Too Close to the Sun: Have We Taken Carbon Offsets Too Far?

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Zachary Abruzzese

Spring, 2023

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Bryn E. Seabrook, Department of Engineering and Society

STS Research Paper

Introduction

Has humanity doomed itself? Human industrial activity has raised the global average temperature by over one degree Fahrenheit and increased the concentration of carbon dioxide in the atmosphere by 50% (NASA, 2022). These effects are permanent. Even if humans stopped all carbon emissions today, the global temperature would not begin to decline until the end of the millennium (Solomon et al., 2009). There are numerous adverse effects to global temperature rise, the most well-known of which is increasing sea levels, which according to Solomon will incur "substantial irreversible commitments to future changes in the geography of the Earth because many coastal and island features would ultimately become submerged" (Solomon et al., 2009). Because the population of the United States is concentrated for the most part along the coasts, losing land to the ocean in coastal areas will displace a large amount of the population, leading to mass migration, increased congestion, and numerous other undesirable consequences (United States Census Bureau, 2021). Thus, attempting to reduce carbon emissions to curb the effects of climate change is essential for the long-term survival of humanity.

A recently developed technology that hoped to reduce carbon emissions, the carbon offset, appeared 25 years ago during a climate conference. The carbon offset was supposed to work as a tradable commodity, with each offset being equivalent to some amount of carbon dioxide. Governments would then be able to purchase or sell these offsets to offset the carbon released from activity within their country by funding carbon-capture technology or green development in other countries. However, the carbon offset has become less and less effective at reducing carbon output. Since carbon emissions are difficult to measure, and since emissions everywhere contribute to the concentration of carbon dioxide in the atmosphere, it is difficult to simply look at data to determine if the carbon offsets are working. The open feedback loop

created allows for the carbon offset to appear to work without giving evidence of it working. If the carbon offset is not working as intended, then humanity is vastly underestimating the amount of carbon dioxide emitted into the atmosphere, which could have disastrous consequences. This research explores how features of the carbon offset permit it to continue to function despite its apparent flaws.

Research Question and Methods

This paper answers the question, why have carbon offsets been an ineffective tool for tackling climate change? A case study is used to explore how government-regulated carbon offsets have been used and exploited. Additionally, the paper delves into the individual's behaviors when confronted with carbon offsets. Carbon offsets are utilized both by large polluting companies (such as electrical and manufacturing companies) as well as by individual people (such as offsetting the emissions from an airline flight), so it is important to understand how these two separate groups have reacted to the new technology of the carbon offset.

Background

Carbon offsets allow "carbon to be reduced in the global atmosphere by compensating for excess emissions in one location through carbon reductions in another" (Lovell & Liverman, 2010). The practice of carbon offsetting came into existence because of the Kyoto Protocol of 1997, which set emissions standards for most developed countries. However, the protocol included fines for noncompliance with the emissions standards, meaning that countries agreeing to the protocol wanted a way to ensure that they were always able to comply with the emissions standards (Lecocq & Ambrosi, 2007). The solution was to create the Clean Development Mechanism (CDM), whose job is to support eco-friendly development in developing countries

by allowing developed countries to "credit their greenhouse gas inventory with the emissions captured from afforestation or reforestation" and "promote the development of carbon pollution reduction projects such as hydroelectric dams and industrial gas destruction factories" (Wilman & Mahendrarajah, 2002 & Bryant et al., 2015). These two techniques work to reduce overall global carbon emissions despite limited emissions reduction from these developed countries.

Though the CDM "left many ambiguities unresolved," it does have a strict set of rules and regulations for emission targets and what constitutes a carbon credit (Lovell & Liverman, 2010). However, with the introduction of the CDM came a separate issue: the voluntary carbon offset. Carbon offsets under the CDM are counted as compliance offsets because countries use these offsets to comply with the Kyoto Protocol. Voluntary offsets, however, have no formal regulations or even a definition of what a carbon credit truly represents. Since climate change has become a hot button issue, companies, especially airlines, across the world have begun to take advantage of voluntary offsets by using marketing campaigns that promise net-zero carbon emission operations (Watt, 2021). For example, Southwest has an entire webpage complete with a Frequently Asked Questions section dedicated solely to their carbon offset program (Southwest Airlines, 2022). However, since companies and individuals utilize the voluntary offset market, there is little evidence that these methods are truly helping mitigate climate change. Instead, they at best push the problem off to developing nations and at worst fail to mitigate carbon emissions at all. Southwest, on their website, has a description of some of the projects that their carbon offsets go towards, one of which is titled "The Guatemalan Conservation Coast." The description of this project says that it "supports existing natural forest, avoiding carbon emissions that would result from unplanned deforestation and degradation" (Southwest Airlines, 2022). This statement appears extremely vague, and again highlights one of the problems with the under-regulated

voluntary carbon offset market. Thus, it can be very difficult to judge which forms of carbon offsets, if any, provide an effective method for beginning to address climate change.

STS Framework

The technological fix is the framework through which the analysis is conducted. The technological fix is the theory that some technologies should not be implemented because they do not address the root cause of the problem. According to Byron Newberry, technological fixes "run the risk of proliferating into universal *easy ways out*" (Newberry, 2005). These easy ways out can create their own problems in addition to not fully addressing the original problem they were meant to solve, which is a bad feature of any technology.

The psychology behind the technological fix is sensical. Max Oelschlaeger describes the technological fix in terms of human nature, stating that a problem (in this case, poverty) *could* be resolved by large-scale societal change (1979). However, he mentions that "it seems unlikely (i.e., contrary to human nature) that any nation will significantly modify its behavior. But the technological fix promises apparently more certain results, since it avoids the necessity of changing people's habits and motivations" (Oelschlaeger, 1979). Large-scale societal change (more commonly known as a revolution) does not happen often and, for global problems (such as climate change), the revolution must happen across the globe. Many historical revolutions have been long, bloody, and unsuccessful, which makes the technological fix appear to be a much nicer, easier alternative. Oelschlaeger also touches on human instinctual myopia—the instant gratification of a quick, supposed "fix" usually feels much better than the knowledge that slow incremental changes will eventually solve the problem.

Oelschlaeger also drives home the point that looking for solutions purely from technology is never going to work because humans are complex creatures with emotions and motivations and innate sociability while technology does not and could never have the same complexity. He states that if we suppose that complex issues can be broken down into "manageable technical ones," "the ethical, legal, economic, religious, or political aspects of a social problem can be ignored [and] once the technological problem is solved, the solution can be implemented and the entire problem thereby resolved, thus shortcutting the trouble of dealing with other complicating issues" (Oelschlaeger, 1979). If the prior assumption were correct, technology could save us all. But technology cannot stave off ethical and legal problems because it is not human. In fact, since technology is always created within the limits of society with funding from society, it cannot effectively change society as it is difficult if not impossible to predict the future needs of a society that does not currently exist.

Technological fixes have been around since the existence of technology, however awareness of the modern technological fix first appeared in the mid-twentieth century. For example, dichlorodiphenyltrichloroethane (DDT) was created in the 1940s and was an effective pesticide. However, this pesticide caused health problems for humans and other animals as well as pests. In 1972, the Environmental Protection Agency (EPA) banned the use of DDT (EPA, 2023). DDT was a technology that solved a problem without regard for societal effects, which eventually led to its discontinuation. The same logic can apply to carbon offsets—they solve a problem without regard for their side effects, which makes them an ineffective and dangerous technology to use.

Results and Discussion

Introduction

The carbon offset is, overall, a helpful technology that reduces emissions. However, on a large scale its utilization is flawed, causing it to inaccurately depict the net amount of carbon dioxide emitted into the atmosphere. This flawed emissions data can have lasting consequences for future climate change policy. Use of carbon offsets by individuals presents behavioral problems. Individuals, due to the nature of the technological fix, are prone to increase carbon emissions when presented with offsets, likely because of a lack of tangibility of the climate change effects of their actions. Negative behavioral repercussions to carbon offsets also include the feeling of reward or accomplishment upon having done something good (offset the carbon of some activity), which due to its easiness prevents the individual from performing other environmentally-friendly, more difficult actions. What started as a useful technology that actively worked to reduce emissions "proliferat[ed] into universal *easy ways out*", that have become convoluted, overused, and impractical in the fight against climate change (Newberry, 2005).

Systematic Issues (California Case Study)

Technological fixes are dangerous because they appear to solve their respective problems. One particular case study in California exemplifies how the carbon offset is implemented while failing to perform as it is supposed to. According to Song (2021), "one in three [carbon] credits issued through California's primary forest offset program" are "ghost credits"; carbon credits (which represent one ton of carbon dioxide emissions) that do not actually account for any extra carbon sequestration. These "ghost credits" come from several sources. First, California's carbon credit system uses base carbon sequestration data for forestry. For different regions, there is an associated regional average carbon baseline depending on the carbon capture ability of the trees in the forest. A forest can earn carbon credits by capturing or holding more carbon than the

baseline—the additional carbon sequestered on the land is transformed into carbon credits, which can then be sold to businesses. Landowners can thus plant trees that store lots of carbon on their land and make money, incentivizing people to participate. The issue with this system is setting an accurate baseline. It is impossible to survey every individual forest before any changes are made and then again afterwards to measure its specific base carbon capture and improved carbon capture, so the government of California generalized the land into a few different regions with vastly different regional averages (Song, 2021). This generalization leads to the system being exploitable, as exemplified by the map in Figure 1. The entire highlighted region is one zone with one regional average baseline.

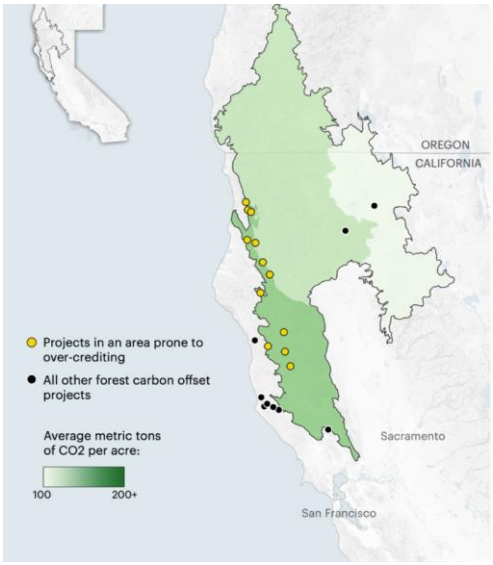

Figure 1. Map of carbon offset forests on border between two regions (Song, 2021)

Since higher carbon storing trees can grow larger and more efficiently closer to the coast, nearly all of the carbon sequestration forests are located as close to the coast as possible while still remaining in the inland zone to enjoy a much lower regional average. According to Song, a "10,000-acre forest of coastal redwoods and Douglas firs with carbon levels of 200 tons per acre could earn zero credits west of the line, or 624,000 credits east of it. The choice is between no

money and more than $8 million." A 624,000 credit, $8 million bonus for planting trees on one side of an arbitrary line is not an example of the system working to perfection, and it does lead to credit overcompensation. These forests are in no way sequestering that much more carbon than they otherwise would have, which results in carbon credits being created for carbon that was never and will never be sequestered. Though regional average manipulation appears to be the most egregious of the "ghost credit" creators, other activities occur as well that create carbon credits without actually reducing the amount of carbon in the atmosphere. Most carbon forestry is focused on protecting the land from deforestation due to logging, however, without a net decrease in logging overall, the same amount of carbon is still being released into the atmosphere, just in a different location (Song, 2021). The other side of this issue is if the land was not going to be deforested in the first place (Song, 2021). Exaggerated and oversimplified, one could have someone to show up with a bulldozer, make a big show of denying them access, and then earn money from the government. This example is obviously unrealistic, but the sentiment is the same. California is creating a significant amount of carbon credits that do not represent the carbon sequestration performed by its people.

California has some of the strictest environmental laws in the United States, meaning that companies must comply with the California Air Resources Board (CARB) standards for carbon emissions. The idea with the board's standards was to place a cap on the amount of carbon certain types of businesses was allowed to emit (the selected businesses are "responsible for 85 percent of California's greenhouse gas emissions", though this figure does not include individual carbon emissions, such as those induced by transportation or water heating), and slowly decrease the cap every year to reduce emissions to a predetermined standard (Song, 2021 and CARB, 2022). Thus, offsets are essential to Californian businesses, which face the choice of significantly

reducing emissions (a systematic change that takes a lot of time and money) or buying carbon offsets (a cheaper and lower-effort solution). While offsets are only "allowed for up to 8 percent of a facility's compliance obligation", the period over which these standards were enforced required a decrease in emissions of about 15 percent, meaning that about half of a company's reduction in emissions could come from carbon credits (CARB, 2015). Since these carbon credits are unreliable at best and one-in-three fake at worst, California's emissions are higher than anyone expects.

To give some context for how much additional carbon could be released on top of California's already-large emission number, data from CARB show that there were 183,327,861 allowances allocated for the year 2020 (CARB, 2020). Supposing businesses take full advantage of the program and utilize all of the offsets they are allowed (8 percent of total allowances), about 14,500,000 tons of carbon (as one allowance is equivalent to one credit which is equivalent to one ton of CO_2) would be covered by offsets. However, it is likely that not all businesses use all of their allowed offsets, so 10,000,000 is a more likely number. According to Song's findings, one-third of these offsets are "ghost credits", meaning that one ton of carbon was emitted without sequestering one ton of carbon. That leaves 3,300,000 tons of carbon that remains unaccounted for. According to CARB data, California emitted 407 million tons of carbon in 2020 (CARB, 2022), meaning that just under 1 percent of California's *total* emissions are missing from its data, which is a rather significant amount. CARB's Emissions Trading Program, which only focuses on large polluting companies, had a cap that declined at "about 3 percent annually". California's emissions, therefore, are not decreasing remotely as fast as they are expected to, and since California uses prior emissions data to project allowances in coming years, there are real, lasting consequences for these ghost credits.

Environmental laws and standards, like California's, should work. Requiring businesses to comply with emissions standards to operate forces them to reduce emissions and gets around the issue of only having a tax—some businesses would be profitable enough to just pay the tax and would not comply. But by requiring businesses to lower their emissions, you lower emissions overall. However, the introduction of one technological fix to the system undermines it entirely. The carbon offset was a quick, easy fix for Californian businesses. If the quick fix were the only effect, there would not be a problem. However, one cannot break down complex, large-scale societal issues such as climate change into "manageable technical [problems]" without considering the societal effects of a solution to one of those technical problems (Oelschlaeger, 1979). In the case of California's carbon credits, these societal effects reared their heads in the form of land developers looking to take advantage of a poorly created zoning system and logging companies simply logging somewhere else. Above all, however, is the reality that California's own creation was lying to it. The technological fix was not only an ineffective solution, but it actively made the problem worse.

Consumer Issues

Carbon offsets have their problems on the large scale due to systematic exploitation, however the problems on the individual level deal much more with human behavior. Again, individual behavior when presented with a technological fix nearly always results in humans taking the easy way out. The carbon offset even gives a small satisfaction bump, as people feel they are "doing their part" to help with climate change. Even if all voluntary offsets worked effectively and had no problems, they still encourage behaviors that overall hurt the environment.

A German research group conducted a study on youth hostel visitors to attempt to understand their behavior as it relates to carbon offsetting. The research was conducted by setting up four different scenarios, which were then each applied to one-fourth of the bedrooms in the hostel. The control bedrooms had a decal in the shower about the energy use of heating water and its carbon footprint along with a temperature gauge on the shower. One of the experimental sets of rooms had the same setup as the control, but the decal also mentioned that the hostel was part of a program that offset all carbon usage by the guests. The other two experimental sets had the same decals (one with no hostel offset announcement, one with), but also included a water meter on the shower head temperature gauge to show the user how much water they were using over the course of the shower (Gunther et al, 2020).

The research group's findings indicate that people who were offered the carbon offset (without the water meter feedback) used on average 15.5 percent more energy in their showers, while individuals in both sets of rooms with the water meter feedback used 3.9 percent less energy when compared to the control group (Gunther et al, 2020). The excessive use by the group who were offered the carbon offset illustrates yet another problem with the technological fix. Since it is so easy to counteract the bad environmental effects of sitting in a hot shower for longer, people will consistently do it. The "easy way out" may, according to Gunther, "alleviate feelings of guilt and reduce one's sense of responsibility" (Gunther et al, 2020). People will use their carbon offsets, think "I've done my part", and continue to act as they were before. In theory, continuing to act as before after paying for a carbon offset would be a net positive—all else being equal, the individual still funds green projects that otherwise would not have occurred. However, as mentioned above, carbon offsets on the government regulated level are questionable in terms of their effectiveness, and voluntary unregulated offsets are even less reliable. Though

individually purchasing carbon offsets does, on average, lower the amount of carbon emitted into the atmosphere, its effects are much less intense than supposed.

The other major issue with individually purchasing carbon offsets is the human behavioral response to it. A study by Gneezy and Rustichini (2000) was conducted to explore the effects of a small fine on parents' tardiness in picking their children up from daycare. Instead of the fine acting as a deterrent for showing up late, the fine instead became simply a cost associated with showing up late—parents viewed the fine as justification for coming late. So long as the value of the fine was less than the perceived value of the extra time they were able to use before picking up their children, the parents would continue to show up late and just eat the cost. Common individually purchased carbon offsets, such as ones offered by airlines to offset the carbon emissions of a flight are similar to the small fine paid by the parents. Southwest Airlines charges $6.72 (as of March 22, 2023) to offset the carbon emissions generated by a roundtrip flight from Washington, D. C. to Los Angeles, a flight of roughly 2,500 miles (Southwest Airlines, 2023). A much shorter (and thus likely more commonly taken) flight from Washington, D. C. to Manchester, New Hampshire costs only $1.72 to offset (Southwest Airlines, 2023). The fine that parents in the study paid was approximately five United States Dollars (USD), which was converted from Israeli New Sheckels (NIS) (the currency used in the study), so the monetary amounts are comparable. Thus, individuals who pay for carbon offsets from airlines may be inclined to fly more, as they would consider the additional, insignificant cost as a "fee" or fine associated with flying. In paying this fine, the individual rationalizes their decision to fly when they otherwise would not.

The technological fix when applied to an individual alters their behavior in a way that not only does not help solve the original problem, but in fact actively makes it worse. Allowing

individuals the reward of having helped the environment through carbon offsets encourages them to partake in other behaviors that counteract their environmental efforts (Gunther et al, 2020). Because of the technological fix, people assume that their work is complete; that no further effort is required. When purchasing a carbon offset, one does not think to oneself about the behavioral pattern the offset can create, they get a warm glow and move on with their life.

Carbon Offsets and the Technological Fix

One of the main issues with the carbon offset is the issue of tangibility. Carbon offsets offer no evidence of reducing emissions to the individual (apart from a receipt that *says* that it worked), but they also offer no evidence to the contrary. This lack of evidence allows the individual to continue going about their business (with a little glow inside from saving the planet). To help mitigate the effects of a lack of tangibility, researchers have suggested that "concrete representations of what products will become after recycling can … lead to increased recycling" (Habib et al, 2021). To extrapolate this small recycling program to all possible environmentally friendly activities is difficult and a lot of work, as it represents true societal and behavioral changes that could actually mitigate the effects of climate change.

Climate change is a societal issue—it affects and will affect nearly every person alive on Earth. According to Max Oelschlaeger (1979), "social problems might be overcome through 'social engineering,' that is by changing man's habits, motivations, and behavior", instead of an easy-to-use technological advancement. Gunther's (2020) research showed that, in the rooms where a water meter was attached to the showerhead, water usage dropped when compared to the control rooms, regardless of if there was an offset program in place for the rooms. Forcing hostel guests to see the amount of water they are using and the immediate impact of their showers improved the tangibility of "saving the environment", and many reacted and made changes

(Gunther et al, 2020). With many different programs resembling the instant feedback of the water meters, society's habits could change, providing a solution that the carbon offset could not.

Limitations and Future Work

Limitations of this study include a lack of resources such as receipts or business documents detailing how specifically businesses interact with carbon offsets. They also include a lack of time, as the two studies presented in the research are not the only two examples of the use of carbon offsets. Thus, it may be difficult to generalize the findings to society as a whole. Future research into carbon offsets should study further the role human behavior plays in carbon offsets, as human behavior is what drives the technological fix.

Conclusion

Carbon offsets, due to their nature as a technological fix, are an ineffective way to fight climate change. Failures of the carbon offset at the governmental and individual level necessitate an implementation of societal changes to effectively fight climate change. Paying for a carbon offset provides a good feeling and helps (if only a little). However, there are behaviors that are much more helpful for the environment, even if they require more work, such as using public transit or even showering for one fewer minute per day. If we can begin to slowly promote behaviors like these, slowly but surely humanity will collectively put up a good fight to keep our planet alive.

References

Bryant, G., Dabhi, S. & Bohm, S. (2015). 'Fixing' the climate crisis: Capital, states, and carbon offsetting in India. *Environment and Planning A, 47*, 2047-2063. https://doi.org/10.1068/a130213p

California Air Resources Board. (2022). *2000-2020 GHG inventory (2022 edition)*. Retrieved March 20, 2023 from https://ww2.arb.ca.gov/ghg-inventory-data

California Air Resources Board. (December 6, 2019). *Cap-and-trade program vintage 2020 allocation summary.* Retrieved March 20, 2023 from https://ww2.arb.ca.gov/sites/default/files/2022-12/nc-v2023%20Public%20Allocation%20Summary.pdf

California Air Resources Board. (February 9, 2015). *Overview of ARB emissions trading program*. Retrieved March 20, 2023 from https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/guidance/cap_trade_overview.pdf

Environmental Protection Agency. (April 3, 2023). *DDT – A brief history and status*. Retrieved April 23, 2023 from https://www.epa.gov/ingredients-used-pesticide-products/ddt-brief-history-and-status

Gneezy, U., & Rustichini, A. (2000). A Fine Is a Price. *The Journal of Legal Studies*, *29*(1), 1–17. https://doi.org/10.1086/468061

Günther, S. A., Staake, T., Schöb, S., & Tiefenbeck, V. (2020). The behavioral response to a corporate carbon offset program: A field experiment on adverse effects and mitigation strategies. *Global Environmental Change, 64*, 102123. https://doi.org/10.1016/j.gloenvcha.2020.102123

Habib, R., White, K., Hardisty, D. J., & Zhao, J. (2021). Shifting consumer behavior to address climate change. *Psychology of Climate Change (2021)*, *42*, 108–113. https://doi.org/10.1016/j.copsyc.2021.04.007

Lecocq, F., & Ambrosi, P. (2007). The clean development mechanism: History, status, and prospects. *Review of Environmental Economics and Policy*, *1*(1), 134–151. https://doi.org/10.1093/reep/rem004

Lovell, H., & Liverman, D. (2010). Understanding Carbon Offset Technologies. *New Political Economy*, *15*(2), 255–273. https://doi.org/10.1080/13563460903548699

Newberry, B. Mitcham (Ed.). (2005). Encyclopedia of science technology and ethics (4, 1901-1903). Farmington Hills, MI: Macmillan Reference USA

NASA. (2022, September 26). *Home – climate change: Vital signs of the planet*. NASA. Retrieved November 4, 2022, from https://climate.nasa.gov/

OELSCHLAEGER, M. (1979). The Myth of the Technological Fix. *The Southwestern Journal of Philosophy*, *10*(1), 43–53. http://www.jstor.org/stable/43155445

Solomon, S., Plattner, G.-K., Knutti, R., & Friedlingstein, P. (2009). Irreversible climate change due to carbon dioxide emissions. *Proceedings of the National Academy of Sciences*, *106*(6), 1704–1709. https://doi.org/10.1073/pnas.0812721106

Song, L. & Temple, J. (April 29, 2021). The climate solution actually adding millions of tons of CO2 into the atmosphere. *MIT Technology Review*, *124*(2).

https://www.propublica.org/article/the-climate-solution-actually-adding-millions-of-tons-of-co2-into-the-atmosphere

Southwest Airlines. (2022). *Carbon offset program: Southwest Airlines*. Carbon Offset Program | Southwest Airlines. Retrieved November 4, 2022, from https://www.southwest.com/carbon-offset-program/

Southwest Airlines. (2023). *Carbon offset program: Southwest Airlines*. Carbon Offset Program. Retrieved March 22, 2023, from https://www.southwest.com/carbon-offset-program/#calculator

United States Census Bureau. (2021, October 19). *2020 population distribution in the United States and Puerto Rico*. Census.gov. Retrieved November 4, 2022, from https://www.census.gov/library/visualizations/2021/geo/population-distribution-2020.html

Watt, R. (2021). The fantasy of carbon offsetting. *Environmental Politics*, *30*(7), 1069–1088. https://doi.org/10.1080/09644016.2021.1877063

Wilman, E. A., & Mahendrarajah, M. S. (2002). Carbon Offsets. *Land Economics*, *78*(3), 405–416. https://doi.org/10.2307/3146898