so I think that creating that is relevant and that is also think of the learning setting outside the school and the classroom.

P: How do you suggest we do that? Would it be through, say like a field trip or a field activity?

FCM: It could be that.

M: It could be like some primary photos, things like that that even if they can't physically be there they can see examples that are on the island, that are places that do exist and are tangible to them?

FCM: Of course, yeah. Photos and videos are good to bring to the classroom. And then if you combine that with the idea of field trips and getting out. And it doesn't have to be far, you know, places far from the communities. Sometimes some of these problems you can see them real close by, you don't have to go that far. But learning to identify them you know, and know that that thing that I see there, it's not just normal, it's not just what should be. What's causing that, and why should I care about that. I think those connections are pretty important.

M: You had mentioned previously about how the youth led group had done activities, kind of like you had said water garden is, I believe, an example? What sort of activities do you think would be feasible and applicable to apply to a public school and try and implement.

FCM: It really depends on the schools and on the resources they have, and that's a challenge. But I know that the school gardens have been pretty much successful. You can keep them very contained and it could be still within the school. So that works. Also establishing a relationship with things that happen in the community. For example I know that in some cases they have like a community garden that then they bring the students. If you cannot do the garden in the school then you can bring the students to the community garden. So, that kind of thing. Of course there's a lot of different initiatives that are happening, a lot of the work that is to be done and it would be good if you set it up in a way that is a guideline for the curriculum or the lesson is that part of the work is for the teachers to look and do that mapping of resources outside the school. So if I do that mapping then I can identify and be able to do this connecting and going and doing all these kinds of things. And that could be a part of the standard guidelines of the lesson, like how you prepare for the lesson is to do that mapping and to recognize the social mood. Also encouraging research through the lesson. I think it's a very, very useful way of learning about it. So it's not only showing them that this is happening, that this is important, but go and interview someone in that area that has been affected and ask them how things have changed in the last 50 years. So integrating research into the lesson is hands-on, again it's very important for the students to be engaged, and it's not the same thing that they're used to so you want to break that routine.

M: That about covers what I had to say.

P: So I think we're all set. Thank you.

Interview 5: Marcela Cañon

Natural Resources Director, Bahía Beach Resort and Golf Club
Date & Time: November 6, 2014; 2 p.m.

Emma (E): Do you mind if we record?

Marcela Canon (MC): No that's alright.

Princesa (P): We would first like to start off by asking what your area of expertise was? What you do for your work?

MC: I am a marine biologist. I work with environmental sciences basically. And what I do right now is I work with a resort, a nature sanctuary. We are located in the mouth of the Rio Espiritu Santo river. So we our like totally connected to the rainforest of el Yunque, through the Rio Espiritu Santo river and we are one of the neighbors of the river. And we work in the conservation of the whole watershed cause that's how you should approach environmental education and how you should approach your neighbors if you want to conserve an area. So we have been working with that and what I do being a marine biologist and a master of environmental science, is trying to be responsible for the landscape and we work toward the improvement of the whole watershed with different step by step. So right now I have been working with Pedro and with the different activities around the river, this is one of them actually, and trying to put more people in organizations around that river. So that is what I basically do.

P: Okay. So do participate in any sort of environmental initiatives.

MC: I do. I lead them.

P: Oh okay.

MC: We have different activities. One of them is the resort, Bahia Beach Resort located in Rio Grande, and in the resort, in the nature sanctuary, we have an environmental education program. The basic one is that we educate our staff, environmental education, different topics. I haven't dealt with climate change yet. That's something I haven't done, I work with recycling, waste, nature conservation, things that, and of course I mention climate change but not like something specific about it. We educate our members of our club, our residents and also our guests because we have a hotel. We are the first five star hotel in Puerto Rico, a St. Regis. So we have a St. Regis there. So our guests, we educate through activities, one of them is nature tours. We provide nature tours for our guests. And we provide kayak nature tours for our guest so we provide information around that. We also have a close relationship with the community, every year we have an environmental campaign and that campaign has three components. One is like a contest between schools, which is like a joint contest. And you can read it here, I don't know if you saw the poster. The second thing that we do is a - we provide workshops for public schools. So that's why we are going to need to work together. So we provide workshops for public schools on different topics. Each year we have a different topic for our campaign. Two years ago it was mangroves, guardians of the coast, so the emphasis was on the coastal line mangroves. Then it was the Rio Espiritu Santo River, by itself, so we focused on the Rio Espiritu Santo River and then extrapolate that for everywhere else. And the third one is the, I mean the last one that we had was the Al Mar Bahia, that's our foundation but I wasn't talking about the foundation, I was talking about the environmental problem that we have. Not talking about the resort, it's complicated because you can't because I don't want to talk about the resort I want to share the basic things with the kids in the Palmer schools in Rio Grande. For something that is really important is education in Puerto Rico lacks a lot of components and the environmental component is one of those. So that environmental component is mostly lacking in the schools, they don't have tools, there is no interest in some case, there is no knowledge. So I think it is important because of that. And we identified that even though they have free education, the quality of the education is not that good in public schools. We also provide workshops and conferences, for private schools in San Juan. The best schools in San Juan, I have given conferences and workshops and that's part of our environmental education commitment. So the third component of our campaign, as I mentioned the drawing contests, the conferences, and the third one is beach clean-up. So we have a beach clean-up, its massive, well not massive, but we usually have 300 people from the community come and that is another involvement in an education opportunity. And so during the year I keep on training our staff in the environment. I am marine biologist; I am the natural resource director of the resort. And what I do is that, usually a resort doesn't have someone who is always working on that issue. And Ashley, the person I am going to introduce you to, is the environmental assistant. And they all work on that. So we work with our guests but we also work with other things and with training our staff is basically environmental education. It's how I train them because they need to understand what we have and how they can relate to it, to take care of it. That's it.

P: The kind of guests you get at the resort are they usually local, are they more from maybe outside of Puerto Rico or is it a combinations of people from Puerto Rico and tourists?

MC: It's mostly people from the states from the east coast. Mostly our main areas are New York and Boston. There is some people from the west coast also, some Europeans, not many Puerto Ricans, some Puerto Ricans especially during summer. But it's a luxury hotel I mean it's on the level; it is five diamonds, five stars. So at the level we are it is difficult to provide to the local market. But that's the hotel. But as I mentioned to you we are a resort that has residents. So we are a club. SO we have members. Our members are mostly Puerto Ricans so we have members. We have residents, we have villas and houses and our residents are mostly Puerto Ricans but there are a lot of New Yorkers and people from the east coast. So it is a mix in the resort part, residents and club, its like 60% Puerto Ricans, 40% outsiders. For the hotel it would be about 90% from the states, 6% Europeans. We have Puerto Ricans but not as many, especially groups.

P: Regarding the Rio Espiritu Santo, have you noticed any problems regarding it, anything to do with climate change, I know you said you don't really focus on this a lot, but have you maybe heard of or noticed anything about that?

Michael (M): Or any changes that have occurred that could be tied to climate change?

MC: I don't know if there are any problems ecosystemically or in the river currents, I don't know that. We don't study that. Maybe Felipe could have told you yesterday. I don't have that information. What I know is that we need to talk about adaptation. And we need to talk to people about how to manage or how to prevent, you can't really prevent climate change on that level, but you can help. You can be part of the solution, since the beginning with the prevention part. And that's education. So it's not just talking about climate change and how climate change is a massive thing that you can't manage, and it has to be solved by the governments, no no no no. It's how you produce climate change every day, with your actions your increasing the effects of climate change. So I would focus on different ways, prevention, I'm not just talking about students but I am talking about the river, too. You know, cause I don't study it so I couldn't tell you the changes in the river, but I think that we have to talk about adaptation with the agriculture people, with the people that are living around the river. But we have to put it in ways that they can understand it. And so that is something that is eventually, that we need in the river. We are having a low increase in temperature during the last years and we are seeing how it is hotter and hotter and hotter. Maybe its not a pattern, it hasn't been proved that is happening with the rates right now but we've seen it and its tendency. So having that tendency, its been producing changes in the river itself. So I see that. You see how birds, migratory birds, are getting here later or earlier depending on how the year goes and the temperature rise. And that affects the river mouth, because they come to the river mouth and to the mangroves in that area. So there are changes that I've seen but I couldn't tell you exactly because I don't study it. Now, measures to mitigate, mitigation, adaptation, things like that are how we should talk to people around the river by giving them facts and options. But I also going back and talking about simple things. Like how in Puerto Rico we use fossil fuel to produce electricity and how much fossil fuels increase climate change right now. So if you don't drive your car as much or if you don't use as much light in your house, you can diminish that. Talking about education, I think that would be a way to start and to get people engaged with little things, a part from projects around the river of course, for adaptation and mitigation.

M: As something that I am just curious as to whether it has been something that has been occurring, is that you said that temperatures have been changing, have you noticed if rain patterns have been changing in the last few years?

MC: Yeah, it's something that I've noticed. About a month ago, two months ago, they had a climate change summit. And they were showing the figures of how it's been changing and there has been an increase in temperature, and there has been a change of rain problems. So it's moved a little bit, that shift, and how the rain patterns are related. I have to check but they had really interesting figures and how it hasn't been proved really having the increased temperature right now. And the level of the ocean has also been increasing steadily in Puerto Rico. So there is lot of useful information…

M: So it is something that has been seen?

MC: …and it has been seen. And also…

M: And it has been studied?

MC: Yeah people have studied that, so you can find that information.

P: DO you know where we could find that information? Because it might be helpful for our project…

M: Useful for our group.

P: Right

MC: Maybe you should look at the climate change summit presentations. I can send you an email, one of the emails, so you can check. It has the agenda. I have some data since I took a lot of notes, you know I was really interested. They have the actual recording and all that, they have been checking the problems and seeing what is going and what's happening with some species. So they have a lot of information. I was surprised. They do have some information, but they had some interesting information that had applied like research.

P: Going of our project as something to develop a curriculum, what do you think is something that is really important to kind of to share with students especially within the first couple of lessons. What do you think are the some of the most important topics of climate change that are relvant? And maybe note even climate change but environmental education?

MC: Photosynthesis. I've been giving workshops to kids, 4^{th} grade/ 5^{th} grade, and they don't know what that is. I mean the basics. Go to the basics. How plants photosynthesize, how the forest can change the microclimate of the plants. Why? If you study photosynthesis and how it breathes, you know when it breathes it holds a lot of water, and that way you can change the microclimate. They don't know that. There aren't too many people. And those kinds of facts are the kind of facts that I think engage kids. Oh cool, so we get water from it or moisture really. And its cooler when you are around plants. You feel how the microclimate changes. So those kinds of things, of course at first you have to go into the basics. That is why I am saying photosynthesis. The relationship between the sun, plants, the soil, water, basic elements and those relationships, and how that gets more complex and complex when you put the atmosphere, gases and how the soil can get real hot and how that can affect it. So you can build upon those things. So I would go basic things of life, like the elements, then processes, like photosynthesis, or how the earth gets heated and all that. Those are things that are very basic. And then I would build up to other concepts more complex and how those things affect and how things happen in different areas of the world. And then I would put that into how what's happening in the world can really affect you, where you live. What's happening in China, cause we are all connected. And then I would build up to the ozone hole and how that happened, how is it being fixed. How have we been tackling some of the problems, and we have been not solving them totally, but at least not making them something totally negative. How we can work to make this better, and we can really adapt. I was talking about from your day to day, how you can solve this. Because if you talk about climate change usually people think oh that's something major and it is not related to me. How you are related to it. What do you do in your day-to-day lifestyle that affects this? What I was telling you before; I think you should include that in the curriculum. It can't just be like basic science, no. It has to be something that you can related it to, and that you can solve and fix from your perspective. Like having a restoration project of the river, carbon fixation and you explain what that is with a project you can do in your backyard. You know what I mean, so starting with basics, building into more complex, and then how you…

M: How you can apply in, like, a physical sense, that you can do it hands-on.

MC: Exactly. So you understand it, you can relate to it, and then you understand the bigger complex thing, is like the climate change concept that belongs to everyone that has to be dealt with in the UN and things like that and how you relate it to that.

(*We paused the interview to discuss our project and our goals, and Eduardo Agostini joined the conversation*)

M: I am kind of curious as to, like with climate change happening, what would be since you do work at a resort and that is part of it, what would some of the economic effects that would be a product of like let say the sea rising or increases in temperature or changes in rain patterns and those sort of effects of climate change? How do you think it would affect like economic situations?

MC: I think like the tourism industry or in this case the hospitality industry is one of the most affect, a part from ecosystems of course. But this industry is very much affected by climate change. And in places like small islands, like Puerto Rico, the effect is much higher. And that's how it happens. So whenever you have the effect, you are going to be hit financially. I mean, if it rains, instead of raining four months, its five months or two months. If it totally changes, you are going to be affected. If the sea rises, I mean, you are going to have to do different projects. So the way I would approach it, would be, again, adaptation, mitigation. How a hotel or a resort or complex, whatever from the beginning, from the development, thinks about these kinds of things it can happen. How they can affected, and how they can adapt and how they can like adapt in the next hundred years, you know when they have this kind of business they are hoping to be at least 50 years. So what are the problems they have to work with and that's how I think. The effects, you can see them right now, also, in this industry at least. You can see how the tourism pattern changes. People don't go as much to some places, and more to others, depending on how weather is affecting one or the other. And it is just like a decision that the public makes because they see things happening. Even things like the fires in California, those could be increased by climate change, and you know that. So when those things happen, I mean, the huge areas for things like tourism stop completely because of fear and that's in the short run. In the long run, the effects are going to be more devastating. And they are always going to be financial. So its as you mentioned…

M: So it is really harmful to businesses?

MC: Yeh. So everything that you mentioned, and it's the same thing, they see it like something that affects the whole world but not me or my business. That's how I see it. And that's now like what's happening. Before we finish, Ashley and Eduardo went to the summit in Puerto Rico to the United Nation Climate Change Conference two years ago.

Ashley Perez (AP): It was one year ago.

MC: Exactly. They are from the University of Puerto Rico so they represented the University. And also Ashley went as a representative of the Puerto Rican government to the climate change summit. So they can give you the also, you know they studied a lot about it, so they can give you lots of things.

Eduardo Agostini (EA): I was going to answer your question cause something happened here like probably six months ago. Ah it was a small hotel, very small business, but the guy took the investment and bought like prime real estate on the beach. It was a nice beach; he had complete access to the beach. Now the water is hitting the entrance of the hotel. So imagine if you spent a million dollars,

MC: It's been in the family for years and years.

EA: So they made the hotel with you know, it's going to be like a super small luxury hotel. The best part about it was that they had the beach in front of it. What else could you ask for? Well there is no beach for them now. This property is probably now worth almost nothing because in five or ten years the sea is going to cover it.

M: So imagine like places like Isla Verde and stuff?

EA: Yeah. Especially Condado.

MC: But there is a place, it is pretty close to Isla Verde, where it's happening right now. Where there is a mile, almost two miles, where it almost lost the beach completely, during the last eight months. Tomorrow the tourism company of Puerto Rico is organizing a public hearing

M: Kinda like a town meeting a little bit?

MC: No, it's a public hearing. It's like a step to try to mitigate that.

P: It's sorta like trying to get the public interested in the problematic, and trying to pass laws based around that. And that's what the public hearing is right?

MC: So what they are doing tomorrow is a public hearing to see what is going on in that area, specifically that hotel. And it's not just the hotel but it's the whole area. So they are going to do it tomorrow and after that they will enforce some laws that exist; what to do and how to build by the beach and things like that. And they are also, I guess, going to try to pass other laws and make some of these people invest in mitigation, or the municipality. That's what they are looking for; they are looking for the municipality to invest in mitigation. So the use of like hospitality or whatever can be still be *(inaudible)* because they invested a lot of money. And that's happening tomorrow, actually. So if anybody wants to go, because its something that is affecting everyone. So what else?

M: We about covered that. Yeah that was pretty thorough.

MC: Listen guys, as you interview so many people and you're trying to get something. There are a lot of different curriculums out there and information, environmental information, everywhere. I mean that is something you can get everywhere. There are some pretty cool tools, even in YouTube. I mean there are like so many things developed by NASA, even little models developed by NASA for what climate change is. So you can get all those, get all the sources, as many things as you want. We have a limitation here, with having things in Spanish because they speak Spanish. But also you can get interesting things in English. List all of them as part of the lecture. Because I know, that you do a research, to give to your teachers and to Pedro, and I will eventually get it too. And that is going to be useful and you are going to get all the sources and everything. And then you find all the different links and information that people can get, even if it is not part of the lecture.

P: Like an appendix or something.

MC: Like in an appendix. Everything that you find that is useful. Because you are doing such a detailed research, that it would be great. And people could have access to that. When I talk about people, I talk about…

M: Teachers?

MC: Mostly

P: So for example the US forest services, have a "baul de actividades" something like that could be in the appendix.

MC: Exactly. That you found on YouTube or Google or whatever, anything that you found. You can put the link and just list them as an extra. It's going to be like part of the product, but annex with lots of detail. So if you want to teach them about Methane, and how Methane works, here is a cool video that you can use. Or if you want to talk about whatever, here is a cool model that you can show or whatever or readings, if you found something interesting that you read, pretty cool. And you think like this is gonna be like useful. For this topic, use these readings. Are you gonna have something like that?

M: I think we were definitely going to have like places for further expansion. And that like if someone wanted to further investigate topics that there would be some amount of resources there to do that.

P: I think there was more supposed to be kind of expanding on the curriculum itself.

MC: Yeah but this would be at the end, as like a list of references to share with the teachers. Because when you provide the lecture to every kid in that class, they are going to ask a lot of questions that the teacher might not be able to answer. But maybe they can either direct them to this or study it themselves and provide the answers, you know. Somebody maybe, you know, there is a teacher who maybe is trying to read about it and is like oh my God why do I have to do this. But then maybe he finds something that interests them and he has the list and he goes to the list and he gets more information. And maybe he will get a hook, cause you know how people get different entry points in their mind. So maybe this would help. For me it would be great, because you could go and tell the students. Because I was telling them we do this workshop, and provide them. So, kids get tired really easily and 1-hour lecture, that's not possible. Like you just said, we are going to do a one hour lecture, and put all the concepts in one, the teacher is going to have to divide it into three different sessions or something like that. And I think that might be better, instead of giving just one block with that set. Its going to be like, eeh I am going to puke climate change cause that's what happens with these kids.

P: And I think that was one of the things were thinking of,

M: That's why we kinda wanted the activities and stuff so that it would break up so it's not like a single lecture.

MC: Yesterday or the day before, I was with this group of people in my kids' school and there were presenting this very elaborative process. Kids with computers, I didn't like it. But the main thing in this class was timing; a typically eleven year old is not going to keep his attention for forty minutes, not even at the end of the class. So if you talk about an hour, for kids, you don't have them there anymore, especially for something so heavy and so many concepts and all that. So maybe having something that's an hour but it is varied so it's three modules, something like that. That could be useful. And even for the teacher, cause he can have further readings for the activities. So have like the twenty minutes and an activity; the same thing and then the other twenty minutes and another activity; then the other twenty minutes and another activity. If you don't want to do the activities anymore and just do the whole hour that is your decision as a teacher. It depends on your students, or how you want to invest your time.

AP: So what is your project about?

EA: Sustainable development education?

P: It's more just climate change education. So teaching the students in Rio Grande about…

MC: Related to the Rio Espiritu Santo River…

EA: So what are the biggest polluters in the world?

P: Europeans

EA: Europeans? Yeah, that's where all the oil that's burned up. They're the ones who buy it.

P: That wasn't research based that was just observation based.

EA: Have you done corporate research on who are the companies that most pollute?

P: We didn't as far as…

M: In some of the sources we saw some of the types of sources that it will come from like, it will be like "x" percentage of the world would be, let's say, from fossil fuels but it won't be like particular areas. Its just kind of like whatever that source is will say there, but not the location of the source, if that makes sense.

EA: Yeah

P: But explicitly corporate we haven't really done. So we haven't seen like oh BP is doing this much…

EA: So the way it works is basic science. All of humanity needs electricity for consumption and production. That's our main goal, producing electricity because we are going to need it. We are always going to need more, because we are always going to need more people. There is an actual figure for that. How many electricity does the world consume in one day, one year, one month, right? So what happens is that the markets are regulated by the government. And they try to do it so that all the interests are served. So there's going to be 20% petroleum, 20% coal, 20% renewable, 20% bio fuels. And they create different markets, different energy markets, and they regulate them so one can't compete for the other. That's not going to happen anymore. What happen was that, ah, now solar and renewables have open market. And for the first time they decided that we are going to use more renewables than any other source.

P: Now who decided this? Germany?

EA: This was decided at the conference of parties.

AC: That we went to last year.

P: Okay. Because from the laymen's perspective, it doesn't seem like there is any change.

EA: So right now, I think gas prices…

AC: They are trying to get it up, like Germany is doing complete renewable now.

P: Are they really? So for example, when you drive in a car, you are not going to fill it with petro, now you are fueling with…

AC: With like energy from the sun. So for example, because like the place you are charging it is getting its energy by solar power.

EA: They are at 54% consumption of electricity that is provided from solar or wind turbines.

MC: The thing is that we are in the States. We are not committed to it, yet.

EA: But it's a market. They don't have to be committed to it, because now it is a competition.

MC: Yes and no, because if you are still getting incentives for coal and for other things. You are still going to have…

P: There is a lot of financial incentives in the US,

MC: A lot.

P: That's why I think the Sudan,

EA: Yeah, but I can sell my kilowatt-hour cheaper than any other company.

P: And they get in trouble for it in some situations. Or you know there are plenty of things where it is like you can have a solar powered light or you can have a wind turbine. And people argue that it is an eyesore or they make really silly arguments. And because of that there hasn't been, at least for my understanding and my perspective, there hasn't been much of a unified movement or even national or even like regional to really push towards renewable energy, its been more…

AP: It's been scattered…

EA: Because you have to understand that there are different markets, there is the petroleum market.

MC: But we aren't talking about that right now (*some arguing between Marcela and Eduardo)* Listen to this; it is the same thing that I was mentioning to you about the complex. And how you eventually have to talk to the kids about the conference of the (*inaudible*) and the work about climate change, cause even though the United States are not part of that yet. They are, they are like a supporter, but you have to know what's going on. So you give them all the concepts. You know what I mean, that's what I was telling you. You have to go to every different level, but you have to try not to get lost into like some things because they are not going to understand what they do to impact or not to impact. So you have to keep it simple here. *(some arguing between Marcela and Eduardo).* But you have to go eventually to those complex concepts. So you understand how this is being driven by economic figures instead of like facts of what's good or bad for the environment. It's more of like a market, as you said. It's been market based, it's important for the kids to know it. Those are some of the complex concepts you have to go into with them and give them the option to know. Why and how I can change this, if I change my consumption problems, if I am willing to do it as an individual. As an individual, how can I change what's going on.

P: Almost like boycotting in a sense, like if oh well petroleum is really, like the petroleum industry really drives a lack of movement towards renewable energy, well then I will just walk or bike…

MC: Or how do I become a vegetarian or eating just fish, which is like eventually helpful to the ocean. And how like I stop eating cow and then I help to decrease Methane production, have you read about that?

M: Yeh

MC: For like climate change, the most important of the gases is Methane. Methane is produced in massive amounts, by the cattle farm.

M: Yeh, we talked about that.

MC: And if its intensive, its worse because they are fed and fed and fed. And they just produce gases. So if it's like a regular household of cows or whatever, it's different.

P: Then from my understanding…

MC: It's for milk production. Because if it is for milk production it is different than meat production.

P: Because if it's for meat, they raise it and kill it.

MC: So those things are important, these kids, because I am going back to your project. *(talk about timeline of project).* It's important to show those things, those facts.

P: But cows are really good for you, if it's healthy.

MC: That's the thing. I mean I am not saying you should tell them…

P: Never eat a cow.

MC: To not use that but how all the industries, because it's the industry not the cow. It's the whole industry. And the impacts, and that's the information they should get and not just the concept of climate change, but where those gases come from and how we can diminish that, as individuals. I feel terrible because I drive a jeep. And I turn on the AC and open the window and everything. And I think okay I am turning on the AC and it's horrible. At least, I think about it. I mean, I think there is like 80% of the population that don't even think about it.

P: But maybe if infrastructure was made better, you wouldn't need as much AC. I am just hypothesizing.

MC: No of course. But since I moved to Puerto Rico, I have been like, and it's terrible because you start to do the same things that you should be avoiding. But if you teach people from the beginning, they can grasp these things, and really make changes. And those changes are really important. And that's what we are looking for. So those things are important.

Interview 6: Ashley Pérez & Eduardo Agostini

Ashley Perez: Natural Resources Assistant, Bahía Beach Resort and Golf Club
Eduardo Agostini: Communications Director at United Nations Puerto Rico Youth Delegation
Date & Time: November 6, 2014; 3 p.m.

Emma (E): What is your area of expertise, or who have you mainly worked with?

Ashley Pérez (AP): Okay. So, I'll start and then Eduardo will go. I'm an environmental scientist and I work with Marcela at Bahia beach resort as an environmental assistant. Basically, we do all of the conservation educational work within the property and within the community around the area and, apart from that, I help out with the sierra club sometimes and, like we were saying before, last year we went to the United Nations framework convention on climate change as representing Puerto Rico as Puerto Rican youth delegation and basically working with the government and different entities. That sums it up.

Eduardo Agostini (EA): Yeah. I guess my area of expertise is politics. I'm a lobbyist for the sierra club; I do environmental lobbying. The other thing I consider my expertise on is in renewable energy. That's corporate development and the actual, you know, developing the project so actual people change to renewables.

E: So what is the Sierra Club exactly?

EA: Alright. The Sierra Club is the biggest non-profit in the United States. It's also the oldest. It's the number one conservation non-profit organization in the world. It has over a hundred million members and we have closed over twenty coal plants in the last ten years. We have – basically we declare war on everything that's not renewable, everything that's not sustainable. Our main campaign is "Beyond Oil, Beyond Coal, Beyond Natural Gas". People want to change to natural gas now. I don't know why. So, Sierra Club is an NGO that – I don't know, we do so many different things I get lost, but it's really big.

E: Have either of you been a part of, like, Environmental education initiatives at all?

AP: Yes. We've been – well, me in particular. Like I said, throughout SoulBahia, which is Bahia Beach resort's NGO, we do work with the community and we walk into a lot of the communities that you guys are working with, and basically give them trainings on different environmental themes, specifically things they have around their communities like El Yunque National Rainforest, the Spiritu Santo river and different areas around that. Apart from that, I've also worked in environmental education with the Sierra Club a lot, specifically the SSC, which is the Sierra Student Coalition. It's basically the youth group of the Sierra Club, and I've worked with training a lot of youth in leadership initiatives along with Eduardo. Around that we've worked with educating on leatherback turtles and different ecosystems around the island, like coastal ecosystems and rainforest ecosystems and basically how it influences people's lives and all that. So, that's what I've done in educating the public on these things.

EA: So, I educate people on environmental lobbying and, with Ashley, we used to have a summer program called "sprog'. We used to invite a lot of high school student, a lot of college students that want to learn more about environmental sciences, or just the environment, helping the community. We've probably talked to, or educated, more than two hundred people already on a one to one basis. My other part of the job is I have to explain to them why it's better to change to solar than to the public grid of the petroleum company. So, I have to sit down and explain to them why solar is cheaper, it's more affordable, and better technology than what they have today. I don't know. I guess I've educated a lot of people on that sort of stuff.

E: So, talking about climate change, do either of you know any particular studies that have been done about climate change in either the Caribbean or Puerto Rico itself?

AP: Well, in Puerto Rico there's actually a committee that's based on climate change. Specifically, they've worked mainly in – and it's actually under the Natural Resources Department of Puerto Rico. I don't remember the name exactly, but it's based more around the effects of climate change around our coast because it's – I think a thing that worries us most is that we are an island in the middle of the Caribbean. We are a pretty small island so, if sea level rises and a lot of different things happen with climate change, we would really be impacted in that sense. So, this group has mainly worked with research on based on sea level rise, on impacts on corals, and a lot of things based around the coast and they have a lot of good research based around that and the have a lot of proposals based on adaptation and mitigation. So, that's mainly what has been done locally and, last year when we were preparing to go to the United Nations framework convention on climate change, we got to meet with these people and we got to get together with different types of groups that have been mainly doing a lot of community outreach to try to help communities in a lower scale to actually try to adapt or look for some methods to mitigate climate change. Around the Caribbean there are different networks that work together that I could get you the names for. Also, if you're interested –

EA: There's one called the ELAC.

AP: Yes! We can get you the names for all of them. Eduardo will probably remember and we'll get you the names for them.

E: So, what are the main issues and impacts of climate change that you've seen in Puerto Rico?

AP: In Puerto Rico I guess it has to do with what we were talking about before. Climate change would really impact Puerto Rico very negatively and it already has in the sense that, as I said, we are an island in the Caribbean and we are pretty small and we are in the tropics. So Puerto Rico is a small island but it is very diverse in ecosystems and ecosystems here are, sort of, very micro and they are very specific to certain weather changes and temperature changes so anything that changes a little bit can impact the ecosystem very negatively and there is a lot of species that are very specific to certain micro ecosystems within the island. So, I guess to resume it all, things like rising sea levels would basically make a lot of our coast disappear - a lot of the areas where a lot of species are dependent on. There's a lot of coastal forests around the island that could really be impact if they basically just disappear. In that sense, There's a lot of reefs, a lot of coral reef experts here today, so you could talk to them about that also, but things like acidification. We've already seen that. Especially on the east coast of Puerto Rico there's a lot of corals that are actually, basically, disappearing and it's because of this rise in temperature around the world. Things like El Yunque National Rainforest, that you guys are there. If the temperature keeps on rising this forest will tend to get a lot less rain, especially if there's a lot of development around its coast. It'll have a very negative affect on the rainforest because clouds will go up higher it won't rain on the rainforest and, throughout the years, they've been seeing that rain coming down less and less on this rainforest, so that's a worry. Especially on the top of the rainforest, there's a few different species that are specific to that area, so those species would basically disappear because they have nowhere else to go. Puerto Rico also has a dry forest and there's a lot of cave systems so a lot of these areas would also be impacted by it, but those are just some examples that I've mentioned before.

EA: Yep. Rising sea levels, a lot of species that are – it's going to get hotter or colder – where they're going to get their environment destroyed, and basically what Ashley said. I can't add anything else to that.

E: So, are there ways to adapt to these changes such as specific forms that especially kids can do.

AP: With kids, I guess, let me see. I'm thinking specifically where you guys are going to be doing this. Are you going to be doing this in Rio Grande where there's probably a lot of kids who live close to the coast and those who live closer to the rainforest. I guess it has to do mainly with that these kids really need to understand that they are right in the middle of a hydrographic zone – that everything they do around their communities and there houses basically impacts the river areas and all of these areas where water will come to, and that'll eventually impact all of the coastal zones that they are used to. So, I guess it has to do with that – with educating on how to get rid of waste properly, specifically if they are so close to these areas. So, even if they think that they're right in the middle of the forest, that they throw a bottle into the forest, that will eventually runoff maybe into where there's a river and that will eventually get into the ocean. I guess it mainly has to do with them mainly understanding that everything they do around their lives, there's that connection. There's that connectivity in nature, they're right around the rainforest, but they're connected to the river which is connected to oceans which is connected to the reefs which is connected to the water that they get into their houses and all that. Just getting them to understand that there's nothing separate between their lives and that connectivity that we're talking about. It has to do with around that.

EA: If I were to adapt I'd just move somewhere else.

AP: (*laughs*) That's adaptation at its finest!

EA: I can't really do much here! I guess if we have rising sea levels we're going to have a lot of these government contracts building these giant walls so the houses don't get buried under water. Apart from that, I don't really see how an island can really adapt to climate change.

AP: Another thing that, when you're going to go to these kids and all that, I think another thing that hasn't been – it's starting to be of more importance in Puerto Rico right now – is that these kids, they need to learn that whatever they do in their lives if they want to – for example, if they like a beautiful area close to the ocean, that they need to better understand that it's not just going in there and building their house wherever you want, it's that you need to think things through and you need to have a more sustainable view on things. So, I think that could also help you with educating on these things. That they need to think about everything that they do in their lives in a more sustainable manner. Even if they want to build their house right here, it's fine just so long as you do it consciously and as long as you do it in a way that you are not impacting the area around you,that you're actually helping it and that you're watching out for conservation.

EA: I guess if we were to adapt here, if climate change really happens, I guess would expand that boat park, right? We'd have an underwater hotel or something!

AP: (*laughs*) If water levels keep on rising we'd be safe up here, but that [hotel] wouldn't be, down there!

EA: A beautiful ocean view…

AP: Yeah! Definitely and ocean view!

E: So, What are some of the main financial or cultural consequences of climate change?

AP: If you want to be specific on Puerto Rico, Puerto Rico has a lot – well, mainly most of the population and most of the industry; Puerto Rico has a lot of pharmaceutical industries and also, since Puerto Rico receives petroleum by ships, a lot of these plantations would need this petroleum from right on the coast, so that would be a big problem. We're tempting a really big natural disaster where water would actually come a lot further in and that would these pharmaceutical industries, the petroleum that is coming into the area because it wouldn't have a stable place to be settled because all that area might be destroyed, and also a lot of the population of the island is right along the coast. I guess, financially, it would be a very big disaster and on the industrial side of it, it would also be a pretty big disaster.

EA: Could you repeat the question?

E: Yes. What's the socioeconomic consequences of climate change?

EA: Climate change in Puerto Rico in general? I have to be honest. For me, climate change is the best thing that's ever happened to the world. I'm being honest, because what's deriving from climate change is a huge opportunity for, especially islands, to change completely to a renewable energy market. This is not sustainable. No matter how low they buy the raw materials, they still have to bring it in a ship here, so it's always going to cost a lot of money to bring the energy here because we don't have coal. We don't have natural gas. Right? So, financially, I think that climate change is going to help not only Puerto Rico, but the world in the sense that the energy business is probably going to be the number one business in the next ten years.

Princesa (P): So, by climate change you mean if people adapt to climate change?

EA: No. I'm saying from these horrible mistakes that have happened, the greatest opportunity for the planet has also risen.

P: But, if you don't take it, then –

EA: But we're actually taking it! That's some of the misinformation you get in the environmental community. You know, that the good guys are always losing and the bad guys are always winning? No, it's the complete opposite. the bad guy is the petroleum industry, the coal industry, the natural gas industry are actually losing a lot of money

AP: It's starting to happen like Eduardo said.

EA: The energy business has doubled for the last eight years. It has doubled. If this month we sell a million solar panels, by this date next year we'll have sold two million! We're only eight doublings away from beating all of the fossil fuels.

AP: Apart from that, lock out the window! (*Points behind her*) Have you seen all the solar panels out there?

Michael (M): Wow, that is a lot!

AP: That was unheard of a year ago in Puerto Rico. This area, it is not completely sustainable now, but they're aiming for that and those solar panels are powering part of that energy in this place right now.

M: This is something I definitely have seen in the states even in New York. My mom works with a company that sells them and that's the hugest new thing. They've been selling a lot of solar panels.

P: I have a similar case where my mom is trying to start a small solar farm.

AP: That's good! That's what we're aiming for too also in our personal lives.

EA: I want to install a million solar panels… well maybe not; that's a lot.

P: Even at our school there's a couple of streetlamps that are solar powered. They have a solar panel just on top of it that's what turns on the streetlamp.

M: Yeah, and it's light sensitive.

EA: They're also smart appliances. But my main goal is to build a megawatt farm. a megawatt farm is 3800 solar panels and a solar farm – a one megawatt solar farm, which is the maximum allowed by law – would give power to maybe ten thousand people that are not going to consume electricity. If you create a megawatt farm you would save, over the course of twenty-five years, I think it's five million gallons of gas that will not be burnt. It will not be burnt so people can turn on their Apples and turn on their TV's.

AP: Yes. You can live comfortably. You know, you don't really have to worry about turning off the air conditioning at a certain time or something like that.

EA: On the financial/economic side, for every problem, new solutions emerge. That's what living is all about. We grow up and find new problems and then new alternatives. I think the recycling business is going to boom like no one has ever seen before. It's going to be a ton of money to be made on garbage. People just picking up garbage and going from rags to riches because they developed a processing plant, and the energy business is probably going to be the most exciting business in the world in the next ten years.

AP: But, in order for all these things to happen I think the whole multi-sectorial thing is really important. You need to have everybody on board for these things to work. To have the business side of it, the government side of it, the community side of it, kid side of it and making sure it all merges together for it to work in that sense. So that's why it's important to have things like this [symposium] and a lot of community based groups and NGOs that are actually pushing for these types of things. And, another thing. Another financial pillar in Puerto Rico that would be impacted, like Marcela was saying before, is tourism. Tourism is mainly one of the main economies on the island and most of the tourism is basically based around coasts. A lot of these hotel businesses were built around twenty years ago. Maybe even more, so things have changed a lot along the coast from twenty years back to now. A lot of these hotels are starting to see things change around their areas, like the one Eduardo was talking about before [with Marcela].

M: So there are some good and some bad that could happen? As is the case with most things –

AP: Yeah. Of course.

E: What ideas or things about climate change is the public of Puerto Rico unaware of right now?

AP: I guess with that it has to do mainly on what people you're talking to on the island.

P: Well, just like the everyday person.

EA: The every day Puerto Rican is not aware that he belongs to the US or that he has a right to vote! I don't think they think much about climate change. They know it's happening, they know "oh! global warming" but –

AP: They don't know exactly what it is. It really is outside of their reality.

EA: Yeah. 95% of the people here don't even acknowledge that climate change is even a problem. Don't quote that number though!

AP: But really, the schools that you guys are going to be going into when you're preparing everything that you're going to do – you need to be very aware that these are kids that, I've been to their schools and some of these kids live five minutes from the rainforest yet they've never been to the rainforest, so it's those types of kids that you're going to be going into their schools. It's very important what you're doing because it is bringing in something that they've probably never even heard about or that they're very far away from. Maybe they've mentioned it a little bit in their science class, but they don't fully grasp or understand it, so I guess that what you guys are doing is going to be really important in that sense. You need to be very – you know, explain to them thing that obviously are very close to what their reality is so that they can actually get passionate about it and are understanding it a bit better.

EA: Do you guys know why climate change exists? There is a reason, it's not just a coincidence.

M: It is a natural cycle. It's more the we [humans] exacerbate it.

EA: Yes, but it has a reason and it's very simple. It has one single answer that explains the whole mess that we're in. Well, people are behind everything, but I don't thing God created climate change because he hates us or something, but the main reason is energy. Everything is energy. People tend to believe that climate change happens because of market development and overproduction, and yeah, it does. It does affect it, but if factories were running on renewables. We weren't talking about climate change or global warming, but about scarcity of resources or how we are going to regulate raw materials for production and consumption. Because we were not doing renewables the main choice for people and governments like China and US, they have their own market. China's the coal market, US is the oil market, European nations are the natural gas, oil, and coal market combined. Because they choose to keep playing with those markets, they don't have a choice to get out. They're not going to leave the entire population without electricity. That's the reason we have climate change. It's the reason we decided on oil 250 years ago and the reason why we have climate change today. So, I think the main point that people obviate is that it is not a production or regulating or government thing, or even the good guys against the bad guys. This is just what we chose. We chose petroleum and it worked out well. All of this was built with petroleum, and now we're accepting that we're, you know, taking the consequences. But, if people choose another alternative energy, we wouldn't have climate change. We could overproduce whatever we want. It wouldn't pollute – it would throw carbon emissions to the air.

M: Carbon among other things…

EA: Yeah.

M: Nasty Sulfur…

EA: And Mercury…

P: I can't wait for the day that mercury is not in the ocean.

EA: That's another market that's going to emerge. Every single problem that you see on climate change is an opportunity to actually help out the world and make a lot of money for it. It's true. People don't see it that way. People talk about "green" jobs and say "green" jobs don't exist, or say that "green" jobs must be terrible, but these are "green" jobs! I have a green job and I can make a lot of money saving the environment. You know? It's a good deal.

E: So, you've worked with children in the area on environmental education? What are some specific activities that have worked well?

AP: They like videos a lot. I think that with – usually I've taken up groups that are either older kids that are eleventh or twelfth grade and I've taken a lot of – from seventh to twelfth graders mainly, so having a little game on a table doesn't work with them because they're not that small. What's worked best for me is I've tried to be funny and that works sometimes. But, videos and talking. They like to talk about cute animals, like if your talking about the river you have to relate it to the manatees. And them seeing – you tell them all these things about the river and the structure of the mangroves for example or the contaminant or sediments on the river and then you show them a video of the manatee and you explain to them why this manatee could be hurt by all these things, and that really gets to them. Like seeing that leatherback turtles or the actual reefs – how pretty they are beautiful a healthy coral reef looks and how horrible an impacted coral reef looks. Those things actually hit home for them. That's what's worked for me.

M: Would it hit home even more so if it was species that are endemic to this island such as the coqui?

AP: Yes. Exactly. And, anytime I do my presentations I work with species that are native to the island and are native to the areas where they are around. So, I can also help you with that to try and identify what species are going to be more relatable to them that they've seen in their lives and that are close to their neighborhoods. I could definitely help you out with that.

M: That would be great since we did look into trying to fit certain species like the Puerto Rican parrot, certain species of coquis that are endangered because of human activities that are tied to climate change.

AP: Yeah, and with the Puerto Rican parrot, these kids live there in Rio Grande and there's a parrot rehabilitation center in El Yunque, but they've never seen a parrot in their lives. Most Puerto Ricans have never seen a parrot in their life. Eduardo has never seen a parrot in his life, and that's why – the only reason I've ever seen one is because I actually went to the center.

EA: I never got invited.

M: I don't have any other questions. Do either of you have any other question?

E & P: No.

E: Well, thank you very much for sitting down with us.

AP: You're welcome!

E: This will be very helpful!

Interview 7: Isabel Rivera

Archeologist, University of Puerto Rico, Rio Piedras, Department of Sociology and Anthropology
Date & Time: November 10, 2014; 1 p.m.

Princesa (P): Is it alright if we record this interview, so that we can have a transcript of it so that we can refer to it?

Isabel Rivera (IR): Yes

P: Okay thank you.

IR: Yep, no problem.

P: So our first question is, what your area of expertise is? Kind of like what you do…

IR: I specialize in environmental archaeology. And within it I have three specialties which are climate change, landscape reconstruction and ecological context of coastal invertebrates, particularly mollusks.

P: With that do you have any maybe environmental education initiatives that you also are a part of?

IR: Do I have what?

P: Do you do any sort of initiatives with maybe environmental education or just maybe an outreach to people about what you do at all.

IR: I have a subject currently running that involves citizens, so my project calls for integration with citizens with an interest in environmental subjects to work with us in a research where we are investigating how people have impacted what has been the long term impacts on the Grand de Manati River *(inaudible)* and in relationship to environmental change. So in that context, where we are doing surveys of the general area, we are incorporating the public and we are using informal education to talk about climate and environmental change and how people respond to or effect the environment from a long term perspective so in general terms. In that sense, I consider that outreach because we are using informal education and research to show people how knowledge is (*inaudible*) and people. SO we integrate the knowledge, the local ecological knowledge, into our project. In addition to that, I am part of the ILOC? Industrial Latino (*inaudible*) Climatico. I am collaborating with them as well. So currently I have a course, last semester I taught a course on the archaeology of climate change. So my students are asking me to expand the program for an additional semester. I am currently working with them, it's an individual study class where I have 6 students and they are doing research on climate change in Puerto Rico during the last seven thousand years. And for the start of that research, we'll go through the ILOC? Industrial Latino (*inaudible*) Climatico, we're also incorporating what are the main concerns that people are identifying in contrast to the main concerns of the government. And we are in touch with the communities and we will be publishing our results in a scientific journal, in the general newspapers and media.

P: Do you find that when you do this sort of outreach with teaching people using the research, do you find that to be particularly effective? Do you think people respond well to it and that they learn from it? Do you find that it can be improved? What result do you see from doing those outreaches?

IR: In terms of the community, or my contact with the general public, the research of the citizen program, it is a project in which we are investigating how informal education works for the information for the public. So its not just my project, my project is intended to be a larger project. We have statistically analysis of some of what we are doing and we interview people before, during, and after working on the project to make sure how effective our methods are. And so far we have (*inaudible*) an hypothesis. Especially on the archaeology project that I direct, the research itself is not just archaeology. So what concerns the archaeology problem, our methods have proven to be very successful in conveying our concerns and gathering the concerns of the public, informing our behavior. As people have given a very (*inaudible*) reviews of our project, so it is just hypothesis, and it is just informative. In terms of my teaching at the university, I also have observed positive results and I have seen people changing their behavior towards climate. And the fact that I have these students that have continued with me, and are currently developing and implementing new ways in which they can share our discoveries and our information with the public that is also very encouraging. So I believe in the project because I have been working at the university for just 32 years. I have been working on this project for a short period so far, but I have had a very good result.

P: For our project we are developing a climate change curriculum for middle school students in Rio Grande, we hope to do sort of a pre and post test to measure its effectiveness, kind of like what you just mentioned. We kind of want to research how this is effective, like how it is known to be effective to have a pre and post-test, how to develop one. Do you have any sort of resources we could look into?

IR: I could put you in contact; give you the address of the people who are working of that aspect of the project. And I can give you their information Ruben Esperera, from the Puerto Rico. And I think you could directly contact the (*inaudible*) project we also have already have some publication, they are mostly in the form of posters. But we are still writing our results because the project is not over yet, so we are still working on our results for a more wider publication. But I think it might be best if you go ahead and directly contact (*inaudible*), she is the CI of the project. So she could give you a summary of our results and informal education and what aspects are working and how you can measure your progress before and after we develop our forms, (*inaudible*). So everything has been very particular; it's a complicated project, evaluating your concepts but it is very rewarding. If you send me an email reminding me, I can send you all the contacts.

P: We will make sure to email you a few minutes after we finish up, that would be really great. Thank you so much. Go back to the questions of climate change, what are the main issues or impacts that you observed in Puerto Rico from climate change?

IR: What type of impacts are you referring to, because the impacts can be very broad? Do you mean social impacts, or natural impacts or what specifically are you referring to?

P: I meant natural impacts, and then also social impacts but as two separate sort of questions so if you could first please address natural ones if you have observed any.

IR: Well that's a very very very huge question. In terms of natural changes, there has been a very wide variation on precipitation ranges, and temperature changes, and seasonality and I am referring to big perspective. I work in a much larger context than like the last one hundred years. We are working on the last seven thousand years; that is the whole story of people living on the island. In that sort of big scale, we are seeing changes in precipitation, temperature and seasonality, you know how the difference between summer and winter and also in the frequency and intensity of storms. Actually the paper that they are writing at the moment is referring just to the last hundred years. In order to understand the last one hundred years, you have to understand at least the last five hundred years if not more. After the maybe mid 19th century we finished what is known as "the little ice age", it what was a period that was very cold and dry. And after that the climate has been more rigorous with more precipitation during the 19th century. But the last one hundred years have been in a trend of drying up and dryer than "the little ice age". So the main impact is not going to be solved immediately, but possibly in a hundred years time, then we are going to be in the drying trend. But at the moment we are in a rather wet period, we consider the last seven thousand years. And the moisture level at the moment is actually pretty similar to the conditions that were prevalent ten thousand years ago.

P: I was going to ask if this drying that has been occurring, is this drying a natural sort of drying or is it anthropogenic or perhaps is it…

IR: There is a combination of factors, certainly the climate during the last hundred years, and there are some others that support finding the beginning of the trends that we are experiencing at the moment starting in doing the revisioning in 1950 and that's why we recording the last period, the period where humans have had the strongest impact in the environment. But, it is never that simple. So if the current climate change is anthropogenic only, that is a mistake because there is never a single factor. However, the climatic process which is so complex, responds to the series of interconnected connections globally. There are changes that are natural. In the case of the last one hundred years, human's activity has had a particularly significant aspect in some of the factors that regulate climatic trends. The main impact that we will be seeing or the main impact of the climate that we will experience in approximately the next one hundred years, most climatologists agree that those characteristics will be affected by the increase in greenhouse gases and other aspects and deforestation and other aspects that are directly linked to human activity. However, it is naïve to say that human activity, that climate change is caused by human activity, because it's not. It's a combination of human activity in the last one hundred years and natural processes. So it's a complex scenario of factors that are affecting one and the other. Certainly, especially in the last one hundred years, we can see the effects of human activity in some of the main aspects that affect climatic characteristics.

P: So as far as social impacts of this kind of climate change, have you observed any of those? Maybe socioeconomic, on culture, or industry…

IR: It's just as complex, I would never say something is a natural catastrophe because crises are not natural they are social. So whenever we say there is a natural disaster, it is not necessarily a natural disaster it's a social disaster. Its people that suffer because of the way they have organized their society or how they depend on things. In the case of Puerto Rico, we have six thousand years of human activity on the island and in those six thousand years, there is many hundreds of thousands of, millions of people that have lived and modified our ecosystem. So whenever we have changes and we depend on particular aspects of the environment, we have to acknowledge that people have changed the environment. So in the case of social crisis, or in response to climate change, in the past we had a severe crisis six thousand years ago. So for example, six thousand years ago we (*inaudible*) and this affected the entire Caribbean. They have the movement of people all around. Four thousand years ago, you had that movement of people and the redistribution of people and that affected archaeology in different ways. One thousand years ago, there was a decrease in moisture and precipitation on the island. So you had dryer periods and that also simulated a high movement of people in what already was established in the Caribbean as a long distance network, social-support network. And along those social-support networks, as there were droughts in other areas, there was a movement of people coming into the wetter areas. And that also affected (*inaudible*) and to understand that in particular. During the "little ice age" there were also changes in the intensity and frequency of hurricanes, and people were dependent on particular resources from Europe or from the business on the island and fruits that might have been affected by hurricanes. And so this would be a record of crisis and there are historical records of people making the best out of climatic conditions. So whenever they would have good climatic conditions or different distribution of precipitation through the year, people would take advantage of those things. So, sometimes social responses to climate change are not always negative. There are also positive responses to climate change. In the case of current Puerto Rican conditions, our society is currently highly dependent on particular and very specific mammals options for the system. So first we depend on imported product, so we are displacing our vulnerability. Also, if we were going to change that, say that if something happens so that we couldn't import our food any more than we are going to be severely affected by the fact that we have lost, through our ecological knowledge, we lack productivity of our land. So that is another problem that we going to be facing. And actually, what I find most worrying is the impact of precipitation on the production of the system's resources (*inaudibl*e). However, the government is focusing on the loss of coastal lands so they are more concerned with sea level rise and how we are going to be losing the characteristics of the current coast and that may not be the main problem that we are going to be facing. There is a difference between what we are going to be facing due to climate change and the priorities of the climate change council for Puerto Rico. So, that is something that needs to be addressed. But there is something to take away, with sea level rise we are going to be losing one, and we are also going to be losing the sea as a resource (*inaudible*) and the exploitation of coastal resources and the acidification of oceans. So all those factors, so if we are just going to simplify a condition that might present a problem in our society at the moment, food production would be one of the main issues because of our vulnerability. Because we have lost the ecological knowledge of how to make the best of our island, we are currently dependent on others to supply our food and to supply our water. In our recent past, at the beginning of the 20th century, most houses had water storage and would gather rain water and that would be stored in the houses. So they were less vulnerable to a lack in water. At the moment we depend on the government to supply water to everyone. So there is a loss of knowledge that increases the vulnerability.

P: So if these are the main issues that people are vulnerable to as a society, what ways so you think people can adapt to make themselves less vulnerable as the global climate changes?

IR: (*inaudible*) increased knowledge, and increased investment in, identification of options to apply in case your main option failed. So definitely I would argue for an investment in local agriculture and all these ecological projects and an investment, and it's not because I am an archaeologist, in archaeology because as archaeologists we can gather information that has been lost, the knowledge that has been lost historically. So we can show people what has been done in the past and what these people used because the magnitude of climate change that we are going to be experiencing in the near future, is not something that has never happened before, the magnitude of change has happened before. We have had in the past, a strong variability in climate and people in Puerto Rico have responded to it. So we can use archaeology to recover that knowledge and increase our resilience to future change. So aside from increasing knowledge, we need to empower our people to produce their own product, so other ecological products are certainly the way to go, especially if they invest in usable food, and not just earth, and not just the supplies for meals but trying to supply people. Certainly we need to reduce our carbon footprint. And to realize that we live in a tropical island we cannot expect to consume so much energy modifying our small, baby environment using all this air-conditioning. So we need to not consume so much energy. So there are some other aspects to consider in terms of our consumption, to reduce our consumption and reduce our misused production. And increase our production of food and the way we manage our portable water because those are the main aspects that we are going to be facing soon. But the first thing that we need to address is knowledge, so we need to increase how people understand and how people identify options to respond in one facing crisis and increasing the number of available responses that they could be facing even if their options (*inaudible*). For example, if we know that sea level is going to rise, we cannot expect the government to supply and restore the problem. The government cannot stop sea level rise. So the people need to know that sometimes they will have to move, and they will have to be less costly to relocate or stay in the place trying to invest more to keep things in a static state without changing. Change is going to happen and we cannot avoid it. So that is one of the things that is important, and we can see that archaeologically. In the past, there was a period two thousand years ago, of particularly high precipitation that involved a lot of instability in the rivers and the adaptation strategy that locals used was relocating to a different location. And two hundred years later when the precipitation reduced in the area became stable then they returned to the area that they used to inhabit in the past. So that is one strategy that we can see from the archaeology perspective as well.

P: In terms of education, do you think that it is important to address any certain group over another? For example, maybe youth or maybe people within a sort of adult age range? Or do you think it is best to do sort of an all-around education…

IR: I think all-around, I think everyone needs to be involved in an education program. However, I don't think education problems should be seen as linear. I do not think that a program where I go to a school or a community and I say "Hey guys, I am going to teach you about climate change and how we are going to survive". That will never be successful. In order for change to happen, it needs to integrate the community. The decision needs to come from the community itself, as well as the threats that they feel they will be facing and the process of identifying threats. In order for change to happen, it has to come from the community and the entire community needs to be concerned. For example, we have had in Puerto Rico many times in which people have tried to refuse disposal or change attitude to throwing away garbage all-around. And whenever, it is a program in which you have someone outside of the community or a foreigner or a person external to a community that comes and tells everyone "Hey you have to start throwing out (*inaudible*) on the road" it never works. You might have ads or you might have an investment in an educational or there is an ad in the news or the cinema or a lot of people at meetings or programs or things like that. But the attitude at the end does not change, because it is external. But if change comes from the community itself, then it will be long term. That's why I feel that our project is so successful in Manati, because we are integrating the community at the community level and we are respecting their own interests and their own goals. So in order for things to be successful, there needs to be taking into account each community in particular and the threats that community will be facing. And if that's with children, which I know is your main objective for developing a curriculum for schools, it should start with (*inaudible*) and you should try to reach the parents. But, even if you change the children, it will not directly change the parents. And the parents can also affect how much credibility the children can give to what they learn in school. So it would have to be an integrated program, to involve whole communities and not just those from the school.

P: So I don't think we have any additional questions, so we will send an email about the contact information for the other people involved that project.

IR: Okay

P: Thank you very much.

IR: And also, in terms of education, environmental education, I think you should talk, specifically about the education program and how to educate communities, you should talk to Frederico Cintron-Mistoso, the guy that emailed me. So if you talk to him directly, ask him directly about education, and community activism from an anthropological view, he is the guy to talk to because that is precisely what he does, he specializes in education from an environmental point of view and he is involved in communities in that area. I would strongly suggest that you talk to him as well.

P: We actually just did on Friday, so it's kind of funny you mentioned that.

IR: Cool.

P: Thank you very much.

IR: You are welcome let me know if there is any way I can help.

P: We will. Thank you.

Interview 8: Isabel Pares Ramos

Environmentalist, Landscape management researcher
Date & Time: November 13, 2014; 9:30 a.m.

Emma (E): Do you mind if we record you?

Isabel Pares (IP): No. It's okay.

E: So, as I was saying, with our project so far we've just been doing interviews with people like yourself and next week we hope to start interviewing teachers and start developing the lesson plan that we will test out on a ninth grade 4-H group in Río Grande at the, I think it's the Palmer school. So, that's our progress so far.

IP: Are you using, like, a model. A model of a curriculum that you would like to develop for Río Grande?

E: We've been researching lots of different climate change education modules online and such and kind of we're going to use those as inspiration for our lesson plan, but we don't exactly have a – it's our task to create it on our own with using different inspiration.

IP: You know, if it is the first time that a club 4-H develops climate change curriculum here in the island?

E: I'm pretty sure. We don't know yet. We're waiting to talk with the teacher we're working with on Friday, tomorrow actually, and so we're going to talk with her and observe one of her classes as they take a field trip to El Yunque.

IP: Oh, great!

E: So, We'll have to wait to see what her opinions of the project are and such.

Princesa (P): So, as far as our questions, our first question is: we would like to know what your area of expertise was.

IP: Well, I did undergrad in environmental science and geography here at the University of Puerto Rico and then I did a masters in international cooperation and urban development. I've been mixing both of them in terms of research. I've done a lot of scientific and social research for the past ten years and I've worked with land use change with the human dimensions of environmental change, demographic changes in Latin America, usually from the university ecology lab and with the forest service.

P: Going off of that, what kind of organizations or environmental education initiatives have you participated in or that you were a part of.

IP: Well, environmental organizations, they're a lot here in Puerto Rico. When you're studying environmental science, you are very into it. The major ones such as in San Juan: the Eletuaria de San Juan, that's a big one. It's a unique project that is over twenty years old and they've been restoring the whole around the San Juan basin area. That's an important one. I have also founded my own organization but I work with a different type of environmental issues such as transportation and CO_2 emissions to reduce CO_2 emissions by having a carpooling project, the first one in Puerto Rico. Very dependent on what you're looking for.

P: So where in the island have you focused your studies? You mentioned San Juan just now. Is that really where you primarily work or have you worked in other forests or anywhere else on the island?

IP: Well, in terms of landscape, I've – Usually my work is related to remote sensing so I work at the landscape level. That means the whole island and usually from cartography lab you work a lot with maps and with GIS and you look at the island as a whole, not into a specific forest. My research was about land use changes in Puerto Rico from 1990 to 2000 and how population changes affected those land use changes like agriculture, forest expansion, and deforestation. That was ten years ago that I did that research but more recently I've been looking at – I work at El Yunque on the Atlas project looking at different environmental factors. Social factors economic factors, around the municipalities that are in El Yunque, the forest.

P: What sort of landscape change have you found? I'm just curious. What kind of, over the past ten, twenty years, what changes have there been?

IP: Yeah. That last study revealed that most agricultural lands that are being lost was due to suburban development. Many people talk about deforestation and the island was truly recovering. The forests were recovering ten years ago because people abandoned farmlands and they migrated to the city. So, those lands become abandoned and they started the process of natural regeneration. As well, people were moving to the suburbs because it's cheaper there so that expansion also – they expanded in primary agricultural land around coastlands, around the coastlines, and also areas that are now very steep. You can see how the plants and landscape is changing.

P: What studies have you done specifically about climate change in the Caribbean or Puerto Rico? I know you've done studies about different aspects like landscape usage, but what about them might be more reflective of climate change overall?

IP: I've only been working with climate change for two months now. I just started this project that I presented at the symposium last week. I've only been working for two months in there, so the first step of the project is make a vulnerability assessment of agricultural lands and forestry - how vulnerable it is to climate change. We're working on that right now, so it's very – I think that's going to be the first study related to climate change we're going to do, looking deeply into variables and what's happening around the island.

P: Is there anything that you have found so far that's maybe a common trend or something?

IP: The lab that I work at, they've been looking at climate data, and so far the models say that in 2100 the island is going to be very dry, so we're going to have a lot of changes in our life zones, a lot of changes in where you can grow things and that's a very important aspect of climate change. You need to really look into the future. We're just starting to look at what are the effects of droughts, of changes in rainfall patterns, in the agricultural sector, and what that means for production. I don't know if you guys have heard about the drought that happened in Puerto Rico during the summer. It was just a couple weeks without rain and that was devastating for the island. That's just a small proof of what can happen in the long-term when the island gets drier and drier, as we have no good adaptation practices.

P: Is that dryness a definite reality? Is that a definite? Or as the land has been reforested – I mean I read somewhere that reforestation helps cool the island because of, just, the natural processes of different cycles and different gas cycles. If that continued, would that fate be, on the island, that it would still become drier or is it possible that it changes?

IP: Well, the analysis, they are based on patterns of annual rainfall and annual temperatures over already reforested today – and the patterns still, the weather is going to get drier and hotter, so the trees, they grow slower. Many species grow slower on those parameters. The maps are showing that we are going to have, under different scenarios of greenhouse gas emissions, depending on the scenario and depending on development and industry production, you're going to have a between one degree and five degree warming. That's kind of how it's looking.

P: Celsius?

IP: Yeah.

P: So, you kind of touched a bit upon what those – what the impacts of that kind of drying would be. Could you maybe go into a little more detail about the climate change drying up the island?

IP: Well, that's not really my area of expertise, but I can tell you that definitely we have no water, then this drier climate means a lot of stress – environmental stress – because of lack of rainfall, lack of water, hotter winds, etc. There can be many plagues as well, many diseases that would affect not only agriculture but also the healthy forest, not to mention the social impacts of all these environmental dynamics, but we're talking about the ecological impacts you can have. We are an island, so our coastline is going to be really effected. We don't have that many sources of potable water. Many of our waters are underground, and if those aquifers get dried, then we are going to have a lot of issues not only for the population, but also for agriculture production and forestry.

P: So, from the social standpoint, what would be the effects there?

IP: Well, of climate change in general? What we have is many people live on our coastline. We have a lot of communities that are going to be affected by see level rise, by the impacts of extreme weather events, as much of our population is very vulnerable already. They, if you see the map of coastal communities, many of them have water intrusion and their houses are affected. Farmland is affected already by water intrusion, so, we are a country that is not prepared for – we haven't started the adaptation processes yet. So, I think it's a necessity that we start educating people, especially young children, to start thinking about what we can do: what we can change in our everyday behavior and the way we build a country just to make it more resilient to climate change.

P: Why especially in children?

IP: Because it's more different, I think, when you're trying to the perception of adults here. And, especially children, they're still living here. When you get a young adult, here the social conditions on the island are not that stable, so they're leaving. Many people are leaving everyday to live in the states, so you're educating people that are going anyway go and live in the States, so it's better to educate the children that are going to live here for a long time and you need to start from a young age, understanding what are the implications of climate change under today and also in the future because that's what's more important.

P: So what kind of aspects of climate change do you think the public might be unaware of?

IP: Maybe the effects on food production. But also that's a challenge as well since we don't produce a lot of the food that we eat. Mostly, we import 85% of all the things that we eat and at the same time, climate change and the effects – it's all going to affect food supply exchange on the island, so trying to link climate change with food production and how it affects us, like on the table of what we eat, what food is accessible to us today that is not going to be for us in the future, what can we start producing. Maybe it's a good opportunity to start looking for ways to improve the relationship between children and the environment, and try to motivate them to grow their own food, to be more resilient to climate change and talk all about food security and all those concepts that people are not really taking into account today when they make decisions on how to act and what's their relationship with nature.

P: So for that food supply, that would have to change again how the landscape is used I would think. Right?

IP: Yeah.

P: How would it change? You said there was a migration of people toward people living in urban and suburban areas, and then there was that benefit that there was some reforestation from those agricultural lands. What would have to be done to maintain that balance not having as much deforestation as there was in the past, but being adequately able to supply food to adapt to climate change?

IP: That's definitely the dialogue, the discussion; what method of production and system we're going to adopt produce food for 3.7 million people. We're definitely not going to reach – we're not going to be able to produce enough food for everybody, but we can start with some crops and some commodities that are very important for the diet of people here. You have many options today. Not only technological advances, allow you to produce more, but there's also many ecological ways to produce food such as agroforestry and agricology. They are looking and many people on the island, especially the small-scale still, are looking at those practices to see and to show the rest of the people that it is going to be possible to grow food without really cutting forests down or going back to those intense agricultural practices that were very harmful for the soil, the consuming of water that are not really the best ways to move forward when you're thinking of climate change and the impacts it's going to have already. But if you want to go back to those practices that are not ecologically sustainable – They've started to look at different methods of production, but that's still under discussion.

P: Out of curiosity, if you combined agroforestry and urban gardening and urban farming, do you think that those coupled together would create enough food for everybody? If every household, or every other household had a plot of beans or something?

IP: It would be amazing but I haven't done the calculations or anything. But, the problem is that we have a lot of people living here and especially in urban areas and urban areas are very decayed and there are not many green spaces. I think there are many potential areas you can rescue to build urban gardens but you would need to teach many people how to grow their own food, because they lost that know-how and have no connection with the land. They lost that so they don't' know how to grow food, so you really need to educate them first before trying to follow – to promote – urban gardening and other stuff because you need to have people that can manage that in the long-term. There are areas that could be rescued for that. Many, many areas in San Juan that I can think of and all around the island, but how do you convince people that that's the right way to go? That's another question.

P: For our curriculum, like you said, we're trying to educate children, which you said is really important. That is really what our curriculum is aimed to do. What do you think would be something that would be a good thing to teach, or maybe a good activity to help people adapt to climate change and learn about the effects of climate change?

IP: Well, since I'm working on this project that is related to food production I – it's amazing how neglected the figure of a farmer is. I think many children, they don't recognize, and they don't value what a farmer is because they come from, you know, urban neighborhoods. They are not connected to the lands and it would be amazing to just try to promote. Kind of to teach children the importance of working the lands. Not only as a farmer, but working as a forester or just a profession more related to building a relationship with the land that human people don't mention. I think that if you ask many children, they don't know. They don't even know where food comes from! Just visiting farms or just teaching them that, really, where your tomatoes come from. The answer is not from a supermarket because they really – they've never asked themselves where food comes from and maybe they're not even aware of the capability that they have when they learn to grow their own food. So, I think that's very much some aspect that needs to be tackled, you know, to just make agriculture an attractive thing, like farming is attractive or forestry is attractive. All the kids, they want to be lawyers or doctors and everything because that's what society tells you is good, but those other professions are really neglected and I think it would be very interesting to see how kids react about being more closer to the land – working the land.

P: As we develop our lessons, then should we do something like that where we have, maybe, a lesson or activity that has "here's where we talk about food"? Is that a thing you suggest would be a good idea?

IP: I think it would be. It would be fantastic. Also there are many traditions and knowledge about growing food that has been lost over generations that are simply not connected to the land, and it would be a good opportunity to rescue that know-how and traditional knowledge that people have of how to grow food here. Especially crops that are very local like yuca, yautía, or even beans that people will eat them everyday but we don't grow them anymore because our food, our local cuisine, is mostly imported because we lost the control of the production on the island. So, I think that would be very interesting and that is connected with nutrition that's connected with just empowering kids to be more conscious about what they eat, to be more healthy, so I think it's like a circle. If you talk about health, like club 4-H it is very important – the health part. So, you can connect that with nutrition and food production. Maybe developing some skills in kids that help them in the future to be more independent in terms of food production.

P: Can you think of any other questions?

E: No, I'm good.

Michael (M): I can't think of anything else.

P: It seems like that is it. Thank you.

Environmental Specialist Interview Coding Charts

Filipe Cano

Climate Change	Education	Public Opinion
Eco-friendly use of land	Agroforestry initiative	Unaware of entirety of climate change
Behavioral adaptation	Children's Forest	Very complex, very scary
Change in rain patterns	Use of art	
New diseases	Hands on education	
Elfin Woods Warbler	Video	
Habitat shift	Photography	
Food webs	Planting trees	
Nutrient cycling	Interactive social map	
Extinctions	Smartphone app	
Coastal flooding	First component- "what is climate change? What is climate? What is weather?"	
Adaptation- Improving local habitat	Dog Analogy	
Adaptation- reduce heat island effects/ plant trees	Don't go too deep, lose them very quickly	
Adaptation- practice recycling habits	Challenge them	
Effect of Endemic Species	Relatable	
	Superficial intro of greenhouse gases	
	Optimistic	
	Nature Watch (group)	

Edgardo Gonzalez

Climate Change	Education Techniques	Public Opinion
Changes in coastal areas	Develop initiatives to educate people about climate change adaptation	People are not really concerned
Infrastructure	Start by understanding the basics	People don't see it "in their backyard"
Loss of coastal resources	As simple as possible	"It will not happen to us"
Patterns of rain	How it will affect student, tier out to larger and larger scales of relevance	Haven't received enough education on topic
Adaptation: Alternative uses for coastal areas	Make it understandable at personal level	Doesn't seem to have an immediate effect on lives
Adaptation: Monitoring the changes in the climate		
Adaptation: Infrastructure (construction)		
Agricultural Adaptation: Changes in pest management		
Agricultural Adaptation: Develop new agricultural practices		
Coastal erosion		
Coastal changes = Impact on tourism activities		
Coastal changes = Impact on fishermen		
Effects secondary economic recourses		

Carolyn Krupp

Climate Change	Education Techniques	Public Opinion
Rain events and weather patterns are changing	Project Learning Tree	
Temperatures are fluctuating	Hands on learning	
	Conservation education	
	El Yunque should be more involved in education	
	Conservation and conservation ethics	
	Big picture – global-ness.	
	Show how things have changed locally/regionally	
	Outdoor learning opportunities	
	Learn about the impacts of climate change on area	
	Expose students to rivers and watersheds	
	Interconnectivity	

Federico Cintron-Moscoso

Climate Change	Education Techniques	Public Opinion
Loss of coast??	Sierra Club	Environmental education not taught in public schools
We live in a globe	Need to learn how to live with the environment	
	Sustainability	
	Need to understand the environment	
	Process in reflection (on climate change)	
	Knowledge of environment and our attitudes about the environment and identification of criteria to make decisions about future.	
	Make local and relevant	
	Convey the sense of understanding to beyond classroom and home.	
	Photos	
	Videos	
	Learn to identify abnormalities that result from climate change	
	Guideline for teachers	
	Encourage research	
	Integrate research into lesson. Ex: interview someone in the area that has been affected by climate change and ask how things have changed.	

Marcela Cañon

Climate Change	Education Techniques	Public Opinion
Low increase in temperature	Conservation	No interest, no knowledge
Birds are migrating later or earlier in the year	Be a part of the solution- prevention	That's something major- not related to me
Fossil Fuel production	Make it relevant	
Mitigation	Adaption- agriculture and the river	
Change in rain problems	Keep it basic	
Sea level rise	How what's happening in the world can affect you	
Photosynthesis	Build it to be more complex	
Relationship between sun, soil, water, plants	Public hearings	
Hole in the Ozone	Tools created by NASA, etc	
Effects on tourism and hospitality	Videos	
Coast disappearing	List of references for teachers	
Renewable Energy	Intersperse lecture with activities	
	How it is market based	
	Explain the different complex figures	

Ashley Pérez and Eduardo Agostini

Climate Change	Education Techniques	Public Opinion
Small island	Sierra Club	Outside of their reality
Large impact by sea level rise	In the middle of a hydrographic zone- Rio Grande	Don't acknowledge it as a problem
Disappearing of corals	Videos	Don't fully grasp or understand it
affect micro-ecosystems	Cute animals	
Coasts disappear	Comparing an effected region to a not effected region	
Precipitation change		
Extinction		
Connectivity of Nature		
Impact on pharmaceutical industry		
Renewable Energy Market		
Megawatt farm		
Recycling business		
Business, government, community on the same page		
Scarcity of resources		
Endemic Species		

Isabel Rivera

Climate Change	Education Techniques	Public Opinion
Wide variation of precipitation ranges	Integration with community	Knowledge about the productivity of land
Variation on temperature changes	Respecting interests and goals	Knowledge of the past and how they dealt with climate change
Seasonality	Involving parents	Social responses to climate change aren't always negative
Frequency and intensity of storms		
Drying trend		
Human's affect on climate		
Increased greenhouse gases		
Deforestation		
Climate change is not solely caused by human factors		
Puerto Rico is dependent on certain mammal species		
Dependence on imported product		
Sea level rise		
Loss of coastal lands		
Exploitation of coastal resources		
Acidification of oceans		
Vulnerability of food production		
Dependent on others to supply water and food		
Adaptation- produce own product		
Adaptation- not consume as much energy		
Adaptation- reduce our misused production		

Isabel Pares Ramon

Climate Change	Education Techniques	Public Opinion
Agricultural lands being lost due to suburban development	Adaptation: Educate people, especially youth, to think about what we can do	Island has no good adaptation practices
Island expected to be very dry by the year 2100	Motivate students to grow their own food	
Drought on island as devastating	Improve relationship between children and environment	
Weather is going to get drier and hotter	Teach children the importance of working the lands (farmer, forester, etc.)	
Changes in precipitation make trees grow slower	Make agriculture an attractive thing	
Between a 1 and 5 degree warming (Celcius)	Rescue traditional knowledge and teach it to	
Drier climate = environmental stress	Connect students with food production	
Diseases and plagues		
Effect on coastline		
If aquifers dry there will be issues with population, agriculture production, and forestry		
Sea level rise		
Extreme weather events		
Water intrusion		
Effects on food production		
Effect food supply exchange		
Adaptation: Agroforestry and agriculture and urban gardening		

Educator Interviews:

The following interviewees were selected by and were deemed to have significant knowledge and expertise in educational topics.

Interview 1: Amabel Soto

Ninth grade mathematics teacher, Carmen L. Feliciano Carreras del Sector Palmer Middle School, Río Grande, Puerto Rico
Date & Time: November 18, 2014; 11 a.m.

This interview was conducted in a mixture between English and Spanish. The following transcript has had all of the Spanish portions translated into English, with the original wording in parenthesis next to the translation.

Michael (M): And we've started

Princesa (P): Can we remember you? *(¿Podemos recordarse?)*

Amabel Soto (AS): Record *(Grabar)*

P: Record! Record, excuse me *(¡Grabar! Grabar, permiso.)*

AS: Yes *(Si)*

P: Okay. First I wanted, uh, we want to know what subject you teach, but – *(Primero quería…uh queremos saber cual tema usted enseña, pero –)*

AS: The subject from today? It's transformations, and there are different types of transformations. There's reflection, rotation, and translation that we're working with. *(El tema de hoy? Son transformaciones, y hay diferentes formas de transformaciones – transformations – esta reflexión, rotación, y translación, que la estamos trabajando)*

P: But you work as a mathematics teacher, yes? *(¿Pero trabaja como maestra de matemáticas, si?)*

AS: Mathematics, yes *(Matemáticas, si.)*

P: What subjects do they offer here [at this school]? So, there is mathematics and there is English, but what else? *(¿Cuales temas se ofrecen aquí? ¿Entonces, hay matemáticas y hay ingles pero cual más?)*

AS: Ah, Spanish, social studies, English, and some electives like visual arts. Eh, here there is theater, music, art, physical education, home economics, and industrial art. *(Ah, español, estudios sociales, ingles, y algunas electivas como bellas artes. Eh, aquí esta teatro, música, arte, educación física, salud, economía domestica, y arte industrial.)*

P: How long have you been teaching for? *(¿Por cuánto tiempo ha estado enseñado?)*

AS: For twenty years. *(Por 20 años.)*

P: And here? *(¿Y aquí?)*

AS: Here, eighteen. *(Aquí, dieciocho.)*

P: And what grade do you teach? *(¿Y cuál grado de estudiantes usted enseña?)*

AS: Ninth grade *(Noveno grado)*

P: Ninth, not any other grade, just this one? *(Noveno, no de otro grado, solo esto?)*

AS: Aha, at the moment just ninth grade *(Aha, en este momento solo noveno grado.)*

P: And have you always taught – *(Y siempre enseñado –)*

AS: I've always taught ninth, or I have for a while but not always. I've taught all grades. *(Siempre he enseñado noveno, pues hace mucho tiempo si pero no siempre. Enseñado todos los grados.)*

P: Okay. Can you describe a typical day in your class? *(Okay. ¿Usted puede describir una día típico en su clase?)*

AS: A typical day? *(¿Un día típico?)*

P: Mmhmm

AS: The students, right, arrive at the classroom and have to, right, work with the routine activity, the day's instructions, and then, well they go to the lesson, right, that one has planned for the class. Then, well, one answers questions like you all saw and one gives them work to do or gives it to them the next class. *(Los estudiantes, verdad, llegan al salón de clase, hay que, verdad, trabajar con la actividad de rutina, de las instrucciones del día, y luego entonces pues se va a la lección, verdad, que uno tiene planificado en la clase. Luego pues se contestan preguntas como ustedes vieron y se deja haciendo un trabajo o se les da seguimientos de la próxima clase.)*

P: And do they behave well, they don't have any problems or – *(Y se portan bien, no tienen problemas o –)*

AS: In general, there's always exceptions. *(Por lo general, siempre hay sus excepciones.)*

P: But there isn't chaos? *(Pero no hay caos?)*

AS: No, there's not chaos. *(No, no hay caos.)*

P: That's good. Um, what tools and education styles do you use? For example you used an iPad [in the lecture that we just observed] – *(Que bueno. Um, cuales herramientas y estilos de educación usted use? Por ejemplo, uh, usó el iPad –)*

AS: The iPad, yes, the iPad, the computer, right, with different manipulative strategies. It depends on the topic really. *(The iPad, sí, el iPad, eh, la computadora, verdad, con diferentes estrategias manipulativos. Dependo en el tema, verdad.)*

P: And do you always use activities with the whoe class? So that they can – *(Y siempre usa esas actividades con toda la clase? Para que ellos pueden –)*

AS: Well , sometimes we do work in separate groups *(Bueno, a veces hacemos trabajo en grupos, apartes.)*

P: But, um, it's not always lecture? *(¿Pero, um, no son siempre lectura?)*

AS: No, no. We do distinct things. Yes, especially in mathematics, it's not just the whiteboard and answering exercise questions. We do different types of activities. *(No, no. Nos hacemos cosas distintas. Sí, especialmente en matemáticas, no es solamente la pizarra y contestar ejercicios. Hacemos diferentes tipos de actividades.)*

P: And that, um, *(Y eso, um,)* is that – do you find that efficient?

AS: Yes, because what I – they see the different types of math, understand? By doing different things, well, it movitaves them, especially in mathematics, which they don't like, many people don't like to do math. But they do different things and that helps motivate them. And like we saw today, right, what we're going to do today, looking for things. And that helps them a lot to motivate them and make them practice more. (*Yes, porque yo lo – ellos veen las matematicas diferentes, entiendes? Hacer cosas diferentes, pues, lo motivan, especialmente en matematias, que no les gusta, hacer matematicas mucha de la gente. Pero ellos hacen diferentes cosas y eso los ayuda a que estén motivados. Y que vamos a hacer hoy, verdad, que vamos a hacer hoy, buscando cosas. Y eso los ayudan bien a que se motiven y hacer, verdad, a practicar más.)*

P: So they practice more and they learn and their grades are good? *(¿Entonces se practican mas y se aprenden y sus notas salen buenos?)*

AS: They get better. Always, when they study, because I can do a mountain of things in the classroom, but if they don't study, well, what I do doesn't matter – *Bell (Mejoran. Siempre cuando estudien, porque yo puedo hacer montones de cosas en el salón de clases, pero si ellos no estudian, pues, nada vale que yo – Bell)*

P: But, um, Okay. Do you know if they teach climate change in this school? *(Pero, um, okay. ¿Sabe si enseñan cambio climático en la escuela?)*

AS: Climate change? I believe so, in science class. *(¿Cambio climático? Creo que si, en la clase de ciencias.)*

P: Okay, and you were always a math teacher, not – *(Okay, y usted siempre era de matemáticas, no –)*

AS: Yes, yes, yes, always math. I integrate other things for example recycling, right, in math class so that it can integrate, well we try to have topics of all different areas including, well, environmental problems. *(Sí, sí, sí siempre la tema de matemáticas. Yo integro otras cosas por ejemplo el reciclaje, verdad, en la clase de matemáticas para se integra, pues, tratamos de tener temas de todas la aéreas incluyendo, pues, las problemas ambientales.)*

P: So, like, what have you done specifically with like environmental things with a mathematics class?

AS: Okay, we work with volume – with the concept of volume in mathematics. So we use how to calculate the volume of space for how to better trashcans – the capacity of trashcans. What is the trashcan's volume? So that they can know how much trash is accumulated in that trashcan and they can, in general, and there, well, we integrate then, if we go to a recycling center so that they can bring the materials and work with that using specifically mathematics within the concept of solid waste. *(Okay, trabajamos con volumen – con el concepto del volumen en matemáticas. Pues usamos cómo calcular el volumen de espacios para como dar mejor los zafacones – cantidad de zafacones. ¿Qué volumen tiene el zafacón? Para saber cuánto basura se acumula en ese zafacón y pueden, en general, y ahí, pues, integramos entonces, si vamos a un centro de reciclaje para que ellos trajeen los materiales y trabajaran con eso usando específicamente la matemáticas dentro del concepto de desperdicios sólidos.)*

P: Um, what kind – do you ever have any problems when you're teaching a new topic?

AS: A what?

P: Do you have like, uh, problems teaching a new topic? In a class.

AS: In a specific topic?

P: Just any topic

AS: Yes, especially in fractions. They have a lot of problems with fractions.

P: So, how do you, uh, get them to kind of overcome that?

AS: Ah, I'm trying to use the manipulative to encourage that they're doing them. That's is not – that is a problem that they have, uh, from the elementary schools.

P: So, do you give them worksheets like today or –

AS: Yes

P: Okay

AS: Worksheets and some other things that they try to incorporate the fractions in say a problem that they have.

P: Do they kind of end of getting better grades eventually or does it just kind of coast somewhere?

AS: It comes. We have a diversity in the classroom.

P: Um, and then for when you develop a curriculum and our lesson plan, how do you do that? How do you specifically do that, or how do they do it at your school?

AS: Uh, the lesson plan? Ah, we always make the lesson plans the week before to integrate all the activities and, not always, the plan – we can use the plan, all the things that we plan to do, but we try.

P: So when you make a lesson plan, do you, um, how do you…[To Emma] Can you take over our lesson plan question, because I'm not sure what I'm trying to ask any more

Emma (E): Um,

P: I'm trying to be like, do you make, like, activities or do you plan – how in detail do you plan for a lesson? Cuz we have to try to make a lesson

AS: Oh, that – there's different things because, you need to have the unit that you want, the whole unit, that you want to develop. And then you are going to part every skills, because inside that – the unit – you have different skills. And then you are going to try with one skill each. Then when you have the plan for each skill.

M: So it's based off of the student's learning objective? From this lesson they will gain this and be able to do this after the lesson?

AS: Yes

M: Okay

P: And then for homework, uh, do you give out a lot of it

AS: Um, I'm uh, not – I don't want to. I don't like to give homeworks to the students, because they don't do it. And the other day we needed to begin with the same thing because they didn't do it. But I don't like to use homeworks. Uh, it's good if they do it because homework – they practice in the home. This is what one would want, right? *(Esto es que uno quisiera, verdad?)* It's how we want it but that is not the real thing. Regrettably *(Lamentablemente.)*

M: Um, would you happen to maybe know a reason perhaps why they don't do the homework?

AS: They are lazy. They don't want to make anything of school in their home. There's some students, maybe 20% of the students want to do it because they are good students and want to make better. But they – [the] other 80% students – they don't want to work in home. That's the reason

P: I'm sad to say I would have been that student

AS: Excuse me?

P: I would have been in the 80%, I'm sorry.

M: Me too

AS: That 80% don't like it.

P: I'm sorry to all my teachers now. Um, so do teachers here do any sort of field trips or anything? You mentioned the recycling –

AS: Yes, uh, the field trip you told? Yes we would – we have right here. Specifically the centro de acopia. I don't know how to say it in English but recycle –

M: Recycle center

AS: Recycle center, right. And we have right here in the school, but we are doing about all those things, field trips, specifically arquitectura. They go to some places that, uh, somebody talk about how math includes in different arts.

P: So, uh, is a field trip something where you go off of the school grounds or can you be outside and doing something kind of outdoors but it's still –

AS: No, outdoors right here in the school

P: So you can have a field trip where you're doing something on the ground, but it's a field trip

AS: Mmhmm

P: And are there ever any problems with coordinating field trips, like do you have to do permission slips or –

AS: Sometimes. That depends on the skills.

P: Okay. Um, are you personally – do you think that field trips are really helpful for school, or for the classroom?

AS: Yes, yes. Everything that you do extracurricular is good for the students.

P: How come?

AS: Because they have other experience that is not inside of the classroom, and they need it too.

P: To kind of make it more interesting?

AS: Yes, and they see how they can apply it – use it. For example, the math outside. How they can integrate math with other disciplines like math with science, math with art.

P: Math with arquitecture.

AS: Yes

P: Um, do they ever do sort of big projects at the school? So like instead of one little project with the class it's like the whole grade does a project or something

AS: Specifically we do the project of the recycle, and we began with one group, last year, and then the other group during this year is incorporated with the project and they are now incorporating now the whole school to know the benefits of recycling, and use the recycling [uh? 13:56] image in the classroom.

P: So they all – are students getting more involved in that?

AS: Yes.

P: And do they like it?

AS: Yes, they like it.

P: Okay. Um, I guess in math you don't really have this but do you ever have any sort of tricky or maybe controversial topics? In math you wouldn't really I guess. Kind of like in a science class if one has to talk about evolution versus religion, like that becomes controversial sometimes.

AS: Mmm. No, no that's not really math.

P: I dunno, it was on our list of questions.

AS: Yes, I know (*Giggle*)

P: So, that was pretty much it, do you guys have any other questions?

M: Nope

E: No

M: That pretty much covered it. So thank you very much.

E: Thank you

AS: You're welcome, you're welcome.

Interview 2: Stephanie Santos

Visual arts teacher, Carmen L. Feliciano Carreras del Sector Palmer Middle School, Río Grande, Puerto Rico ; 4-H participant.
Date & Time: November 18, 2014; 1 p.m.

This interview was conducted in a mixture between English and Spanish. The following transcript has had all of the Spanish portions translated into English, with the original wording in parenthesis next to the translation. The English translations may have some wording corrections, as there was some difficulty with the language barrier, and some incorrect word usage was understood through inference.

Michael (M): We've started

P: We know that you teach art class; how long have you taught for? *(Sabemos que usted enseña clase de arte, ¿por cuánto tiempo ha enseñado clase?)*

Stephanie Santos (SS): Twenty-three years. *(Veintitrés años.)*

B: And here? *(¿Y aquí?)*

SS: In this school, eight. *(En este esquela, ocho.)*

P: Eight. What grade do you teach? Or grades? *(Ocho. ¿Cual grado de estudiantes? ¿O cuales grados?)*

SS: The intermediate level: seventh, eighth, and ninth. *(El nivel intermedio: séptimo, octavo, y noveno.)*

P: Oh, seventh, eighth, ninth. And that's all intermediate? *(Oh, séptimo, octavo, noveno. ¿Y todo eso es intermedio?)*

SS: All of that is intermediate in Puerto Rico. *(Todo eso es intermedio en Puerto Rico.)*

P: Okay. Can you describe a typical day in your class? *(Okay. ¿Puede describir un día típico en su clase?)*

SS: Well the typical day for an art elective is a bit chaotic because it is an elective with work, a lot of activity, sometimes very messy, but very enthusiastic because the students really like art. *(Pues el día típico de un taller de arte es un poco caótico porque es un taller de trabajo, mucha actividad, a veces mucho reguero, pero mucho entusiasmo porque a los estudiantes les gusta mucho el arte.)*

P: Why do they like it? *(¿Por qué se gustan?)*

SS: Why do they like it? *(¿Por qué les gusta?)*

P: Mmhmm!

SS: Art is unique. Art class helps you express yourself. And in art something's not good or bad. As a form of expression, your expression is as valid as another person's expression. And the students have that liberty, because in art two plus two is not four, it's what you want. *(El arte es único. La clase de arte te ayuda a expresarte. Y en el arte, no es que esté bien o esté mal. Como expresión, tu expresión es tan válida como la expresión de él. Y los estudiantes tienen ese libertad, porque en el arte dos más dos no es cuatro, es lo que tu quiera.)*

P: Mmhmm, yeah. To teach a topic, do you use special tools or educating styles like – it's difficult with art but when you teach a new one what do you use to do it? *(Mmhmm, sí. Para enseñar un tema, ¿usa herramientas especiales o estilos de educar como – es difícil con el arte pero cuando enseña una nueva que es lo que usa para hacerlo?)*

SS: I use a reference for teachers – a curriculum framework. *(Yo uso una referencia que es para los maestros – un marco curricular.)*

P: Okay

SS: In those documents I can find distinct units, which are that topics that I work with. With an activity I have the most freedom and it allows me and I work to the students' liking, to their age, to the moment that we are in. But yes I have a regulatory documentation that has curriculum maps and planning guides. *(En esos documentos yo voy a encontrar distintas unidades, que son los temas que yo trabajo. Para la actividad, es donde es más libre y me dejo llevar por el gusto de los estudiantes, por la edad de los estudiantes, por el momento en que estamos. Pero sí tengo una documentación normativa que son mapas curriculares y guías del plan.)*

P: And with that, you develop your – *(Y con eso, desarrolla sus –)*

SS: I develop my class activities, exactly. *(Yo desarrollo mis actividades de clase, exacto.)*

P: Okay. Eh, have you ever taught climate change? *(Okay. Eh, ¿ha enseñado cambio climático?)*

SS: I work much better with the topic of the environment, but through creation. But it does inform the students about the benefits of using trash, for benefits for the earth, for the environment, for the planet, which is all connected to the topic. *(Trabajo más bien el área ambiental, pero atreves de la creación. Pero sí se informan los estudiantes de los beneficios de utilizar la basura, para beneficios de la tierra, del ambiente, del planeta, que está conectado el tema.)*

P: Because there is a lot of trash right now. *(Porque hay mucho basura ahora.)*

SS: Of course. And one of the things that obviously affects us is the mismanagement of waste. I do projects where I use trash as material. *(Claro. Y una de las cosas que obviamente nos afecta es el mal manejo de los desperdicios. Yo hago proyectos donde yo utilizo la basura como material.)*

P: For art. *(Para arte.)*

SS: Exactly, to create art. And I always tell them and I touch upon the topic of the importance of environmental conservation through reusing or recycling. *(Exactamente, para crear arte. Y siempre les hablo y les toco del tema de la importancia de conservación ambiental atreves de la reutilización o le reciclaje.)*

P: And do they listen to that, do they pay attention to that message? *(¿Y ellos se escuchan a eso, se portan atención a este mensaje?)*

SS: Yes, they show interest, well they show more interest in what they are going to do. Not the information because they're adolescents and they do things quickly. But one tries because at least it creates the awareness. *(Si, muestran interés, pues muestran más interés en lo que van a ser. No la información porque son adolecentes y ellos son de rápido hacer. Pero uno trata que por lo menos creen la conciencia.)*

P: Can you please describe the 4-H group? *(¿Puede describir el grupo de 4-H, por favor?)*

SS: The 4-H group is a group of very committed students. They are students with very good grades, who always accept the challenge to do more. One presents a project to them and they always say that yes, they are going to do it. And it's a group of students that any teacher would love to have. Time and time again, because they are people that are always going to do. Students with very good grades. *(El grupo de 4-H son estudiantes bien comprometidos. Son estudiantes con muy buenas notas, que siempre aceptan el reto de hacer más. Les presentan un proyecto y siempre dicen que sí, que lo van a hacer. Y es un grupo de estudiantes que cualquiera maestra quisiera tener. Repetidas veces porque son personas que siempre van a hacer. Estudiantes de muy buenas notas.)*

P: And they're part of the group *because* they have good grades, or it's a coincidence or – (*Y están parte de este grupo* porque *tienen buenas notas, o una coincidencia o –)*

SS: Well, they're part of 4-H because they're very disciplined and committed. Obviously their grades are important because if they had bad grades they could not participate in the outdoor activities because that would affect their grades. *(Pues, son parte de 4-H porque son muy disciplinados y comprometidos. Obviamente las notas son importantes porque si tuvieran malas notas no podía participar de las actividades de afuera porque sí van a afectar.)*

P: So then did the school pick the students and put them in this group? *(Entonces, ¿la escuela se escogió estos estudiantes y se pusieron en ese grupo?)*

SS: I picked them. *(Yo los escogió.)*

P: You? (¿Usted?)

SS: I made the selection because I had known the studentes for two years. I saw them grow. And I saw over time they were more committed. *(Yo hice la selección porque yo conocí a los estudiantes hace dos años lo que conozco. Lo he visto crecer. Y he visto que pasa el tiempo y más comprometidos están.)*

P: So, you met them in the – *(Entonces, usted los conocieron en el –)*

SS: The seventh grade. And now they are in the ninth. *(Séptimo grado. Y ahora están en el noveno.)*

P: And last year you chose them – *(Y en el año pasado tú los escogieron –)*

SS: I had already chosen them, and many of them were already in 4-H. *(Ya yo los había escogido, y muchos de ellos ya estaban en 4-H.)*

P: Oh. Outside of the school? Or – *(Oh. ¿Fuera de la escuela? O –)*

SS: 4-H is outside of the school, but I work in the project with my kids in the school. But the activities are all related with this organization. What this group of 4-H specifically is is the Casa del Árbol, and that's why we are in El Yunque. *(4-H es fuera de la escuela, pero en ese proyecto yo lo trabajo con mis niños* *de la escuela. Pero las actividades todas son relacionadas con esa organización. Que específicamente ese 4-H, es la Casa del Árbol, que por eso estamos en El Yunque.)*

P: Mmhmm.

SS: That group will be in charge of the nursery where there are trees. The 4-H group from this school basically belongs to El Yunque. To the forest. *(Ese grupo va estar a cargo de ese vivero que es donde esta los arboles. Es que el 4-H de esta escuela básicamente pertenece a El Yunque. Al bosque.)*

P: And do they do anything more than that or do they focus in – *(Y se hacen algo más de eso o tienen una enfoque en –)*

SS: The focus of this group of 4-H is mainly environmental. If we go out to El Yunque to do photographic work we also go to rescue trees, to do seeding work, that is in the nursery. We go out to areas that always have to do with caring for the environment, with enjoying the surroundings, nature, nature, nature. *(El enfoque de este grupo de 4-H es mucho de ambiente. Si salimos a El Yunque a hacer trabajo fotográfico también salimos a rescatar arboles, hacer trabajo de siembra, eso es en el vivero. Salimos a aéreas que tienen siempre que ver con cuidado ambiental, con disfrutar del entorno, naturaleza, naturaleza, naturaleza.)*

P: What is "viveo"? *(¿Qué es viveo?)* Oh! Live.

SS: It's a place where you go to work with tres, like a nursery of trees. *(Vivero es un lugar donde tu vas a trabajar con los arboles, como un nusery de arboles.)*

P: Oh, Okay. So you all do field trip activities a lot. *(Oh, Okay. Entonces ustedes hagan actividades del campo muchas veces.)*

SS: In 4-H we're always out of the school. *(En 4-H todo tiempo, fuera de la escuela.)*

P: Are they successful? *(¿Tienen éxito?)*

SS: Always. *(Siempre.)*

P: Always, why? *(Siempre, ¿Por qué?)*

SS: When the students go out of the classroom, they learn more. They learn more in terms of academics and they learn more in terms of things that have to do with interpersonal relationships, with teamwork, with appropriate behavior. Many times there are better results with students outside of the classroom. *(Cuando los estudiantes salen del salón de clase, aprenden más. Aprenden más en la académica y aprenden mas en lo que tiene que ver con las relaciones interpersonales, con el trabajo en equipo, con comportamiento adecuado. Se tienen muchas veces mejores resultados con los estudiantes fuera del salón.)*

P: And why is that? Why do those activities help? Why do they have more interest in them? *(¿Y por qué es? ¿Por qué esas actividades se ayuden? ¿Por qué tienen más interés?)*

SS: Because they're out in the fresh air, because they're in natural surroundings, because they are surrounded by nature. And human beings connected with nature learn more. They learn better. They have more stimulation. Looking around in an enclosed space is never the same, never. I hope that every one could have projects like this, and take out their students from the classroom and take them away from the chalkboard. The students would have better results, and they would behave better. *(Porque están en el aire libre, porque están en su entorno, porque los rodea la naturaleza. Y el ser humano conectado con la naturaleza aprende más. Aprende mejores. Tienen muchos estímulos. Miren el espacio encerado, no es lo mismo, jamás. Ojala todo el mundo tuviera proyectos así, y los sacara del salón de clase los alejara de la pizarra. Tuviera mejores resultados, y se portara mejor.)*

P: Do they do projects here that are bigger than one class. Like a project with two classes or a project with the whole school. *(¿Aquí se hagan proyectos más grandes de una clase? Como un proyecto de dos clases o de toda la escuela.)*

SS: Integration *(¿Integración?)*

P: Yes. *(Si.)*

SS: The math teacher and I are working on an integrated project. She is working with waste management, I think a recycling center, where she brings trash – metals, paper – and there I work with here so that I can rescue the trash and convert it into art work. That project is an integration of mathematics and art. *(La maestra de matemáticas estamos trabajando en un proyecto integrado. Que ella está trabajando con manejo de desperdicios, crea un centro de acopio, que es donde se pone la basura– metales, papel – y de ahí yo trabajo con ella para yo rescatarlo para convertirlo en las piezas de arte. Ese proyecto es de matemáticas y de arte integrado.)*

P: So this school is willing to do those - *(Entonces este esquela está dispuesto a hacer esos –)*

SS: Yes, integration. (Si, la integración.)

P: Okay. When you are teaching an art class do you ever have topics that are controversial? *(Okay. Cuando estas ensenando la clase de arte, ¿nunca tiene temas que son controvertidos?)*

SS: Controversial topics? It's that – maybe it's the age that the students are – that controversy is not so present. Maybe if they were older, but we're well – we concentrate in an area of creativity. That is to say that it is pretty individual. To create controversy, I believe that controversy is normal in growing adolescents, but in correlation with the class topics, not so much. Our dynamic doesn't give to it. *(¿Temas controversiales? Es que la – tal vez en la edad que ellos están – esa controversia no se da tanto. Tal vez si fueran más grandes, pero somos bien – nos concentramos en la aérea de creatividad. Que es bastante individual. Que para crear la controversia, yo creo que es la controversia normal de adolecentes que están creciendo, pero en correlación de las temas de la clase, no se da. Nuestra dinámica no se da.)*

P: Okay. Eh, outside of the class, there are activities, do you have activities related to the environment or climate change that you do? *(Okay. Eh, fuera de la clase, tiene actividades, ¿usted tiene actividades con el medio ambiente o cambio climático que usted haga?)*

SS: Well, look, with it – and it is linked to the change that we have gardens in which we work with at the edge of the school, that we work with planting. And we plant trees and do landscaping, and they are working also with benefiting the environment because when they are planting they benefit the climate and the environment. That is work I have with additional projects. All of my students have that experience because it is an area at the edge of the school. *(Pues, mira, con el – y está vinculado a lo del cambio nosotros tenemos unos jardines que trabajamos en lo exterior de la escuela, que, haciendo trabajo del siembra. Y sembramos arboles y hacemos landscaping, y ellos están trabajando también beneficiando el ambiente porque cuando ellos están sembrados benefician al clima y al ambiente. Ese trabajo yo lo tengo con proyectos adicional. Todos mis estudiantes tienen la experiencia porque es un aérea que está en los exteriores de la escuela.)*

P: But that is outside of the school, it's not connected with the school? *(Pero eso es fuera de la escuela, ¿eso no es conectado la escuela?)*

SS: I connect it because when they work with planting, we don't forget elements of art. The color, the shape, a garden is to beautify. And art works with beauty. So in some way there is a connection. *(Yo lo conecto porque cuando ellos trabajan la siembra, no olvidamos los elementos del arte. El color, la forma, un jardín es para embellecer. Y el arte trabaja con la belleza. Así que de alguna manera tienen conexión.)*

P: But that is not something that you all do with the school, just – *(Pero eso no es algo que ustedes haga con la escuela, solo –)*

SS: I do it with my students, from my class, in a part of the school that needs rescuing to fix it or planting. *(Yo lo hago con mis estudiantes, de mi salón, en un lugar del escuela que necesite ser rescatado para arreglarlo o sembrar.)*

P: Oh Okay. So they have gardens her in – *(Oh Okay, entonces tienen jardines aquí en –)*

SS: Benefits, exactly, in the same school *(Beneficias, exacto, a la misma escuela.)*

P: Oh, Okay. I think that that is it, those are all of our questions. *(Oh, Okay. Pienso que eso es, eso es todo nuestros preguntas.)*

SS: Perfect! *(¡Perfecto!)*

Interview 3: Marganese Sanjunto

Ninth grade science teacher, Carmen L. Feliciano Carreras del Sector Palmer Middle School, Río Grande, Puerto Rico
Date & Time: November 18, 2014; 3 p.m.

Emma (E): Do you mind if we record you?

Marganese Sanjunto: No.

Princesa (P): the first question we wanted to know what subject you teach.

MS: Earth Science. That's the current subject in, like, middle school for especially the ninth grade for students around 13 to 14 years old.

P: Okay. Do you only teach ninth grade or do you teach other grades as well?

MS: Currently, I'm just teaching ninth grade. Like, two years before, I was teaching eighth and ninth grade.

P: how long have you been teaching for?

MS: The last 9 years.

P: Wow, and then here?

MS: No, I have been only three years in this school, but currently I was around the island in other public schools and private schools.

P: Okay. Could you describe what a typical day in your classroom is like, please?

MS: Noisy… (*laughs*) I'm pretty messy. Actually, it's like the same dynamic of I present a topic and they have to divide in groups, and do the topic I am teaching, like the activity you were seeing. It's like not every single day, but mostly everyday we will usually use the computer and present the topic and then we start to discuss it and construct and make different diagrams on the board and they write it down and we start discussing all of the topic together.

P: We, so far in the other on of the classes we've been in, there's been similar dynamics where there'll be a group that goes along with whatever is being learned or being taught to? Is that common in this school or is that something that everybody does?

MS: No, it's not. It depends on the topic, but we are trying to make more activities that uses that pin-on.

P: The entire school?

MS: The entire school.

P: Is that just the school or does that go out further, like the entire island doing that?

MS: The entire island.

P: Do you know why?

MS: Well, we had, like, new standards this year that were using the next generation science standards and the common course like the activities. They are directed that students are going to remain in groups and they are going to use that.

P: so when you're teaching a topic and you're kind of doing these activities, what do you use? Like what's a kind of activity you use a lot?

MS: I use labs, group activities, we have a lot of things we have to do and write and create.

P: Is climate change taught in any way in this school?

MS: What?

P: Do you ever teach climate change?

MS: Climate change? Yes we do.

P: To what extent?

MS: We use it in my grade in this unit, but actually the art teacher is using that. She's using her class to teach the consequences of climate change and what can we do to stop it and prevent it. The math teacher is also using it, the English teacher, so it's a general topic that is being used as, specifically in my grade, as a topic in our different classes.

P: Is that just this school or is that kind of in the area or the island.

MS: In the island, because we have these new standards and it's one of the topics that is present.

P: - Is teaching climate change. So do you usually have – is it usually successful teaching climate change or is it kind of, because it's so new, it's hard to tell if kids are learning from it or not.

MS: No. They actually know a lot about climate change and what causes and what can we do. So, we get all that information and they bring it to class and we discuss, like, what chemicals are involved, what human actions are involved, what nature conservation concerns are involved.

P: So when you're teaching a topic – any sort of topic at all – and it's new, do you have any problems teaching it to the students? Do they, maybe they're not always receptive to it? do you usually have any sort of trouble with getting kids into new material and getting them involved in it and motivated to learn it.

MS: Yeah, always. When there's a new topic we have issues with the students because they have a lot of misconceptions and we start asking them questions and then they tell us what they know about the topic and from there we start directing the class.

P: and then you say, "This is true. This isn't true"?

MS: Yes.

P: Okay. So, how do you personally develop your lesson plan for the students?

MS: Well, the papers I gave you? Every teacher now has to create units using the standards. So we have these units that come from the Department of Education and they are separated in the different subjects. We have all this information and we have to use it to create our own units using what the kids know and all the other things involved in the book that we use primarily. So, we have to use all this information that the department [DoE] gives us and create our own units.

P: And having new standards – does that make it hard to do that with all the things you have to use for it, and the new standards? Is it harder to develop a curriculum?

MS: It is because all this information from the standards that they are giving us are new. The had started in this august, so we have to take time to get involved with all the new stuff and redesign our classes.

P: We you ever – do you use field trips in your class at all?

MS: We do.

P: Do you ever have trouble making them happen or do they happen rather easily for you?

MS: They are pretty easy to do.

P: Okay. Do you find them useful for your students?

MS: They are.

P: What kind do you use?

MS: Well, next week we're going to a geologist to different parts of the island and we're going to use the geologist to take the kids and he's going to teach them about the different types of rocks and how Puerto Rico was created around the planet's tectonic plates of the Caribbean and the local area. It's an activity that we don't have the facilities to do in a school, but when we use the field trips, there's another experience for the students and they are pretty receptive to it and they learn more.

P: Do you ever do, kind of, large-scale projects? So, instead of in just one class do you ever do one that is maybe with an entire grade or the entire school?

MS: Not really. Not in my experience.

P: Okay. Going off of climate change material, do you ever have – is it ever controversial for you? Do you ever have to, sort of, find a way to deal with it being controversial if it is?

MS: there's usually a relatedness that comes from the news and all the stories that they read on the Internet so it's not a big issue. They are really related to the topic

P: So, do you think that the students here are – you say they're actually pretty well aware of climate change?

MS: Yes I do.

P: Okay.

MS: They actually are upset because we teach them about climate change, but they are really upset about the government and all the other areas that they don't do what they're supposed to do to stop it from happening.

E: What time during year do you go over climate change?

MS: That's the first unit, actually from August and – August, September and half of October. That's the first unit. It's all about climate and temperature and we have the topic involved in that unit.

E: Alright. so you were talking about the standards – the new standards. Is there any way we can view those, or are they on the internet or anything?

MS: Yes. They are actually on the webpage of the department under the science faculty, but I actually have it right here.

E: Okay!

MS: (she gets the binder containing the new standards) this is for ninth grade, okay? We have, like, a map with different units. Climate change is in this unit [1]. This has the curriculum maps that we use. Here we have all the vocabulary that we have to work with the kids. For the whole unit, here's the different activities that we can use and the different questions that we have to make the kids understand the questions and from there start teaching them all the different topics. So, it's actually a lot of reading we have to do in each unit. This just came in August, so in the summer we were told that this is going to change in all the areas; Spanish teaching, English teaching, Science, and Math. Social Studies, they haven't turned to the new standards, but in the other classes they have. So, it's a lot of information and we have to create all our own units and from there our own lesson plans. What I gave you is a unit that uses – this unit over here – I'm sorry. It's all in Spanish.

Michael (M): No problem.

E: We can understand it a little!

MS: Well, that unit that I gave you takes all of this. That includes a lot of vocabulary and notes. Do you want to review it?

E: Yeah.

M: I have a question then while they're doing that. Are there any difficulties that you find in using this. Are there any things that may be hard to follow or not intuitive?

MS: the structure that they use to put all the information together is kind of hard. For me, it's not that hard because I have a masters degree in curriculum, so I'm used to creating units but for a regular teacher that doesn't have any classes in curriculum design, it's really hard.

M: Okay.

MS: And, there's a lot of topics in each unit and sometimes the time is not enough and we have to start teaching a topic but we can't tell the kids a lot of information about it because we are pretty limited on the time that they gave us.

M: So how do you then pick and choose between the topics that you do include and then choose to exclude due to time?

MS: We have to choose the topics that are more related and that the kids are used to. So, the topics that are included in previous grades. For example, climate change is a topic they are very used to since fourth grade, so it's easier to teach that topic but there are other topics like in geology. Tectonic plates is a really hard topic because they are not used to it. They are used to listening about volcanoes and earthquakes, but the different layers of the earth – they're not used to it and they don't understand what are they made of and all the history that it takes to start talking about tectonic plates. So, there are topics that are harder to teach and sometimes we are really behind. In reality, there are a lot of topics that we are not going to be able to teach in the whole grade. We can teach the first unit, second unit, but the last unit is astronomy and I'm sure that I'm not going to be able to, in May, teach this because time and all the complexities of the document.

M: If you had a recommendation of, since we are trying to develop a few lesson plans that deal with climate change, of how to make it so it could be easily taught within the time frame, what would those be?

MS: A time recommendation to teach the topic of climate change? Well actually, the first unit is not that bad because the have to teach it in seven weeks, but the other ones are harder, so around seven week we can deal with, including climate change and teaching students temperature and the difference between climate and time and stuff like that. But if we start the same temperature –teaching temperature scales – so they can actually under stand what is it: low temperature or high temperature? That part that includes math is crazy because they have a lot of issues with math. So if we teach then to change from Fahrenheit to Celsius, actually that takes around a week. There are thing about climate change that we can teach them, but other are going to take more time if you want to be more specific about it.

M: It's better to keep it more at a conceptual level then?

MS: If you keep it at a conceptual level, it's easier, but if we want to teach the whole spectrum of what climate change is, it's going to take a while. Around five, six, seven, eight weeks to teach all the things that are related to it and the difference between global warming and climate change.

P: I have one question actually. When you guys teach climate change, how in depth do you go? Do you talk about El Yunque in particular or is it just a general "what global climate change is"?

MS: General, and we can give then examples of what they can find. Here in this school we talk to then about El Yunque because it's really near but in other schools they use a lot of other parts. Like in Guanica, they teach them about the one forest in Guanica and the difference between Guanica and El Yunque and the temperature difference and the difference between the rain. So we use those examples to teach them, and we use others examples. For example, there is that picture over there of the Kilimanjaro and a few decades ago it was much different because it had more snow and the temperature – the climate effect has changed a lot of the Kilimanjaro Mount – It's a volcano, right? So, that's what we do. We use local examples, but usually we teach climate change in a really wide concept. We don't get more specific because of the time and we maybe don't have the facilities to do it. You were seeing in class - it was really hard since I was trying to use the Google Earth application and some kids have their cell phones with them, but they were using my iPad and using my computer. They were even using the globe model too. It's pretty hard because we don't have the resources which makes it even more hard and the instruction about the topic needs to be wider in general. If you have more resources, you can make other activities that are more specific and the process is more enlightening for them [the students].

P: Do you guys have any further questions?

M: I think that is all we have to ask. Thank you for sitting down and doing this with us.

Interview 4: Cybele Londoño

Biology teacher, Academia del Perpetuo Socorro – High School, San Juan
Date & Time: November 21, 2014 ; 12:30 pm

Emma (E): do you mind if we record you?

Cybele Londoño (CL): As long as you can un-record any really stupid thing I say I'm fine! No problem. You can record me if you want to. Although, it makes me nervous…

E: (*laughs*) Don't worry. So, we were just wondering what is the subject you teach?

CL: Okay, I've been teaching – right now I teach biology and AP Biology, but I used to teach life science, earth science, physical sciences, biology, AP biology, and chemistry because I had six classes I taught. I had very small groups, but I had to teach all of them, so I'm pretty familiar with the curriculum. I've developed my own biology curriculum for both my AP and my regular classes. I am originally a biologist, or was I guess. Then, I became a teacher after that. What else?

E: Maybe we should sit instead of walking and talking….

CL: If you want to ask me the next question I can start thinking about it.

Princesa (P): Okay. How long have you been teaching?

CL: I've been teaching since '99, but I have taken some time off because I had kids. I had three kids, so I took 4 years somewhere in there to take care of my daughter when she was young.

E: So, basically we were creating this curriculum on climate change. Have you had any experience with teaching climate change?

CL: we have taught, I mean *I* have taught particular units in earth science that are related to climate, weather, atmosphere – those kinds of things, definitely. We've talked about that. It tends to be very general because it doesn't address climate change specifically.

(Found a place to sit)

E: so, what age or grade level do you teach?

CL: Okay. Right now I'm teaching 15 and 16 year olds and 17 and 18 year olds.

E: could you describe what a typical day in your classroom would be like?

CL: Okay. A typical day in my classroom. Well, I teach five different groups of students, so each group is really quite different than the other. Three of those groups are regular biology groups, then, I have an honors group and an advanced placement [AP] group. Each group is really different from the other. I'm supposed to teach the same material to the regular students and then the honor biology group are a little bit more advanced, and my AP biology group is supposed to be even more advanced. That is with the seniors. In reality, each group is so different – they have their own personalities, their own dynamics – so, I really don't end up teaching the same material or the same way to all of the groups. Pretty much, my day flows according to blocks and we have some free periods but more than anything I focus on content. I'm very a content teacher. I didn't specialize or anything, like in special ed. I'd rather be interested in giving a lot of content in an organized manner, keeping them very busy so that they don't misbehave. That's a big issue for teens.

E: What kind of educational tools are your favorite to use or that you find most effective?

CL: I see. I use a number of different techniques, strategies, and tools even. We've got – certainly I have labs that we do, so that's really hands on, very kinesthetic. Kids have to, you know, prepare in advance, which frequently they don't, so I need to explain before we go into the lab. That gives kids a hands-on perspective, but if you don't explain it before and after, it's like you didn't do it. Somehow it does not record in their heads. We use a lot of video. There are different particular, what do you call those, companies that develop video materials for teachers. One is RicoChe and they're pretty good. We have Kans Academy that's also pretty good, so I pick and choose and take material from them. I also use mastering Biology. That's a – it comes on disks and is sold by [Pierson], not that I want to promote Pierson or anything. So, videos, labs – I try to show them stuff a lot, like if I have actual live organisms I show them. If I have skeletons, fossils. I try to use a lot of hands-on, but that's more difficult when the groups are larger. We do use – I use a very traditional fill-in-the-worksheet and I do that sometime because kids get very hyper and that really calms them down. I don't know. Maybe they're very used to it or very comfortable with that kind of technique but, even though it's not really recommended anymore, they really like to sit down and fill in a crossword puzzle, do classwork, paperwork. They like to use the book, read through it and fill out questions. Again, I don't find that that's that useful in terms of making them learn the material. It helps them review but only if you go over it with them. Frequently, I find that students are just not paying attention to stuff.

P: So, what do you use that you find is effective when you teach?

CL: let me think about that. The most effective stuff is really making it – well, first I find that, if you come up with a presentation, you introduce the subject. What makes it most effective, what makes a subject, when you present a new subject, is first of all doing a lot of brainstorming with the students – letting them provide you with information about them. you need to know who they are before you can teach them anything, really you need to know what do they have inside their heads because usually they have huge misconceptions. I was dealing with that today, and I'll tell you a little bit about it in a minute, but they have misconceptions so we brainstorm about the subject and I try to find out where they are in terms of a particular subject, particularly if it's something new. it's useful to come up with a short video or presentation to kind of get them thinking about it a little bit more. Then, explaining it yourself, really explaining it and, perhaps, reading from the textbook but not reading the whole textbook. Just choose small excerpts from the book that you're using, usually teachers are still using books, so reading short excerpts from the book and talking about it, explaining it, and asking them. Really addressing them like they're people, not just sponges that are absorbing. I find that if you don't – everything needs to have a beginning, a middle, and an end. If you don't start from the beginning or assess at the end they're not going to pick up on the material very well. some student do, but many don't. you lose them in that way. Today we were talking about energy and kids have the funniest misconceptions about energy. they think that if you sleep you get energy. why do they think that? because that's what their parents tell them – if you don't sleep you won't have any energy. so, what I ask the is, "what is energy and how do you get it?"

They go, “well, you get it from sleeping.” or they might not even know what energy is. They certainly don’t know all of the different types of energy or that energy can be transferred, so you really have to spend a lot of time on these particular concepts and, even though they kind of know, they don’t really know. Now something I don’t spend time on is the cell because everybody has been studying the cell since kindergarten. They’ve done models. They’ve done this. Everybody kind of has an idea of the cell, so we try to really address misconceptions on the different topics that we’re covering.

E: have you ever worked with any controversial subject matters?

CL: Definitely. We deal with controversial subject matter all the time. In fact, the topic, one of the biggest controversial subjects that I deal with is evolution. I work at a catholic school and, fortunately, these particular students are pretty open-minded and most of them accept that evolution is a fact. But, I used to teach at a Baptist school. I was not allowed to teach about evolution. It was not allowed. I just could not even use that word. That was not acceptable in that school. So, I couldn’t teach a lot of material because that’s a huge and important concept in biology – it’s a central, core theme in biology – but we couldn’t teach it.

P: When you do teach it at this school, what’s something that you use to kind of – I almost want to say break the ice, about that?

CL: What I say to them is, “okay. We’re going to talk about evolution. It’s a very important subject in our class. You may have heard, or your parents may have spoken to you about it. In reality in my classes, I teach you what science teaches. This is not about what we believe, but rather what’s being taught in this field at this time.” I try to kind of remove the controversy from it I think. This is what the books are telling us, and again, you have the right and your parents have the right to teach you whatever they teach you, and if you don’t want to believe that evolution occurs, it’s up to you. Then, I go on to say that evolution is simply change over time, modification upon descent to try to take the stigma away from it. It works pretty well in this school, but this school is a higher socioeconomic level and they tend to be much more open-minded for some reason. I don’t know why, but the Baptist school won’t even allow that I even teach it. My students were telling me I was going to go to Hell because I was talking about evolution, so it made it very difficult. I left that school. I couldn’t teach there. I didn’t feel comfortable because I’m also Jewish and it was a problem. It was a big problem. I couldn’t be Jewish. I was told, “If you’re going to be Jewish, that’s fine, but don’t tell anybody.” It was not a good place for me whereas this school is perfectly accepting of this, of my practices.

E: So, how do you go about developing a lesson plan?

CL: Okay. There are different ways of developing lesson plans, certainly. If I was in your shoes –you guys are clearly brilliant people studying really difficult careers or difficult subject matters – probably the main challenge for you would be getting down to the students’ level. Really coming down a little bit because you’re probably really good at math I suppose and you probably know a lot. You may not be aware of what they don’t know, so what I would do is, if I was doing to develop – first I would choose a subject. I suppose you have some subject matter that’s specific about climate change, that you want to teach. I would start out with the beginning. what is the beginning what you want to teach? I assume you’ll start with some definitions, finding the very specific subjects that have to do with climate change. Address those, but in a very condensed manner. I know you’re going to be dealing with the atmosphere and think of subjects like "what do they really need to know to be able to acquire the knowledge you want to impart?" I would make a list of that. what do you really need to know first. Then, I would develop your subject, your content, again, in a very specific manner, kind of in a bullet fashion, until you really know what it is you're trying to teach them. Do you already know what you're trying to teach them?

E: Yes. We kinda have to lessons that we're developing. one's going to be on the greenhouse effect and the different greenhouse gases and ways to reduce greenhouse gas emissions. That's the first lesson. The second lesson is going to be about the impacts of climate change, so on how it causes warmer oceans, how it causes changes in sea levels.

CL: But, you've got a lot of material here. A beginning, from what I can hear that you are saying is you're talking about gases. Definitely, you need to talk about the atmosphere. They might not even know that the atmosphere is made up from a mixture of gases. I would go into, what are gases? What gases are available? What are present in our atmosphere, and talk about those concentrations. Also, explain how they are not fixed, how they can change over time. I would talk about – so you have gases and atmosphere. Then, I would talk a little bit about the effect of temperature and pressure on gases. you're dealing with areas where there is, at higher elevations, you're going to have lower air pressure. at lower elevations you're going to have higher air pressure. they might not know much about air pressure or that much about temperature that affects gases. I would use cars as an example, since everyone has gotten into a hot car. They know how, when yu get into a hot car, it's so hot. essentially, they understand the green house effect when using an example of getting into a hot car, so they do kind of know, but not know. I would talk about, for example in San Juan, I would use the fact that, when you get into a building – in old San Juan the buildings are really tall because hot air rises. So, how does that/what does that have to do with climatic change? Since you're dealing with the changes in temperature, that's all related. Again, I'm going to let you decide and figure out how it's all related, but you're dealing with gases, pressure, and temperature. I would develop a lesson first on gases, a short one, and then one on temperature and pressure and the greenhouse effect. Why not mix them? Because if you mix them you have too many details and the kids are not going to be able to separate them in their own minds. When they get to ninth grade usually they take earth science. Eighth or ninth grade.

P: They seem to be taking it now, yeah at the ninth grade.

CL: So it depends on the school really. And they don't really understand physics, yet. And they are not that good at algebra. So you need to kind of all really tone it down to their level. Because if you have a really great group, and they are really advanced; you can explain all this with physics and algebra and talk about pressures and gases. These kids don't know this, they don't understand this. And they probably learned photosynthesis but in a very general manner. So you may want to talk about that too. So, so far you got a lesson plan, on gases, air temperature, and effect of altitude on. Then of course you have to talk about climate, what is climate? How does is it differ from weather? If you are teaching in Puerto Rico, talk about hurricanes because they are interested in that. And use the ocean also, because they know the ocean; so talk about the ocean, use the ocean. If they are in El Yunque, then they are aware that it rains a lot in el Yunque. They might not know why it rains so much there. So, see, you've got a lot of material. You've got a lot of material to develop. May I ask you something?

P: Mhmm.

CL: Are you going to try to develop this and then try to do it? Or did you already develop it, these lesson plans?

E: We're testing out; we're basically testing out two lesson plans.

CL: You've already developed them?

E: Yeah. We are in the process of developing.

CL: Would you like me at them before you take them to your school and give you feedback? Or would you rather me not touch it and let you guys just do all the work?

E: We can send it to you, we still have some edits, but…

Michael (M): We have to make it more…

E: Yeah, we still have to finish it up but like…

CL: Because I can give you feedback based on my opinion, but it would just be my opinion. Again I talk a lot, but I think I have a pretty good sense of all of this. I think you are doing a beautiful job. It's very, very interesting what you are trying to do. Okay next question?

(paused when we trying to relocate our questions)

E: Actually that was all the questions we had, specifically.

P: Was that really? That was very quick?

CL: It's because I talk so fast, I know. And that's me without coffee. It's helpful for me to be very hyper. Because my students, it's how I stay one step ahead of them.

(Brief talking about another question to ask)

E: We are translating everything into Spanish for our curriculum, because the school we are working with is not bilingual at all.

CL: That tends to become an issue. It's not so easy. I think so. I have taught in English speaking schools and I have taught at bilingual schools. And in English speaking schools, the English is better. So they really do understand English now. Where I am teaching now, they understand English but they tend to have difficulty with tests. They don't test well in English. There are many words that they don't know. If you are translating, just make sure you get a really really good translator. Make sure that they really translate well, so that you can explain your subject well, and address the issues that you want to address well. I don't know, I would say keep it simple. Make it short, but give yourself the opportunity to lengthen it if necessary.

E: That's something that we are planning on doing. What we will be testing out two lessons that kind of cover most topics of climate change but in kind of a superficial level almost. And then be able to expand on those for our project's sake. But we will not be able to actually test those out. But we will expand them, so we can do more in depth lessons about the different subjects.

CL: But when I say make it long enough. I mean, you don't want kids without anything to do during a period. So you want to make them long enough in terms of time use. Pacing is one of the hardest things when you do lessons because you might have something wonderful but it might only last twenty minutes. What do you do with these monkeys for the next twenty five minutes? So give yourself enough activities, even if you don't use them all. First, have enough activities. And something that I find, that tends to become a problem is when we cover subjects in a very general way then when they take a test they don't know enough. You have to simplify it but teach other relevant content any way and find a way to make it easier for them. That's where you have to do your work. Make it easier and more understandable for them, so they can have breadth but also depth so that they know enough.

M: Okay so kind of an example that might be…

CL: Okay an example. Like sometimes we talk about gases and how our atmosphere is a mixture of gases. But you also need to tell them what gases these are. What are the specific gases and what are their proportions and they might not understand why it's a mix. And why it's a mix and you don't see the parts. You have to tell them it's a mix and it's homogeneous and its transparent and clear. And give them like a little handout of the different specifics of the atmosphere and the different percentages of each gas. So they have something to hold on to. So you can explain that is a mix, but also give them what's involved and what's in the mix. You see, so some teachers say "oh it's a mix" but they don't go into that much detail but you need to give them the detail. So when they have a test that asks what is the percentage of "CO_2 in the environment, they can answer that question. Or what is the percentage of oxygen or they need to know for example that ozone is a pollutant if you have it down here, but up there it is necessary or required. Those kinds of details that give kids a kind of edge for testing but sometimes take up a lot of your time. So provide that one way or another. But don't forget to explain that it's a mix, do you see what I am saying.

P: Yeah, even if it's just like a table that says all these things.

CL: Also, remember, when you do take tables nobody reads a lot. Kids don't read a lot. They don't want to read. So make it big enough, colorful and simple. Don't put too much stuff in your tables. What I've realized over the years, nobody reads anything. A few really really smart great kids like to read but they don't want to read any more. Kids want it all like this (snaps her finger). If you could do interactive stuff using your computer, that's better for them. I mean, it's better for them in the sense that they are more likely to use that. Don't expect that they are going to read a lot they won't. Some will but most won't. A lot of kids are very auditory, and they don't read well. Or they don't want to read. And that's a big issue they don't know how to read and write any more. I'm sure you've found that. Did that happen to you, do your read and write well?

P: I was always a bookworm so…

CL: So you read and write well, what about you do you read and write well?

E: I don't know. Well, I write pretty well. I don't read very well. I've never had a liking for it.

CL: Okay, so you are the kind of person that gets a lot out of these video clips and google.

E: Absolutely.

CL: So use that. That's very available nowadays. Use it as much as you want to. Let your kids know that is out there. Give them links. You don't want to read about it. Watch this link. And then assess, assess, assess. Always assess at the end, otherwise they are not going to do it.

M: Cause I know I am like personally, like a very auditory person. So like a song about something might like teach me so much more than reading something.

CL: So like if I tell my students, read chapters four and five over the Thanksgiving break. They aren't going to do it. But if I say, I am going to put this disk online or I am going to give it to you as a link. Please look at this video, this PowerPoint presentation and it's the same stuff that is in the book. But they are going to be much more likely to go through that. Our children today are not what they used to be. The attention span is about 8 seconds. I mean, they are so not able to pay attention anymore. I mean I am talking about you guys. Am I?

P: Yeah

CL: And they are worse because they have ipods, ipads, computers. Even kids who don't have a lot of money, have access to ipads, ipods, i-whatever. So you are looking at a very different population than I had when I started. And we have to evolve with them, or we will not have work in two or three years. I'm afraid of what will happen in five years. I don't know. Okay. You guys feel free to contact me. I want to become a teacher's teacher someday. I have so much experience. I don't mean to boast, but I've been in, you know, I've been in this so long, and I know – I wish I could, you know, teach at a teachers college and really share all this with people who are going to use it. So please contact me any time.

M: I actually have a question then on that same note, then. In terms of what sorts of materials to provide for teachers who may not be accustomed to teaching a science topic like this, what –

CL: Okay, new teachers

M: Or even just teachers who, they may teach a subject that, such as art, that isn't necessarily intrinsically related to climate change. What sort of material would you say that we should provide to them?

CL: If I were you and I were going to talk to an art teacher, I would focus it all towards artistic. There's so much beautiful stuff that kids can do with art and climate. I mean, they can do collages, they can do, they can make, they can draw planet Earth in different ways, they can make models using models of the atmosphere using Play-dough clay, things like that. If you look at a book for example, open a book, one of your books that have information about climate change that you wanna teach, I bet you have a lot of beautiful illustrations. How can you transfer that into an art lesson? How can you convert that? And I bet you can think of and find ways to use construction paper to make models of the atmosphere. I mean there's so many layers of the atmosphere. Why is the sky blue? I mean, that's one right there. You can do, for example, you can have – you can do stuff with particulate matter that will stick onto paper with jelly. You can take paper and jelly and go out and find particulate matter that can be observed under a microscope or that can be used in some way as a stencil for some artwork. I don't know, I mean, let your imagination go but look at what's available. You have maps, you have models of different layers. Climate change, you involve temperatures so you can do stuff with water, how water rises what it gets hot. You can show kids boiling water and you can show them how the bubbles are coming up, things like that. I don't know if this helps – does it help?

M: Yeah it does.

CL: I mean I just – you have a lot of knowledge and you have imagination, just let it go for a while. Brainstorm. Before you try to do stuff just brainstorm and write it all down, write it all down and then organize. Puke it out, clean it up. (*Laughter*)

M: Yup, I mean that's just a weird question that I had.

CL: If you wanna email me with any questions –

E: Yeah, absolutely.

CL: If you wanna send me stuff, I'm happy to look at it. Let me give you my email. As a teacher I'm very, very creative and sometimes I'm too creative and that can be a problem for me. Because when you creative you also have to be very organized, and it's hard sometimes. It's easy to be creative, hard to be more organized. And you really have to be very organized. I mean you're very creative probably (*Motions to Emma*). You're very creative probably, also.

M: Yeah, because we found that we're trying to do a bunch of creative, sort of innovative approaches towards teaching it and it's harder to stay organized when trying to do all that.

CL: I think that we can't throw out the baby with the bath water. Teachers have known how to teach for years, for millennia, and now we're trying to throw away all of this expertise and if you're gonna teach something to students you have to actually teach it to them. You have to require that they use their memory. You have to use basic cognitive skills to acquire their knowledge, and you have to provide a framework for that knowledge to fit. Provide a framework, and like a closet, like a bunch of shelves. If they don't have those shelves, they can't squeeze in the information. They might put it somewhere where it doesn't belong. So you have to give them frameworks. And you have to provide them information and knowledge. Nowadays we try to be so creative and innovative, that we stay away from providing frameworks. You have to provide it. They are not going to learn unless they have somewhere to put it in. I don't know if this makes sense.

E: It does.

CL: Okay. Alright, well good.

Educator Interview Coding Charts

Amabel Soto

Education Techniques	Environmental Education	Puerto Rican Education
Interactive activities	Integration of math and environment: volume of trashcans and students take trashcans to recycle center	School: Spanish class, social studies, English class, electives: theater, music, art, PE, home ec., industrial art
Group activities		
Activities integrating technology		
Manipulative strategies		
Worksheets		
Develop lesson plan to integrate activities		
Have a plan for each learned skill		
Not big on homework		
Field trip = anything outside (including school grounds)		
Field trips give students better understanding		

Stephanie Santos

Education Techniques	Environmental Education	Puerto Rican Education
Curriculum framework	Creation – benefits of using trash	4H group belongs to el Yunque
Distinct units	Environmental conservation	
Curriculum maps and planning guides	Planting and landscaping	
Develop class activities		
Field trips- very successful		
Teamwork- on field trips		
Connection with Nature		
More stimulation- outside of classroom		

Marganese Sanjunto

Education Techniques	Environment Education	Puerto Rican Education
Use computer	New standards involve climate change education	Hands on activities on the whole island
Class discussion	Students know about climate change, its causes, what people can do, how people are involved, chemicals involved, etc.	New standards (2014) include more group work and creative activities
Diagrams	Students are upset about current state the world is in with respect to climate change	Teachers have to create their learning units using standards
Field trips – geologist for example	Only just had their first unit earlier this year (fall, 2014)	Limited time to teach everything to standard
Field trips help them learn more – effective!	Climate change education is pretty general, but they try relating it to their region	
Choose topics that the students are more related to and are used to		

Cybele Londoño

Education Techniques	Environment Education	Puerto Rican Education
Labs	Talk about the atmosphere	
Explanations before and after activities	What are gases?	
Traditional fill-in worksheets	Ocean and hurricanes	
Fill out questions		
Brainstorming		
Need to know the students and any misconceptions		
Explanation and asking questions		
Reading small excerpts from books		
Address them like they are people		
Start from the beginning		
Assess at the end		
Definitions		
Address specific subjects in a condensed manner		
Keep it simple. Make it short		
Have a lot of activities planned		
Breadth and Depth		
Use colorful, simple tables		
Links to videos		
Incorporate art –collages		
Use models		
Use frameworks		

Appendix C: Proposed Learning Unit - Pre-test

Pre-test for lessons 1 and 2

Estimated time: 10 minutes

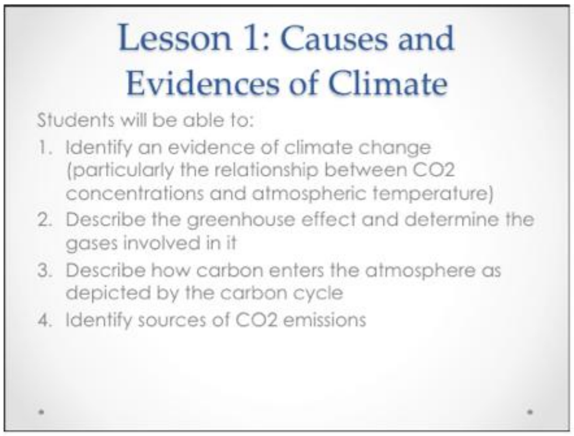
Give students the following pre-test a day before conducting lesson 1. This pre-test addresses learning objectives of lesson 1 and lesson 2. The responses that are highlighted below correspond with the answer to each question.

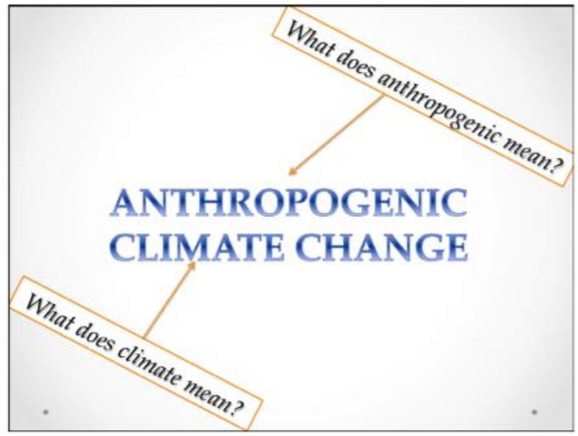
Name: *Provide space for response*

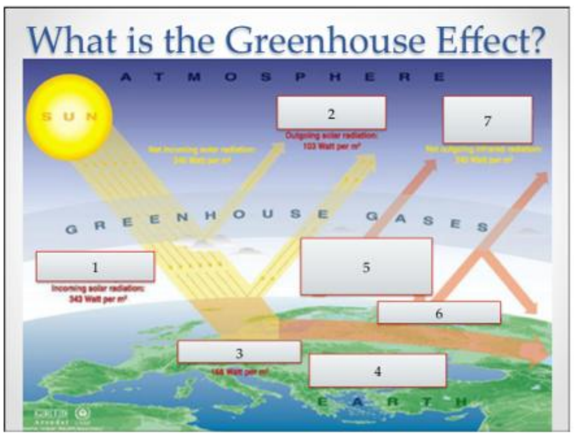
1. Which of the following is not a greenhouse gas? (Objective 2)
    a. Carbon dioxide
    b. Propane
    c. Methane
    d. Water vapor
2. What is the relationship between CO_2 concentrations and global temperature? (Objective 1)
    a. There is a positive correlation
    b. There is a negative correlation
    c. There is no correlation
    d. There is a slant correlation
3. From among the following, what do greenhouse gases trap in the atmosphere? (Objective 2)
    a. Water
    b. Oxygen
    c. Carbon dioxide
    d. Thermal energy
4. Which of the following is not a way that humans can decrease greenhouse gas emissions? (Objective 4)
    a. Use natural lighting during the day
    b. Move from cities into suburbs
    c. Drive a car with increased gas mileage
    d. Unplug items when not in use
5. Which of the following describes a predicted effect of climate change in Puerto Rico? (Objective 7)
    a. The seasons will become more extreme. The dry season will become drier while the wet season will be wetter
    b. 85% of the island will be under water by the year 2050
    c. A large portion of native species will disappear from Puerto Rico within the next 15 years

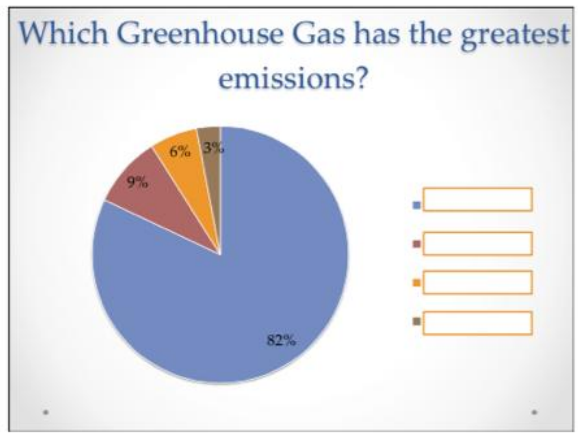
   d. Smog levels will increase in San Juan due to increases in average annual temperature
6. Which of the following is not an effect of climate change that is currently affecting Puerto Rico? (Objective 6)
   a. Rising sea levels
   b. Changes in the habitats of native animals
   c. Changes in precipitation patterns
   d. Decreased coastal erosion
7. Which of the following is an effect of climate change that affects wildlife? (Objective 6)
   a. Greenhouse gases are poisoning animals
   b. Animals are migrating farther north than usual
   c. Animals are migrating at different times of the year
   d. Greenhouse gases are affecting reproduction patterns
8. What is the highest source of man-made carbon dioxide emissions? (Objective 4)
   a. Electricity
   b. Transportation
   c. Industry
   d. Residential/Commercial
9. Which is not an environmental effect of warmer oceans? (Objective 5)
   a. Rising sea levels
   b. Coral reef changes
   c. Changed chemical compositions
   d. Increased waves
10. What is an impact of changing animal and plant habitats on humans? (Objective 7)
    a. Increased noise pollution due to coqui overpolulation
    b. Lower food supply due to precipitation changes
    c. Architectural damage due to birds nesting in city buildings
    d. Increase of growth of poisonous plants in residential areas
11. Climate change experts have stated that increases in greenhouse gases can lead to increases in atmospheric temperature. Which is not an effect of a warmer atmosphere? (Objective 5)
    a. Warmer oceans
    b. Longer days
    c. Changing conditions for animals and plants
    d. More evaporation
12. Which of the following does not directly affect atmospheric carbon levels? (Objective 3)
    a. Plant respiration
    b. Animal respiration
    c. Decay of organic matter
    d. Burning of fossil fuels

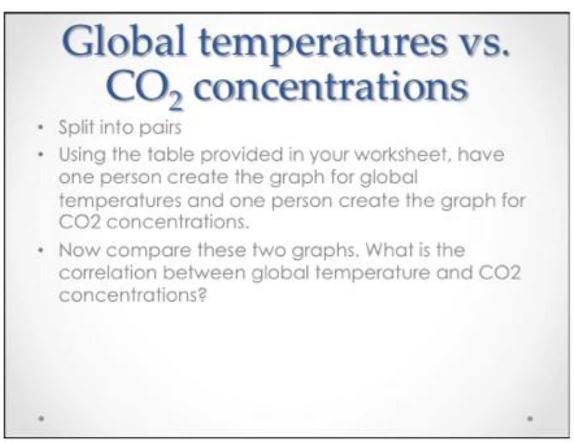
Appendix D: Lesson PowerPoint Presentation

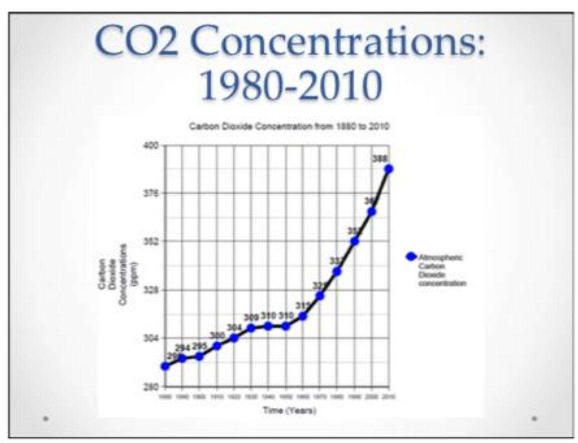




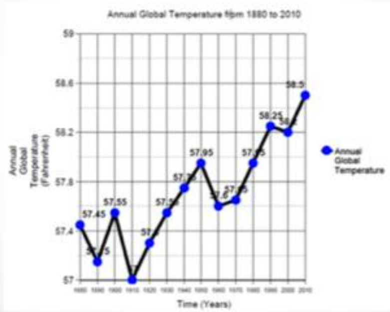






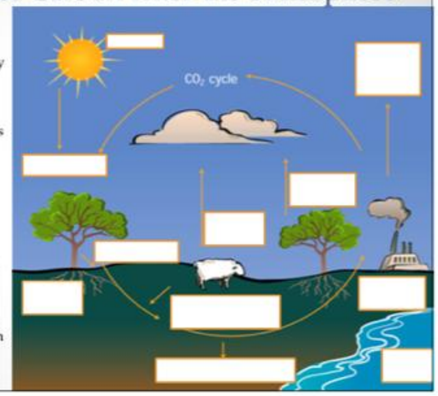


Global Temperature: 1980-2010

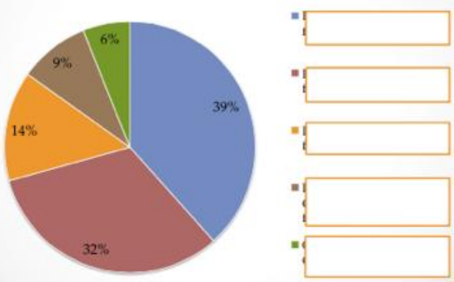


How does Carbon enter the atmosphere?

List of terms:
- Auto and factory emissions
- Animal Respiration
- Dead Organisms and waste productions
- Decay Organisms
- Fossils and Fossil Fuels
- Ocean Uptake
- Organic Carbon
- Plant Respiration
- Photosynthesis
- Root Respiration
- Sunlight



Which is the highest source of Carbon dioxide emissions?



Activity: Pictionary

Sources of CO2 emissions

- The teacher will split you up into groups of four or five.
- Pick a person to start
- Start the timer for one minute
- The first person to start will draw a source of CO2 emissions
- The rest of the group will try to guess what the source is before time is up

So how can we reduce CO2 emissions?

Homework

Students will complete the following activities, like a scavenger hunt.

- Find a brief story from someone you know about how Climate Change affects him or her. Write down a description of this story.
- Find an object (a picture or the object) you use or describe an activity you encounter in *your* life that emits greenhouse gases.
- Describe a new way to use this object or complete this activity in a way that emits less greenhouse gases.

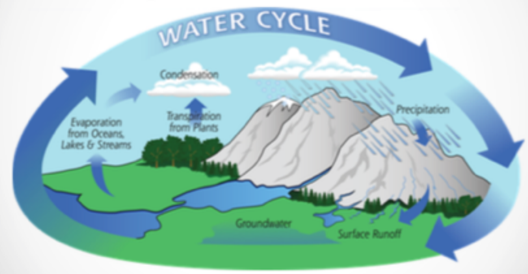
Lesson 2: Impacts of Climate Change

Students will be able to:

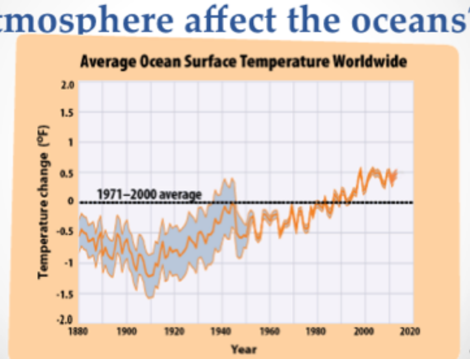
1. Determine the impacts of a warmer atmosphere on the earth (in particular on the water cycle and oceans)
2. Determine the impacts of climate change on habitats (in particular the impacts of rising sea levels and changing precipitation patterns in el yunque)
3. Determine the impacts of climate change on humans – how changing precipitation patterns, rising sea levels, and changing animal and plant habitats affect humans

What are some natural processes that can be affected by a warmer atmosphere?

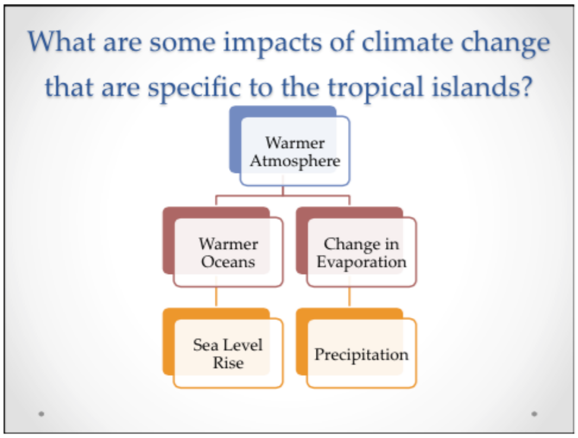
What are the impacts of a warmer atmosphere on the water cycle?



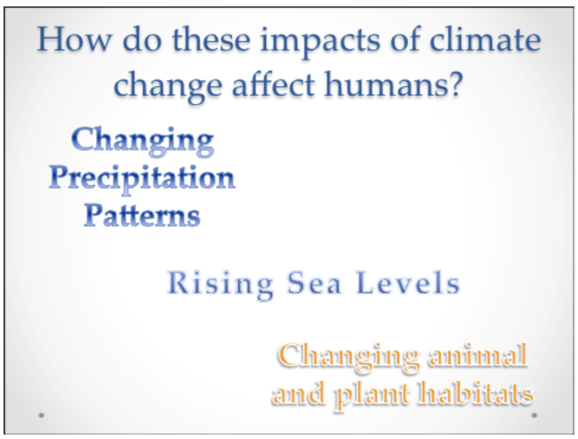
How would a warmer atmosphere affect the oceans?



What are possible environmental effects of warmer oceans?


What are some impacts of climate change that are specific to the tropical islands?
Warmer Atmosphere
Warmer Oceans
Change in Evaporation
Sea Level Rise
Precipitation


Habitat Shift Activity


How do these impacts of climate change affect humans?
Changing Precipitation Patterns
Rising Sea Levels
Changing animal and plant habitats

Appendix E: Proposed Learning Unit - Lesson 1

Lesson 1: Causes and Evidence of Climate Change

Part I: Pre-Homework

The students will be asked to watch a relevant Mythbusters at the following link:

https://www.youtube.com/watch?v=pPRd5GT0v0I

This video describes the greenhouse effect through an experiment. The mythbusters set up three transparent boxes; one filled with CO2, one filled with methane and the other set as control. They then monitor the temperature differences between the three boxes of a period of time.

Part II: In-class activities

Slide 1: Learning Objectives

Estimated time: 1 minute

Purpose: Inform students of the learning objectives for the lesson.

Students will be able to:

1) Identify an evidence of climate change, focusing on the relationship between CO_2 concentrations and atmospheric temperature.

2) Describe the greenhouse effect and identify the gases involved in it.

3) Describe how carbon enters the atmosphere as depicted by the carbon cycle

4) Identify sources of CO2 emissions

Slide 2: Climate Change:

Estimated time: 3 minutes

Purpose: This slide provides an introduction to the concepts of climate and weather, as well as establishing a basic definition of anthropogenic climate change.

Split students into pairs, then pass out a worksheet packet of the blank graphs that will be presented in this lesson to each pair of students. Introduce the topic of climate change by defining each of the words in “anthropogenic climate change”. Change is to be defined as “to make the form, nature, content, future course, etc., of (something) different from what it is or from what it would be if left alone”. Students are not expected to provide this formal definition, but are expected to recognize that change denotes a difference between two states of being. Ask the class the definition of climate. Ask for volunteers to answer the question. The definition of climate that you would be looking for is “the long-term precipitation and temperature patterns of an area”. Some follow-up questions you can ask are “What is the difference between weather and climate?” with the answer being that weather is the short-term patterns of precipitation and temperature such as a hot day or a thunderstorm while climate is the long-term patterns. Or "What is the climate in Puerto Rico?" with the answer being tropical. Lastly it is important to define the term anthropogenic as meaning "caused or produced by humans". State that this lesson will primarily cover anthropogenic climate change.

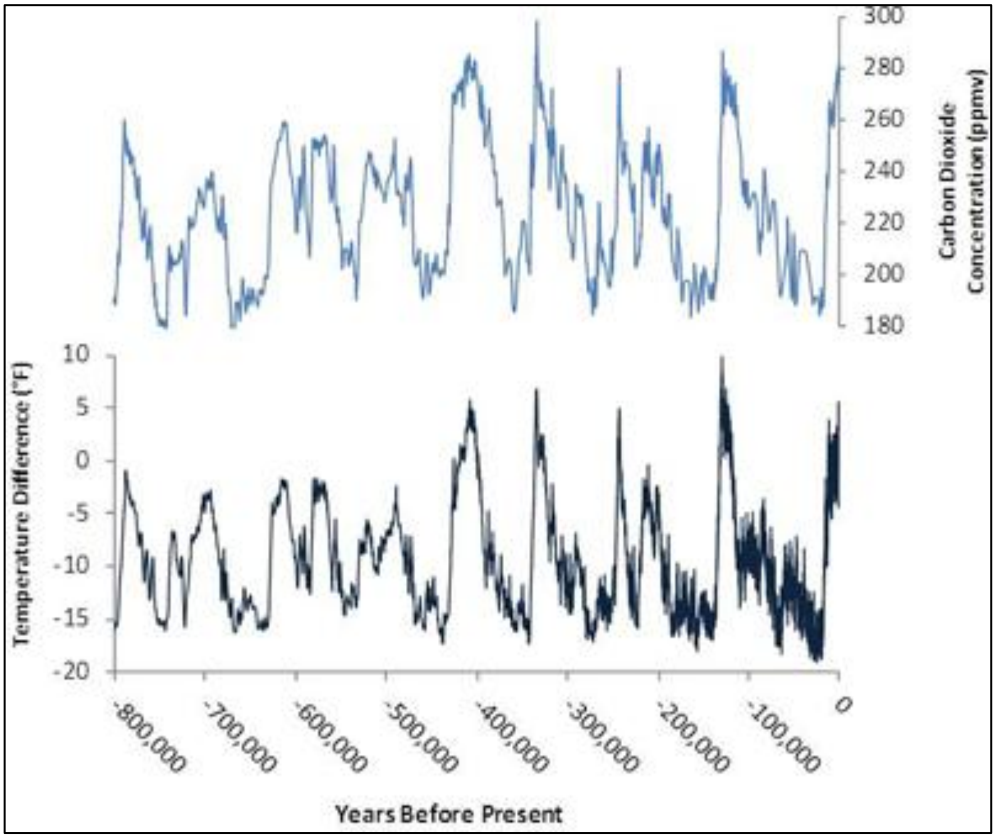


Figure 11: Depiction of natural climate change over the Earth's history

The Environmental Protection Agency's website says the following about natural climate change: Estimates of the Earth's changing carbon dioxide (CO_2) concentration (top) and Antarctic temperature (bottom), based on analysis of ice core data extending back 800,000 years. Until the past century, natural factors caused atmospheric CO_2 concentrations to vary within a range of about 180 to 300 parts per million by volume (ppmv). Warmer periods coincide with periods of relatively high CO_2 concentrations. NOTE: The past century's temperature changes and rapid CO_2 rise (to 390 ppmv in 2010) are not shown here.

Slide 3: What is the greenhouse effect?

Estimate time: 6 minutes

Purpose: Illustrates how solar energy heats up the Earth and how greenhouse gases in the atmosphere increase the absorption of infrared heat in the Earth’s atmosphere (Objective 2).

First, establish a definition of a greenhouse gas by asking students what they believe the definition of a greenhouse gas to be. A greenhouse gas is formally defined as any gas that absorbs infrared radiation produced by solar warming of the Earth's surface (Dictionary.com). Examples of these gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_x), and water vapor (H_2O [*g*]). The greenhouse effect can be formally defined as an atmospheric phenomenon in which infrared radiation of short wavelengths is easily transmitted into the Earth’s atmosphere (specifically the troposphere), while infrared radiation of longer wavelengths is less easily transmitted out of the atmosphere (specifically the troposphere) due to its absorption by atmospheric greenhouse gases (dictionary.com)

Use an analogy that describes this effect using an actual greenhouse. In this analogy, the atmosphere is like the “glass” of the greenhouse. Thermal energy from the sun is allowed to pass into the “glass”, yet is partially unable to pass back out of the “glass”. This trapped energy then increases the temperature within the greenhouse. Refer back to the Mythbusters video the students watched the previous night for homework.

Next, Go through each of the steps of the greenhouse effect. Identify the various points in the accompanying diagram where each step of the greenhouse effect occurs. The locations of these points in the diagram are labeled as points 1 through 7. Ask the students what they think is happening at each designated location on the diagram. An answer key to these points is provided below the blank diagram.

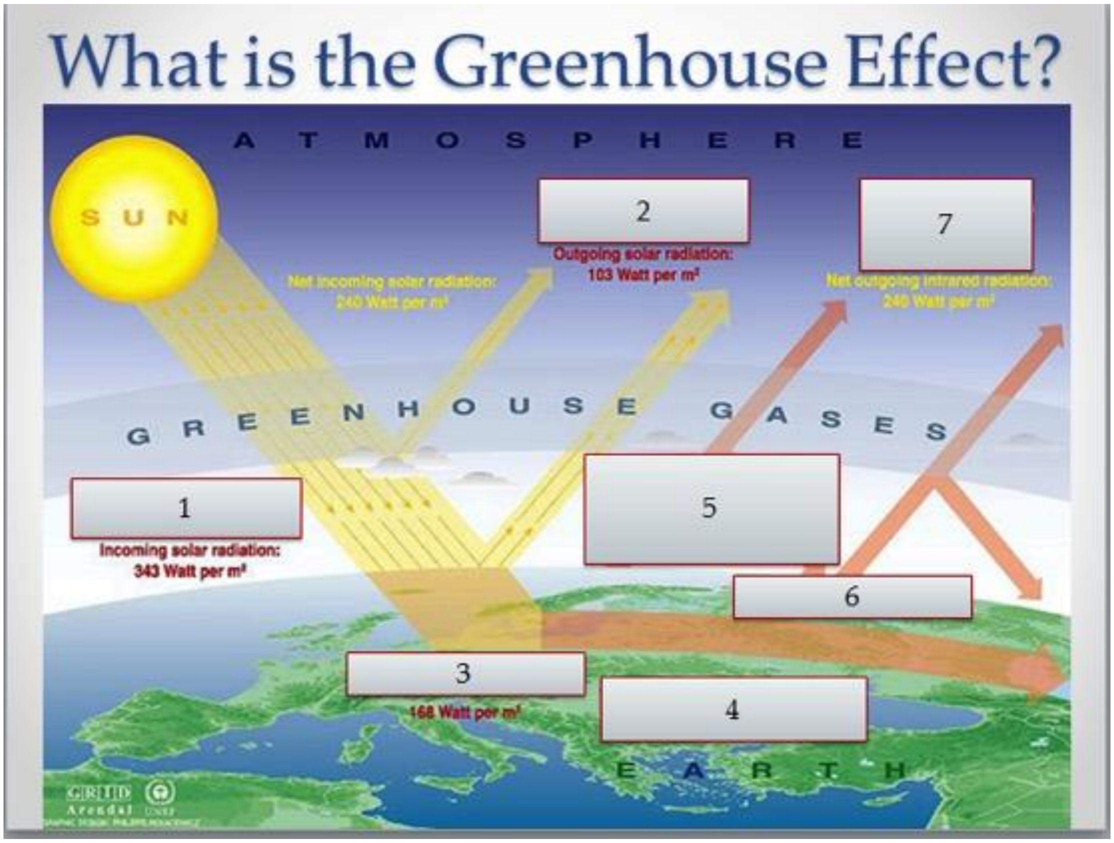


Figure 12: Greenhouse Effect diagram

Point 1: Solar radiation passes into the Earth's atmosphere.

Point 2: Some of this radiation is reflected back into space by the atmosphere and Earth's surface.

Point 3: The remaining radiation that was not reflected outward is then absorbed by the Earth's surface.

Point 4: The solar radiation that was absorbed by the Earth's surface is converted to thermal heat. This thermal energy heats the Earth's surface and is then radiated back out from the surface.

Point 5: A portion of the radiated thermal energy is absorbed by atmospheric greenhouse.

Point 6: The portion of thermal energy that was not absorbed by the greenhouse gases travels back to the surface where it is emitted outward yet again.

Point 7: This thermal energy is reflected back off the surface of the earth and back out to space.

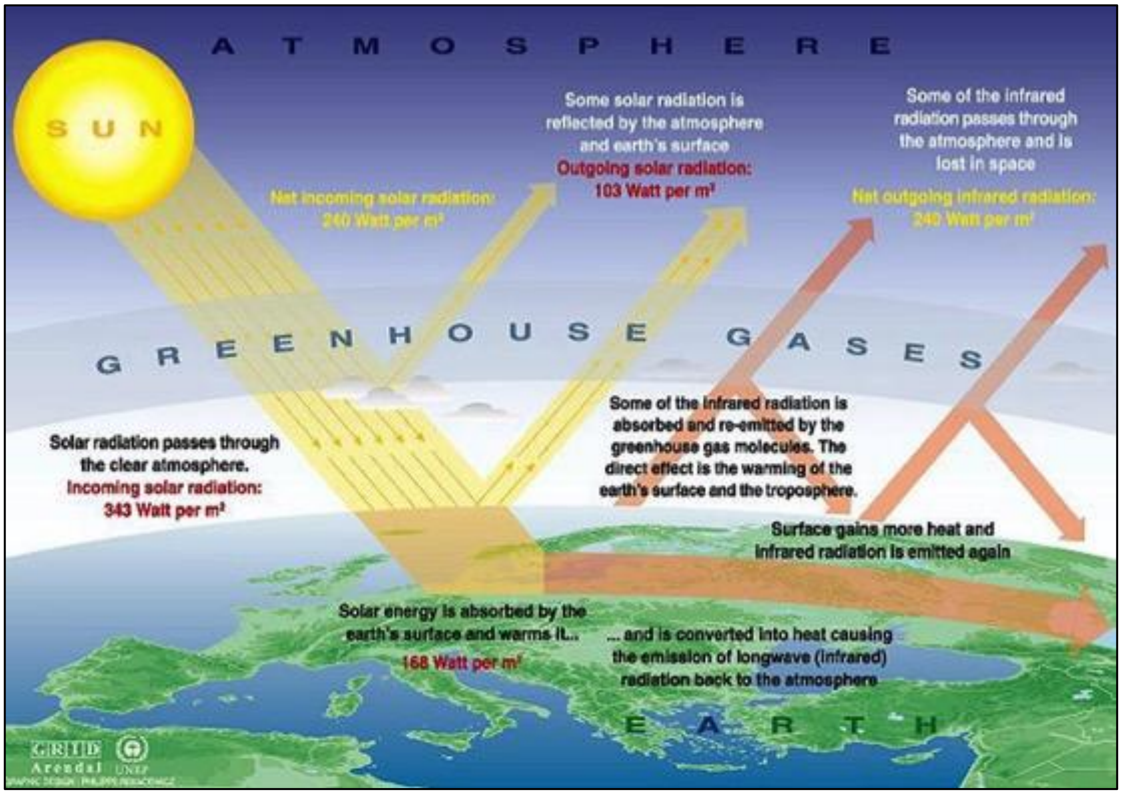


Figure 13: Diagram of the greenhouse effect (GRID Arendal and UNIP)

Slide 4: Which greenhouse gas has the greatest emissions?

Estimated time: 5 minutes

Purpose: Defines the different greenhouse gasses (Objective 2).

Ask the students what they believe is the greenhouse gas with the highest emissions and then reveal the answer. Next, ask what they believe is the second greenhouse gas with the highest emissions and then reveal the answer. Continue in this manner, until all four of the greenhouse gases are revealed. Have students fill out their own graph as it is discussed. The answers include CO_2 (carbon dioxide), CH_4 (methane), NO_x (nitrous oxides), F-gases (Fluorocarbons).

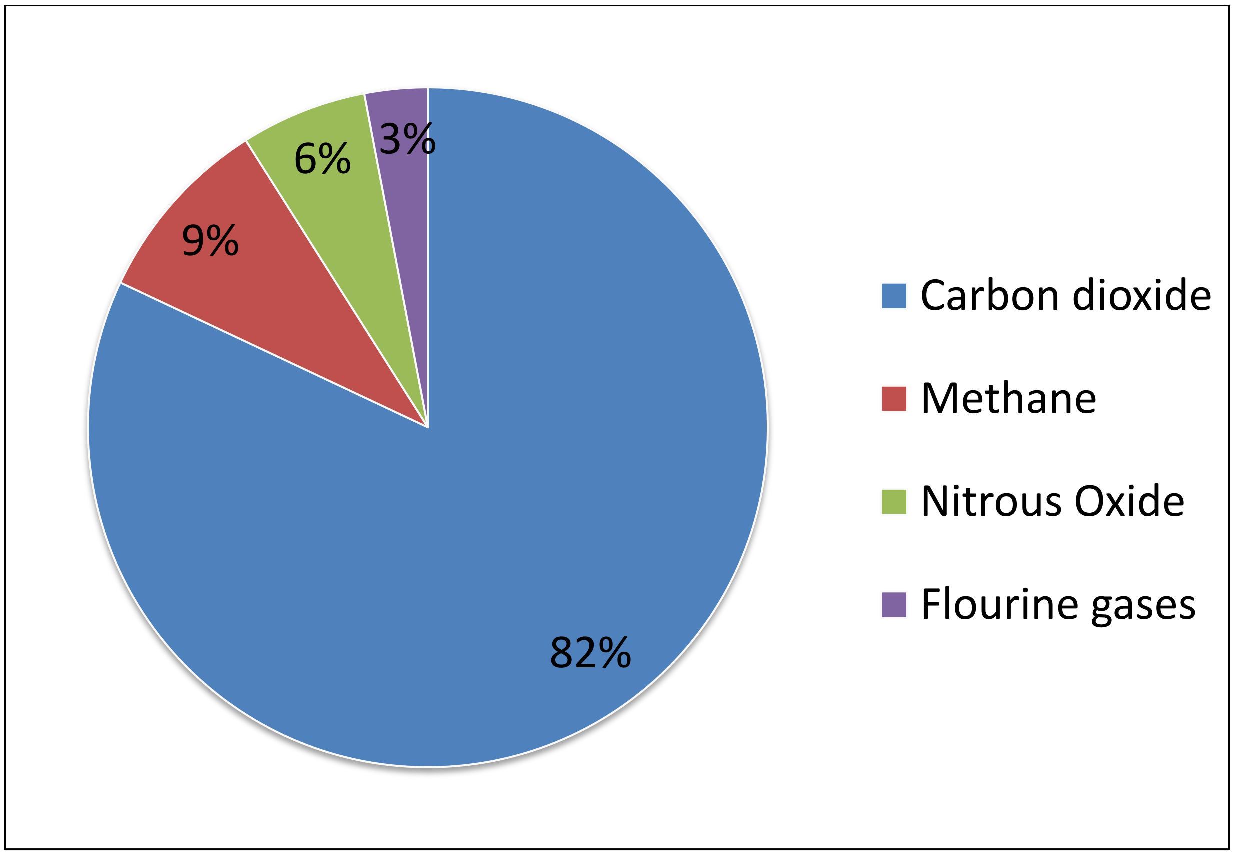


Figure 14: Relative percentage of greenhouse gases in terms of greenhouse gas emission levels (Environmental Protection Agency)

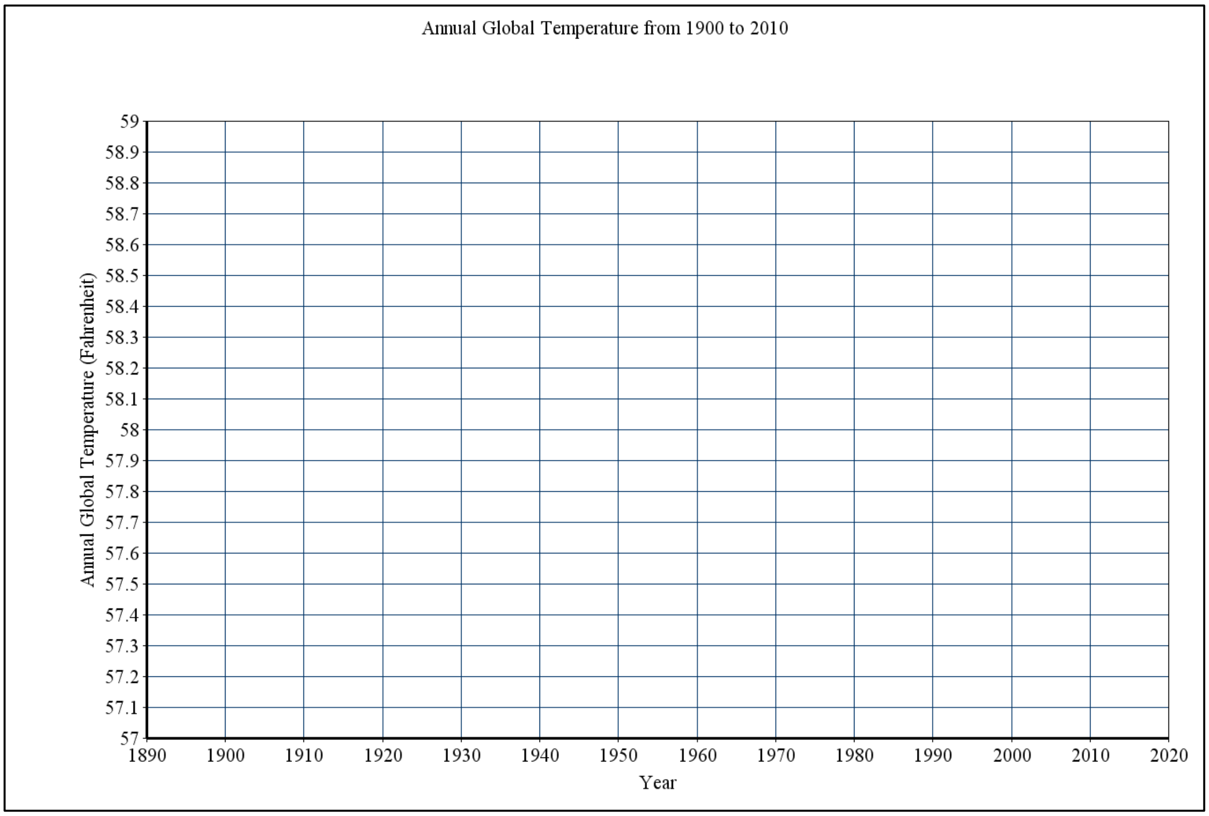
Explain that these gases are not necessarily bad for the environment. Carbon dioxide is only an issue because it is currently present in the highest amounts recorded in the Earth's history. It is for this reason that the remainder of the lesson will focus on the effects of carbon dioxide concentrations on mean global temperature.

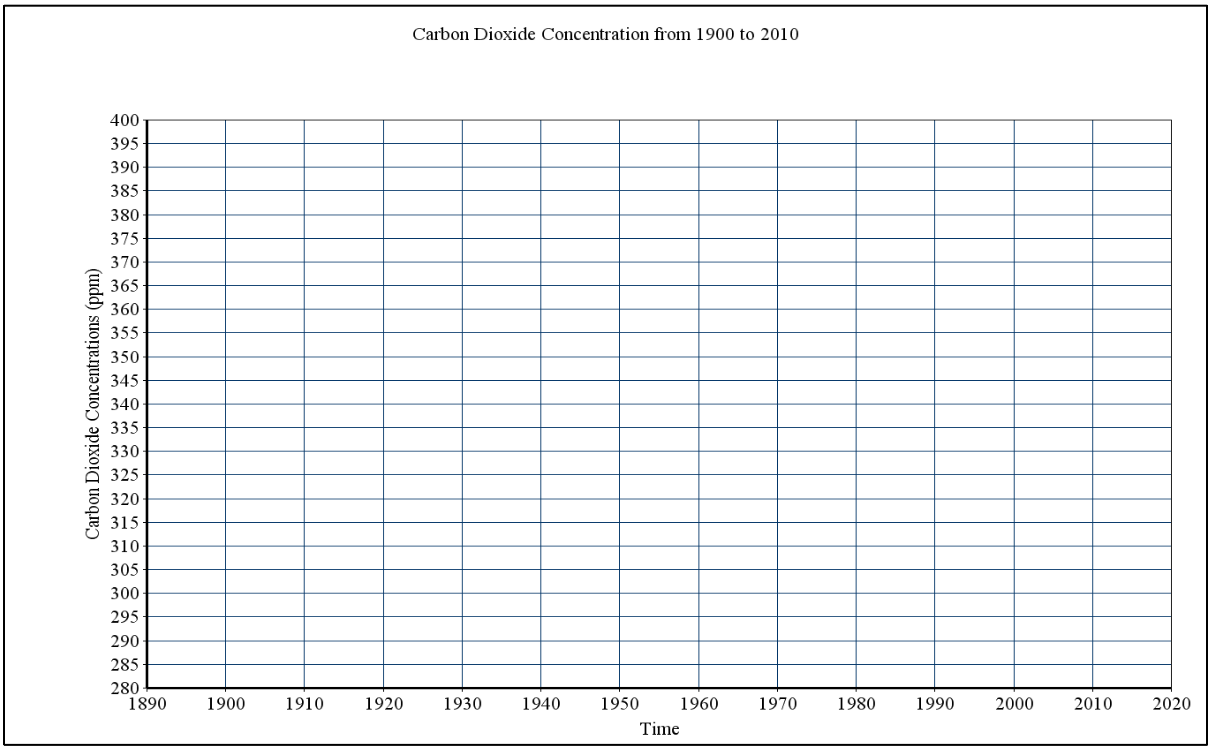
Slides 5 - 7: Evidence of Climate Change Graph:

Estimated time: 10 minutes

Purpose: Have students identify evidence of anthropogenic climate change by proving that increases in CO_2 concentrations are *positively correlated* with increases in global temperature (Objective 1). Have students identify evidence of anthropogenic climate change by proving increases in CO_2 concentrations can *cause* increases in global temperature (Objective 1).

Provided below are two blank graphs that are provided to students in the worksheet packet.





Ask students to fill in the above graphs in their worksheets. Students will work in pairs, with one student creating the CO_2 concentration graph and the other creating the temperature graph. Give the students 5 minutes to complete their graphs. Furthermore, give them another minute to compare the two graphs that they have created. The data for these graphs was extrapolated from the graph in Figure 3.

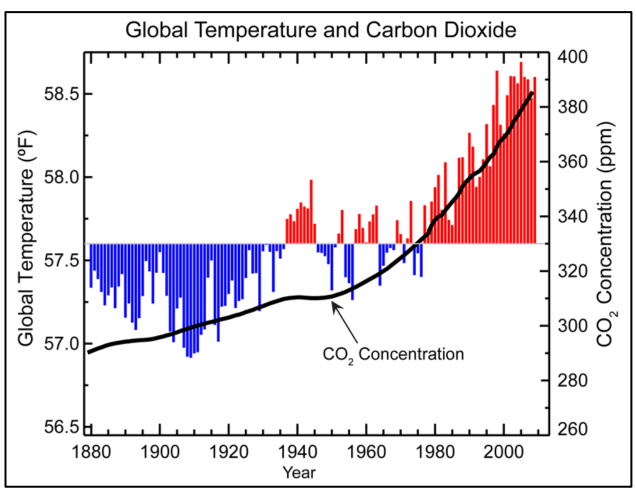
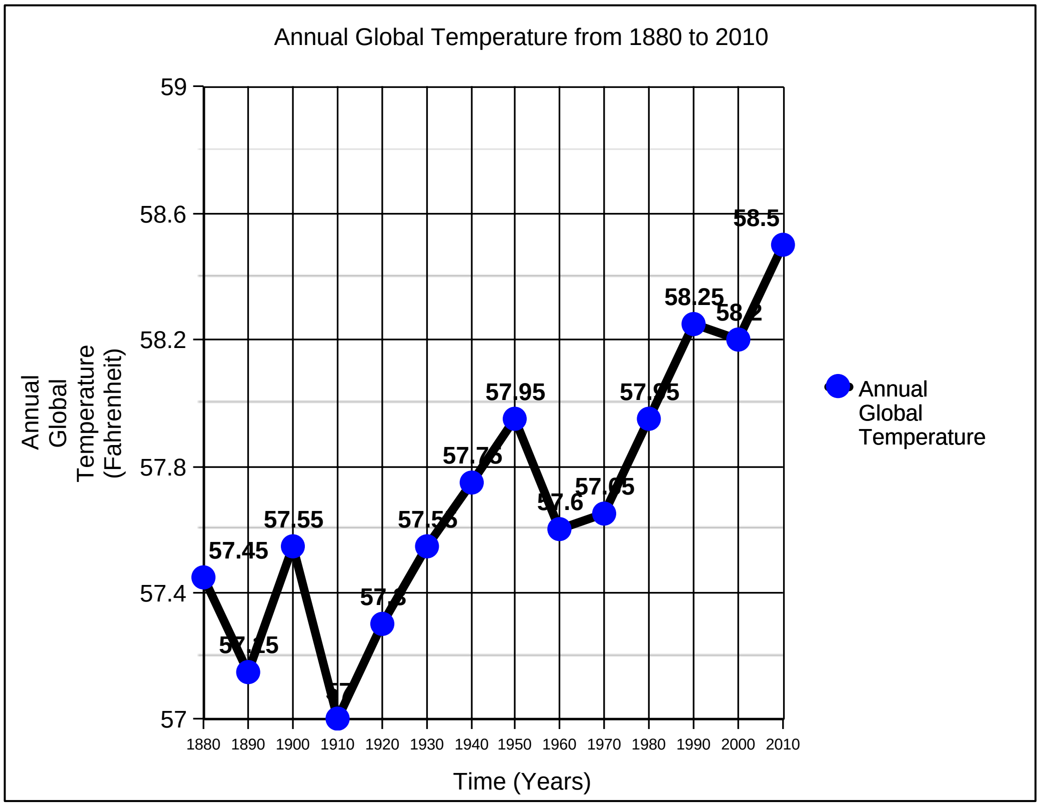
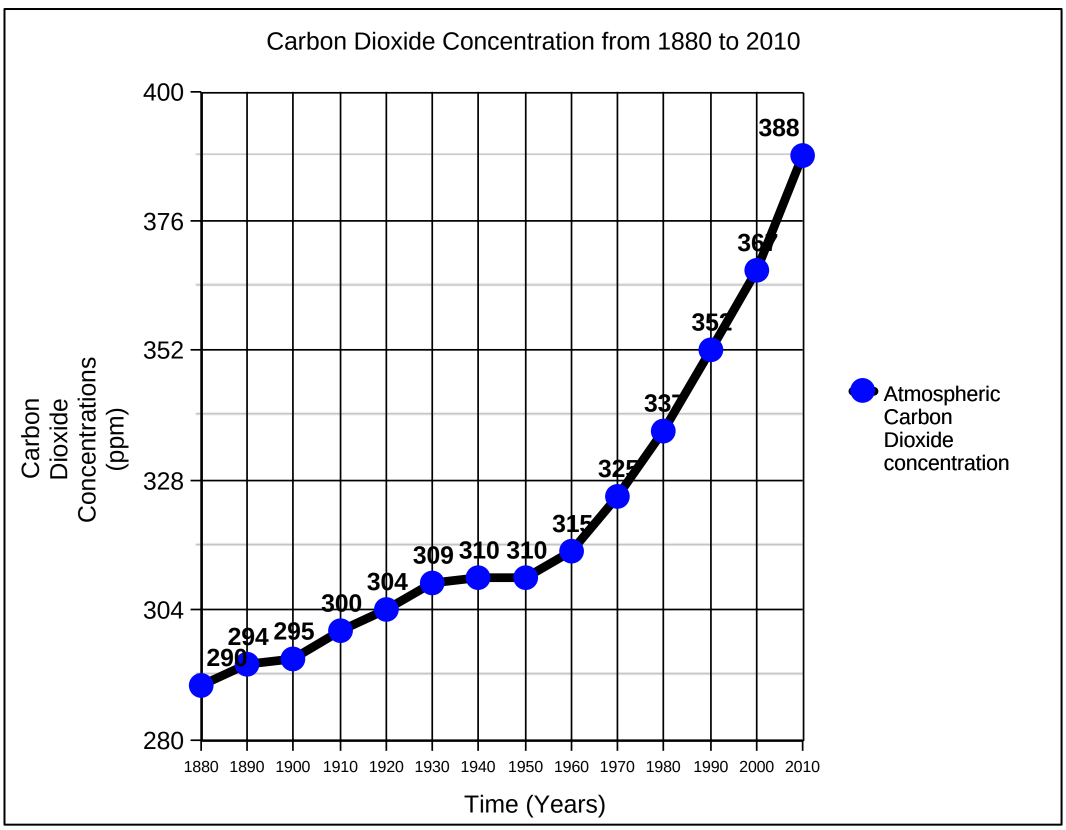


Figure 15: A Comparison of Carbon Dioxide Concentrations and Global Temperature over the last century (National Oceanic and Atmospheric Administration)

The completed graphs should look similar to the graphs below.


Annual Global Temperature from 1880 to 2010
Annual Global Temperature (Fahrenheit)
59
58.6
58.2
57.8
57.4
57
58.5
58.25
57.95
57.45
57.55
57.6
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Time (Years)
Annual Global Temperature


Carbon Dioxide Concentration from 1880 to 2010
Carbon Dioxide Concentrations (ppm)
400
376
352
328
304
280
388
315
309
310
310
304
300
294
295
1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Time (Years)
Atmospheric Carbon Dioxide concentration

Go over the graph and have students correct their graphs if necessary. Ask the students what they think this graph means. Discuss with students the *correlation* between CO_2 concentrations and global temperature. Next, ask students to apply their knowledge of greenhouse gases to the findings of their graphs. What predictions can be made? The prediction that should be made is as follows: increasing CO_2 concentration will *cause* atmospheric temperatures to increase. Provided below are additional representations of the increases in greenhouse gases and temperature, respectively.

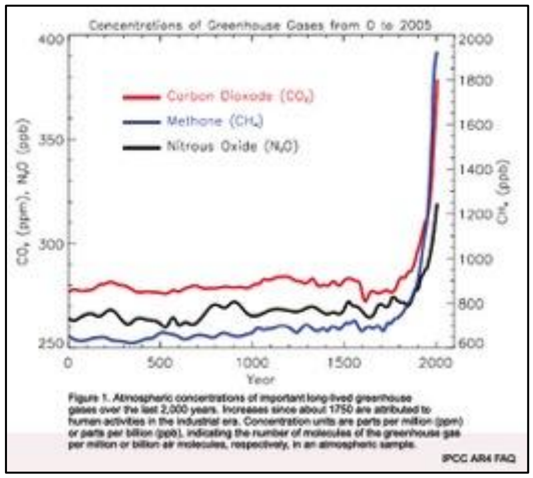


Figure 16: Greenhouse Gas concentrations from Year 0 to 2005 (Global Greenhouse Warming)

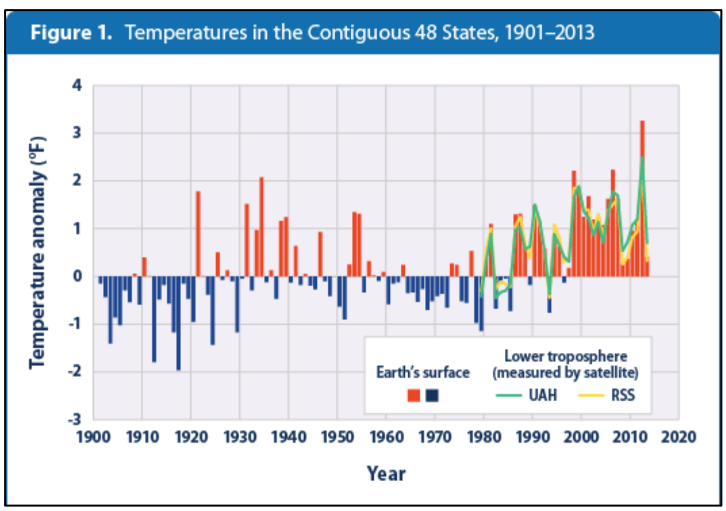


Figure 17: Relationship between Global Temperature Anomaly and Carbon Dioxide Concentration (Environmental Protection Agency)

Slide 8: How does carbon dioxide enter the atmosphere?

Estimated time: 7 minutes

Purpose: demonstrate the carbon cycle and how carbon enters the atmosphere as CO_2 (Objective 3).

Because Carbon dioxide has the greatest emissions, discuss with the class how carbon enters the atmosphere. Ask the students to fill out the diagram below on their worksheets. Students will continue working in the same pairs as before. They can use the list of term to help determine which term belongs in which space. This list of terms is comprised of the labels present in the diagram below. Give students some time to discuss their ideas.

Explain each step of the carbon cycle with the entire class, starting with sunlight, and then moving onto photosynthesis, living organic carbons, and animal/plant respiration. man-made carbon emission should be mention separately, as they are not a part of the natural carbon cycle. Explain that all living beings contain carbon. Furthermore, explain that carbon is exchanged between the oceans, air, and organisms via numerous natural functions. An important aspect of the carbon cycle involves the decay of organisms into the soil, returning nutrients to the soil. In cases where anaerobic decomposition has occurred over millions of years, fossil fuels can be formed, explaining why high amounts of carbon are emitted in the atmosphere as a product of burning fossil fuels.

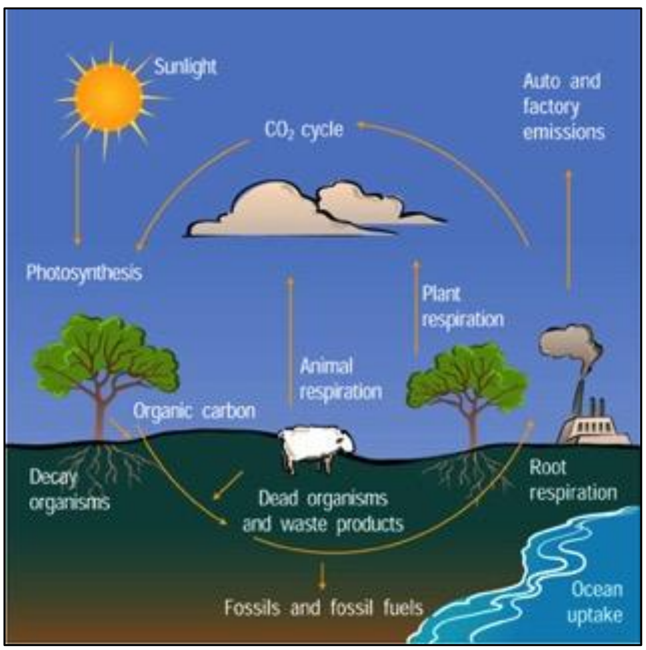


Figure 18: Simplified depiction of the carbon cycle (UCar.edu)

Before administering this lesson, consult the diagram below for a more detailed representation of the carbon cycle and the various related processes. For further student learning, students may consult the website provided at the end of this document for an interactive version of the below diagram.

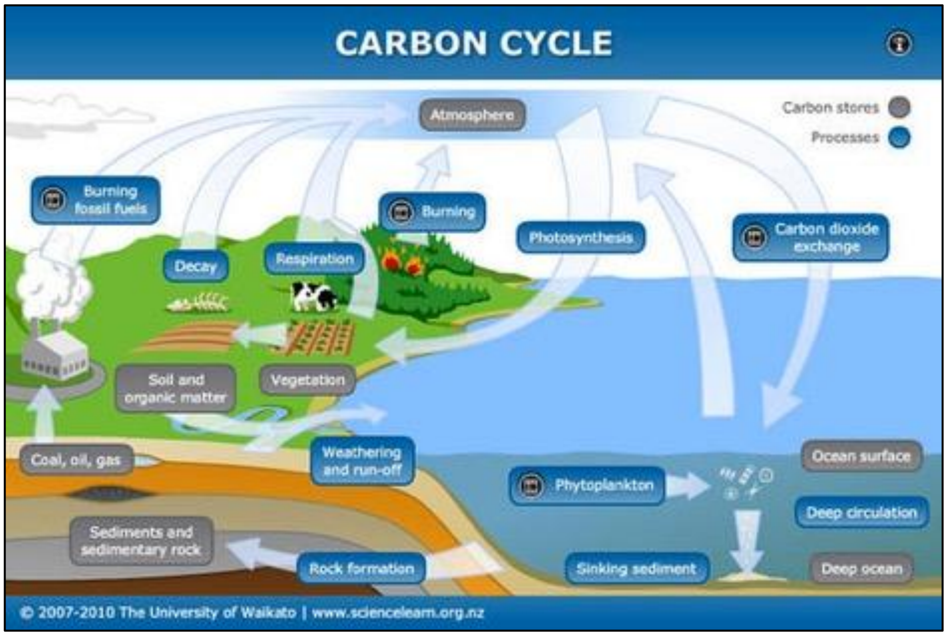


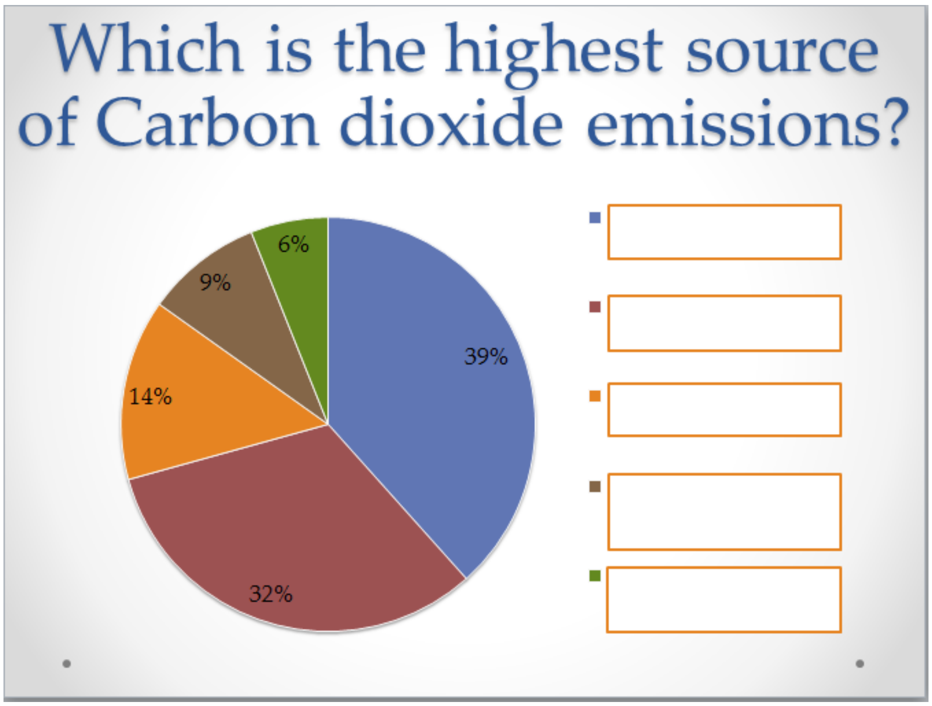
Figure 19: Detailed depiction of the carbon cycle (Sciencelearn.org)

Slide 9: Which is the highest source of carbon dioxide emissions?

Estimated time: 5 minutes

Purpose: determine the greenhouse gases that have the greatest emissions amounts (Objective 3 and Objective 4)

The pie chart below will be provided to students, however the titles will be removed.



Ask the students what they believe is the highest source of carbon dioxide emissions and then reveal the answer. Ask what they believe is the second highest source of carbon dioxide emissions and then reveal the answer. Continue in this manner, until all five sources are revealed. Have students fill out their own graph as it is discussed. The correct answers include electricity, transportation, industry, residential and commercial, and non-fossil fuel combustion. Inform students of the basic chemical formula for combustion ($C + O_2 \rightarrow CO_2$) and that this is the basic process that will produce the CO_2 that is emitted into the atmosphere. This equation should either be verbally stated or written on the board.

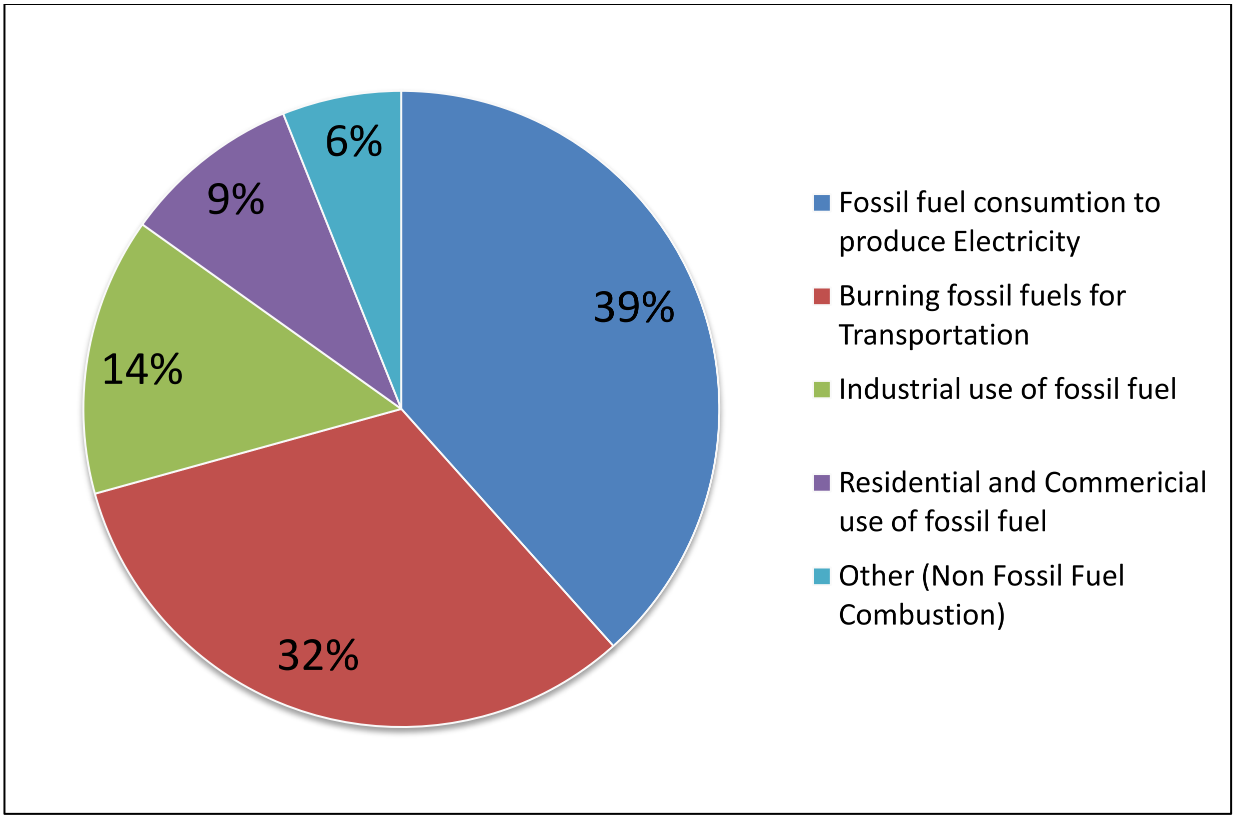


Figure 20: Breakdown of carbon dioxide emission by source of emission (Environmental Protection Agency)

Slide 10: Activity- Pictionary (Sources of CO_2 emissions)

Estimated time: 10 minutes

Purpose: illustrate the different sources of CO_2 emissions (Objective 4)

Split the class into groups of four or five students. Give each group a timer and have them randomly select four index cards per group, each labeled with sources of CO_2 emissions. Each group will pick a person to draw first, and that person will randomly select one of the index cards and attempt to draw the source listed on a blank piece of paper. The remaining members of the group must attempt to guess the source that is being drawn. The team will only be given one minute to guess the source being depicted. Should the group be unsuccessful in guessing the source, the answer will be provided after the minute has elapsed. The group will then decide on a new person to draw and continue this process until all four cards have been selected.

After this process is complete, have each group categorize the source listed on each card, placing them into the four categories. Students will write their categorizations on the picture that corresponds to each source of carbon emission. The categorizations are as follows:

Electricity: light bulb, air conditioner, computer

Transportation: car, plane, motorboat

Industrial: Factory, smoke stack, freight train

Commercial/Residential: furnace, campfire, barbeque

.

Slide 11: How can we reduce CO_2 emissions?

Estimated time: 5 minutes

Purpose: Encourage students to think proactively about what they can personally do to reduce CO_2 emissions (Objective 4).

Ask the students how society as a whole can reduce CO_2 emissions. Discuss this openly with the students.

Possible responses may include:

- Use less energy
    - turn off lights when you aren't using them
    - don't leave the TV on when you aren't watching it
    - don't overuse air conditioning
- Don't drive as much- walk when you can or use public transportation
- Eat less red meat
- Use energy-efficient appliances
- Recycle or reuse products when possible
- Buy local produce

Then, ask students how they personally can reduce CO_2 emissions. Write the responses on the board to create a list of ideas. Make sure to distinguish the differences between what society can do and what the students can personally do. Also, make sure to emphasize that individual actions can make an impact. These actions, when done by many individuals, can have a huge impact in lessening carbon dioxide emissions.

Part III: Homework activity

Inform students that there are two copies of the homework activity at the end of the worksheet pack. Each student should answer the questions and return the worksheet the next day.

Instructions:

Students will complete the following activities, like a scavenger hunt.

1. Find a brief story from someone you know about how climate change affects him or her. Write a description of this story.
2. Find an object (a picture or the object) that you use or describe an activity that you encounter in *your* life that emits greenhouse gases.
3. Describe a new way to use the object or complete the activity that you chose in step 2 in a way that emits less greenhouse gases.

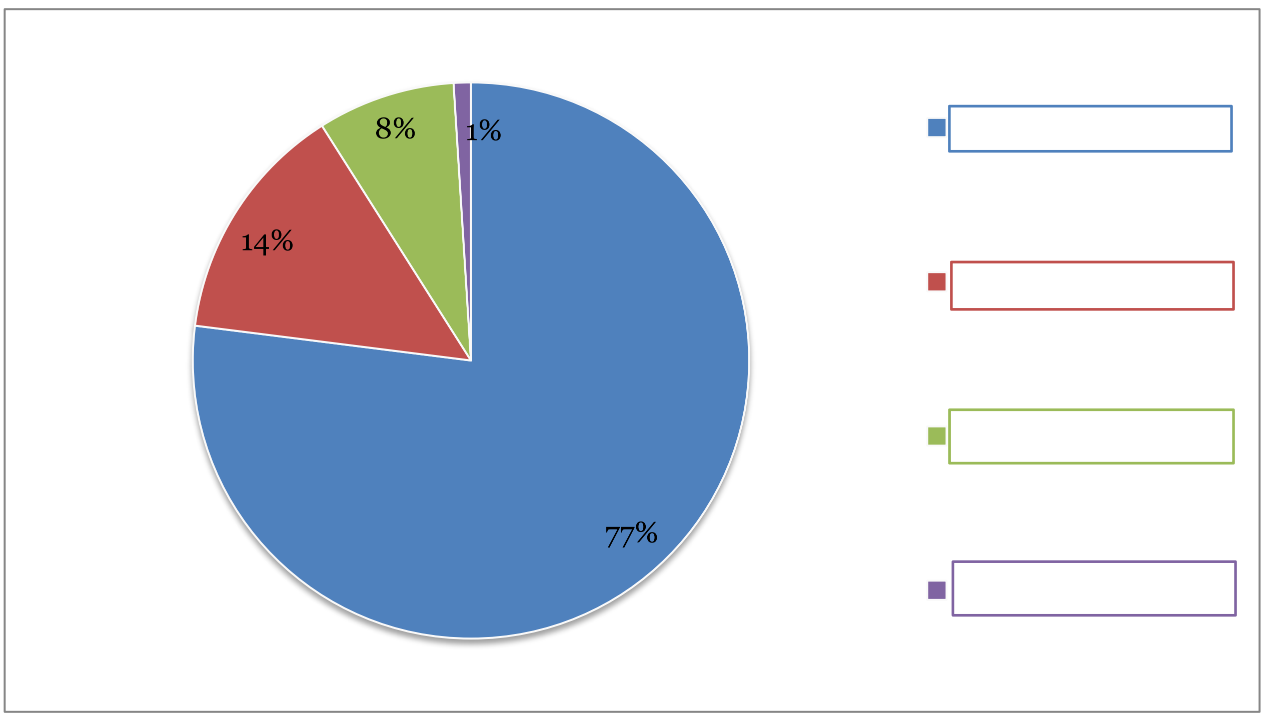
Part IV: Additional materials

Lesson 1 Worksheet (English)

Lesson 1: Causes and Evidences of Climate Change

Please fill out the following graphs when your teacher instructs you to do so.

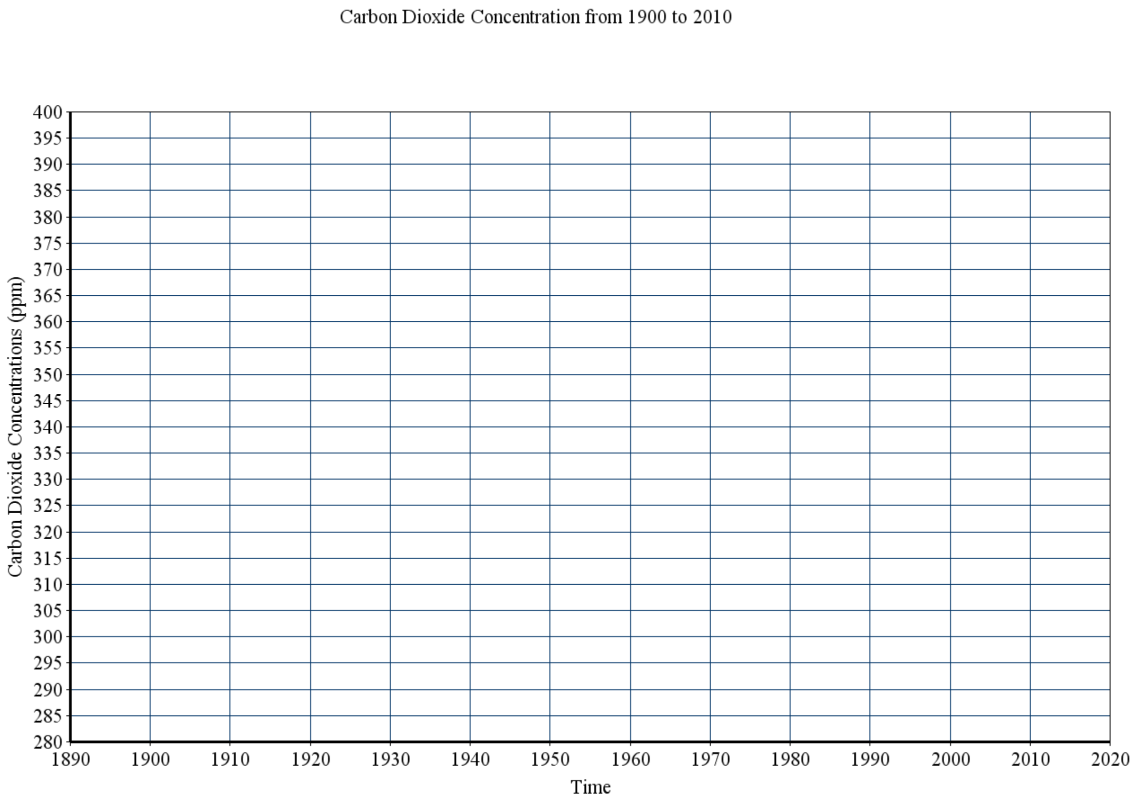
1. Which Greenhouse Gas has the greatest emissions? *Fill out this graph as the class discusses what the greenhouse gas with the greatest emissions is.*



2. Global Temperatures vs. CO_2 Concentrations: *Split into pairs. Using the below table, have one person create the graph for global temperatures and one person create the graph for CO_2 concentrations.*

CO_2 Concentration Graph:

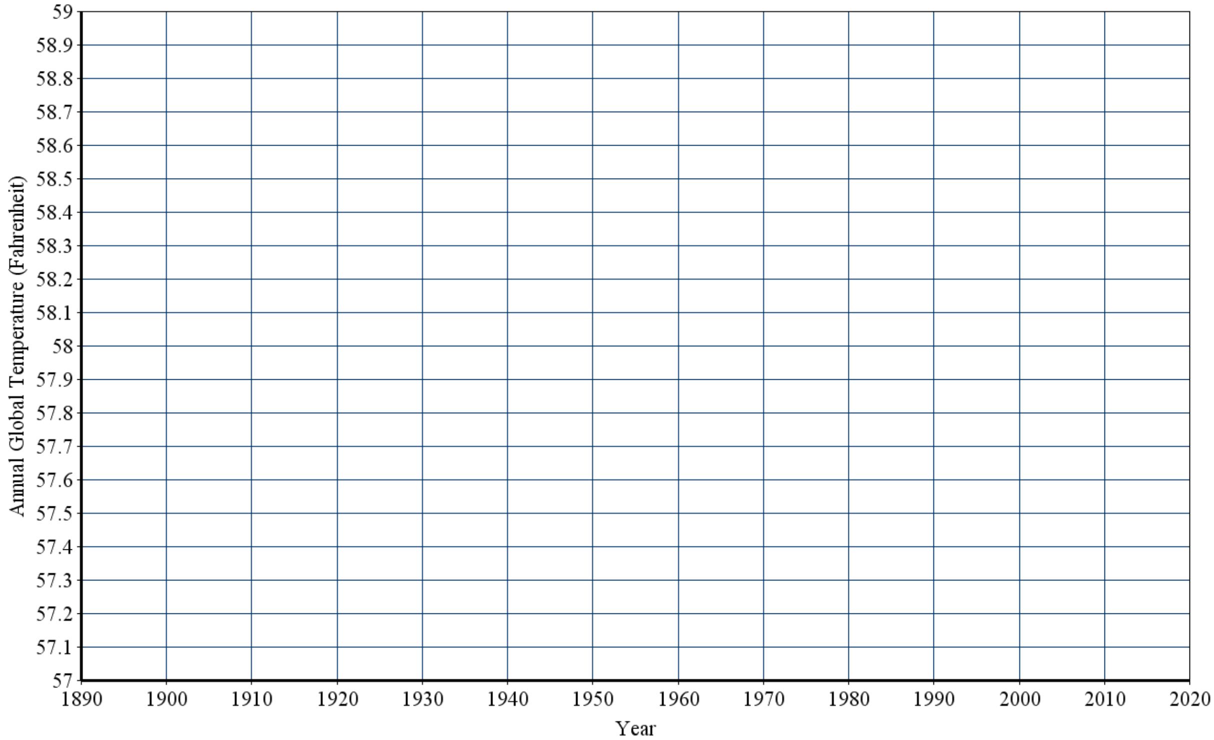
Year	**CO2 (ppm)**
1880	290
1890	294
1900	295
1910	300
1920	304
1930	309
1940	310
1950	310
1960	315
1970	325
1980	337
1990	352
2000	367
2010	388



Global Temperature Graph:

Year	Temp (F)
1880	57.45
1890	57.15
1900	57.55
1910	57.0
1920	57.3
1930	57.55
1940	57.75
1950	57.95
1960	57.6
1970	57.65
1980	57.95
1990	58.25
2000	58.2
2010	58.5

Annual Global Temperature from 1900 to 2010

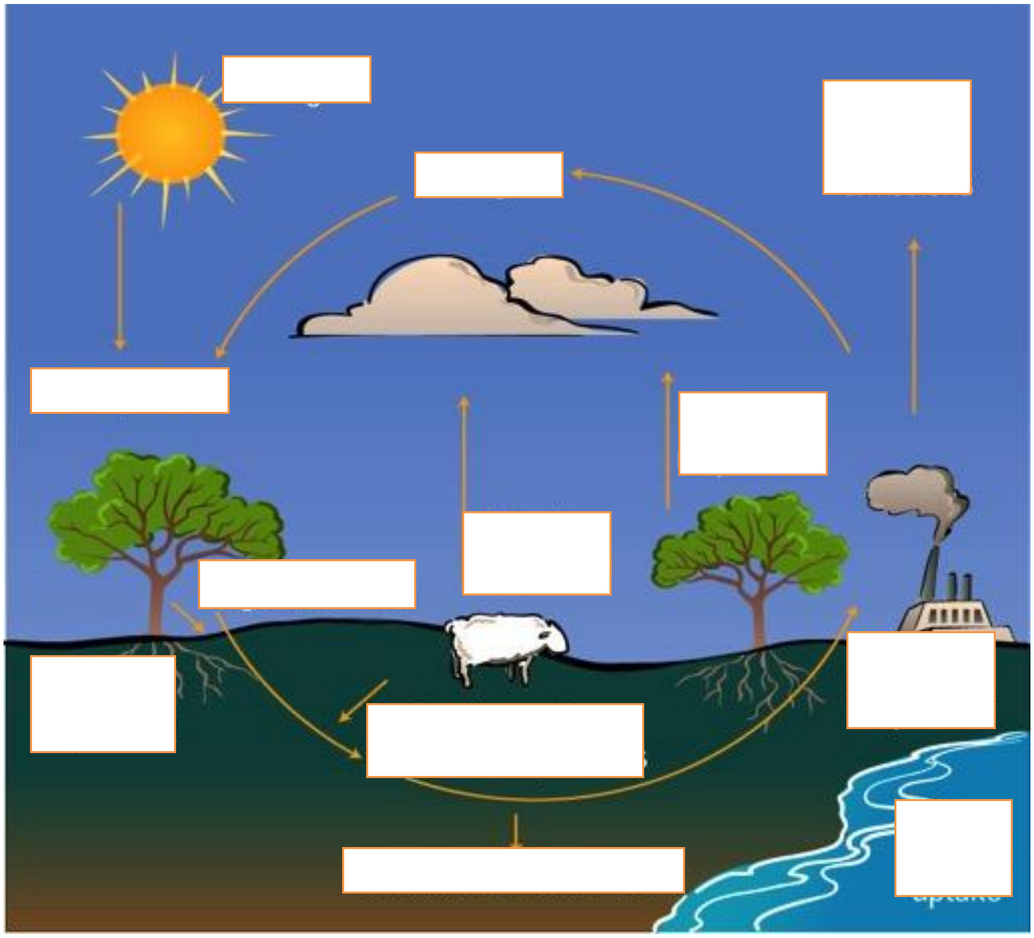


Now compare these two graphs. What is the correlation between global temperature and CO_2 concentrations?

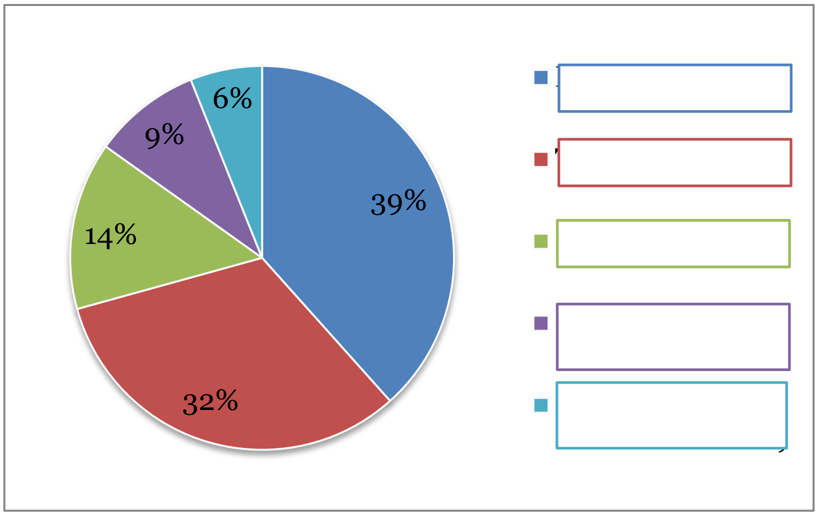
3. How does carbon enter the atmosphere?

Working in a pair,

Word Bank
Auto and factory emissions
Animal Respiration
Dead Organisms and waste productions
Decay Organisms (Fungi)
Fossils and Fossil Fuels
Ocean Uptake
Organic Carbon
Plant Respiration
Photosynthesis
Root Respiration
Sunlight



4. Which is the highest source of carbon dioxide emissions? Fill out this graph as the class discusses what the highest source of carbon dioxide emissions is.



Pictionary Activity Worksheet (English)

Pictionary Activity: *Below are the cards to be used for the Pictionary activity. Cut out the cards before class and give each group 4 cards.*

Light Bulb	Light Bulb
Air Conditioner	Air Conditioner
Computer	Computer
Car	Car
Plane	Plane
Motorboat	Motorboat
Factory	Factory

Smoke Stack	Smoke Stack
Freight Train	Freight Train
Furnace	Furnace
Campfire	Campfire
Barbecue	Barbecue

Homework Activity Worksheet (English)

Name:____

Homework Activity

1. Find a brief story from someone you know about how Climate Change affects him or her. Write down a description of this story.

2. Find an object (a picture or the object) you use or describe an activity you encounter in *your* life that emits greenhouse gases.

3. Describe a new way to use this object or complete this activity in a way that emits less greenhouse gases.

Appendix F: Proposed Learning Unit- Lesson 2

Lesson 2: The Impacts of Climate Change

Part I: In-Class Activities

Slide 13: Learning Objectives

Estimated time: 1 minute

Purpose: Inform students of the learning objectives for the lesson.

Read these learning objectives to the students.

Students will be able to:

5) Identify the predicted impacts of a warmer atmosphere on the earth, focusing on the water cycle and oceans

6) Determine the impacts of climate change on animals and plants in El Yunque, focusing on the impacts of rising temperature and changing precipitation patterns.

7) Determine the impacts of climate change on humans, especially how changing precipitation patterns, rising sea levels, and changing animal and plant habitats affect humans

Slide 14:What causes a warmer atmosphere?

Estimated time: 3 minutes

Purpose: Review what was discussed in the previous lesson by discussing how increased CO_2 causes atmospheric temperatures to increases.

Ask the question to the class of students, having them provide various answers based on the previous lesson. This question is meant to be a quick review of topics that students will have learned in the previous day's lesson on the causes and evidence of climate change. Continue this discussion until students have provided three accurate responses. Possible responses may include increases in CO_2 concentrations, increased greenhouse gas emissions, continued deforestation, and continued burning of fossil fuels.

Slide 15: What are some natural processes that can be affected by a warmer atmosphere?
Estimated time: 5 minutes
Purpose: Explain the impacts of a warmer atmosphere on natural processes (Objective 5).

Briefly explain that a warmer atmosphere affects many natural cycles and processes, including the nitrogen cycle, carbon cycle, and water cycle, among others. Provided below are explanations of these cycles as well as a description of the predicted impacts.

Carbon Cycle – The carbon cycle, as explained in the previous lesson, starts with the sun's energy being used for photosynthesis in plants. Plants and animals can both be identified as organic carbons. Both animal respiration and the burning of fossil fuels contribute CO_2 to the atmosphere. Additionally, plants and animals contribute carbon to the earth when they decompose. Oceans act as carbon sinks and can take in atmospheric carbons. Lastly, there are deposits of carbon that are locked away in glacial ice and bedrocks, but this carbon is much less accessible. Anthropogenic contributions to the carbon cycle are strongly tied to climate change. A significantly warmer atmosphere (due to anthropogenic climate change) would indicate that distribution of accessible carbon would greatly differ from any other period in the Earth's recorded history. Looking at CO2 levels from the past 800000 years substantiates this conclusion. Before the past decade, it is believed that atmospheric CO_2 levels had not risen past 300 ppm.

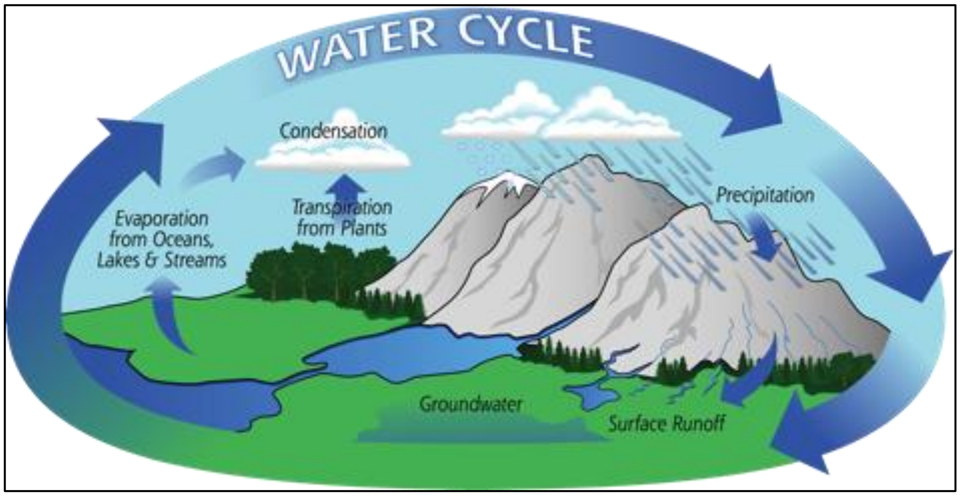
Nitrogen Cycle – The nitrogen cycle contains 4 main processes: nitrogen fixation, ammonification, nitrification, and denitrification. Nitrogen fixation is the process of converting nitrogen gas (N_2) to ammonium (NH_4^+). This process is primarily done by certain bacteria and allows certain organisms to utilize nitrogen directly from the atmosphere. Next ammonification occurs when organic nitrogen is converted into NH_4^+ by organisms that decompose matter such as various fungi. From there, NH_4^+ is converted into nitrate (NO_3^-) by bacteria in the process known as nitrification. Lastly, the anaerobic process of denitrification occurs which converts NO_3^- into nitrogen gas (N_2), nitrous oxide gas (NO_2), nitrous oxide (N_2O) and nitric oxide (NO). Due to human activities, there are excess amounts of atmospheric nitrogen oxides (NO_X). Nitrous oxides are currently the world's third largest contributor to temperature increases of the atmosphere. This is due to increased release of nitrogen into the atmosphere during the combustion of fossil fuels. Furthermore, this accumulation of nitrogen has been seen to affect the functionality of varied ecosystems. Other human impacts include increased concentrations of ammonia (NH_3) due to increased fertilizer use and increased NO concentrations due to the elevated presence of N_2 in the atmosphere in the last century.

Water Cycle – The water cycle describes the collective movements of water throughout terrestrial and oceanic biomes, and the atmosphere. Basic processes involved in this cycle are evaporation, transpiration, precipitation, and condensation. This process will be described in greater detail in the following slides. The water cycle would be affected in terms of increased evaporation and resultant decreased precipitation. This phenomenon can be confusing for students since a common misconception would be that increases in evaporation lead to increased precipitation. While this is somewhat true, the former description does not account for global wind patterns affecting the tropics and subtropics. The winds in subtropical areas (such as Puerto Rico) carry the moisture-laden air to equatorial tropics, therefore increasing rainfall in the tropics, but decreasing it in the subtropics.

Slide 16: What are the specific impacts of a warmer atmosphere on the water cycle?

Estimated time: 8 minutes

Purpose: Explain how a warmer atmosphere impacts the water cycle (Objective 5).



Show students the above diagram. Explain the various steps listed.

Evaporation: The changing of liquid water into water vapor

$$[H_2O\ (l) + \text{Energy} \rightarrow H_2O\ (g)].$$

Condensation: The changing of water vapor into liquid water in the form of clouds or fog

$$[H_2O\ (g) \rightarrow H_2O\ (l) + \text{Energy}].$$

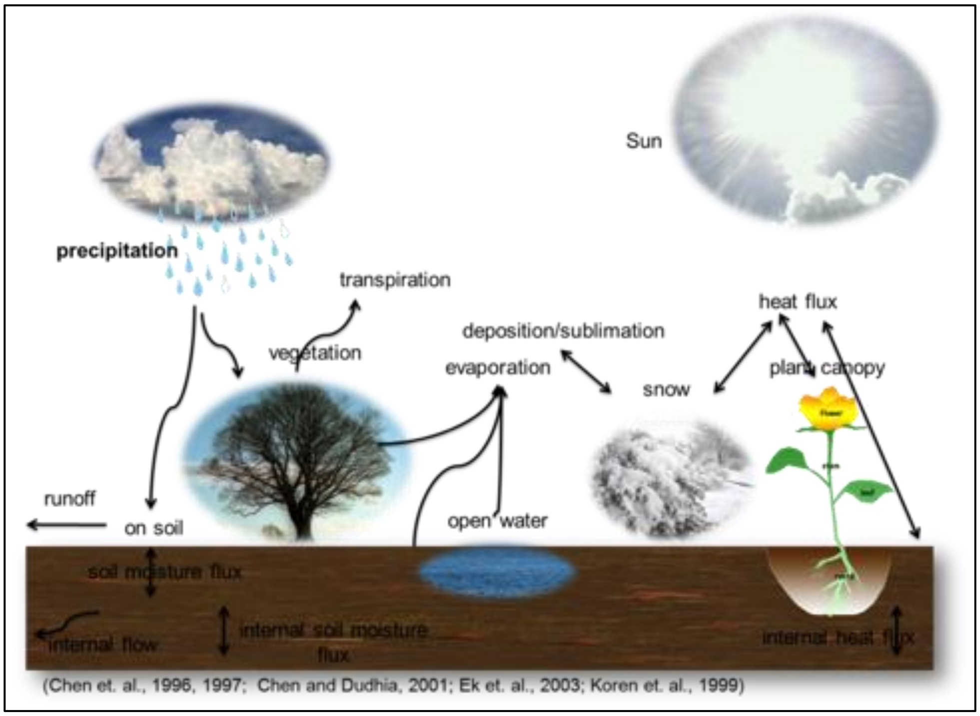
Transpiration: The evaporation of liquid water from vegetation. It creates a cooling effect when it occurs in large-scale scenarios, such as tropical rainforests.

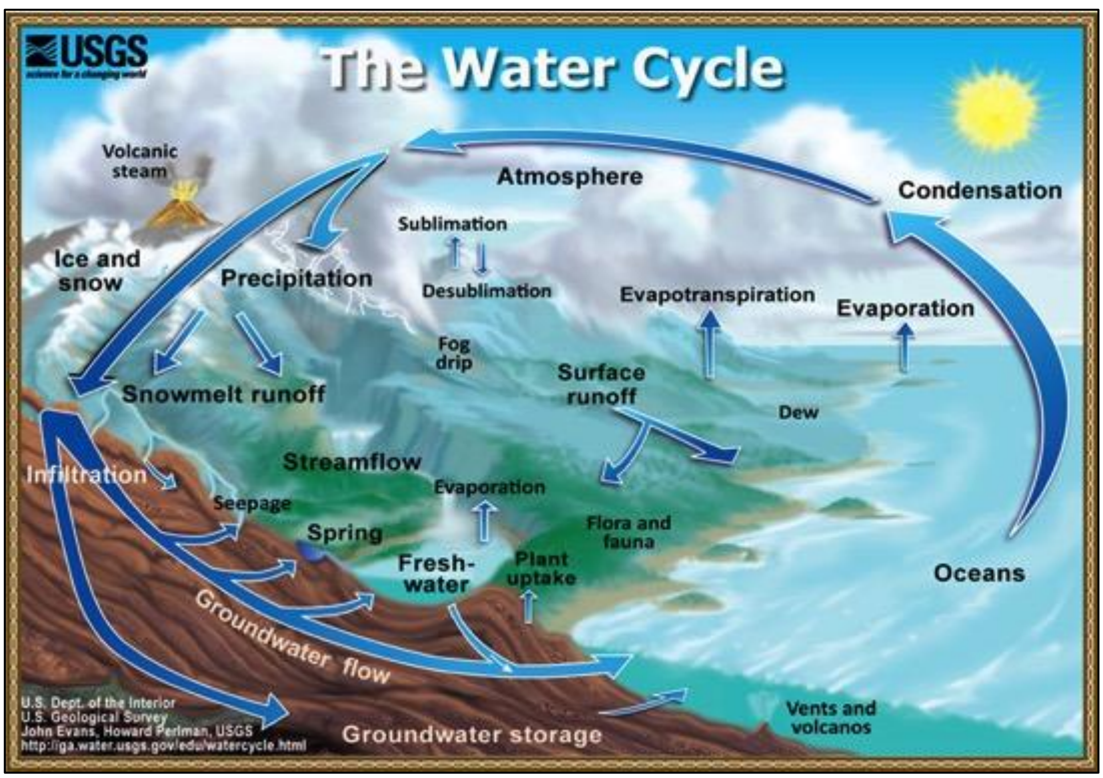
Runoff: The transfer of liquid water from one physical location to another, usually from a higher elevation to a lower elevation and/or body of water.

Precipitation: The falling of liquid water from clouds or fog down to the surface of the earth. Precipitation can take the form of rain, hail, snow, sleet, and fog drip.

Next, lead a guided inquiry, asking how a warmer atmosphere might affect each of these steps. It is important that you frame the changes that may occur in the broad sense (i.e. precipitation changes and evaporation changes). This will ensure that this discussion does not become too narrowly focused on topics that will not be addressed.

Two more detailed and holistic depictions of the water cycle are provided below for the purpose of instructors being able to better understanding some of the more intricate portions of water cycle.


Sun
precipitation
transpiration
heat flux
deposition/sublimation
vegetation
evaporation
snow
plant canopy
runoff
on soil
open water
soil moisture flux
internal flow
internal soil moisture flux
internal heat flux
(Chen et. al., 1996, 1997; Chen and Dudhia, 2001; Ek et. al., 2003; Koren et. al., 1999)

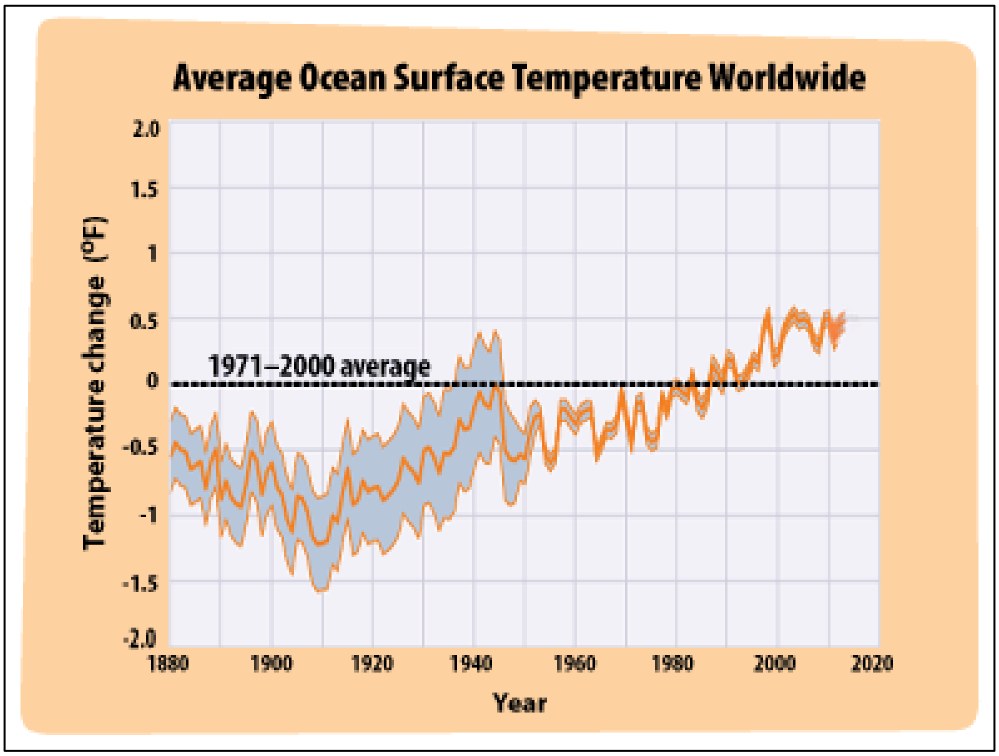

USGS
The Water Cycle
Volcanic steam
Atmosphere
Condensation
Sublimation
Ice and snow
Precipitation
Desublimation
Evapotranspiration
Evaporation
Fog drip
Surface runoff
Snowmelt runoff
Dew
Streamflow
Infiltration
Evaporation
Seepage
Flora and fauna
Spring
Fresh-water
Plant uptake
Oceans
Groundwater flow
U.S. Dept. of the Interior
U.S. Geological Survey
John Evans, Howard Perlman, USGS
http://ga.water.usgs.gov/edu/watercycle.html
Groundwater storage
Vents and volcanos

Slide 17: How would warmer atmosphere affect the oceans?

Estimated time: 3 minutes.

Purpose: Describe how increased atmospheric temperatures cause increased ocean temperatures (Objective 5).

Ask students how a warmer atmosphere affects the oceans. Have students provide different ideas. If students do not provide the answer "warmer oceans" after 2 minutes, you should provide the response. The following graph will then be displayed. This graph shows the change in ocean temperatures from 1880 to 2012, relative to the average ocean temperature from 1971 to 2000.



Slide 18: What are possible environmental effects of warmer oceans?

Estimated time: 4 minutes

Purpose: Discuss the effects of warmer oceans (Objective 5).

Ask students what the possible environmental effects of warmer oceans are and discuss each topic further. Then ask students what effects of warmer oceans would particularly affect Puerto Rico.

Possible Answers include the following:

Rising sea levels – Sea ice will begin to melt more rapidly as ocean temperatures rise, creating excesses of liquid water that will cause global sea levels to rise.

Changed chemical composition – Warmer oceans can more readily act as a sink of carbon dioxide. As more CO_2 is added into the ocean, the chemical process of creating carbonic acid ($CO_2 + H_2O \Leftrightarrow H_2CO_3$) happens in greater amounts. This can lead to slight shifts (or potential differences) in the ocean's pH toward acidic levels ($pH<7$).

Coral reef changes – as the chemical composition of oceans change, fragile habitats like the coral reef will change, namely by experiencing excessive coral bleaching. Coral then dies, eliminating prime aquatic habitats.

Loss of aquatic wildlife – as the chemical composition of oceans change, certain species of fish and plants will be poorly adapted to new chemical conditions. As well, species many also be unable to survive in warmer waters and die as a result.

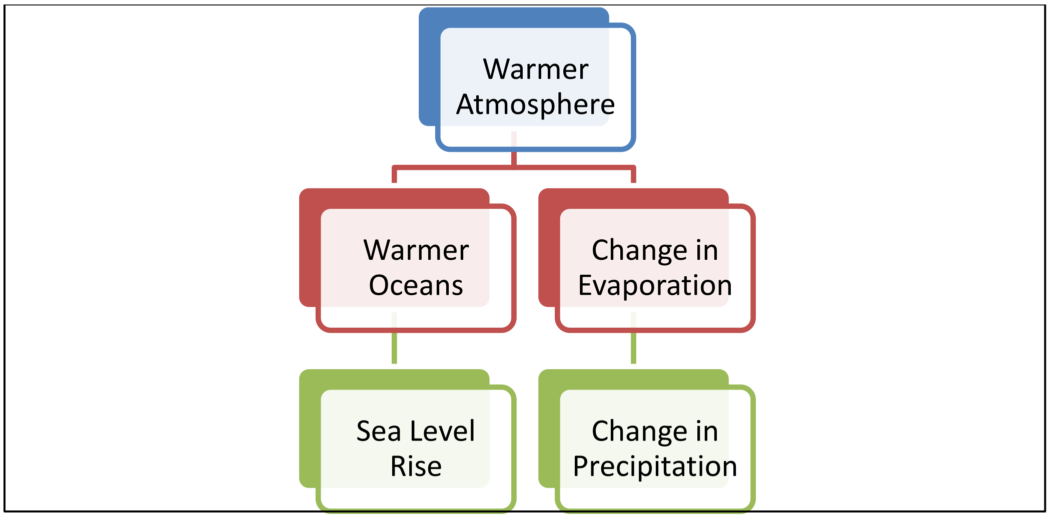
Habitat shifts – Species that are not well adapted to the rising temperatures in the oceans will cause them to move to other areas that have conditions they are more accustomed to.

Slide 19: What are the impacts of a warmer atmosphere on the water cycle?

Estimated time: 4 minutes

Purpose: Review the effects of a warmer atmosphere on oceans and the water cycle (Objective 5).

Review the below diagram with the class in order to emphasize how a warmer atmosphere can cause warmer oceans which can cause sea levels to rise and can change evaporation which can cause precipitation changes.



Warmer atmosphere: This is caused by increased greenhouse gas emissions. This observed heating effect has a profound impact on the water cycle. In particular, rates of all processes involving evaporation would become increased. Additionally, increased global temperature due to increased greenhouse effect would lead to warmer oceans.

Warmer oceans: The oceans would experience a similar warming effect as a result of increased greenhouse effect. These warmer oceans would lead to the occurrence of many other phenomena, including the thermal expansion of the oceans water and the increased melting of sea ice.

Sea level rise: Sea levels could rise drastically if continued climate change were to occur. This is partially due to slight thermal expansion of water as it is heated. This effect is usually very miniscule when involving small amounts of liquid. However, this expansion would be able to be observed and measured when occurring in large bodies of water, such as the ocean. Another source of sea level rise would be the melting of sea ice and increased glacial melting/run-off, which would deposit excess liquid water into the ocean.

Change in evaporation: Evaporation would increase in tropical regions as global temperatures increase. This would occur in all processes that involve evaporation, including transpiration. The atmosphere's capacity to hold water would increase by 7% for each degree Celsius that atmospheric temperature rises. This allows for increased ability to hold water meaning that the atmosphere's saturation point for holding water vapor would become greater. According, as the amount that water is held in the atmosphere changes, so does patterns on precipitation.

Change in precipitation: Depending on the region, precipitation could either increase or decrease. Wind patterns are a crucial factor in whether precipitation will increase or decrease. Equatorial regions, such as the Amazon, will experience increases in precipitation. This is largely because winds will carry the excesses of evaporated moisture to these areas. Puerto Rico is an area that would, although variable in its rain patterns across the island, experience a general decrease in precipitation. Additionally, Puerto Rico would experience more extreme seasons, with less rain falling in the dry seasons and more rain falling in the wet season. The most immediate impact of a drying trend in Puerto Rico would be increased likelihood of droughts.

Slide 20: Habitat Shift Activity

Estimated Time: 20 minutes

Purpose: Illustrate the effects of changes in precipitation and increased global temperatures on animals and plants (Objective 6).

Students will be given an activity to further illustrate the effects of precipitation changes and increasing global temperature, specifically on Puerto Rico.

Goal: Understand the effects of climate change on animal and plant habitats in El Yunque and how these effects are connected and can cause habitat shifts for animal species that are endemic to, or only found on, Puerto Rico.

Each group will be provided with:

-Picture of a typical Puerto Rican mountain, labeled with different habitat descriptions

-Pictures of various animals of El Yunque that are endemic to Puerto Rico including coquís, Puerto Rican parrots, and elfin woods warblers

-Pictures of various plants of El Yunque that are native to Puerto Rico including the sierra palm, aceitillo falso , and bananas.

-Instruction sheet describing the activity, as well as the habitat requirements for the different animals and plants

Directions:

-Divide students into groups of 5

-Students will first place the different habitats on the picture of the mountain based on their required temperature and precipitation levels. This information is provided in the tables accompanying this activity.

-Have students place the provided animals into their corresponding habitats on the picture of the mountain by following their respective habitat descriptions and needs. Specifically, use each animal's temperature range, diet, possible eleavations and precipitation needs to determine its placement on the mountain diagram. This information is provided in the tables accompanying this activity.

-Next, students will look at each scenario described below, and move each habitat according to the changes that have occurred due to that specific climate change.

-Students will then move animals and plants to new locations as the instruction sheet describes habitat changes that are reflective of climate change.

Note: If animals cannot be placed in any of the habitats, they should be left off of the page.

-Students will reflect on how climate change can affect the various biomes and animal habitats in Puerto Rico.

Students will write their responses to each question on the provided worksheets. When all teams have finished, go over the questions with the students. Students are expected to see the disappearance of the elfin woods habitat as well as the elfin-woods warbler. They also will see that the habitats of most of the listed species will shift up the mountain to higher elevations.

Discuss with students that habitat shift is not something that is only hypothetical, but is actually happening in Puerto Rico. One species that is currently experiencing habitat shift is the elfin-woods warbler. This species is currently seeing the disappearance of its prime habitat, the elfin forest, and being forced to relocate to habitats that it is not well suited for. This is a trend that has been noted by USFS species managers in El Yunque National Forest. Should current climate change trends continue, the elfin-woods warbler would eventually completely disappear Puerto Rico. Similar trends have also been observed for other species that are endemic, or can only be found in Puerto Rico, such as the Puerto Rican parrot.

Slide 21: How do the predicted impacts of climate change affect humans?

Estimated time: 5 minutes

Purpose: Discuss the effects of rising sea levels, changing precipitation patterns, changing animal and plant habitats on human beings in Puerto Rico (Objective 7).

Ask students to brainstorm how each of these phenomena (rising sea levels, changing precipitation patterns, changing animal and plant habitats) can affect human beings in Puerto Rico. The effects may include water and food shortages, loss of coastal zones, more extreme weather and its economic consequences

According to the Intergovernmental Panel on Climate Change (IPCC), regions such as Puerto Rico, and the Caribbean as a whole, will experience decreases in precipitation as climate change continues to occur at its current rate. This is a matter of concern for the island of Puerto Rico, since many of its habitats are reliant on rainfall. With decreases in rainfall, there would be definite impacts on the inhabitants of Puerto Rico including increased potential for droughts and water shortages. Furthermore, the 2014 IPCC report on small islands greatly describe the affects humans would face as a result on climate change. Particular statements that capture many of the issues Puerto Rico faces are as follows:

> Intensive coastal development in the limited coastal zone, combined with population growth and tourism, has placed great stress on the coast of some small islands and has resulted in dense aggregations of infrastructure and people in potentially vulnerable locations (pg. 1623).
>
> Extreme weather and climate events such as tropical cyclones, storm surges, flooding, and drought can have both short- and long-term effects on human health, including drowning, injuries, increased disease transmission, and health problems associated with deterioration of water quality and quantity. Most small island nations are tropical areas with weather conducive to the transmission of diseases such as malaria, dengue, filariasis, and schistosomiasis (pg. 1624).

Part II. Additional Materials

Habitat Activity (English)

Step 1: Set-up
Cut out the pictures of each of the animals and plants below, as well as the names of the forests.

Coqui:

Puerto Rican boa:

aceitillo falso :

Tabonuco Forest

Puerto Rican parrot:

Puerto Rican twig anole:

Little fire ant:

Palo Colorado Forest

Sierra Palm Forest

Elfin-woods warbler:

Sierra Palm:

Bananas:

Elfin Forest

Forest Requirements: The forests below can only exist where the precipitation level and the average temperature ranges match the below requirements.

Forest Level	Precipitation Levels (inches/year)	Average Temperature Range (° F)
Tabonuco Forest	< 100	80– 85
Palo Colorado Forest	150- 180	75 – 80
Sierra Palm Forest	100-150	70 – 75
Elfin Forest	> 180	65 – 70

Animal and Plant Requirements: The animals and plants below can only exist where the precipitation level, the average temperature ranges, and diet match the below requirements.

Animal	Habitat Temperature Range (° F)	Habitat Precipitation Range (inches/year)	Diet	Predators
Coquí	65– 85	> 32	insects	Puerto Rican boa
Puerto Rican parrot	70– 85	< 150	plants	Puerto Rican boa
Elfin-woods warbler	65– 75	< 200	insects	Puerto Rican boa
Puerto Rican boa	80– 85	< 100	birds and lizards	None
Puerto Rican twig anole	80– 85	< 100	insects	Puerto Rican boa
Sierra palm	70– 75	< 150	photosynthesis	Puerto Rican parrot
Aceitillo falso	80– 85	< 100	photosynthesis	Puerto Rican parrot
Little fire ant	65 – 85	Any	plants	Birds and lizards
Bananas	75 – 85	< 180	photosynthesis	Little fire ant and Puerto Rican parrot

<u>Step 2: The original condition</u>

According to the original condition below, place the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then place the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Original Condition:

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**	90	82
2	**2000-2500**	165	77
3	**2500-3000**	125	72
4	**> 3000**	190	67

Step 3: The effects of changing temperatures and precipitation levels on habitats.

Scenario 1: The precipitation levels have decreased from their original levels by 50 inches per year.

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**		82
2	**2000-2500**		77
3	**2500-3000**		72
4	**> 3000**		67

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 2: The average temperatures of all of the habitats have increased from their original measurements by 5° F

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**	90	
2	**2000-2500**	165	
3	**2500-3000**	125	
4	**> 3000**	190	

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 3: The precipitation levels have decreased from their original levels by 50 inches per year AND the average temperatures of all of the habitats have increased from their original measurements by 5° F

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	< 2000		
2	2000-2500		
3	2500-3000		
4	> 3000		

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 4: The precipitation levels have decreased from their original levels by 75 inches per year AND the average temperatures of all of the habitats have increased from their original measurements by 10° F.

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	< 2000		
2	2000-2500		
3	2500-3000		
4	> 3000		

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Step 4: Reflection

Answer the following questions.

1) What can be said about the effect that changes in precipitation levels have on the plants and animals?

2) What can be said about the effect that changes in temperature have on the plants and animals?

3) What can be said about the effect that changes in both temperature and precipitation levels have on the plants and animals?

4) As the animal habitats change in response to the above scenarios, what can be said about its affects on the food chains?

Appendix G: Proposed Learning Unit - Post-test

Post-test

Give students the following post-test the day after conducting lesson 2. This post-test adresses learning objectives of lesson 1 and lesson 2. The responses that are highlighted below correspond with the answer to each question.

Name:____

1. Which of the following is not a greenhouse gas? (Objective 2)
    a. Carbon dioxide
    b. Propane
    c. Methane
    d. Water vapor
2. Which of the following is not a way that humans can decrease greenhouse gas emissions? (Objective 4)
    a. Use natural lighting during the day
    b. Move from cities into suburbs
    c. Drive a car with increased gas mileage
    d. Unplug items when not in use
3. What is the highest source of man-made carbon dioxide emissions? (Objective 4)
    a. Electricity
    b. Transportation
    c. Industry
    d. Residential/Commercial
4. What is the relationship between CO_2 concentrations and global temperature? (Objective 1)
    a. There is a positive correlation
    b. There is a negative correlation
    c. There is no correlation
    d. There is a slant correlation
5. Which of the following describes a predicted effect of climate change in Puerto Rico? (Objective 7)
    a. The seasons will become more extreme. The dry season will become drier while the wet season will be wetter
    b. 85% of the island will be under water by the year 2050
    c. A large portion of native species will disappear from Puerto Rico within the next 15 years
6. Which is not an environmental effect of warmer oceans? (Objective 5)
    a. Rising sea levels

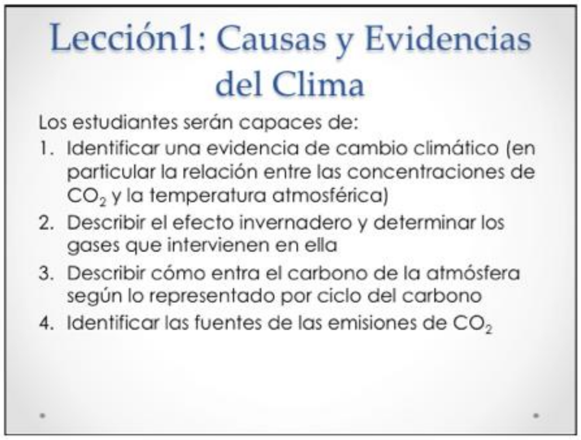
b. Coral reef changes
c. Changed chemical compositions
d. Increased waves

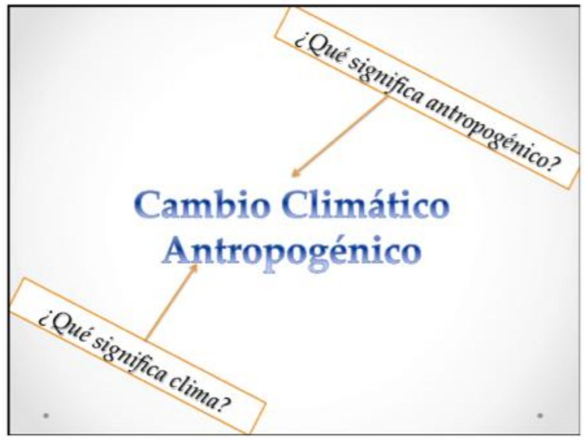
7. From among the following, what do greenhouse gases trap in the atmosphere? (Objective 2)
    a. Water
    b. Oxygen
    c. Carbon dioxide
    d. Thermal energy
8. Climate change experts have stated that increases in greenhouse gases can lead to increases in atmospheric temperature. Which is not an effect of a warmer atmosphere? (Objective 5)
    a. Warmer oceans
    b. Longer days
    c. Changing conditions for animals and plants
    d. More evaporation
9. Which of the following is an effect of climate change that affects wildlife? (Objective 6)
    a. Greenhouse gases are poisoning animals
    b. Animals are migrating farther north than usual
    c. Animals are migrating at different times of the year
    d. Greenhouse gases are affecting reproduction patterns
10. Which of the following does not directly affect atmospheric carbon levels? (Objective 3)
    a. Plant respiration
    b. Animal respiration
    c. Decay of organic matter
    d. Burning of fossil fuels
11. What is an impact of changing animal and plant habitats on humans? (Objective 7)
    a. Increased noise pollution due to coqui overpolulation
    b. Lower food supply due to precipitation changes
    c. Architectural damage due to birds nesting in city buildings
    d. Increase of growth of poisonous plants in residential areas
12. Which of the following is not an effect of climate change that is currently affecting Puerto Rico? (Objective 6)
    a. Rising sea levels
    b. Changes in the habitats of native animals
    c. Changes in precipitation patterns
    d. Decreased coastal erosion

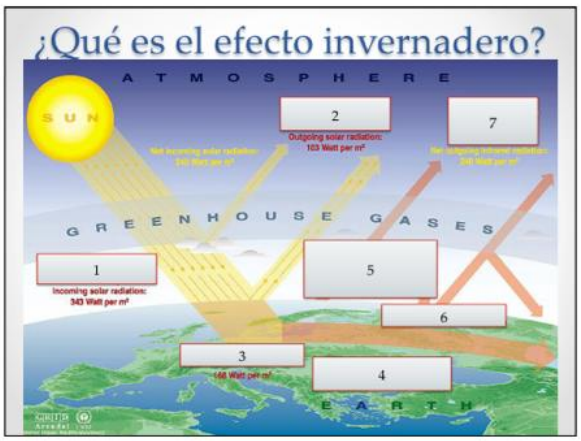
Answer the following questions honestly and openly. Your feedback will be utilized and is greatly appreciated

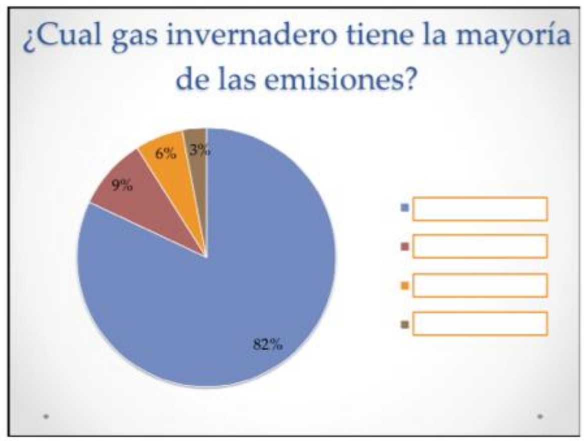
1. Did you enjoy the past two lessons?
2. Name one thing you liked about the lessons.
3. Name one thing you did not like about the lessons.
4. Do you have an interest in learning more about climate change after taking part in these lessons?
5. State one additional climate change subject you would like to learn about that was not included in the lessons.
6. State one thing you did not know before the lesson that you now know after completing these lessons.

Appendix H: Lesson PowerPoint Presentation (Spanish)

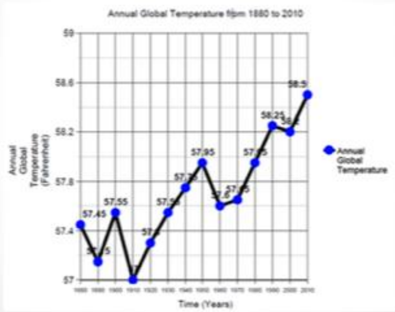






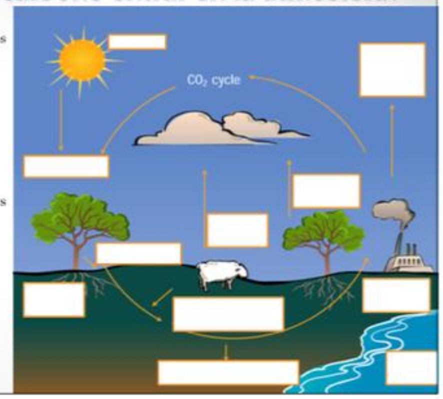


Temperatura Global: 1980-2010

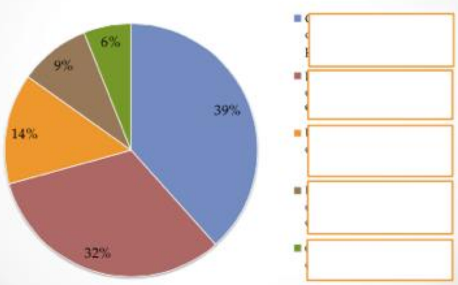


¿Cómo carbono entrar en la atmosfera?

Lista of términos:
- Emisiones de carros y fábricas
- Respiración de los animales
- Organismos muertos y productos de desecho
- Hongos
- Fósiles y combustibles fósiles
- Absorción del océano de carbono
- Carbono orgánico
- Respiración de las plantas
- Fotosíntesis
- Respiración de las raíces
- Luz del sol



¿Cuál es la fuente con la mayoría de las emisiones del dióxido de carbono?



Actividad: Pictionary Fuentes de emisiones de CO_2

- La maestra les dividirá en grupos de cuatro o cinco
- Escoge una persona a empezar
- Inicie el temporizador por un minuto
- La primera persona escogerá un fuente de emisiones de CO_2 y se lo dibuja.
- El resto del grupo tratará de adivinar que el fuente es antes que el tiempo se acaba

¿Cómo podemos reducir emisiones de CO_2?

…

Tarea

Los estudiantes completarán las siguientes actividades, igual como una búsqueda de tesoro

- Encuentra una historia breve de alguien que usted conoce sobre como el cambio climático se le afecta. Escribe una descripción de la historia.
- Encuentra un objeto (o un foto de ese objeto) que usted use, o describe una actividad de su propia vida, que emite gases invernadero.
- Describe una manera nueva para usar este objeto o para cumplir este actividad en una manera que emite menos gases invernaderos.

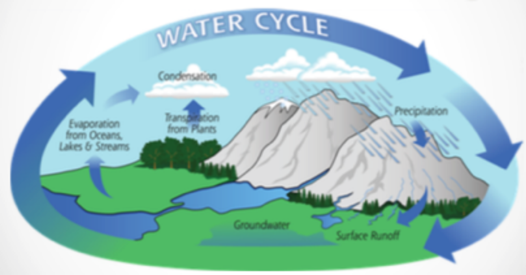
Lección 2: Los Impactos de Cambio Climático

Los estudiantes serán capaces de:

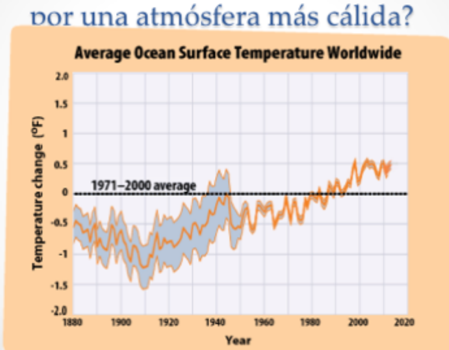
1. Identificar los impactos predichos de una atmósfera más cálida, centrándose en el ciclo de agua y los océanos.
2. Determinar los impactos de cambio climático en los animales y las plantes de El Yunque, centrándose en los impactos de una temperatura aumentada y en cambios en patrones de precipitación.
3. Determinar los impactos del cambio climático en los seres humanos, especialmente cómo cambios en patrones de precipitación, aumentos en niveles océanos, y cambios en los hábitos de los animales y plantas afectan los seres humanos.

¿Cuáles procesos naturales pueden ser afectados por una atmósfera más cálida?

¿Cuáles son los impactos específicos de una atmósfera más cálida en el ciclo de agua?



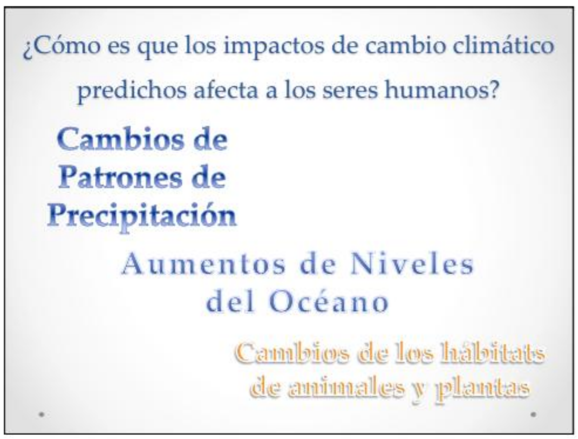
¿Cómo es que los océanos serían afectados por una atmósfera más cálida?



¿Cuáles son posibles efectos ambientales de océanos más cálidos?


¿Cuáles son los impactos de una atmósfera más cálida en ciclo de agua?
Atmósfera más Cálida
Océanos más Cálidos
Cambios en Evaporación
Aumento del Nivel del Mar
Cambios en Precipitación


Actividad del Cambio de Hábitat


¿Cómo es que los impactos de cambio climático predichos afecta a los seres humanos?
Cambios de Patrones de Precipitación
Aumentos de Niveles del Océano
Cambios de los hábitats de animales y plantas

Appendix I: Proposed Learning Unit (Translated) – Pre-test

Pre-prueba

Hora prevista: 10 minutos

Dar a los estudiantes la siguiente pre-prueba un dia antes de la realizacion de lección 1. Esta pre-prueba se dirige a los objectivos de lecciones 1 y 2. Las respuestas destacados abajo son las respuestas correctas.

Nombre: ____

1. ¿Cuál de los siguientes no es un gas invernadero? (Objetivo de Aprendizaje 2)
    a. Dióxido de carbono
    b. Propano
    c. Metano
    d. El vapor de agua
2. ¿Qué es la relación entre las concentraciones de CO_2 en la atmósfera y la temperatura global? (Objetivo de Aprendizaje 1)
    a. Hay una correlación positiva
    b. Hay una correlación negativa
    c. No hay correlación
    d. Existe una correlación diagonal
3. De los siguientes, ¿cual es algo que los gases invernadero atrapan en la atmósfera? (Objetivo de Aprendizaje 2)
    a. Agua
    b. Oxígeno
    c. Dióxido de carbono
    d. La energía térmica
4. ¿Cuál de los siguientes no es una manera en que la gente pueden disminuir emisiones de gases invernaderos? (Objetivo de Aprendizaje 4)
    a. Utilice iluminación natural durante el día
    b. Mudar de las ciudades a los suburbios
    c. Manejar un carro con un mayor rendimiento de gasolina
    d. Apagar dispositivos electrónicos cuando no esté en uso
5. ¿Cuál de los siguientes describe un efecto predicho del cambio climático en Puerto Rico? (Objetivo de Aprendizaje 7)
    a. Las estaciones serán más extrema. La estación seca se volverá mas seco, mientras que la temporada de lluvias será más húmedo
    b. 85% de la isla estará bajo el agua para el año 2050
    c. Un gran parte de las especies nativas desparecerá de Puerto Rico de los próximos 15 años

   d. Niveles de esmog aumentaran en San Juan debido a los aumentos de la temperatura media anual
6. ¿Cuál de los siguientes no es un efecto de cambio climático que está afectando Puerto Rico en este momento? (Objetivo de Aprendizaje 6)
   a. El aumento del nivel del mar
   b. Los cambios en los hábitats de los animales nativos
   c. Los cambios en los patrones de precipitación
   d. Disminución de la erosión costera
7. ¿Cuál de los siguientes es un efecto del cambio climático que afecta la vida silvestre? (Objetivo de Aprendizaje 6)
   a. Los gases invernaderos están envenenando los animales
   b. Los animales están emigrando más al norte de lo habitual
   c. Los animales están migrando en diferentes épocas del año de lo habitual
   d. Los gases invernaderos están afectando los patrones de reproducción
8. ¿Cuál es la mayor fuente de emisiones de dióxido de carbono por el hombre? (Objetivo de Aprendizaje 4)
   a. Electricidad
   b. Transporte
   c. Industria
   d. Residencial / Comercial
9. ¿Cuál no es un efecto ambiental de los océanos más cálidos? (Objetivo de Aprendizaje 5)
   a. El aumento del nivel del mar
   b. Cambios de arrecifes de coral
   c. Composiciones químicas cambiado
   d. El aumento de las olas
10. ¿Qué es un impacto en los seres humanos del cambio de los hábitats de animales y plantas? (Objetivo de Aprendizaje 7)
   a. El aumento de la contaminación acústica debido a superpoblación de los coquíes
   b. Bajo suministro de alimentos debido a cambios en patrones de precipitación
   c. Daño arquitectónico debido a las aves que anidan en edificios de la ciudad
   d. Aumento del crecimiento de las plantas venenosas en las zonas residenciales
11. Expertos en cambio climático han dicho que el aumento de gases invernaderos pueden provocar un aumento de la temperatura atmosférica. ¿Cual no es un efecto de una atmosfera cálida? (Objetivo de Aprendizaje 5)
   a. Océanos mas cálidos
   b. Días más largos
   c. Cambio de condiciones para los animales y las plantas
   d. Mas evaporación
12. ¿Cuál de los siguientes no afecta directamente los niveles de carbono en la atmosfera? (Objetivo de Aprendizaje 3)
   a. Respiración de las plantas

b. La respiración animal
c. Descomposición de la materia orgánica
a. La quema de combustibles fósiles

Appendix J: Proposed Learning Unit (Translated) – Lesson 1

Parte I: Pre-Tarea

Se les pedirá a los estudiantes a ver un episodio relevante Mythbusters en el siguiente enlace:

https://www.youtube.com/watch?v=pPRd5GT0v0I

Esta video describe el efecto invernadero atravez de un experimento. Los Mythbusters preparan tres cajas transparentes: una llena de CO_2, una llena de metano, y una como un variable de control. Se monitorean las diferencias en temperatura entre las tress cajas durante un período de tiempo.

Parte 2: Actividades de Clase

Diapositiva 1: Objetivos de Aprendizaje

Hora prevista: 1 minuto

Lee a los estudiantes los siguientes objetivos de aprendizaje.

Los estudiantes serán capaces de:

1) Identificar una evidencia de cambio climático, centrándose en la relación entre las concentraciones de CO_2 y la temperatura atmosférica

2) Describir el efecto invernadero e identificar los gases que intervienen en ella

3) Describir cómo entra el carbono de la atmósfera según lo representado por ciclo del carbono

4) Identificar las fuentes de las emisiones de CO_2

Objetivo: Informar a los estudiantes de los objetivos de la lección

Diapositiva 2: Cambio Climático:

Hora prevista: 3 minutos

Divide los estudiantes en parejas, luego pasa un paquete de hojas de trabajo con los gráficos blancos que serán presentados en esta lección a cada pareja. Introduce el tema de cambio climático por definir cada de las palabras de “cambio climático antropogénico”. El cambio debe ser definido como “hacer la forma, la naturaleza, contenido, curso futuro, etc. De (algo) diferente de lo que es o de lo que sería si se queda solo”. No se espera que los estudiantes proporcionan esta definición formal, pero si se espera que ellos reconocen que el cambio denota una diferencia entre dos estados del ser. Pregunta a la clase la por definición de clima. Pedir voluntarios para contestar la pregunta. La definición de clima que usted tiene que buscar es “los patrones de precipitación y temperatura a largo plazo de una área”. Algunas preguntas de seguimiento que usted puede pedir son “¿Que es la diferencia entre tiempo y clima?”, en que la respuesta es que el tiempo es los patrones de precipitación y temperatura a corto plazo, como un día calor o un tormenta, mientras que la clima es los patrones a largo plazo. Una pregunta diferente puede ser “¿Cuál es la clima de Puerto Rico?”, en que la respuesta es que la clima es tropical. Al final, es importante que defina el término antropogénico en el sentido de “causado o producido por los seres humanos”. Dile a los estudiantes que este lección cubrirá principalmente el cambio climático antropogénico.

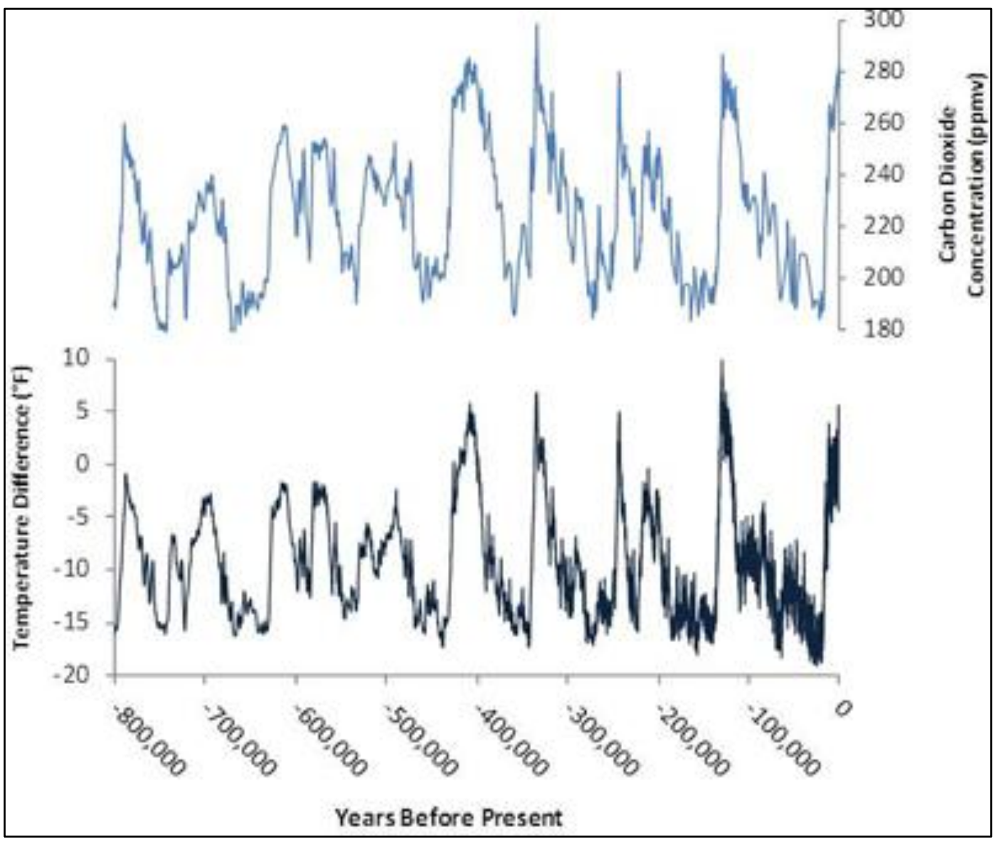


Figure 21: Una representación de cambio climático natural sobre la historia de la Tierra

\La página web de la Agencia de la Protección Ambiental (EPA) dice lo siguiente sobre el cambio climático natural: Estimaciones del cambio de las concentraciones del dióxido de carbono (CO2) de la Tierra (arriba) y las temperaturas antárticas (abajo), basado en el análisis de los datos de las muestras de hielo se extiendan 800.000 años de antigüedad. Hasta el siglo pasado, los factores naturales causaron concentraciones de CO_2 en la atmósfera a variar dentro de un rango de aproximadamente 180 a 300 partes por millón por volumen (ppmv). Periodos más cálidos coinciden con periodos de concentraciones relativamente altas de CO_2. NOTA: Los cambios de temperatura del siglo pasado y el aumento de las concentraciones de CO2 (a 390 ppmv en 2010) no se muestran aquí.

Objetivo: Este diapositiva presenta una introducción a los conceptos de clima y te tiempo, así como establecer una definición básica de cambio climático antropogénico.

Diapositiva 3: ¿Que es el efecto invernadero?

Hora prevista: 6 minutos

Primero, establece una definición de un gas invernadero por preguntar los estudiantes que ellos creen la definición de un gas invernadero es. Un gas invernadero se define formalmente como cualquier gas que absorbe la radiación infrarroja producida por el calentamiento solar de la superficie de la Tierra (dictionary.com). Ejemplos de estos gases son el dióxido de carbono (CO_2), el metano (CH_4), el oxido nitroso (NO_x), y el vapor de agua (H_20 [g]). El efecto invernadero se define formalmente como un fenómeno atmosférico en que la radiación infrarroja de de longitud de onda corta se transmite fácilmente en la atmosfera de la Tierra (específicamente en la troposfera), mientras que la radiación infrarroja de longitudes de onda más largas se transmite con menos facilidad fuera de la atmosfera (específicamente en la troposfera) debido a su absorción por los gases atmosféricos de efecto invernadero (dictionary.com).

Use una analogía que describe este efecto utilizando un invernadero real. En la analogía, la atmosfera es como el “vidrio” del invernadero. Energía térmica del sol pase por el “vidrio”, pero es parcialmente incapaz de salir fuera del “vidrio”. Esta energía atrapada luego aumenta la temperatura dentro del invernadero. Refiera al video de Mythbusters que los estudiantes vieron la noche anterior para su tarea.

Luego, pase por cada paso del efecto invernadero. Identifica los puntos en el diagrama acompañada en que cada paso del efecto ocurre. Las locaciones de estos puntos en el diagrama son etiquetado como puntos 1 a 7. Pregunta a los estudiantes que ellos piensan está pasando a cada punto del diagrama. Se proporciona un clave de respuestas a estos puntos debajo del diagrama.

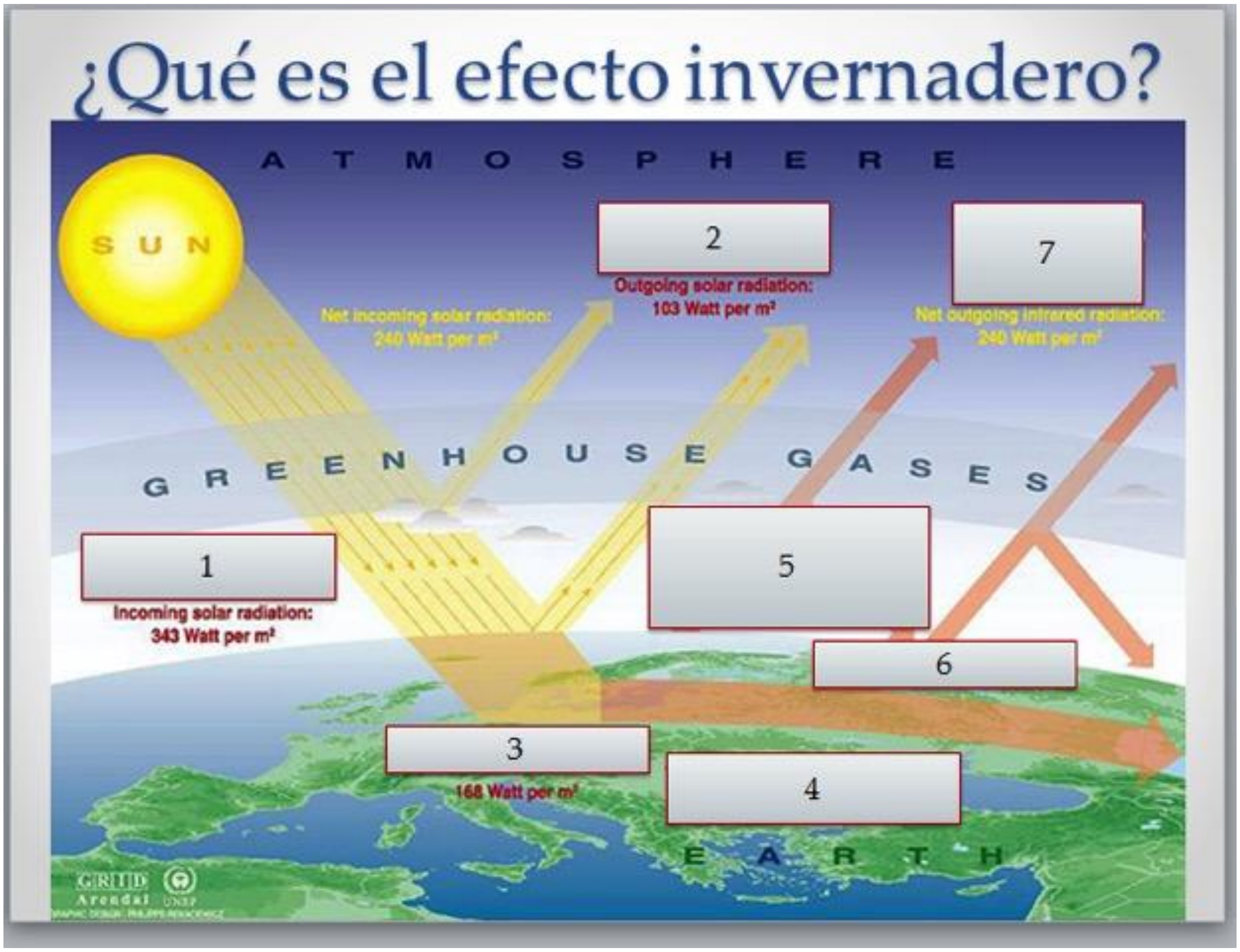


Figura 22: Un grafico del efecto invernadero

Punto 1: La radiación solar pasa a la atmosfera de la Tierra

Punto 2: Parte de esta radiación es reflejada de vuelta al espacio por la atmosfera y la superficie terrestre.

Punto 3: La radiación restante que no era reflejada hacia el exterior es absorbido por la superficie terrestre.

Punto 4: La radiación solar que fue absorbida por la superficie de la Tierra se convierte en calor térmico. Esta energía térmica calienta la superficie de la Tierra y luego se irradia de nuevo fuera de la superficie.

Punto 5: Una parte de la energía térmica radiada es absorbida por efecto invernadero atmosférica.

Punto 6: La parte de la energía térmica que no fue absorbida por los gases invernaderos viaja de regreso a la superficie, donde se emite hacia el exterior una vez más.
Punto 7: Esta energía térmica se refleja fuera de la superficie de la tierra y de vuelta al espacio.

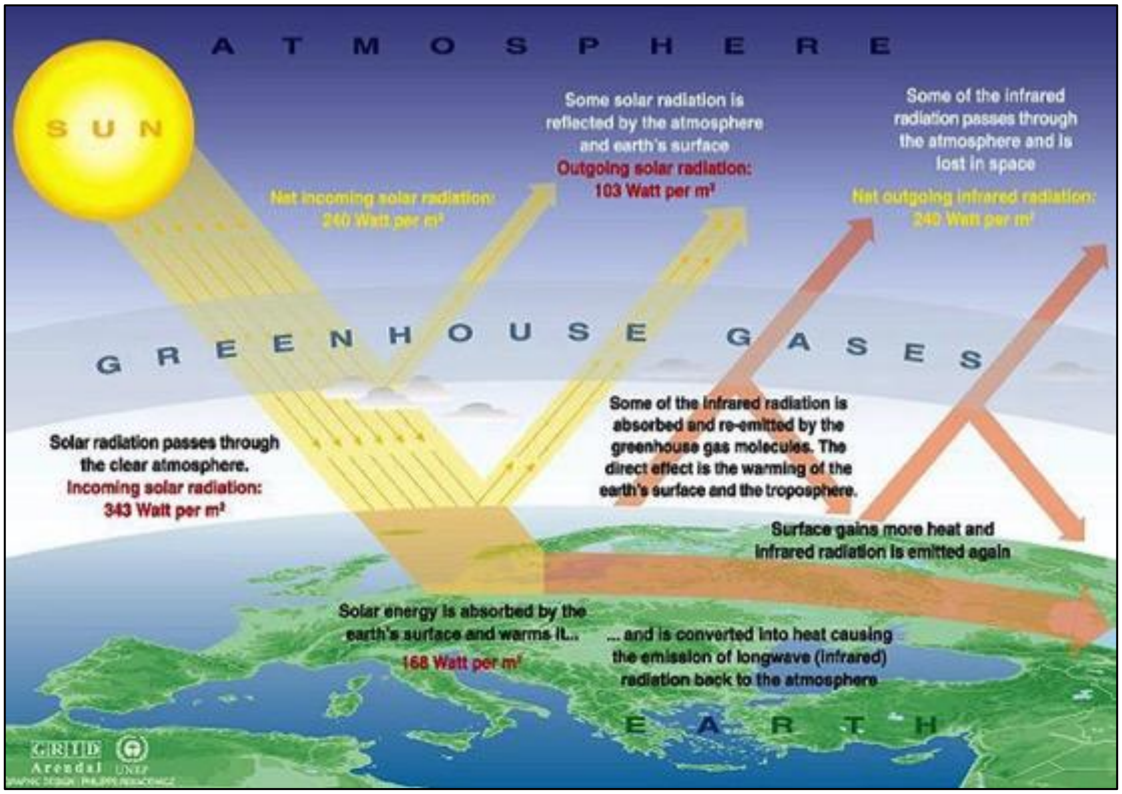


Figura 23: Un diagrama del efecto invernadero (GRID Arendal y UNIP)

Objetivo: Ilustra cómo energía solar calienta la Tierra y cómo los gases invernaderos en la atmosfera aumentan la absorción de calor infrarrojo en la atmosfera de la Tierra.

Diapositiva 4: ¿Cual gas invernadero tiene la mayoría de las emisiones?

Hora prevista: 5 minutos

Pregunta a los estudiantes cual gas invernadero que ellos creen tiene la mayoría de las emisiones atmosféricas y luego revele la respuesta. A continuación, pregunta lo que ellos creen que es el segundo gas invernadero con las emisiones más altas y luego revele la respuesta. Continúa así hasta que los cuatro de los gases invernaderos son revelados. Haga que los estudiantes completen su propio grafico durante la discusión. Las respuestas son (en orden) el dióxido de carbono (CO_2), el metano (CH_4), los óxidos nitrosos, y gases fluorados.

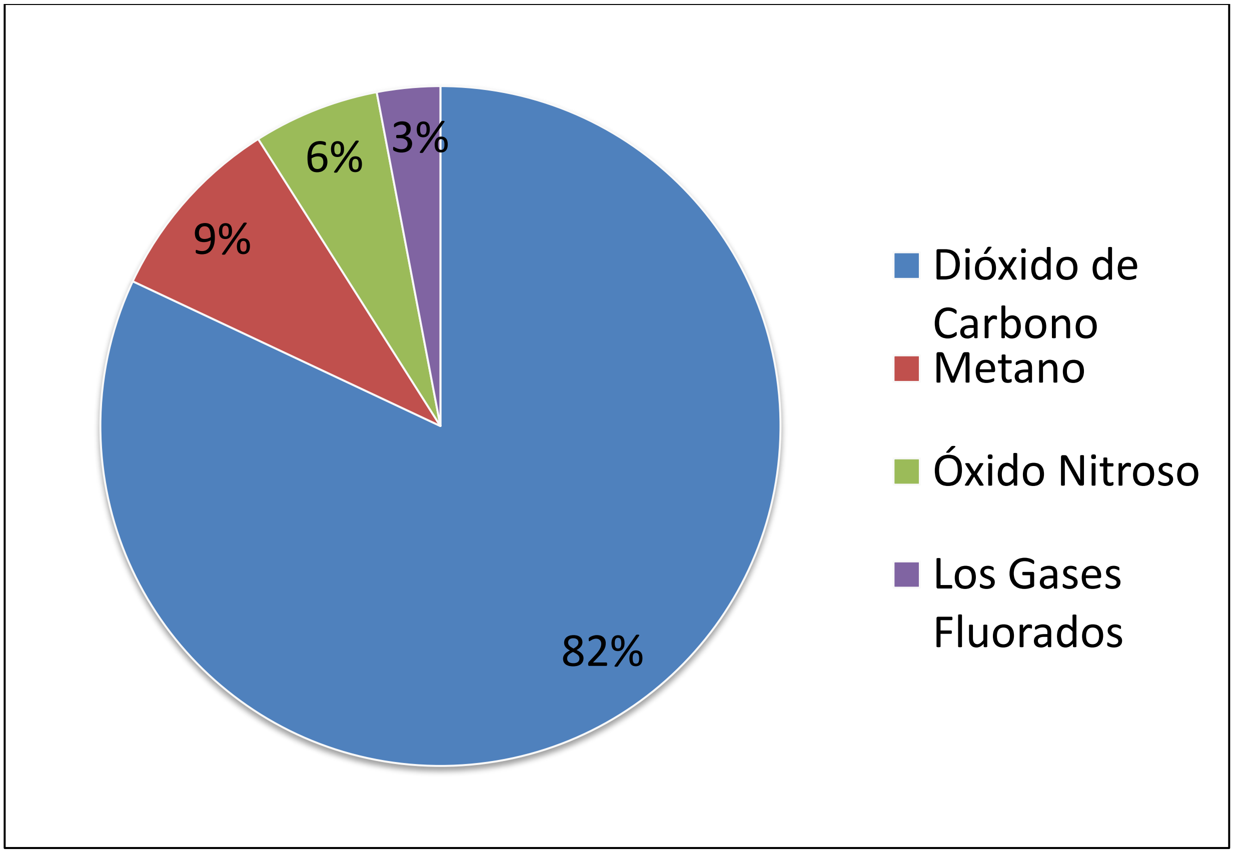


Figura 24: Porcentaje relativo de gases invernaderos en términos de los niveles de emisión de gases invernaderos (Agencia de la Protección Ambiental).

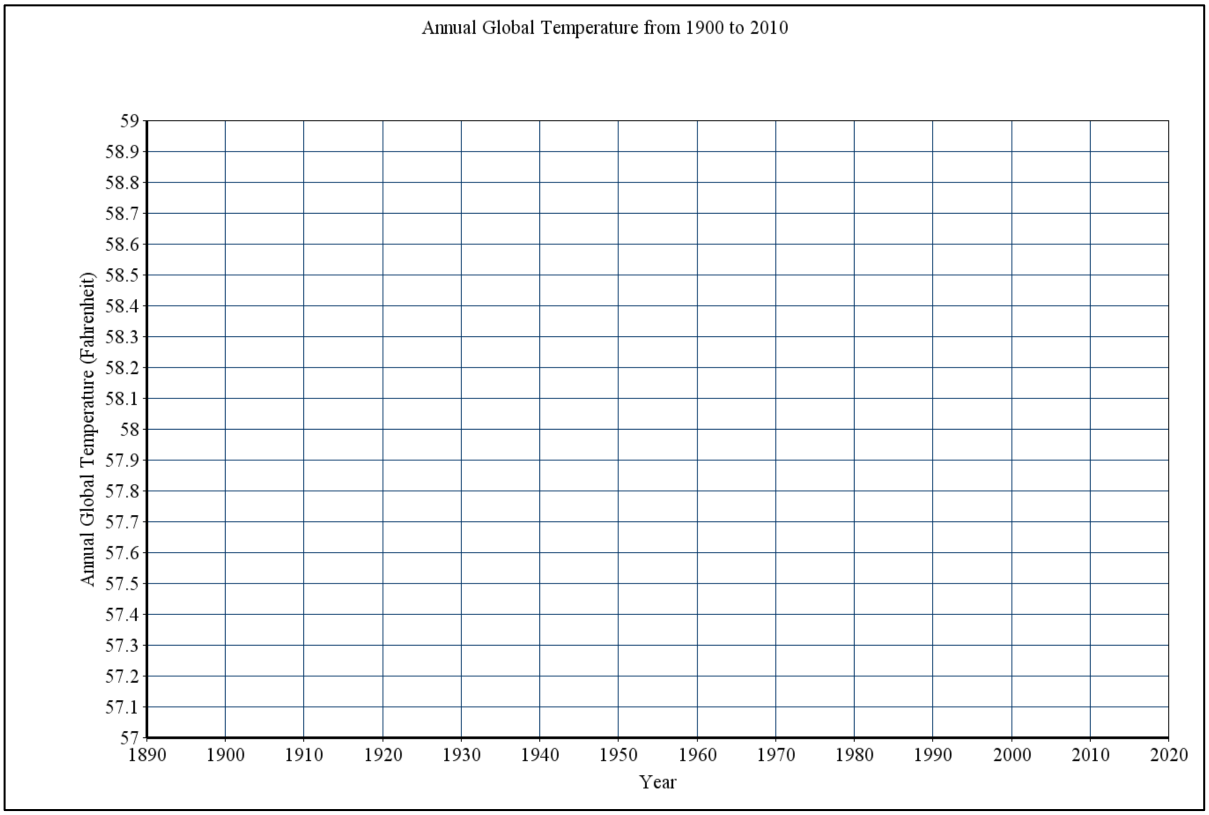
Explique que estos gases no son necesariamente malos para la ambiente. El dióxido de carbono es un problema solo porque en este momento hay los niveles más altos de sus concentraciones en la historia de la Tierra. Es por esta razón que el resto de la lección se centrará en los efectos de las concentraciones de dióxido de carbono en la temperatura media global.

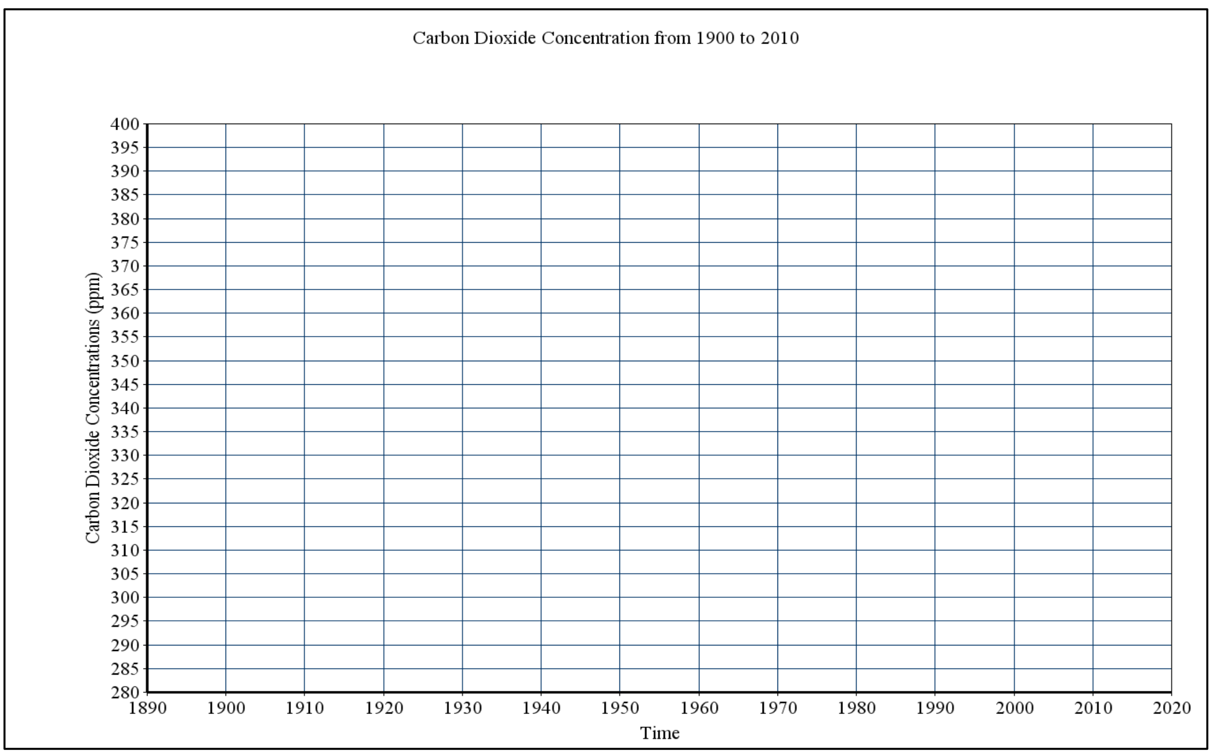
Objetivo: Definir los gases invernaderos diferentes (Objetivo de Aprendizaje 2).

Diapositivas 5 - 7: Gráficos sobre la evidencia de cambio climático

Hora Prevista: 10 minutos

Abajo se proporcionan dos gráficos vacios que se ofrecen a los estudiantes en el paquete de hojas de trabajo.





Pida a los estudiantes para llenar los gráficos anteriores en sus hojas de trabajo. Los estudiantes trabajarán en parejas, con un estudiante de crear el grafico de la concentración de CO2 y el otro de crear el gráfico de la temperatura. Dar a los estudiantes 5 minutos para completar sus gráficos. Además, les dan un minuto para comparar los dos gráficos que han creado. Los datos de estor gráficos se extrapolaron a partir de la grafica en la Figura 3.

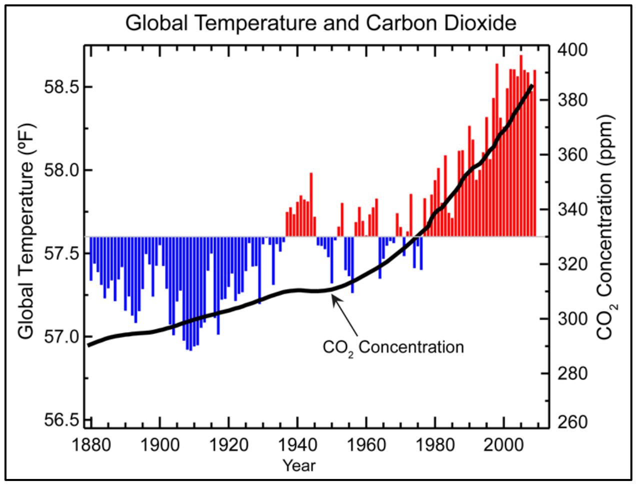
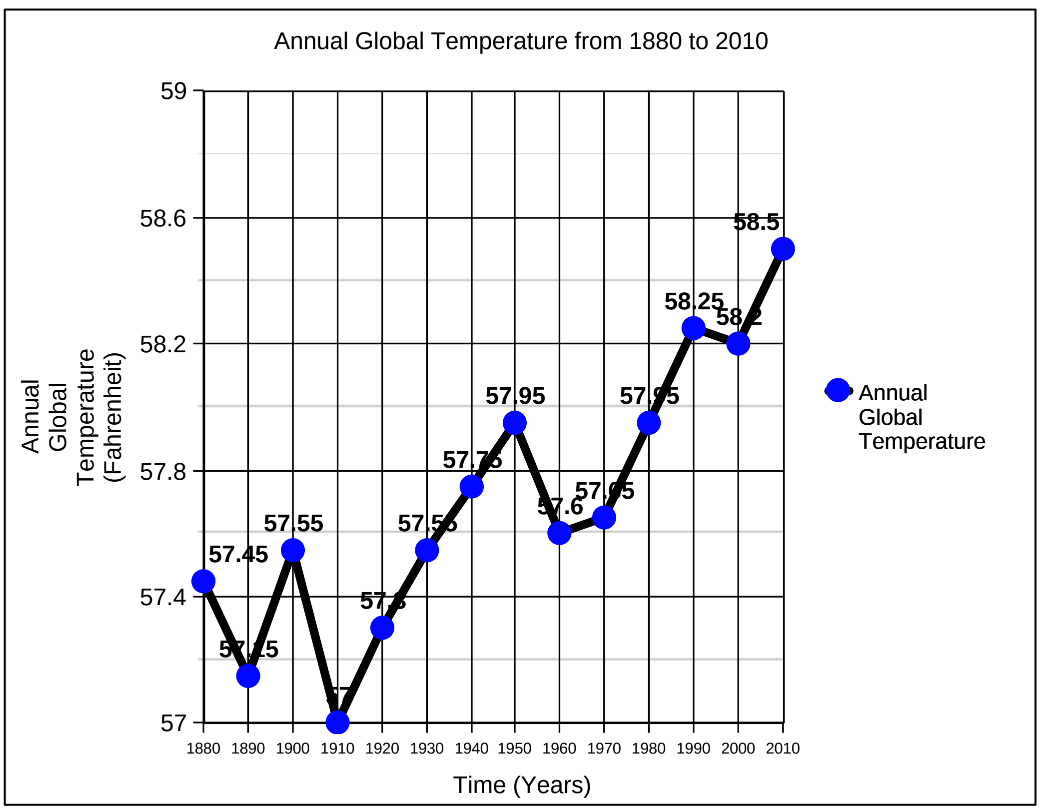
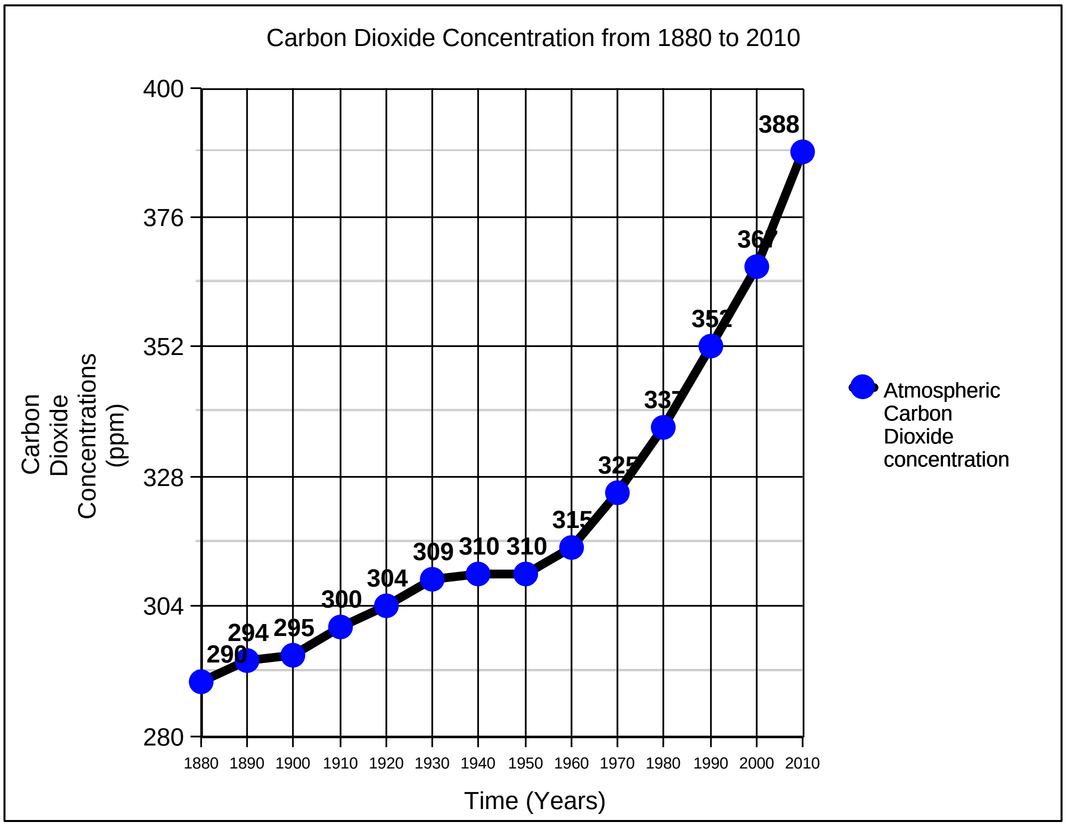


Figura 25: Una comparación de las concentraciones de dióxido de carbono y la temperatura global durante el siglo pasado. (National Oceanic and Atmospheric Administration)

Los gráficos completos deben parecer como los gráficos de abajo.





Revise el grafico y haga que los estudiantes corrijan sus gráficos, si es necesario. Pide a los estudiantes pensar lo que el gráfico significa. Discuta con los estudiantes de la *correlación* entre las concentraciones de CO_2 y la temperatura global. Luego, pida a los estudiantes aplicar sus conocimientos de gases invernaderos a los resultados de sus graficas. ¿Qué puede ser predicho? La predicción de que debe hacerse es la siguiente: el aumento de la concentración de CO_2 *causa* a las temperaturas atmosféricas a aumentar. Abajo se proporcionan representaciones adicionales de los aumentos de gases invernaderos y la temperatura, respectivamente.

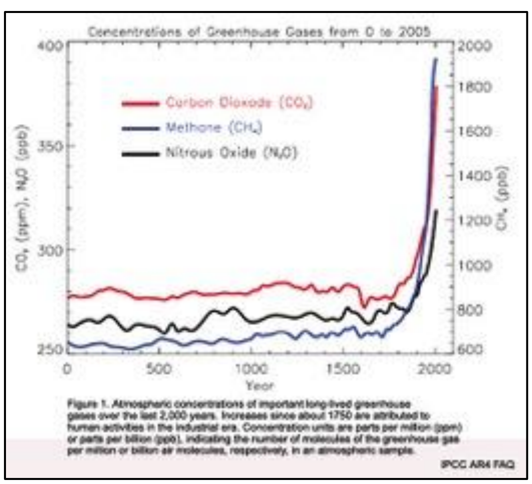


Figura 26: Concentraciones de gases invernaderos desde el año 0 hasta el año 2005 (Global Greenhouse Warming)

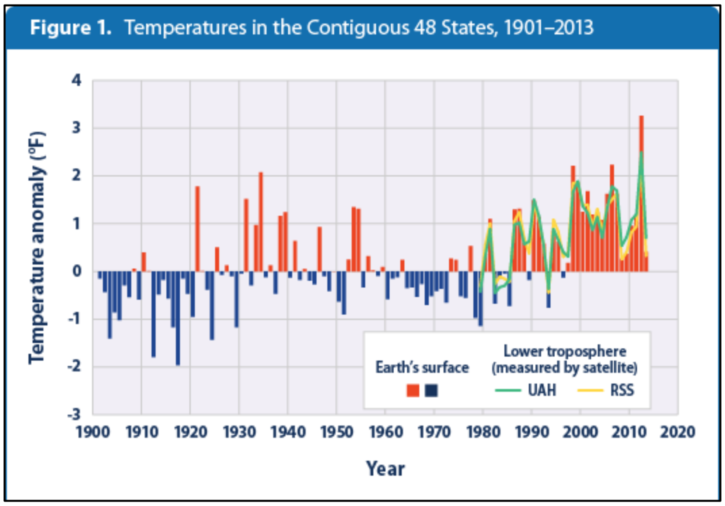


Figura 27: Relación entre la temperatura global de anomalías y la concentración de dióxido de carbono (EPA)

Objetivo: Que los estudiantes identifican evidencia del cambio climático antropogénico por demonstrar que los aumentos en las concentraciones de CO2 se correlacionan positivamente con el aumento de la temperatura global (Objetivo de Aprendizaje 1). Pida a los estudiantes identificar evidencias del cambio climático antropogénico por demonstrar que los aumentos en las concentraciones de CO2 pueden causar aumentos en la temperatura global (Objetivo de Aprendizaje 1).

Diapositiva 8: ¿Cómo carbono entrar en la atmosfera?

Hora prevista: 7 minutos

Debido a que el dióxido de carbono tiene las mayores emisiones de los gases invernaderos, usted debe discutir con la clase cómo entra el carbono la atmosfera. Pida a ellos que llenan el siguiente diagrama en sus hojas de trabajo. Los estudiantes continuaran a trabajar en las mismas parejas como antes. Ellos pueden usar el banco de palabras para ayudar a determinar cual término pertenece en cual espacio. Este banco de palabras se compone de las etiquetas presentas en el siguiente diagrama. Dé a los estudiantes tiempo para discutir sus ideas.

Explique cada paso del ciclo de carbono con toda la clase. Empieza con la luz solar, y después de pasar a la fotosíntesis, el carbono dentro de las plantas y los animales vivos, y la respiración de las plantas y los animales. Las emisiones de carbono artificiales deben ser mencionadas separadas, ya que no son parte del ciclo natural del carbono. Explique que todos los seres vivos contienen carbono. Además, explica que el carbono se intercambia entre los océanos, el aire, y los organismos a través de numerosas funciones naturales. Un aspecto importante del ciclo del carbono consiste en la descomposición de los organismos en el suelo, qué vuelva nutrientes a la tierra. En los casos en que se ha ocurrido descomposición anaeróbica por millones de años, los combustibles fósiles se pueden formar, explicando por qué altas cantidades de carbono se emiten en la atmosfera como producto de la quema de combustibles fósiles.

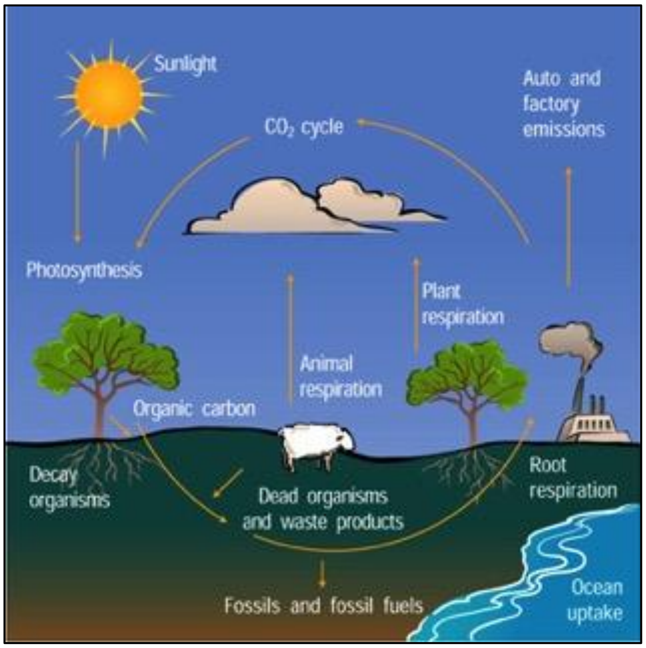


Figura 28: Una representación simplificada del ciclo del carbono (UCar.edu)

Antes de administrar esta lección, consulte el siguiente diagrama para una representación más detallada del ciclo del carbono y los diversos procesos relacionados. Para mayor aprendizaje de los estudiantes, ellos pueden consultar el sitio web, que se proporciona al final de este documento, para una versión interactiva de la figura.

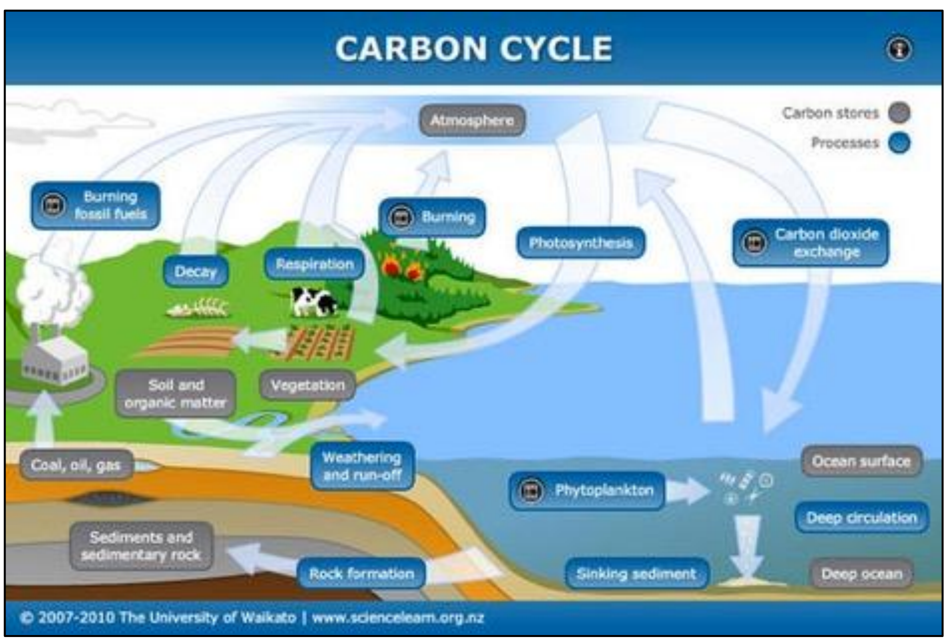


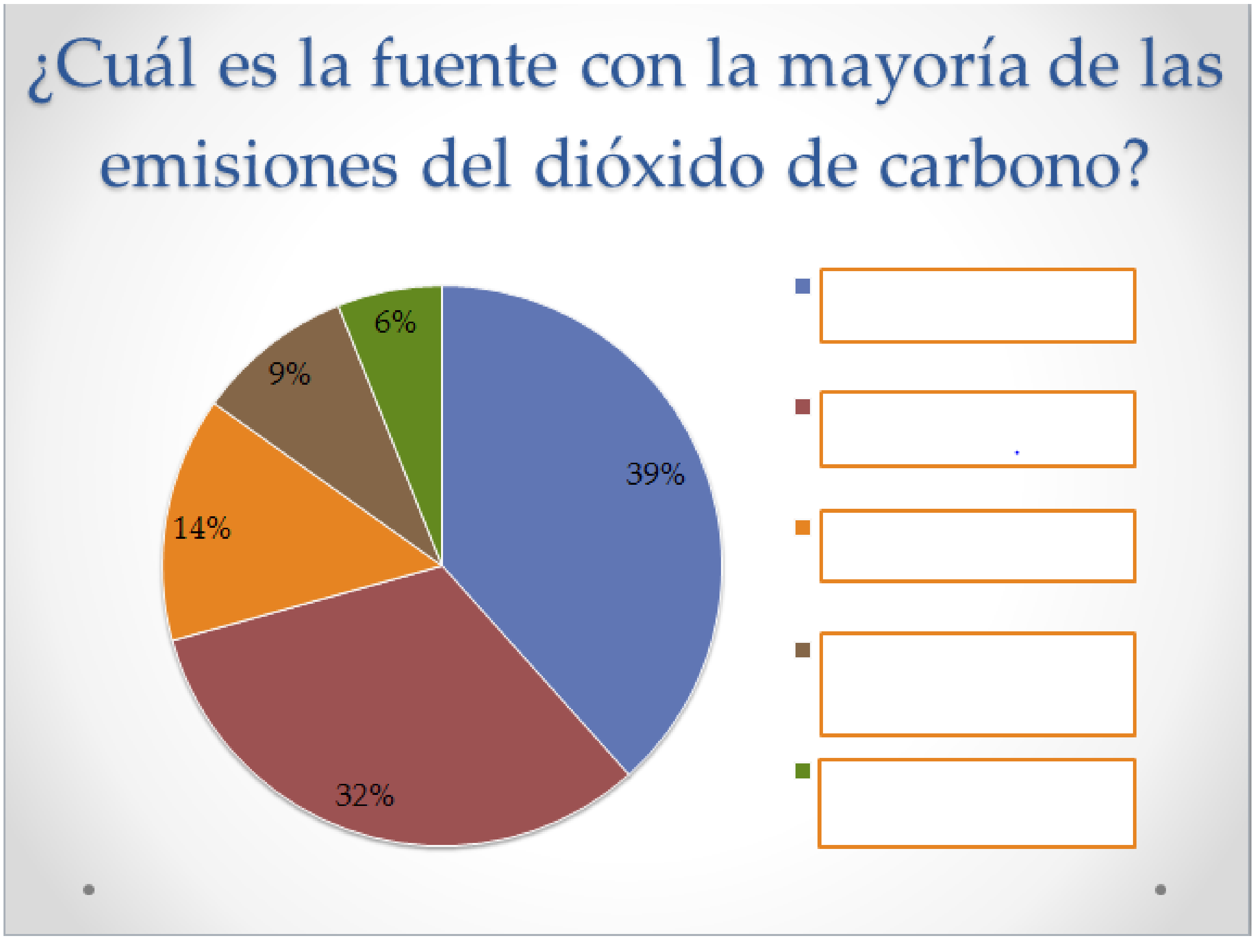
Figura 29: Representación detallada del ciclo del carbono (Sciencelearn.org)

Objetivo: Demonstrar el ciclo del carbono y cómo entra el carbono de la atmosfera en forma de CO_2 (Objetivo de Aprendizaje 3).

Diapositiva 9: ¿Cuál es la fuente con la mayoría de las emisiones del dióxido de carbono?

Hora prevista: 5 minutos

El gráfico abajo será proporcionado a los estudiantes, pero los títulos serán eliminados.



Pregunta a los estudiantes lo que creen es la mayor fuente de emisiones de dióxido de carbono y luego revela la respuesta. Pregunte lo que ellos creen que es la segunda mayor fuente de emisiones de dióxido de carbono y revuela la respuesta. Continúe de esta manera, hasta que todas las cincos fuentes se revelan. Haga que los estudiantes completen su propio grafico durante la discusión. Las respuestas correctas son la electricidad, el transporte, la industria, aparatos residenciales y comerciales, y la combustión de combustibles no fósiles. Informa los estudiantes de la formula química básica para la combustión (C + O2 → CO2) y que es el proceso básico que va a producir el CO2 que se emite a la atmosfera. Esta ecuación debe ser ya sea verbalmente o escrito en la pizarra.

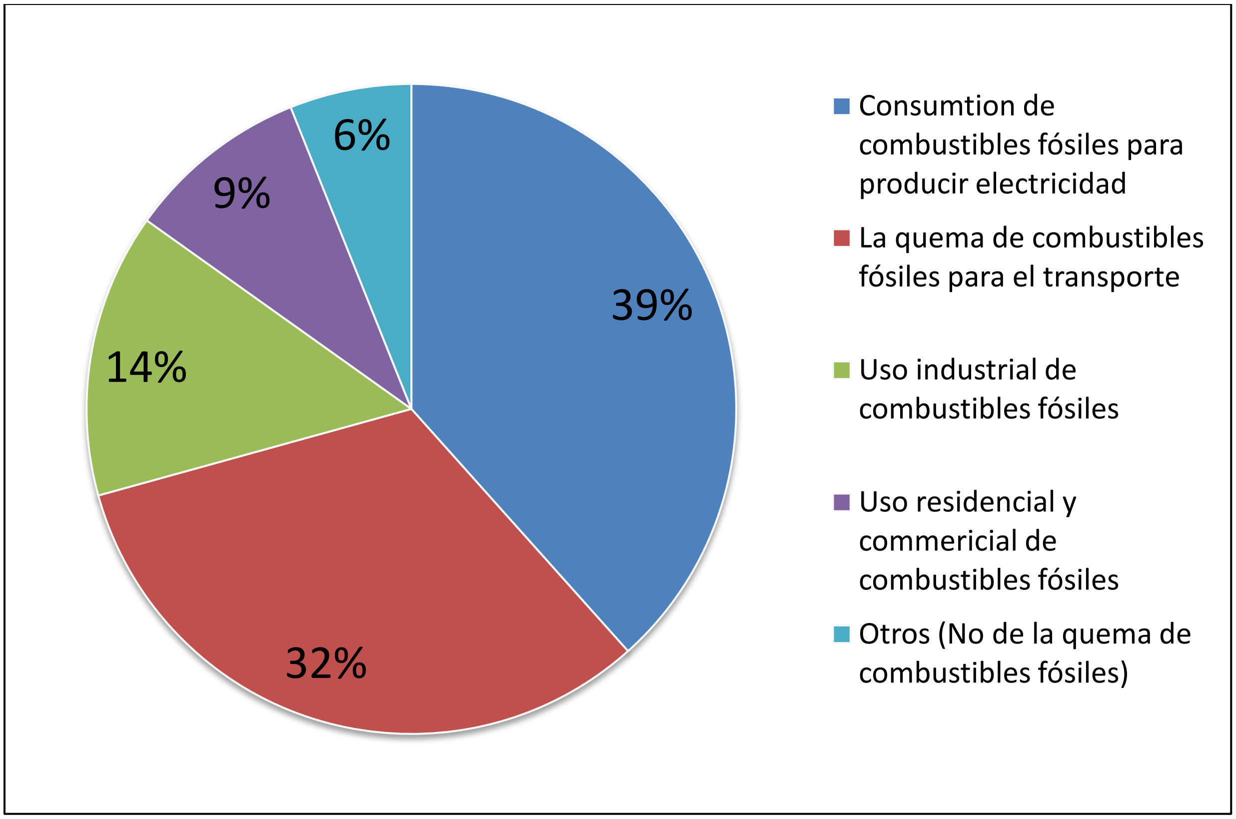


Figura 30: Distribución de las emisiones de dióxido de carbono por fuente de emisión (EPA)

Objetivo: Determinar los gases invernaderos que tienen las mayores cantidades de emisiones. (Objetivos de Aprendizaje 3 y 4)

Diapositiva 10: Actividad: Pictionary (Fuentes de emisiones de CO_2)

Hora prevista: 10 minutos

Divide la clase entre grupos de cuatro o cinco estudiantes. Dé a cada grupo un temporizador y haga que se les seleccionan al azar cuatro tarjetas para el grupo, cada una etiquetada con fuentes de emisiones de CO2. Cada grupo elegirá a una persona a dibujar primero, y esa persona seleccionara al azar una de las tarjetas y tratar de dibujar la fuente que aparece un una hoja de papel. Los otros miembros del grupo deben tratar de adivinar la fuente que se está dibujando. El equipo solo se dará un minuto para adivinar la fuente que se está representado. Si el grupo no tiene éxito en adivinar la fuente, se la proporcionara la respuesta después de que el minuto transcurre. Luego, el grupo decidirá en una nueva persona para dibujar, y continuarán este proceso hasta que todas las cuatro cartas se han seleccionado.

Después de este proceso se haya completado, haga que cada grupo categoriza la fuente que aparece en cada tarjeta, colocándolos en las cuatro categorías. Los estudiantes escribirán sus categorizaciones en la imagen que corresponde a cada fuente de emisión de carbono. Las clasificaciones son como sigue:

Electricidad: Bombilla, Aire Acondicionado, Computadora

Transporte: Carro, Avión, Motora

Industrial: Fabrica, Pila de Humo, Tren de Carga

Comercial/Residencial: Horno, Fogón, Barbacoa

Objetivo: Ilustrar las diferentes fuentes de emisiones de CO_2 (Objetivo de Aprendizaje 4).

Diapositiva 11: ¿Cómo podemos reducir emisiones de CO_2?

Hora prevista: 5 minutos

Pregunta a los estudiantes cómo la sociedad en su conjunto puede reducir las emisiones de CO_2. Hable de este tema abiertamente con los estudiantes.

Respuestas posibles pueden incluir:

- Utilice menos energía
    - Apaga las luces cuando no las esté utilizando
    - No deje el televisor cuando no lo está mirando
    - No se debe usar el aire acondicionado demasiado
- No maneja tanto – camina cuando puedas o utiliza el transporte público mas
- Coma menos carne roja
- Utiliza aparatos de ahorro energético
- Recicla o reutiliza productos cuando sea posible
- Compre productos locales

Luego, pide a los estudiantes cómo ellos personalmente pueden reducir las emisiones de CO_2. Escribe las respuestas en la pizarra para crear una lista de ideas. Asegúrese de distinguir las diferencias entre lo que la sociedad puede hacer y lo que los estudiantes pueden hacer personalmente. Además, asegúrese de hacer hincapié en que las acciones individuales pueden hacer in impacto. Estas acciones, cuando se hace por muchas personas, pueden tener un gran impacto en la disminución de las emisiones de dióxido de carbono.

Objetivo: Animar a los estudiantes a pensar de forma proactiva sobre lo que pueden hacer personalmente para reducir las emisiones de CO2 (Objetivo de Aprendizaje 4).

Parte III: Tarea

Diapositiva 12: Tarea

Informar a los estudiantes que hay dos copias de la actividad al final del paquete. Cada estudiante debe contestar las preguntas y entregar la hoja de trabajo el próximo día.

Instruciones:

Los estudiantes completarán las siguientes actividades, igual como una búsqueda de tesoro

1. Encuentra una historia breve de alguien que usted conoce sobre como el cambio climático se le afecta. Escribe una descripción de la historia.
2. Encuentra un objeto (o un foto de ese objeto) que usted use, o describe una actividad de su propia vida, que emite gases invernadero.

3. Describe una manera nueva para usar este objeto o para cumplir este actividad en una manera que emite menos gases invernaderos.

Enlaces usados para las figures:

Figura 1: http://www.epa.gov/climatechange/science/causes.html

Figura 2: http://www.grida.no/publications/vg/africa/page/3110.aspx

Figura 3: http://www.epa.gov/climatechange/ghgemissions/gases.html

Figura 4: http://www.global-greenhouse-warming.com/greenhouse-gas.html

Figura 5: http://www.ncdc.noaa.gov/indicators/

Figura 6: http://www.epa.gov/climatechange/science/indicators/weather-climate/temperature.html

Figura 7: https://eo.ucar.edu/kids/green/cycles6.htm

Figura 8: http://sciencelearn.org.nz/Contexts/The-Ocean-in-Action/Sci-Media/Interactive/Carbon-cycle

Figura 9: http://www.epa.gov/climatechange/ghgemissions/gases/co2.html

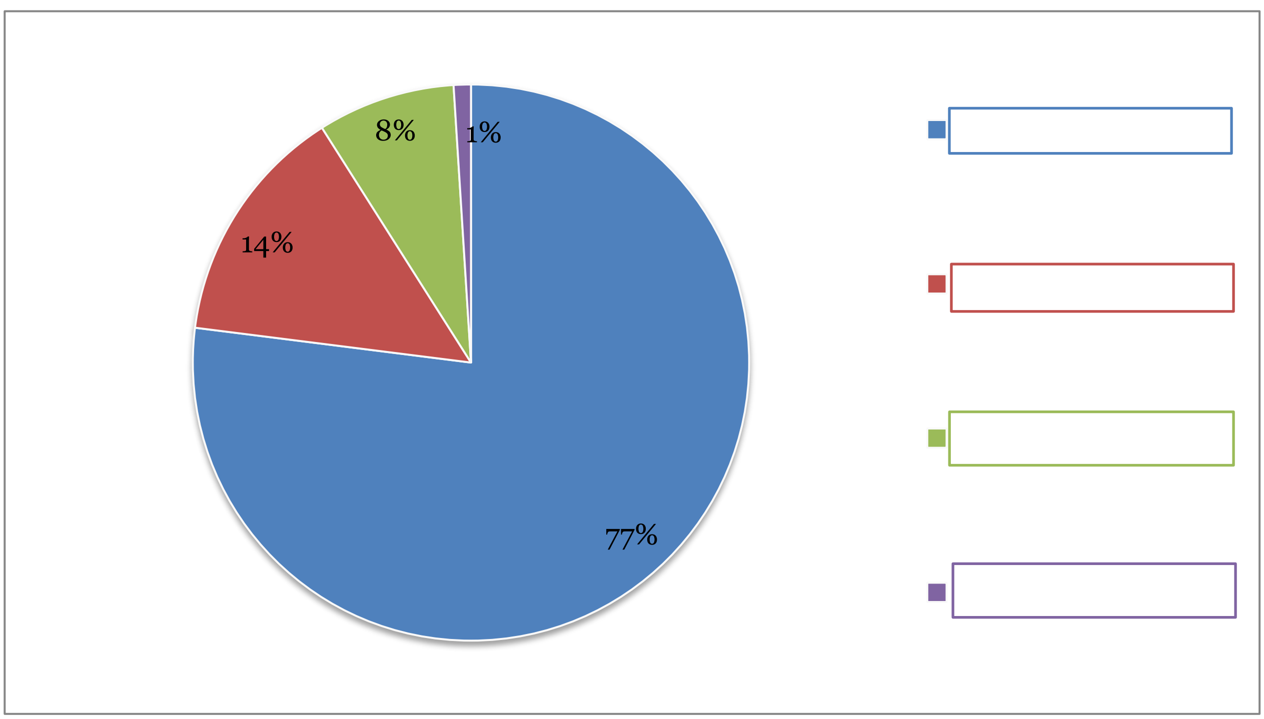
Parte IV: Materiales Adocionales

Lesson 1 Worksheet (Spanish)

Lección 1: Causas y Evidencias del Cambio Climático

Por favor completa los siguientes gráficos cuando su maestra le indica que lo haga.

1. ¿Cual gas invernadero tiene la mayoría de las emisiones? *Completa este grafico mientras que la clase discute cual gas invernadero tiene la mayoría de las emisiones.*



2. Temperaturas globales vs. Concentraciones de CO_2: *Dividir en parejas. Usando la tabla de abajo, tenga una persona a crear el grafico de las temperaturas globales y una persona a crear el grafico de las concentraciones de* CO_2.

Gráfico de la concentración de CO_2:

Año	**CO2 (ppm)**
1880	290
1890	294
1900	295
1910	300
1920	304
1930	309
1940	310
1950	310
1960	315
1970	325
1980	337
1990	352
2000	367
2010	388

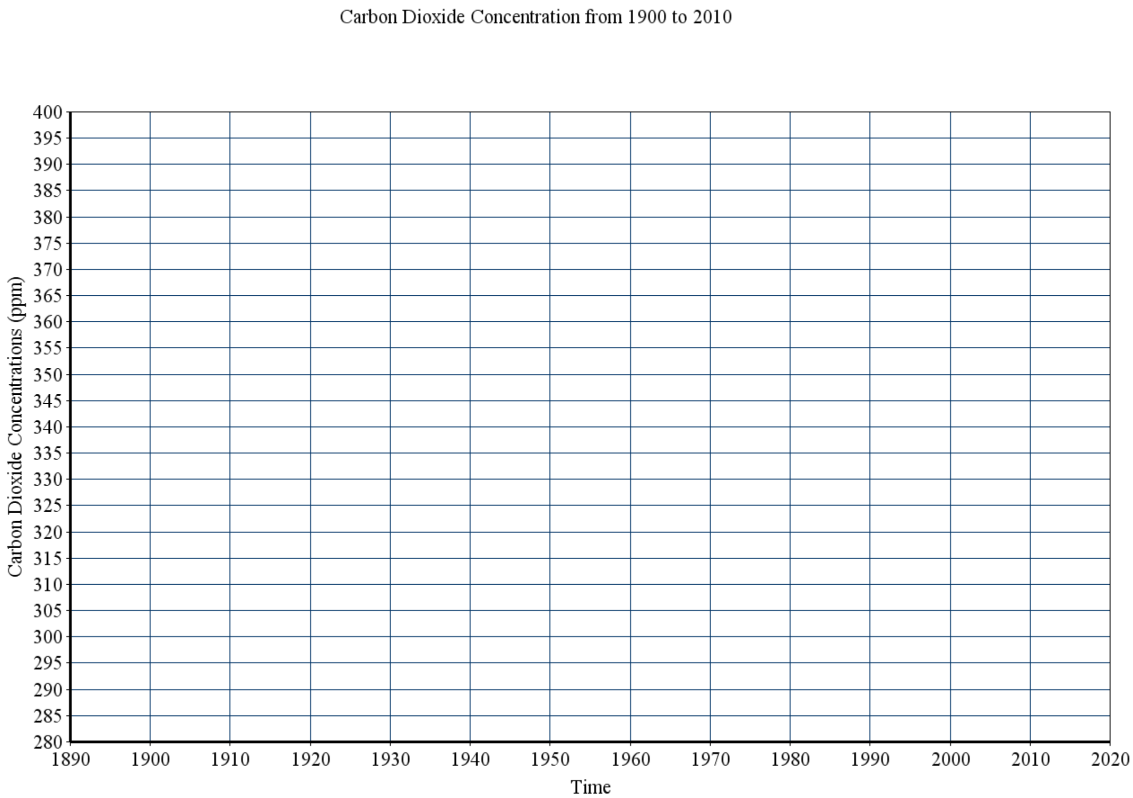
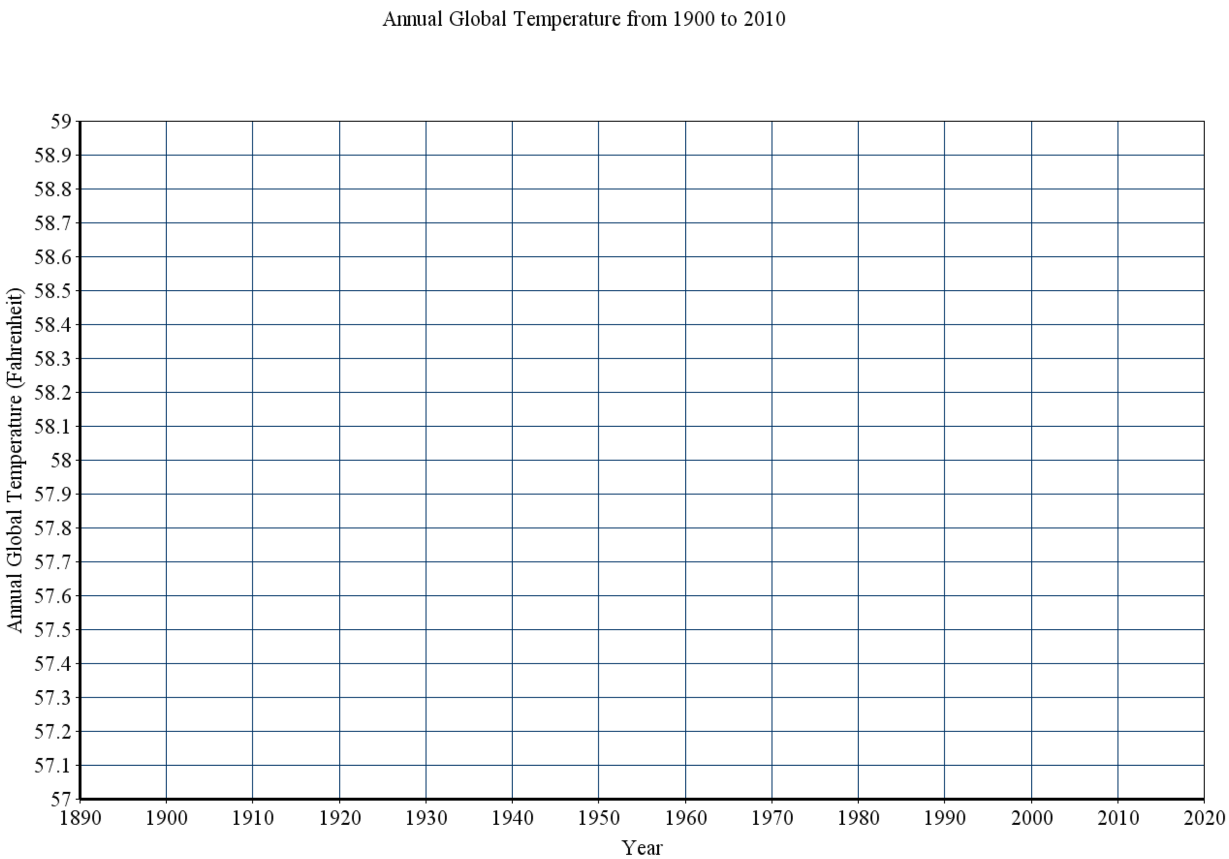


Gráfico de la Temperatura Global:

Año	**Temp (F)**
1880	57.45
1890	57.15
1900	57.55
1910	57.0
1920	57.3
1930	57.55
1940	57.75
1950	57.95
1960	57.6
1970	57.65
1980	57.95
1990	58.25
2000	58.2
2010	58.5

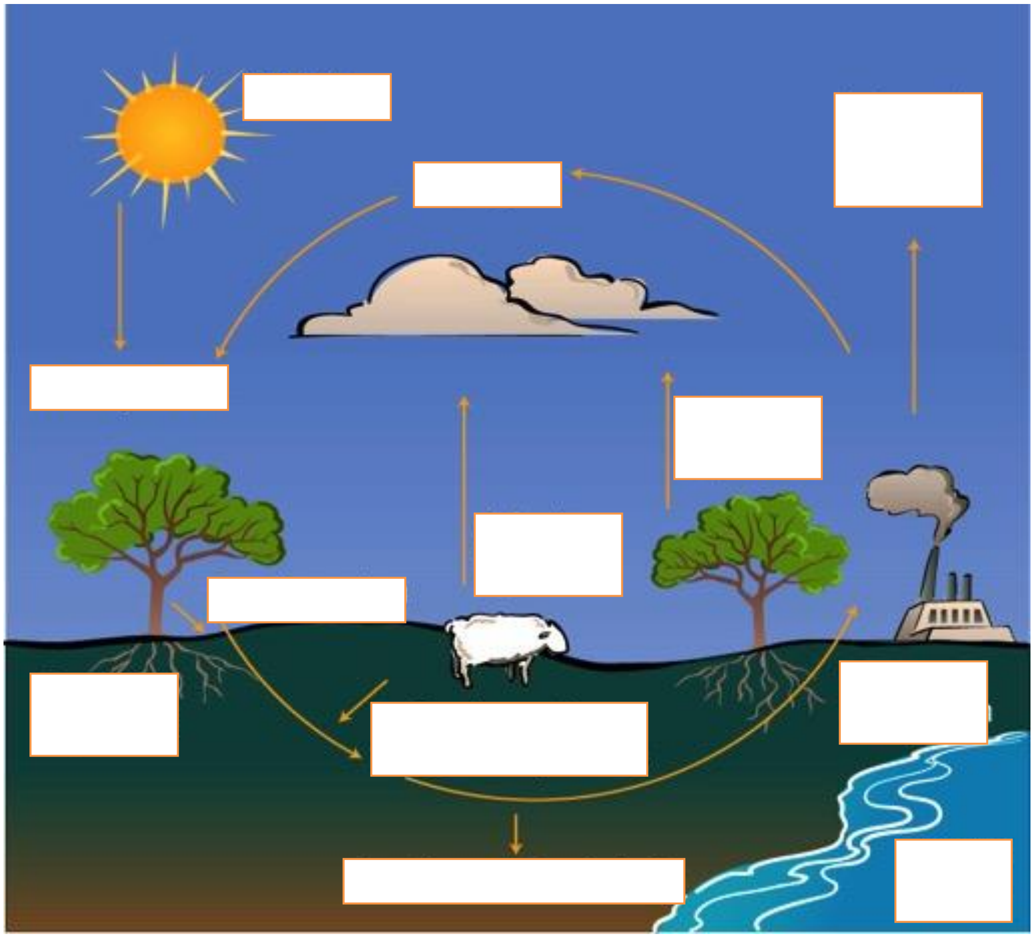


Ahora compara los dos gráficos. ¿Qué es la correlación entre la temperatura global y concentraciones de CO_2?

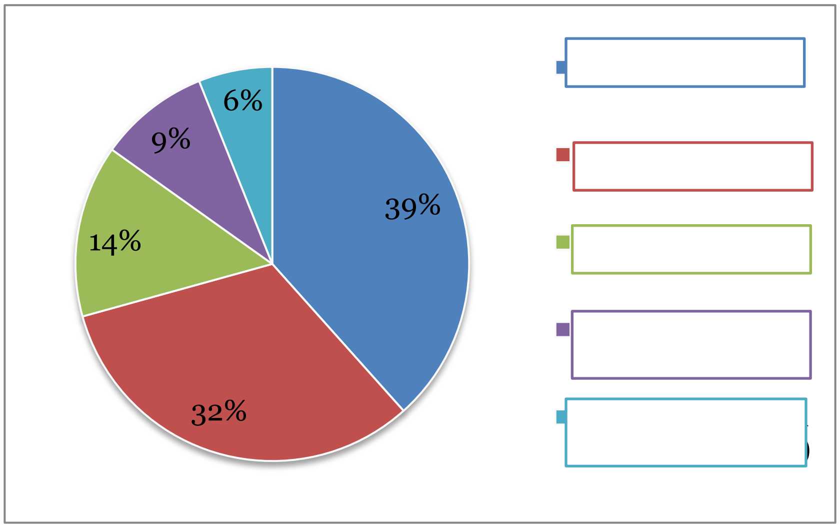
Absorción del océano de carbono

3. ¿Cómo carbono entrar en la atmosfera? *Trabajando en parejas, completa el grafico abajo usando el banco de palabras*

Banco de Palabras
Emisiones de carros y fabricas
Respiración de los animales
Organismos muertos y productos de desecho
Hongos
Fósiles y combustibles fósiles
Absorción del océano de carbono
Carbono orgánico
Respiración de las plantas
Fotosíntesis
Respiración de las raíces
Luz del sol



4. ¿Cuál es la fuente con la mayoría de las emisiones del dióxido de carbono? *Completa este grafico mientras que la clase discute que es la fuente con la mayoría de las emisiones de dióxido de carbono.*



Pictionary Activity (Spanish)

Actividad de Pictionary: *Abajo se presentan las tarjetas que se utilizaran para la actividad de Pictionary. Recorta las tarjetas antes de la clase y dar a cada grupo 4 tarjetas.*

Bombilla	Bombilla
Acondicionador de aire	Acondicionador de aire
Computadora	Computadora
Carro	Carro
Avión	Avión
Motora	Motora
Fábrica	Fábrica

Pila de Humo	Pila de Humo
Tren de Carga	Tren de Carga
Horno	Horno
Hoguera	Hoguera
Barbacoa	Barbacoa

Homework Activity (Spanish)

Nombre:____

Búsqueda del Tesoro

1. Encuentra una historia breve de alguien que usted conoce sobre como el cambio climático se le afecta. Escribe una descripción de la historia.

2. Encuentra un objeto (o un foto de ese objeto) que usted use, o describe una actividad de su propia vida, que emite gases invernadero.

3. Describe una manera nueva para usar este objeto o para cumplir este actividad en una manera que emite menos gases invernaderos.

Appendix K: Proposed Learning Unit (Translated) – Lesson 2

Lesson 2 Instructor Guide (Spanish)

Lección 2: Los Impactos de Cambio Climático

Diapositiva 13: Objetivos de Aprendizaje

Hora prevista: 1 minuto

Lea estos objetivos de aprendizaje a los estudiantes.

Los estudiantes serán capaces de:

5) Identificar los impactos predichos de una atmósfera más cálida, centrándose en el ciclo de agua y los océanos.

6) Determinar los impactos de cambio climático en los animales y las plantes de El Yunque, centrándose en los impactos de una temperatura aumentada y en cambios en patrones de precipitación.

7) Determinar los impactos del cambio climático en los seres humanos, especialmente cómo cambios en patrones de precipitación, aumentos en niveles océanos, y cambios en los hábitos de los animales y plantas afectan los seres humanos.

Objetivo: Informar los estudiantes de los objetivos de aprendizaje de la lección.

Diapositiva 14: ¿Qué causa una atmósfera más cálida?

Hora prevista: 3 minutos

Haga esta pregunta a los estudiantes, y hace que se ofrecen diversas respuestas basadas en la lección anterior. La pregunta se pretende ser una revista breve de los temas que los estudiantes aprendieron el día anterior durante la lección sobre las causas y evidencias de cambio climático. Continúe la discusión hasta que los estudiantes han proporcionado tres respuestas exactas. Respuestas posibles incluyen aumentos en las concentraciones de CO2, aumentos en las emisiones de los gases invernaderos, la continuación de deforestación, y la continuación de la quema de combustibles fósiles.

Objetico: Revisar lo que era discutido en la lección anterior por discutir cómo aumentos en concentraciones de CO2 causa a las temperaturas atmosféricas se aumentan.

Diapositiva 15: ¿Cuáles procesos naturales pueden ser afectados por una atmósfera más cálida?

Hora prevista: 5 minutos

Brevemente explique que una atmósfera más cálida afecta muchos ciclos y procesos naturales, incluyendo el ciclo de nitrógeno, el ciclo de carbono, y el ciclo de agua, entre otros. Está proporciona abajo explicaciones de estos ciclos así como una descripción de los impactos predichos de una atmósfera más cálida.

El ciclo de carbono – El ciclo de carbono, como se explica en la lección anterior, se inicia con la energía del sol. Se utiliza para la fotosíntesis en las plantas. Ambos las plantas y los animales pueden ser identificados como carbonos orgánicos. La respiración de animales y la quema de combustibles fósiles añaden CO_2 a la atmósfera. Además, las plantas y los animales contribuyen el carbono al suelo cuando descomponen. Los océanos actúan como sumideros de carbono y pueden absorber carbonos. Finalmente, hay depósitos de carbono que son atrapados en el hielo glacial y en roca madre, pero esto carbono no es muy accesible. Contribuciones antropogénicas al ciclo del carbono están fuertemente ligados al cambio climático. Una atmosfera mucha más caliente (debido al cambio climático antropogénico) indicaría que la distribución de carbono accesible diferiría mucho de cualquier otro periodo de la historia de la Tierra. Mirar a las niveles de CO_2 de los últimos 800.000 anos corrobora esta conclusión. Antes de la última década, se cree que los niveles de CO_2 en la atmósfera no se habían levantado más de 300 ppm.

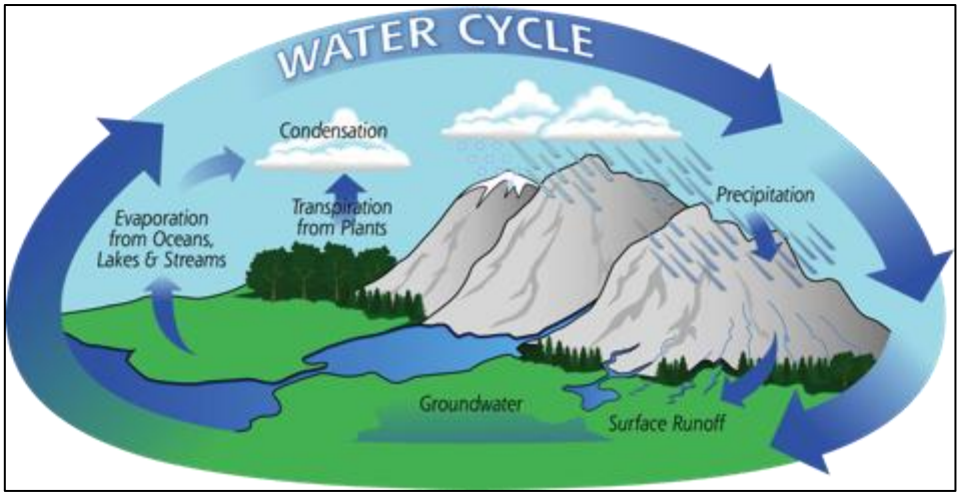
El ciclo de nitrógeno – El ciclo de nitrógeno contiene 4 procesos principales: la fijación de nitrógeno, amonificación, nitrificación, y desnitrificación. La fijación de nitrógeno es el proceso de convertir el gas de nitrógeno (N2) a amonio (NH_2^+). Este proceso se realiza principalmente por ciertas bacterias, y permite que ciertos organismos utilicen nitrógeno directamente de la atmósfera. Luego, amonificación se ocurre cuando el nitrógeno orgánico esta convertido a amonio por organismos que descomponen la materia, como diversos hongos. Después, el amonio se convierte en nitrato (NO_3^-) por las bacterias en el proceso conocido como nitrificación. Finalmente, los procesos anaeróbicos de desnitrificación ocurren, que se convierten el nitrato al gas de nitrógeno (N_2), gas de óxido nitroso (NO_2), óxido nitroso (N_2O) y óxido nítrico (NO). Debido a las actividades humanas, hay un exceso de las cantidades de óxidos de nitrógeno (NO_X) atmosféricos. Los óxidos de nitrógeno en este momento son el tercer mayor contribuyente del mundo a aumentos de la temperatura atmosférica. Esto es debido al aumento de la liberación de nitrógeno en la atmosfera durante la combustión de combustibles fósiles. Además, esta acumulación de nitrógeno se ha visto para afectar a la funcionalidad de los ecosistemas variados. Otros impactos humanos incluyen concentraciones de amoniaco (NH_3) aumentados, debido a un aumento en el uso de fertilizantes y el aumento de las concentraciones de óxido nítrico de elevada presencia de N_2 en la atmósfera en el siglo pasado.

El ciclo de agua – El ciclo de agua describe los movimientos colectivos de agua a través de biomas terrestres y oceánicas y de la atmósfera. Los procesos básicos involucradas en esto ciclo son evaporación, transpiración, precipitación, y condensación. Este proceso se describirá con mayor detalle en las siguientes diapositivas. El ciclo de agua se vería afectado en términos de aumento de la evaporación y la consiguiente disminución de las precipitaciones. Este fenómeno puede causar confusión para los estudiantes, ya que un error común sería creer que los aumentos de evaporación causan aumentos en precipitación. Esto es algo cierto, pero la anterior descripción no da cuenta de los patrones de vientos globales que afectan a las zonas tropicales y subtropicales. Los vientos en las zonas subtropicales (como Puerto Rico) llevan el aire cargado de humedad a los trópicos ecuatoriales, por lo tanto, causando el aumento de la precipitación en los trópicos pero precipitación disminuyendo en los subtrópicos.

Objetico: Explicar los impactos de una atmosfera más cálida en los procesos naturales (Objetivo de Aprendizaje 5)

Diapositiva 16: ¿Cuáles son los impactos específicos de una atmósfera más cálida en el ciclo de agua?

Hora prevista: 8 minutos



Muestra a los estudiantes el diagrama arriba. Explique los pasos que se indican abajo.

Evaporación: El cambio de agua líquida a vapor de agua.

$$[H_2O\ (l) + \text{Energía} \rightarrow H_2O\ (g)]$$

Condensación: El cambio de vapor de agua a agua líquida en la forma de nubes o niebla

$$[H_2O\ (g) \rightarrow H_2O\ (l) + \text{Energía}]$$

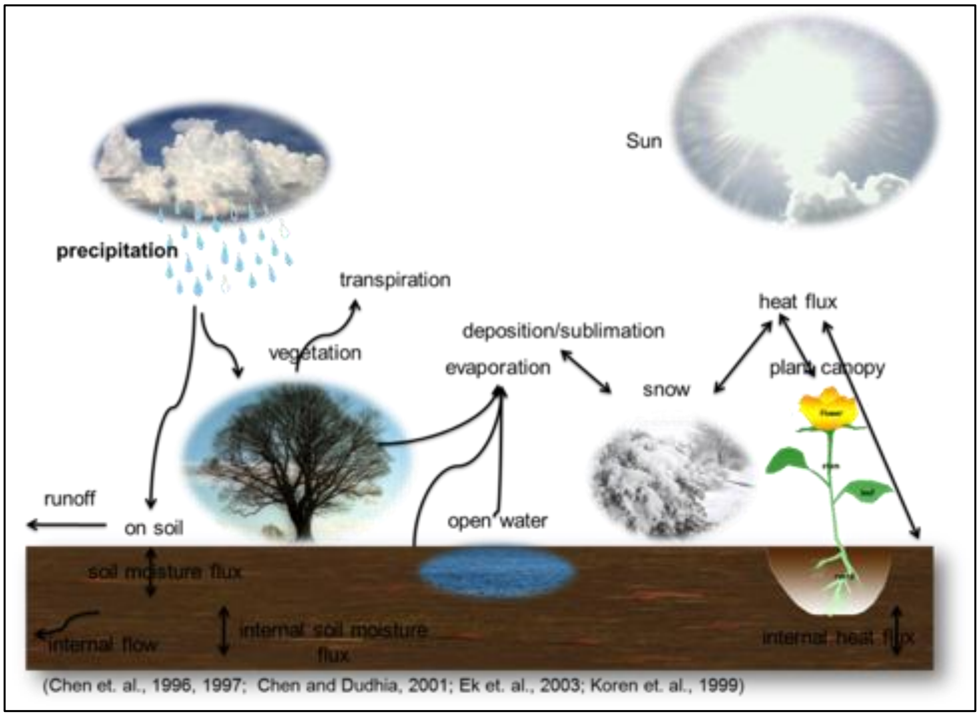
Transpiración: La evaporación del agua líquida de la vegetación. Se crea un efecto de enfriamiento cuando ocurre en escenarios de gran escala, como en selvas tropicales.

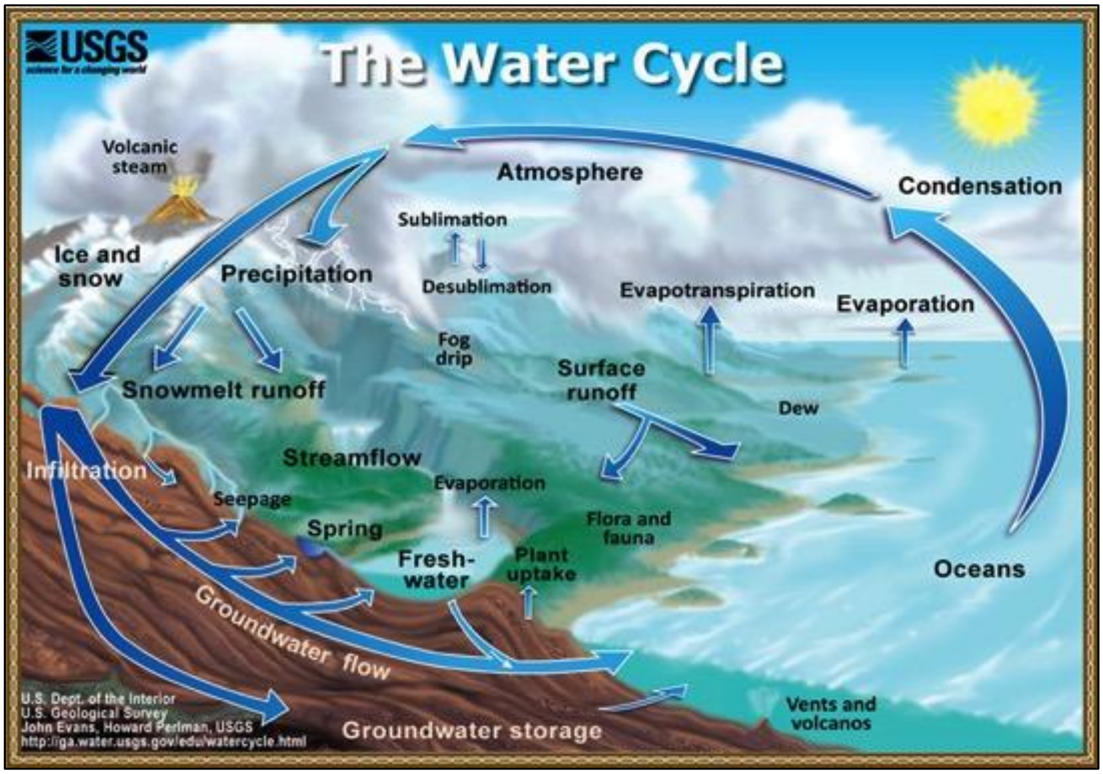
Escorrentía: La transferencia de agua líquida de un lugar físico a otro, por lo general de una elevación superior a una elevación inferior y/o a un cuerpo de agua.

Precipitación: La caída de agua líquida desde las nubes o niebla hacia abajo a la superficie de la Tierra. La precipitación puede tomar la forma de lluvia, granizo, nieve, aguanieve, y goteo de la niebla.

Siguiente, guía la clase en una investigación verbal por preguntar cómo una atmósfera más cálida podría afectar a cada uno de estos pasos. Es importante que encuadre los cambios que pueden ocurrir en el sentido amplio (es decir, cambios en las precipitaciones y en evaporación). Esto asegurará que esta discusión no sea demasiado centrada estrechamente en temas que no se trataran.

Dos representaciones más detalladas e integrales del ciclo de agua se proporcionan abajo para que instructores pueden mejorar sus conocimientos de algunas de las partes más complejas del ciclo de agua.



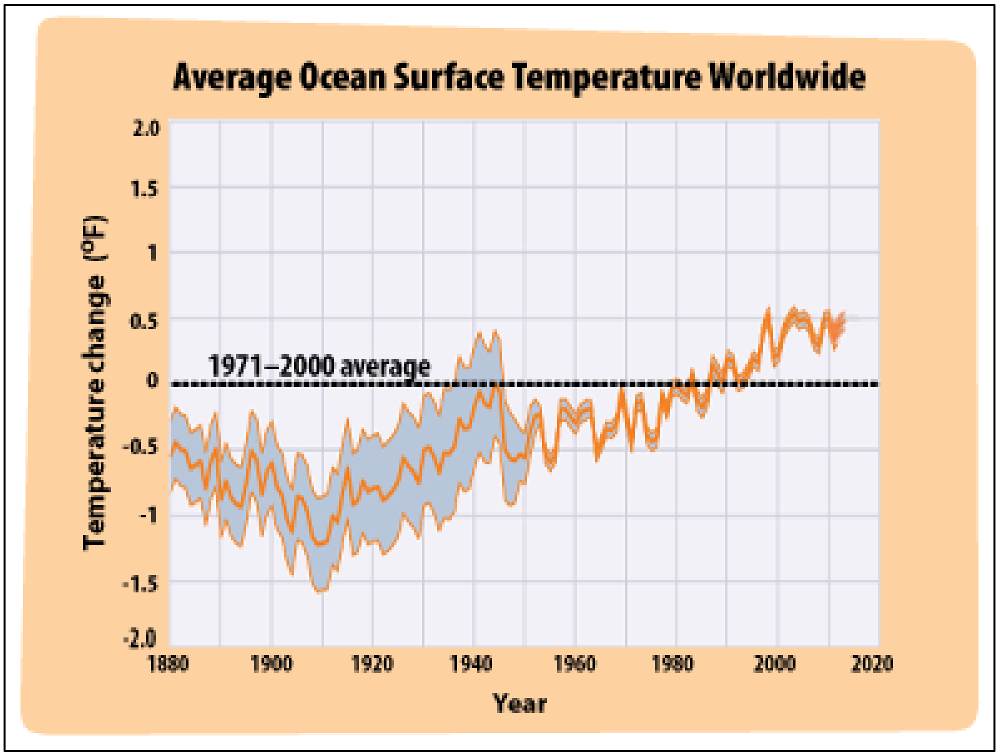


Objetivo: Explicar cómo una atmósfera más cálida afecta el ciclo de agua (Objetivo de Aprendizaje 5).

Diapositiva 17: ¿Cómo es que los océanos serían afectados por una atmósfera más cálida?

Hora prevista: 3 minutos.

Pregunta a los estudiantes cómo una atmósfera más cálida afecta a los océanos. Haga que los estudiantes proporcionan ideas diferentes. Si los estudiantes no proporcionan la respuesta "océanos más cálidos" después de dos minutos, usted debe proporcionar la respuesta. El gráfico siguiente se mostrará. Esto gráfico muestra el cambio en las temperaturas océanos desde el año 1880 hasta 2012, en comparación con la temperatura media de los océanos desde 1971 hasta 2000.



Objetivo: Describir cómo temperaturas aumentadas de la atmósfera pueden aumentar las temperaturas oceánicas (Objetivo de Aprendizaje 5)

Diapositiva 18: ¿Cuáles son posibles efectos ambientales de océanos más cálidos?

Hora prevista: 4 minutos

Pregunta a los estudiantes cuales son posibles efectos ambientales de océanos más cálidos y discute cada respuesta más a fondo. Luego, pregunta a los estudiantes cuales efectos de océanos más cálidos afectaría Puerto Rico en particular.

Respuestas posibles incluye la siguiente:

El aumento del nivel del mar – El hielo del mar comenzará a derretirse más rápidamente a medida que las temperaturas del océano aumentan, creando excesos de agua líquida que hará que los niveles del mar aumentan.

Composición química cambiado – Océanos más cálidos pueden actuar más fácilmente como sumidero de dióxido de carbono. Medida que más CO2 es añadido en el océano, el proceso químico de la creación de ácido carbónico ($CO_2 + H_2O \Leftrightarrow H_2CO_3$) ocurre en mayores cantidades. Esto puede dar lugar a pequeños cambios (o diferencias de potencial) en el pH del océano hacia niveles ácidos ($pH < 7$)

Cambios de arrecifes de coral – Mientras que la composición química de los océanos cambia, hábitats frágiles, como los arrecifes de coral van a cambiar, es decir al experimentar excesivo blanqueamiento de corales. Coral luego muere, eliminando habitas acuáticos principales.

La pérdida de la fauna acuática – Mientras que la composición química de los océanos cambia, ciertas especias de peces y plantas estarán mal adaptadas a las nuevas condiciones químicas. Además, muchas especias también serán incapaces de sobrevivir en aguas más cálidas y morirá como resultado.

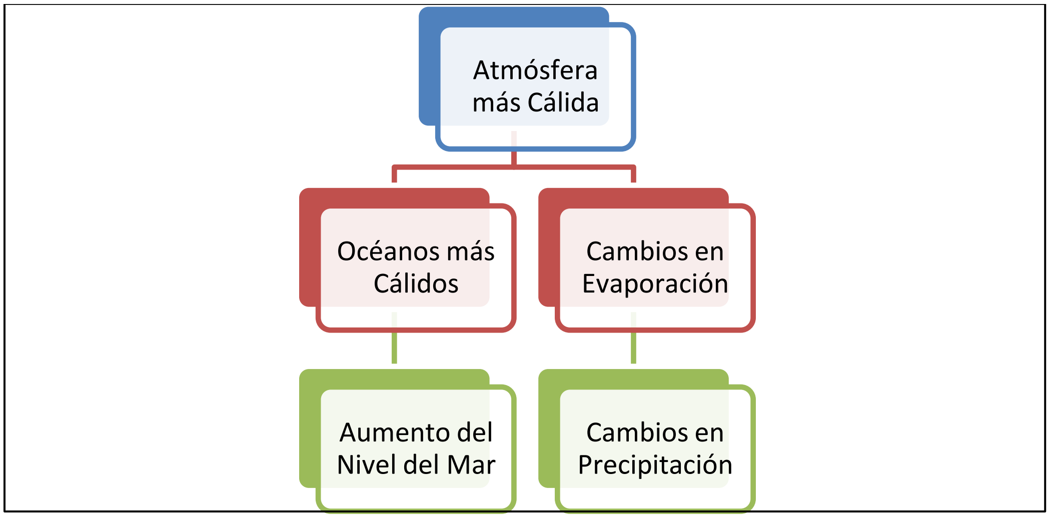
Cambios de hábitat – Las especies que no se adaptan bien a la subida de las temperaturas en los océanos se verán obligados a desplazarse a otras zonas que tienen condiciones que están más acostumbrados.

Objetico: Discutir los efectos de océanos más cálidos (Objetivo de Aprendizaje 5).

Diapositiva 19: ¿Cuáles son los impactos de una atmósfera más cálida en ciclo de agua?

Hora previsto: 4 minutos

Revise el siguiente diagrama con la clase para subrayar cómo una atmosfera más cálida puede causar océanos más calientes que pueden causar los niveles del mar se elevan. También pueden cambiar la evaporación, qué puede causar cambios en las precipitaciones.



Atmósfera más Cálida: Esto es causado por aumentos en las emisiones de gases invernaderos. Este efecto observado de calentamiento tiene un profundo impacto en el ciclo de agua. En particular, las tasas de todos los procesos de evaporación se aumentarían. Además, el aumento de la temperatura global debido al aumento del efecto invernadero llevaría a los océanos más cálidos.

Océanos más Cálidos: Los océanos similarmente experimentarían un efecto de calentamiento como un resultado de aumento del efecto invernadero. Estos océanos más cálidos llevarían a la aparición de muchos otros fenómenos, incluyendo la expansión térmica del agua de los océanos y el aumento del derretimiento del hielo marino.

Aumento del Nivel del Mar: Los niveles del mar podrían aumentar drásticamente si continua el cambio climático llegara a ocurrir. Esto es parcialmente debido a una ligera expansión térmica del agua a medida que se calienta. Este efecto suele ser muy minúscula cuando involucra pequeñas cantidades de líquido. Sin embargo, esta expansión sería mucho más grande y podría ser observado y medido cuando se produce en grandes cuerpos de agua, como el océano. Otra fuente de aumento del nivel del mar sería la fusión del hielo del mar y el derretimiento/ la escorrentía de los glaciares, lo que depositar el exceso de agua líquida en el océano.

Cambios en Evaporación: La evaporación se incrementaría en regiones tropicales mientras que las temperaturas globales aumentan. Esto podría ocurrir en todos los procesos que implican la evaporación, incluyendo la transpiración. La capacidad de la atmosfera para retener el agua se incrementaría en un 7%

por cada grado centígrado que la temperatura atmosférica aumenta. Esto permite una mayor capacidad de retener agua, lo que significa que el punto de saturación de la atmosfera para aguantar vapor de agua se convertiría en una mayor. En consecuencia, como la cantidad de agua que se mantiene en la atmosfera cambia, también lo hace en los patrones de precipitación.

Cambios en Precipitación: Dependiendo de la región, la precipitación podría aumentar o disminuir. Los patrones de viento son un factor crucial en si la precipitación aumentara o disminuirá. Regiones ecuatoriales, como el Amazonas, experimentarán aumentos en las precipitaciones. Esto es en gran parte debido a los vientos llevarán a los excesos de humedad evaporada a estas áreas. Puerto Rico es un área que, aunque variable en sus patrones de lluvia en toda la isla, experimentar una disminución general de la precipitación. Además, Puerto Rico experimentaría estaciones más extremas, con menos lluvia que cae en las estaciones secas y más lluvia que cae en la estación húmeda. El impacto más inmediato de una tendencia a la sequía en Puerto Rico seria el aumento de la probabilidad de sequías.

Objetivo: Repasar los efectos de una atmósfera más cálida en los océanos y en el ciclo de agua (Objetivo de Aprendizaje 5).

Diapositiva 20: Actividad del Cambio de Hábitat

Hora Prevista: 20 minutos

Objetivo: Ilustrar los efectos de cambios en las precipitación y el aumento de la temperatura global en los animales y las plantas (Objetivo de Aprendizaje 6).

Los estudiantes recibirán una actividad para ilustrar los efectos de cambios en las precipitaciones y el aumento de la temperatura global, específicamente en Puerto Rico.

Meta: Comprender los efectos del cambio climático en los hábitats de animales y plantas en El Yunque y cómo estos efectos se conectan y pueden causar cambios de hábitat para animales que son especies endémicas, o especies que sólo se encuentran en Puerto Rico.

A cada grupo de estudiantes se le proporcionará:

- Una foto de una montaña típica de Puerto Rico, etiquetado con diferentes descripciones de hábitats.
- Fotos de varios animales de El Yunque que son endémicas de Puerto Rico, incluyendo coquíes, cotorras, y reinitas de bosque enano.
- Fotos de diversas plantas de El Yunque que son nativas de Puerto Rico incluyendo la palma de sierra, aceitillo falso, y guineos
- Una hoja de instrucciones que describe la actividad, así como los requerimientos de hábitat para los diferentes animales y plantas.

<u>Instrucciones:</u>

- Divide a los estudiantes en grupos de 5

- Los estudiantes primero colocarán los diferentes hábitats en la imagen de la montana en función de sus niveles de temperatura y precipitación requeridos. Esta información se proporciona en las tablas que acompañan a esta actividad.
- Haga que los estudiantes colocan los animales proporcionados en sus correspondientes hábitats en la imagen de la montaña siguiendo sus respectivas descripciones y necesidades de hábitat. Específicamente, use el rango de temperatura, la dieta, posibles elevaciones, y las necesidades de precipitación de cada animal para determinar su colocación en el diagrama. Esta información se proporciona en las tablas que acompañan a esta actividad.
- Luego, los estudiantes se verán en cada escenario descrito abajo, y moverán cada hábitat de acuerdo a los cambios que se han producido debidos a que el cambio especifico de clima.
- Los estudiantes entonces moverán a los animales y plantas a nuevos lugares como la hoja de instrucciones describe los cambios de hábitat, que son reflejo de los cambios climáticos.
    - Nota: Si los animales no pueden ser colocados en cualquiera de los hábitats, deben ser dejados fuera de la página
- Los estudiantes reflexionarán sobre como el cambio climatice puede afectar a los distintos biomas y hábitats de los animales de Puerto Rico.

Los estudiantes escribirán sus respuestas a cada pregunta en las hojas de trabajo. Cuando todos los grupos han terminado, repase las preguntas con ellos. Los estudiantes deben ver la desaparición de los bosques enanos, así como la reinita de bosque enano. También verán que los hábitats de la mayor parte de las especies enumeradas se desplazarán a elevaciones más altas de la montaña.

Discute con los estudiantes que cambios en habitas no es algo solo hipotético, pero en realidad está pasando en Puerto Rico. Una especie que está experimentando actualmente cambio de su hábitat es la reinita de bosque enano. Actualmente esta especie se enfrenta a la desaparición de su hábitat principal, el bosque enano, y se ve obligada a trasladarse a hábitats a que no se está bien adaptada. Esta es una tendencia que se ha observado por los administradores de las especies del USFS en El Yunque. En caso de continuar las tendencias actuales del cambio climático, la reinita de bosque enano eventualmente desaparecería por completo de Puerto Rico. Tendencias similares se han observado en otras especies que son endémicas a Puerto Rico, o sólo se pueden encontrar en Puerto Rico, como la cotorra puertorriqueña.

Diapositiva 21: ¿Cómo es que los impactos de cambio climático predichos afecta a los seres humanos?

Hora prevista: 5 minutos

Pida a los estudiantes que piensen cómo cada uno de estos fenómenos (aumento del nivel del mar, cambios en los patrones de precipitación, cambios en los hábitats de animales y plantas) puede afectar a los seres humanos en Puerto Rico. Los efectos pueden incluir escasez de agua y escasez de alimentos, la perdida de zonas costeras, un clima más extreme y sus consecuencias económicas.

Según el Panel Intergubernamental sobre el Cambio Climático (IPCC), regiones como Puerto Rico, y como el Caribe en su conjunto, experimentarán disminuciones en la precipitación mientras que el cambio climático continúa ocurriendo al ritmo actual. Este es un motivo de preocupación para la isla de Puerto Rico, ya que muchos de sus hábitats son dependientes de las lluvias. Con la disminución de las lluvias, no habría impactos definitivos sobre los habitantes de Puerto Rico, incluyendo el aumento de potencial de las sequías y escasez de agua. Por otra parte, el informe de 2014 del IPCC sobre las pequeñas islas describir un gran medida los efectos humanos enfrentarían como resultado del cambio climático. Declaraciones particulares que captura muchas de las cuestiones Puerto Rico se enfrente son los siguientes:

> Desarrollo costero intensivo en la zona costera limitada, combinando con el crecimiento de la población y el turismo, ha puesto gran énfasis en la costa de algunas pequeñas islas y ha resultado en agregaciones densas de la infraestructura y la gente en lugares potencialmente vulnerables (pg. 1623).
>
> Fenómenos meteorológicos y climáticos extremos, como ciclones tropicales, tormentas, inundaciones y sequias pueden tener efectos tanto a corto como a largo plazo en la salud humana, incluyendo el ahogamiento, las lesiones, el aumento de la transmisión de enfermedades y problemas de salud asociados con el deterioro de la calidad del agua y la cantidad. La mayoría de los pequeños estados insulares son las zonas tropicales con clima favorables para la transmisión de enfermedades como la malaria, el dengue, la filariasis y la esquistosomiasis (pg. 1624).

Objetivo: Discutir los efectos del aumento del nivel del mar, el cambio de los patrones de precipitación, el cambio de los hábitats de animales y plantas en los seres humanos en Puerto Rico (Objetivo de Aprendizaje 7)

Habitat Activity (Spanish)

<u>Paso 1: Preparar</u>
Recorta los dibujos de cada uno de los animales y las plantas abajo, así como los nombres de los bosques.

Coquí:

Boa de Puerto Rico:

Aceitillo Falso:

Cotorra Puertorriqueña:

Lagartijo ramita de Puerto Rico:

Hormiguita de fuego:

Reinita de bosque enano:

Palma de Sierra:

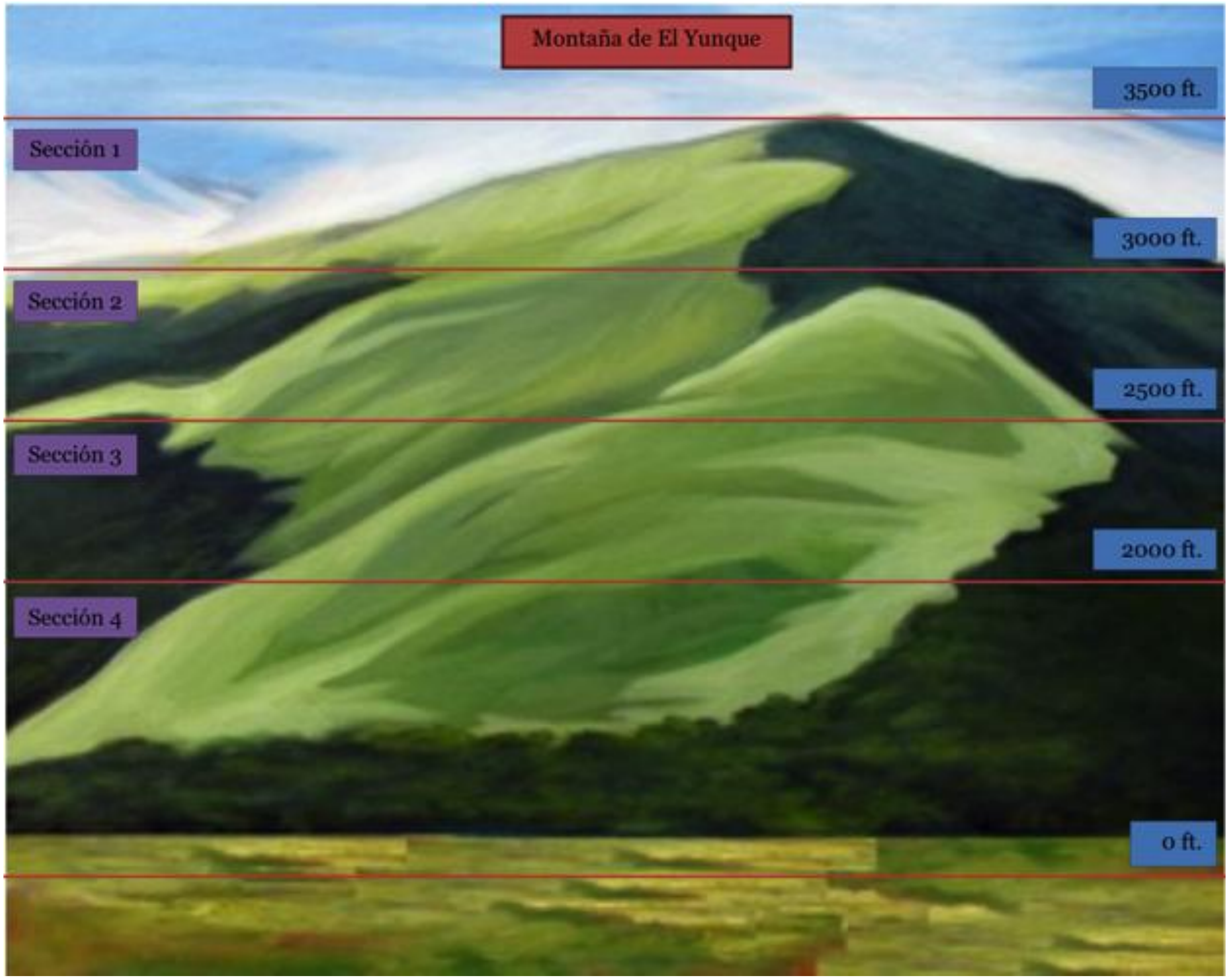
Guineos:

Bosque Tabonuco

Bosque del Palo Colorado

Sierra Bosque de Palmeras

Bosque Enano



Requisitos Forestales: Los bosques a continuación sólo pueden existir donde el nivel de precipitación y la temperatura promedio oscila coinciden con siguientes requisitos

Nivel del Bosque	Niveles de Precipitación (pulgadas/año)	Rango de Promedio Temperatura (° F)
Bosque Tabonuco	< 100	80– 85
Bosque del Palo Colorado	150- 180	75 – 80
Sierra Bosque de Palmeras	100-150	70 – 75
Bosque Enano	> 180	65 – 70

Requisitos de Animales y Plantas: Los animales y las plantas a continuación sólo pueden existir donde el nivel de precipitaciones, la temperatura promedio oscila, y la dieta coinciden con las siguientes requisitos

Animal	Rango de temperatura de hábitat (° F)	Rango de Precipitación de Hábitat (pulgadas/año)	Dieta	Depredadores
Coquí	65– 85	> 32	Insectos	Boa de Puerto Rico
Cotorra Puertorriqueña	70– 85	< 150	Plantas	Boa de Puerto Rico
Reinita de bosque enano	65– 75	< 200	Insectos	Boa de Puerto Rico
Boa de Puerto Rico	80– 85	< 100	Aves y Largatos	Ninguno
Lagartijo ramita de Puerto Rico	80– 85	< 100	Insectos	Boa de Puerto Rico
Palma de Sierra	70– 75	< 150	Fotosíntesis	Cotorra Puertorriqueña
Aceitillo Falso	80– 85	< 100	Fotosíntesis	Cotorra Puertorriqueña
Hormiguita de fuego	65 – 85	Any	Plantas	Aves y Largatos
Guineos	75 – 85	< 180	Fotosíntesis	Hormiguita de fuego y Cotorra Puertorriqueña

<u>Paso 2: El condición original</u>

De acuerdo a la condición original de abajo, coloque los bosques en la sección de elevación en el imagen de una montaña de El Yunque qué tiene los niveles de precipitación y temperatura promedio que se requieren para ese bosque. A continuación, coloque los animales y las plantas en la sección de elevación en el foto que tiene los niveles de precipitación, temperatura promedio, y la dieta que se requieren.

Condiciones Originales:

Sección	Elevación (ft. sobre nivel del mar)	Nivel de Precipitación (pulgadas/año)	Temperatura Media (° F)
1	**< 2000**	90	82
2	**2000-2500**	165	77
3	**2500-3000**	125	72
4	**> 3000**	190	67

<u>Paso 3: Los efectos de cambios en temperatura y en niveles de precipitación en los hábitats.</u>

Escenario 1: Los niveles de precipitación han disminuido respecto a sus niveles originales por 50 pulgadas por año.

Completa el siguiente grafico. Cambia los niveles de precipitación y cambia la temperatura media oscila de acuerdo con el escenario anterior.

Sección	Elevación (ft. sobre nivel del mar)	Nivel de Precipitación (pulgadas/año)	Temperatura Media (° F)
1	**< 2000**		82
2	**2000-2500**		77
3	**2500-3000**		72
4	**> 3000**		67

Mueva los bosques en la sección de elevación en la foto de una montaña de El Yunque. Asegúrese de que el bosque está en la sección de elevación de El Yunque qué tiene los niveles de precipitación y temperatura promedio que se requieren para ese bosque. A continuación, mueva los animales y las plantas en la sección de elevación qué tiene los niveles de precipitación, temperatura promedio, y la dieta que se requieren para ese bosque.

Escenario 2: Las temperaturas medias de todos los hábitats han aumentado 5°F de sus medidas originales

Completa el siguiente grafico. Cambia los niveles de precipitación y cambia la temperatura media oscila de acuerdo con el escenario anterior.

Sección	Elevación (ft. sobre nivel del mar)	Nivel de Precipitación (pulgadas/año)	Temperatura Media (° F)
1	**< 2000**	90	
2	**2000-2500**	165	
3	**2500-3000**	125	
4	**> 3000**	190	

Mueva los bosques en la sección de elevación en la foto de una montaña de El Yunque. Asegúrese de que el bosque está en la sección de elevación de El Yunque qué tiene los niveles de precipitación y temperatura promedio que se requieren para ese bosque. A continuación, mueva los animales y las plantas en la sección de elevación qué tiene los niveles de precipitación, temperatura promedio, y la dieta que se requieren para ese bosque.

Escenario 3: Los niveles de precipitación han disminuido respecto a sus niveles originales por 50 pulgadas por año y las temperaturas medias de todos los hábitats han aumentado 5°F de sus medidas originales

Completa el siguiente grafico. Cambia los niveles de precipitación y cambia la temperatura media oscila de acuerdo con el escenario anterior.

Sección	Elevación (ft. sobre nivel del mar)	Nivel de Precipitación (pulgadas/año)	Temperatura Media (° F)
1	**< 2000**		
2	**2000-2500**		
3	**2500-3000**		
4	**> 3000**		

Mueva los bosques en la sección de elevación en la foto de una montaña de El Yunque. Asegúrese de que el bosque está en la sección de elevación de El Yunque qué tiene los niveles de precipitación y temperatura promedio que se requieren para ese bosque. A continuación, mueva los animales y las plantas en la sección de elevación qué tiene los niveles de precipitación, temperatura promedio, y la dieta que se requieren para ese bosque.

Escenario 4: Los niveles de precipitación han disminuido respecto a sus niveles originales por 75 pulgadas por año y las temperaturas medias de todos los hábitats han aumentado 10°F de sus medidas originales

Completa el siguiente grafico. Cambia los niveles de precipitación y cambia la temperatura media oscila de acuerdo con el escenario anterior.

Sección	Elevación (ft. sobre nivel del mar)	Nivel de Precipitación (pulgadas/año)	Temperatura Media (° F)
1	**< 2000**		
2	**2000-2500**		
3	**2500-3000**		
4	**> 3000**		

Mueva los bosques en la sección de elevación en la foto de una montaña de El Yunque. Asegúrese de que el bosque está en la sección de elevación de El Yunque qué tiene los niveles de precipitación y temperatura promedio que se requieren para ese bosque. A continuación, mueva los animales y las plantas en la sección de elevación qué tiene los niveles de precipitación, temperatura promedio, y la dieta que se requieren para ese bosque.

Paso 4: Reflección

Contesta las siguientes preguntas.

1) ¿Qué se puede decir sobre el efecto que los cambios en los niveles de precipitación han sobre las plantas y los animales?

2) ¿Qué se puede decir sobre el efecto que los cambios en temperatura han sobre las plantas y los animales?

3) ¿Qué se puede decir sobre el efecto que los cambios en ambos la temperatura y los niveles de precipitación han sobre las plantas y los animales?

4) A medida que los hábitats de los animales cambian en respuesta a los escenarios anteriores, ¿qué se puede decir acerca de sus efectos en las cadenas de comida?

Appendix L: Proposed Learning Unit (Translated) – Post-test

Pos-Prueba

Dé a los estudiantes el siguiente pos-prueba al día siguiente de la realización de la lección 2. Este pos-prueba se centra en los objetivos de aprendizaje de la lección 1 y la lección 2. Las respuestas que se destacan abajo se corresponden con la respuesta correcta de cada pregunta.

Nombre:____

13. ¿Cuál de los siguientes no es un gas invernadero? (Objetivo de Aprendizaje 2)
    a. Dióxido de carbono
    b. Propano
    c. Metano
    d. El vapor de agua
14. ¿Cuál de los siguientes no es una manera en que la gente pueden disminuir emisiones de gases invernaderos? (Objetivo de Aprendizaje 4)
    a. Utilice iluminación natural durante el día
    b. Mudar de las ciudades a los suburbios
    c. Manejar un carro con un mayor rendimiento de gasolina
    d. Apagar dispositivos electrónicos cuando no esté en uso
15. ¿Cuál es la mayor fuente de emisiones de dióxido de carbono por el hombre? (Objetivo de Aprendizaje 4)
    a. Electricidad
    b. Transporte
    c. Industria
    d. Residencial / Comercial
16. ¿Qué es la relación entre las concentraciones de CO_2 en la atmósfera y la temperatura global? (Objetivo de Aprendizaje 1)
    a. Hay una correlación positiva
    b. Hay una correlación negativa
    c. No hay correlación
    d. Existe una correlación diagonal
17. ¿Cuál de los siguientes describe un efecto predicho del cambio climático en Puerto Rico? (Objetivo de Aprendizaje 7)
    a. Las estaciones serán más extrema. La estación seca se volverá mas seco, mientras que la temporada de lluvias será más húmedo
    b. 85% de la isla estará bajo el agua para el año 2050
    c. Un gran parte de las especies nativas desparecerá de Puerto Rico de los próximos 15 años
    d. Niveles de esmog aumentaran en San Juan debido a los aumentos de la temperatura media anual
18. ¿Cuál no es un efecto ambiental de los océanos más cálidos? (Objetivo de Aprendizaje 5)

a. El aumento del nivel del mar
b. Cambios de arrecifes de coral
c. Composiciones químicas cambiado
d. El aumento de las olas

19. De los siguientes, ¿cual es algo que los gases invernadero atrapan en la atmósfera? (Objetivo de Aprendizaje 2)
    a. Agua
    b. Oxígeno
    c. Dióxido de carbono
    d. La energía térmica
20. Expertos en cambio climático han dicho que el aumento de gases invernaderos pueden provocar un aumento de la temperatura atmosférica. ¿Cual no es un efecto de una atmosfera cálida? (Objetivo de Aprendizaje 5)
    a. Océanos mas cálidos
    b. Días más largos
    c. Cambio de condiciones para los animales y las plantas
    d. Mas evaporación
21. ¿Cuál de los siguientes es un efecto del cambio climático que afecta la vida silvestre? (Objetivo de Aprendizaje 6)
    a. Los gases invernaderos están envenenando los animales
    b. Los animales están emigrando más al norte de lo habitual
    c. Los animales están migrando en diferentes épocas del año de lo habitual
    d. Los gases invernaderos están afectando los patrones de reproducción
22. ¿Cuál de los siguientes no afecta directamente los niveles de carbono en la atmosfera? (Objetivo de Aprendizaje 3)
    a. Respiración de las plantas
    b. La respiración animal
    c. Descomposición de la materia orgánica
    b. La quema de combustibles fósiles
23. ¿Qué es un impacto en los seres humanos del cambio de los hábitats de animales y plantas? (Objetivo de Aprendizaje 7)
    c. El aumento de la contaminación acústica debido a superpoblación de los coquíes
    d. Bajo suministro de alimentos debido a cambios en patrones de precipitación
    e. Daño arquitectónico debido a las aves que anidan en edificios de la ciudad
    f. Aumento del crecimiento de las plantas venenosas en las zonas residenciales
24. ¿Cuál de los siguientes no es un efecto de cambio climático que está afectando Puerto Rico en este momento? (Objetivo de Aprendizaje 6)
    g. El aumento del nivel del mar
    h. Los cambios en los hábitats de los animales nativos
    i. Los cambios en los patrones de precipitación
    j. Disminución de la erosión costera

Conteste las siguientes preguntas con sinceridad y abiertamente. Sus comentarios se utilizarán y es muy apreciada.

1. ¿Disfrutó las dos últimas lecciones?
2. Mencione una cosa que te gustó de las lecciones.
3. Mencione una cosa que no te gustó de las lecciones.
4. ¿Tiene interés en aprender más sobre el cambio climático después de tomar parte en estas lecciones?
5. Mencione un tema adicional de cambio climático que le gustaría aprender acerca de que no se incluyó en las lecciones.
6. Mencione algo que usted no sabía antes de las lecciones que usted ahora sabe después de completarlas.

Appendix M: SPSS Output and Additional Graphical Analysis

SPSS Outputs

SPSS Output: Descriptive Statistics for all 5 Classes

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
FourH	19	50.00	16.67	66.67	36.8437	3.67827	16.03321	257.064
ClassThree	21	33.34	8.33	41.67	25.3976	2.60233	11.92537	142.215
ClassFour	24	58.33	.00	58.33	34.7221	3.15901	15.47593	239.504
ClassFive	23	41.67	.00	41.67	18.8400	2.88000	13.81201	190.772
ClassSix	21	50.00	8.33	58.33	29.7614	2.96417	13.58352	184.512
Valid N (listwise)	19							

SPSS Output: Paired Samples T Test within Subjects for 4-H Pre- and Post-test scores

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreTest	42.3092	13	15.38930	4.26822
	PostTest	55.7700	13	18.75370	5.20134

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreTest & PostTest	13	.427	.145

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	PreTest - PostTest	-13.46077	18.49061	5.12837	-24.63454	-2.28700	-2.625	12	.022

SPSS Output: ANOVA Test Comparing the 5 Classes

Descriptives

TestScores

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
4 H	19	36.8437	16.03321	3.67827	29.1159	44.5714	16.67	66.67
Class 9-3	21	25.3976	11.92537	2.60233	19.9693	30.8260	8.33	41.67
Class 9-4	24	34.7221	15.47593	3.15901	28.1872	41.2570	.00	58.33
Class 9-5	23	18.8400	13.81201	2.88000	12.8672	24.8128	.00	41.67
Class 9-6	21	29.7614	13.58352	2.96417	23.5783	35.9446	8.33	58.33
Total	108	28.9354	15.43162	1.48491	25.9917	31.8790	.00	66.67

SPSS Output: Independent Samples T Test between Class 9-2 and 9-3

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	9.20	19	4.4211	1.92399	.44139
	9.30	21	3.0476	1.43095	.31226

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00002	Equal variances assumed	1.531	.224	2.578	38	.014	1.37343	.53275	.29493	2.45193
	Equal variances not assumed			2.540	33.070	.016	1.37343	.54068	.27350	2.47337

SPSS Output: Independent Samples T Test between Class 9-2 and 9-4

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	9.20	19	4.4211	1.92399	.44139
	9.40	23	4.0435	1.79591	.37447

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00002	Equal variances assumed	.121	.730	.657	40	.515	.37757	.57497	-.78448	1.53963
	Equal variances not assumed			.652	37.389	.518	.37757	.57884	-.79486	1.55001

SPSS Output: Independent Samples T Test between Class 9-2 and 9-5

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	9.20	19	4.4211	1.92399	.44139
	9.50	23	2.2609	1.65742	.34560

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00002	Equal variances assumed	.210	.649	3.910	40	.000	2.16018	.55255	1.04344	3.27692
	Equal variances not assumed			3.853	35.820	.000	2.16018	.56059	1.02305	3.29732

SPSS Output: Independent Samples T Test between Class 9-2 and 9-6

Group Statistics

	VAR00001	N	Mean	Std. Deviation	Std. Error Mean
VAR00002	9.20	19	4.4211	1.92399	.44139
	9.60	21	3.5714	1.63007	.35571

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
VAR00002	Equal variances assumed	.628	.433	1.511	38	.139	.84962	.56213	-.28834	1.98759
	Equal variances not assumed			1.499	35.497	.143	.84962	.56689	-.30064	1.99989

Pre-test and Post-test Data for the 4-H Class:

Pre-test (Paired Samples)

Student #	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Total	Percentage
1	D	C	C	D	C	D	D	A	B	B	D	D	3	12	25.00%
2	B	A	C	B	B	B	A	A	D	B	B	C	8	12	66.67%
4	C	D	C	C	A	C	D	C	C	C	D	C	2	12	16.67%
5	B	D	A	B	D	D	C	C	C	B	C	D	5	12	41.67%
6	B	B	D	B	A	D	D	C	C	B	B	A	5	12	41.67%
7	D	NONE	B	B	B	D	D	B	C	B	B	A	4	12	33.33%
10	B	D	B	A	A	D	A	B	C	A	B	C	5	12	41.67%
11	D	B	D	A	A	D	A	D	C	B	B	D	5	12	41.67%
13	B	A	C	C	C	D	A	D	D	B	B	C	7	12	58.33%
14	D		C	D	A	B	B	B	D	D	B	A	3	12	25.00%
16	B	D	D	B	A	A	D	A	D	A	B	C	8	12	66.67%
17	B	A	C	B	C	A	A	C	C	C	B	C	5	12	41.67%
18	B	A	C	C	A	B	D	B	C	B	B	C	6	12	50.00%
ANSWER KEY:	B	A	D	B	A	D	C	A	D	B	B	C			
Score	8	4	3	6	7	7	1	3	4	8	10	7	CLASS AVE		5.38
	13	13	13	13	13	13	13	13	13	13	13	13	CLASS ST DEV		1.62
Percentage	61.54%	30.77%	23.08%	46.15%	53.85%	53.85%	7.69%	23.08%	30.77%	61.54%	76.92%	53.85%	CLASS MIN		3.00
													CLASS MAX		8.00

Post-test (Paired Samples)

Student #	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Column1	Percentage
1	B	B	A	A	C	D	A	B	B	C	B	D	9	12	75.00%
2	B	B	A	A	B	C	C	B	A	B	B	D	7	12	58.33%
4	D	C	C	C	C	C	B	C	A	A	B	B	1	12	8.33%
5	B	B	A	A	C	D	A	B	A	C	B	C	8	12	66.67%
6	B	B	A	B	C	C	D	B	C	C	B	D	9	12	75.00%
7	B	B	A	A	B	C	C	D	D	A	C	D	5	12	41.67%
10	B	B	B	B	A	C	C	B	C	C	B	D	8	12	66.67%
11	B	C	A	B	A	C	D	B	A	B	D	B	5	12	41.67%
13	B	A	A	B	C	C	B	B	B	C	B	D	6	12	50.00%
14	B	B	C	B	A	C	D	B	A	A	D	D	6	12	50.00%
16	B	B	C	A	C	D	D	B	C	D	B	D	9	12	75.00%
17	B	B	A	A	C	C	D	B	A	C	B	B	8	12	66.67%
18	B	B	A	C	A	C	C	B	B	C	B	B	6	12	50.00%
ANSWER KEY:	B	B	A	A	A	D	D	B	C	C	B	D			
Score	12	9	9	6	4	3	5	11	3	6	10	8	CLASS AVE		6.75
	13	13	13	13	13	13	13	13	13	13	13	13	CLASS ST DEV		2.24
Percentage	92.31%	69.23%	69.23%	46.15%	30.77%	23.08%	38.46%	84.62%	23.08%	46.15%	76.92%	61.54%	CLASS MIN		1.00
													CLASS MAX		9.00

Pre-test Scores: 9-2 Class

Student #	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Total	Percentage
1	D	C	C	D	C	D	D	A	B	B	D	D	3	12	25.00%
2	B	A	C	B	B	B	A	A	D	B	B	C	8	12	66.67%
3	B	D	B	C	C	D	A	A	A	B	B	D	5	12	41.67%
4	C	D	C	C	A	C	D	C	C	C	D	C	2	12	16.67%
5	B	D	A	B	D	D	C	C	C	B	C	D	5	12	41.67%
6	B	B	D	B	A	D	D	C	C	B	B	A	5	12	41.67%
7	D	NONE	B	B	B	D	D	B	C	B	B	A	4	12	33.33%
8	B	C	D	C	NONE	B	B	D	C	C	A	AB	2	12	16.67%
9	C	C	C	B	C	D	B	C	C	C	C	B	2	12	16.67%
10	B	D	B	A	A	D	A	B	C	A	B	C	5	12	41.67%
11	D	B	D	A	A	D	A	D	C	B	B	D	5	12	41.67%
12	B	C	C	D	A	C	A	D	C	C	D	B	2	12	16.67%
13	B	A	C	C	C	D	A	D	D	B	B	C	7	12	58.33%
14	D		C	D	A	B	B	B	D	D	B	A	3	12	25.00%
15	B	C	D	D	A	A	D	B	B	D	A	B	3	12	25.00%
16	B	D	D	B	A	A	D	A	D	A	B	C	8	12	66.67%
17	B	A	C	B	C	A	A	C	C	C	B	C	5	12	41.67%
18	B	A	C	C	A	B	D	B	C	B	B	C	6	12	50.00%
19	C	C	C	A	A	D	C	A	C	D	C	A	4	12	33.33%
ANSWER KEY:	B	A	D	B	A	D	C	A	D	B	B	C			
Score	12	4	5	7	10	10	2	5	4	9	11	7	CLASS AVE		4.31
	19	19	19	19	19	19	19	19	19	19	19	19	CLASS ST DEV		2.02
Percentage	63.16%	21.05%	26.32%	36.84%	52.63%	52.63%	10.53%	26.32%	21.05%	47.37%	57.89%	36.84%	CLASS MIN		2.00
													CLASS MAX		8.00

Pre-test Scores: 9-3 Class

Student #	Age	Sex	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Column1	Percentage (%)
1	14	F	C	A	C	A	B	C	D	C	A	D	A	B	1	12	8.33%
2	14	M	B	B	D	A	B	D	B	A	NONE	A	A	B	4	12	33.33%
3	14	F	A	C	B	B	D	A	A	C	C	B	C	C	3	12	25.00%
4	13	F	A	C	B	B	D	A	A	C	C	C	C	C	2	12	16.67%
5	14	F	D	A	C	D	A	D	A	A	B	B	A	B	5	12	41.67%
6	14	M	D	B	A	C	B	A	D	D	C	A	B	C	2	12	16.67%
7	14	M	D	A	C	D	A	D	A	A	B	B	A	B	5	12	41.67%
8	14	F	D	A	C	D	A	D	A	D	B	A	A	B	3	12	25.00%
9	15	F	D	A	C	D	A	D	A	A	B	B	A	B	5	12	41.67%
10	15	M	D	A	C	D	A	D	A	A	B	B	A	B	5	12	41.67%
11	14	F	B	C	D	C	D	C	D	B	C	A	B	C	4	12	33.33%
12	14	M	D	B	A	A	B	D	C	D	B	D	C	A	2	12	16.67%
13	15	F	A	C	D	C	D	D	C	D	C	C	D	B	3	12	25.00%
14	15	M	A	B	C	A	B	A	C	D	B	A	D	A	1	12	8.33%
15	14	M	D	A	B	A	B	D	C	A	C	A	A	B	4	12	33.33%
16	14	M	D	B	A	C	B	B	C	D	A	A	B	D	2	12	16.67%
17	14	M	C	A	A	C	D	A	B	C	D	D	A	C	3	12	25.00%
18	14	F	C	D	A	C	B	D	D	B	B	C	A	C	2	12	16.67%
19	14	M	B	MULTIPLE	MULTIPLE	A	D	C	B	A	C	D	A	B	2	12	16.67%
20	14	F	MULTIPLE	MULTIPLE	MULTIPLE	A	B	C	A	C	B	D	A	C	1	12	8.33%
21	14	F	C	A	A	A	A	C	C	A	C	B	A	D	5	12	41.67%
ANSWER KEY:			B	A	D	B	A	D	C	A	D	B	B	C			
		Score	3	9	3	2	6	10	6	8	1	6	3	7	CLASS AVE	3.05	
			21	21	21	21	21	21	21	21	21	21	21	21	CLASS ST DEV	0.00	
		Percentage	14.29%	42.86%	14.29%	9.52%	28.57%	47.62%	28.57%	38.10%	4.76%	28.57%	14.29%	33.33%	CLASS MIN	1.00	
															CLASS MAX	5.00	

Pre-test Scores: 9-4 Class

Student #	Age	Sex	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7	Q11 (O5	Q12 (O3)	Score	Total	Percentage (%)
1	14	M	A	C	C	C	C	D	C	A	B	C	C	A	3	12	25.00%
2	14	M	D	B	B	B	A	B	A	B	A	B	D	C	4	12	33.33%
3	14	M	D	B	B	B	A	C	D	D	A	B	D	C	4	12	33.33%
4	14	M	D	C	C	C	A	C	C	D	C	B	A	B	3	12	25.00%
5	14	M	B	C	A	D	A	A	A	B	C	B	MULTPILE	B	3	12	25.00%
6	14	F	D	A	D	C	B	C	D	B	B	D	B	B	3	12	25.00%
7	14	M	B	D	B	C	B	C	C	A	A	D	A	B	3	12	25.00%
8	14	F	B	C	B	C	A	C	D	B	C	C	C	A	2	12	16.67%
9	14	M	B	B	C	D	A	B	B	A	C	B	C	D	4	12	33.33%
10	14	F	B	C	B	C	D	A	C	A	D	B	D	C	6	12	50.00%
11	14	F	B	C	C	C	A	C	D	A	B	A	D	C	4	12	33.33%
12	14	F	B	C	D	C	A	C	D	A	B	B	D	B	5	12	41.67%
13	14	M	B	D	C	A	A	C	D	C	D	C	C	D	3	12	25.00%
14	15	M	B	A	B	B	C	D	A	A	B	A	B	C	7	12	58.33%
15	13	F	B	A	B	B	C	D	A	A	B	C	B	C	7	12	58.33%
16	14	M	B	A	B	B	C	D	C	C	C	D	B	C	7	12	58.33%
17	14	F	B	B	B	B	B	D	C	C	C	D	B	C	6	12	50.00%
18	14	F	B	B	D	D	A	B	C	C	A	B	C	D	5	12	41.67%
19	14	F	D	B	C	A	D	B	A	B	B	A	D	A	0	12	0.00%
20	14	F	B	B	D	D	A	B	D	C	A	B	B	C	6	12	50.00%
21	14	F	B	D	B	B	A	D	D	A	C	A	D	D	5	12	41.67%
22	14	M	B	D	B	C	C	C	A	D	B	A	B	B	2	12	16.67%
23	14	M	D	B	A	B	D	A	D	D	B	A	D	C	2	12	16.67%
24	14	M	B	B	C	D	B	A	C	A	A	B	B	C	6	12	50.00%
ANSWER KEY:			B	A	D	B	A	D	C	A	D	B	B	C			
		Score	17	4	4	8	12	6	8	9	2	10	7	11	CLASS AVE	4.24	
			24	24	24	24	24	24	24	24	24	24	24	24	CLASS ST DEV	0.00	
		Percentage	70.83%	16.67%	16.67%	33.33%	50.00%	25.00%	33.33%	37.50%	8.33%	41.67%	29.17%	45.83%	CLASS MIN	0.00	
															CLASS MAX	7.00	

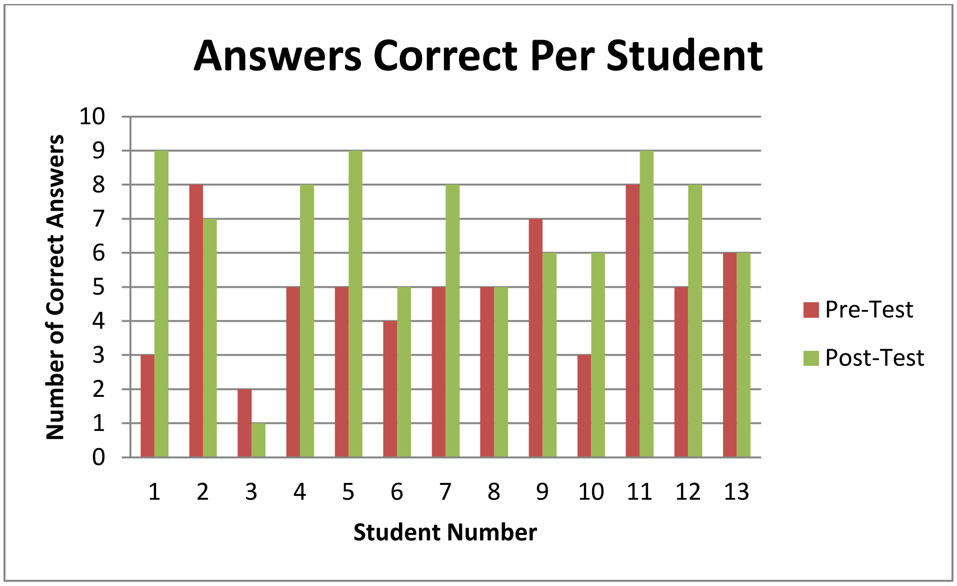
Pre-test Score: 9-5 Class

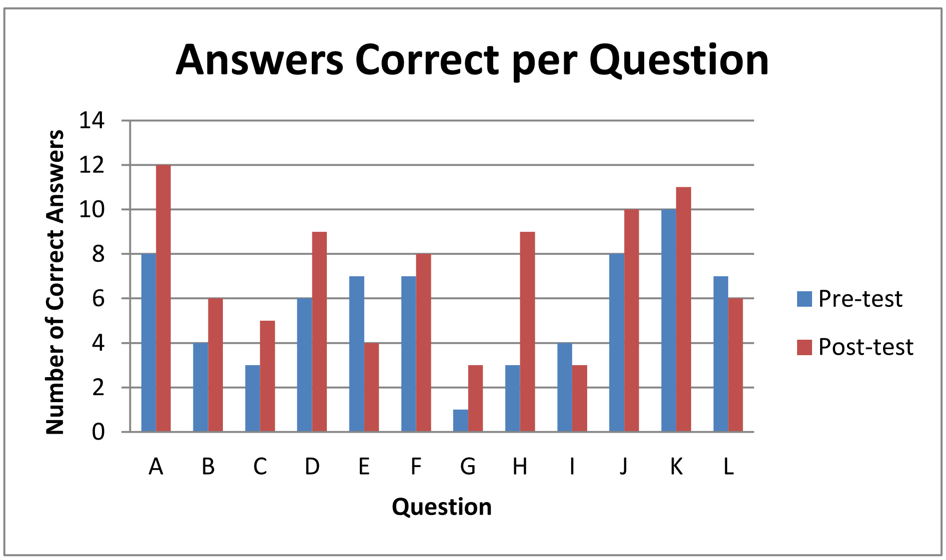
Student #	Age	Sex	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Total	Percentage (%)
1	14	M	D	B	A	C	B	D	A	C	C	A	D	B	**1**	**12**	8.33%
2	14	M	B	C	B	A	D	B	C	A	C	B	C	A	**4**	**12**	33.33%
3	14	M	B	B	B	C	C	B	C	D	B	A	C	B	**2**	**12**	16.67%
4	14	M	D	C	B	A	B	C	B	B	B	B	D	D	**1**	**12**	8.33%
5	14	F	D	B	A	D	C	B	A	A	D	C	A	C	**3**	**12**	25.00%
6	14	F	D	B	A	D	C	B	A	A	C	A	B	A	**2**	**12**	16.67%
7	14	F	D	B	B	D	C	B	A	D	A	D	D	B	**0**	**12**	0.00%
8	14	F	D	B	B	D	C	B	A	D	A	D	D	B	**0**	**12**	0.00%
9	15	M	B	A	B	B	A	B	A	A	B	C	B	A	**5**	**12**	41.67%
10	14	M	B	A	B	D	B	B	A	A	C	B	A	A	**4**	**12**	33.33%
11	15	M	D	D	C	D	A	C	A	A	B	B	D	C	**4**	**12**	33.33%
12	15	M	D	C	A	NONE	B	B	A	D	D	A	A	B	**1**	**12**	8.33%
13	14	F	A	B	B	D	B	C	B	A	C	A	D	A	**1**	**12**	8.33%
14	14	F	D	A	B	B	D	B	B	C	D	A	B	B	**4**	**12**	33.33%
15	14	M	D	B	A	C	A	D	C	B	B	C	B	A	**4**	**12**	33.33%
16	14	F	B	A	C	C	D	B	D	B	B	B	C	A	**3**	**12**	25.00%
17	14	F	B	A	C	C	D	B	D	B	B	B	C	A	**3**	**12**	25.00%
18	14	M	A	B	A	A	D	C	D	B	A	B	B	A	**2**	**12**	16.67%
19	14	M	A	D	C	C	B	B	B	D	C	A	D	A	**0**	**12**	0.00%
20	14	M	B	D	C	C	B	B	B	C	C	C	A	C	**2**	**12**	16.67%
21	14	M	A	D	B	C	B	A	C	D	C	NONE	D	A	**1**	**12**	8.33%
22	14	M	A	B	B	C	D	B	D	C	C	NONE	A	A	**0**	**12**	0.00%
23	14	M	C	A	B	C	B	D	C	B	A	B	B	A	**5**	**12**	41.67%
ANSWER KEY:			B	A	D	B	A	D	C	A	D	B	B	C			
		Score	7	6	0	2	3	3	5	7	3	8	6	3	**CLASS AVE**	2.24	
			23	23	23	23	23	23	23	23	23	23	23	23	**CLASS ST DE**	1.67	
		Percentage	30.43%	26.09%	0.00%	8.70%	13.04%	13.04%	21.74%	30.43%	13.04%	34.78%	26.09%	13.04%	**CLASS MIN**	0.00	
															CLASS MAX	5.00	

Pre-test Scores: 9-6 Class

Student #	Age	Sex	Q1 (O2)	Q2 (O1)	Q3 (O2)	Q4 (O4)	Q5 (O7)	Q6 (O6)	Q7 (O6)	Q8 (O4)	Q9 (O5)	Q10 (O7)	Q11 (O5)	Q12 (O3)	Score	Total	Percentage (%)
1	15	M	C	D	D	D	A	B	A	A	D	B	B	D	6	12	50.00%
2	15	M	B	A	D	C	B	D	B	B	B	B	A	A	5	12	41.67%
3	15	M	B	A	A	MULTIPLE	B	D	A	C	NONE	NONE	NONE	NONE	4	12	33.33%
4	14	M	B	A	B	C	A	D	B	A	B	B	A	B	6	12	50.00%
5	14	M	C	A	C	C	A	C	B	C	B	A	B	B	3	12	25.00%
6	14	F	A	C	B	B	A	D	C	C	D	B	A	C	7	12	58.33%
7	16	F	D	A	B	C	D	A	D	B	B	C	A	C	2	12	16.67%
8	14	F	B	D	B	C	D	B	C	B	A	B	D	C	4	12	33.33%
9	15	M	C	C	D	B	A	B	B	B	D	A	D	C	4	12	33.33%
10	14	F	D	C	D	A	C	A	D	B	C	A	C	D	1	12	8.33%
11	14	M	C	B	B	B	B	B	A	D	C	A	C	A	1	12	8.33%
12	14	F	A	B	B	A	C	D	B	A	C	B	D	B	3	12	25.00%
13	14	M	A	A	A	A	B	D	A	B	C	C	C	B	2	12	16.67%
14	15	M	D	A	C	A	D	A	A	A	A	B	A	C	4	12	33.33%
15	14	M	B	D	A	A	A	C	MULTIPLE	D	C	A	C	D	2	12	16.67%
16	15	F	A	A	D	D	C	B	D	B	B	C	B	D	2	12	16.67%
17	15	M	B	C	A	C	A	D	D	C	A	B	D	B	4	12	33.33%
18	14	M	B	B	C	A	A	C	D	B	D	A	A	B	3	12	25.00%
19	14	M	C	A	D	A	B	A	D	B	D	C	A	B	3	12	25.00%
20	13	M	B	B	D	A	B	B	C	C	D	C	B	A	5	12	41.67%
21	14	M	D	D	C	C	C	A	C	A	D	B	C	A	4	12	33.33%
ANSWER KEY:			B	A	D	B	A	D	C	A	D	B	B	C			
		Score	8	9	7	2	8	7	4	5	7	9	4	5	CLASS AVE	3.57	
			21	21	21	21	21	21	21	21	21	21	21	21	CLASS ST DEV	0.00	
		Percentage	38.10%	42.86%	33.33%	9.52%	38.10%	33.33%	19.05%	23.81%	33.33%	42.86%	19.05%	23.81%	CLASS MIN	1.00	
															CLASS MAX	7.00	

Additional Graphs: Comparing Pre- and Post-tests of the 4-H Group





Question Letter	Pre-test Question Number	Post-test Question Number
A	1	1
B	2	4
C	3	7
D	4	2
E	5	5
F	6	12
G	7	9
H	8	3
I	9	6
J	10	11
K	11	8
L	12	10

Appendix N: Revised Lesson PowerPoint Presentation

Lesson 1: Causes and Evidences of Climate

Students will be able to:

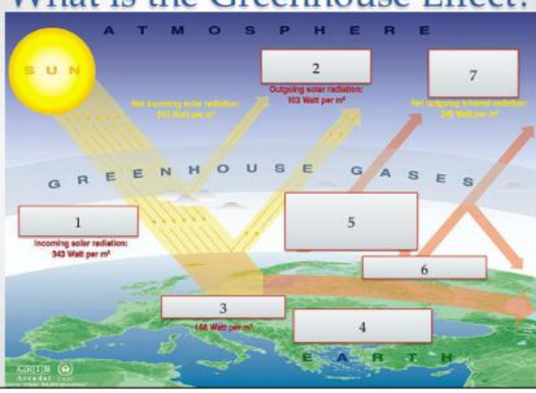
- Identify an evidence of climate change, focusing on the relationship between CO_2 concentrations and atmospheric temperature.
- Describe the greenhouse effect and identify the gases involved in it.
- Describe how carbon enters the atmosphere as depicted by the carbon cycle
- Identify sources of CO2 emissions

ANTHROPOGENIC CLIMATE CHANGE

What does anthropogenic mean?

What does climate mean?

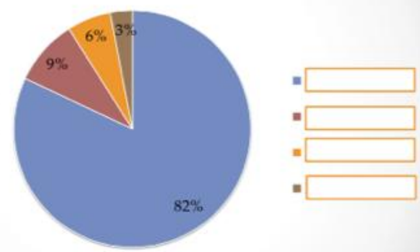
What is the Greenhouse Effect?



Which Greenhouse Gas has the greatest emissions?

List of terms:

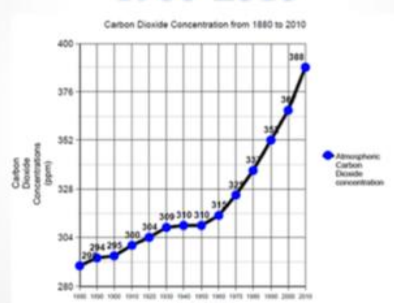
- Fluorine Gases
- Methane
- Carbon Dioxide
- Nitrous Oxides



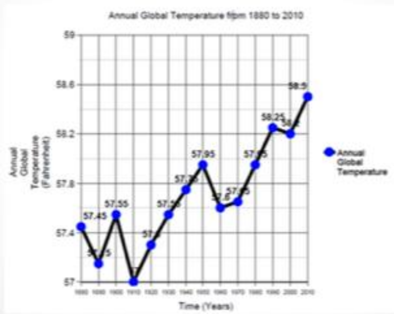
Global temperatures vs. CO_2 concentrations

- Split into pairs
- Using the table provided in your worksheet, have one person create the graph for global temperatures and one person create the graph for CO2 concentrations.
- Now compare these two graphs. What is the correlation between global temperature and CO2 concentrations?

CO2 Concentrations: 1980-2010



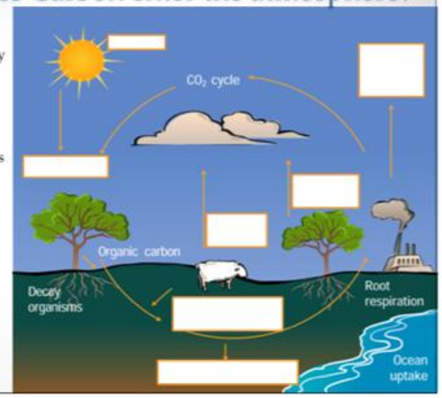
Global Temperature: 1980-2010



How does Carbon enter the atmosphere?

Word Bank:

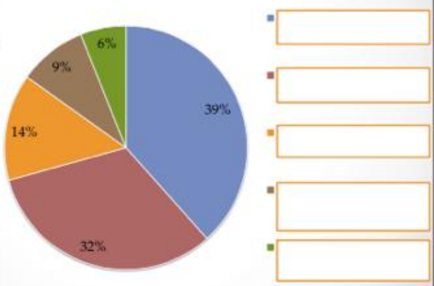
- Auto and factory emissions
- Animal Respiration
- Dead Organisms and waste productions
- Fossils and Fossil Fuels
- Plant Respiration
- Photosynthesis
- Sunlight



Which is the highest source of Carbon dioxide emissions?

Word Bank:

- Burning fossil fuels for Transportation
- Fossil fuel consumption to produce Electricity
- Residential and Commercial use of fossil fuels
- Other (Non fossil fuel combustion)
- Industrial use of fossil fuels



Activity: Pictionary

Sources of CO2 emissions

- The teacher will split you up into groups of four or five.
- Pick a person to start
- Start the timer for one minute
- The first person to start will draw a source of CO2 emissions
- The rest of the group will try to guess what the source is before time is up

So how can we reduce CO2 emissions?

Homework

Students will complete the following activities, like a scavenger hunt.

- Find a brief story from someone you know about how Climate Change affects him or her. Write down a description of this story.
- Find an object (a picture or the object) you use or describe an activity you encounter in your life that emits greenhouse gases.
- Describe a new way to use this object or complete this activity in a way that emits less greenhouse gases.

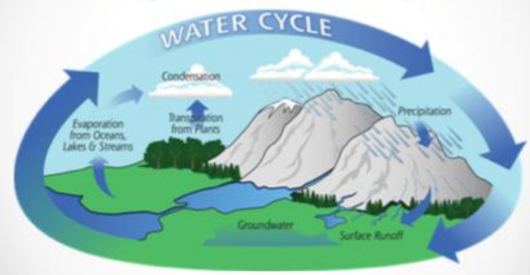
Lesson 2: Impacts of Climate Change

Students will be able to:

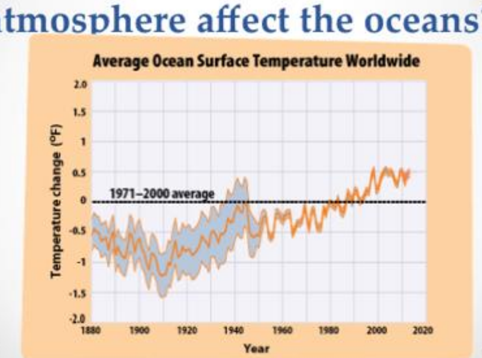
- Identify the predicted impacts of a warmer atmosphere on the earth, focusing on the water cycle and oceans
- Determine the impacts of climate change on animals and plants in El Yunque, focusing on the impacts of rising temperature and changing precipitation patterns.

What are some natural processes that can be affected by a warmer atmosphere?

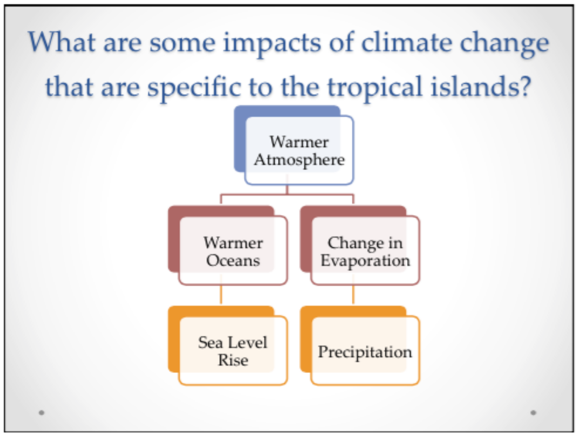
What are the impacts of a warmer atmosphere on the water cycle?



How would a warmer atmosphere affect the oceans?



What are possible environmental effects of warmer oceans?


What are some impacts of climate change that are specific to the tropical islands?
Warmer Atmosphere
Warmer Oceans
Change in Evaporation
Sea Level Rise
Precipitation


Habitat Shift Activity

Appendix O: Revised Learning Unit - Lesson 1

Pre-Homework

The students will be asked to watch a segment of an episode of Mythbusters entitled "Mythbusters tests global warming theory - does CO_2 warm air?" on Youtube at the following link:
https://www.youtube.com/watch?v=pPRd5GT0v0I

This video describes the greenhouse effect through an experiment. The Mythbusters set up three transparent boxes; one filled with CO2, one filled with methane and the other set as control. They placed an ice sculpture in each box and shined the same degree of light on each box. They then monitor the temperature differences between the three boxes over a period of time.

Lesson 1: Causes of Climate Change

Lesson Materials:

- Climate Change PowerPoint (Lessons 1 and 2)
- Lesson 1 worksheets
- Pictionary Activity
- Scissors
- Timer
- Homework activity

Slide 1: Learning Objectives

Estimated time*:* 1 minute

Purpose*:* Inform students of the learning objectives for the lesson.

Instructions:

Read these learning objectives to the students.

Students will be able to:

1. Identify an evidence of climate change, focusing on the relationship between CO_2 concentrations and atmospheric temperature.
2. Describe the greenhouse effect and identify the gases involved in it.
3. Describe how carbon enters the atmosphere as depicted by the carbon cycle
4. Identify sources of CO2 emissions

Slide 2: Climate Change:

Estimated time: 3 minutes

Purpose: This slide provides an introduction to the concepts of climate and weather, as well as establishing a basic definition of anthropogenic climate change.

Instructions:

- Split students into pairs and pass out the Lesson 1 Worksheet to each pair of students.
- Ask the class to define each of the words in "anthropogenic climate change".

> **Anthropogenic-** can be defined as "caused or produced by humans".
>
> **Change -** can be defined as "to make the form, nature, content, future course, etc., of (something) different from what it is or from what it would be if left alone". Change denotes a difference between two states of being
>
> **Climate-** can be defined as "the long-term precipitation and temperature patterns of an area".

- State that this lesson will primarily cover anthropogenic climate change.

Some follow-up questions you can ask are:

> **"What is the difference between weather and climate?"**
> Weather is the short-term patterns of precipitation and temperature such as a hot day or a thunderstorm while climate is the long-term patterns.
>
> **"What is the climate in Puerto Rico?"**
> Tropical

Additional Information:

The Environmental Protection Agency's website says the following about natural climate change: Estimates of the Earth's changing carbon dioxide (CO_2) concentration (top) and Antarctic temperature (bottom), based on analysis of ice core data extending back 800,000 years. Until the past century, natural factors caused atmospheric CO_2 concentrations to vary within a range of about 180 to 300 parts per million by volume (ppmv). Warmer periods coincide with periods of relatively high CO_2 concentrations. NOTE: The past century's temperature changes and rapid CO_2 rise (to 390 ppm in 2010) are not shown here.

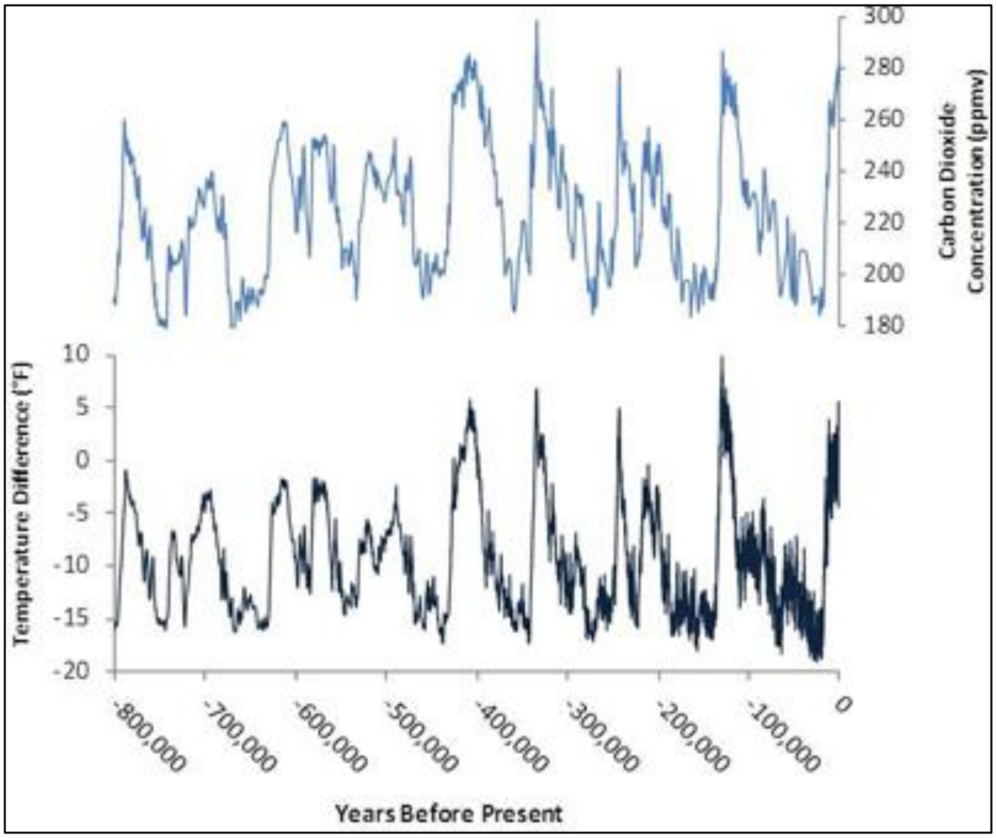


Figure 31: Natural climate change over the Earth's history

Slide 3: What is the greenhouse effect?

Estimate time: 6 minutes

Purpose: Illustrates how solar energy heats the Earth and how greenhouse gases in the atmosphere increase the absorption of infrared heat in the Earth's atmosphere (Objective 2).

Instructions:

- Ask students what they believe the definition of a greenhouse gas to be and for examples of greenhouse gases. Below is the formal definition of a greenhouse gas as well as the examples of greenhouse gases.

  Greenhouse gas- any gas that absorbs infrared radiation produced by solar warming of the Earth's surface (Dictionary.com).

  Examples- carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_x), and water vapor (H_2O [g]).

- Ask students what they learned about the greenhouse gas effect from the Mythbusters video the students watched the previous night for homework. Below is a formal definition of the greenhouse effect.

  The greenhouse effect- an atmospheric phenomenon in which infrared radiation of short wavelengths is easily transmitted into the Earth's atmosphere (specifically the troposphere), while infrared radiation of longer wavelengths is less easily transmitted out of the atmosphere (specifically the troposphere) due to its absorption by atmospheric greenhouse gases (dictionary.com).

- Explain the analogy of the greenhouse effect being an actual greenhouse. In this analogy, the atmosphere is like the "glass" of the greenhouse. Thermal energy from the sun is allowed to pass into the "glass", yet is partially unable to pass back out of the "glass". This trapped energy then increases the temperature within the greenhouse.

- Go through each of the steps of the greenhouse effect. Ask the students what they think is happening at each designated location on the diagram. Below are the descriptions of what is occurring at each part of the diagram.

  Point 1: Solar radiation passes into the Earth's atmosphere.

  Point 2: Some of this radiation is reflected back into space by the atmosphere and Earth's surface.

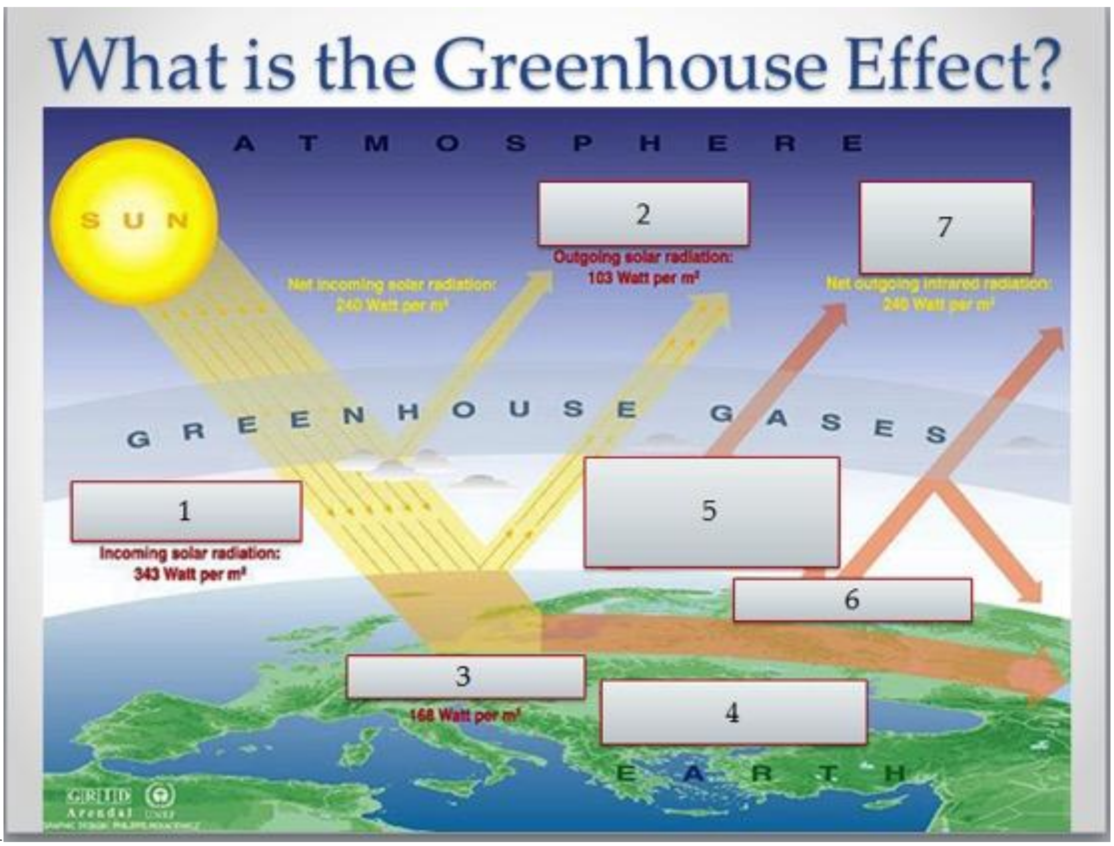
  Point 3: The remaining radiation that was not reflected outward is then absorbed by the Earth's surface.

Point 4: The solar radiation that was absorbed by the Earth's surface is converted to thermal heat. This thermal energy heats the Earth's surface and is then radiated back out from the surface.

Point 5: A portion of the radiated thermal energy is absorbed by atmospheric greenhouse.

Point 6: The portion of thermal energy that was not absorbed by the greenhouse gases travels back to the surface where it is emitted outward yet again.

Point 7: This thermal energy is reflected back off the surface of the earth and back out to space.



1

Figure 32: Greenhouse Effect diagram

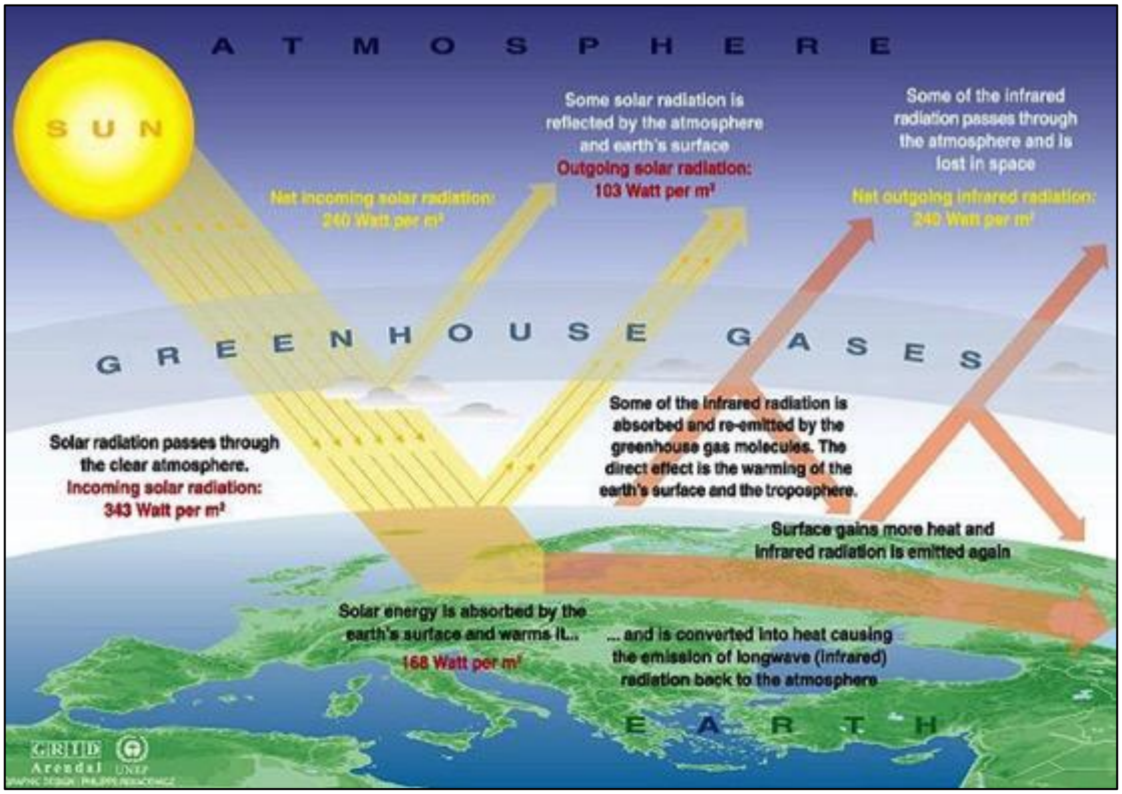


Figure 33: Diagram of the greenhouse effect (GRID Arendal and UNIP)

Slide 4: Which greenhouse gas has the greatest emissions?

Estimated time: 5 minutes

Purpose: Defines the different greenhouse gasses (Objective 2).

Instructions:

- Ask the students what they believe is the greenhouse gas with the highest emissions and then reveal the answer.

  The answers include CO_2 (carbon dioxide), CH_4 (methane), NO_x (nitrous oxides), F-gases (Fluorocarbons).

- Ask what they believe is the second greenhouse gas with the highest emissions and then reveal the answer.

- Continue in this manner, until all four of the greenhouse gases are revealed. Have students fill out their own graph as it is discussed.

The pie chart below will be provided to students, however the titles will be removed.

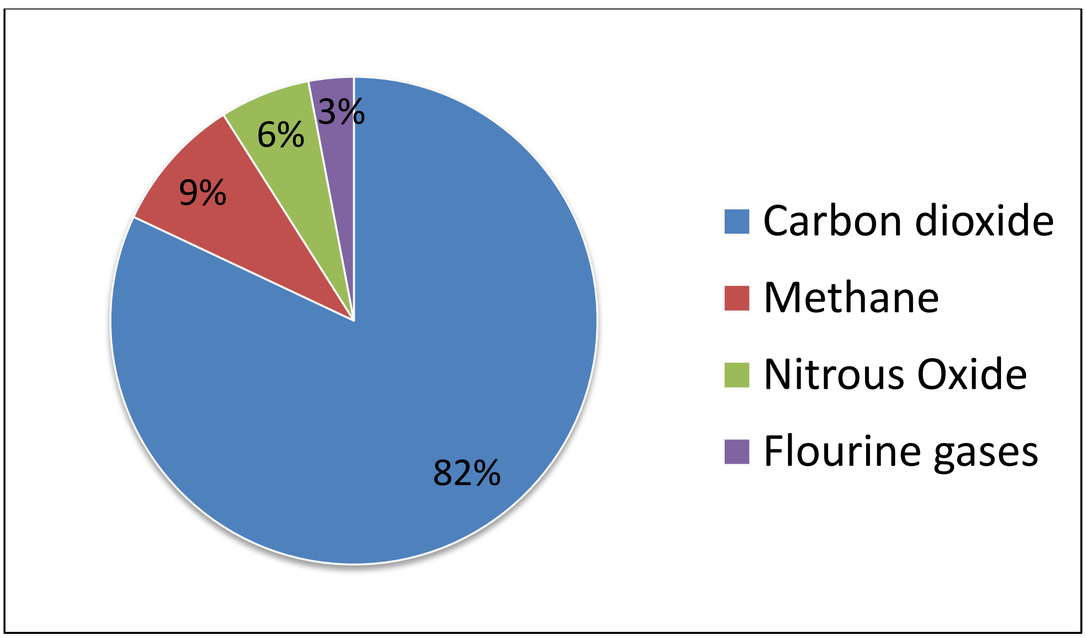


Figure 34: Relative percentage of greenhouse gases in terms of greenhouse gas emission levels (Environmental Protection Agency)

- Explain that these gases are not necessarily bad for the environment. Carbon dioxide is only an issue because it is currently present in the highest amounts recorded in the Earth's history. It is for this reason that the remainder of the lesson will focus on the effects of carbon dioxide concentrations on mean global temperature.

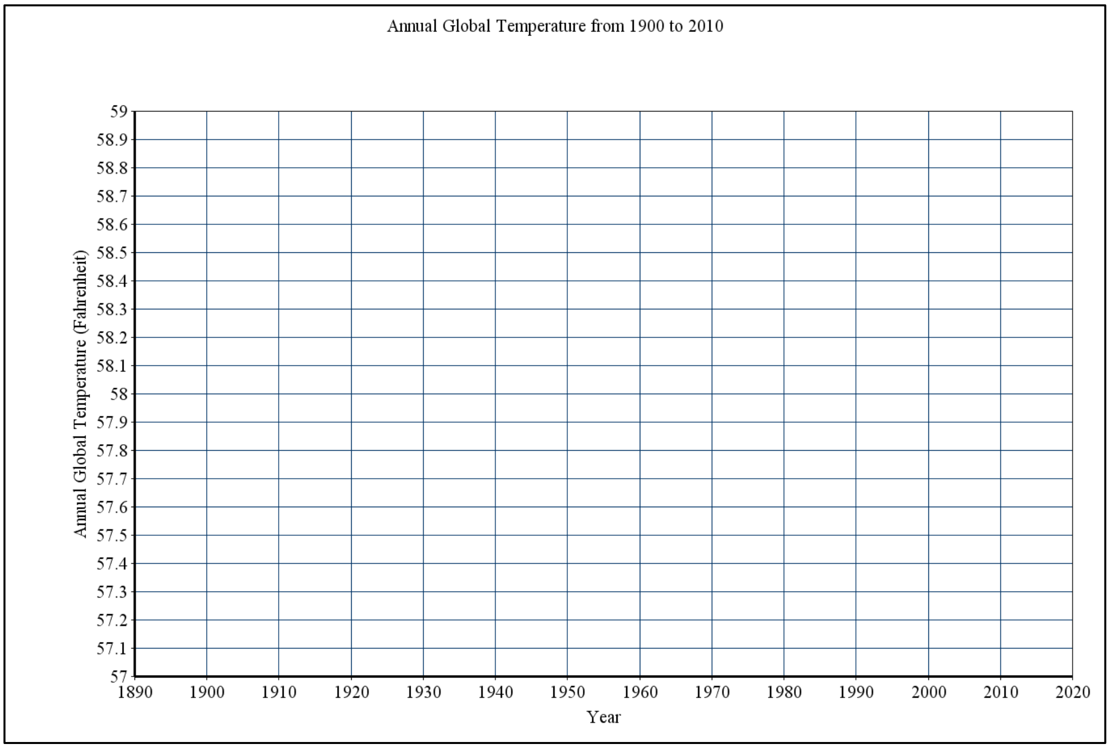
Slides 5 - 7: Evidence of Climate Change Graph:
Estimated time: 10 minutes

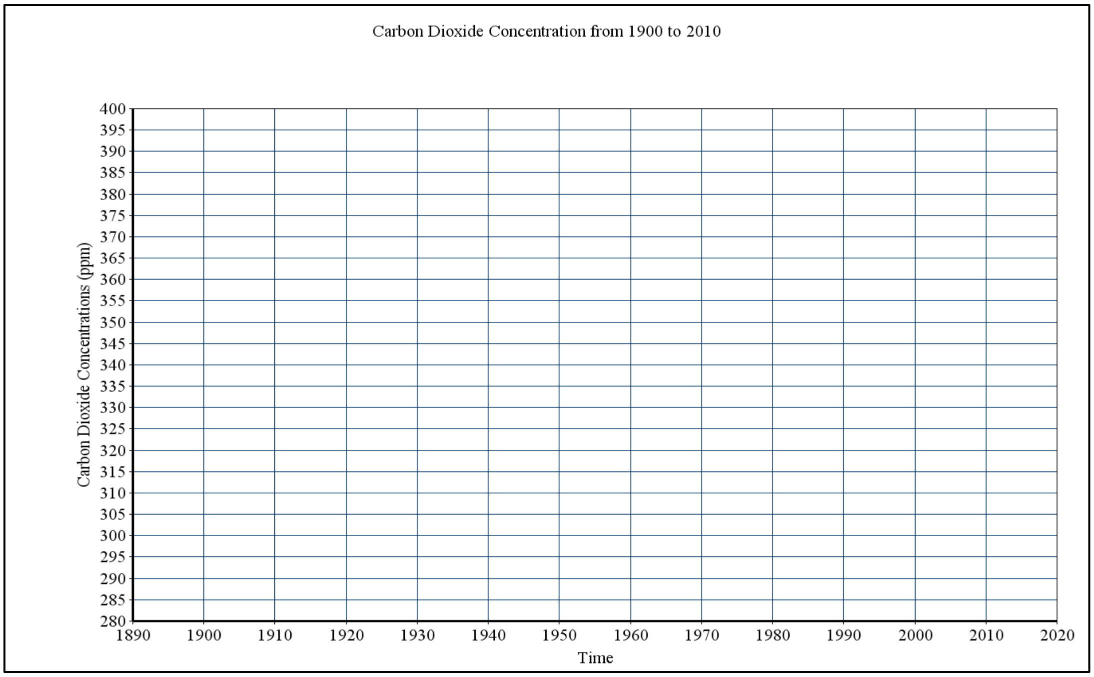
Purpose: Have students identify evidence of anthropogenic climate change by proving that increases in CO_2 concentrations are *positively correlated* with increases in global temperature (Objective 1).

Instructions:

- Ask students to fill in the graphs in their worksheets. Students will work in pairs, with one student creating the CO_2 concentration graph and the other creating the temperature graph. Give the students 5 minutes to complete their graphs. Give the students another minute to compare the two graphs that they have created.

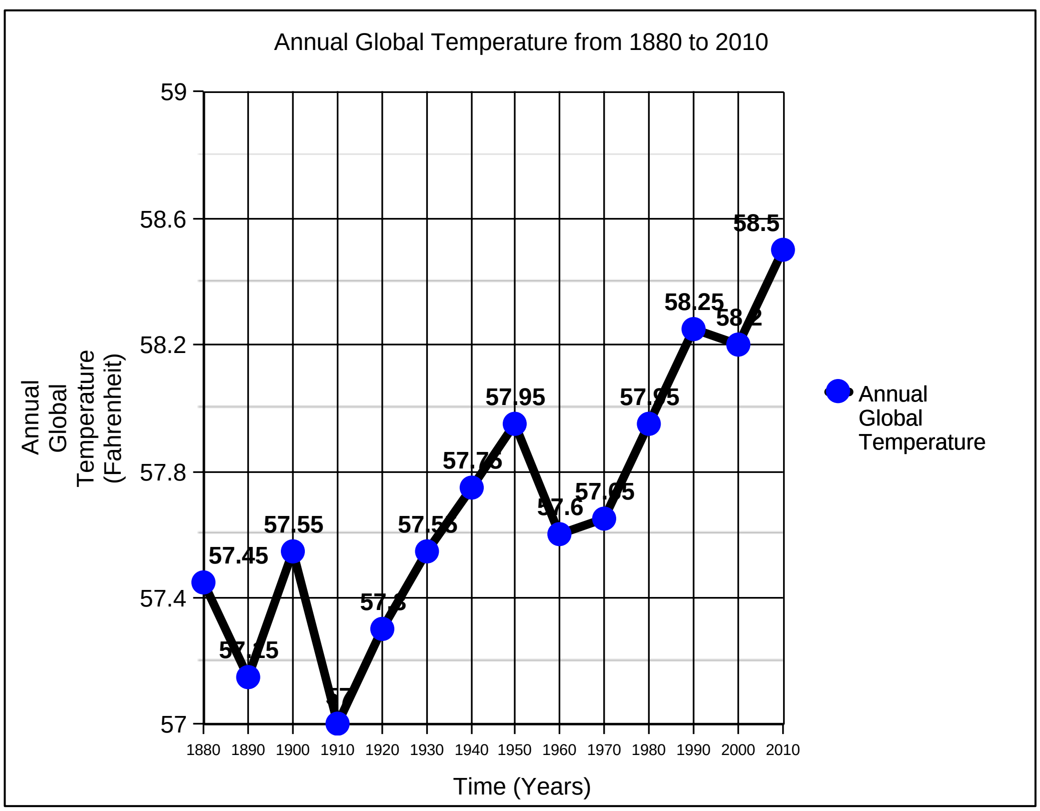
Provided below are the two blank graphs that are provided to students in the worksheet packet.

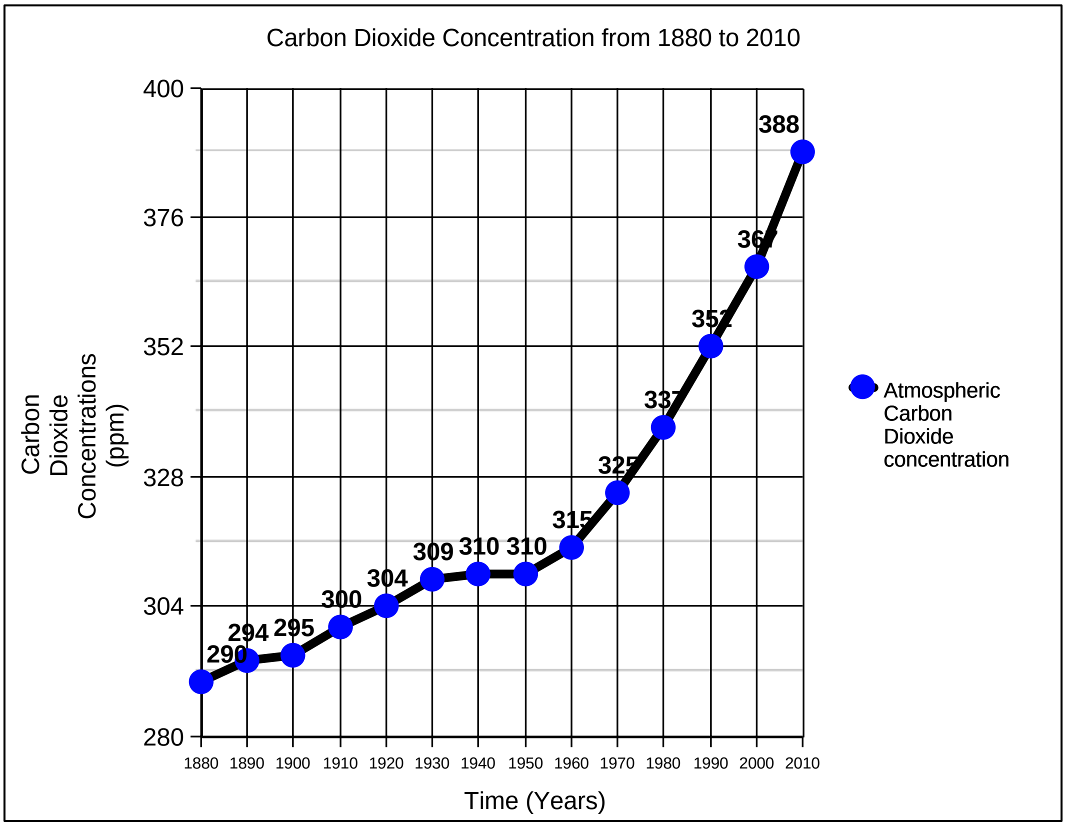




- Go over the graph and have students correct their graphs if necessary. Ask the students what they think this graph means. Discuss with students the *correlation* between CO_2 concentrations and global temperature.

  The completed graphs should look similar to the graphs below.





- Ask students to apply their knowledge of greenhouse gases to the findings of their graphs. What predictions can be made? The prediction that should be made is as follows: increasing CO_2 concentration will *cause* atmospheric temperatures to increase.

Note: The data for these graphs was extrapolated from the graph in Figure 3.

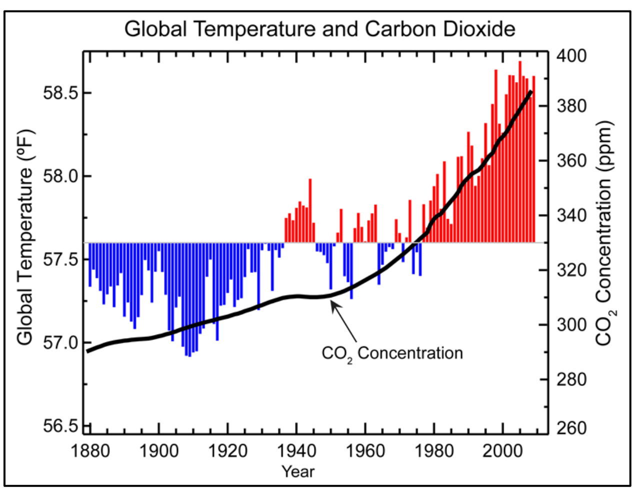


Figure 35: A Comparison of Carbon Dioxide Concentrations and Global Temperature over the last century (National Oceanic and Atmospheric Administration)

***Additional Information*:**

Provided below are additional representations of the increases in greenhouse gases and temperature, respectively.

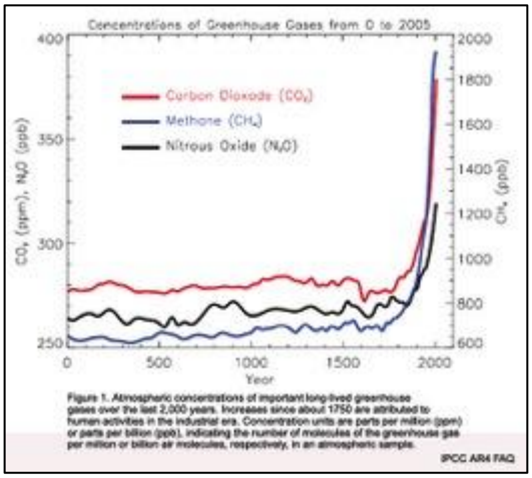


Figure 36: Greenhouse Gas concentrations from Year 0 to 2005 (Global Greenhouse Warming)

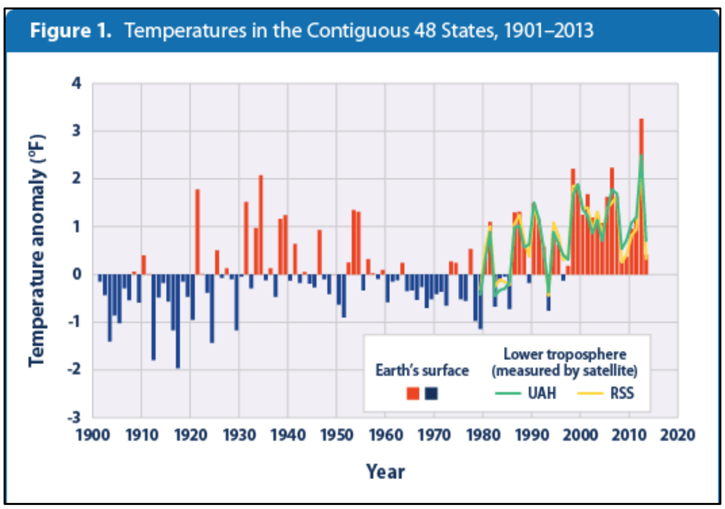


Figure 37: Relationship between Global Temperature Anomaly and Carbon Dioxide Concentration (Environmental Protection Agency)

Slide 8: How does carbon dioxide enter the atmosphere?

Estimated time: 7 minutes

Purpose: demonstrate the carbon cycle and how carbon enters the atmosphere as CO_2 (Objective 3).

Instructions:

- Because Carbon dioxide has the greatest emissions, discuss with the class how carbon enters the atmosphere.

- Ask the students to fill out the diagram below on their worksheets. Students will continue working in the same pairs as before. They can use the list of terms to help determine which term belongs in which space. This list of terms is comprised of the labels present in the diagram below. Give students some time to discuss their ideas.

- Explain each step of the carbon cycle with the entire class starting with sunlight, and then moving onto photosynthesis, living organic carbons, and animal/plant respiration. Man-made carbon emission should be mention separately, as they are not a part of the natural carbon cycle. Explain that all living beings contain carbon. Furthermore, explain that carbon is exchanged between the oceans, air, and organisms via numerous natural functions. An important aspect of the carbon cycle involves the decay of organisms into the soil, returning nutrients to the soil. In cases where anaerobic decomposition has occurred over millions of years, fossil fuels can be formed, explaining why high amounts of carbon are emitted in the atmosphere as a product of burning fossil fuels.

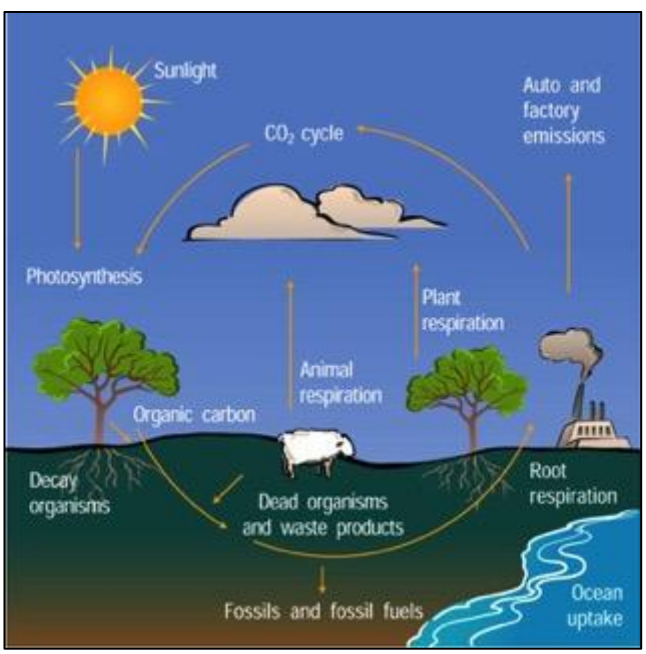


Figure 38: Simplified depiction of the carbon cycle (UCar.edu)

Additional Information:

Before administering this lesson, consult the diagram below for a more detailed representation of the carbon cycle and the various related processes. For further student learning, students may consult the website provided at the end of this document for an interactive version of the below diagram.

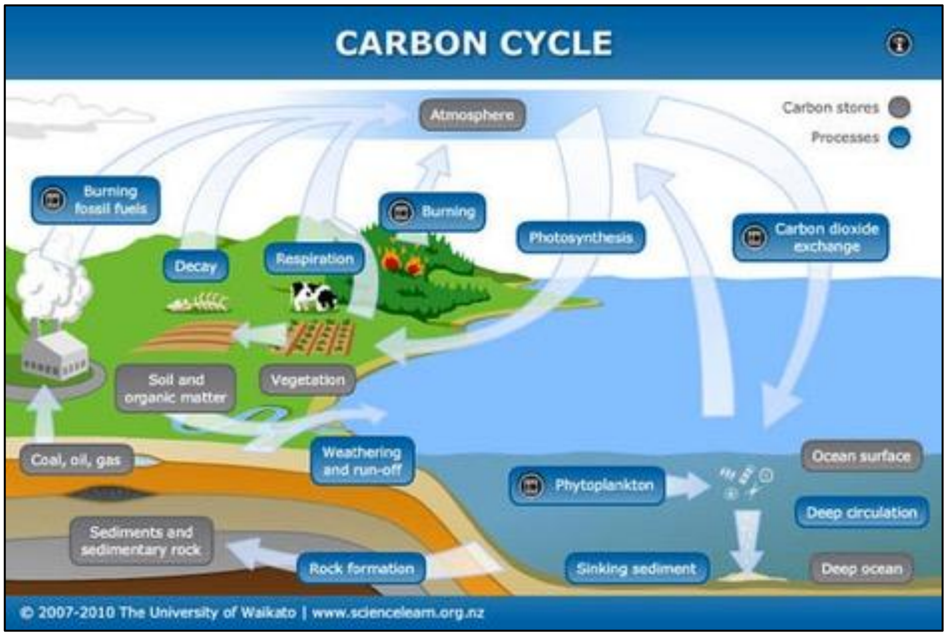


Figure 39: Detailed depiction of the carbon cycle (Sciencelearn.org)

Slide 9: Which is the highest source of carbon dioxide emissions?

Estimated time: 5 minutes

Purpose: determine the sources of carbon dioxide that have the highest emissions (Objective 4)

Instructions:

- Ask the students what they believe is the highest source of carbon dioxide emissions and then reveal the answer.

  The answers include electricity, transportation, industry, residential and commercial, and non-fossil fuel combustion.

- Ask what they believe is the second highest source of carbon dioxide emissions and then reveal the answer.

- Continue in this manner, until all five sources are revealed. Have students fill out their own graph as it is discussed.

The pie chart below will be provided to students, however the titles will be removed.

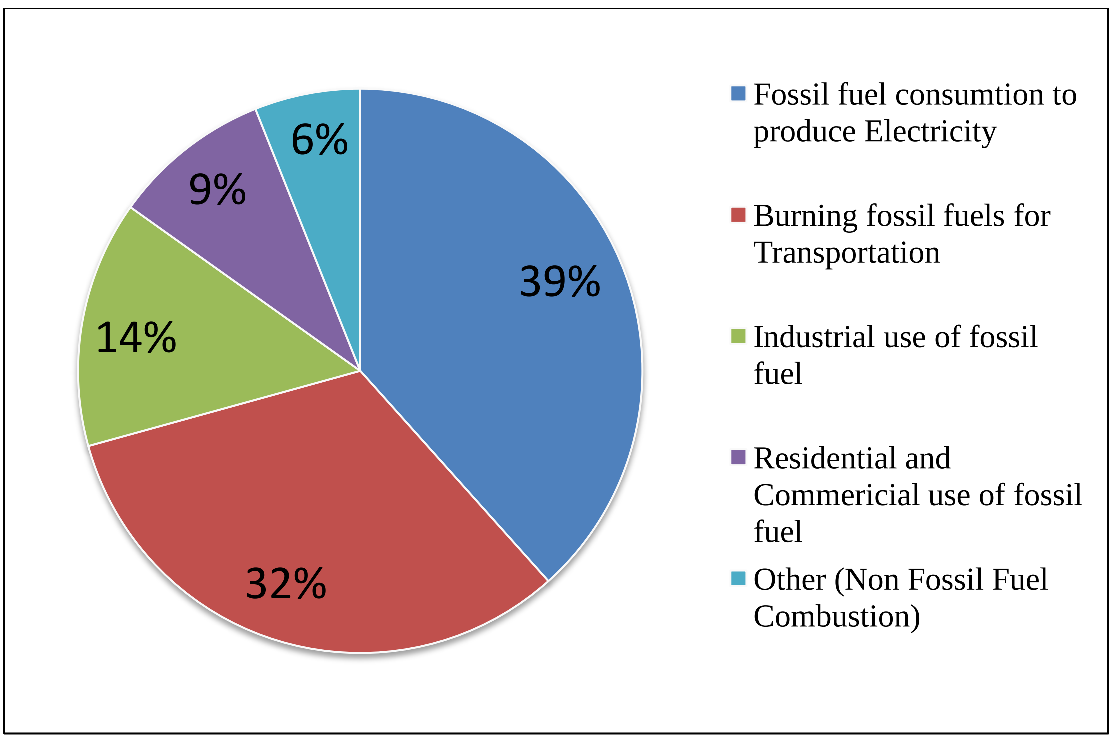


Figure 40: Breakdown of carbon dioxide emission by source of emission (Environmental Protection Agency)

Note: Inform students of the basic chemical formula for combustion ($C + O_2 \rightarrow CO_2$) and that this is the basic process that will produce the CO_2 that is emitted into the atmosphere. This equation should either be verbally stated or written on the board.

Slide 10: Activity- Pictionary (Sources of CO_2 emissions)

Estimated time: 10 minutes

Purpose: illustrate the different sources of CO_2 emissions (Objective 4)

Instructions:

- Split the class into groups of four or five students.

- Give each group a timer and have them randomly select four index cards per group, each labeled with sources of CO_2 emissions.

- Each group will pick a person to draw first, and that person will randomly select one of the index cards and attempt to draw the source listed on a blank piece of paper. The remaining members of the group must attempt to guess the source that is being drawn. The team will only be given one minute to guess the source being depicted. Should the group be unsuccessful in guessing the source, the answer will be provided after the minute has elapsed. The group will then decide on a new person to draw and continue this process until all four cards have been selected.

- Have each group categorize the source listed on each card, placing them into the four categories. Students will write their categorizations on the picture that corresponds to each source of carbon emission. The categorizations are as follows:

  Electricity: light bulb, air conditioner, computer

  Transportation: car, plane, motorboat

  Industrial: Factory, smoke stack, freight train

  Commercial/Residential: furnace, campfire, barbeque

.

Slide 11: How can we reduce CO_2 emissions?

Estimated time: 5 minutes

Purpose: Encourage students to think proactively about what they can personally do to reduce CO_2 emissions (Objective 4).

Instructions:

- Ask the students how society as a whole can reduce CO_2 emissions. Discuss this openly with the students. Possible responses may include:

  Use less energy
  - Turn off lights when you aren't using them
  - Don't leave the TV on when you aren't watching it
  - Don't overuse air conditioning

  Don't drive as much- walk when you can or use public transportation

  Eat less red meat

  Use energy-efficient appliances

  Recycle or reuse products when possible

  Buy local produce

- Ask students how they personally can reduce CO_2 emissions. Write the responses on the board to create a list of ideas. Make sure to distinguish the differences between what society can do and what the students can personally do. Also, make sure to emphasize that individual actions can make an impact. These actions, when done by many individuals, can have a huge impact in lessening carbon dioxide emissions.

Homework activity

Instructions:

Pass out the homework activity to each of the students. Each student should answer the questions and return the worksheet the next day. Below are the questions provided in the homework.

Students will complete the following activities, like a scavenger hunt.

4. Find a brief story from someone you know about how climate change affects him or her. Write a description of this story.
5. Find an object (a picture or the object) that you use or describe an activity that you encounter in *your* life that emits greenhouse gases.
6. Describe a new way to use the object or complete the activity that you chose in step 2 in a way that emits less greenhouse gases.

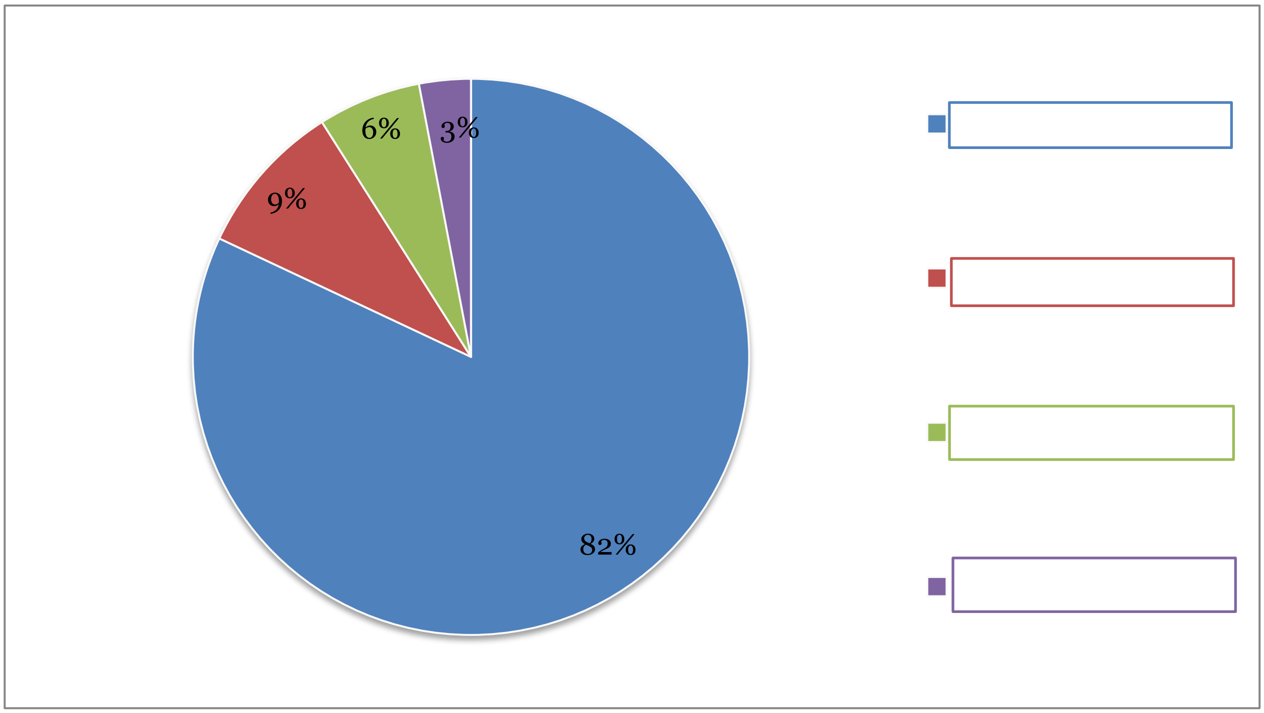
Appendix P: Student materials

Lesson 1 Worksheet

Lesson 1: Causes and Evidences of Climate Change

Please fill out the following graphs when your teacher instructs you to do so.

1. Which Greenhouse Gas has the greatest emissions? *Fill out this graph as the class discusses what the greenhouse gas with the greatest emissions is.*

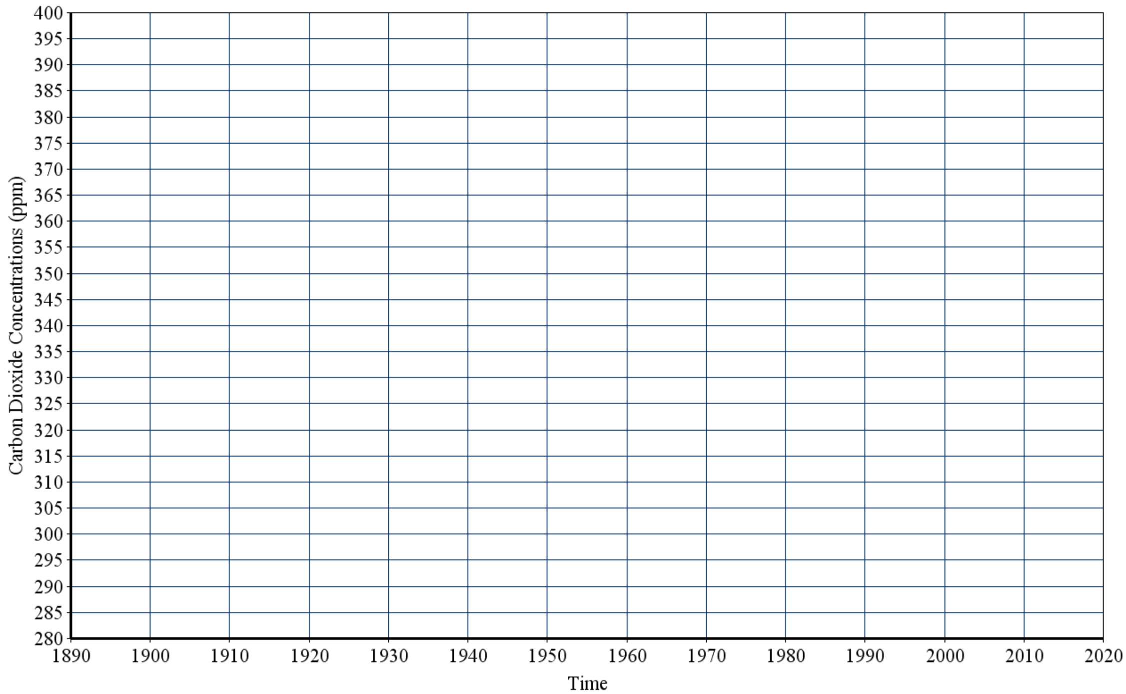


Word Bank			
Fluorine Gases	Methane	Carbon Dioxide	Nitrous Oxides
Examples:			
Aerosol Products	Bulvine Fecal Matter	Fossil Fuel Burning	Trash Incineration

2. Global Temperatures vs. CO_2 Concentrations: *Split into pairs. Using the below table, have one person create the graph for global temperatures and one person create the graph for CO_2 concentrations.*

CO_2 Concentration Graph:

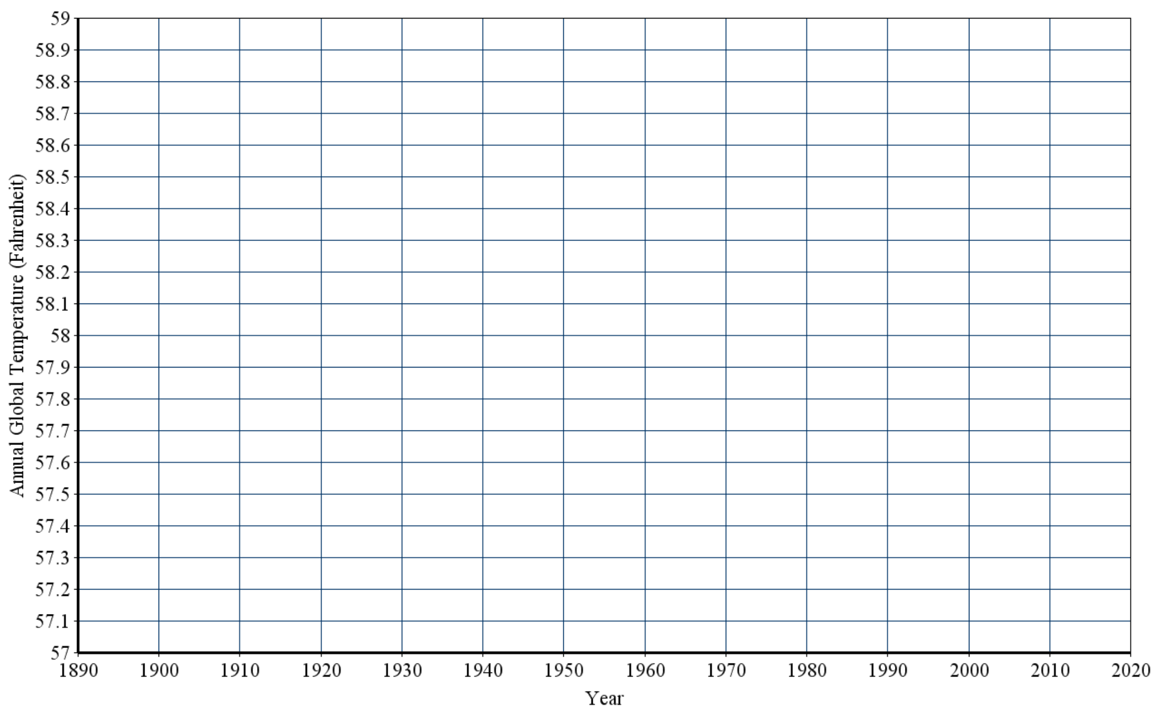
Year	**CO_2 (ppm)**
1890	294
1900	295
1910	300
1920	304
1930	309
1940	310
1950	310
1960	315
1970	325
1980	337
1990	352
2000	367
2010	388



Global Temperature Graph:

Year	**Temp (F)**
1890	57.15
1900	57.55
1910	57.0
1920	57.3
1930	57.55
1940	57.75
1950	57.95
1960	57.6
1970	57.65
1980	57.95
1990	58.25
2000	58.2
2010	58.5

Annual Global Temperature from 1900 to 2010



Now compare these two graphs. What is the correlation between global temperature and CO_2 concentrations?

3. How does carbon enter the atmosphere?

Working in a pair, fill out the below graph using the word bank below

Word Bank

Auto and factory emissions

Animal Respiration

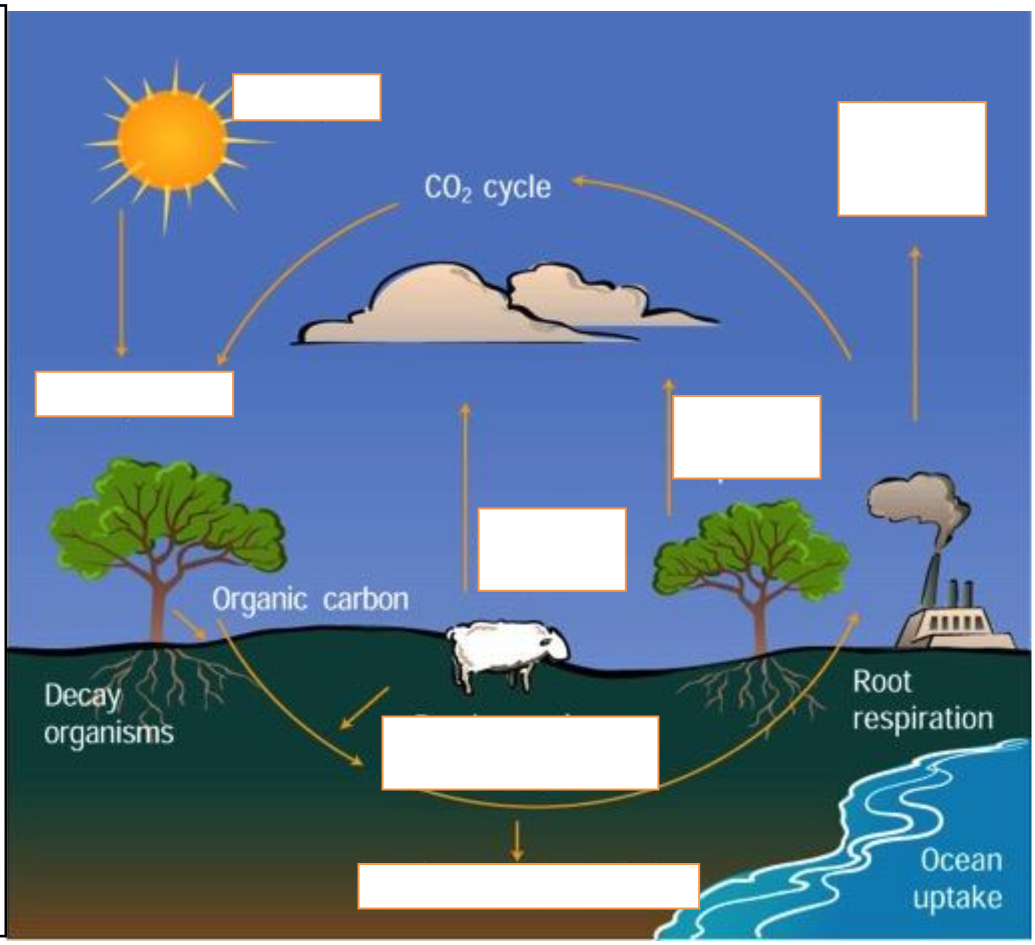
Dead Organisms and waste productions

Fossils and Fossil Fuels

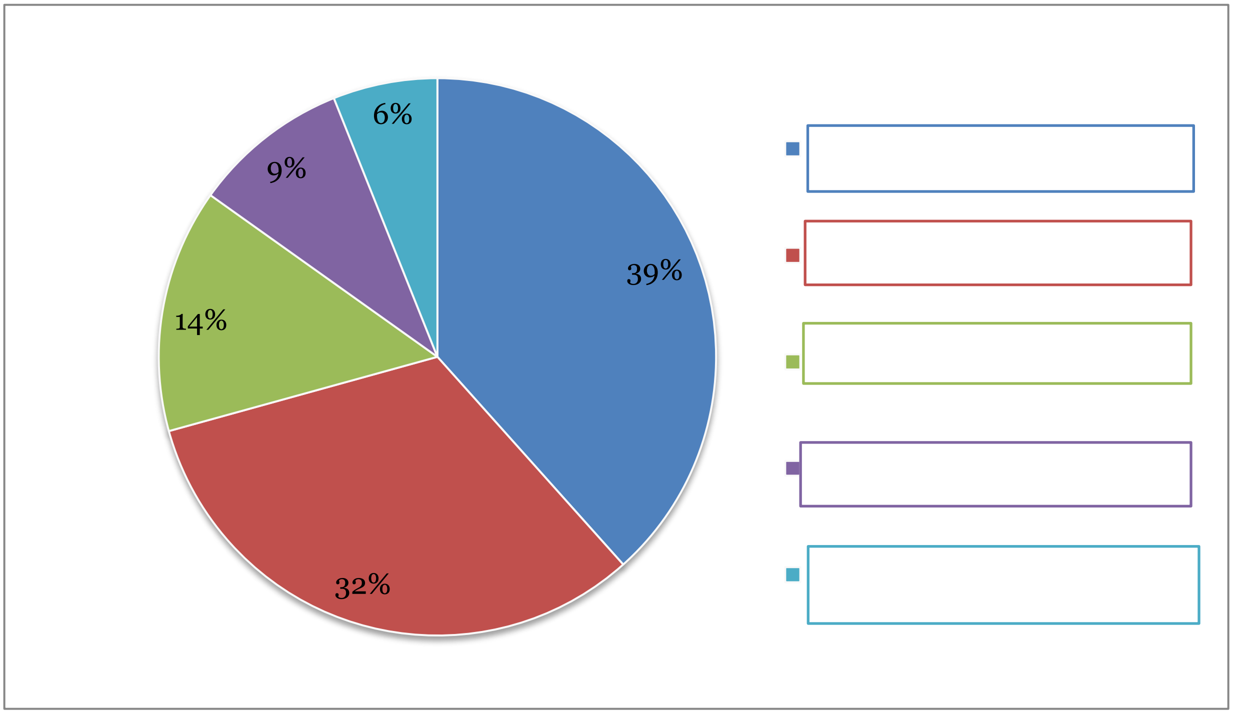
Plant Respiration

Photosynthesis

Sunlight



4. Which is the highest source of carbon dioxide emissions? Fill out this graph as the class discusses what the highest source of carbon dioxide emissions is.



Word Bank
Burning fossil fuels for Transportation
Fossil fuel consumption to produce Electricity
Residential and Commercial use of fossil fuels
Other (Non fossil fuel combustion)
Industrial use of fossil fuels

Pictionary Activity Worksheet

Pictionary Activity: *Below are the cards to be used for the Pictionary activity. Cut out the cards before class and give each group 4 cards.*

Light Bulb	Light Bulb
Air Conditioner	Air Conditioner
Computer	Computer
Car	Car
Plane	Plane
Motorboat	Motorboat

Factory	Factory
Smoke Stack	Smoke Stack
Freight Train	Freight Train
Furnace	Furnace
Campfire	Campfire
Barbecue	Barbecue

Homework Activity Worksheet

Name:____

Homework Activity

4. Find a brief story from someone you know about how climate change affects him or her. Summarize this story below.

____
____
____
____
____
____

5. Think of an object (a picture or the object) you use or describe an activity you encounter in *your* life that emits greenhouse gases.

____
____
____

6. Describe a new way to use this object or complete this activity in a way that emits less greenhouse gases.

____
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Appendix Q: Revised Learning Unit - Lesson 2

<u>Lesson 2: The Impacts of Climate Change</u>

Lesson Materials:

- Climate Change PowerPoint (Lessons 1 and 2)
- Habitat Shift Activity
- Scissors

Slide 13: Learning Objectives

Estimated time: 1 minute

Purpose: Inform students of the learning objectives for the lesson.

Instructions:

Read these learning objectives to the students.

Students will be able to:

5. Identify the predicted impacts of a warmer atmosphere on the earth, <u>focusing on</u> the water cycle and oceans

6. Determine the impacts of climate change on animals and plants in El Yunque, focusing on the impacts of rising temperature and changing precipitation patterns.

Slide 14: What causes a warmer atmosphere?

Estimated time: 3 minutes

Purpose: Review what was discussed in the previous lesson by discussing how increased CO_2 causes atmospheric temperatures to increases.

Instructions:

- Ask the question to the class of students, having them provide various answers based on the previous lesson. This question is meant to be a quick review of topics that students will have learned in the previous day's lesson on the causes and evidence of climate change.

- Continue this discussion until students have provided three accurate responses. Possible responses may include increases in CO_2 concentrations, increased greenhouse gas emissions, continued deforestation, and continued burning of fossil fuels.

Slide 15: What are some natural processes that can be affected by a warmer atmosphere?

Estimated time: 5 minutes

Purpose: Explain the impacts of a warmer atmosphere on natural processes (Objective 5).

Instructions:

- Briefly explain that a warmer atmosphere affects many natural cycles and processes, including the nitrogen cycle, carbon cycle, and water cycle, among others. Provided below are explanations of these cycles as well as a description of the predicted impacts.

  Carbon Cycle – The carbon cycle, as explained in the previous lesson, starts with the sun's energy being used for photosynthesis in plants. Plants and animals can both be identified as organic carbons. Both animal respiration and the burning of fossil fuels contribute CO_2 to the atmosphere. Additionally, plants and animals contribute carbon to the earth when they decompose. Oceans act as carbon sinks and can take in atmospheric carbons. Lastly, there are deposits of carbon that are locked away in glacial ice and bedrocks, but this carbon is much less accessible. Anthropogenic contributions to the carbon cycle are strongly tied to climate change. A significantly warmer atmosphere (due to anthropogenic climate change) would indicate that distribution of accessible carbon would greatly differ from any other period in the Earth's recorded history. Looking at CO2 levels from the past 800000 years substantiates this conclusion. Before the past decade, it is believed that atmospheric CO_2 levels had not risen past 300 ppm.

  Nitrogen Cycle – The nitrogen cycle contains 4 main processes: nitrogen fixation, ammonification, nitrification, and denitrification. Nitrogen fixation is the process of converting nitrogen gas (N_2) to ammonium (NH_4^+). This process is primarily done by certain bacteria and allows certain organisms to utilize nitrogen directly from the atmosphere. Next ammonification occurs when organic nitrogen is converted into NH_4^+ by organisms that decompose matter such as various fungi. From there, NH_4^+ is converted into nitrate (NO_3^-) by bacteria in the process known as nitrification. Lastly, the anaerobic process of denitrification occurs which converts NO_3^- into nitrogen gas (N_2), nitrous oxide gas (NO_2), nitrous oxide (N_2O) and nitric oxide (NO). Due to human activities, there are excess amounts of atmospheric nitrogen oxides (NO_X). Nitrous oxides are currently the world's third largest contributor to temperature increases of the atmosphere. This is due to increased release of nitrogen into the atmosphere during the combustion of fossil fuels. Furthermore, this accumulation of nitrogen has been seen to affect the functionality of varied ecosystems. Other human impacts include increased concentrations of ammonia (NH_3) due to increased fertilizer use and increased NO concentrations due to the elevated presence of N_2 in the atmosphere in the last century.

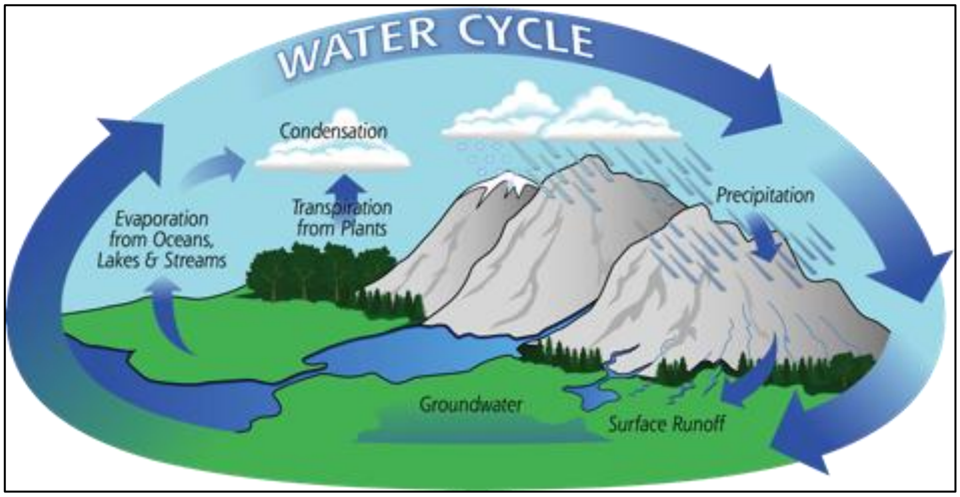
  Water Cycle – The water cycle describes the collective movements of water throughout terrestrial and oceanic biomes, and the atmosphere. Basic processes involved in this cycle are evaporation, transpiration, precipitation, and condensation. This process will be described in greater detail in the following slides. The water cycle would be affected in terms of increased evaporation and resultant decreased precipitation. This phenomenon can be confusing for students since a common misconception would be that increases in evaporation lead to increased precipitation. While this is somewhat true, the former description does not account for global wind patterns affecting the tropics and subtropics. The winds in subtropical areas (such as Puerto Rico) carry the moisture-laden air to equatorial tropics, therefore increasing rainfall in the tropics, but decreasing it in the subtropics.

Slide 16: What are the specific impacts of a warmer atmosphere on the water cycle?

Estimated time: 8 minutes

Purpose:_ Explain how a warmer atmosphere impacts the water cycle (Objective 1).

Instructions:



- Show students the above diagram. Explain the various steps listed.

  Evaporation: The changing of liquid water into water vapor

  $$[H_2O\ (l) + \text{Energy} \rightarrow H_2O\ (g)].$$

  Condensation: The changing of water vapor into liquid water in the form of clouds or fog

  $$[H_2O\ (g) \rightarrow H_2O\ (l) + \text{Energy}].$$

  Transpiration: The evaporation of liquid water from vegetation. It creates a cooling effect when it occurs in large-scale scenarios, such as tropical rainforests.

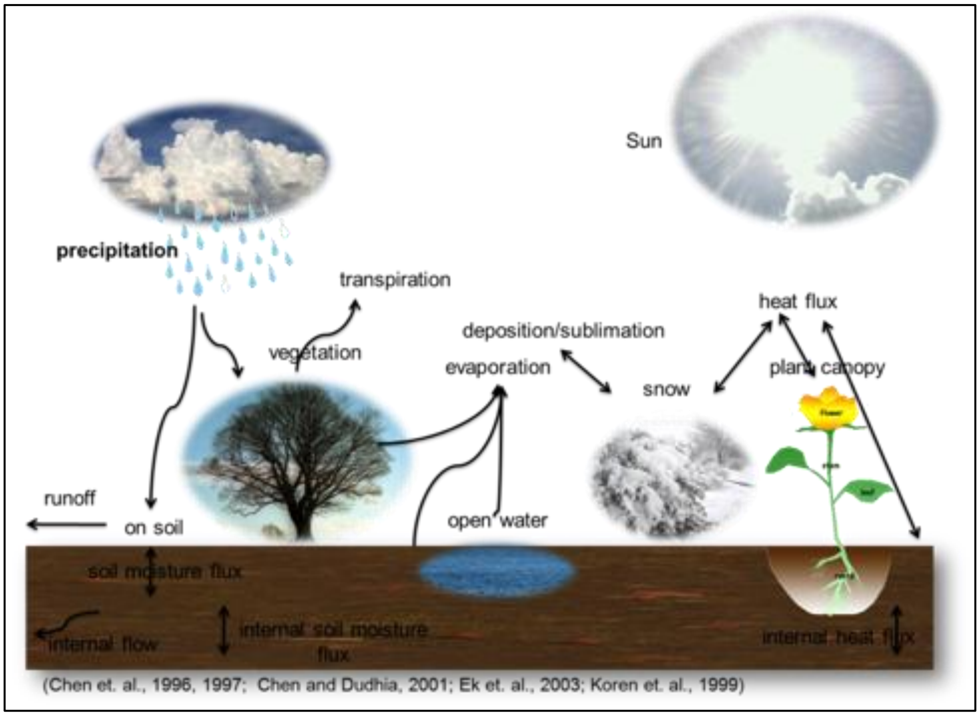
  Runoff: The transfer of liquid water from one physical location to another, usually from a higher elevation to a lower elevation and/or body of water.

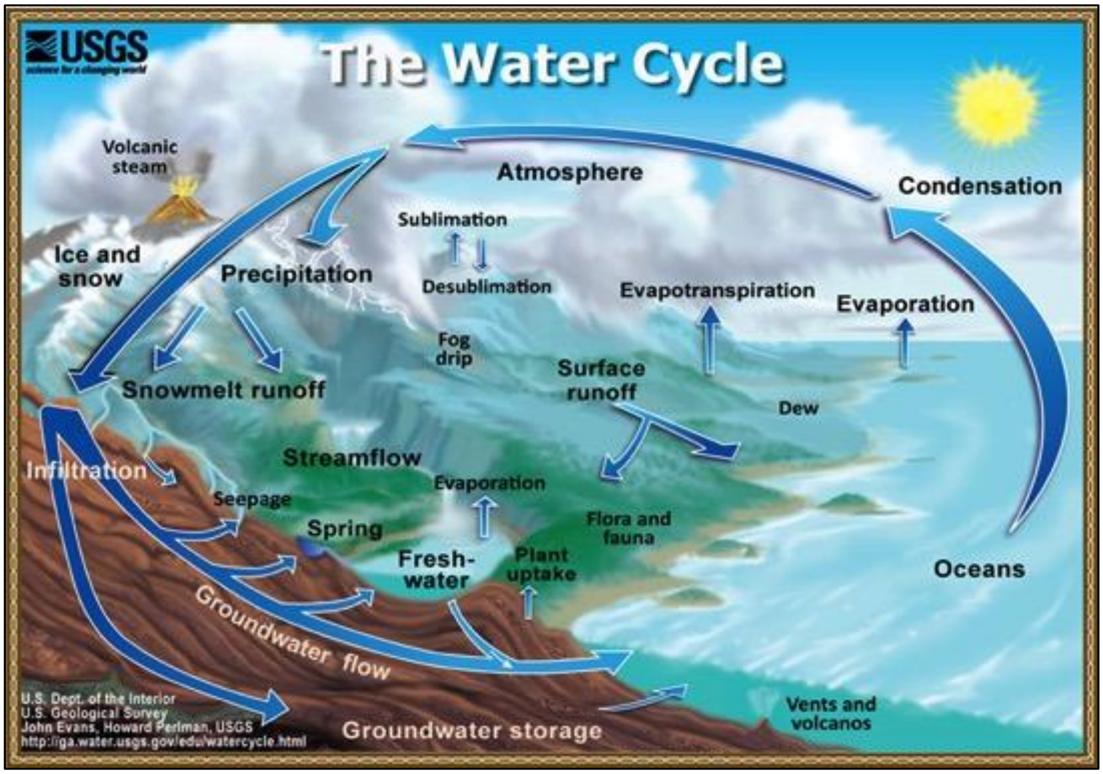
  Precipitation: The falling of liquid water from clouds or fog down to the surface of the earth. Precipitation can take the form of rain, hail, snow, sleet, and fog drip.

- Ask how a warmer atmosphere might affect each of these steps. It is important that you frame the changes that may occur in the broad sense (i.e. precipitation changes and evaporation changes). This will ensure that this discussion does not become too narrowly focused on topics that will not be addressed.

Additional Information:

Two more detailed and holistic depictions of the water cycle are provided below for to better your understanding of some of the more intricate portions of water cycle.




USGS
science for a changing world
The Water Cycle
Volcanic steam
Atmosphere
Condensation
Sublimation
Desublimation
Ice and snow
Precipitation
Evapotranspiration
Evaporation
Fog drip
Surface runoff
Snowmelt runoff
Dew
Streamflow
Infiltration
Evaporation
Seepage
Flora and fauna
Spring
Fresh-water
Plant uptake
Oceans
Groundwater flow
U.S. Dept. of the Interior
U.S. Geological Survey
John Evans, Howard Perlman, USGS
http://ga.water.usgs.gov/edu/watercycle.html
Groundwater storage
Vents and volcanos

Slide 17: How would warmer atmosphere affect the oceans?

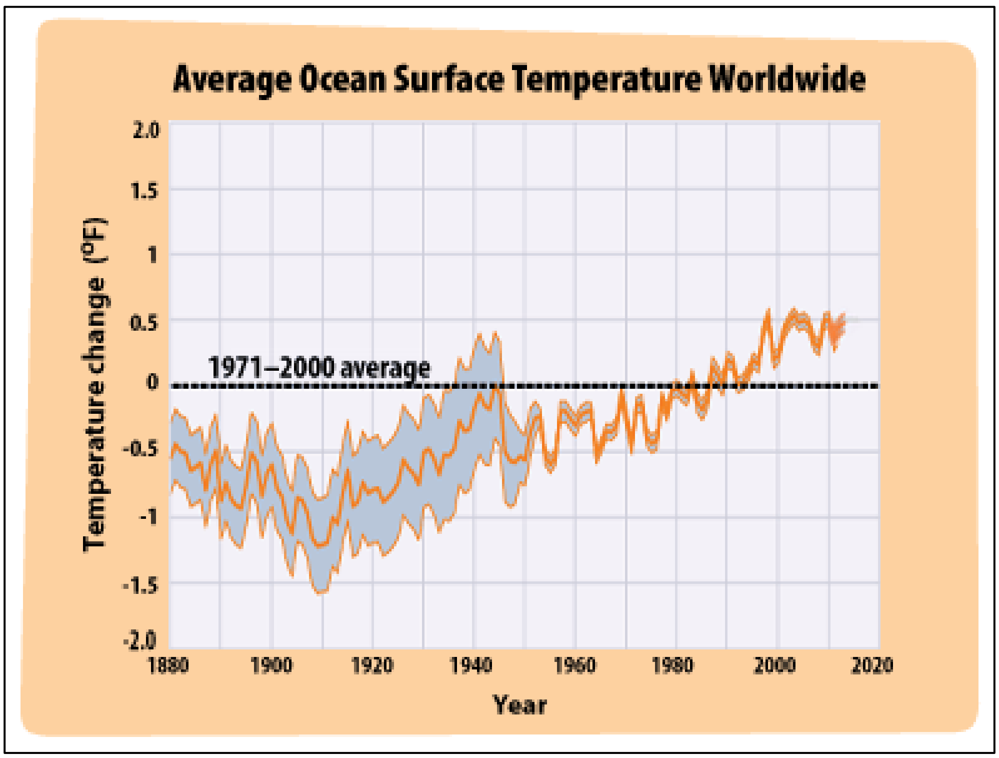
Estimated time: 3 minutes.

Purpose: Describe how increased atmospheric temperatures cause increased ocean temperatures (Objective 5).

Instructions:

- Ask students how a warmer atmosphere affects the oceans. Have students provide different ideas. If students do not provide the answer "warmer oceans" after 2 minutes, you should provide the response.

- Then display the following graph. This graph shows the change in ocean temperatures from 1880 to 2012, relative to the average ocean temperature from 1971 to 2000.



Slide 18: What are possible environmental effects of warmer oceans?

Estimated time: 4 minutes

Purpose: Discuss the effects of warmer oceans (Objective 5).

Instructions:

- Ask students what the possible environmental effects of warmer oceans are and discuss each topic further. Then ask students what effects of warmer oceans would particularly affect Puerto Rico. Possible Answers include the following:

  Rising sea levels – Sea ice will begin to melt more rapidly as ocean temperatures rise, creating excesses of liquid water that will cause global sea levels to rise.

  Changed chemical composition – Warmer oceans can more readily act as a sink of carbon dioxide. As more CO_2 is added into the ocean, the chemical process of creating carbonic acid ($CO_2 + H_2O \Leftrightarrow H_2CO_3$) happens in greater amounts. This can lead to slight shifts (or potential differences) in the ocean's pH toward acidic levels ($pH<7$).

  Coral reef changes – as the chemical composition of oceans change, fragile habitats like the coral reef will change, namely by experiencing excessive coral bleaching. Coral then dies, eliminating prime aquatic habitats.

  Loss of aquatic wildlife – as the chemical composition of oceans change, certain species of fish and plants will be poorly adapted to new chemical conditions. As well, species many also be unable to survive in warmer waters and die as a result.

  Habitat shifts – Species that are not well adapted to the rising temperatures in the oceans will cause them to move to other areas that have conditions they are more accustomed to.

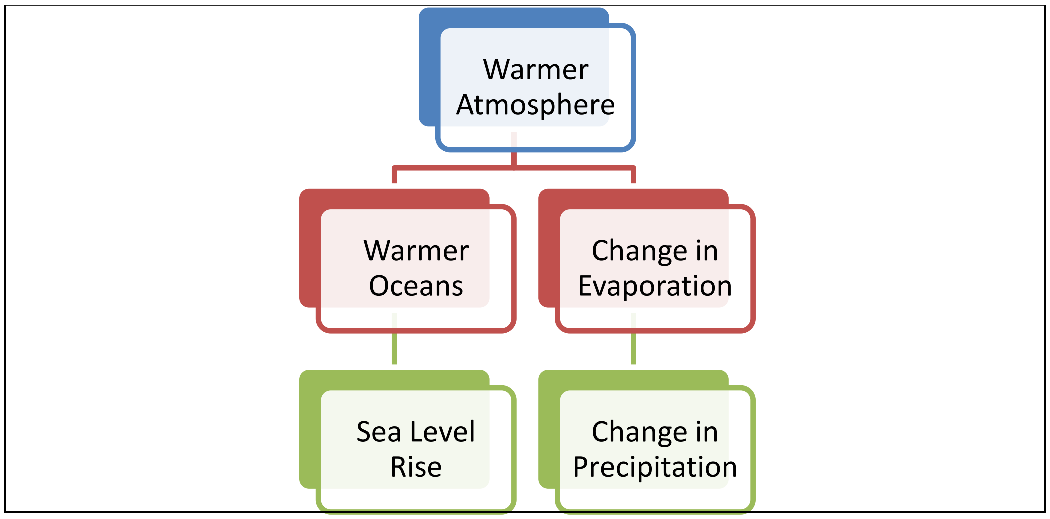
Slide 19: What are the impacts of a warmer atmosphere on the water cycle?

Estimated time: 4 minutes

Purpose: Review the effects of a warmer atmosphere on oceans and the water cycle (Objective 5).

Instructions:

- Review the below diagram with the class in order to emphasize how a warmer atmosphere can cause warmer oceans which can cause sea levels to rise and can change evaporation which can cause precipitation changes.



Warmer atmosphere: This is caused by increased greenhouse gas emissions. This observed heating effect has a profound impact on the water cycle. In particular, rates of all processes involving evaporation would become increased. Additionally, increased global temperature due to increased greenhouse effect would lead to warmer oceans.

Warmer oceans: The oceans would experience a similar warming effect as a result of increased greenhouse effect. These warmer oceans would lead to the occurrence of many other phenomena, including the thermal expansion of the oceans water and the increased melting of sea ice.

Sea level rise: Sea levels could rise drastically if continued climate change were to occur. This is partially due to slight thermal expansion of water as it is heated. This effect is usually very miniscule when involving small amounts of liquid. However, this expansion would be able to be observed and measured when occurring in large bodies of water, such as the ocean. Another source of sea level rise would be the melting of sea ice and increased glacial melting/run-off, which would deposit excess liquid water into the ocean.

Change in evaporation: Evaporation would increase in tropical regions as global temperatures increase. This would occur in all processes that involve evaporation, including transpiration. The atmosphere's capacity to hold water would increase by 7% for each degree Celsius that atmospheric temperature rises. This allows for increased ability to hold water meaning that the atmosphere's saturation point for holding water vapor would become greater. According, as the amount that water is held in the atmosphere changes, so does patterns on precipitation.

Change in precipitation: Depending on the region, precipitation could either increase or decrease. Wind patterns are a crucial factor in whether precipitation will increase or decrease. Equatorial regions, such as the Amazon, will experience increases in precipitation. This is largely because winds will carry the excesses of evaporated moisture to these areas. Puerto Rico is an area that would, although variable in its rain patterns across the island, experience a general decrease in precipitation. Additionally, Puerto Rico would experience more extreme seasons, with less rain falling in the dry seasons and more rain falling in the wet season. The most immediate impact of a drying trend in Puerto Rico would be increased likelihood of droughts.

Slide 20: Habitat Shift Activity

Estimated Time: 20 minutes

Purpose: Illustrate the effects of changes in precipitation and increased global temperatures on animals and plants (Objective 6).

Students will be given an activity to further illustrate the effects of precipitation changes and increasing global temperature, specifically on Puerto Rico.

Goal: Understand the effects of climate change on animal and plant habitats in El Yunque and how these effects are connected and can cause habitat shifts for animal species that are endemic to, or only found on, Puerto Rico.

Each group will be provided with (in the Habitat Shift Activity packet):

- Picture of a typical Puerto Rican mountain, labeled with different elevations
- Pictures of various animals of El Yunque that are endemic to Puerto Rico including coquís, Puerto Rican parrots, and elfin woods warblers
- Pictures of various plants of El Yunque that are native to Puerto Rico including the sierra palm, aceitillo falso , and bananas
- Labels of each of the forests including Elfin Woods, Sierra Palm, Palo Colorado, Tabonuco
- Instructions on how to complete each scenario, as well as the habitat requirements for the different animals and plants
- Questions for students to reflect on the activity

Instructions:

- Divide students into groups of 5
- Students will first place the different habitats on the picture of the mountain based on their required temperature and precipitation levels. This information is provided in the tables accompanying this activity.
- Have students place the provided animals into their corresponding habitats on the picture of the mountain by following their respective habitat descriptions and needs. Specifically, use each animal's temperature range, diet, possible elavations and precipitation needs to determine its placement on the mountain diagram. This information is provided in the tables accompanying this activity.

- Next, students will look at each scenario described below, and move each habitat according to the changes that have occurred due to that specific climate change.

- Students will then move animals and plants to new locations as the instruction sheet describes habitat changes that are reflective of climate change.

  Note: If animals cannot be placed in any of the habitats, they should be left off of the page.

- Students will reflect on how climate change can affect the various biomes and animal habitats in Puerto Rico by answering the question provided in the packet.

- When all teams have finished, go over the questions with the students.

  Students are expected to see the disappearance of the elfin woods habitat as well as the elfin-woods warbler. They also will see that the habitats of most of the listed species will shift up the mountain to higher elevations.

- Discuss with students that habitat shift is not something that is only hypothetical, but is actually happening in Puerto Rico.

  One species that is currently experiencing habitat shift is the elfin-woods warbler. This species is currently seeing the disappearance of its prime habitat, the elfin forest, and being forced to relocate to habitats that it is not well suited for. This is a trend that has been noted by USFS species managers in El Yunque National Forest. Should current climate change trends continue, the elfin-woods warbler would eventually completely disappear Puerto Rico. Similar trends have also been observed for other species that are endemic, or can only be found in Puerto Rico, such as the Puerto Rican parrot.

Habitat Activity

<u>Step 1: Set-up</u>

Cut out the pictures of each of the animals and plants below, as well as the names of the forests.

Coqui:

Puerto Rican boa:

aceitillo falso :

Tabonuco Forest

Palo Colorado Forest

Puerto Rican parrot:

Puerto Rican twig anole:

Little fire ant:

Sierra Palm Forest

Elfin-woods warbler:

Sierra Palm:

Bananas:

Elfin Forest


El Yunque Map
3500 ft.
Section 4
3000 ft.
Section 3
2500 ft.
Section 2
2000 ft.
Section 1
0 ft.

Forest Requirements: The forests below can only exist where the precipitation level and the average temperature ranges match the below requirements.

Forest Level	Precipitation Levels (inches/year)	Average Temperature Range (° F)
Tabonuco Forest	< 100	80– 85
Palo Colorado Forest	150- 180	75 – 80
Sierra Palm Forest	100-150	70 – 75
Elfin Forest	> 180	65 – 70

Animal and Plant Requirements: The animals and plants below can only exist where the precipitation level, the average temperature ranges, and diet match the below requirements.

Animal	Habitat Temperature Range (° F)	Habitat Precipitation Range (inches/year)	Diet	Predators
Coquí	65– 85	> 32	insects	Puerto Rican boa
Puerto Rican parrot	70– 85	< 150	plants	Puerto Rican boa
Elfin-woods warbler	65– 75	< 200	insects	Puerto Rican boa
Puerto Rican boa	80– 85	< 100	birds and lizards	None
Puerto Rican twig anole	80– 85	< 100	insects	Puerto Rican boa
Sierra palm	70– 75	< 150	photosynthesis	Puerto Rican parrot
Aceitillo falso	80– 85	< 100	photosynthesis	Puerto Rican parrot
Little fire ant	65 – 85	Any	plants	Birds and lizards
Bananas	75 – 85	< 180	photosynthesis	Little fire ant and Puerto Rican parrot

Step 2: The original condition

According to the original condition below, place the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then place the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Original Condition:

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**	90	82
2	**2000-2500**	165	77
3	**2500-3000**	125	72
4	**> 3000**	190	67

Step 3: The effects of changing temperatures and precipitation levels on habitats.

Scenario 1: The precipitation levels have decreased from their original levels by 50 inches per year.

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**		82
2	**2000-2500**		77
3	**2500-3000**		72
4	**> 3000**		67

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 2: The average temperatures of all of the habitats have increased from their original measurements by 5° F

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**	90	
2	**2000-2500**	165	
3	**2500-3000**	125	
4	**> 3000**	190	

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 3: The precipitation levels have decreased from their original levels by 50 inches per year AND the average temperatures of all of the habitats have increased from their original measurements by 5° F

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**		
2	**2000-2500**		
3	**2500-3000**		
4	**> 3000**		

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Scenario 4: The precipitation levels have decreased from their original levels by 75 inches per year AND the average temperatures of all of the habitats have increased from their original measurements by 10° F.

Fill in the graph below, change the precipitation levels and average temperature ranges according to the above scenario.

Section	Elevation (ft. above sea level)	Precipitation Level (inches/year)	Average Temperature (° F)
1	**< 2000**		
2	**2000-2500**		
3	**2500-3000**		
4	**> 3000**		

Move the forests in the elevation section on the El Yunque map. Make sure that the forest is in the elevation section of El Yunque that has the precipitation levels and average temperature ranges that are required for that forest. Then move the animals and plants in the elevation section on the El Yunque map that has the precipitation levels, average temperature ranges, and diet that are required for that forest.

Step 4: Reflection: Answer the following questions.

1) What can be said about the effect that changes in precipitation levels have on the plants and animals?

2) What can be said about the effect that changes in temperature have on the plants and animals?

3) What can be said about the effect that changes in both temperature and precipitation levels have on the plants and animals?

4) As the animal habitats change in response to the above scenarios, what can be said about its affects on the food chains?

Appendix R: Additional Lesson Outlines

Lesson 3: Water

The goal of this lesson is to expand upon of the effects that climate change would have on water as stated in Lesson 2. The lesson is designed to emphasize the impacts that climate change would have on water, specifically bodies of water and the water cycle.

Learning Objectives:

Students will be able to:

1. Understand and identify the components of the water cycle
2. Determine how warmer global temperatures affect the water cycle
3. Determine the effects that rising sea levels would have on Puerto Rico
4. Determine the cause of changed precipitation patterns with respect to climate change
5. Determine the consequences of changing precipitation patterns in Puerto Rico

Topics of Interest:

Review the water cycle from Lesson 2

Review how anthropogenic climate change results in increased greenhouse gasses. These include sulfur dioxide, SO_2, which when combined with water vapor acidifies rain and damages aquatic life and forest fauna, and carbon dioxide CO2, which is a major contributor to rising global temperatures.

Explain how rising global temperatures leads to the melting of polar ice caps, leading to more water in the ocean and higher sea levels.

Explain how sea level rise affects small islands like Puerto Rico. This includes coastal erosion and a loss of the island's landmass.

Explain how rising global temperatures leads to more water evaporation, which changes precipitation cycles.

Explain the consequences of changed precipitation patterns, including wetter rainy seasons and dryer dry seasons. Explain how this leads to droughts and flooding. Use examples like the drought that occurred in Puerto Rico in the summer of 2014 to emphasize the impact that this would have on the island. Explain how changed precipitation patterns affect plant and animal habitats, similar to the activity in Lesson 2.

Activity: *Suggested by Edgardo Gonzalez (See Appendix B)*

This activity is designed to show students how trees contribute to natural cycles, more specifically the water cycle.

<u>Materials</u>: Plastic shopping bag

1. Take students to a tree outside with branches that are low enough to reach.

2. Place a plastic bag or have students place plastic bags over a tree branch. Be sure to get most of the leaves that are on that branch into the bag.
3. Close the bag.
4. Leave the bag and the tree alone for some time. Time can be occupied with other activities, class lecture, etc. This can include material that covers tree function and biological/chemical cycles that trees are associated with. Examples include the carbon cycle and the water cycle (transpiration).
5. Eventually, return with students and remove bag(s). The bags should have water, which can show more concretely how trees work. Emphasize to students that the water in the bag is only part of what was produced from one tree, and that therefore an entire forest of trees would have a large amount of water involved in its cycles. Emphasize the importance of vegetation overall.

Activity: Island in a box

Note: This activity can be scaled up or scaled down depending on what resources are readily available.

Materials:

- 12” x 12” x 6” solid bottomed container
- Gravel
- Platform to build the island on.
- Sand
- 12” ruler x2
- Duct tape
- Building markers (some sort of token; such as buildings from the game “Monopoly”)
- People markers (2 tokens that can represent people in two colors; blue and green)
- Water

Step One: *Students must set up the initial box apparatus*

1. Place the container on the ground with the opening facing upwards.
2. Use the duct tape to tape one of the rulers vertically onto one of the faces of the container. Make sure that the tape is placed near the top of the container, and that the ruler is attached securely.

Step Two:

1. Place the small platform in the center of the box apparatus.
2. Place the gravel/rock on top of this platform and slightly around the platform, until it is no longer visible.
3. Pour the sand over the gravel and on the bottom of the container until the bottom of the container is no longer visible. Leave an inch from each box wall uncovered, and make sure that the gravel is mostly covered. If done correctly this island should look like a miniature “mountain” in the center of your container.

Step Three:

1. Place the markers according to the following parameters:
    a. Industries (houses) must be located within an inch and a half from the coast of the island.
    b. The blue people (fishermen) cannot live more than two inches from the coast, as their main source of income is dependent on the ocean.
    c. The green people (farmers) must be placed at least three inches from the coast, as they cannot grow crops in salty soils.
2. Have students note the rough placement of the people and buildings on a provided worksheet, as this is the initial condition of the island

Step Four:

1. Pour the water into the box until it reaches the half-inch mark on the ruler.
2. Students will move the people further inland as sea levels rise, according to their specifications outlined in step 3. However, the industries must stay stationary and will therefore be lost they are covered in water.
3. Students should note what has occurred on the island, including whether industries were lost or people were displaced.
4. Add another half-inch of water (the ruler should read 1 inch). Note any displacement of people or loss of industries.
5. Repeat this pouring and displacing process until the water reaches the 3 inch mark on the ruler.

Potential Follow-up Questions:

- How many industries remained on the island?
- How far inland did the people have to move?
- What did you observe about the sand as the water was added?
- What effect of climate change would this correspond to in reality?

Lesson 4: Impacts on Humans, Adaptation, and Mitigation

The goal of this lesson is to convey to students how climate change impacts humans, as well as ways in which humans can adapt to and mitigate these changes.

Learning Objectives:

Students will be able to:

1. Identify ways in which climate change would have an effect on various aspects of human society, industries, and economy
2. Define adaptation and identify ways in which one can adapt to climate change
3. Define mitigation and identify ways in which one can mitigate climate change

Video:

The following video has people from Belize, Bolivia, and Brazil sharing personal stories about how climate change has affected their lives. These stories focus primarily on water, which is one of the ways in which climate change will have a negative impact on people, especially in Puerto Rico

https://www.youtube.com/watch?v=Lv2XxXNqZa8

This video has subtitles in English and Spanish

Topics of Interest:

Impacts on Humans

Explain how climate change would have an effect on various aspects of society

These include the tourism industry, the food industry, the energy industry, and more.

Explain how climate change could affect tourism industry in Puerto Rico. Pay close attention to how sea level rise erodes beaches, one of the island's biggest tourist attractions.

Explain how climate change could affect the food industry in Puerto Rico. Mention that the island imports a majority of its food products, lending itself to becoming vulnerable to negative effects of climate change in other parts of the world.

Explain how climate change could affect the energy industry and Puerto Rico's ability to have electricity. Focus on how, as an island, it must import fossil fuels to make electricity.

Mention how importing goods requires the use of more fossil fuels so that transport vehicles may travel and bring said goods to the island.

Adaptation

Begin by defining adaptation.

Provide different examples of adaptation and how they help one adapt to the effects of climate change. Examples can include changing where one lives or changing one's diet.

Mitigation

Begin by defining mitigation; be sure to compare to the definition of adaptation so that students understand the difference.

Provide different examples of mitigation and how it is that they mitigate the effects of climate change. Examples can include recycling, agroforestry, and urban gardens.

Lesson 5: Recycling

The goal of this lesson is to provide an in depth understanding of recycling and its benefits.

Learning Objectives:

Students will be able to:

1. Identify the benefits on the environment that recycling has
2. Identify various ways in which one can recycle

Topics of Interest:

Introduce the topic of recycling and how it benefits the environment. Explain how recycling reduces production rates, thus reducing greenhouse gas emissions.

Explain how recyclables in landfills can be problematic, especially with the example of trash burning.

Explain various ways that one can recycle

Activity:

Have students complete activity 3.3 on page 145 of the Baúl de Actividades sobre Bosques Tropicales.

This activity introduces students to the concept of composting, an effective way to dispose of and reuse food waste in a way that does not release greenhouse gases into the atmosphere (as opposed to trash burning) (See Appendix R)

Activity:

Have students complete activity 3.4 on page 149 of the Baúl de Actividades sobre Bosques Tropicales.

This activity introduces students to the concept of reducing, reusing, and recycling materials as a method to practice better waste management in Puerto Rico (See Appendix R)

Activity: Art activity using recycled material

Divide class into groups of 6 – 8 students

Have each group choose which material they wish to work with: paper, aluminum, or plastic

Lesson 6: Food

The goal for this lesson is to teach students the societal and economic impact that global warming would have on Puerto Rico's food industry.

Learning Objectives:

Students will be able to:

1. Identify how much of Puerto Rico's food supply is imported and where it is imported from
2. Identify the economic, time, and environmental costs of importing food from various countries to Puerto Rico
3. Identify ways to improve Puerto Rico's self-sustainability through agriculture

Topics of Interest:

Introduce students to how much of Puerto Rico's food supply is imported from other countries.

Introduce which countries import food to Puerto Rico, what they import, and what percentage of the island's food supply is provided by each country.

Explain to students the amount of money, time, fuel, etc. is required for these importations. Emphasize how much fossil fuel burning has to occur to deliver them.

Explain how buying food that is locally grown significantly reduces negative human impacts on the environment

Introduce the topic of agroforestry

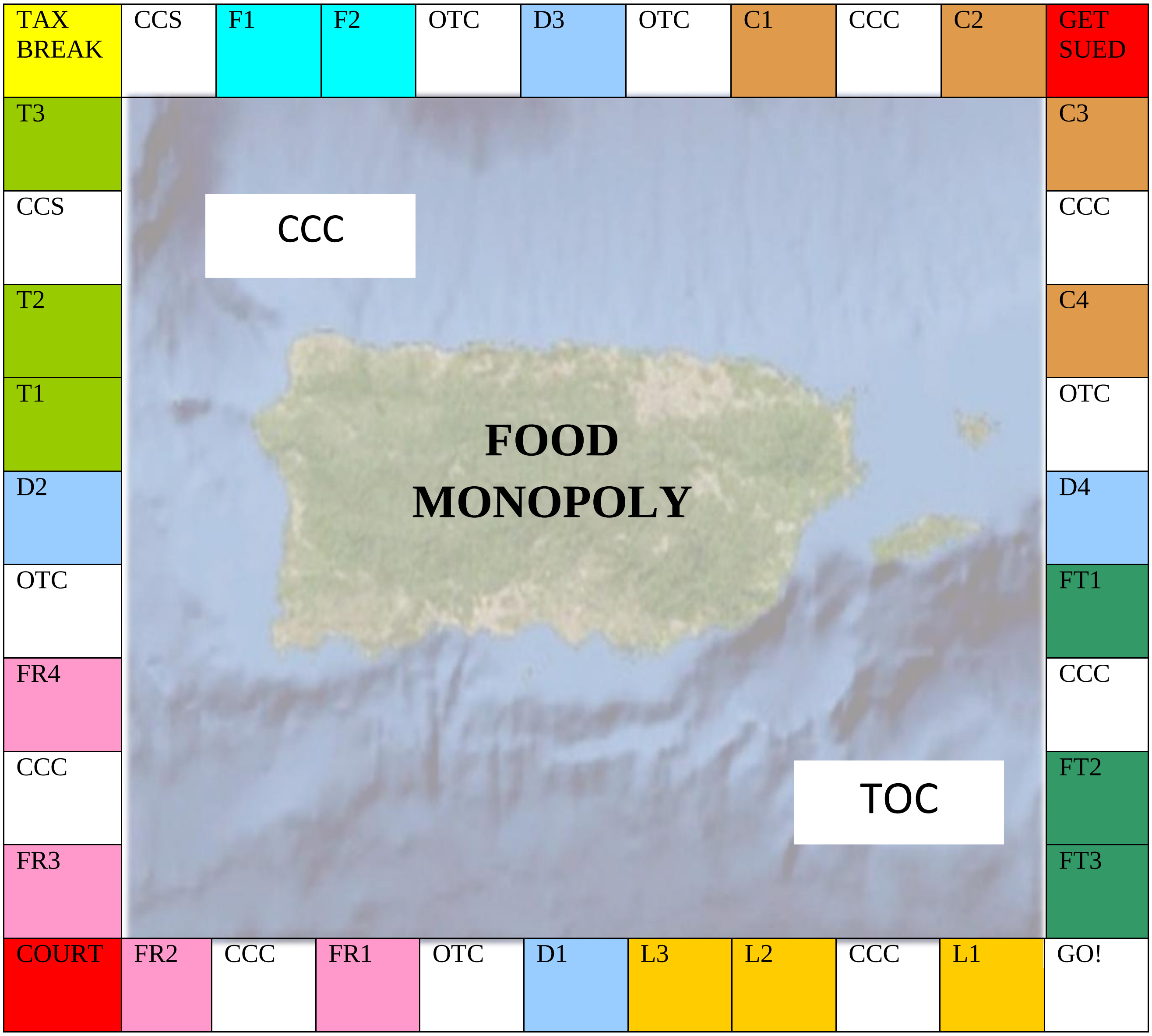
Introduce the topic of urban gardening

Explain how agroforestry and urban gardening can help Puerto Rican food supply, economy, etc.

Activity: Food Monopoly

Students will pick a token to represent them. They will role a die, and move the number of spaces that corresponds to the number they role. Throughout this game, students will encounter opportunities to buy and sell food industries, as well as encounter various climate change choices (CCCs) and trade-off card (TOCs). These cards have the power to move the student's playing token to specific properties, or to give money to or take money from a player. Climate Change Choices cards describe an effect of climate change on a particular crop or type of industry, and require students to make economic decisions based upon the described effect. Trade-off cards describe how the food industries are all connected, and can affect each other.

Below is an example of a possible board design, with all necessary information and keys below the design. The numbers presented in this design are arbitrary, and may be changed if desired.



MONEY TYPES AVAILABLE:

$100,000

$500,000

$1,000,000

$2,000,000

$5,000,000

$10,000,000

$50,000,000

PROPERTY KEY

Property Category	Property Name	Property Code	Property Value ($)	Product Cost ($)	Property Sale Value ($)
Legumes	Beans	L1	500,000	100,000	200,000
Legumes	Lentils	L2	700,000	300,000	400,000
Legumes	Peanuts	L3	1,000,000	400,000	500,000
Fruits	Guava	FR1	1,100,000	600,000	600,000
Fruits	Breadfruit	FR2	1,500,000	800,000	800,000
Fruits	Coconut	FR3	1,700, 000	900,000	1,000,000
Fruits	Passion Fruit	FR4	2,000,000	1,100,000	1,200,000
Tubers	Platano	T1	5,000,000	1,500,000	1,400,000
Tubers	Yuca	T2	5,600,000	2,500,000	2,000,000
Tubers	Yautía	T3	6,300,000	2,800,000	2,500,000
Fish	Red Snapper	F1	11,000,000	4,700,000	3,500,000
Fish	Grouper	F2	12,300,000	5,800,000	5,000,000
Coffee	Café Crema	C1	15,000,000	8,700,000	6,800,000
Coffee	Café Rico	C2	18,000,000	9,200,000	9,000,000
Coffee	Yaucono Coffee	C3	23,700,000	11,700,000	11,500,000
Coffee	Alto Grande	C4	30,000,000	14,400,000	14,000,000
Forest	Toro Negro	FT1	54,300,000	26,800,000	25,000,000
Forest	Guanica	FT2	76, 900,000	40,000,000	36,000,000
Forest	El Yunque	FT3	100,000,000	63,000,000	48,000,000

DOCK KEY:

Property Category	Importer Name	Property Code	Property Value	# of Docks Owned	Dock Usage Cost ($)
Dock	Nicaragua	D1	25,000,000	1	12,500,000
Dock	Australia	D2	25,000,000	2	25,000,000
Dock	China	D3	25,000,000	3	37,500,000
Dock	USA	D4	25,000,000	4	50,000,000

OTHER TILE KEY:

Name	Meaning	Name	Meaning
CCC	Climate Change Card.	Court	Once in court, on must stay for 3 turns.
TOC	Trade-off Card.	GO!	When passing go, collect $20,000,000.
Got Sued!	Travel directly to court. Do not collect the money from passing the "GO!" tile.	Tax Break	If you land on this, you gain all the tax money paid during the game.

Appendix S: Activity Bibliography

CO_2 Observation Activity:

This activity is designed to demonstrate how CO_2 works as a greenhouse gas. The following link shows a video of the activity:

https://www.youtube.com/watch?v=kwtt51gvaJQ

Materials:

- Alka-Seltzer
- Two empty two-liter soda bottles
- Two thermometers (preferably temperature probes. Ex: LoggerPro)
- Lamp

1. Begin by filling the bottles with water.
2. Place two Alka-Seltzer tablets into one bottle. Alka-Seltzer releases CO_2 as it dissolves, therefore this bottle should have CO_2 sitting in it during this activity.
3. Measure the temperature of the bottles
4. Close the bottles, and let the lamp shine on the bottles. Make sure that there is equal distribution of light onto both of these bottles. The light from the lamp should act as a heat source and warm up the bottles of water.
5. Let the bottle sit for a while, at least 40 minutes.
6. After time passes, measure the temperatures of the two bottles. Both bottles should have increased temperatures. Note: the bottle with the dissolved Alka-Seltzer should have a higher temperature than the bottle with just water.
7. Explain reasoning for the temperature difference to the students. The bottles act like the Earth's atmosphere, allowing heat to pass through and escape in a limited matter, and the lamp acts like the sun. The demonstration shows how CO_2 traps heat and warms up the contents of the bottle, similar to how it traps heat in our atmosphere.

Activity 3.3; *Baúl de Actividades*

Activity 3.3 on page 145 of the Baúl de Actividades sobre Bosques Tropicales

This activity is available in the Baúl de Actividades sobre Bosques Tropicales, a book of classroom activities provided by the USFS in 1990s whose activities related to environmental awareness, forest preservation, etc. The book was intended to be used by educators in conjunction with a chest of resources so that they may educate their students on the book's topics. The description below is a summary of the activity in English. For the original activity description, see page 327.

<u>Instructions:</u>

1. Pass out the attached worksheet so that the students can answer the guided question.
2. Demonstrate to the students how one makes compost.
3. Explore possible uses for compost
4. Indicate that a way to follow-up with this activity is to do an experiment fertilizing a plant with organic compost soil and comparing the plant to another that has not been fertilized.

3.3 APRENDAMOS A HACER NUESTRO PROPIO ABONO NATURAL

Resumen:
El manejo y la disposición de los desperdicios sólidos es uno de los problemas más apremiantes que enfrenta nuestro país. Afortunadamente cada uno de nosotros puede contribuir a su solución. Mediante esta actividad los estudiantes tendrán la oportunidad de preparar composta.

Trasfondo:

El manejo y la disposición de los desperdicios sólidos es uno de los problemas más apremiantes que enfrenta nuestro país. Anualmente generamos 8,100 toneladas de desperdicios sólidos. Esta cifra continúa aumentando. La solución está en nuestras manos. Afortunadamente la mayoría de los desperdicios sólidos pueden ser reciclados, es decir transformados para ser usados nuevamente. De estos residuos sólidos el 25% son ***materiales biodegradables***, residuos de alimentos y jardinería, los cuales pueden ser usados como acondicionadores de suelos.

Los materiales biodegradables luego de pasar por el proceso de descomposición natural, poseen un alto contenido de nutrientes. El uso de la ***composta*** reduce la necesidad de utilizar abonos artificiales.

La preparación de composta es un proceso sumamente sencillo (ver Ilustración #1). A continuación ofrecemos el procedimiento a seguir:

1. Seleccione el lugar adecuado:

   Escoja un lugar en el patio. Para mejorar el proceso de descomposición, éste debe tener sombra y estar protegido del viento. Evite elegir un lugar cerca de los árboles ya que las raíces pueden penetrar la composta.

2. Para mantener el patio limpio, debe cercar o delimitar el área. Los materiales a utilizarse para cercar pueden ser: tela metálica, bloques de concreto o paletas de madera. Para asegurar una apropiada ventilación, humedad y aumentar la rapidez del proceso, coloque en el fondo de la pila lanas, paja y pedazos de madera.

3. Recupere los desperdicios orgánicos:

   Compile hojas, grama, heno, paja, cáscaras de huevo, granos de café, vegetales, frutas, alimentos y otros.

4. Triture los materiales:

   Este es un proceso opcional que se lleva a cabo para reducir el tamaño de ciertos materiales y acelerar su descomposición.

5. Forme la pila de composta:

   Comience su pila con seis pulgadas de material orgánico recuperado (desperdicios de jardinería, cartón, papel y otros). Provea la humedad adecuada, por lo menos un 50%. Repita este paso varias veces.

6. Voltee la composta:

   Voltee la pila con un tridente o pala varias veces entre días. Esta estará lista en un mes. Por otro lado, revolver la composta asegura una completa descomposición. El producto final es un material con olor a terreno, con un color oscuro y textura suave. Este producto puede ser utilizado en los alrededores de la casa como aditivo

Niveles: Grados 6 al 9

Materias: Estudios Sociales, Ciencias

Conceptos:
- Interdependecia
- Cooperación-solidaridad
- Reciclaje de materia orgánica (composta)

Destrezas:
- Trabajo en equipo, organización

Propósitos:
- Conocer un método de reciclaje: la composta.
- Identificar los beneficios ambientales y económicos de la composta.
- Integrar el tema de uso de suelos y el manejo de desperdicios sólidos.

Materiales:
- Video* "El oro marrón del agricultor"
- Televisor y videograbadora
- Muestras de composta
- Publicaciones educativas ADS*
- Anejo #1 - Preguntas guías
- Ilustración #1

Tiempo:
- Actividad: 60 minutos

para un jardín o como abono para sus cultivos y árboles.

Descripción de la actividad:

1. Presente el video *El oro marrón del agricultor*.
2. Reparta el Anejo #1 (Preguntas) para que los estudiantes contesten las preguntas guías.
3. Conteste las preguntas de los estudiantes después de la película.
4. Atienda los temores y prejuicios de los estudiantes en relación con la materia orgánica.
5. Haga una demostración de cómo hacer la composta.
6. En lo posible, los estudiantes deben tener parte activa en la demostración.
7. Explore cuántos estudiantes estarían interesados en hacer composta y pida que preparen composta en la escuela o en sus hogares.
8. Explore posibles usos para esa composta.
9. Indique que una manera de dar seguimiento a la actividad es hacer un experimento abonando una planta con la tierra orgánica de composta y compararlo con una planta sin abonar.
10. Haga una visita de seguimiento para compartir resultados.
11. Entregue los materiales de información a los estudiantes para que cuenten con material de referencia en el desarrollo del proyecto.
12. Póngase a la disposición de los estudiantes para consultas en el proceso de hacer la composta y provea los teléfonos de otras entidades o agencias que ofrecen asesoramiento y apoyo. (Autoridad de Desperdicios Sólidos)
13. Se recomienda integrar en este proyecto a los empleados del comedor escolar.
14. Esta es una actividad que se puede coordinar con los maestros de ciencias como parte del estudio de cambios en la materia y es altamente recomendada para sectores rurales.

Evaluación:

Un mes más tarde ofrezca la oportunidad, a los estudiantes que hicieron la composta, de hacer una presentación en clase sobre su experiencia.

- Si tuvieron éxito y cómo ha sido de beneficio la composta producida.
- Si no completaron la actividad, que discutan por qué.

Referencias:

- Autoridad de Desperdicios Sólidos. 1996.
- Banco Popular de Puerto Rico. 1995.

Otros Recursos:

Lecturas Suplementarias

- La Isla Desechable: El Problema de los Desperdicios Sólidos en Puerto Rico. Banco Popular de Puerto Rico.

Videos

- El Oro Marrón del Agricultor. Instituto de Educación Ambiental. (18:00 minutos)

APRENDAMOS A HACER NUESTRO PROPIO ABONO NATURAL

ANEJO #1

Preguntas guía para el video " El oro marrón del agricultor"

¿Qué es composta?

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¿Qué materiales podemos utilizar para hacer composta?

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¿Qué lugares podemos utilizar para hacer composta?

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¿Qué usos podemos darle a la composta?

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¿Qué beneficios para el ambiente representa la composta?

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____

APRENDAMOS A HACER NUESTRO PROPIO ABONO NATURAL

Ref: Archivos de INEDA

Ilustración #1

Activity 3.4; Baúl de Actividades

Activity 3.4 on page 149 of the Baúl de Actividades sobre Bosques Tropicales

This activity is available in the Baúl de Actividades sobre Bosques Tropicales, a book of classroom activities provided by the USFS in 1990s whose activities related to environmental awareness, forest preservation, etc. The book was intended to be used by educators in conjunction with a chest of resources so that they may educate their students on the book's topics. The description below is a summary of the activity in English. For the original activity description, see page 332.

Preparation:

1. In the class before ask students to walk around with a plastic bag during the day and deposit all of the waste that they generate into it. They should bring the bag to the next class. Clarify that they should not include sanitary waste
2. Label 5 boxes:
    a. 2 for trash
    b. 2 for recyclables
    c. 1 for solid waste
3. Prepare three stations in an adequate location

Activity Description:

1. The day of the class discuss the following questions with the students
    a. How did it feel to carry the plastic bag all day?
    b. Where do you think all of those materials will end up
    c. Observe the materials in the bad. Do you think all of it is "trash"?
    d. Discuss the concept of "trash" after presenting the background
2. Divide the class in two groups; groups A and B
3. Ask the students who placed solid waste in station C what they generated
4. Then, members of each group will stand at the back of station C in a single file. The last person in each line will be facing station C
5. Begin a race or a fast walk. Each member of each team will go towards station C, take something from the box and run back to the station corresponding to their team. They will deposit the material in the box of recyclables or for trash according to what they believe to be correct. Then they will go back to their group and give a tap on the back to the next person in line. This signal will indicate that the next person must do the same thing (it is important that the rest of the group hangs back to prevent them from helping to identify the materials)
6. The game ends when all of the members of one of the teams have participated
7. The winning group will be whichever one has correctly separated the most number of materials
8. Then, each student will take a material and answer the following questions:
    a. Is it recyclable?
    b. With what material is it made of?
    c. In what way can it be recycled?

3.4 RELEVO DE MATERIALES RECICLABLES

Resumen:
El ***reducir, reusar y reciclar*** los materiales que lanzamos al zafacón son alternativas sencillas en las que todos podemos participar para solucionar el problema del manejo de los despendicios sólidos en Puerto Rico. Para comenzar es importante que tengamos claro que no todo lo que desechamos es ***basura***. En esta actividad los estudiantes aprenderán a diferenciar los ***materiales reciclables*** del resto de los ***desperdicios sólidos*** y conocerán las formas en que los bosques reciclan naturalmente.

Trasfondo :

El estilo de vida de nuestra sociedad promueve la generación de grandes cantidades de desperdicios sólidos. Sólo tenemos que observar nuestro comportamiento desde que nos levantamos en la mañana. En el desayuno probablemente botamos una botella de jugo, una caja del cereal, la envoltura de algún bizcocho. Luego en la merienda desechamos una lata de refresco y la envoltura de las papitas. Finalmente, para la cena quizás nuestros padres se detienen en algún restaurante de comidas rápidas y desechamos cajas, decenas de servilletas, vasos y las bolsas que empacan nuestros alimentos. Si multiplicamos esta basura por todas las personas que habitan en nuestra isla llegaremos a la conclusión de que es una cantidad alarmante.

Nuestras actividades están en conflicto con el funcionamiento de los sistemas naturales. Los bosques así como otros ecosistemas nos revelan la forma correcta de manejar nuestros recursos naturales. En los ecosistemas nada es desechable, todo tiene una función y por tanto constantemente se devuelve a la corriente de uso. Si nos detenemos a observar los ciclos naturales de oxígeno, agua, nutrientes y minerales, observamos como todos los materiales naturales son reciclados constantemente. Veamos algunos ejemplos:

Ciclo de Nutrientes:

- Las plantas toman los nutrientes del suelo para preparar azúcares, para su alimentación y la de otros seres vivos.
- Los animales consumen las plantas y devuelven los nutrientes al suelo a través de sus desechos biológicos.
- Las plantas y los animales mueren, se descomponen y devuelven los nutrientes de sus cuerpos al suelo.

Ciclo de Oxígeno:

- Las plantas producen oxígeno como un producto del proceso de fotosíntesis.
- Los animales usan el oxígeno para respirar.
- Los animales exhalan el bióxido de carbono.
- Las plantas usan el bióxido de carbono para el proceso de fotosíntesis.

Ciclo del Agua:

- El sol evapora el agua de los cuerpos de agua.
- El vapor de agua condensado forma las nubes.
- Las nubes liberan el agua como lluvia.
- Las plantas y animales usan el agua.
- El agua que no se usa regresa a los cuerpos de agua superficiales o bajo la tierra.

Niveles: Grados 5 al 9

Materias: Estudios Sociales, Física, Biología

Conceptos :
- Reciclaje
- Manejo de desperdicios sólidos
- Conservación de recursos

Destrezas :
- Trabajo en equipo, evaluación, causa y efecto

Propósitos:
- Exponer a los estudiantes a la idea de que los bosques reciclan constantemente sus componentes.
- Concientizar a los estudiantes sobre los valiosos recursos contenidos en la "basura" que desechamos.
- Motivar a los estudiantes a participar en la solución del problema de manejo de los desperdicios sólidos.
- Conocer algunos materiales reciclables.

Materiales:
- Área grande para correr
- 5 cajas grandes (2 x 2 x 1.5 aproximadamente)
- Guantes desechables
- Anejo #1 - Esquema

Tiempo :
- Actividad: 50 minutos

Ciclo de los Minerales:

- Los minerales se acumulan formando montañas y luego mediante la erosión se convierten en sedimentos.
- Nuevos minerales salen de los volcanes y otros van a parar al interior de la tierra.

El ser humano por el contrario, ha fabricado materiales que por su composición y cantidad no pueden ser procesados por la naturaleza. Una vez desechamos estos materiales, permanecen por mucho tiempo en nuestros suelos y aguas, contaminándolos. ¿Alguna vez nos hemos preguntado a dónde va a parar toda esa "basura"? Muchos sabemos que a los ***vertederos***. Sin embargo, el problema no termina ahí, la realidad es que el espacio en los vertederos se está agotando drásticamente. Ya en el 1994, en Puerto Rico, la mitad de éstos tuvieron que ser cerrados. Los existentes se están llenando a un paso acelerado. También muchas personas lanzan los desperdicios en vertederos clandestinos, lugares como áreas abandonadas y cuerpos de agua.

Además, desechamos los residuos que generamos de nuestras actividades naturales considerándolos "basura". Usualmente llamamos basura a todos aquellos materiales que lanzamos al zafacón. Sin embargo, la mayor parte de éstos son recursos muy valiosos. Por tanto es más correcto llamarlos residuos o desperdicios sólidos. Dentro de los materiales que tratamos como basura están las latas de aluminio, los envases de vidrio y plástico, el papel, los periódicos y las hojas. Todos estos materiales se conocen como materiales reciclables ya que a través del proceso de reciclaje pueden ser convertidos en nuevos productos. Es decir, con las latas de aluminio podemos fabricar nuevas latas de aluminio, con las hojas podemos hacer abono y así con el resto de los materiales. Pero la única forma en que esto se puede lograr es si cada uno de nosotros se toma un tiempito y separa los materiales reciclables del resto de los residuos sólidos y los lleva a su centro de depósito más cercano, o participa de algún programa especial de reciclaje.

La reducción en la fuente, la reducción de la elaboración de bienes, y el reuso de éstos son las alternativas principales para solucionar este problema. La reducción en la fuente se refiere a que las empresas utilicen empaques ambientalmente amigables y que los consumidores evaluemos los productos y bienes que vamos a comprar antes de adquirirlos. Esto con el fin de minimizar los desperdicios que generamos. Algunas alternativas son reducir la cantidad de empaque innecesario, considerar el uso de productos concentrados, comprar productos de tamaño grande en vez de empaque individual y comprar y usar productos duraderos en vez de desechables.

Es necesario que poco a poco modifiquemos nuestros hábitos de consumo. Evitemos el uso de ***productos desechables*** como platos, vasos y utensilios de cartón o plástico. En vez de botar la ropa que no vas a usar compártela con aquellos que puedan necesitarla. ¡Sé creativo! Muchas personas preparan artesanías con materiales que hubieran ido a parar a la "basura". Antes de lanzar algún producto al zafacón pensemos en cómo podemos reusarlo. En ocasiones lo hacemos rutinariamente. En nuestros hogares usamos los recipientes de la mantequilla como vasos, las latas de galletas para guardar artículos y las cajas de regalos para una próxima ocasión, entre otros. Además, comprar artículos fabricados con materiales reciclados y evitar comprar artículos individuales con exceso de envoltura son otras formas de contribuir a la solución de este problema. Para que el reciclaje tenga el impacto esperado sobre la generación de los desperdicios sólidos, es necesario que sea combinado con la reducción de éstos.

Si reciclamos y reducimos la basura, además de estar ahorrando espacio en los vertederos, también estaremos protegiendo nuestros recursos naturales. ¿Cómo? Sencillo, tomemos por ejemplo el papel : cada vez que reciclamos el papel evitamos que se corten más árboles para producir papel.

Preparación:

1. En la clase anterior pida a los estudiantes que durante ese día caminen con una bolsa plástica y depositen en ésta todos los desperdicios sólidos que generen. Deberán traer la bolsa a la próxima clase. Acláreles que no incluyan desperdicios sanitarios.
2. Identifique las 5 cajas:
   - ☒ 2 basura
   - ☒ 2 reciclables
   - ☒ 1 desperdicios sólidos
3. Prepare tres estaciones en un área bastante amplia según se muestra en el Anejo #1 (Esquema).

Descripción de la Actividad:

1. En el día de la clase discuta las siguientes preguntas (use la información del trasfondo):
   - ★ ¿Cómo se sintieron al cargar con esa bolsa durante todo el día?
   - ★ ¿Dónde creen que van a parar todos esos materiales?
   - ★ Observen los materiales contenidos en la bolsa. ¿Creen que todo eso es "basura"?
   - ★ Discuta el concepto "basura" según presentado en el trasfondo.
2. Divida la clase en 2 grupos; grupos A y B
3. Pida a los estudiantes que coloquen en la estación C los desperdicios sólidos que generaron.
4. Luego los miembros de cada grupo se pararán de espaldas a la estación C formando una fila india. La última persona de cada fila se colocará mirando hacia la estación C.
6. Comience la carrera o caminata rápida. Cada miembro del equipo saldrá hacia la estación C, tomará un material de la caja y correrá hacia la estación que le corresponda (ver Anejo #1) depositará el material en la caja para reciclables o para basura según crea correcto. Luego regresará a su grupo y le dará una palmadita en la espalda a la próxima persona en la fila. Esta señal le indicará que repita el mismo proceso (es importante que el resto del grupo permanezca de espaldas

a la estación C para evitar que ayuden en la identificación de los materiales.)

7. El juego concluye cuando en alguno de los equipos hayan participado todos sus integrantes.
8. El equipo ganador será aquel que haya separado correctamente el mayor número de materiales.
9. Luego cada estudiante tomará un material y contestará las siguientes preguntas :
   - ★ ¿es reciclable?
   - ★ ¿con qué recurso se fabrica?
   - ★ ¿de qué forma se puede reusar?

* Nota aclaratoria: Es importante señalar que el 69% de los desperdicios que se generan en Puerto Rico son potencialmente reciclables. Sin embargo al presente no contamos con el mercado ni con la infraestructura para reciclarlos todos. La Autoridad de Desperdicios Sólidos tiene como meta reciclar el 35% de éstos para el año 2,000.

Ejemplos :

Lata de Aluminio - *mineral bauxita* - se recicla para convertirse en nuevas latas: en este proceso se ahorra energía y agua.

Botella de Vidrio - *arena* - las botellas se rompen en pequeños pedazos y luego se derriten y se mezclan con nuevo vidrio para hacer nuevas botellas y jarras. De este modo ahorramos energía.

Papel - *tronco de los árboles* - se recicla para hacer nuevo papel - se reusa al usarse por ambas caras, evita la deforestación.

Periódico - *tronco de los árboles* - se recicla para hacer nuevo papel - puede ser compartido con los vecinos, evita la deforestación.

Recipientes plásticos de leche - *petróleo* - se producen artículos de plástico, puede ser usado como recipiente para jugos o agua. Se conserva el petróleo, fuente de energía no renovable a corto plazo.

Hojas - se utilizan en la producción de abono, se reponen nutrientes a la tierra para uso de plantas y animales.

7. Finalice discutiendo las siguientes preguntas: (utilice los ejemplos del trasfondo)
   - ★ ¿Cómo creen que los ecosistemas naturales procesan sus desperdicios?
   - ★ ¿Qué conocen del problema del manejo de los desperdicios sólidos en Puerto Rico?
   - ★ ¿Creen que hay algo que podamos aprender de la naturaleza ?
   - ★ ¿De qué forma podemos imitarla?

Enriquecimiento:

- Motive a los estudiantes a desarrollar un programa de reciclaje en su salón de clase.
- Discuta con los estudiantes el cuento: "Pablo y Marisol van a la playa y aprenden sobre reducción, reutilización y reciclaje"

Evaluación:

Solicite a los estudiantes que preparen un plan de reducción y reciclaje en su casa.

Este debe incluir los siguientes aspectos:

- Los materiales que van a reciclar.
- Los materiales que podrían reusar y reducir y ¿cómo?.
- ¿En qué lugar de su casa colocarían los materiales reciclables?
- ¿Quién se encargará de enjuagarlos?
- ¿Cada cuánto tiempo los llevarían a los centros de depósito?
- Razones para motivar a su familia a participar en el programa.

Referencias:

- Adaptado de USDA Forest Service. 1994. Branching Out to the Youth of America: "Recycling Relay".
- Banco Popular de Puerto Rico. 1995.
- Environmental Protection Agency. 1990.

Otros Recursos:

Lecturas Suplementarias

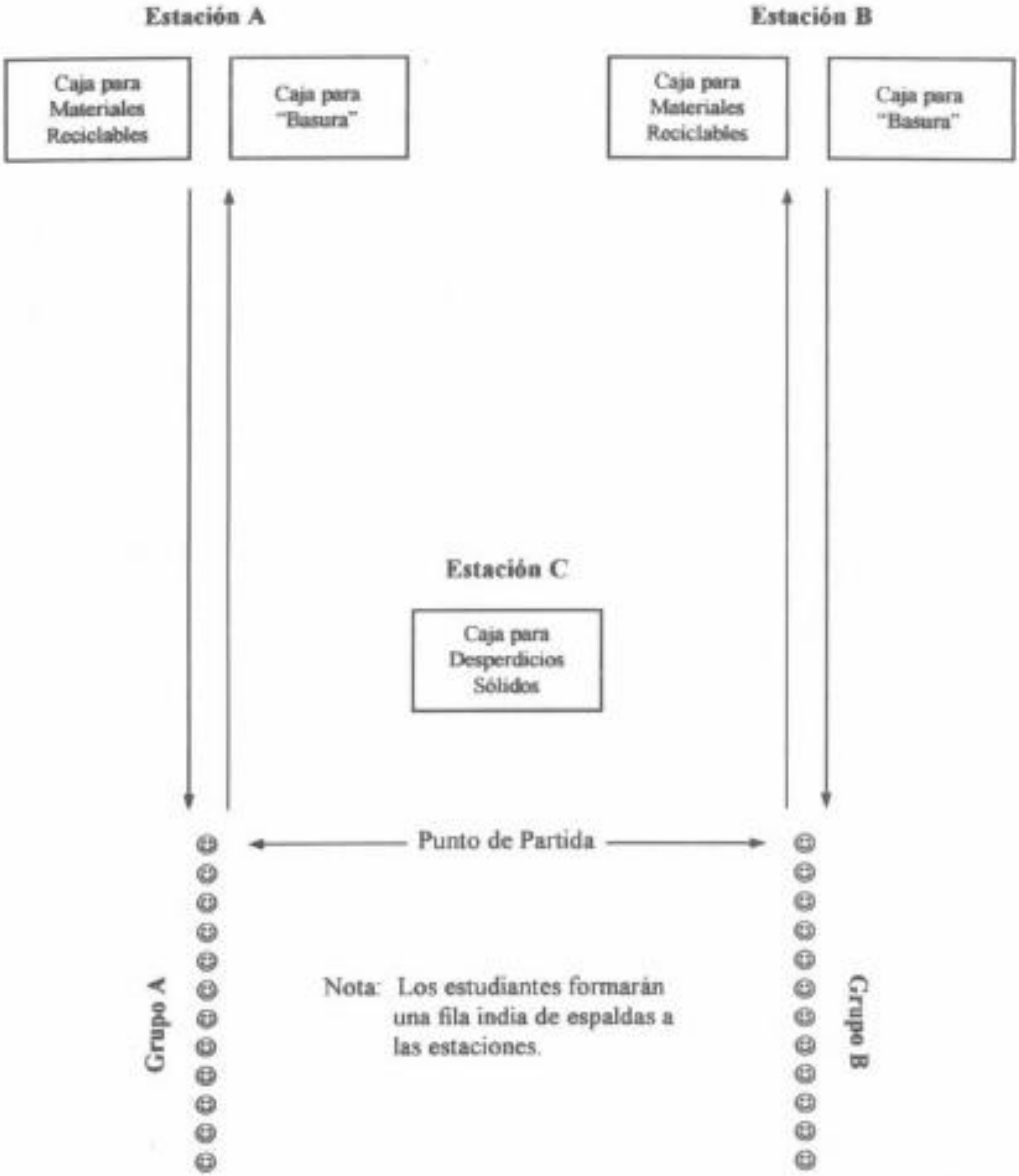
- El Consumo: La Nueva Religión.

Publicaciones

- La Isla Desechable: El Problema de los Desperdicios Sólidos en Puerto Rico.
- Reduce, Reusa, Recicla.
- Yo Reciclo en los "Drop-Offs".
- Pablo y Marisol van a la Playa y Aprenden Sobre Reducción, Reutilización y Reciclaje.

Videos

- Arropados por la Basura.


Estación A
Caja para Materiales Reciclables
Caja para "Basura"
Estación B
Caja para Materiales Reciclables
Caja para "Basura"
Estación C
Caja para Desperdicios Sólidos
Punto de Partida
Grupo A
Grupo B
Nota: Los estudiantes formarán una fila india de espaldas a las estaciones.

Climate Kids

This website, produced by the Earth Science Communications Team at NASA's Jet Propulsion Laboratory and California Institute of Technology, aims to teach children about the environment and about the various aspects of climate change. This is done through a variety of games, activities, videos, and more.

http://climatekids.nasa.gov/

The following activities are taken from the website, and can be applied to our lessons.

Bag an old T-shirt

In this activity, students repurpose an old t-shirt into a reusable shoping bag. The shirt colar and sleeves are cut off, and strips of fabric are removed from the sleeve cut-outs. Students use these strips to weave the shirt shut to finish the bag.

http://climatekids.nasa.gov/tshirt-bag/

Make Sun S'mores

This activity is a fun way for students to harness and understand solar energy. Students build a solar oven using a cardboard box, aluminum, and plastic wrap. The students then put the solar oven in direct sunlight and use the heat from the Sun to make s'mores.

http://climatekids.nasa.gov/smores/

Do a Science Fair Project

The topics of the science fair proposed in this activity are alled related to topics of climate change. This is a good final project to have students do at the end of a climate change unit. Students can either test a hypothesis, answer a question, or show how nature works. The students must design their research and create an exibit or a display to showcase their work. They must also write a short report that explains their project.

http://climatekids.nasa.gov/science-fair/

Videos

ClimateKids: What is happening in the ocean?

This video, presented by NASA's ClimateKids, describes greenhouse gasses and the effects that anthropogenic climate change has on the world's oceans. The video includes scientific concepts in a way that is more likely to be understood by elementary school students as well as middle school students.

http://climatekids.nasa.gov/ocean/

Accompanying the video is information about the importance of oceans and ocean functions, coral reefs, marine life, and ocean chemistry.

Mythbusters: The Great Ice Debate

Mythbusters SP11 – "Young Scientist Special" #4 *The Great Ice Debate*

This video describes the greenhouse effect through an experiment. The mythbusters set up three transparent boxes; one filled with CO2, one filled with methane and the other set as control. They then monitor the temperature differences between the three boxes of a period of time.

https://www.youtube.com/watch?v=pPRd5GT0v0I

The Human Impact of Climate Change: Personal Stories from Belize, Bolivia, and Brazil

The following video has people from Belize, Bolivia, and Brazil sharing personal stories about how climate change has affected their lives. These stories focus primarily on water, which is one of the ways in which climate change will have a negative impact on people, especially in Puerto Rico. This video can be used to supplement Lessons 3 and 4 in Appendix Q

https://www.youtube.com/watch?v=Lv2XxXNqZa8

This video has subtitles in English and Spanish