Assignment #8
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Executive Summary

The scientific community has officially recognized climate change and declared that human activities are very likely the cause of climate change. The planet's natural cycles, such as photosynthesis and the carbon cycle, produce a standard amount of greenhouse gases each year. However, the Keeling curve demonstrates that the amount of atmospheric carbon dioxide has exceeded the natural yearly cyclic variation. The scientific community has realized that natural reservoirs in the carbon cycle cannot continue to take in all the extra carbon without impacting the planet and the average human lifestyle. Thus, precautionary methods must be put in place to delay or halt the impact of climate change on our world.

In order to reduce carbon emissions over the next fifty years, significant action must be taken. One strategy, proposed by Socolow and Pacala in 2006, is the implementation of wedges. Implementing a wedge involves using a currently available emission-reducing technology or practice, and gradually scaling it up over the next fifty years so that a total of 25 Gigatons of carbon will be prevented from being released into the atmosphere over fifty years and so that one full Gigaton of carbon will not be released into the atmosphere in the year 2059. Currently, scientists, politicians, and other organizations are recommending a variety of emissions reductions scenarios. The target reductions levels that are commonly discussed are 550 parts per million (ppm), 450 ppm, and 350 ppm. This policy proposal is based around the goal of reducing atmospheric carbon dioxide levels to 500 ppm by the year 2059, which will require the implementation of nine wedges. This goal is politically feasible, as the American Climate and Energy Security Act of 2009 currently calls for an even lower goal of 450 ppm.

Implementing nine wedges will also mitigate or negate the extreme effects of global warming. Establishing the amount of atmospheric carbon dioxide at 500 ppm would prevent a dramatic change in temperature such as more than three degrees Celsius over the next century. A change in temperature larger than 3ºC could lead to a dangerous rise in sea levels, destruction of ecosystems, and loss of animal and plant species, all of which would cause damage to human life and behaviors. Many of the wedges included in this proposal are politically possibly to implement as well. Some, such as an increase in automobile efficiency, will increase the ability of US companies to compete internationally as well as reduce American dependence on foreign

oil. Other wedges, such as updating public transportation and increasing the efficiency of homes, will create more jobs.

Five wedges of the sustainability triangle will be implemented within the energy sector: increasing the energy efficiency of buildings, increasing the efficiency of power generation, switching coal electricity production to natural gas electricity production, and increasing wind electricity production eightyfold. The current energy usage of buildings, which accounts for 40 to 50 percent of greenhouse emissions, can be reduced if the best available technology is installed into all new and existing buildings. The turbine and high-temperature fuel cell technology to increase power plant efficiency from 40 to 60 percent already exists, and would reduce emissions by 1.0 Gigaton C per year. Burning of natural gas emits 45 percent less carbon dioxide than coal. Lastly, wind energy production creates zero greenhouse gas emissions, is a renewable resource, and could count as two wedges if production is increased eightyfold.

Three of the nine wedges would come from the transportation sector. One of the wedges, doubling the efficiency of all the world's cars from 30 to 60 miles per gallon, would actually be implemented twice to make the average fuel efficiency 90 miles per gallon. These two wedges could be achieved by improving hybrid and hydrogen fuel cell technology. The third wedge from the transportation sector would come from cutting passenger miles from 10,000 per year to 5,000, which would entail better public transportation and infrastructure policy, and monetary incentives to drive less. Wedges from the transportation sector are the most effective at involving the public, and transportation and infrastructure projects would create millions of new jobs. Policy changes also tend to drive public opinion on a long-term scale, which will in turn influence future policy decisions.

The final wedge comes from the sequestration sector. Most sequestration strategies, such as carbon capture sequestration, are very expensive to implement and are highly uncertain. Deforestation, on the other hand, is extremely low-cost since it does not require further research or technology. Ending deforestation would have an immediate positive effect on the earth's climate as well as the global economy, since most deforestation occurs in underdeveloped nations. Since deforestation bans already exist in many other countries, it would be relatively easy to set up the policies to phase it out completely.

This policy proposal of using nine wedges to achieve 500 ppm by 2056 is within the United States' ability to implement. The wedge strategy is an appropriate approach to mitigating

climate change because of its use of existing technologies. By drawing upon solutions from all sectors, the proposal draws on industry and private citizens to change their habits for the better of the environment without placing the economic burden solely on one group. This overarching proposal will insure that future generations will not be given the heavy burden of dealing with many environmental tipping points that could lead to huge negative impacts on economics, politics, wildlife, and human lifestyles.

Overview of Science

Lead author: Willa Freedman

The science behind climate change is extremely complex and has been much-debated over the last fifty years. Since it was founded in 1988, the Intergovernmental Panel on Climate Change (IPCC) has been reviewing and collecting research in order to determine the scientific consensus on climate change. After evaluating peer-reviewed research occurring before 2007, a majority of climate scientists have agreed that global warming is "very likely" to be caused by anthropogenic greenhouse gas emissions in the 2007 assessment report.[1]

The greenhouse effect is one of the fundamental principles underlying climate change. While the earth's atmosphere and clouds reflect some of the radiation from the sun right away, the atmosphere absorbs the rest of the radiation. Greenhouse gases, which include carbon dioxide, methane, water vapor, and ozone, account for less than one percent of atmospheric gases and absorb the thermal infrared radiation emitted by the sun and reflected by the earth. The storage of energy in the greenhouse gases leads to the warming of our atmosphere and is essential to determining the earth's temperature. However, when a higher percentage of greenhouses gases is in the atmosphere, the atmosphere absorbs too much energy and the temperature will increase.[2]

Another principle in climate change is the carbon cycle, which shows the movement of carbon between the locations of emission and storage. Carbon dioxide can be created through natural and human activities, such as the decomposition process of fallen leaves and the combustion process of fuel for industry. Before the Industrial Revolution, a balance was achieved through which carbon reservoirs could safely hold all the emitted carbon. However, by

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[1] R.K. Pachauri and A. Reisinger (eds.), IPCC, 2007: Climate Change 2007: Synthesis Report. Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland, 104.

[2] Michael Mann and Lee Kump, Dire Predictions: Understanding Global Warming (New York: DK, 2008) 22-23.

emitting more carbon through industrialization, the balance of the carbon cycle was upset and more carbon ended up in the atmosphere, resulting in an increase in surface temperature.[3]

The Keeling curve has proven to the scientific community that carbon dioxide levels are rising. Since the first data was taken in 1958, there has been a steady increase in atmospheric carbon dioxide. The curve also shows the cyclical nature of carbon dioxide due to the seasons and the location of earth's landmass. Since most of the earth's landmass is in the Northern hemisphere, the absorption of carbon dioxide during the Northern hemisphere's growing season outweighs the release of carbon in the Southern hemisphere. The curve shows an average annual increase of 1.4 ppm on top of the cyclic variation of approximately 5 ppm. This annual increase has been considered by the climate scientists to be attributed to anthropogenic carbon dioxide emissions.[4]

Natural feedbacks also add to the problem of climate change. A feedback loop is a secondary response to an environmental forcing that can either amplify or dampen the effects in the future. For instance, a positive feedback loop is the ice-albedo feedback, which occurs when the melting of ice creates more water that absorbs more of the sun's energy, thus heating the water and melting more ice.[5]

An increase in temperature will cause many different problems in the earth's climate. Since nine wedges will be used to counteract the effects of global warming, the amount of carbon dioxide in the atmosphere will be approximately 500 ppm. This level of carbon dioxide would lead to a temperature increase of more than 2º Celsius by the end of the 21st century. [6] Such warming could lead to irreversible damage to the Greenland ice sheet, a decrease in Artic Ocean sea ice, and a reduction in the West Antarctic ice sheet, resulting in potentially more than 5 meters sea level rise.[7] This rise in sea level would cause loss of landmass, extreme damage to coastal populations, and a higher chance of flooding, all of which would lead to major loss of gross domestic product.[8] Potentially, 21 to 52 percent of species, especially amphibians and

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[3] Mann and Kump, 26-33.
[4] Cutler J. Cleveland, "Mauna Loa curve." The encyclopedia of earth, Mar. 2007, 11 May 2009 <http://www.eoearth.org/article/Mauna_Loa_curve>.
[5] V. Ramaswamy, (ed.), IPCC, 2001: Climate Change 2001: Synthesis Report. Third Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland, 353.
[6] Mann and Kump, 105.
[7] Mann and Kump, 98.
[8] Mann and Kump, 110-111.

inhabitants of coral reefs, would become extinct with a rise in temperature.[9] Extreme climate change could irreversibly damage ecosystems, which heavily rely on a range of temperatures to exist healthily.[10] Furthermore, different areas of the world would be impacted differently. For instance, more precipitation would occur in tropic areas (which would exacerbate the intense flooding already present in the region).[11] All of these results of a temperature increase exceeding 2ºC would wreak havoc on society. Carbon dioxide levels must be stabilized around 500 ppm if we want to avoid these harmful effects.

Policy Overview

Lead author: Dominique Hazzard

If the world's current emissions pattern continues, atmospheric carbon dioxide levels will rise far above many scientifically recommended thresholds, including the threshold of 500 ppm of carbon dioxide in the atmosphere. In order to reduce carbon emissions over the next fifty years, actions must be taken. One proposed strategy for action is the use of wedge triangles. This involves using currently available emission-reducing technologies and practices, or wedges, and gradually scaling them up over the next fifty years so that each wedge will prevent 25 Gigatons C from being released into the atmosphere over fifty years and so that one full Gigaton of carbon per wedge will not be released into the atmosphere in the year 2059.[12]

Currently, there are many different emissions reductions scenarios being championed by various organizations, scientists, and politicians. The target reductions levels that are commonly discussed include 550 ppm, 450 ppm, and 350 ppm. Nicholas Stern, a leading British economist, believes that stabilizing atmospheric carbon concentrations at 550 ppm over the next fifty years is an economically feasible goal that will "substantially reduce" the worst impacts of climate change.[13] Stern believes that by promoting emissions trading, sharing technology among nations, reducing deforestation, and helping vulnerable countries adapt to a changing climate, the goal of 550 ppm in fifty years can be reached. Joseph Romm believes that a more appropriate target is 450 ppm of carbon in the atmosphere in fifty years. According to Romm, 450 ppm is "achievable

[9] Mann and Kump, 119.
[10] Mann and Kump, 113.
[11] Mann and Kump, 89.
[12] Robert Socolow and Stephen Pacala, "A Plan to Keep Carbon in Check", Scientific American 2006
[13] Stern Review: The Economics of Climate Change, 2005, http://www.hm-treasury.gov.uk/d/Summary_of_Conclusions.pdf

from an economic and technological perspective," and a goal of 550 ppm is too risky because of feedback cycles.[14] Currently, the the American Climate and Energy Security Act of 2009 is targeted towards a goal of 450 ppm.[15] Finally, a frequently referenced reduction target is 350 ppm of carbon dioxide in the atmosphere. This target is supported by environmentalists such as Bill McKibben[16], and many activist organizations such as Energy Action Coalition. Renowned climate scientists James Hansen testified before the United States Congress that the safe level of atmospheric carbon dioxide is at most 350 ppm, a level that is still feasible to achieve.[17]

The chosen target reduction level for this policy proposal is a reduction to 500 ppm of atmospheric carbon by the year 2059. Achieving this goal will require the United States to implement nine Stabilization Wedges, preventing 225 Gigatons of carbon from being released into the atmosphere over the next fifty years and nine Gigatons of carbon being released in the year 2059 alone. This proposal suggests the use of nine wedges, which will be further outlined in this portfolio. The goal of 550 is a politically reasonable one. The goal uses the precautionary principle, which is the idea that if there is scientific evidence that a problem might cause severe or irreversible harm to the public or to the environment there is a responsibility to intervene. Climate scientist Joseph Romm believes that the goal of 550 ppm, a commonly promoted atmospheric carbon level, is a "rationally impossible and morally impossible choice", because it comes dangerously close to the threshold that is predicted to possibly cause irreversible and uncontrollable damage to the climate system because of feedback mechanisms.[18] This proposal seeks to avoid that damage by aiming for a lower atmospheric carbon level. The wedges this proposal suggests to implement the carbon reduction goal were chosen because the technology they require is already developed, and because they are not as expensive or politically sensitive as other wedges, such as tripling nuclear electricity production or implementing carbon capture

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[14] Romm, March 1 2008, "Climate Progress", http://climateprogress.org/2008/03/31/is-450-ppm-carbon-dioxide-politically-possible-1/

[15] The American Climate Security and Energy Act of 2009, http://energycommerce.house.gov/Press_111/20090331/acesa_summary.pdf

[16] Bill McKibben, "Remember This: 350 Parts Per Million," *Washington Post* (2007) http://www.washingtonpost.com/wp-dyn/content/article/2007/12/27/AR2007122701942.html

[17] James Hansen, "Testimony before Congress on 350ppm" http://www.grist.org/article/twenty-years-later

[18] Romm, March 1 2008, "Climate Progress", http://climateprogress.org/2008/03/31/is-450-ppm-carbon-dioxide-politically-possible-1/

and sequestration at coal-fired fire plants.[19] The aim of this proposal is to choose a carbon reduction goal and an implementation strategy that are as safe, cost effective, and politically feasible as possible while still taking effective action against climate change.

Overview of Energy Sector Strategies

Lead author: Taylor Sanchez

Five wedges can be achieved within the energy sector. The first comes from increasing the energy efficiency of buildings. This wedge is one of the most cost-effective ways to reduce greenhouse emissions, since 40 to 50 percent of greenhouse emissions come from the energy use of buildings,[20] and can be achieved if electricity use in homes, offices, and stores is cut by twenty-five percent. This can be done by increasing the efficiency of existing and new buildings, and ensuring that buildings are using the best available technology to prevent energy loss.[21] The guidelines set up by the U.S. Green Building Council include efficiency strategies like improving insulation efficiency, installation of energy efficient appliances (like Energy Star Appliances), and switching to the use of compact fluorescent light bulbs (CFLs).[22] If the most efficient insulation was installed in new buildings and if the insulation in homes was upgraded, energy would be saved and emissions would be reduced because nearly 70 percent of a home's energy use is due to inefficient insulation. [23]Appliances in buildings also account for a large amount of energy consumption, but Energy Star appliances use 10 to 50 percent less energy than standard appliances. CFLs use 75 percent less energy than an incandescent bulb and also last longer. If all of these strategies were implemented, energy consumption would be reduced significantly and building owners would save on energy bills.[24]

Economically, increasing the efficiency of buildings may have consequences for lower income families. Initially, the cost of upgrading or installing these strategies will be high. This

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[19] Harrington and Handler, Wedge #9

[20] "Energy Efficiency-Buildings." Energy Conservation and Management Division. New Mexico Energy, Minerals and Natural Resource Department. http://www.emnrd.state.nm.us/ECMD/EnergyEfficiencyBuildings/energyefficiencybuildings.htm.

[21] Bourque and Morrow, Wedge #3

[22]"Home." U.S. Green Building Council. http://www.usgbc.org/Default.aspx.

[23] "Energy Efficient Insulation." The Renewable Planet. http://www.therenewableplanet.com/green/reduceenergy/energy-efficient-insalation.aspx.

[24] "Energy Star Qualified Products." Energy Star. http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

may prevent those with lower incomes from buying these products. In the long term, the savings from energy bills will ultimately pay for the initial cost of the efficiency strategy.

A second wedge can be implemented by increasing the efficiency of power plant power generation. Currently power plants produce electricity at 40 percent efficiency and emit 3.0 Gigatons C per year, but if their efficiency were increased to 60 percent the emissions would only equal 2.0 Gigatons C per year.[25] In order for a power plant to increase its energy efficiency it would have to change the way in which fuel is converted into energy. More efficient ways of converting fuel into electricity include using better turbines, high-temperature fuel cells, and combining both technologies.[26] Although all of these technologies exist, they are not widely used by companies. Once the technology that would allow the plants to increase the conversion efficiency is installed, emissions could be reduced quickly. Unfortunately, this technology is very expensive and time-consuming to build. The current energy demands of the country are so high that it would not be in the power plants' interests to use time and resources to implement the efficient technology. However, if they did implement these technologies despite the costs and time consumption, emissions would be reduced by 1.0 Gigaton C per year.[27]

A reduction by 1.0 Gigaton C per year would also be accomplished by implementing a third wedge in which fuel used by power plants was switched from coal to natural gas. Natural gas is the cleanest burning fossil fuel, emitting 45 percent less carbon dioxide than coal.[28] One wedge can be achieved if fuel is switched to this cleaner fuel. The U.S. has a large supply of natural gas and there are plenty of available pipelines that could transport the gas to the necessary locations. Although switching to natural gas will reduce greenhouse emissions, it becomes problematic because natural gas is a non-renewable resource and there are only 63 years left of the U.S. natural gas supply left due to the country's energy demands. Once the demand goes up and the supply drops, the price of the natural gas will begin to increase which would cause economic troubles. As the supply becomes scarce the U.S. would have to obtain its natural gas from international locations, which could lead to tense international negotiations.[29]

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[25] Cooper and Daley, Wedge #4
[26] "The Wedge from Efficient Baseload Coal Plants," Princeton. http://www.princeton.edu/~cmi/resources/Wedges/Efficient%20Baseload%20Coal%20Plants8.16.pdf.
[27] Cooper and Daley, Wedge #4
[28] Gaglini and Goldleaf, Wedge #8
[29] "How Much Natural Gas is There?" Resources. NaturalGas.org. http://naturalgas.org/overview/resources.asp.

Finally, in order to achieve both the fourth and fifth wedges, wind electricity could be harnessed instead of the burning of fossil fuels. Wind is a renewable, domestic energy source and produces zero greenhouse gas emissions. It is also widely available and low-priced, costing 4 to 6 cents per kilowatt hour. In order to implement one wedge, current wind production must increase by approximately forty fold. This would require three percent of U.S. land area needs to house the wind turbines. If the percentage of land area used were to be doubled to achieve a second wedge, this would require current wind electricity production to increase by eighty fold, and would require a total of six percent of the Unites States' land area.[30] Despite its environmental advantages, wind energy does have some disadvantages. Constituents of land opposed the construction of wind turbines on their land. The aesthetic value of the land maybe affected by the turbines and the low-frequency sounds they produce may affect constituents.[31] Just as the other energy sectors strategies were economically demanding, wind would require a large investment to implement.

Overview of Transportation Sector Strategies

Lead author: Sonrisa Cooper

The most effective and easily implemented wedges from the transportation sector would be doubling the efficiency of the world's cars from 30 to 60 miles per gallon (mpg), and cutting the miles traveled by all passenger vehicles in half. We actually recommend taking fuel efficiency one step further by increasing it to 90 mpg, which would represent one more wedge, thus removing one additional gigaton of carbon from the atmosphere.

Tripling the fuel efficiency of the world's cars from 30 to 90 mpg would be the most successful option in the transportation sector. The first wedge, which is removed by increasing the average fuel efficiency to 60 mpg, could be implemented by forcing all car companies to produce hybrid cars. Currently, the fuel economy for a Toyota Prius, the most popular hybrid car on the market, is 46 mpg.[32] Considering that this is already more than halfway to the original goal of 60 mpg, it is likely that improving technology will make it possible to surpass 60 mpg within fifty years. Developing hydrogen fuel cell technology will also allow us to reach the 90 mpg threshold by 2050. Both hydrogen fuel cell cars and hybrid cars have a much smaller

[30] Hazzard and Henry, Wedge #10

[31] "Advantages and Disadvantages of Wind Energy." Wind & Hydropower Technologies Program. U.S. Department of Energy. http://www1.eere.energy.gov/windandhydro/wind_ad.html.

[32] "2009 Toyota Prius," US Department of Energy, http://www.fueleconomy.gov/feg/findacar.htm

structure and engine than a typical car, which allows their engines to operate much closer to their maximum load.[33] Even though most hydrogen cars are not road-ready yet, by 2050 we can expect that their production will be advanced enough to increase average fuel efficiency to 90 mpg. However, since hybrid and hydrogen cars have significantly higher production costs than internal combustion engine vehicles, implementing these two wedges would require heavy subsidies from the government to car companies as an incentive to build more fuel-efficient cars.

Another wedge from the transportation sector that could be easily implemented would be cutting miles traveled by all passenger vehicles in half. This would require a major shift in transportation and infrastructure policy as well as public opinion, but could also potentially boost the economy while reducing carbon dioxide emissions. In order to make two billion car drivers cut their mileage from 10,000 miles per year to 5,000, policymakers would need to give drivers a monetary incentive to drive less, such as a gas tax.[34] This tax would need to be sufficiently high enough to discourage people from driving. The tax might not be very effective at the beginning, but policy changes tend to influence people's values, so we expect that drivers would start to drive less and use public transportation. Revenues from the tax could be used to fund more public transportation and infrastructure projects. According to the American Public Transportation Association, if we were to implement the $47.8 billion of needed transit projects, the United States would create 1.3 million new jobs. With the current state of the economy, a wedge that creates jobs would be easier to implement politically than a more radical wedge that requires extensive research and new technology.

We considered scaling up ethanol production to create more eco-friendly biofuels, but this wedge has far too many complications to be a feasible option for implementation. Ethanol comes from corn, which is a major agricultural crop in many parts of the world. A potential problem is that developing countries would replace their agriculture crops with biofuel crops, increasing the likelihood of food shortages in the areas already more vulnerable to shortages.[35] Other problems include widespread pesticide runoff and high transportation costs.[36] Although ethanol is currently being used at a very small scale (one percent of the world's total fuel),

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[33] Al-Mashouk and Barnes, Wedge #1
[34] Bax and Brown, Wedge #2
[35] Oliver, Rachel, "Biofuels: 'Green Gold' or Problems Untold?" CNN, http://www.cnn.com/technology
[36] Sawyer and Sebastian, Wedge #13

biofuel crops already use one percent of the entire planet's croplands.[37] Scaling up biofuel production by a factor of thirty, which is what the wedge calls for, would have detrimental effects on the world's crops that would completely outweigh the benefits of implementing the wedge.

Overview of Sequestration Sector Strategies

Lead author: Sonrisa Cooper

Most sequestration strategies are either too expensive or controversial to implement, but phasing out all deforestation over the next fifty years would not require any new technology and is already beginning to take effect in many parts of the world. We considered other strategies such as carbon capture sequestration in electricity production and conservation tillage as well, but these two wedges cost more and do not have the same predictable effects as completely ending deforestation.

Forests are one of the world's most important carbon sinks, storing almost forty percent of the carbon found in the atmosphere.[38] Deforestation, especially in developing countries where it is most common, is an enormous threat to the earth's climate. Phasing out deforestation by 2050 would eliminate approximately 25 percent of greenhouse gas emissions.[39] Deforestation is a large part of the economies of many developing countries, so to implement this wedge, the developing world would need some sort of economic incentive for sustainable development, such as a cap-and-trade system for trees or having developed nations pay developing nations for logging rights.[40] The United Nations Environment Programme has already taken action to end deforestation through its Division for Sustainable Development,[41] and deforestation bans already exist in most European countries, China, Thailand, and Costa Rica, along with numerous other countries.[42] Since the policy is already in place in many countries, it would be relatively easy to implement this wedge. The wedge would have added social benefits as well – deforestation and

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[37] Oliver

[38] Gardner, Timothy "U.N. launches program to cut deforestation emissions" Reuters, http://www.reuters.com/article/environmentNews/idUSTRE48N91C20080924

[39] Gardner

[40] Willis-Norton, Wedge #14

[41] "Combating Deforestation," United Nations Division for Sustainable Development, http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21chapter11.htm

[42] "Potential Policy Approaches and Positive Incentives to Reduce Emissions from Deforestation in Developing Countries," World Rainforest Movement, http://www.wrm.org.uy/GFC/material/Incentives_Reduce_Emissions.html

environmental exploitation by developed countries is a major part of the reason that developing countries are so poor. Ending dangerous slash-and-burn methods and reforesting the land in developing countries can make it much easier for them to recover from natural disasters and improve biodiversity.

Conservation tillage on the world's agricultural soils is another wedge option in the sequestration sector, but would be much more difficult to implement than phasing out deforestation. Conservation tillage is counterintuitive for farmers, so the government would need to invest in education resources to help farmers adapt to the new techniques.[43] It would also require farmers to purchase new equipment. Although conservation tillage has more benefits in the long run, it is more expensive on an individual level in the short run. Attempting to convert farmers to a completely new form of agriculture management would too hard to implement on a large scale with such a short timeframe.

We also considered carbon capture sequestration (CCS), which captures CO2 from electricity production and pumps it into geological sinks, such as depleted gas fields or deep saline aquifers.[44] CCS has been successful when applied at a small scale, but there is huge scientific uncertainty about the effects of using CCS for large operations. There is doubt that CCS successfully mitigates CO2 emissions at all – the energy used for storage, compression, and transportation in CCS actually uses thirty percent more coal than a conventional plant, and CCS plants release forty percent more nitrogen oxides and sulfur oxides than a conventional plant.[45] While this strategy may seem highly efficient, the costs of implementing the technology and the high uncertainty would make it impossible for the wedge to work within fifty years.

Conclusion

Implementing the sustainability triangle is a big step towards reducing the greenhouse gas emissions of people worldwide. All of these wedge strategies are economically and politically feasible. Climate change is a daunting problem, and steps like this proposed strategy need to be taken in order to ensure a safe and habitable world for future generations to come. If greenhouse gas emissions are not reduced soon the world should prepare for dramatic and irreversible changes on Earth.

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[43] Smith and Thayer, Wedge #15
[44] IEA Greenhouse Gas R&D Programme, http://ieagreen.org.uk/ccs.html
[45] Flanagan and Dechert, Wedge #5