Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2018 Volume II: Engineering Solutions to 21st Century Environmental Problems

Humans as Invasive Species: Their Impact on the Environment and Adaptations to Live with the Changes to our Climate

Curriculum Unit 18.02.04
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Introduction

I teach primarily sophomores in New Haven, CT a city with over one hundred and twenty three thousand residents whose average salary is approximately thirty-five thousand dollars a year. Throughout New Haven, over twenty thousand students include forty-two percent African America, forty-one percent Hispanic, fourteen percent Caucasian, two percent Asian American, and one percent other ethnic backgrounds. Many students have never left Connecticut, let alone the city itself. With this, it is hard for the students to grasp the magnitude of many global phenomena unless it directly impacts them. It's not that they don't have the ability to understand it, it's just too foreign of a concept to them. I can pass on my knowledge and lecture all I want, but if the students do not have the desire to learn, then the entire message will be lost. I plan to engage them in such a way that they will be able to relate to the topic and want to learn and interact with the lessons.

Rationale

Since humans have started to expand their settlements and industrialize, they have been able to release approximately 555 gigatons of carbon dioxide ($GTCO_2$) into the atmosphere. This can be traced back to be the underlying reason that there are observed temperature and sea level changes. The average temperature over land has increased 0.85 degrees Celsius (°C) and the sea level has risen 0.19 meters (m). [1]

Ecology is the study of the relations of organisms to one another and to their physical surroundings. Through years of coevolution, most ecosystems have become self-sustainable, but even the slightest change can affect an entire area. With the introduction of an invasive species, a nonnative organism that was brought from another area, can come a disruption of a delicate preexisting ecological balance. This will be my segue into connecting the students' lives into the topic. Climate change is something that the students can identify with. Living on the shoreline, the students can start to make observations that things are changing, such as increased extreme weather phenomenon, shifting seasons causing plants and crops to sprout at different times. The sea level in the Long Island Sound less than a mile away from them is rising.

After introducing the impact that climate change has had on our environment and how we don't live in a bubble where we are unaffected by our actions as a human race, I would want to start looking into ways that we can adapt to with the changing world. Some areas are already being affected by this change in the climate and some people believe it is too late to turn back now. Using twenty-first century engineering solutions, hopefully we can understand what is causing this climate change, and then we can start thinking about ways that we can move forward.

Introduction to Invasive Species

An invasive species can be defined as an organism that has been introduced into a new area, typically due to human interference, and has caused some sort of environmental damage. Species can be introduced into a new area purposely or accidentally. Some organisms can be intentionally introduced as a food source, for sport hunting, government subsidization, and/or to be kept as an exotic pet. A commonly held belief is that since the organism has not done great damage in their home environment, then the damage they would cause in a new environment would be negligible. Some species may also be transported without the knowledge of the people who are doing the exporting. Some species travel inside shipping crates, stowaway in ships, and/or adhere to the vessels. In some cases, and due to the lack of coevolution amongst the native species and the new species, natural selection cannot keep up and the new specie may thrive.

Indigenous to Southeast Asia, the Burmese Python was once a permitted pet in the U.S. and was thought to be released into the wild by pet owners. These apex predators were able to disrupt the food chain very rapidly due to the fact that they fed on almost all of the consumers within the food web without the threat of being eaten themselves. Since the Burmese Python was able to continue to thrive uninterrupted, over the course of 2003 to 2011, it was noted that the population of raccoons, bobcats, opossums, and white-tailed deer had decreased by 99.3%, 87.5%, 98.9%, and 94.1 respectively due to overeating by this organism. [2] The human population is a reflection of the situation of the Burmese python in Florida. According to fossil record, early hominids had started in what is now Africa and now live in almost every habitable area on the planet. The human race has spread around the planet and can be traced back to be the ultimate cause for many environmental issues. For many invasive species, an easy fix would be to eliminate them to stop their spread, but that isn't a viable option for the human population. Alternative methods for dealing with humans and their impact on the environment.

Humans and Carbon Dioxide Emissions

With a sudden warming of the atmosphere, surface, and ocean, there must be a cause of why this is all happening within the past century and why it's so much more drastic within the past twenty years. The atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) have all increased to levels not observed in over eight hundred thousand years. [3] Carbon dioxide levels have increased by 40% since pre-industrial times. This is primarily attributed to the burning of fossil fuels. Methane and nitrous oxide have each increased by 150% and 20%, respectively. These historical comparisons are made possible by taking samples from ice cores. In artic regions where ice has been consistently frozen, scientists have drilled far enough down and retrieved samples of ice that froze eight hundred thousand years ago. In those ice crystals are gaseous pockets of past atmospheres. The deeper within an ice core a sample is taken, the older it is. As new snow and ice accrues, over time, more snow and ice will accumulate over it, making a new layer. Over the course of several thousand years, ice crystals become buried, but by drilling and collecting samples, accurate estimates of air quality from the pase can be made.

From 1750 to 2011, the amount of carbon dioxide released into the atmosphere has been estimated. In that time span, we've released about 375 Gt of carbon into the atmosphere produced by fossil fuel combustion and cement production. Deforestation and other land use change has also added about 180 Gt of carbon into the atmosphere as well. The planet has found its own ways to reabsorb the carbon that is being released into the atmosphere. Out of the 555 Gt of carbon released, approximately 155 Gt of carbon has been taken back into the ocean and 160 Gt of carbon has accumulated in natural terrestrial ecosystems. All of that carbon going back into the ocean isn't beneficial. It decreases ocean pH. With more carbon dioxide, the oceans undergo a process called "acidification" where the carbon dioxide and water chemically combine to create carbonic acid, a weak acid, but when 155 Gt of carbon is added to the ocean, it's enough to decrease the ocean's pH by 0.1.

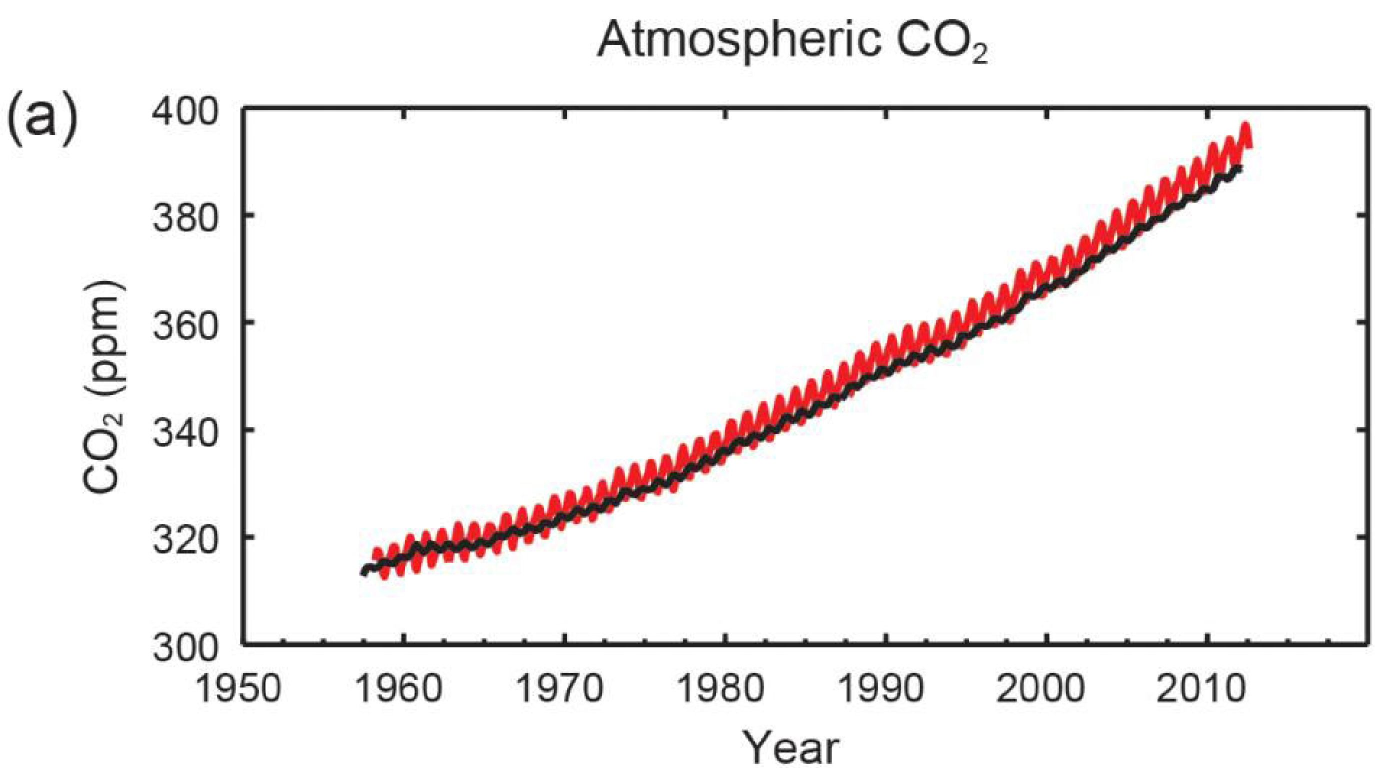

Figure 1: Multiple observed indicators of a changing global carbon cycle: (a) atmospheric concentrations of carbon dioxide (CO2) from Mauna Loa (19°32'N, 155°34'W – red) and South Pole (89°59'S, 24°48'W – black) since 1958. Full details of the datasets shown here are provided in the underlying report and the Technical Summary Supplementary Material. {Figures 2.1 and 3.18; Figure TS.5} (IPCC, 2013)

The Human Effect on the Ecosystem

Due to the presence of humans and their actions, the earth has undergone environmental changes. Climate scientists have been observing trends since the 1950's and have noticed that there is evidence that the atmosphere and the oceans have warmed, the extent of ice cover and glaciers have decreased, the sea level is rising, and that the concentration of greenhouse gases have increased. [4] Looking at the thirty year span of 1983 to 2013, it is likely that it was the warmest thirty year period in over one thousand-four hundred years. In this time period, the Earth's surface had increased its temperature by 0.85 degrees Celsius (°C). The number of cold days and nights have decreased, and inversely, the number of warm days and nights have increased. Throughout parts of Europe, Asia, and Australia, we've also reported an increase in the number of heat waves. Also, in parts of Europe and North America, the amount and intensity of precipitation has also increased.

The Earth's surface and the atmosphere aren't the only places that are being warmed. The oceans have also started to notice an increase in temperature in the upper most portion. The largest observable increase in temperature of the ocean has occured within the first 75 meters (m) of depth where there has been an increase of 0.11°C per decade from 1971 to 2010. [5]

Warming temperatures have given rise to increased melting of the cryosphere. Over the last two decades, the ice sheets around Greenland and Antarctica have lost mass, glaciers have decreased in size, spring snow cover in the arctic sea and Northern hemisphere have decreased, and permafrost temperatures in parts of Northern Alaska and Russia have increased. [6] When considering glaciers between 1971 and 2009, an average of 226 gigaton (Gt) of ice was lost per year. Within that forty eight year span, the ice melt fluctuated greatly. Looking at the period between 1993 and 2009, still within that same forty eight year span, but toward the end of it, it can be observed that an average of 275 Gt of ice melted from glaciers per year. Using this data, it can be concluded that as time went on, the impact by humans had increased the loss rate glacial ice. To understand how much ice is being lost each year, 1 Gt of ice is roughly equivalent to 1 square kilometer (km^3). Thus, by the end of 2009, approximately 275km^3 of ice is being lost each year.

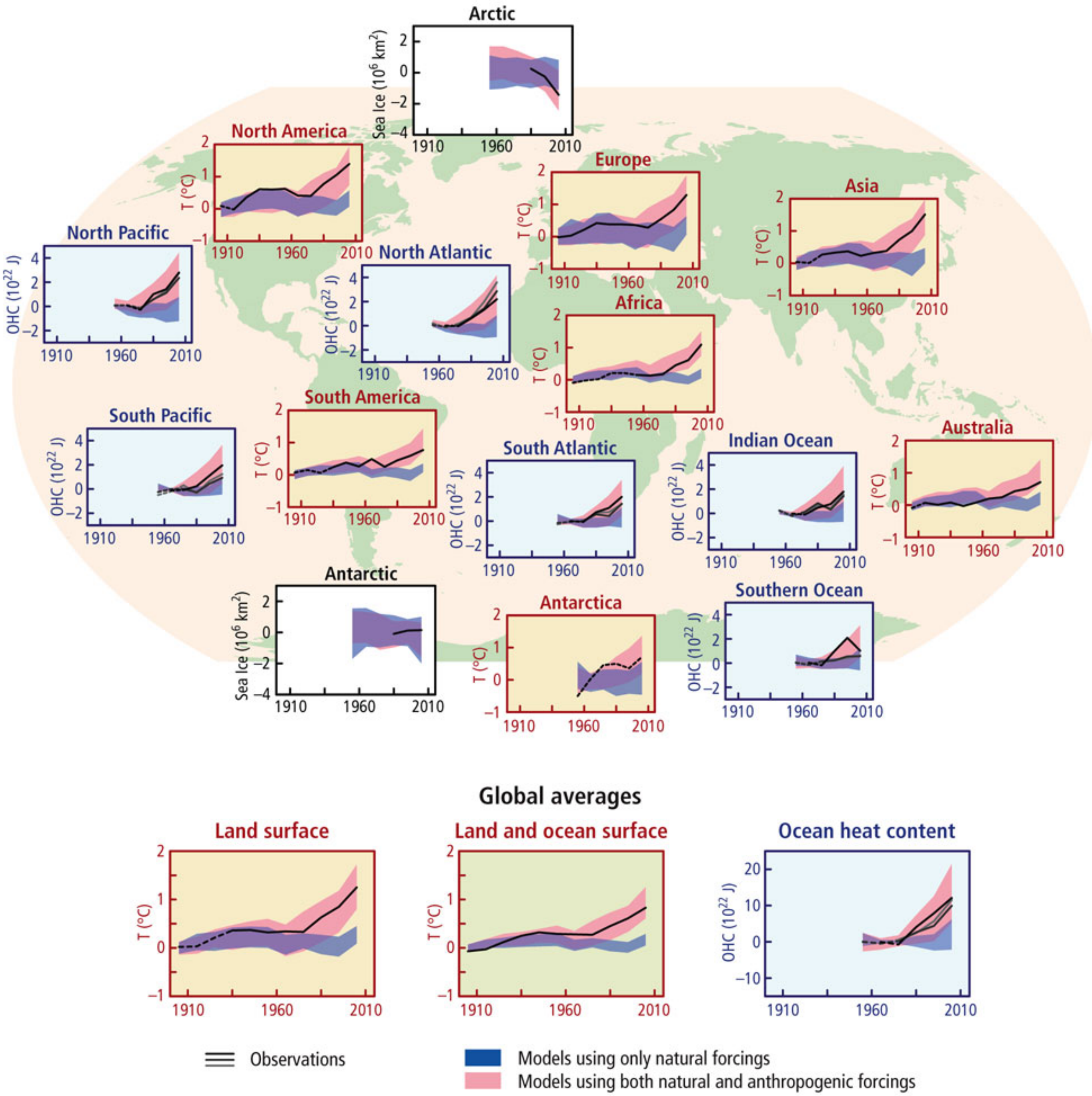

Figure 2: Comparison of observed and simulated climate change based on three large-scale indicators in the atmosphere, the cryosphere and the ocean: change in continental land surface air temperatures (yellow panels), Arctic and Antarctic September sea ice extent (white panels), and upper ocean heat content in the major ocean basins (blue panels). Global average changes are also given. Anomalies are given relative to 1880–1919 for surface temperatures, 1960–1980 for ocean heat content and 1979–1999 for sea ice. All time-series are decadal averages, plotted at the centre of the decade. For temperature panels, observations are dashed lines if the spatial coverage of areas being examined is below 50%. For ocean heat content and sea ice panels the solid line is where the coverage of data is good and higher in quality, and the dashed line is where the data coverage is only adequate, and thus, uncertainty is larger. Model results shown are Coupled Model Intercomparison Project Phase 5 (CMIP5) multi-model ensemble ranges, with shaded bands indicating

the 5 to 95% confidence intervals. For further technical details, including region definitions see the Technical Summary Supplementary Material. {Figure 10.21; Figure TS.12} (IPCC, 2013).

The rate in which sea level rising has increased to a higher rate in over two millennia. Between 1901 and 2010, global sea rose about 0.19m. In that entire span of 1901 to 2010, the sea level rose about 1.7 millimeters (mm) per year, but looking at different periods during that one hundred and nine year span, the average rise of the sea level increased the closer we get to the present day. The span between 1971 and 2010, the sea level rose an average of 2.0 mm per year and the span between 1993 and 2010, there was an average increase of 3.2 mm per year. Since there is such a lower average when looking at the span of over one hundred years as opposed to just a span of almost twenty years, it indicates that the sea level is rising much faster in the present day.

The cause of the sea level rise can be attributed to glacial ice melt and water thermal expansion. Approximately 75% of the rising seas levels can be attributed to glacier mass loss and through thermal expansion due to temperature increases. As the glaciers melt, the water that was once frozen and attached to it, enters the ocean and adds more to its volume. This melting of the ice has raised sea levels by 0.76 mm per year. The other large contributing factor is the warming of the oceans. As water warms, it increases the volume. The same phenomenon can be seen in mercury thermometers. As the mercury warms, it expands and the top level rises. Beyond warming water and glacial melting, the other factor that has increased the sea level is land water storage (0.38 mm per year).

With more greenhouse gases in the atmosphere, a positive radiative forcing (RF) has been observed (Figure 3). Radiative forcing quantifies the amount of energy entering earth and leaving earth. A positive RF would indicate a warming and a negative RF would indicate a cooling. For the most part, our planet is undergoing a positive RF. Scientists have been able to record the amount of energy coming from the sun, by the use of satellites in orbit around the planet, and have come to a conclusion that the energy from the sun has not significantly changed to the point where that would increase the radiative forcing. The only other option that would cause our planet to continue to warm would be due to the planet not emitting as much energy into space as it used to. This is due to the energy becoming trapped by the different gases in the atmosphere. The total RF due to human interference in 2011 was 2.29 watt per square meter (W/m^2). Some halocarbons and short-lived gases contribute to the RF, but the majority of the RF can be contributed to carbon dioxide emissions that caused an RF of 1.68 W/m^2 and methane caused an RF of 0.97 W/m^2 Cumulatively, all of the contributing RF is greater than 2.29 W/m^2, but some emissions have been linked to lowering RF, like aerosols from volcanic activity and solar irradiance (Figure 4). Small global eruptions from volcanos can contribute to -0.11 W/m^2 and cloud adjustments caused -0.9 W/m^2. Overall, even though there are natural factors that lead to a negative RF, human derived atmospheric drivers cause RF to be positive.

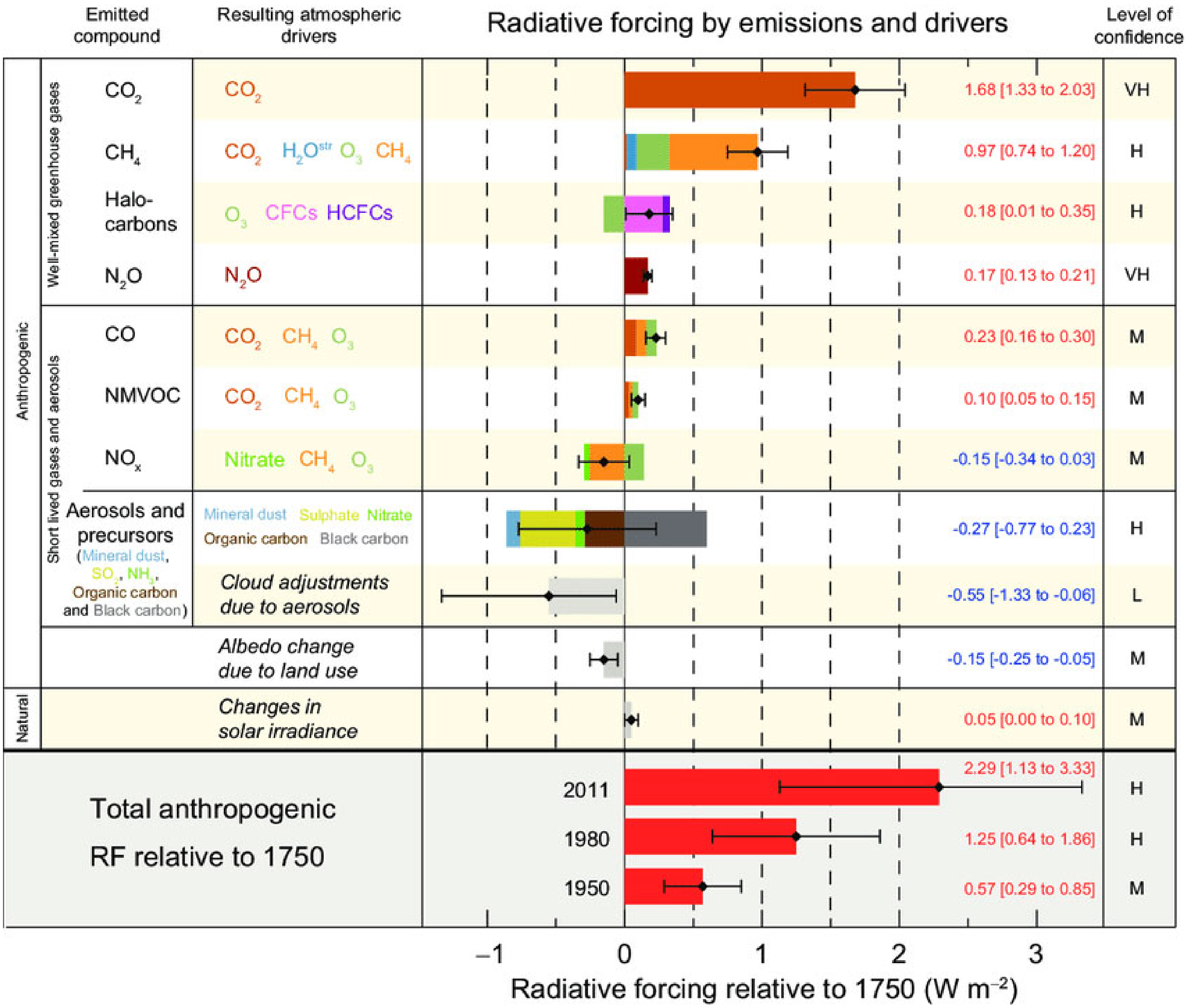

Figure 3: Radiative forcing estimates in 2011 relative to 1750 and aggregated uncertainties for the main drivers of climate change. Values are global average radiative forcing (RF14), partitioned according to the emitted compounds or processes that result in a combination of drivers. The best estimates of the net radiative forcing are shown as black diamonds with corresponding uncertainty intervals; the numerical values are provided on the right of the figure, together with the confidence level in the net forcing (VH – very high, H – high, M – medium, L – low, VL – very low). Albedo forcing due to black carbon on snow and ice is included in the black carbon aerosol bar. Small forcings due to contrails (0.05 W m–2, including contrail induced cirrus), and HFCs, PFCs and SF6 (total 0.03 W m–2) are not shown. Concentration-based RFs for gases can be obtained by summing the like-coloured bars. Volcanic forcing is not included as its episodic nature makes is difficult to compare to other forcing mechanisms. Total anthropogenic radiative forcing is provided for three different years relative to 1750. For further technical details, including uncertainty ranges associated with individual components and processes, see the Technical Summary Supplementary Material. {8.5; Figures 8.14–8.18; Figures TS.6 and TS.7} (IPCC, 2013).

It is evident that humans have caused an increase greenhouse gas emissions which has caused an increase of radiative forcing. An increase of radiative forcing increases the warming of the atmosphere, surface, and oceans. An increase in temperature causes an increase in severe weather anomalies and increased ice melt. An increase of ice melt combined with an increase of temperature contributes to the increase of sea level rising.

The Human Effect on Living Things

Due to the changing climate, some organisms may no longer be adapted to live in certain ecosystems anymore. Whether it be due to the change increase of temperature, change in precipitation, loss of habitat, or change in pH, some organisms will not be able to live in that area anymore because they are not adapted to the new conditions. Organisms need to adapt to survive in one of two ways, genetically or due to plasticity. [7] Some organisms can undergo micro-evolution where organisms are born with mutations that allow them to better adapt. Organisms can be selected through mating because they already have a genetic trait that will help them survive. This takes time and could take numerous generations for the organism's offspring to be better suited for their environment. In general, the earth's climate is changing a rate that far faster than the processes of evolution. Other organisms rely on plasticity, or a short term response where an organism can adapt within their own lifetime. Plastic adaptations rely on the organism's ability to adapt morphologically, physiologically, or behaviorally.

Some organisms have the ability to detect changes in their environment because of their dispersal patterns. [8] Birds, insects, and marine invertebrates who travel and colonize in large groups tend to disperse in their areas. When slight changes to the temperature or pH of the habitat occurs, they become less dispersed and have more competition for the resources. Other times, the organism needs to move to new areas that they are more adapted for. These organisms who need to relocate due to environmental changes are at an increased risk of extinction. [9]

Due to the climate shift, global marine species distribution and marine biodiversity will decrease in sensitive regions. [10] Shifts in marine species migrations due to projected warming will cause high latitude invasions and high local extinction rates in the tropics and semi-enclosed seas. With fish migrating to avoid sensitive areas, fisheries in higher latitudes are expected to observe a more species rich catch rate. By 2100, the ICPP predicts that the oxygen minimum zones, areas in which fish cannot survive, will continue to expand despite all mitigation strategies.

Other organisms that are being affected are those that are used for agriculture. Crops and other plant life that are very sensitive to change in temperature and water levels are already experiencing changes in their flowering stages. Some species of plants have advanced their flowering stage by approximately 5.1 days per decade for the past fifty years. [11] Plants are responding to abiotic factors in the environment, such as temperature and rainfall. Some plants, like ragweed, are having a longer pollen seasons which has contributed to the increase of seasonal allergies and hay fever. [12] These plants are also affected by drying trends and increased temperatures. Agriculture is being damaged by the lack of precipitation in some areas, causing a lack of food for many regions.

Human Adapt to their Mistakes

Greenhouse gases will continue to be released into the atmosphere. Present day society's runs on the energy collected from the burning of fossil fuels. With the continued use of fossil fuels, there will continue to be an increase of warming in our climate. Using different models that can consider different representative concentration pathways, scientists are able to make estimates of climate impact in the year 2100. These models can forecast what would happen if very strict limits are placed into effect and they can make a prediction on what would happen if no mitigation strategies are started. This way, they can look into both best case and worst case scenarios, within reason.

Mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Between the years of 1970 and 2000, there was an increase of 0.4 gigatons of carbon dioxide (GtCO_2) per year. [13] As time progressed, the amount of carbon dioxide released each year increased to 1.0 GtCO_2 per year. Over half of the combined carbon dioxide released into the atmosphere in the past two hundred and fifty years have been within the last forty years. In 1750, the combined carbon dioxide emissions from fossil fuels and cement production was approximately 420 GtCO_2. In 2010, that number almost tripled and released about 1300 GtCO_2. Without any addition mitigation, the results could be an average surface temperature increase anywhere between 3.7°C to 4.8°C by the year 2100. In addition to an increase of surface temperature, an increase of extreme precipitation in areas of high latitude and along the equator will be observed. Extreme precipitation would include more intense and more frequent rainfall. In areas along the tropics, this could be seen as an increase in frequency of monsoons.

If left unchecked, as the temperature increases, ice melt within glaciers and permafrost will increase. By 2100, glaciers will start to melt at a faster rate and decrease anywhere between 35 to 85%. Northern Hemisphere spring snow cover will decrease and 25% and 81% of permafrost will have melted. With the combined increase surface temperature and ice melt, the sea level will also start to rise at a more aggressive rate. If no mitigation strategies have been put in place, sea level could rise by 0.82 m by 2100. Thermal expansion would account for 55% of the rise and glacial melt would account for 35%.

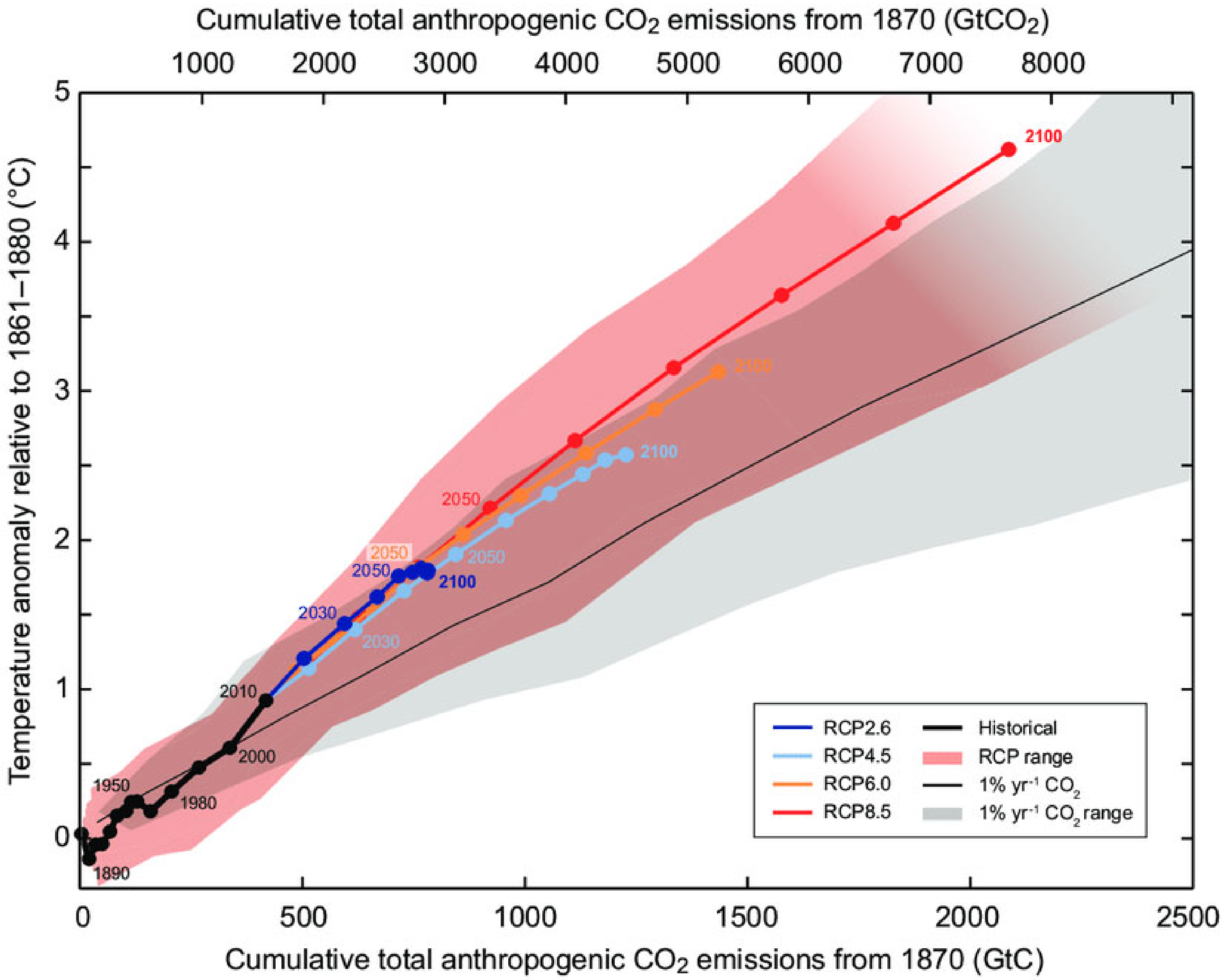

Figure 4: Global mean surface temperature increase as a function of cumulative total global CO2 emissions from various lines of evidence. Multi-model results from a hierarchy of climate-carbon cycle models for each RCP until 2100 are shown with coloured lines and decadal means (dots). Some decadal means are labeled for clarity (e.g., 2050 indicating the decade 2040−2049). Model results over the historical period (1860 to 2010) are indicated in black. The coloured plume illustrates the multi-model spread over the four RCP scenarios and fades with the decreasing number of available models in RCP8.5. The multi-model mean and range simulated by CMIP5 models, forced by a CO2 increase of 1% per year (1% yr–1 CO2 simulations), is given by the thin black line and grey area. For a specific amount of cumulative CO2 emissions, the 1% per year CO2 simulations exhibit lower warming than those driven by RCPs, which include additional non-CO2 forcings. Temperature values are given relative to the 1861−1880 base period, emissions relative to 1870. Decadal averages are connected by straight lines. For further technical details see the Technical Summary Supplementary Material. {Figure 12.45; TS TFE.8, Figure 1}

Each area around the world has a vastly different climate and therefore, would be affected differently by the effects of climate change brought on by greenhouse gas emissions. If mitigation strategies do not fix the problem or do not fix them fast enough so that adverse effects are not stopped in time, adaptation strategies must be put into effect to live with the outcomes. Certain climate related drivers of impact have been identified, along with potential adaptations to help get us through.

The idea of changing to adapt with the climate may seem simple at first, but will weigh heavily on the economy. Small islands in the Pacific will have an issue to adapt due to their high coastal area to land mass ratio. It would be far too financially taxing on an area like that to start coastal renovations like sea walls. Areas in Africa that are expected to see a change in their precipitation can also bring new vector-bourne diseases. A simple solution would to increase health care in those areas, but those areas may not even have a basic healthcare system established yet. These solutions may seem easy enough, but without proper funding, cannot happen. To combat sea level rise, costs associated with damages and adaptations would cost several percentage points of gross domestic product. [16] To best live with climate change, would be to slow down the carbon emission and adopt mitigation strategies to reduce carbon levels to pre-industrial times. In the meantime, an adaption that could help many people would be to install early warning systems to alert citizens of potential hazards.

Classroom Activities

Activity One: Introduction to Invasive Species

Objective: The students will be able to explain how organisms can disrupt an ecosystem

Materials: Food web, Youtube Video: *The threat of Invasive Species – Jennifer Klos* , Internet access

The students should have an idea on what a food web and coevolution are by now. In a typical ecosystem, there are producers and consumers. To prevent the overpopulation of producers (plants), there are primary consumers (herbivores/omnivores) that eat them. To prevent the overeating of the producers and the overpopulation of primary consumers, the secondary consumers (omnivores/carnivores) eat them. This is the process of coevolution where overtime, organisms evolve and adapt alongside others to maintain a balance.

Student will be given a food web and asked “Who will be effected if a single organism is removed from this system?” Students will share with one another what they believe will happen when someone disrupts the food web. The teacher will go on to explain that even though two organisms may not be directly related in a food web, the two effect one another. If one were to not be part of the system, some organisms go hungry and some thrive. Students will be asked “If removing an organism from an ecosystem could disrupt everything, what will happen if a new organism is introduced?”

Students will watch TEDEd’s video on invasive species and see what will happen if a new organism is introduced into an ecosystem. [17] Without evolving and adapting with the other organisms, this new organism can continue to flourish without the threat of any natural predator. This is what makes them invasive. The fact that they are introduced into a new area and causes damage to the ecosystem and the organisms that live there. The students will choose from a list of invasive species and do independent research to answer the following questions:

1. Where did it come from?
2. How was it introduced into the new area?
3. What damages has it caused?

4. Have there been any attempts to stop it? If not, what could be a way to stop it?

Activity Two: Humans and Carbon Dioxide Emissions

Objective: The students will be able to compare the rate of human population growth to carbon dioxide emission.

Materials: Graphs of human population growth and greenhouse gas emission overtime.

Students will be asked to recall the concept from the previous lesson of organisms disrupting the natural flow within an ecosystem. Students will be asked "Understanding what an invasive species is and what it does, do you think that humans would qualify as one?" Students will share with another their thoughts before coming back to the general forum.

Teacher will explain to the students that ever since the industrial revolution, as many parts of the world was developing, the amount of fossil fuel burning increased to meet the demand. Teacher will explain to the students that we can track how much carbon dioxide and other greenhouse gases are in the atmosphere are different time periods by a process in which ice is extracted from permafrost. In areas where the snow does not melt, every time it snows, it covers the previous layer of snow. Each layer of ice crystals holds a frozen remnant of the atmosphere at the time in which the snow fell and they can be collected and measured. With this method, scientists can get an accurate measurement for how much carbon dioxide was in the atmosphere during that time period.

Students will look into how the human population have grown in the past few centuries. Students will also look into the amount of greenhouse gases being released into the atmosphere over the course of time. Students will compare the maps of population growth and greenhouse gases release to look into a correlation between the two.

Activity Three: The Human Effect on the Ecosystem

Objective: The students will be able to compare environmental factors from before and after the human population started to grow exponentially.

Materials: Graphs of temperature, ice melt, sea level change, and pH concentration of oceans

Students will be asked to recall the concepts from the previous lesson of how humans have increased the amount of greenhouse gases since their population started to rise. Students will be asked "What do greenhouse gases do to effect the environment?" Students will think back to previous science classes and share with one another about how greenhouse gases keep heat from escaping the atmosphere. With more heat being trapped, there will be an increase in temperature.

Students will look at a map that shows the increase of average temperature over the course of time. The teacher will explain to the students that when they looked into the amount of greenhouse gases being released into the atmosphere last class, they can watch a correlation between the amounts of gases released with a rise in temperatures. The teacher will explain that there are other factors that are being effected by the amount gases being released.

Students will be given a map of the planet and look into how key aspects have changed over the course of time. Students will look into the changes of surface and water temperature, ice melt, sea level rise, change in weather patterns (increase/decrease of precipitation), acidification, etc.

Activity Four: The Human Effect on Living Organisms

Objective: The students will be able to explain how changes to the ecosystem can affect their lives

Materials: Journal, Internet Access

Students will be asked to think about how greenhouse gases have affected the ecosystem and recall the information from the previous class. The students will be asked "If the environment is changing, how will this affect the living things that live in the environment?" Students will share out their ideas on how living organisms can affected by the factors from the previous class.

The teacher will explain how for certain areas, they may see a change in temperature, change in weather, or change pH. In some areas, with the increasing amounts of greenhouse gases, we start to see changes in usual weather phenomenon. In some areas, we are seeing an increase of temperature but also a change in precipitation levels. In some areas, we are seeing a decrease of usual precipitation and an increase of extreme precipitation. This has an effect of crop development which has a direct impact on our and other organism's food source.

The teacher will pose the question, "How do you think your life will be effected by the changing of the climate?" Students will share out their ideas. Some answers to expect are the easy ones including how the temperature will get hotter or the ocean is getting higher. The teacher will explain how there are many more aspects of our lives that are being effected by the climate. The teacher will give the example of eating a bowl of oatmeal for breakfast. "How many of you have eaten a bowl of oatmeal for breakfast? It's easy, convenient, and tasty. Where does oatmeal come from though? Many places, like Quaker Oats, get their oats from Iowa, out in the Midwest. Imagine if the Midwest started to see an increase of temperature and a decrease of precipitation due to climate change, what happens to the oats?"

The teacher will explain to the students that they will asked to record what they had done/will do in a 24-48 hour timeframe (or over the weekend). "Your goal is to record what you do, even the smallest of details, and you are going to try and find out as many possible ways in which your life will have to change if the climate is changing. What will happen to your morning commute to school if precipitation and/or extreme weather phenomenon increase? What will happen to the food you eat if farmers can no longer raise cattle in certain environments?"

Students will record what they've done the day before class or come back to school with their recordings and share their normal routine. Students will then share how their lives aren't safe from the changing climate.

Activity Five: Humans Adapt to Their Mistakes

Objective: The students will be able to design an adaptation in which humans can undergo to live with the environmental changes.

Materials: Chart Paper, Markers/Colored Pencils

The students will be asked to quickly reshare their information from last class about the negative effects that greenhouse gas emissions is having on living organisms. The teacher will ask "What are some ways in which we can stop these negative effects?" Students will share their ideas on ways we can try and engineer solution to the issues that are occurring. The teacher will explain that this is called “mitigation” or the act of reducing the severity of something. Actions like recycling, driving less, using alternative energy are all valid ways in which we can reduce the amount of greenhouse gas emissions that we are putting into the atmosphere.

The teacher will ask “What happens if we don’t fix the problems in time though? What happens if the problems continue to progress as we are trying to fix them since not everyone is on board? What can we do?” The students will be given the prompt of rising sea levels as an example. The teacher will explain “As temperature increases, the sea level will continue to slowly rise and coastal cities will eventually start to flood. What can we do to stop this?” Students will share their thoughts about this problem. The teacher will explain “Some adaptations that have already been put into effect are the constructions of seawalls. Areas of sand and dirt are dug out and a wall is erected to stop erosion and to create a barrier to stop the water from reaching residential areas.” The teacher will show examples of this.

The students will be posed with the task to take on one of the environmental effects identified in the previous class and design an adaptation so that we can live with the change. The students will create a poster to be used in a gallery walk that will include the following:

1. What issue are they attempting to live with?
2. What is their engineering solution?
3. How will this work to help?
4. Will this be a permanent fix?
5. Are there any potential hazards with this engineering solution?

Appendix

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

The students will work to understand how human activity has damaged the environment and how that has hurt biodiversity. Afterward, the students will design strategies to see how they could live with the affects that come with climate change.

Resources

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