FROM THE INSTRUCTOR

In WR 150, "Climate Change: Science and Action," students grappled with the questions of how and whether our global society can mitigate and adapt to climate change. One of the greatest challenges of the course was for students to examine a real-world problem over which they as individuals have little control. It can be difficult to conceive of an original persuasive argument when you know from the outset that significant sociopolitical barriers stand in the way of implementation. While students weren't required to present possible solutions, many did. A number of these solutions, Gregory Bond's among them, were feasible, plausible, and expressed in a way the average educated adult could grasp without specialized knowledge.

Because of this accessibility, "Reforestation and Sustainable Investments" is more than a student's successful assignment: it also exemplifies some of the real-world applications of classroom writing skills. Furthermore, this essay illustrates the author's evolution, from a non-expert undergraduate student concerned about the topic and invested in learning more, to a knowledgeable science writer laying forth a fresh perspective on climate action.

Greg's essay is a model of the kind of simple, clear logic necessary to bridge the gap between scientific inquiry and public understanding. This piece makes a complex subject simple and comprehensible. Greg worked hard over the semester to reach the point where he understood the nature and breadth of the problem, could synthesize an original approach from multiple sources, and could lead the reader to see exactly why a multifaceted approach to global warming mitigation could be, and perhaps one day *will* be, effective at stabilizing atmospheric carbon dioxide levels.

Sasha Vivelo
WR 150: Climate Change: Science and Action

From the Writer

Throughout my life, I have always had a passion for being environmentally friendly and for spreading environmental awareness to others. Thus, when my professor approached our class with our final assignment of the semester, I knew I wanted to spread awareness yet again, synthesizing articles from class as well as research about climate change I had completed on my own.

This paper is a culmination of my 1 a.m. brain blasts, consistent frustration, and endless excitement. Through this research process, I learned much more about the impact humans have on our planet, and the seemingly endless challenges that climate change creates. Despite these problems, however, my paper aims to showcase how humans can reverse these effects if we simply think a little differently.

GREGORY BOND is a sophomore in the College of Fine Arts studying Painting and Graphic Design. Born in Clarksburg, West Virginia, and raised in Walpole, Massachusetts, Gregory enjoys acting and singing within the Boston University community. In the future, he hopes to cultivate his artistic pursuits further. He would like to thank both Professor Lacey and Professor Vivelo for their constant support, guidance, and passion for teaching.

GREGORY BOND

REFORESTATION AND SUSTAINABLE INVESTMENTS: EXPLORING SOLUTIONS FOR CLIMATE CHANGE

Imagine this scenario: a "tropical storm…[dumps] more than 20 inches of rain on Florida" (McKibben). At the same time, "the largest fire in New Mexico history [burns] on, and the most destructive fire in Colorado's annals [claims] 346 homes in Colorado Springs" (McKibben). Shortly after, "a heat wave across the Plains and Midwest [breaks] records that had stood since the Dust Bowl" (McKibben). No, this scene is not from another post-apocalyptic movie—it is from Bill McKibben's article "Global Warming's Terrifying New Math" and is a description of true events in present-day North America.

With these effects of climate change becoming more apparent every day, researchers, scientists, and climatologists alike are studying new methods to mitigate global warming before it destroys the planet. A handful of scientists—such as Shaun C. Cunningham from Deakin University in Victoria, Australia—believe that humanity already has the methods it needs to stop this imminent threat, through either reforestation efforts or sustainable investments. However, studies show that reforestation attempts on their own do not sequester enough carbon and do not last long enough to halt and reverse the effects of climate change. Similarly, in existing research, sustainable investments do not work fast enough or produce enough energy to reverse global warming. In addition, there are currently not enough resources to successfully execute policies to directly reduce man-made carbon emissions. However, instead of attempting to mitigate climate change through reforestation or sustainability separately, scientists should utilize the effects of a combination of reforestation efforts and sustainable investments in order to save the planet from further temperature increase, and furthermore, humankind. Individually, these reforestation and sustainability efforts are not strong enough to reverse climate change; however, when utilized together, these attempts may yield promising results.

Researchers believe that reforestation efforts could potentially mitigate the effects of climate change through carbon sequestration. In his 2014 study "Reforestation with Native Mixed-Species Plantings in a Temperate Continental Climate Effectively Sequesters and Stabilizes Carbon within Decades," Shaun C. Cunningham researched the ability of native mixed-species plantings to reverse biodiversity loss and sequester carbon in Victoria, Australia. Cunningham found that in a "medium rainfall area, native mixed-species plantings provide comparable rates of [carbon] sequestration to local production species, with the…additional benefit of providing better quality habitat for native biota" (Cunningham). Cunningham's results highlight how "using native-mixed species plantings is an effective alternative for carbon sequestration to standard monocultures of production species, [as]…they can effectively store carbon, convert carbon into stable pools, and provide greater benefits for biodiversity" (Cunningham). Through his study, Cunningham seems to find an effective route in creating a successful reforestation method while also sequestering carbon and providing habitat for native fauna. Thus, reforestation sites that model Cunningham's mixed-species sites should be able to sequester carbon from the atmosphere, effectively combating climate change.

However, these Australian reforestation sites are not lasting as long as researchers expect—in fact, they are shrinking relatively quickly. In his 2016 study "Models of Reforestation Productivity and Carbon Sequestration for Land Use and Climate Change Adaptation Planning in South Australia," Trevor J. Hobbs researched the productivity and carbon sequestration abilities of 264 reforestation sites in South Australia, similar to the location of Cunningham's study. Hobbs discovered an added layer within Cunningham's study: the ability of these mixed-species reforestation sites to mitigate climate change depends directly on the amount of rainfall in the area. For example, in a mixed-stratum (50% trees) area where annual rainfall is greater than 750 mm, there was a mean total carbon sequestration rate of around 43.79 (CO_2-e Mg ha^{-1} $year^{-1}$) over 65 years (Hobbs). Alternatively, in a mixed-stratum area where the rainfall zone is only 251-350 mm per year, there was only about a mean total carbon sequestration rate of around 2.82 (CO_2-e Mg ha^{-1} $year^{-1}$) over the 65-year span (Hobbs). In addition to this added layer, however, Hobbs discovered that the amount of plants in each reforestation area decreased over time, despite their ability to sequester carbon in high rainfall zones. In the same mixed-stratum area with a mean annual rainfall of 750 mm per year, the initial mean plant density was 2233 (plants ha^{-1}), but after 25 years, this density dropped to 1281 (plants ha^{-1})—almost half the original amount (Hobbs). Therefore, although Cunningham's mixed-species reforestation areas hold promise in sequestering carbon effectively, Hobbs' study shows that these areas consistently shrink in size over time. Reforestation attempts alone are thus ineffective in mitigating climate change in the long run, as these areas shrink relatively quickly, proving unable to sequester carbon for long periods of time.

Alternatively, some researchers believe that sustainable investments—such as bioenergy plantations—could sequester enough atmospheric carbon to reverse the effects of climate change. In Julia Rosen's article "The Carbon Harvest," climate change scientist Naomi Vaughan from the University of East Anglia argues in favor of these bioenergy plantations. Vaughan states that in order "to limit warming, humanity…needs negative emissions technologies (NETs) that…would remove more CO_2 from the atmosphere than humans emit" (Rosen 734). These technologies, Vaughan states, "would [also] buy time for society to rein in carbon emissions" (Rosen 734). Rosen highlights one specific negative emissions technology, where the idea "is to cultivate fast-growing grasses and trees to suck CO_2 out of the atmosphere and then burn them…to generate energy" (Rosen 734). However, instead of "being released back into the atmosphere, the…carbon would be captured and pumped underground" (Rosen 734). This sustainable negative emissions technology holds promise—if successful, these fast-growing plants could sequester enough carbon to reverse the effects of carbon emissions.

Unfortunately, however, this specific negative emissions technology would require an abundance of resources that humanity may be unable to offer. For example, in order to remove "half of [the carbon that] humans have emitted since the…Industrial Revolution," the bioenergy crops would need an area "at least as large as India and possibly as big as Australia" (Rosen 735). Furthermore, "cutting down trees to make [this] new farmland…[would] release far more carbon into the atmosphere than bioenergy crops can sequester" (Rosen 737). Additionally, in order to "sequester 3.7 billion tons of CO_2," crops would "use almost as much water as is in Lake Michigan," and "many scenarios require that much carbon or more to be removed each year" (Rosen 736). Water is already "a scarce commodity in [places like] Montana, [where] irrigated crops are…the biggest consumer of [water]" (Rosen 736). Although these sustainable negative emissions technologies have potential, the sheer amount of resources required to execute these technologies makes them unrealistic, as creating these crops would release irreversible amounts of carbon in the

atmosphere, and maintaining the crops would use up large amounts of fresh water. This type of sustainable investment alone is thus not an effective route in mitigating climate change, as humanity is unable to provide the resources to successfully grow these crops.

Another sustainability effort that could possibly combat climate change is more obscure: creating policies on livestock rearing. In his study "Climate Change Mitigation Through Livestock System Transitions," researcher Petr Havlík found that approximately "30% of the global land area is used for livestock rearing, and expansion of the sector is a major driver of land-use change" (Havlík). For example, "between 1980 and 2000, 83% of agricultural land expansion in the tropics occurred at the expense of forests, and livestock were a major contributor" (Havlík). However, not only do these livestock contribute significantly to deforestation, but they also contribute to greenhouse gas emissions. Havlík states that "livestock contribute…80% of all agricultural non-CO_2 emissions, [making] them responsible for…12% of all anthropogenic greenhouse gas emissions" (Havlík). With livestock contributing to both deforestation and greenhouse gas emissions, the solution seems simple: governments should create policies to curb the detrimental effects of livestock rearing. However, the livestock industry is essential to many governments, in addition to many peoples' diets, making any kind of policy difficult to execute. On the individual level, "livestock are the source of 33% of the protein in human diets," meaning that many people would have to find alternate sources of protein in their daily life if governments were to create livestock policies (Havlík). Furthermore, livestock "provide many…services such as traction, manure, risk management, and regular income" (Havlík). Because of the essentiality of the livestock industry, any sort of policy change would require the global cooperation of individuals as well as governments—a difficult task to achieve. Therefore, curbing livestock rearing is an unlikely solution to mitigating climate change, as these policies would require the cooperation of many on a global scale.

Alternatively, in order to combat climate change, some legislators have introduced policies to reduce man-made carbon emissions. For example, in the article "The 80% Solution: Radical Carbon Emissions Cuts for California," Jane Long states that "in 2005, the governor of California issued an executive order requiring the state to reduce its CO2 emissions to 80% below the 1990 level by 2050" (Long). This order consists of four steps, which include "[decreasing] the demand for fuel, [increasing] the demand for electricity, [and using] low-carbon biofuels" (Long). Long also discusses possible measures that could make technology much more efficient, such as "[demolishing] or [retrofitting]…current buildings to much higher efficiency standards, [creating] new buildings…to much higher efficiency standards, [and developing] automobiles…to average over 70 miles per gallon" (Long). Through this government policy, legislators hope to reduce the amount of carbon emissions that humans produce. If these steps to reduce man-made atmospheric carbon are successful, legislative policies could possibly result in cleaner forms of fuel, thus mitigating the effects of climate change.

However, according to current expectations, there is neither enough time nor enough resources readily available to complete this California policy's emission reduction goal by 2050. Jane Long addresses this problem in her study, stating that California "is expected to be able to produce or import enough biofuels to meet only about half of its requirement for fuel" (Long). Unfortunately, if this expectation is accurate, "the remaining [fuel] demand would…be met with fossil fuel, which would generate emissions that would total about twice the state target" for 2050 (Long). Furthermore, this plan to reduce man-made carbon emissions would "require substantial

infrastructure [that is] likely to be expensive," in addition to the development of "a biofuel with no net emissions" (Long). With neither enough biofuel to fulfill the state's fuel requirement nor a biofuel with zero net emissions, the chance that this California policy will mitigate climate change is unlikely. Additionally, without enough funding, updating current buildings and creating new buildings to be energy-efficient will be extremely difficult. Therefore, unless states can produce sufficient amounts of funds and clean fuel, policies reducing man-made carbon emissions are ineffective in reversing the effects of climate change.

Thus, these reforestation and sustainability efforts—as separate entities—are not effective enough to mitigate climate change; however, when scientists combine the effects of these investments, the outcome yields promising results. In his TED Talk, *How to Green the World's Deserts and Reverse Climate Change*, Biologist Allan Savory discusses one potential combination of sustainability and reforestation efforts. Savory states that the buildup of carbon in the atmosphere is due, in part, to the fact that "two-thirds of the land on Earth is beginning to desertify"—the process of fertile land turning into desert (Savory). People often attribute this desertification of grasslands to overgrazing, and thus usually "take livestock off of this arid land" to allow the area to regrow (Savory). Taking cattle off of this arid land, however, does not result in reforestation—rather, this removal of livestock further promotes desertification. Savory points out that "large herds [of animals] dung and urinate all over their food, and they…keep moving, [preventing] the overgrazing of plants, while the periodic trembling [allows] for the covering of soil" (Savory). When humans remove livestock from arid land, there is no cover of urine and dung on the soil. This bare soil cannot hold water, and "allows for [immediate evaporation and] runoff—the cancer of desertification" (Savory). Therefore, Savory proposes a combination of sustainable behavior and reforestation efforts to create a seemingly unusual solution: to increase the level of cattle and grazing in order to promote the reforestation of these arid regions.

Although increasing grazing levels seems counterintuitive, Savory argues that this method could reverse the effects of climate change. By "increasing the cattle and grazing by 400%" and making sure that these large herds keep moving, these animals would cover the arid "soil [in] dung and urine," allowing the soil to "absorb the rain" (Savory). Through this cover of excrement, the arid land would be able to retain rainwater. Furthermore, this retention of rainwater would allow previously desertified land to become fertile. With these large areas of arid land transforming into fertile land, there would be new areas for the growth of plants that would "store carbon," reducing atmospheric carbon levels (Savory). Scientists have tested this method in Patagonia, Argentina, where the planned grazing of "25,000 sheep" resulted in a large amount of excrement covering arid soil, which allowed the soil to hold rainwater once more, bringing "back 50% of [the] land" (Savory). Furthermore, when herds do not feed upon these grasslands, the plants sometimes "shift to oxidation" rather than decaying biologically, which results in "woody vegetation and bare soil" (Savory). People usually burn off these oxidized plants; however, this burning "still leaves the soil bare and releases carbon" into the atmosphere—giving off more "damaging pollutants than 6,000 cars… [for every] hectare" burned, and people burn "almost 1,000,000,000 hectares…every single year" in Africa (Savory). Therefore, despite being inefficient separately, this combination of sustainable efforts and reforestation methods could potentially sequester enough carbon from the atmosphere to mitigate climate change. This combination would furthermore reduce an abundance of man-made carbon emissions, as people would no longer have to burn thousands of hectares of oxidized plants. Savory states that through this method of livestock increase and planned grazing, humans can "take enough carbon from the atmosphere and store it in the soil to return climate

change back to pre-industrial levels" (Savory). This livestock increase would thus act as a negative emissions technology, similar to the bioenergy crops that "The Carbon Harvest" discusses. Thus, by combining these two pre-existing methods of climate change mitigation, scientists could effectively reverse the effects of global warming and save the planet.

Furthermore, employing these strategies together would not demand the resources and global cooperation that these strategies require individually. For example, Julia Rosen previously states that in order to sequester enough carbon to mitigate climate change, these crop areas would require as much water as is in Lake Michigan. According to Savory, however, planned grazing creates fertile land that would not require immense amounts of water, as the excrement of the livestock would allow the soil to hold rainwater. Additionally, the movement of livestock would ensure that the entire area has a cover of excrement, efficiently securing rainwater within the soil. Rosen also introduces the notion that these crops would require an area of land "the [size] of Australia," and many also question whether global cooperation will be necessary to make increased livestock policies possible (Rosen 735). These crops, however, would only use land that is currently desert, ensuring that no human relocation would occur. Additionally, Australia is currently mostly desert, meaning that if scientists carried out Savory's study in Australia, the country could be reforested completely over time, thus fulfilling the land requirement Rosen proposes. By keeping the practice within one country, the demand for global cooperation also disappears, as Australia has enough area to sequester enough carbon to mitigate climate change for the planet. Australia has also supported reforestation policies in the past, reinforcing the possibility of practicing Savory's study within the country. In his paper, *Reforestation Incentives in the UK and Australia: A Comparative Evaluation*, Dr. Steve Harrison states that in 1982, the Australian Prime Minister "announced the establishment of the National Tree Program," which aimed to "increase tree cover, [promote]…action….to conserve plants and regenerate trees, [and develop] public awareness of the value of trees" (Harrison 10). Thus, based on its past interest in reforestation attempts, Australia would likely implement Savory's study in its deserts, eliminating the need for global cooperation. Therefore, a combination of reforestation attempts and sustainable investments requires fewer resources and less global cooperation than that of an individual strategy.

Thus, reforestation efforts and sustainable investments, when separate, are not effective enough to reverse climate change; however, when scientists combine the two, the outcome is promising and powerful. Although numerous reforestation studies demonstrate an effective sequestration of carbon, these reforestation areas are shrinking fairly rapidly. Similarly, sustainable investments such as bioenergy crops or livestock policies seem like they could effectively combat climate change; however, these investments require an abundance of resources or global cooperation, respectively, making them ineffective. Additionally, the use of governmental policies to directly reduce man-made carbon emissions holds promise, but the lack of biofuel resources makes this method unsuccessful in mitigating global warming. When scientists like Allan Savory utilize these methods together, however, the results hold promise in combating desertification, and thus, climate change as a whole. This combination of methods also requires fewer resources and less global cooperation than any strategy requires individually. With scientists such as Savory experimenting with and combining pre-existing methods of climate change mitigation, there may be a possibility of reversing the effects of global warming, and furthermore, saving the planet for humanity.

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