EGRS 451 Fall 2019 Capstone Project:

Carbon Capture and Storage

Authors:

Nika Cinicola, ‘20

Diana De La Torre, ’20

Ryan Goncalves, ’20

Skye Liu, ’20

Introduction

In 2019, Lafayette College published the Climate Action Plan (CAP) 2.0 with the intent of achieving carbon-neutrality by the year 2035. Although it is not the first CAP in higher education, nor within Lafayette itself, the CAP's presence remains highly relevant and promises that another community will take action to combat the ever-worsening effects of climate change. Many colleges and universities hope that by reducing their carbon footprint, they can aid in the worldwide effort to decrease the number of greenhouse gases in the atmosphere.

Lafayette College has been making efforts towards sustainability even before the early 2000s. In the year 2008, the school developed its first CAP, which resulted in a twenty percent reduction in carbon emissions between 2008 and 2017 (2019 Climate Action Plan, 2019, p.6). Then, in 2017, and motivated by President Alison Byerly's support for the Paris Agreement through the "We Are Still in Pledge," Lafayette College began the development of an updated plan to reduce its carbon footprint (Office of Sustainability, 2018, p. 6). Now, after two years of planning and editing, Lafayette's CAP 2.0 is ready for use and filled with a variety of recommendations that seem feasible for Lafayette. Many of the proposed solutions are already in progress on campus. Some of the new proposals are known for their success in other schools, while others are more modern techniques and therefore less studied. For this project, our team will be looking at the technique known as carbon capture and storage (CCS), and the ways it can be effectively used by the college.

The Concept behind CCS

To understand the implementation of CCS and how it works, one must understand the basics of the carbon cycle. In short, the carbon cycle is the continuous process of carbon leaving the atmosphere, being stored on Earth, and then later released back into the atmosphere. Storing of carbon is found in an assortment of reservoirs, including oceans, living organisms, and the Earth itself; carbon can release through processes such as decomposition or the burning of fossil fuels (NOAA, 2019, n.p.). The Carbon Cycle "maintain[s] a balance that prevents all of Earth's carbon from entering the atmosphere or from being stored entirely in rocks. This balance helps keep Earth's temperature relatively stable" (Riebeek, 2011, n.p.). As the amount of carbon released into the atmosphere begins to overwhelm the amount absorbed, it has become significantly more pressing to develop tactics to reduce and remove the excess CO----2-.

Various industrialized technologies and organic strategies can perform the process of CCS. Industrialized techniques capture CO-2- from the atmosphere through a variety of techniques before it gets transported to another location and stored beneath the Earth's surface in geological formations (Carbon capture, 2019, n.p.). Organic methods follow the carbon cycle, typically relying on the natural processes that remove CO-2 from the atmosphere and store it in sinks such as plants, soil, and the ocean (Thompson, A., 2012, n.p.). By improving conditions of natural sinks, or by increasing the number in existence, humans can assist this natural process by increasing its efficiency. As specified in the CAP, Lafayette College will be looking into the use of organic CCS methods, specifically those possibly applied at the Metzgar complex.

The Project

The CAP 2.0 states that in Phase 2 (2021-2025), Lafayette College wants to "Achieve carbon neutrality at Metzgar Fields Athletic Complex" to "expand its status as a living laboratory, providing opportunities for hands-on education in carbon-efficient technology and sustainable design" (2019 Climate Action Plan, 2019, p.14). In other words, the project will serve as a micro model that Lafayette College can use as valuable feedback for the whole college.

Metzgar Fields, a college-owned property, is located about three miles northwest of the College Hill campus. The sports complex is part of this 80-acre plot of land. It houses buildings and fields for Lafayette College's varsity sports teams, as well as intramural and recreational programs. Two of the main buildings located on the property are the Kamine Varsity House, which contains the men's and women's locker rooms, varsity team rooms, and training and medical spaces, and the Morel Field house (Metzgar Fields, 2019, n.p.). The plot of land also contains one of Lafayette's popular sustainability efforts, LaFarm. The college directly operates the three-acre space and provides products that the dining halls use, it is sold on campus and donated to the Easton community (Office of Sustainability, 2018, p.5). Together, LaFarm's greenhouse, the athletic buildings on the property, stadium lights, and the maintenance technologies used regularly are significant consumers of electricity. In 2017, electricity production accounted for 27.5 percent of the United States' GHG emissions, making it one of the most significant GHG producers, second only to the transportation sector. According to the EPA, "approximately 62.9 percent of our electricity comes from burning fossil fuels, mostly coal and natural gas" (Sources of Greenhouse Gas Emissions, 2019, n.p.). As a result, Metzgar's heavy energy consumption contributes noticeably to Lafayette's overall carbon footprint. To successfully use Metzgar as a demonstration of Lafayette's capabilities of achieving carbon neutrality, Lafayette needs to begin implementing changes that can lead to balancing out the complex's net emissions.

This project has considered two alternatives that approach carbon storage at a level feasible for the small size of Lafayette. One option is the use of no-till agriculture, cover crops, perennial cropping systems, and other organic farming techniques to improve soil quality and increase the land's ability to store carbon. This technique would be particularly applicable at LaFarm since the organization already uses techniques of a similar type. Another potential alternative that Lafayette College could undertake is reforestation. Forests play a significant role in the environment: "They regulate ecosystems, protect biodiversity, play an integral part in the carbon cycle, support livelihoods, and supply goods and services that can drive sustainable growth" (Forests and Climate Change, 2019, n.p.). According to Mary Booth, an ecologist at the Massachusetts-based Partnership for Policy Integrity, when it comes to drawing down carbon, "forests are the only proven, scalable technology we have" (Elbein, S., 2019, n.p.). Given the large amount of unused land on the Metzgar Fields Complex, Lafayette has the capability of decreasing its net emissions by growing its own forest. Planting trees at other locations, including the walkway at Metzgar that leads from the parking lot to Oak's Stadium, within LaFarm, and potentially even in spots that are on campus.

Our group has taken the first steps towards achieving this critical goal. In our project, we have considered the feasibility and cost of obtaining carbon-neutrality at the Metzgar Fields Complex through the alternatives previously mentioned. By looking at the social, political, technical, and economic contexts, we hope to provide an analysis that can serve as a starting point when Lafayette College and the Office of Sustainability take the next steps to achieve their end goal.

Social Context

Lafayette College has implemented the Climate Action Plan (CAP) 2.0 to help mitigate its contribution to carbon emissions in the atmosphere. Lafayette College is seeking to address the problems we all face with climate change in implementing different sustainable solutions on campus to mitigate those effects. Climate change is a crisis that “does not respect national boundaries… nor does it care about public opinion” (Paul Hardisty, Sivapalan, & Brooks, 2011, n.p.); therefore, Lafayette College is taking the initiative with the CAP to set an example that solutions can be implemented and tested at the campus level. More specifically, with Lafayette College taking action to redesign its initial CAP, it opens the opportunity for groups on campus and others to implement sustainable solutions that will help us reach carbon neutrality by 2035. Having the CAP pushes Lafayette College to implement different solutions, such as CCS at Metzgar Field, and model the different ways communities and schools can implement sustainable solutions at a more local scale.

There are many ways communities, schools, organizations, etc., that can get involved in learning more about sustainable practices and technologies that can help with improving the environment and ensuring there is a habitable world for future generations. Also, people who have the resources and are knowledgeable on the issues surrounding climate change and possible solutions to this can help motivate others in implementing technological, political, and social fixes, which Lafayette College is going through with the CAP 2.0. It is crucial to understand, though, the importance of why the Lafayette College community has enacted this plan; they have also recognized that we, as citizens of the world, are facing a global climate crisis. There has been an increase in social responsibility driving people to take action in decreasing carbon emissions because of the adverse effects of climate change and variability in weather experienced in the United States (IPCC, 2007, n.p.). It is also clear that anthropogenic activities have been exacerbating the effects of climate change, so it is everyone's responsibility to make changes that can benefit not only themselves but the people surrounding them and their environments (IPCC, 2013, n.p.). Even focusing specifically on communities that live in poverty and do not have access to resources that can help them mitigate and adapt to the effects of climate change, they are disproportionately affected by these effects. Some communities live in poverty and lack the resources to help them implement sustainable solutions that can help improve some of the impacts of climate change. Therefore, in researching and establishing sustainable solutions in Lafayette College, it can help communities understand what the most feasible solutions are that can help communities at risk of facing more significant effects of climate change. Lafayette College is experiencing a shift in practices and research working towards implementing different solutions that can help reach the CAP's goal of achieving carbon neutrality by the year 2035.

Within the United States, some numerous industries and institutions are making moves to reduce their carbon footprint. Over the past decade, colleges and universities throughout the country have developed their plans to combat the growing issue of climate change. This dramatic increase in involvement is linked to the American College and

University Presidents' Climate Commitment. The ACUPCC originated in 2007 when 152 college and university presidents agreed to work towards carbon neutrality within their institution, which further increased by 525 schools by 2014 (Sirianni, P., & O'hara, M., 2014, p. 503). The success of each institution has varied, often dependent on the goals set and the funding they were willing to contribute (Sirianni, P., & O'hara, M., 2014, p. 517). By analyzing the shortcomings and successes of various institutions, as well as considering the ever-increasing research, it will be possible for colleges to develop more effective plans of action. Colleges who have implemented different solutions towards mitigating and adapting to the effects of climate change are especially influential and serve as a crucial stepping stone for Lafayette College to follow.

Using these past cases, Lafayette will be able to understand what solutions are the most feasible for its size and characteristics and pursue the end goal of carbon neutrality by 2035. Specific schools, such as Massachusetts Institute of Technology (MIT), is working towards integrating sustainability practices and knowledge across their whole school, from students to partners, in which "education, research and innovation [are] on [their] campus" ("MIT Sustainability," 2019, n.p.). Some of the methods MIT has introduced and implemented on their campus focus on community engagement and ensuring people are part of this experience. Their school focuses on five different scales, which include sustainable campus systems, leadership and capacity, building, urban living laboratory, collaborative partnerships, and you. These specific sectors come from MITs, MITOS Strategy framework which is broken down into four different areas of responsibility, which "MITOS inspires and enables the continuous generation of breakthrough sustainability solutions to transform for campus, city and globe" ("MIT

Sustainability" 2019, n.p.). MIT has taken into consideration many of the aspects focused on these projects, which include the partnership with communities and creating collaborative space between people. Another college that has been working towards being more sustainable practices and solutions is St. Olaf College, located in Minnesota. St. Olaf has *Sustainability Principles*, which focuses on many ideas such as educating students on sustainability, "restor[ing] natural landscapes for both practical and aesthetic reasons," and "explor[ing] the spirit of nature in religious study and practice." For example, St. Olaf College already has existing natural areas that are responsible for absorbing carbon, including both agricultural and forest lands (Natural Lands, 2019, n.p.). Still, it has also used reforestation techniques to increase carbon absorption. In the area referred to as the "Big Woods", St. Olaf has planted "over 40,000 tree seedlings and nursery stock trees…over 90 acres of woodland habitat" in addition to seven acres of coniferous forest throughout its forest restoration attempts (Restored Woodlands, 2019, n.p.). In a study conducted by a St. Olaf student, the biotic carbon sequestration abilities of natural forest on campus, Norway Valley, is compared between the years of 2012 to 2014. The techniques used so far with St. Olaf's are the closest to what we propose for Lafayette's CAP. As seen in the above cases, smaller schools are entirely capable of implementing natural carbon capture methods. Therefore, this shows that Lafayette College can implement solutions in the community that will allow for an educational purpose use of the Metzgar Field in implementing CCS.

Lafayette College designed the CAP to create the most efficient campus by implementing sustainable solutions by engaging the Lafayette community in hopes of encouraging students, communities, and other schools the process of becoming a carbon-neutral college (2019 Climate Action Plan, 2019, n.p.). The effects of climate change are a wakeup call to many and Lafayette College is using it as an opportunity to "use [the] campus as a living laboratory that enables transformational learning experiences for students and teaches them to live within environmental bounds" (2019 Climate Action Plan, 2019, p. 3). Furthermore, many organizations on campus are student-led, focusing on sustainability and educating the community on different topics such as sustainable living tips, how to recycle and what are common misconceptions, food justice topics, and more. Some of the organizations that had a considerable contribution towards pushing implementing the CAP are the following: ECOreps, Lafayette Food and Farm Cooperative (LaFFCo), Lafayette Environmental Awareness and Protection (LEAP), and the Society of Environmental Engineers and Scientists (SEES) (2019 Climate Action Plan, 2019, p. 10). Not only are student organizations taking charge of helping with the CAP, but there are also faculty and staff that have been researching ways that Lafayette College can implement different solutions that will the campus reach carbon neutrality by the year 2035. It is an incredibly perfect opportunity for Lafayette College to model the implementation of sustainable fixes to help mitigate the effects of climate change and help understand the implementation process to help reach carbon neutrality at a college.

Lafayette College has many opportunities to meet the CAP goal by 2035. The CAP describes the different ways the college can reach carbon neutrality, which include transforming campus heat and hot water generation, installation of HVAC systems, improving transportation, and many others mentioned in the CAP. One of the other methods that can help Lafayette College reach carbon neutrality is the technological solution of CCS. There are many benefits when it comes to implementing CCS, especially when considering it will be a new technical method Lafayette College will implement. Lafayette College will be using the 125 acres of land at the Metzgar Field to implement CCS solutions, specifically reforestation, which we will mention in the upcoming sections. The goal is to implement CCS at Metzgar Field, which will help in opening up the opportunity in community engagement and allowing this project to be an educational experience for students at Lafayette College. Having the chance to implement CCS at Lafayette College and using it as a teaching tool can help push towards educating people about climate change, its effects, and the solutions that can help in mitigating and adapting to those effects. The groups focusing on sustainability, and classes willing to take part in this opportunity, can have the chance to take part in implementing CCS, learn how it is beneficial towards the environment, and learn how it will benefit everyone in the long run. However, one of the constraints is that there is not enough research on CCS because it is such a new technological solution towards capturing and storing carbon and findings ways that it will be the most effective and economically feasible (Markusson et al., 2012, n.p.). Other countries such as Norway have extensive research on CCS engagement, which has benefited them; however, because of the scope we are working with, Lafayette College falls under a more local based model in implementing CCS solutions. Because Lafayette College has taken the initiative to focus on finding solutions to reach carbon neutrality, it shows that the Lafayette community is active and wants to make a change towards improving our environment and ensuring there is a habitable planet for future generations.

Lafayette's presence in the Easton community and partnership with other colleges in different sectors will help set a standard for communities and colleges to follow and implement solutions that can help improve their carbon footprint. Using Metzgar Field as a model that Lafayette College can use CCS as one of the many options for reaching carbon neutrality can help motivate others to use CCS as a solution towards storing carbon. CCS, however, is not the only solution towards assisting Lafayette in reaching carbon neutrality by 2035, especially in considering its carbon footprint, which we will mention in the upcoming sections. Some of the solutions that help reduce carbon emissions are through the “land-use changes (forest clearing and agricultural practices), building design and operation, transport, and notable electrical power generation” (Paul Hardisty, Sivapalan, & Brooks, 2011, n.p.). Most of these other solutions are already being planned out by other capstone groups and Lafayette College, so this puts the campus in a better position towards reaching carbon neutrality. Also, there are contributions towards reducing GHGs by other countries. Still, much of this information cannot be compared to because “on a global scale, the tangible effects of actions taken to reduce emissions of greenhouse gases… have been minimal” (Paul Hardisty, Sivapalan, & Brooks, 2011, n.p.). Implementing CCS solutions at Lafayette College can help in many ways, especially in reaching carbon neutrality at the Metzgar Fields Complex first and modeling in a form that others can potentially follow. Doing so will also help understand what the most effective ways are to implement sustainable solutions on a more local level rather than at the industrial scale. Even though CCS is a small portion of the resolution, there are many other ways the college is participating in reducing their carbon footprint.

There is now a lot more awareness in the issues surrounding climate change and research on how the implementation of different possible solutions work in different communities, industries, schools, and others. Mainly, this can help in allowing people to learn more about the effects of climate change and how they can implement individual solutions in their households or whatever they represent, which works towards engaging communities in implementing sustainable solutions. Lafayette College can follow previous plans implemented by other colleges that can help reach its goal of carbon neutrality.

In our next section, we get into more specifics regarding who are the political actors to either help or constraint the project from moving forward in the implementation of CCS at Lafayette College. Also, it gets to specific policies that must be considered when implementing this project in the future, which you can access here.

Political Context

As awareness of climate change grows, so do the efforts to counteract the damage society has done to the environment. With increasing frequency, countries throughout the world have begun to develop policies meant to encourage environmentally conscious behaviors. These changes often either focus on the proper use of natural resources or the implementation and monitoring of existing or developing technologies. Political actors play a crucial role in determining the success of these policies through the way they design, support, and enforce them. By considering existing policies, as well as the amount of support in the political atmosphere for CCS, our group has analyzed the feasibility of establishing a CCS project on campus.

The issue of climate change has been a significant point of discussion in the political atmosphere for years. The year 1997 marked the first time the development of political action occurred to reduce environmental impacts on a global scale. Although it was not enforced until 2005, the Kyoto Protocol "set binding emissions reduction targets for developed countries only, on the premise that they were responsible for most of the earth's high levels of greenhouse gas emissions" (Denchak, M., 2018, n.p.). Unfortunately, while numerous countries agreed to the goals stated, a percentage of them dropped out before the Protocol's initial expiration date in 2012. The second push for climate change came from the Paris Climate Agreement. Developing the deal had the intent of replacing the Kyoto Protocol and is directed towards all countries with the goal "to substantially reduce global greenhouse gas emissions in an effort…to limit the [climate temperature] increase to 1.5 degrees" (Denchak, M., 2018, n.p.). The United States has failed to support both of these agreements adequately and, most recently, is at risk of completely withdrawing its commitment to the Paris Climate Agreement. The country's lack of success in making significant contributions to global efforts has, however, inspired states, organizations, and institutions to take action on their own accord.

Within Pennsylvania, the Department of Environmental Protection (DEP) (About DEP, 2019, n.p.) plays a significant role in dictating specific regulations for state-based companies and institutions. Similar to many other states in the US, Pennsylvania has joined the effort to develop better environmental-climate policy by creating a Climate Action Plan of its own. The document was published initially in 2009 and remains in use, having been updated most recently in 2019. According to its executive summary, "The Pennsylvania Climate Change Act (Act 70 of 2008, or Act) provides for a periodic report on potential climate change impacts and economic opportunities for the commonwealth"

(Pennsylvania Climate Action Plan, 2019, p.14). It requires the DEP to continually evaluate the impacts of climate change on Pennsylvania (Shortle, J., 2015, p.6) and conduct an inventory of greenhouse gases every year (2018 Pennsylvania Greenhouse Gas Inventory, 2019, p.5) as a means to track progress. As of 2018, the most recent inventory revealed that Pennsylvania is past halfway to achieving its 26% emission reduction goal, set for 2025 (2018 Pennsylvania Greenhouse Gas Inventory, 2019, p.5). The updated Climate Action Plan also added adaptation-focused goals, hoping to create the ability to "anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly form climate-related disruptions" (Pennsylvania Climate Action Plan, 2019, p.36). The progress resulting from the state's Climate Action Plan provides a positive atmosphere for environmental change and encourages other organizations to follow suit. Lafayette College would benefit from looking at the recommendations and data published in these documents as it moves forward with its own Climate Action Plan. Although their scope may be different, some of the solutions mentioned for the state of Pennsylvania – such as improving agricultural or forestry practices – remain applicable and transferable to the college.

But while governing bodies approach the issue of excess greenhouse gas emissions by developing a variety of legislations, environmental groups use more direct methods to create change. Often, these organizations focus on education and raising awareness, or taking action through various projects (Siddons, S., n.d., p.1). Recently, with the strong push for carbon capture techniques, these organizations are turning their efforts towards developing ways to maintain and improve natural land conditions to help with farming and reforestation efforts.

The Nature Conservancy, for example, is a global climate action group that dedicates its efforts to address the most pressing environmental issues. Originating in the United States, there are numerous branches throughout the country, including Pennsylvania. Currently, the organization focuses on four sectors: city development, food and water sustainability, resource conservation, and stopping climate change (What We Do: Our Priorities, 2019, n.p.). By coordinating their projects, and working with external partners (including government officials), The Nature Conservancy has been able to make a positive impact within each of these sectors. Of the many techniques in use, the Nature Conservancy applies carbon capture strategies, arguing that "cutting forests contributes to climate change. But restoring nature—in all kinds of landscapes—is a powerful tool in the race to stop climate change" (Jenkins, M., 2018, n.p.). Even though the scope remains too big, the Nature Conservancy has already assisted in reforestation projects. It will be a beneficial resource for Lafayette if the school moves forward with plans for reforestation.

The Pennsylvania Association for Sustainable Agriculture (PASA) is another influential organization. Unlike the Nature Conservancy, which is more action-based, much of PASA's work focuses on raising awareness to "build a more economically-just, environmentally-regenerative, and community-focused food system" in the farming sector (About PASA, 2019, n.p.). Among the variety of their sponsored projects, PASA produces annual reports to convey their research and findings to a general audience. In its most recent publication, a study done by PASA and Cornell Soil Health Lab, with support from an NRCS Conservation Innovation Grant, actively brought together local farmers and investigated the best management strategies to building healthy soils (PASA, 2019, p.7). PASA's efforts and publications can provide helpful insight that Lafayette can use to further improve upon farming techniques already used at and around LaFarm.

Climate mitigation efforts have increased due to the involvement of political actors as they continue to fund projects and education efforts. These efforts become particularly influential when they focus on community involvement, as seen with the Nurture Nature Center (NNC). The NNC is an Easton-based organization that endeavors to engage with the Easton community in the daily dialogues about environmental issues. In creating the NNC, the goals were to discuss the city's history of flooding and the risk that they still face. Over time, it has broadened its programs towards encouraging community engagement and educating visitors on additional topics such as climate change and food access (Welcome, 2019, n.p.). Although the organization is smaller than the previously mentioned examples, the NNC's knowledge about the Easton community and the city's unique problems makes them a valuable local resource, especially as Lafayette contemplates which actions are best for its campus and the city of Easton.

The Political Context for Lafayette

The political climate outside of Lafayette has been crucial to environmental change for more significant industries and communities. Still, it has also permitted the college the ability to develop its own plan for change. For Lafayette's CAP to be a success in the future, both external and internal actors need to show support and aid in the efforts continually.

The development of Lafayette's Climate Action Plan started in 2008 after the acting college president, Dan Weiss, signed the American College and University Presidents' Climate Commitment. By agreeing to join the ACUPCC, Lafayette pledged to “eliminate its contribution to global warming” by creating a campus-wide plan (Dautremont-Smith, J., 2009, p.3). All institutions who sign the deal are required to calculate their initial GHG emission production rate before developing their course of action. The expectation is to continue to report on progress and reevaluate their plans to continue to promote growth (Dautremont-Smith, J., 2009, p.30). The first CAP motivated noticeable changes in Lafayette’s sustainability initiatives, leading to a twenty percent reduction in the school’s emissions since its establishment (2019 Climate Action Plan, 2019, p.6). Several years later, President Byerly signed the “We Are Still In Commitment,” joining numerous schools in their protest of the US’s potential withdrawal from the Paris Climate Agreement. By doing so, Lafayette agreed to not “take [the US’s] retreat from the global response to the climate crisis lying down” (We Are Still In, n.d., n.p.) and continue forward in their attempts to reduce emissions. As a result, Lafayette College implemented the Climate Action Plan 2.0 and the goal to achieve carbon neutrality by 2035.

Since Lafayette first committed to minimizing its environmental impact, there have been numerous changes in campus policies to promote and support the goal of carbon neutrality. For example, the development of the Campus Energy Policy was to ensure that any new buildings constructed on campus reach the appropriate sustainability goals (Energy Policy, 2019, n.p.). The Campus Facilities Master Plan is another development which discusses changes that could be made to the school’s layout to promote a greener campus (2009 Campus Master Plan, 2009, n.p.). The CAP 2.0 is, however, the most recent development. It will have significant changes in Lafayette College standards and alter the way the school grows and funds its sustainability efforts in the coming years.

The growing presence of sustainability efforts on campus has led to an increase in support for projects such as the carbon storage project at LaFarm and Metzgar field. Current carbon capture techniques range from carbon sequestration to reforestation, with various types of farming methods that fall in between these options. Although most known CCS techniques have been successful in the past, they are not all meant for the scope of Lafayette, given limits on funding, technical abilities, and political feasibility. Of the existing techniques, industrial carbon capture is perhaps the least feasible technique for Lafayette due to uncertainties in both the technical and legal spheres. Since Lafayette's CAP does not consider the alternative, so we will not discuss it in further detail within the political context.

The use of better agricultural practices as a means to increase the amount of carbon stored in organic matter is a highly feasible option for the college. LaFarm already uses techniques meant to improve soil quality, which in turn helps with carbon capture and plant growth capabilities. Although LaFarm lacks the certification as an organic farm, the majority of LaFarm's practices follow organic regulations. Organic farming certification requires farms to meet and maintain strict standards. As long as the farm remains certified, National Organic Program will continuously regulate the farm (National Organic Program, n.d., n.p.). If Lafayette College wanted to achieve this certification, LaFarm would need to meet all requirements and be free of any prohibited practices or substances, which the organization's webpage lists many options (Organic Regulations, n.d., n.p.). While achieving an organic certification might have benefits, LaFarm has been successful in making a positive impact with its given qualifications and should continue to focus on implementing CCS techniques.

Reforestation is perhaps the option that has the highest chance of success for Lafayette. Many other colleges with climate action plans have turned to a similar solution partly because forests act as a significant carbon sink, but also because of the relatively low establishment cost. Additionally, there are numerous organizations and policies in existence that support forest maintenance. Reducing Emissions From Deforestation And Forest Degradation In Developing Countries (REDD+) is among the various forest preservation policies that have created "a demand for carbon sequestration or adaptation services… and incentivize reforestation" (Locatelli et al., 2015, n.p.). Its goal is to reduce the destruction of forests by working with developing countries to use better foresting techniques, reduce emissions from deforestation and forest degradation, as well as improve carbon-stock and forest management techniques (REDD+, 2019, n.p.). With a history of success and a high level of external support for this alternative, a reforestation project holds a lot of promise for Lafayette, especially in combination with LaFarm's practices, as long as it receives the necessary on-campus support.

The success of the Climate Action Plan 2.0 relies on the implementation, but also on the support, funding, and attention it receives. Fortunately, due to the growing awareness on campus, there is a wide variety of individuals and groups willing to help with the development of this plan. Firstly, the Sustainability Office and the Sustainability Committee are two different groups but have both had a vital role in the making of the CAP. As the college begins to progress forward with its plan, the Office of Sustainability will continue to be one of the most prominent leaders and a key player in the CAP's success. Less involved parties, but still relevant, include the Board of Trustees, which holds the responsibility of making the majority of decisions regarding changes on campus, and alums and donors. Without their support, many of the proposed goals become unattainable or will lack the necessary funding. This goes to show that success relies on gaining support not only from those who are directly involved but from those who do not have as prominent of a role.

The last and most valuable player in the CAP's success consists of student, staff, and faculty members who each play a role by reducing their impact on the environment. A large number of on-campus, student-run organizations, however, have a higher impact capacity by acting as implementing structures for efforts directed toward carbon neutrality. The Society of Environmental Engineers and Scientists (SEES), for example, is an organization that researches to help solve current environmental science and engineering problems (SEES, 2019, n.p.). Along with the sustainability office, it could act as a technological infrastructure team that researches what technologies are the best methods. As the farming and reforestation technologies evolve and new challenges appear, it's critical to evaluate the new options and decide which ones are more feasible, both technically and financially. Students with strong science and engineering backgrounds from SEES can assist this process.

Aside from the technical team, student clubs in the outreach and information branch can work toward providing the necessary motivation, understanding, resources, and acknowledgments for the campus and Easton community. EcoReps are a peer environmental group that act as role models and educators on campus. They help execute campus-wide events and promote sustainability through outreach and action; as a result, they would likely be active players in bridging carbon storage projects and campus education in the coming years (EcoReps, n.d., n.p.). LAFFCO, the organization that works towards becoming the liaison between the greater student body and LaFarm (Horowitz, 2015, n.p.), could also play an important role by working towards promoting student involvement at Lafarm and Metzgar field. Lastly, LEAP (Lafayette Environmental Awareness and Protection) is a group working towards campus sustainability by encouraging discussion and awareness of local and national environmental issues and organizing students to action (LEAP, 2019, n.p.). They play an essential role in community outreach and engagement in cooperation with the LANDIS center. They would be another active contributor to creating a connection between the college, the community, and upcoming environmental projects.

So far, the efforts to create a climate action plan have been successful. Lafayette has been able to gain support and now is working towards implementing the desired aspects of the CAP. The last thing to consider before each phase starts is the impact. In the case of using CCS technologies at the Metzgar Athletics Complex, those who will feel the most notable effect participate in Lafayette College's Athletics Program. Due to their heavy reliance on Metzgar Field, any changes to the complex will affect athletes and could result in potential push back if the alterations are too troublesome. LaFarm, on the other hand, will face a different impact because no significant changes will take place in the implementation of farming techniques on the farm. However, LaFarm serves a wide variety of people, including the students and staff at Lafayette, independent farmers who rent the land, and even the city of Easton. Although their level of involvement in LaFarm varies, these broader groups will still feel the impact and will rightfully want to be involved. This dynamic mirrors the procedure of policy implementation in the way that only the upper tier of policy actors determine what can happen. Only after a change do the real impacts become evident, which is why it remains essential to consider all contexts before implementing such a decision.

To read about how the CCS technologies will be used at Lafayette College, click here and continue to the next section.

Technological Context

This section assesses our current state of knowledge regarding the technical dimension of CCS as an option to achieve the college's carbon neutrality goal. It starts with a brief overview of different types of carbon sequestration technology and past CCS practices. By discussing the components and features of industrialized CCS system, this section demonstrates why we chose the natural methods of CCS over large-scale industrialized practice at college level. Then it explores the main natural approaches to increase soil carbon storage, including agroforestry, organic farming and reforestation. After investigating the effectiveness and maturity of relevant technologies associated with these approaches, it narrows down to introducing our two phased reforestation plan starting at Metzger field. This technical report demonstrates the design elements, implementing timeline, material list, risks, relevant skills and knowledge gap of our alternative.

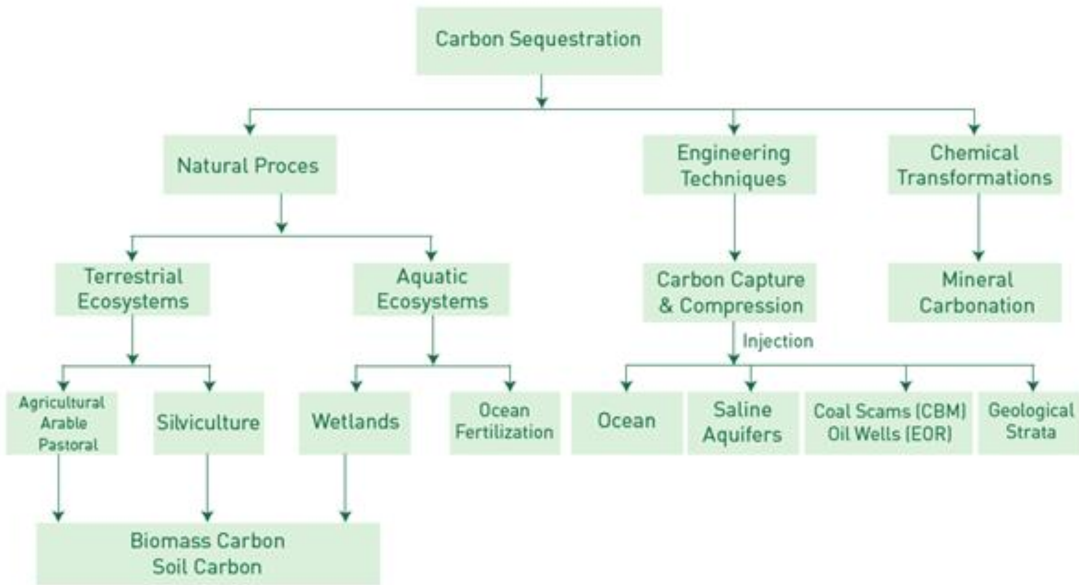

Figure 1. Classification of Carbon Sequestration Strategies (Lal, 2010)

Carbon sequestration is a process whereby CO2 is removed from the atmosphere and stored in the soil carbon pool. The carbon sequestration strategies, as figure 1 shows, are mainly divided into three branches. In this project, we compared the use of natural process and engineering techniques. The later one, engineered CCS, involves the use of technology to collect and concentrate the CO2 produced in industrial and energy-related sources, then transport it to and store at a suitable storage location for a long period of time. In the global context of stabilizing atmospheric CO2 concentration and the continuous dominance of fossil fuels in energy infrastructure, engineered CCS has been recognized as one of the proven mitigation options around the world because of the compatibility of CCS systems with current energy infrastructures (Metz, Davidson, & Coninck, 2005). By 2018, there were 43 large-scale CCS facilities globally with 21 under operation (Global CCS Institute, 2018).

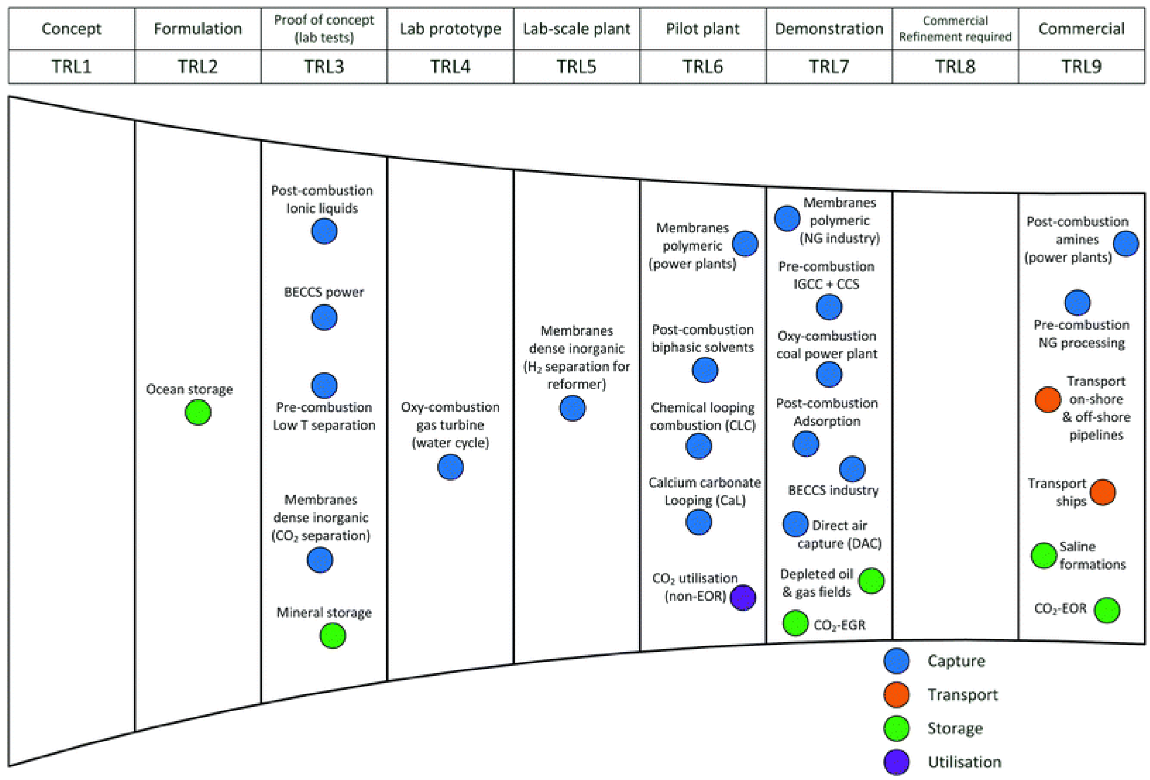

Figure 2. Technology readiness level of carbon capture, storage and utilization technologies (Bui, Adjiman, & Bardow, 2018)

Although the industrialized CCS technologies have advanced at a fast pace in reaction to the urgency of mitigating climate change, its application at college level still faces many technical constraints. The current development progress of the technologies involved in different phases of CCS is unevenly distributed, as Figure 2 illustrates. The discrepancy in their maturity level would increase the rate of failure of the whole system. The key risks of implementing CCS system reside in the transportation and storage phases. Transporting CO2 from industrial site to a proper storage site needs construction of long pipelines. And long-term storage process requires injecting it into a rock formation below the earth’s surface or into the ocean at depths greater than 1,000m followed by physical trapping which might cause leakage and produce environmental hazards (Metz, Davidson, & Coninck, 2005). Additionally, the current CCS system is mostly applied to large point sources of CO_2, like power plants and large industrial processes (Metz, Davidson, & Coninck, 2005) that do not exist at Lafayette College.

The carbon sequestration through natural approach therefore became the focus of our project which uses technologies that could increase the soil carbon storage through natural carbon cycling. The natural process, soil carbon sequestration, is primarily facilitated by photosynthesis of plants through which carbon is sequestered and stored in the form of SOC (Soil Organic Carbon). The current storage of SOC results from interactions among the dynamic ecological processes of photosynthesis, decomposition, and soil respiration (Ontl & Schulte, 2012). Human activities, such as land management and farming, have led to depleted SOC in the past decades. Nevertheless, we can now sequester carbon back into the soil through proper reforestation and farming technologies.

Enhancing soil carbon can yield significant co-benefits, including improved soil health, increased yields and water quality although the effect on carbon storage is limited as soil reaches its carbon saturation point. The Intergovernmental Panel on Climate Change (IPCC) Report on Climate Change and Land has discussed many organic farming techniques that enhances land carbon storage. Some of them are applying agroforestry, using plant varieties with deeper roots, adding organic materials to soil, and changing crop rotations. The potential for these strategies is location-specific, depending on the soil type, prior and current land management practices, environmental conditions and other factors (IPCC, 2019).

Organic farming technologies include non-till agriculture and cover cropping. Tillage is a widely used technique to dig and turn over soil, which release carbon into the atmosphere. Using organic no-till and using annual crops, such as winter rye, foxtail, field peas, and others, can help stabilize the soil and pull in carbon more efficiently (Dr. Nancy Waters). Cover cropping essentially requires for certain crops that can be planted temporarily, especially during the winter time, which helps with storing carbon more efficiently, reduces nitrogen leaching and decreases the possible risk of water erosion (Rodale Institution, 2014).

Agroforestry consists of “traditional and modern land-use systems where trees are managed together with crops and/or animal production systems in agricultural settings” (Buttoud, 2013). And its overall goal is to establish a system “so that the final product is more valuable than in the absence of trees, while the risks of failed harvests and dependence on chemical inputs are reduced” (Buttoud, 2013). The techniques mostly remain the same, but the plant types and the area of land required to implement a successful agroforestry practice may vary. The selection of species plays a major role in this dynamic. Depending on the combinations created, the crops and trees might compete for necessary resources (Buttoud, 2013). And the most frequently used systems of agroforestry include alley cropping, forest farming, windbreaks, riparian forest buffers, silvopasture systems (USDA, 2019).

Some researchers identified A/R (afforestation or reforestation) as the natural solution with the most potential to capture carbon from the atmosphere, potentially sequestering 307 Tg CO2e per year that is equivalent to 21% of current net annual emissions of the United States. (Fargione & Bassett, 2018). Reforestation is converting previously forested land back into forest while afforestation is planting forests on lands where they did not previously grow. Reforestation can have many benefits beyond removing carbon from the atmosphere, such as providing habitat, enhancing soil fertility, controlling floods, and improving air and water quality (IPCC, 2019). Most importantly, it is the most cost-effective carbon sequestration approach. Figure 3 shows various land management options, their potential effect on five ecological and social aspects with low to high confidence level, and their general cost (IPCC, 2019). It indicates that reducing deforestation has relatively high chances in mitigating climate change and moderate implementation cost. Therefore, we decide to investigate how reforestation can help Lafayette College to achieve its carbon neutrality goal.

	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	– L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	←→ L	L	M	M	L	●●
	Reduced soil salinization	—	L	L	L	L	●●
	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
	Reduced landslides and natural hazards	L	L	L	L	L	—
	Reduced pollution including acidification	←→ M	M	L	L	L	—
	Restoration & reduced conversion of coastal wetlands	M	L	M	M	←→ L	—
	Restoration & reduced conversion of peatlands	M	—	na	M	– L	●

Figure 3. Land management options to mitigate climate change (IPCC, 2019)

Reforestation can produce many environmental and social benefits. By increasing base flow during drought and reducing flooding during rainfall events, reforestation reduces the local impact of extreme weather events on society and ecosystems. By stabilizing land against catastrophic movements and reducing run-offs, it could buffer against the negative consequences of climate change on vulnerable groups. By providing habitat to animals and other species, reforestation can enhance livelihood diversification and contribute to global biodiversity conservation. This larger biodiversity can increase the resilience of rural households to climate variations. (Locatelli, Catterall, & Imbach, 2015)

There often exists trade-offs between reforestation for mitigation and biological adaptation. Reforesting with the sole purpose of carbon storage for mitigation or timber production will often lead to negative impacts on biodiversity, water sources and livelihoods. The general guiding principle for reforestation is “climate-smart reforestation”, which is implementing an effective combination of approaches to achieve a balance among societal adaptation, climate mitigation, and ecological resilience. (Locatelli et al., 2015)

The key technical considerations for reforesting at college level are species variety, selection, site-specific conditions and forestry management. Tree mixes can store as much carbon as monocultures, and they are more resilient, have higher rates of water use (Kunert et al. 2012) and provide additional ecosystem benefits (Hulvey et al. 2013). However, tree mixes have a much higher planning and maintenance cost. In terms of species selection, native species are generally better than exotic species for seedling survival. Forestry management include the maintenance of the forest, timber harvesting and risk management of forest fire (USDA, n.d.).

Figure 4. Sketchup Model for Phase One of Reforestation Plan

Our technical plan for reforesting on Lafayette College has two phases that consists of reforesting locations both on and off campus. At Metzgar field, there are a multitude of locations where Lafayette College could reforest. Two alternatives include the oak tree pathway and the department sponsored forest. At the sports complex there is a narrow road with walkways on either side that connects the parking lot to the various fields. This walkway is approximately 300 feet long. Lafayette College potentially could plant 24 total oak trees, 12 on each side of this walkway. Oak trees require a minimum of 25 feet of separation to allow the tree to properly grow. The second alternative is to have each of the schools 15 major departments sponsor and plant a tree each year. Each year each department can pick a native tree and will plant the tree at metzger field. If Lafayette College plants 15 trees each year for 15 years, they will have planted 225 trees by 2035. 225 trees evenly spaced will cover over 3 acres of land.

Planting oak trees are very similar to planting most trees. For this alternative, Lafayette College will purchase young oak trees because they are significantly cheaper and easier to plant than mature oak trees. The process of planting an oak tree is consists of digging a hole, placing the tree in the hole, back filling the hole, and lastly placing a thin layer of mulch around the tree. Each hole should be dug 2-3 times the width of the football, and at a depth so just the trunk flare is above ground. After digging and placing the tree, the original soil will be back filled in. Lastly, a 2-3 inches of mulch should be evenly spread out around the base of the tree. The mulch will help the tree receive the valuable nutrients and water in order to grow. This process will be repeated for all the trees that will be planted. The process of planting an individual tree will be the same for the department sponsored forest.

There are several technical constraints to our reforestation plan. Firstly, the tree species should be native to Easton, Penslyvania as many non-native trees are not be able to grow in the perennial weather and non-native trees may have very bad implications to the native ecosystem. A second constraint is the current spotted lantern fly epidemic. Spotted lanternflies are an invasive species that can kill many of the native trees. The last constraint is the trees that should be planted are required to have a high carbon capture ability.

Economic Context

Benefit-Cost Analysis

The economic factors of this project include Lafayette's current financial standing, the availability of external funding, and the actual cost of the alternatives in question. Before determining the best way to fund the project, we organized which projects are worth the investment. A cost-benefit analysis is one of the standard methods of deciding which option might be ideal. For this analysis, we will consider the do-nothing option, in addition to a general reforestation alternative, and a general organic farming alternative. Aspects that are important to consider are direct costs from implementing and maintaining the choice, as well as the indirect impacts, such as the social cost of carbon. Defining the social cost of carbon is "an estimate, in dollars, of the economic damages that would result from emitting one additional ton of greenhouse gases into the atmosphere" (Rennert and Kingdon, 2019). Comparing both the financial and social costs and benefits permits Lafayette to determine the alternatives that are currently ideal.

In general, there are numerous benefits associated with carbon storage options, any action to combat climate change is a benefit as it acts as additional protection to threats such as extreme weather events or negative health impacts. However, as with any technology, there are risks and other costs involved. For example, when increasing plant life, an area becomes more susceptible to wildfire, pests, and disease (Climate Action

Benefits, 2015). According to the EPA, “The economic value of these changes in carbon storage range from $9 billion in dis-benefits to $120 billion in GHG mitigation benefits (both discounted at 3%)” (Climate Action Benefits, 2015). To conduct a complete cost-benefit analysis for Lafayette College’s alternatives, it will require a more in-depth understanding of the land and how it will be maintained. Due to the variance in numbers associated with carbon capture techniques, we focused our calculations on each option’s effectiveness in capturing carbon.

As stated previously, according to Lafayette College’ s CAP, in 2017, Lafayette College emitted 24,092 MTCO-2e- or 53,113,768 lbs (2019 Climate Action Plan, 2019). Acting under the assumption that there have not been significant fluctuations in this number, it was used as a baseline to compare the storage capabilities of the reforestation alternative and organic farming alternative. Since nothing changes in the do-nothing alternative, we assumed that its net change is equal to zero, neither causing an increase or decrease in the number of emissions stored.

For the organic farming alternative, we considered only the effects of implementing cover crop technology on the three-acre area of LaFarm. According to the IPCC report, cover crops have the capability of increasing “soil carbon stock by between 0.22 and 0.4 t ha-1 yr-1 -” - (IPCC, 2019, 4-60). The calculated average of 0.31tC/ha/yr was the value used. By converting the units of area for LaFarm from acres to hectares (0.4047 ha:1acre), and multiplying it by the carbon stock factor, we found that the annual increase in carbon stock is approximately 0.3764 tC/yr.

We followed a similar process for the reforestation alternative, first converting the units of the total area available for trees (125 acres) into hectares. Based on an article published in *Issues in Environmental Science and Technology*, "Yields of carbon for permanent afforestation are of the order of 1 MgC ha-1yr-1" (Lenton, 2014, 57). Since 1 MgC ha-1yr-1 is equivalent to 1 tC/ha/yr, we multiplied the factor of carbon stored in metric tones by the area available to get an annual storage rate of approximately 50.5875 tC/yr. Just based on these numbers, one would assume that implementing a single alternative is not enough to achieve carbon neutrality at Lafayette College. However, this comparison shows that any option has an impact, and by combining reforestation with other, smaller-impact alternatives, they can play an influential role in reducing the school's emissions.

Modeling Carbon Capture at Metzgar

Lafayette College currently has 69 buildings on campus. In total, these buildings are approximately 1.76 million square feet. The total campus size is 340 acres and includes the roughly 210 acre Metzgar fields. Metzgar field is composed of 125-acre farmland, an 80-acre athletic complex, and 3-acres being LaFarm. Although Metzgar Field accounts for a large portion of the colleges' total acreage, the athletic campus has two buildings that are significantly smaller than most of the buildings on campus. Metzgar athletic field is part of an 80-acre facility that also contains fields for many of the intramural and recreational sports programs. There are two buildings on this property. The main building and central point of the Metzgar Campus are the Kamine Varsity House. This building contains locker rooms for baseball, field hockey, men's lacrosse, women's lacrosse, men's soccer, women's soccer, men's cross country/track & field, women's cross country/track & field and softball. Each locker room is similar and all have flat-panel video monitors as well as internet access. Kamine varsity field house also has locker rooms for visiting teams, officials, and Lafayette's coaching staff as well as an air-conditioned training room with two whirlpools, ultrasound, electrical muscle simulator unit, and many pieces of rehabilitative equipment.

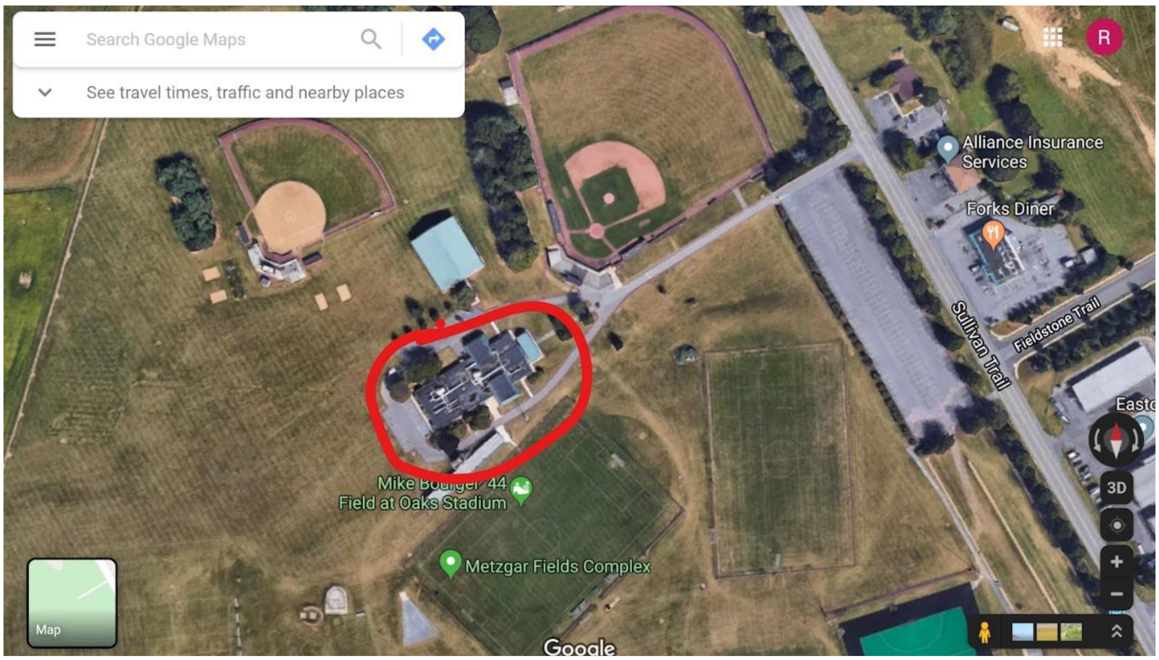

Figure 5. The sports complex at the Metzgar Fields Complex. (The Kamine Varsity House is circled in red)

The carbon capture project will use this building as a micro model for the school. According to the EIA, in 2017, the average annual electricity consumption for a U.S. residential home customer was 10,399 kilowatt-hours (kWh), an average of 867 kWh per month. That means the average household electricity consumption kWh per day is 28.9 kWh (U.S. Energy, 2019, n.p.). In 2018, emissions of carbon dioxide by the U.S. electric power sector were 1,763 million metric tons or about 33% of total U.S. energy-related CO-2 emissions of 5,269 MMmt (U.S. Energy, 2019, n.p.). The average U.S. household produces 7.5 tons of CO-2 equivalents per year. A mature oak tree can absorb as much as 48 pounds of carbon dioxide per year and can sequester 1 ton of carbon dioxide by the time it reaches 40 years old (U.S. Energy, 2019, n.p.). Therefore, it would require 300 mature oaks to cancel the carbon emissions produced from powering the Kamine Varsity house.

This small model can be used by the school to determine how feasible it would be to reforest enough land for Lafayette College to be carbon neutral. It would cost the school $32,000 to plant 320 trees priced at $100 a tree. As explained in the technical analysis, there are two reforestation alternatives. The combination of the 300 department-sponsored trees and the 24 oak trees for the oak tree walkway would plant a total of 324 trees.

The department-sponsored tree project would require each department to plant one tree per semester. Each department will have the option of which tree to plant. On average, native youth trees cost under $100. In total, Lafayette College would have to spend $3,000 annually for this alternative. The oak tree walkway would be a one-time payment to install the trees. Using the same pricing of $100 per tree, this alternative would cost $2,400 to purchase the 24 oak trees.

The combination of both projects would nearly compensate for the carbon produced by the Kamine Varsity field. The two alternatives would cost $32,400 over ten years, roughly $3,240 per year to implement. Planting oak trees alone will not make Metzgar Field carbon neutral by 2035 because oak trees are fully mature in about 40 years. If implemented today, these alternatives will create a foundation that will offset the carbon produced in the Kamine Varsity house by 2065.

Year	Number of Trees Planted	Cost	Potential Co2
1	54	$ 5,400.00	2592 lbs
2	30	$ 3,000.00	1440 lbs
3	30	$ 3,000.00	1440 lbs
4	30	$ 3,000.00	1440 lbs
5	30	$ 3,000.00	1440 lbs
6	30	$ 3,000.00	1440 lbs
7	30	$ 3,000.00	1440 lbs
8	30	$ 3,000.00	1440 lbs
9	30	$ 3,000.00	1440 lbs
10	30	$ 3,000.00	1440 lbs
Total	324 Trees	$32,400.00	15,552 lbs

Figure 6. Cost and potential CO2 in ten years

The price estimate for both alternatives shows the price of purchasing the trees and does not account for the installation labor. Metzgar athletic field has a landscaping company that could plant the oak tree walkway. Students in each major could plant the department-sponsored trees. If students and Metzgar field landscaping companies plant the trees, there would be no labor cost.

Lafayette College campus contains significantly more buildings that are all much larger than the Kamine Varsity house. It would require a much larger reforestation project to cancel out the carbon produced by the college. The college would have to scale the whole project and reforest a much larger plot of land. As mentioned in the cost-benefit analysis, Lafayette College would have to plant 17,289 acres to compensate for the on-campus emissions. Oak trees require a minimum of 25 feet between each rootball to grow to full size. Therefore, spaced 25 feet apart, it would take 64 oak trees to cover 1 acre of land. Sixty-four oak trees multiplied by the total acres are 1,106,537 trees. Priced at $100 a tree, it would cost Lafayette College $110,653,700 to purchase enough trees to reforest 17,289 acres of land.

In conclusion, phase one, Lafayette College will plant 324 trees for $32,400. Along with making Kamine Varsity House carbon neutral, this phase will serve as a micro model for the school to follow. Phase 2 will reforest the remaining 120 acres of land. Following the same pricing of $100 per tree and 64 trees per acre, this phase will cost $768,000. Phase one and phase two together will plant over 8,000 trees and cost over $800,000. In total, this number of oak trees will store 384,000 lbs of carbon each year, which amounts to roughly 1% of the college's total carbon emissions.

Existing financial circumstances

Different financial circumstances must be taken into consideration when implementing sustainable projects, such as carbon capture and storage at Lafayette College. The Climate Action Plan 2.0 mentions "making an initial investment in tools and resources with quick payback periods… [through the] establishment of a green revolving fund that will allow us to undertake higher cost capital projects that will be crucial to achieving our goal of carbon neutrality." The Green Revolving Fund is a fund that Lafayette College needs to work towards implementing because it will help with establishing a set fund that can make not only the carbon capture storage project a possibility, but as well as other sustainable focused projects. Moreover, the college has previously received funding from the Clinton Foundation and the Mellon Foundation. Because the established relationship and knowledge happened before the CAP and CCS, it will be easier for the college to petition for funds to support such technologies. The costs required for either organic farming or the micro model reforestation should not be more than approximately $50,000. When comparing this amount with other expenses that Lafayette has, it would be a significant investment and not as an expensive option towards moving forwards with carbon capture and storage technologies. Some of the benefits of implementing CCS will include less energy usage required, fewer carbon emissions, and higher profits for farmers when applying organic farming (Rodale Institution, 2019). To be successful, Lafayette College must ensure there is a strong foundation in which students, professors, and others can rely on a fund that will help towards implementing sustainable projects and help reach carbon neutrality by the year 2035.

External funding from government and NGOs

The external funding for our project could consist of government grants from federal to state and funding from environmental organizations. The Pennsylvania Farm Bill passed in 2019 has four relevant funding projects that could apply to our case. The first one is Realty Transfer Tax Exemption, a grant for any transfer of preserved farmland to a qualified beginning farmer. As discussed in the political context, leasing the land to a farmer could be a win-win choice. By selecting a qualifies beginning farmer, we might be eligible for this fund as well. The second one, Conservation Excellence Grant Program, funded at $2.5 million, is to provide financial and technical assistance to farmers to install and implement best management practices. This assistance could aid with either organic farming or agroforestry alternatives. The third one is Pennsylvania Rapid Response Disaster Readiness Account, funded at $5 million, to allow for a quick response to agricultural disasters, including actions to contain an outbreak or threat, such as Spotted Lanternfly. The selection of oak tree species as a reaction to Spotted Lanternfly in our alternative provides the opportunity to apply for this fund. The fourth one, P.A. Preferred Organic Initiative, funded at $1.6 million, is to make Pennsylvania the nation's leading organic state by further enhancing the growth of the organic industry and closely aligns with the development goal of LaFarm. Before this new bill, there exists an Environmental Quality Incentives Program funded by USDA that enables eligible farmers and landowners to receive financial and technical assistance to install conservation practices needed to protect natural resources as part of their certified organic or transitioning to an organic operation.

Other than U.S. government funding, the global carbon market mediated by NGOs could provide carbon credits to fund this project. Indigo Carbon, a startup in Boston, gives growers who joined in the 2019 crop season $15 per metric ton of carbon dioxide sequestered. The VCS Program, the world's most widely used voluntary GHG program, has a sophisticated system of rules and requirements for projects to follow to be certified. After certification, it issues project developers available GHG credits called Verified Carbon Units (VCUs). The VCUs can be sold on the open market and retired by individuals and companies to offset their carbon emissions (Verra, 2019). One project certified by this standard is the Bethlehem Authority Improved Forest Management

Project Area, a 17,591-acre split-parcel situated in Monroe County and Carbon County, Pennsylvania. It received 7082 VCUs, which is approximately a quarter-million dollars' market value.

Conclusion

Achieving carbon neutrality at the Metzgar Fields Athletic Complex is a key step to achieving net zero emissions at Lafayette College by the year 2035. The college expects to achieve carbon neutrality by "installing a solar array sized to match the annual electricity consumption at Metzgar Fields and planning and maintaining a forest on a portion of the surrounding farmland to offset emissions from on-site heating loads" (2019 Climate Action Plan, 2019, p.4). While the process will not be easy, and will take significant planning and adjusting, it is within Lafayette's capabilities to accomplish this micromodel at Metzgar Field by the year 2025 .

As a group, we have spent the past semester discussing and analyzing the possibility of achieving carbon neutrality at the Metzgar Complex through carbon capture methods. Located north of Lafayette, the entire complex contains nearly 208 acres. The college-owned plot of land is home to the three-acre space of farmland known as LaFarm and the 80-acre sports field. The sports field also contains two buildings, the Kamine Varsity House and the Morel Field House, which are responsible for consuming the majority of the energy used at Metzgar Fields. The remaining 125 acres can be found further back behind the smaller plots of land and are currently not in use by the college. We concluded that each of these three divisions of land has the capability of supporting carbon capture technologies, and when used in combination with the others, can significantly reduce the amount of carbon dioxide emitted by the complex.

As mentioned in the Technological Context, one of the most common CCS methods is farming. When done properly, agricultural practices can enhance soil capabilities and help with plant growth to make a plot of land more effective at pulling CO_2 from the atmosphere. Currently, LaFarm uses a wide variety of known healthy practices including crop rotations, reduced tillage agriculture, cover cropping, and composting which have allowed the farm to make progress in reducing the school's environmental impact. Unfortunately, due to its size, LaFarm will likely contribute minimally to the overall effort to achieve carbon neutrality. If the school wants to attempt to further increase LaFarm's carbon capture abilities, it can look into applying other techniques including agroforestry and regenerative farming. Agroforestry is the process of mixing trees and crops to achieve farming benefits while regenerative farming is a conservation and rehabilitation approach to a farming system. By choosing plants that vary in terms of size and growth rate, the carbon capture process becomes more efficient and we can benefit in both the short and long term. Recognizing the timeline Lafayette College is working with, it is important to consider how we can capture carbon most effectively. Yet even if the school were to focus more on agricultural practices, it would still need to turn to growing a forest in order to make a significant enough impact.

In general, trees have a high capacity to store carbon and when they are grown together and cover a large span of land, they act as a carbon sink. Due to their capabilities, developing a forested area on Lafayette property would help minimize Lafayette College's carbon footprint. Through our research, we found that in order to adequately reforest a portion of the unused acreage, the college would need to consider several factors that determine which trees to plant. In implementing the option of reforestation, Lafayette College needs to also consider the type of land, soil, and surrounding vegetation, as well as other environmental factors, to ensure the successful growth of any plants or trees chosen. Since there have previously been a forest on the Metzgar Fields, trees will make the most viable option. We recommend the use of oak trees as the best option for Lafayette College. Although oak trees are slow growing, by the time they are fully grown they can store on average 48 pounds of carbon each year. They are also native to Pennsylvania which will allow them to properly grow without having negative implications on the ecosystem. We also learned that oak trees would be particularly beneficial to Easton because they are not eaten by the spotted lanternfly. These insects are an invasive species that has caused chaos on Easton’s ecosystem over the past year, including many native insect and tree species. Our hope is that by planting an increased number of oak trees, Lafayette College will be able to reduce the impact of the infestation while continuing to focus its efforts on decreasing carbon dioxide in the atmosphere.

In order to apply these two CCS methods, we have recommended a two-phase plan for Lafayette College to follow at the Metzgar Complex. Once completed, our hope is that the complex can be used as a micromodel for the on-campus carbon problem and can be used as a reference as Lafayette moves forward, but also for other institutions looking to follow a similar path.

The first phase is broken up into two parts, the Oak Tree Walkway and the Department Sponsored Forest. The walkway will be lined by 24 oak trees, enhancing the entrance into Oaks Stadium and will demonstrate to visitors that Lafayette is in the process of implementing projects to become more environmentally-friendly. The second part serves a similar function and requires the school to reforest a small subsection of the unused land at Metzgar. This alternative is expected to span 10 years and will allow for all 15 educational departments to engage in this sustainable solution. Each semester, all 15 departments will choose and plant a native tree, and by the time 10 years have passed there will be a total of 300 native trees covering 4.6 acres of land. By the end of the first phase, we estimate that 324 trees will have been planted and should account for carbon emitted when powering the Kamine Varsity House. For our project, we made the assumption that operating the building is powered by electricity that causes roughly 7.5 tons of carbon each year.

The changes made during the first phase would complete the proposed micromodel, but in order to become carbon neutral by 2035 a much larger reforestation project will have to be implemented. The second phase we propose is the continued reforestation of unused farmland at Metzgar once any additional technologies, such as solar panels, have been established. By continuing to grow and diversify the plant life in the area, the land's ability to capture and store carbon will become both stronger and more efficient. However, further research should be done as to which types of species would be ideal for the existing conditions, as well as what to do as time progresses and the trees age past their peak efficiency.

Carbon capture and storage is one of many technologies available that can help Lafayette reduce its impact on the environment. Through the implementation of the Climate Action Plan 2.0, Lafayette will not only become more sustainable but it will also become an influential example that can motivate schools, communities, and other organizations to implement their own sustainable solutions and work towards carbon neutrality. With the ever worsening state of the planet, changes need to be made efficiently and effectively. Climate change is a serious issue and will continue to worsen if communities continue to rely on unsustainable methods. There are many ways in which countries, industries, communities, and even individuals can get involved in developing sustainable solutions, but only by working with and listening to each other will progress be possible.

Bibliography

2009 Campus Master Plan. (2009). Lafayette College. Retrieved from https://ldr.lafayette.edu/bitstream/handle/10385/1619/lc-facility-planning-and-construction-master-plan-executive-summary-2009.pdf?sequence=1

2018 Pennsylvania Greenhouse Gas Inventory. (2019, March). Department of Environmental Protection. Retrieved from http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/2019/4-23-19/Inventory%20-%202018.pdf

2019 Climate Action Plan. (2019). Lafayette College. Retrieved from https://sustainability.lafayette.edu/wp-content/uploads/sites/19/2019/04/Climate-Action-Plan-2.0.pdf

(2019). Retrieved from Rodale Institute website: https://rodaleinstitute.org/why-organic/issues-and-priorities/carbon-sequestration/

About DEP. (2019a). Retrieved from https://www.dep.pa.gov/About/Pages/default.aspx

About DEP. (2019b). Retrieved from https://www.dep.pa.gov/About/Pages/default.aspx

About EPA. (2018, February 7). Retrieved from https://www.epa.gov/aboutepa/our-mission-and-what-we-do

About the IPCC. (2019). Retrieved from https://www.ipcc.ch/about/

About PASA. (2019). Retrieved from https://pasafarming.org/about-us/

Addressing Climate Change on Public Lands. (2019). Retrieved from https://www.dcnr.pa.gov/conservation/climatechange/pages/default.aspx

Agriculture. (2019). Retrieved from https://wp.stolaf.edu/naturallands/agriculture/

Assessment of Risk, Legal Issues, and Insurance for Geologic Carbon Sequestration in Pennsylvania. (2009, November). Pennsylvania Department of Conservation and Natural Resources. Retrieved from http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_20033316.pdf

Baker, N. (2014). Aboveground carbon sequestration in Norway Valley. St. Olaf College. Retrieved from https://wp.stolaf.edu/naturallands/files/2016/09/Baker_merged_FOREST.pdf

Bui, M., Adjiman, C., & Bardow, A. (2018). Carbon Capture and Storage: The Way Forward. Royal Society of Chemistry. Retrieved from https://pubs.rsc.org/en/content/articlehtml/2018/ee/c7ee02342a

Buttoud, G. (2013). Advancing Agroforestry on the Policy Agenda: A guide for decision-makers (p. 3). Retrieved from FAO website: http://www.fao.org/3/i3182e/i3182e00.pdf

Board of Trustees. (2019). Retrieved from https://trustee.lafayette.edu/

Organization of the United Nations. Retrieved from http://www.fao.org/3/i3182e/i3182e00.pdf

Carbon capture, utilisation and storage. (2019). Retrieved from https://www.iea.org/topics/carbon-capture-and-storage/

Carbon Dioxide Capture and Sequestration: Overview. (2017, January 6). Retrieved from https://archive.epa.gov/epa/climatechange/carbon-dioxide-capture-and-sequestration-overview.html

Carbon Management Fund Tree Planting Purchases and Labor Cost. (n.d.). Retrieved from http://ocsites.oberlin.edu/edgefund/projects/funded-projects/carbon-management-fund-tree-planting-purchases-and-labor-costs

Carbon Neutrality. (2019). Retrieved from https://www.oberlin.edu/environmental-sustainability/carbon-neutrality

Champaign County Forest Preserve District. (n.d.). Retrieved from https://www.ccfpd.org/.

Climate Action Benefits: Carbon Storage. (2015, June 22). Retrieved from https://www.epa.gov/cira/climate-action-benefits-carbon-storage

Climate Action Implementation Plan. (2008, August 28). Middlebury College. Retrieved from http://www.middlebury.edu/media/view/243071/original/Middlebury_CAP.pdf

Climate Action Plan Acceleration Working Group. (2014, June 27). Cornell Leadership for Climate Neutrality: Strategies & 12-Month Milestones to Accelerate the Climate Action Plan. Retrieved from https://sustainablecampus.cornell.edu/sites/default/files/2019-01/2015_01_24PublicClimateActionAccelerationReport.pdf

Climate Change in PA. Retrieved from http://www.depgis.state.pa.us/ClimateChange/index.html

Commitments and Policies. (2019). Retrieved from https://sustainability.lafayette.edu/guides-policies/

Dautremont-Smith, J. (2009). Implementation Guide. American College and University President's Climate Commitment. Retrieved from https://www.seattleu.edu/media/cejs/files/campus-sustainability/ACUPCC_Implementation-Guide.pdf

Denchak, M. (2018, December 12). Paris Climate Agreement: Everything You Need to Know. Retrieved from https://www.nrdc.org/stories/paris-climate-agreement-everything-you-need-know

EcoReps. (n.d.). Retrieved from https://sustainability.lafayette.edu/aboutus/ecoreps/

Elbein, S. (2019, April 26). How to regrow a forest: Get out of the way. Retrieved November 13, 2019, from National Geographic website: https://www.nationalgeographic.com/environment/2019/04/how-to-regrow-forest-right-way-minimize-fire-water-use/

Energy Policy. (2019). Retrieved from https://facilitiesops.lafayette.edu/policies-and-procedures/energy-policy/

Fast, S. (2012, November 30). Trees Planted in Carbon Offsetting Initiative. Retrieved from https://oberlinreview.org/2682/news/trees-planted-in-carbon-offsetting-initiative/

Fargione, J., & Bassett, S. (2018). Natural Climate Solutions for the United States. Science Advances. https://doi.org/10.1126/sciadv.aat1869

Forests and climate change. (2019). Retrieved from https://www.iucn.org/resources/issues-briefs/forests-and-climate-change

FIWG. (2017). Best Management Practices for Pennsylvania Forests. Retrieved from https://extension.psu.edu/best-management-practices-for-pennsylvania-forests

Garrett, H. E. G., & Buck, L. (1997). Agroforestry Practice and Policy in the United States of America. *Forest Ecology and Management*, *91*, 5–15.

Galarraga, I., Gonzalez ‐ Eguino, M., & Markandya, A. (2011). The Role of Regional Governments in Climate Change Policy. Environmental Policy and Governance, 21(3), 164–182. https://doi.org/10.1002/eet.572

Gibbens, S. (2019, February 1). 15 ways the Trump administration has changed environmental policies. Retrieved from https://www.nationalgeographic.com/environment/2019/02/15-ways-trump-administration-impacted-environment/

Good Agricultural Practices (GAP) & Good Handling Practices (GHP). (n.d.). Retrieved from https://www.ams.usda.gov/services/auditing/gap-ghp

Government Partnerships to Reduce Air Pollution. (2017, January 10). Retrieved from https://www.epa.gov/clean-air-act-overview/government-partnerships-reduce-air-pollution

Greenhouse Gases Equivalencies Calculator - Calculations and References. (2018, December 18). Retrieved from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Horowitz, F. (2015, June 30). Greetings from LaFFCo. Retrieved from https://sites.lafayette.edu/lafarmblog/2015/06/30/greetings-from-laffco/

How We Did it: How Middlebury Achieved Carbon Neutrality in 2016. (n.d.). Retrieved from http://www.middlebury.edu/sustainability/our-commitment/carbon-neutrality/how-did-we-do-it-

Human influence on climate clear, IPCC report says. (2013, September 27). Retrieved from IPCC website: https://www.ipcc.ch/2013/09/27/human-influence-on-climate-clear-ipcc-report-says/

Jenkins, M. (2018, September 1). Carbon Capture. Retrieved from https://www.nature.org/en-us/magazine/magazine-articles/carbon-capture/

IPCC, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

IPCC. (2019). *Climate Change and Land* (Special Report) (pp. 1–1542). Retrieved from https://www.ipcc.ch/site/assets/uploads/2019/08/Fullreport-1.pdf

Lafayette College. (n.d.). Retrieved from Good Agricultural Practices (GAP) & Good Handling Practices (GHP). (n.d.). Retrieved from https://www.ams.usda.gov/services/auditing/gap-ghp

LEAP. (2019). LEAP. Retrieved from https://sites.lafayette.edu/leap/

Lenton, T. M. (2014). The Global Potential for Carbon Dioxide Removal. Issues in Environmental Science and Technology, 38, 52–79. https://doi.org/10.1039/9781782621225-00052

Locatelli, B., Catterall, C., Imback, P., Kumar, C., Lasco, R., Marin-Spiotta, E., … Uriate, M. (2015). Tropical reforestation and climate change: beyond carbon. Restoration Ecology, 23(4). https://doi.org/10.1111/rec.12209

Main Challenges of Agroforestry. (2015, July 24). Retrieved from http://www.fao.org/forestry/agroforestry/90001/en/

Markusson, N., Kern, F., Watson, J., Arapostathis, S., Chalmers, H., Ghaleigh, N., … Russell, S. (2012). A socio-technical framework for assessing the viability of carbon capture and storage technology. Technological Forecasting and Social Change, 79(5), 903–918. https://doi.org/10.1016/j.techfore.2011.12.00leap

Marland, G., McCarl, B. A., & Schneider, U. (2001). SOIL CARBON:POLICY AND ECONOMICS. *Climatic Change*, *51*, 101–117. Retrieved from https://link.springer.com/content/pdf/10.1023%2FA%3A1017575018866.pdf

Metz, B., Davidson, O., de Coninck, H., Loos, M., & Meyer, L. (2005). IPCC Special Report on Carbon Dioxide Capture and Storage. Intergovernmental Panel on Climate Change. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf

Metzgar Fields Athletic Complex. (2018). Retrieved from http://www.goleopards.com/sports/2018/7/26/_facilities_metzgar_fields_html.aspx

MIT Sustainability. (2019). Retrieved from MIT, Office of Sustainability website: http://sustainability.mit.edu/about

Morse, I. (2016, September 30). Lafayette’s first sustainability director announced. The Lafayette. Retrieved from https://www.lafayettestudentnews.com/blog/2016/09/30/lafayettes-first-sustainability-director-announced/

National Organic Program. Retrieved from https://www.ams.usda.gov/about-ams/programs-offices/national-organic-program

Natural Lands. (2019). Retrieved from https://wp.stolaf.edu/naturallands/

Neitz, K. (2019, Summer). A Greener Lafayette: Climate Action Plan steers College toward carbon neutrality by 2035. Lafayette College Magazine. Retrieved from https://magazine.lafayette.edu/summer2019/2019/07/22/a-greener-lafayette/

NOAA. (2019, April 4). What is the carbon cycle? Retrieved from https://oceanservice.noaa.gov/facts/carbon-cycle.html

Nooralvandi, T. (2016, February 24). Organic Farming Techniques. Retrieved from LinkedIn website: https://www.linkedin.com/pulse/organic-farming-techniques-dr-tohid-nooralvandi/

Oberlin College. (2019). Retrieved from https://www.usnews.com/best-colleges/oberlin-college-3086

Office of Sustainability. (2018). Annual Report. Lafayette College. Retrieved from https://sustainability.lafayette.edu/wp-content/uploads/sites/19/2019/01/Sustainability_AnnualReport2018_WEB.pdf

Only 11 Years Left to Prevent Irreversible Damage from Climate Change, Speakers Warn during General Assembly High-Level Meeting. (2019, March 28). Retrieved from https://www.un.org/press/en/2019/ga12131.doc.htm

Ontl, T., & Schulte, L. (2012). Soil Carbon Storage. *Nature Education Knowledge*. Retrieved from https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/

Organic Regulations. Retrieved from https://www.ams.usda.gov/rules-regulations/organic

Our Mission and What We Do. (2018, February 7). Retrieved from https://www.epa.gov/aboutepa/our-mission-and-what-we-do

Our Nation's Air. (2019). Retrieved from https://gispub.epa.gov/air/trendsreport/2019/#home

Overview of Greenhouse Gases. (2019, April 11). Retrieved from https://www.epa.gov/ghgemissions/overview-greenhouse-gases#carbon-dioxide

Overview of the Clean Air Act and Air Pollution. (2019, September 16). Retrieved from https://www.epa.gov/clean-air-act-overview

PASA. (2019, February). PASA Sustainable Agriculture 2018 Annual Report. Retrieved from https://pasafarming.org/wp-content/uploads/2019/02/PASA_AR18-copy-1.pdf

Paul Hardisty, Sivapalan, M., & Brooks, P. (2011, May 9). The Environmental and Economic Sustainability of Carbon Capture and Storage. Retrieved from International Journal of Environmental Research and Public Health website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3108120/

Pennsylvania Climate Action Plan 2018: Strategies and actions to reduce and adapt to climate change. (2019, April 29). Pennsylvania Department of Environmental Protection. Retrieved from http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=1454161&DocName=

2018%20PA%20CLIMATE%20ACTION%20PLAN.PDF%20%20%20%3cspan%20style%3D%22color:blue%3b%22%3e%28NEW%29%3c/span%3e

Progress Cleaning the Air and Improving People's Health. (2019, August 14). Retrieved from https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health

REDD+ Reducing Emissions from Deforestation and Forest Degradation. (2019). Retrieved from http://www.fao.org/redd/overview/en/

Reforestation Overview. Retrieved from https://www.fs.fed.us/restoration/reforestation/overview.shtml

Regenerative Organic Agriculture and Climate Change. (2014). Retrieved from https://mk0rodaleinstitydwux.kinstacdn.com/wp-content/uploads/Regenerative-Organic-Agriculture-White-Paper.pdf

Rennert, K., & Kingdon, C. (2019, August 1). Social Cost of Carbon. Retrieved from https://www.rff.org/publications/explainers/social-cost-carbon-101/

Restored Woodlands. (2019). Retrieved from https://wp.stolaf.edu/naturallands/woodlands/restoration/

Riebeek, H. (2011, June 16). The Carbon Cycle. Retrieved from NASA: Earth Observatory website: https://earthobservatory.nasa.gov/features/CarbonCycle/page1.php

S.E.E.S. (2019). ABOUT SEES. Retrieved from Lafayette College Society of Environmental Engineers and Scientists website: https://sites.lafayette.edu/sees/about-sees-2/

Shortle, J. (2015, May). Pennsylvania Climate Impacts Assessment Update. Environment & Natural Resources Institute. Retrieved from http://www.depgreenport.state.pa.us/elibrary/GetDocument?docId=5002&DocName=2015%20PENNSYLVANIA%20CLIMATE%20IMPACTS%20ASSESSMENT%20UPDATE.PDF%20

Siddons, S. (n.d.). How Environmental Organizations Work. Retrieved from https://money.howstuffworks.com/economics/volunteer/organizations/environmental-organizations.htm

Sirianni, P., & O’hara, M. (2014). Do Actions Speak as Loud as Words? Commitments to “Going Green” On Campus. *Contemporary Economic Policy*, *32*(2), 503–519. https://doi.org/10.1111/coep.12047

Sources of Greenhouse Gas Emissions. (2019, September 13). Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

St. Olaf College. (2019). Retrieved from https://www.usnews.com/best-colleges/st-olaf-college-2382

Statutes and Regulations. (2019). Retrieved from https://www.dep.pa.gov/Business/Land/Waste/Pages/Statutes.aspx

Sustainability Committee. (2019). Retrieved from https://sustainability.lafayette.edu/aboutus/sustainability-committee/

Sustainability Map. (2019). Retrieved from https://www.oberlin.edu/environmental-sustainability/programs/map

Sustainability Principles. (2019). Retrieved from St. Olaf College website: https://wp.stolaf.edu/facilities/sustainability-principles/

The Clean Air Act: Solving Air Pollution Problems with Science and Technology. (2018, March 22). Retrieved from https://www.epa.gov/clean-air-act-overview/clean-air-act-solving-air-pollution-problems-science-and-technology

The Core Writing Team, Pachauri, R. K., & Meyer, L. (2015). Climate Change 2014 Synthesis Report. Intergovernmental Panel on Climate Change. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf

Thompson, A. (2012, December 21). What is a Carbon Sink? Retrieved from https://www.livescience.com/32354-what-is-a-carbon-sink.html

USDA. (2019). Agroforestry Strategic Framework. Retrieved from https://www.usda.gov/sites/default/files/documents/usda-agroforestry-strategic-framework.pdf

USDA. (n.d.). Reforestation. Retrieved from https://www.nrs.fs.fed.us/fmg/nfmg/docs/mn/Reforestation.pdf

U.S. Energy Information Administration - EIA - Independent Statistics and Analysis. (n.d.).
Retrieved from https://www.eia.gov/tools/faqs/faq.php?id=97&t=3.

Verra. (2019). Verified Carbon Standard-Overview. Retrieved from Verra website: https://verra.org/project/vcs-program/

Waters, N. (2019, November 5). *Reforestation Options*.

We Are Still In. (n.d.). Retrieved from https://www.wearestillin.com/

Wesseler, S. (2019, April 5). Reforestation is critical to meeting Paris climate change accord targets, researchers say. Retrieved from https://www.yaleclimateconnections.org/2019/04/reforestation-is-seen-key-to-climate-progress/

Welcome. (2019). Retrieved from https://nurturenaturecenter.org/

What is CCS? (n.d.). Retrieved from http://www.ccsassociation.org/what-is-ccs/

What We Do: Our Priorities. (2019). Retrieved from https://www.nature.org/en-us/what-we-do/our-priorities/

Who We are: How We Work. (2019). Retrieved from https://www.nature.org/en-us/about-us/who-we-are/how-we-work/