The feasibility of a local reforestation project at Colgate University

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Glossary

**Additionality:** The project’s ability to reduce carbon emissions in ways that would have not occurred in the absence of the project

**Allometry:** The measure and study of relative growth of a part in relation to an entire organism or to a standard

**Browsing:** Destruction to trees and vegetation due to animal activity

**CDM:** Clean Development Mechanism: provision of the Kyoto Protocol that allows nations that exceed their carbon limits to invest in and implement sequestration projects in developing nations

**Leakage:** The unintended changes to carbon stocks in a reforestation project

**Photosynthesis:** Trees convert carbon dioxide and water into sugar molecules and oxygen through a series of oxidation and reduction reactions

**Sequestration:** The process through which carbon is stored in biomass from the atmosphere
Executive Summary

This report examines the feasibility of a local reforestation project at Colgate University as a way to reduce the university’s carbon footprint. Our guiding research question is: how can Colgate University implement a successful and legitimate reforestation project in the spring of 2012? This project is part of Colgate’s sustainability goals (as outlined in the Climate Action Plan), but it also reflects our class’s definition of sustainability: maximizing our living, working, and academic standards while minimizing our negative ecological, economic, and social affects.

We chose to outline the plan for a reforestation project because Colgate University emitted 14,451 metric tons of carbon dioxide into the atmosphere in 2010, but has pledged to achieve carbon neutrality by 2019 as part of its Climate Action Plan. In order to reach carbon neutrality by 2019, we need to sequester a portion of our carbon emissions through a carbon-offset project. We recommend that Colgate University should implement a local reforestation plan on the university’s land during the spring of 2012. This project will be a pilot project, and the ultimate goal is the continued implementations of subsequent reforestation projects, which will help us reach carbon neutrality by 2019. Not only would reforestation improve the value of Colgate’s land and increase awareness about sustainability, but it would also be a legitimate way to offset our carbon emissions and reduce our carbon footprint.

In order to create a successful plan, we extensively researched reforestation protocols, carbon sequestration, land use, tree species, and other reforestation projects in higher education. We interviewed John Pumilio (Director of sustainability) to learn more about the Climate Action Plan, Michael Jasper (the Associate Director of Facilities and Manager of Lands and Grounds) to learn about possible Colgate lands that we could use, and Dr. Steven Bick (Colgate’s certified forester) to learn more about which tree species would be best for our project. The information we gained from interviews, along with our background research and literature reviews, enabled us to develop an implementable reforestation strategy geared specifically towards Colgate University.

We found that there was no set standard for such a small reforestation project. Because of this, we took the most crucial information from protocols of private reforestation companies and the protocol from the state of California, and used these to create a new protocol for smaller reforestation projects. After investigating land use and speaking with Michael Jasper, we decided to reforest a one-acre area of land above the old ski hill off Gorton Road. After the land plot was chosen, we determined that the ideal tree species for the area is Black Locust. Lastly, logistics regarding the tree-planting event were considered, which includes how many trees we will plant, who will plant them, how they will be planted, and how long it will take.

For the spring 2012 reforestation project above the ski hill we recommend the following on a one-acre area of land above the old ski hill:

- Planting approximately two hundred and fifty black locust saplings using faculty and student volunteers
- At the end of the pilot project, observing the survival rate and any improvements that can be made for future projects
- Use this project as a guide for the reforestation of future land
Introduction

Our project intends to answer the question: how can Colgate University implement a successful and legitimate reforestation project for the spring of 2012? This research is necessary because Colgate intends to maintain its position as a University that is committed to sustainability and responsible environmental behavior. In addition, Colgate University is devoted to leading the way among higher education, and has pledged to reach carbon neutrality by 2019. Colgate University emitted 14,451 metric tons of carbon dioxide into the atmosphere in 2010 (Climate Action Plan, 2011). Although the university’s greenhouse gas emissions have been reduced greatly from previous years, this is still a considerable amount of carbon dioxide that is contributing to the global problem of climate change (2011).

However, it is unrealistic to think that Colgate University will be able to completely eliminate all of their carbon emissions while upholding the school’s high academic and living standards. As a result, Colgate must sequester, or offset, a fair amount of their emissions elsewhere (2011). Reforestation is one of the most common and practical ways to sequester greenhouse gas emissions, and thus offset an institution’s carbon footprint (Keles, 2006). In recent years, especially after the Kyoto Protocol, reforestation has become one of the most popular method for sequestering carbon from the atmosphere. Therefore, there is plenty of relevant information available to help Colgate create and implement a reforestation project of its own.

Literature Review

The ecological benefits of forests and reforestation

Deforestation, or the removal of most of the trees of a forested area, is one of the most environmentally depreating anthropological activities (Lambin, 2001). Deforestation is often spurred by economic opportunities, many of which are short-term exploitations. Generally, human causes of deforestation are split into three broad categories. First, significant forest cover is eliminated each year due to extractive industries, most notably clear-cutting for lumber production (2001). Second, deforestation is also often the result of land-use changes, where forests are often slashed and burned to make way for other uses of the cleared land. Plantations, heavily industrialized agriculture, and the creation of rangelands or pastureland for grazing livestock such as cattle are three of the most common uses of cleared land (2001). Thirdly, urbanization can also be a cause for deforestation, although it usually has a much smaller impact (2001). Globally, forests are reduced by an estimated 7.3 million hectares each year, an area approximately the size of Panama (Swanson, 2006).

Although most deforestation occurs in countries with higher poverty rates and rapidly expanding populations, the amount of land-use change in the Untied States since European settlement is still drastic (Lambin, 2001). Since the 17th century, the United States has lost twenty eight percent of their forested land (Hayward, 2011). Although the country has recently seen a small rise in the amount of forested land, only thirty-three
percent of the country’s land, or approximately 304,022,000 hectares, is currently forested (FAO Forestry, 2010).

As a reaction to widespread deforestation, many institutions are reforesting lands that have been cleared. The formal definition of reforestation is “planting trees, or other activities, to establish tree stands (such as assisting natural regeneration or preparing sites and sowing tree seeds) on areas recently cleared of forests through timber harvesting or natural disaster” (Gorte, 2009).

It is important to distinguish that there is also another method of carbon sequestration, afforestation that also involves establishing trees on an empty area of land. Whereas reforestation is the practice of planting trees on deforested land, where trees once grew, afforestation is the concept of foresting an area of land that has never been forested before (Stavins, 2005). However, this paper will focus only on reforestation, as it is more applicable to Colgate University’s land.

Although forests offer many other ecological and social benefits, land is primarily reforested to sequester carbon dioxide. Carbon dioxide, a greenhouse gas, is released globally at an unnaturally high rate because of anthropogenic activity, primarily from deforestation and the burning of fossil fuels (Malhi, 2002). Atmospheric concentrations of carbon dioxide were about 35% higher in 2005 than concentrations were before the Industrial Revolution (EPA, 2011).

The high presence of carbon dioxide traps heat in the atmosphere, thus leading to an increase in the overall global temperature, which is known as climate change (Malhi, 2002). As a result of climate change, the globe’s ice caps are melting; tropical storms are increasing in quantity and severity; weather patterns are changing, causing unprecedented amounts of droughts and floods; ecosystem habitats are changing, endangering much of the globe’s wildlife; and many other ecological devastations are occurring (2002).

Carbon dioxide exists both in the atmosphere and in “sinks,” areas such as the ocean, soil, and vegetation, which store carbon dioxide (2002). When carbon is sequestered in sinks it is absorbed out of the atmosphere, thus reducing the overall amount of greenhouse gases that contribute to global warming.

Terrestrial ecosystems, including forests, are some of the most important carbon sinks, as they store large amounts of carbon in plant biomass (Canadell, 2008). Globally, terrestrial ecosystem growth removes three billion tons of carbon dioxide from the atmosphere every year, absorbing approximately thirty percent of annual fossil fuel and deforestation emissions (2008).

Forests are the most important terrestrial ecosystem in terms of carbon sequestration. Currently, forests cover about one-third of the Earth’s land surface. During the process of photosynthesis, trees convert carbon dioxide into carbon that is stored in the plant biomass (Nowak, 2002). The greenhouse gas is stored not only within the trees, but also a forest’s understory vegetation, litter, and soil (Malhi, 2002).

Overall, forests in the United States are currently storing about 747 million tons of carbon dioxide (2002). Forests in the United States play a huge role in carbon sequestration compared to other ecosystems, as they account for approximately ninety percent of all terrestrial carbon sequestration (2002).

Many environmentalists agree that reforestation can play a crucial role in balancing our global gas emissions (Keles, 2006). Because carbon dioxide emissions cannot be realistically reduced to zero in the near future, carbon dioxide needs to be
offset elsewhere in order for institutions or other entities to reach carbon neutrality. Although reforestation does carry significant economic costs, implementing these projects results in significant environmental gains (Stavins, 2005).

However, there are many other benefits of reforestation outside or carbon sequestration. Forests are critical to the environment for a variety or reasons, including the creation of biodiversity. Planting trees develops a complex ecosystem that creates underlying vegetation and habitats for wildlife (EPA, 2011). Trees also have many benefits associated with water management. As the trees stabilize the soil and absorb much of the falling precipitation, water can be stored within the soil and trees and reduces the amount of water that runs off the land, minimizing flooding risks (Konijnendijk, 2005). This also means that the water is slowly able to filter through the soil until it reaches the groundwater sources, which means the water is filtered and purified, improving water quality (2005).

Trees also benefit the soil of an area in two different ways. First, the roots stabilize the soil and increase water storage capacity, which prevents soil erosion (Deason, 1997). Second, some trees, known as legumes, facilitate nitrogen fixation and thus improve the nutrients of the soil (Deason, 1997).

In addition to soil, trees also improve local air quality by reducing the amount of pollution in the air. The stomata pores of leaves uptake gaseous air pollution that are diffused into the plant cells, improving air quality (Nowak, 2001). Plants can also intercept airborne particular pollution, which is either absorbed by the tree or trapped on the surface of the plant, although this is usually only a temporary fix (2001). Lastly, reforestation can have social and academic benefits. Reforestation projects can be used to study the succession of forest ecosystems as well as the biology behind carbon sequestration. Reforestation projects are also be used as educational tools to teach people about sustainability and the environment (Sayer, 2005). Because reforestation projects often involve hands-on interaction with planting trees, they can also build community involvement (2005). John Pumilio, the Sustainability Coordinator at Colgate University, said that, “the big thing is just to get people engaged. A lot of times we talk about sustainability and how we want to be a more sustainable campus, but there’s not always a whole lot of opportunities for people to get their hands dirty and feel like they accomplished something that really makes a difference” (J. Pumilio, personal communication, October 6, 2011).

**Carbon dioxide and carbon sequestration**

The carbon cycle is the in and outflow of carbon among reservoirs. The most significant of these reservoirs are the ocean, the atmosphere, and living organisms. Carbon sequestration is the process in which carbon dioxide is absorbed from the atmosphere into other reservoirs. As described by Environmental Science Activities for the 21st Century, trees play an integral role in the carbon sequestration. “During photosynthesis, trees convert carbon dioxide and water into sugar molecules and oxygen through a series of oxidation and reduction reactions” (ESA 21, 3). This sugar is either stored as biomass or used for energy. The ESA 21 provides the chemical equation for photosynthesis:

\[ 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \]
Through this equation, ESA 21 determines that roughly 45% of a tree’s dry mass is carbon (ESA 21, 4). Carbon sequestration values can be calculated based on variables of lifespan, tree types and tree size. In saying that, increasing the total amount of trees in a given forest can increase the carbon sequestered by each carbon sink (forests).

Measuring carbon sequestration rates

The Environmental Science Activities for the 21st Century describes two methods of carbon sequestration measurement. The first is a process based on five major components of a forest. These are defined as trees, understory vegetation, down dead wood, forest floor and soil. There are given parameters for what organic matter can be measured based on diameter for trees, understory vegetation and down wood and soil must be measured at 1 meter in depth. These parameters ensure the carbon measured is accurately representing the potential for sequestration and the actual sequestration rates. Estimations for trees, dead wood, understory vegetation and forest floor are based on equations outlined by Birdsey (1996) and these equations are utilized by the U.S. Forest Service and the Environmental Protection Agency (EPA). These equations are used to estimate tree carbon density based on the region and forest type.

The second method is allometry, or “the measure and study of relative growth of a part in relation to an entire organism or to a standard” (ESA 21, 4). A previous study, Martin and Kloepell et al (1998) determined the allometric equation for deciduous trees that relates the “tree at a height of 1.4 meters to various parameters like the dry mass of the stem, bark, and branches, and the total biomass of the tree excluding roots (ESA 21 5-6). They did so through clear cutting acreage and measuring the carbon mass of each tree.

The ESA 21 report concludes with a case study at Kennesaw State University that used 15 acres of clear-cut trees to verify the previously determined allometric equations in which they were proven to be accurate.

Overall, this is a valuable source in that it provides tremendous insight into the relationship between forests and carbon. However, its applicability to our specific project is minimal. Regarding the two measurement strategies, it is unrealistic for Colgate University to clear several acres of forest to determine how much has been and will be sequestered in the future. Regarding the allometric equations and sequestration rates provided from earlier studies, the potential tree species are not similar and thus they cannot be used.

However, the organization Trees for the Future provides an equation to measure yearly sequestration rates based off of tree specific characteristics such as trunk diameter and tree height. See Appendix for the calculation method.

Protocols for Reforestation Projects

Reforestation protocols are important because they ensure accuracy, transparency, thoroughness, and consistency, thus maintaining integrity of projects. This way, not just any sort of endeavor can be labeled a reforestation project, thus maintaining integrity. The definition for reforestation may seem self-evident, but it is actually one of the first and foremost aspects of establishing protocol. For the purpose of this project we will be using the Compliance Offset Protocol for U.S. Forest Project’s definition of a forest.
project, which comes from the Californian state government: a Forest Project is a planned set of activities designed to increase removals of CO2 from the atmosphere, or reduce or prevent emissions of CO2 to the atmosphere, through increasing and/or conserving forest carbon stocks (Sahota 2011).

The most widely used verification standard for reforestation projects is the Gold Standard. It is used in both the compliance and the voluntary carbon markets. Established in 2003 by the World Wildlife Fund, and over 80 NGOs and governments and multinationals use it. Projects are required to adhere to stringent and transparent criteria that are established by the “secretariat.” The Secretariat consists of 30 people in ten different countries. The Gold Standard outlines protocol for large-scale, small-scale, and micro-scale projects.

The Gold Standard also outlines key elements of the regular project cycle, which accounts for organization in all stages of the project process: project planning, design and reporting, selection of baseline and monitoring methodology, additionally assessment (ensuring that the project is actually altering carbon stocks in the surrounding area), sustainability assessment, and local stakeholder consultation. Baseline methodologies are defined as follows: “A methodology is an application of a baseline approach. The most likely baseline scenario of the project activity is considered to be the land-use prior to the implementation of the project activity” (CDM Rulebook, 2011). Monitoring methodologies are defined as follows: “A monitoring methodology refers to the method used by project participants for the collection and archiving of all relevant data necessary for the implementation of the monitoring plan” (CDM Rulebook, 2011)

Projects must also take additionality, leakage, and local stakeholders into account. All projects must demonstrate additionality: they must reduce anthropogenic emissions of greenhouse gases below those that would have occurred in the absence of the project. The project must also take into account the risk that the activity could have negative environmental, social, and/or economic impacts. Leakage is the unanticipated decrease or increase in greenhouse gas benefits outside of the projects’ accounting boundary. It is not fully understood, and can be caused by market impacts, people moving from place to place, ecological feedbacks, etc. It can be caused by market impacts, people moving from place to pace, ecological feedbacks, product life cycle changes and other ways. Projects that integrate activities (like forest conservation, forest restoration, community development, etc.) have been shown to be more successful in reducing leakage. Monitoring can also estimate leakage, and once it is detected, project carbon offsets should be adjusted (Gold Standard Toolkit, 2008). (Graus & Hendricks, 2004).

In investigating protocols used for conducting reforestation projects, we also looked at the protocols from the state of California. The protocols used in California are compiled into a document called “The Compliance Offset Protocol.” This set of protocols is the direct result of a referendum that was passed in 2008 that put “California on the path to meet the law's goal of reducing GHG emissions to 1990 levels, i.e., 427 million metric tons of CO2 equivalent, by the year 2020, and ultimately achieving an 80% reduction from 1990 levels by 2050. The scoping plan identified a cap-and-trade program as one of the key strategies,” (Cosslett, 2011). Therefore, reforestation protocols had to be considered since reforestation projects are one of the mechanisms that carbon credits can be obtained. In order for a forest project to actually be considered a reforestation project it must meet the following guidelines according to this protocol:
1. The project involves tree planting or removal of impediments to natural reforestation, on land that:
   o Has had less than 10 percent tree canopy cover for a minimum of 10 years; or
   o Has been subjected to a significant disturbance that has removed at least 20 percent of the land’s aboveground live biomass in trees.

2. No rotational harvesting of reforested trees or any harvesting of pre-existing carbon in live trees occurs during the first 30 years after offset project commencement unless such harvesting is needed to prevent or reduce an imminent threat of disease. Such harvesting may only occur if the Offset Project Operator or Authorized Project Designee provides a written statement from the government agency in charge of forestry regulation in the state where the project is located stipulating that the harvesting is necessary to prevent or mitigate disease.

3. The tree planting, or removal of impediments to natural reforestation, does not follow a commercial harvest of healthy live trees that has occurred in the Project Area within the past 10 years, or since the occurrence of a Significant Disturbance, whichever period is shorter.

4. The offset project does not employ broadcast fertilization.

5. The offset project does not take place on land that was part of a previously listed and verified Forest Project, unless the previous Forest Project was terminated due to an Unintentional Reversal (see Section 7) or is an early action offset project transitioning to this protocol according to the provisions of the Regulation and this protocol.

6. If the offset project was an offset project in a voluntary offset program, the offset project can demonstrate it has met all legal and contractual requirements to allow it to terminate its project relationship with the voluntary offset program and be listed using this compliance offset protocol. (Sohota, 2011).

Reforestation projects that are intended for carbon sequestration also must consider at what point the project technically commences. The official start date of an offset project for any sort of forest project is the date on which an activity is first implemented that will lead to GHG reductions or GHG “removal enhancements relative to the forest project’s baseline.” For reforestation projects, you can tell when the commencement date is when the action of planting trees, removing impediments to natural regeneration, or preparing the site actually begins. When either of these things begins, this is technically the commencement date.

In investigating both the governmental and private notions of reforestation protocols, the Gold Standard seems to focus more on social side affects. The Gold Standard asks that the project must also take into account the negative implications that the project
could have environmentally, socially, and/or economically. The project is asked to take sustainable development into consideration, which the Gold Standard defines as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Gold Standard Toolkit 2008). It is actually required that the project needs to create a local stakeholder consultation. That is, key leaders should talk to, identify, and address the concerns of key stakeholders, so that all social implications are accounted for. The outcome of these assessments is to prove that the project is doing no harm (socially).

The Gold Standard and the Compliance Offset Protocol for U.S Forest Projects have been, and continues to be used in private projects, but it primarily reflects considerations for Clean Development Mechanism projects, and governmental projects. Clean Development Mechanism clause is one of the "flexibility" mechanisms defined in the Kyoto Protocol (Metz, Davidson, de Coninck, Loos & Meyer, 2005). It is intended to meet two objectives: (1) to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the United Nations Framework Convention on Climate Change, which is to prevent dangerous climate change; and (2) to assist parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments (Metz, Davidson, de Coninck, Loos & Meyer, 2005).

Reforestation in Higher education

Privately owned forests are essential carbon sinks within the United States. In the Eastern part of the country, privately owned land accounts for more than eighty-two percent of all forested land, significantly more than government-owned land (U.S Forestry, 2011). Individuals own much of this land, institutions, including colleges and universities, also own a fair amount.

However, very few reforestation projects have taken place at higher education institutions in the United States. There have been very few colleges and universities in our nation that have recognized reforestation projects as a method to reduce their carbon footprint and become carbon neutral. Some smaller liberal arts schools have acknowledged the environmental benefits of reforesting land and have organized projects to activate reforestation projects on their campuses (Bellona, 2011).

Hamilton College developed a Climate Action Plan in 2009 that focused on overall sustainability on their campus as well as their plans to neutralize climate change in and around Hamilton College. This plan specifically addresses offsetting the campus’ annual carbon emissions by reforesting 200 acres of land; this would reduce their annual emissions by 2.28% (Bellona, 2011). This would be a very large reduction for a smaller institution like Hamilton College.

Another university that practices reforestation projects in the United States is St. Lawrence. Through their Ecological Sustainability Landscape (ESL) they use their Environmental Studies program to apply sustainable practices all over their campus. These practices range anywhere from energy-efficient materials, eco-friendly products, beekeeping and honey productions, composting toilet system and most importantly reforestation. St. Lawrence University has been developing a tree nursery since 2008 and currently is still maintaining this plot of land. St. Lawrence understands the
environmental benefits that reforesting land has and focuses on using reforestation as a teaching method in their Environmental Studies programs (St. Lawrence, 2007).

The third institution we explored was York College. They have partnered with the City of New York to plant one million trees over the next decade. The main purpose for this is to increase New York’s urban forest by 20% (York College, 2011). In the 2008-2009 academic year York successfully planted 150 trees campus wide and implement various other green practices. York College has made strides in the right direction by partnering with the state of New York to implement eco-friendly practices such as reforestation.

The fourth establishment that has reforested land is Drew University. This university committed itself to a four-year plan that involved planting over 1,100 native trees, and this was successfully finished on April 15 of 2011. Drew University was successful in involving students on campus and thought that they succeeded in forest preservation (Parke, 2011).

The fifth and last institution we looked at was Middlebury College. Middlebury has gone in the right direction when it comes to becoming environmentally friendly. Through the use of LEED buildings, green initiatives and other practices such as reforestation Middlebury is on pace to become carbon neutral. This reforestation project was implemented strictly used to reduce their carbon footprint in hopes of becoming carbon neutral. Middlebury’s project can be model for other schools who wish to do the same. Although most of the planting and agricultural land is located off campus the college still reaps the environmental benefits from planting these trees. Middlebury College plans to achieve carbon neutrality by 2016 (Middlebury, 2011).

Aside from Middlebury there are very few college campuses across the United States that practice reforestation with the goal to become carbon neutral. Hamilton College, St. Lawrence University, York College and Drew University have acknowledged reforestation as a way to become ‘green’ and actively address climate change. These are just some of the institutions in the United States who have future plans to use reforestation projects as a method to become carbon neutral. In saying that, the protocol we develop and implement can potentially be the guide used by other colleges and universities if and when they decide to establish a reforestation project on their campuses. Achieving carbon neutrality through carbon sequestration should be something every institution plans to practice in the near future nationwide.

**Methods**

After forming the research question and some preliminary research, we found we needed to contact some experts to gain more information as well as do more focused research on appropriate tree species, the quality of the soil and carbon sequestration practices. We conducted interviews, took samples for soil analysis, and wrote a petition to gauge student involvement and support. The interviews were performed by members of the group and were either filmed or voice recorded. John Pumilio, Campus Sustainability Coordinator at Colgate University was interviewed first to determine general knowledge as to the role of reforestation on the campus. A snowballing technique was used where each interviewee was asked to recommend another potential interviewee. Dr. Steve Bick was interviewed because of his role as the forester for Colgate and his
knowledge on carbon sequestration and specific trees to the area that may be of use for this project. The last person interviewed was Michael Jasper, the Associate Director of Facilities and Manager of Lands and Grounds. He was contacted because of his experience with land management as well as the viable options of area to be reforested.

Based on the information garnered from the interviews, more in depth research was conducted to determine tree type, soil type and pH, carbon sequestration rates and any previous successful protocols for similar projects. The type of tree we would be able to plant was variable but we were able to research each species recommended by Dr. Bick and Mr. Jasper separately to determine which was best suited for the goals of this project and would have the highest likelihood of survival. Once we had determined possible trees to plant, we tested the soil to determine if the hypothetical choices would in fact be suitable in this area. We used a soil core sample method that involved using a soil core tool to take samples from two sites under consideration for the spring planting date. We then sent the samples to CIC labs to be tested. We researched methods of measuring carbon sequestration of a specific species of trees but it proved difficult to find one method that was widely used. We were eventually able to determine which method was appropriate for this project and focused on determining the sequestration rates of the trees being considered for the project.

Part of this project was writing a protocol for the proposed planting of trees in the spring of 2012 as well as a plan that could be implemented later in the future. We researched academic databases and used our contacts from the interviews to determine if any other higher education institutions had attempted a project similar to this. We focused on ascertaining if other colleges or universities had attempted local reforestation projects as opposed to out of country trips. We also used this research to clarify what materials and logistics would be addressed in the spring of 2012. This led us to the petition we decided to write to quantify student support for the project. Through this petition we hoped to gage the support of students and the possibility of student involvement in the actual planting event.

Results

Developing a protocol for Colgate’s reforestation project

First and foremost, it is important to note that the protocols examined reflect protocols for projects that are mainly governmental in nature. This may seem as though there is little relevance that these protocols could have with a small, Liberal-arts University. We chose to investigate such protocols because they are the most stringent and thorough of all since they are governmental in nature. There is no doubt that the legitimacy of our project’s ability to sequester carbon if we use standards that are good enough for the UN and international/ state governments. There are numerous important considerations raised by both the Gold Standard and The Compliance Offset Protocol U.S. Forest Projects that we should incorporate to the reforestation project at Colgate University:

Firstly, as the Gold Standard points out, the baseline carbon sequestration for the lot that is intended to be reforested must be calculated. According to the Compliance Offset Protocols in California, before this is even done, the specific boundaries for the
project must be defined. The boundaries are necessary for any carbon sequestration calculation. For the purpose of Colgate’s project, the boundaries will strictly only include the eight-acre plot because this is the only land that will be affected. In addition, if we stick to using the mowed area as the boundary, the baseline number will be lower, and hence the change in sequestration will be greater. As the Gold Standard suggest, we should use the “business as usual” methodology to calculate this baseline value. The “business as usual” method stipulates that the baseline is simply the amount of carbon that was being sequestered by the reforested area before the project began. Currently the plot is not sequestering any carbon since it is being mowed, so the baseline is easily calculated since there is no sequestering potential in that 8-acre area. Calculating this is necessary because Colgate needs to demonstrate the project’s additionality if the project is to be recognized as effective. Demonstrating additionality is one of the stipulations set for by both the Gold Standard and the Compliance Offset Protocols in California.

Colgate University should also define its project based on the guidelines that the Compliance Offset Protocols in California stipulates (see the list in the literature review). This way, there is no doubt that our project can be officially and correctly labeled a reforestation project. Our project already meets most of these guidelines, and the others will be easily implementable: The land plot has been subjected to a significant disturbance that has removed at least 20% of the aboveground biomass. Our entire plot to be reforested has been disturbed since it is being mowed. Colgate University should also plan on not using any broadcast fertilizers during the reforestation process. This means that widespread usage of fertilizer would compromise the project’s legitimacy due to the various environmental hazards and health hazards that are associated with chemical fertilizers. Instead, organic material (like compost) should be used. Colgate should also not harvest any of the reforested land within the first thirty years, since this would make it seem as though we replanted the plot of land solely for logging and commercial purposes. The Californian protocols also mandate that all legal requirements are met, and since Colgate owns this land, we do not expect any legal hindrances. The guidelines also stipulate that the project not occur on any land that has been a verified forest project, which Colgate’s land plot has not.

Colgate should create and implement a monitoring methodology, one of the Gold Standard’s criteria. This is important because the Gold Standard also stipulates the projects monitor carbon leakage. Colgate’s monitoring methodology needs to include weeks monitoring of the plot, especially in the beginning stages of the forest’s growth. This is necessary to ensure that the seedlings are safe from deer browse and competing vegetation. The main potential for leakage on Colgate’s land is unexpected die-offs. We expect little leakage to occur from the actual planting event, since the project is of a small scale and not many vehicles transporting volunteers and tools will be needed (especially in comparison to large-scale projects). Monitoring the land will include insuring that no competing vegetation is entering the tree tubes, and that the tree tubes remain intact. Any trees that do die (which hopefully doesn’t happen) need to be recorded so that the carbon it emits once it is no longer a living sink is accounted for. The Gold Standard stresses that accounting for leakage is one of the most important factors in a reforestation project. However, the Gold Standard also notes that projects that involve meticulous monitoring methodologies, and projects that occur within a close-knit community, are most
successful at limiting leakage. Therefore, it can be expected that Colgate’s project experiences little leakage.

Monitoring methodologies also insure that the sustainability goals of the project are being met. It is therefore important that Colgate clearly defines its sustainability goals. We identified 8 main sustainability goals:

1. Create a carbon sink to sequester carbon as part of Colgate’s larger goal to reach Carbon neutrality in 2019
2. Encourage the reforestation of other Colgate lands
3. Improve air quality
4. Improve water quality
5. Improve soil quality
6. Facilitate community building through the actual planting event and the communications involved to ad
7. Create excitement around the project in order to educate the community about Colgate’s general sustainability goals
8. Create an educational tool that can be used in the science, geography, and humanities disciplines

Another important factor that is stressed more in the Gold Standard involves an evaluation of the key stakeholder’s interests. Colgate University is a tight-knit community, so it is important that all of those who use the land and/or will be affected by the project are consulted. In anticipation of one key stakeholder interest, the reforestation project will avoid the current cross-country ski/running path that runs on the outskirts of the plot of land. This way, popular recreational interests are taken into consideration. Key stakeholders in this project include students, faculty, staff, and Hamilton residents that utilize the land for recreational purposes. It is important that the Colgate Community is aware of the project, so that any questions and/or concerns can be addressed. However, we do not expect there to be many (if any) conflicts with the Hamilton or Colgate community, especially since the project will arguably increase the aesthetic value of the recreational lands above the ski hill. This helps ensure that the social side of sustainable development is being addressed, and no one group will be negatively impacted, and no one group will benefit disproportionately.

Land Considerations

Colgate University currently owns approximately 2,200 acres of land within a ten-mile radius of campus (S. Bick, personal communication, October 21, 2011). Of this land, about 1,112 acres are established forestland and 204 acres of old pastureland that are transitioning into forests (S. Bick, personal communication, October 21, 2011). Doms estimates that Maple and Oak trees dominate about two-thirds of the forests, while Hemlock dominates the other third of the forest (Doms, 2010). Cumulatively, Doms estimates that Colgate’s current forest already sequesters 1,244.56 metric tons of carbon dioxide per year (Mt eCO$_2$/year) (2010). Colgate University reportedly emitted 14,451 Mt eCO$_2$ in the year of 2010 (Climate Action Plan, 2011). This means that Colgate-owned forests offset 8.6% of the university’s carbon emissions every year.

Reforesting additional open lands would increase the amount of carbon dioxide that is sequestered, or offset, by forests at a local level. The university has already
located forty-five acres of open space that have the potential to be reforested. A smaller plot of land, probably either one or two acres, will be planted in the spring.

There are a few factors to keep into consideration when identifying a plot of land for reforestation. Firstly, (and arguably most importantly), the soil must be conducive to the type of tree that you wish to plant. Not all trees are suited for all sites on your property. Factors that need to be taken into account include soil moisture, soil fertility, shady conditions, periodic flooding, or exposure to wind and deer browse, soil texture, types of existing vegetation, etc. Soil can vary, it can be either: very soggy year-round, waterlogged in springtime and heavy after rain, sometimes soggy (but usually firm), often firm (even in springtime and after rain, sandy or gravelly (and dry in the summer). How soils can drain determines species of new trees will survive, so figuring out how to characterize the soil in the plot of land to be used is important. The land in Madison County is generally well/moderately-well drained (M.Jasper, personal communication, October 10, 2011).

It is also important to keep in mind the existing vegetation on a plot. Most sites for reforestation are open fields, but some sites also have brush or small trees. “These types of vegetation can prove to be harsh competition for new seedlings…even tall grass can stifle the growth of new seedlings” (Ochterski, Smallidge, Ward, 2009). Competition does not just come in the form of existing competition; browse is another very important factor to consider. Protecting seedlings from deer will allow the growth of seedlings beyond browsing heights. Deer impacts can vary locally; depending on deer herd size. The potential for deer browse raises questions such as whether means of artificial protection for the seedlings will be needed (Ochterski, Smallidge, Ward, 2009).

Once the site is selected, there are several factors that must be addressed in order to prepare it for reforestation. If the site needs to be moves or brush-hogged in order to eliminate existing vegetation, then it is best to mow the site in August if one is planning on a spring planting. This way, minimal growth will occur before the actual planting event.

The site should also be mowed again in October, to ensure that the existing vegetation is completely destroyed. This will also reduce the cover over rodents that could potentially destroy seedlings (Ochterski, Smallidge, Ward, 2009). Mowing will have to continue as vegetation starts to grow back, but “starting with a cleaner slate, you will be less likely to mow down your seedling investment,” (Ochterski, Smallidge, Ward, 2009). This is important because seedlings that are planted within tall grasses do not often survive (Ochterski, Smallidge, Ward, 2009). Grass that grows up over the tops of recently planted seedlings can be inadvertently mowed since they disappear from view, and also they are unable to survive as surrounding plants that are better established more effectively acquire nutrients and water.

Calculating the expected survival rate: soil composition and browsing

In planning a reforestation project there are many factors to take into consideration when deciding on the location and size of land we want to use. First is, understanding the pH and quality of the soil in this plot of land. The minerals, nutrients and acidity that make up the soil can have large impacts on the growth and development of the saplings we plant. Establishing these components is done through simple tests that
can be either done in university labs or even at home with store bought kits. Although each test provides similar results university labs would provide the most accurate results due to being more familiar with the soil and having previous experience doing these tests (Environmental Information, 2011). Soil testing must be done in order to pick an appropriate tree that can mature with that soil’s specific pH levels and nutrients. We need to keep in mind that the pH can change throughout a plot of land that is selected, so testing multiple areas from the plot would be beneficial when determining and choosing a tree type for a reforestation project.

The second major factor that contributes to lowered survival rates of trees is the variation in local climate and geographical position of the plot of land. New York’s climate is highly unpredictable within each season and some problematic conditions that are experienced in this area are heavy snowfall, high precipitation and restricted amounts sunlight. While considering the issue of climate variation we must also look at the geographical positioning of the land and how that can alter the survival rate. Climate variation can be exemplified or minimized based on whether the plot of land is on top of a hill, near the bottom, beside a creek, or near human activity. We cannot fully control the climate that will impact our sapling trees however we can understand patterns in climate and make adjustments accordingly. With the weather playing a key role in the survival rate of the trees planted on our plot of land, it will be important to establish a date for tree planting.

The third and last major component that will impact the overall survival rate of our saplings is wildlife interaction. It is unusual for deer not to be travelling in and around Hamilton, New York throughout the course of a year. Their presence is most abundant during mating season, which happens to fall between the start of November and the middle of December. This is a vulnerable time for the saplings development due to weather conditions and deer browsing only adds to the risk of their survival. In order to limit the effect that wildlife interaction has on our reforestation project we must find a way to provide each sapling tree with protection. This will reduce the vulnerability of each sapling and enhance the over survival rate of our reforestation project.

Identifying potential tree species

There were four potential tree species considered for the 2012 Reforestation Project, based upon carbon sequestration rates, likelihood of survival, and management. Levels of wildlife habitability and native/invasiveness were also considered, yet the main goal for the Reforestation Project is carbon sequestration. As the purpose is for carbon sequestration, the trees will only be effective for the first 80 to 100 years of their lives; thus it is also important to consider uses for the trees after this time period. The trees, after reaching their limit of carbon sequestration, may be cut down in favor of planting younger, less carbon saturated trees. Thus it will be an important factor if the trees, when harvested, will be able to provide other services and not simply be wasted. Furthermore, all will be vulnerable from predation and will require protection measures regardless of particular species. The four species are the Northeast Red Pine, Northeast White Spruce, Sugar Maple, and Black Locust.
**Northeast Red Pine**

The Northeast Red Pine is a relatively fast growing species ranging from 50 to 80 feet in height and 1 to 3 feet in diameter (DOA, 1980). After 100 years of its initial planting, an acre of Red Pine will have sequestered roughly 345.3 metric tons of CO2. Red Pines survive best in loamy and sandy soils in northern regions with cold winters and moderate summers (Forest Service). While native in the Northeast, only a plantation of Red Pine exists on Colgate University’s land that was established in the 1960s and 70s. The Northeast Red Pine has several commercial uses, most notably of which is lumber for construction. Further uses include floorings, pulp, and occasionally furniture depending on the quality. With regards to tree health, the Red Pine faces several threats that are easily spread, particularly in younger trees. Scleroderris and Red Pine shoot blight are potential problems for Red Pines, as well as the Root Collar Weevil and Pine Sawfly. Due to these threats and susceptibility for them to spread, frequent maintenance and observation of the planted acre will be required.

**White Spruce**

The White Spruce grows between 90 and 100 feet high and can reach diameters of 20 inches. After 100 years, an acre of White Spruce will sequester about 237.4 metric tons of CO2. The White Spruce species grows best in clay and loam soils and can survive periods of drought and heat (Charlevoix County). It can also survive a relatively wide range of pH levels, 4.5 – 7.6 (Charlevoix County). The White Spruce can be used for construction lumber and pulp. While very prone and susceptible to wild fire, Colgate University is in a location where this is of minimal concern. The yellow-headed spruce sawfly and spruce budworm are threats to White Spruce.

**Sugar Maple**
Sugar Maples range from 65 to 115 feet in height and 20 to 35 inches in trunk diameter. A one-acre plot will sequester 24.76 metric tons of CO2 in its first 20 years (Brooks and Murray 2009). A native species in the Deciduous Forest Region as well as the Great Lakes, Sugar Maples are capable of surviving in various soils but prefer moist soils with medium to fine textures (Extension Notes Ontario 1995). Sugar Maples provide two primary commercial uses: sap/sugar bush and timber. Sugar bush would require intensive thinning which would hinder the overarching goal of carbon sequestration, thus were Sugar Maple to be chosen, it would be most likely used for lumber once it became saturated with carbon. There are many threats and dangers to Sugar Maple growth and survival, both environmental and biological. Wind, ice, excessive water and numerous insects and wildlife affect Sugar Maples.

*Black Locust*

Black Locusts, native to the Appalachian Mountains, grow in between 30 and 80 feet tall with a trunk one to two feet wide. One acre will sequester roughly 81.69 metric tons of CO2 within the first 100 years of planting. Black Locusts can survive in a wide range of pH, approximately 4.6 to 8.2 (Dickerson, 2002). Due to its durability, the timber is most often used for landscaping purposes including fencing and mine timbers. Protection measures will need to be taken, as it is vulnerable to deer and other wildlife grazing. Black Locusts are also vulnerable to two particular insects, the locust leaf miner and Black Locust borer. However, while these insects can stunt growth, they are not serious threats if planted on high quality sites with other hardwood trees (Dickerson 2002).
Analysis

Why reforest?

We plan on reforesting an acre of land in order to help Colgate achieve its climate goals; we plan on being carbon neutral by 2019. A reforestation project would act as a new carbon sink, partially offsetting a significant amount of our total emissions. A reforestation project is also a potential education tool. Science students could learn from the sequestration process, biology students could learn about plant ecology, and environmental studies students could discuss the issues associated with reforestation and its potential benefits. Ultimately, Colgate is a learning institution, and a reforestation project would enhance the university’s learning goals.

If Colgate’s open lands were left untouched, without any type of mowing or brush hogging, a forest ecosystem would eventually grow back on the land. Although it might take a few years for natural succession to occur, trees and other plants would naturally begin to grow on these areas. According to Bick, “there is very little you can do with your open space land to prevent forests from growing back in place” (S. Bick, personal communication, October 21, 2011).

So if lands regenerate forest ecosystems naturally, why would Colgate spend time and money implementing a reforestation project?

Tree Species Comparison Table

<table>
<thead>
<tr>
<th>Tree Type</th>
<th>Metric Tons CO2 Sequestered per acre for first 100 years (&gt;250 stems per acre)</th>
<th>Height Range (feet)</th>
<th>Trunk Diameter Range (feet)</th>
<th>Uses Post-Carbon Saturation</th>
<th>Threats/Vulnerabilities</th>
<th>Preferred Soil Type</th>
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<tr>
<td>Red Pine</td>
<td>345.3</td>
<td>50 – 80</td>
<td>1 – 3</td>
<td>Construction lumber, flooring, furniture</td>
<td>Collar Weevil, Pine Sawfly, Scleroderris</td>
<td>Loamy, sandy</td>
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<td>White Spruce</td>
<td>237.4</td>
<td>90 – 100</td>
<td>1 – 1.7</td>
<td>Construction lumber, pulp</td>
<td>Yellow-headed spruce sawfly, spruce budworm</td>
<td>Well-drained, mineral soil</td>
</tr>
<tr>
<td>Sugar Maple</td>
<td>24.76</td>
<td>65 – 115</td>
<td>1.7 – 3</td>
<td>Sap, timber</td>
<td>Insects, ice/excessive water</td>
<td>Moist, medium to fine texture</td>
</tr>
<tr>
<td>Black Locust</td>
<td>587.82</td>
<td>30 – 90</td>
<td>1 – 2</td>
<td>Landscaping, fencing</td>
<td>Locust leaf miner and Black Locust borer</td>
<td>Deep, sandy, well-drained</td>
</tr>
</tbody>
</table>
The primary reason to execute a reforestation project is to ensure that a valuable and beneficial tree species grows in the specific area. If a plot of land is left to itself, species of trees and plants that are different from the surrounding ecosystem will often grow back in place. According to Chazdon, “new forests emerging in human-impacted landscapes will not match the original old-growth forests in species composition” (2009). This causes a problem because many of the new species that would grow back into these open lands would be small trees and shrub brush, according to Bick (S. Bick, personal communication, October 21, 2011).

These tree species would only sequester a fraction of the carbon dioxide of old-grow trees, such as pines, oaks, and spruces. In addition, the growth would offer no benefits for biodiversity and wildlife habitat. Overall, reforesting land ensures that a more valuable species grows back – both in terms of carbon sequestration and overall value of the university’s forests (S. Bick, personal communication, October 21, 2011).

Another issue with leaving Colgate’s open lands to naturally regenerate is that this exposes the area to threats from invasive species. “Emerging forests provide breeding grounds for invasive exotic species, which can rapidly colonize established forests in protected areas,” (Chazdon, 2008).

While a forest ecosystem is still in the beginning of its development, it is susceptible to invasive species, which can often outcompete native species and dominate the ecosystem. The establishment of invasive species in these small pockets of open land would be costly to the entire forest, as it would open up the possibility that the invasive species could spread to the established forest ecosystems and replace the native species there.

Another benefit of reforestation over natural regeneration is timing. Since Colgate is planning on becoming Carbon neutral by 2019, it is in the university’s best interest to reforest in order to offset their carbon as soon as possible. Bick stated that a reforestation project is basically “jump-starting the process” (S. Bick, personal communication, October 21, 2011).

The last reason that Colgate would choose reforestation is that it is often seen as a more credible carbon offset than natural regeneration. Often, many people do not count existing forest ecosystems as a way to offset carbon dioxide. Colgate’s forests already sequester 1,244.56 Mt eCO₂ per year, and yet this cannot be counted as a carbon offset because the school did not actively make any changes. Overall, it is most beneficial to invest in a reforestation project that will significantly reduce carbon dioxide and be recognized as a way to reduce the institution’s carbon footprint. Additionally, the investment will ensure that valuable tree species develop in the area and enhance the worth of Colgate’s forests.

Identifying a land plot for reforestation

The plot of land would ideally be close to campus. When selecting the site to be reforested, we looked over a variety of types of land that Colgate owns. Colgate owns at least 400 acres in the parker farms that are leased out for farming purposes, which makes the issue of key stakeholders more complicated. Therefore, these lands are not feasible for the reforestation project since farmers would not appreciate their land being reverted to forest. Colgate also owns more than 100 acres in the Buchus center and 117 acres in
Brookfield, but both these sites are farther away from campus, and would be harder to transport the materials/students for the planting event. There are also several “brush lots” near Hamilton Street, which are feasible to reforest, close to campus, and would not disrupt the livelihood of any key stakeholders. However, since these plots are covered in brush, they would have to be extensively mowed and brush-hogged before planting could take place. In reality, the preparation would have needed to begin by now, since all existing vegetation must be completely cleared in order to ensure the seedlings do not have any competition. This is also a less cost effective option since it involves using more energy and more manual labor.

We have selected a plot of land above the ski hill (closest to Gorton Road) that is currently not used for anything besides only partially being used as part of the ski/running trails (the trails are on the periphery). It is currently being mowed, but is surrounded by forest on all sides. It contains part of the extensive cross-country and ski paths, but the path is on the outskirt of the plot, so it will be easily avoidable during the reforestation project. “Right now we’re mowing lawn, though most of the area is not being used at all. It just seems like we’re wasting work, fossil fuel, and expenses when instead we could be planting trees on that plot of land” (J.Pumilio, personal communication, October 8, 2011).

**Ensuring a high survival rate**

The planting of our reforestation project will take action in the spring in order to allow the sapling to grow and become familiar with their surroundings. Soil quality, wildlife invasion and climate are just a few factors we established that could potentially negatively impact our project. With reforesting one acre of land we are able to effectively measure how vulnerable our chosen plot of land is and make efficient changes to allow overall survival rates to increase and make the reforestation project more successful.

In addressing the wildlife invasion problem we’ve identified two methods of protection for our project. The first being tree tubing that would be placed around each sapling and the second would be to set up fencing around our entire acre of land to eliminate most wildlife interaction. Analyzing both possible solutions, we’ve decided based on cost and implementation that the more practical method would be to use tree tubing to protect the saplings that we plant. These tubes allow sunlight to pass through, but also shield plants from intense winds and protect the seedling from sudden temperature shifts. This protective method will shelter the saplings until they are developed enough to survive on their own even with wildlife interaction, which would be about 2 feet tall. At this time, we would have to return to the plot of land and removed the
tubing to allow further growth of the sapling. Tree Protection Supply offers *Plantra Tree Tubes*, which would provide the protection necessary for our project. This tubing is offered in various lengths, however for our plot of land it would be beneficial to use 1.5-foot tall tubes for each sapling. Each tube would cost $0.95 meaning to plant one hundred trees it would cost around $95.00 dollars (Tree Protection, 2009). Each tube requires a PVC stake for stability and this can also be purchase from Tree Protection Supply for a cost of $0.50 each. The cost to purchasing 100 PVC stake would be approximately $50.00. The combined total for this specific protection method and its materials would be $145.00, a small expense to pay for higher rates of survival for our reforestation project. That being said, these tubes need to be monitored to ensure they are fulfilling their purpose and have not fallen over. Weeds can potentially grow in and around the tubes and eliminating them would improve the development of the sapling. Maintaining the tubing must also be a part of the monitoring methodology to improve survival rates.

Soil samples were taken from this plot of land and the pH was determined. With the specific tree type that we have chosen, the pH level didn’t play as prominent role as we thought it would in its survival. However, we noticed that understanding other dynamics of the soil will be critical for the survival of either the black locust or sugar maple on our plot of land.

Choosing the ideal tree species

The survival of the particular species is paramount for the 2012 Reforestation Project. However, since all are capable of surviving in the region, this does little to narrow the number down. Furthermore, all will require plastic tubing for protection as deer and other wildlife will be a threat to all species. With further respect to wildlife and the tree species’ habitability, as only 1 acre is to be planted, it was determined that all four tree types would not infringe upon current wildlife development and habitat.

After discussion with Colgate University’s Forester, Dr. Stephen Bick, the four tree types were narrowed down to the Sugar Maple and Black Locust. While the Black Locust has the immense advantage over the Sugar Maple in carbon sequestration, the Sugar Maple regenerates naturally and easily due its production of seeds. The Sugar Maple is also very tolerant of shade and Dr. Bick suggests that if the area were to be left un-mowed, the Sugar Maple would eventually establish itself in the acre of land.

However, due to the Sugar Maple’s relatively ineffectiveness in carbon sequestration, the Black Locust appears to be the best to suited for the 2012 Reforestation Project. The Black Locust has many positives. Its potential uses after being saturated with carbon will help Colgate University become more sustainable as it will be able to be used on campus. Furthermore, it is very effective in controlling erosion due to its quick, early growth and soil building capabilities (Dickerson 2002). Furthermore, it is a Nitrogen fixator, maintaining nutrients within the soil for generations. The one issue regarding the Black Locust is its invasiveness, as in the past it has been known to crowd out other plants. Yet as discussed by Ewel and Putz 2004, alien species can be more effective for ecological, economic, and social reasons. We believe the effectiveness of the Black Locust in both its carbon sequestration and soil improvement qualities outweigh the fact that it is an alien species.
Logistics of the tree planting

Planting two hundred and fifty saplings would require labor over a one or two day period. This need could either be supplied by hiring manual labor, giving Buildings and Grounds staff the task, or using faculty, staff, and student volunteers. It would be most beneficial for Colgate’s local reforestation plan to use volunteers as labor as this would provide significant social and educational benefits. “The whole idea of the reforestation project is to get people engaged and involved. There has been interest in reforestation projects for a long time,” said Pumilio (J. Pumilio, personal communication, October 6, 2011).

Student involvement would raise awareness about environmental issues facing our world, as well as how Colgate is addressing environmental degradation with their Climate Action Plan. A reforestation project would hopefully be a hands-on way to build excitement for sustainability initiatives on campus, and hopefully encourage students to get involved in other sustainability initiatives as well. Additionally, the local reforestation project would educate the Colgate community about the importance of trees and forest ecosystems.

Colgate’s Forester, Steven Bick, believes that this one-acre plot of land could be planted with just fifteen volunteers, who were committed to the project for a full day (S. Bick, personal communication, October 21, 2011). However, it would be more beneficial to have as many student, faculty, and staff volunteers involved in the tree-planting event. First, this would allow volunteers to take smaller, less strenuous shifts planting trees, which would most likely increase the quality of the plantings. Second, this would allow for many more individuals to get involve, which would maximize our educational and awareness goal with the project.

In order for the volunteers to reforest the land, Colgate will need to purchase enough tools to be able to plant about one acre of trees. The most widely used and cheapest tool for planting trees is a basic shovel. The preferred version is shovel with a long, narrow blade ideal for digging taller, narrower holes (S. Bick, personal communication, October 21, 2011).

An ideal example is the “True Temper 20 inch Wood D-Handle Drain Spade Shovel” from Lowe’s, item #229832 and model #1546300. Each shovel would cost $24.98 at the Lowe’s in Syracuse, NY.

Another option, the planting bar, is a manual tree-planting tool that is able to quickly create holes in the soil. One example, the “speedy dibble,” is a tool about 36 inches in length and is sold by Forestry Suppliers Inc. from anywhere from $29.75 to $36.95, depending on quantity bought. If Colgate were to purchase between 2-6 shovels they would each cost $33.30. The speedy dibble and other manual tree planting tools are used over traditional shovels because they require limited knowledge and experience to use (S. Bick, personal communication, October 21, 2011). They also create even and identical holes for planting, usually speeding up the process and producing better results, according to Bick (S. Bick, personal communication, October 21, 2011). Both could be stored and used for future reforestation projects, and therefore would be a good investment for the university.

It would be most beneficial for Colgate to facilitate the planting with a planting bar rather than shovels. Because students, faculty, and staff, most with no prior
knowledge of forestry, will be planting these trees, shovels will probably result in incorrectly dug holes. This would most likely lead to a high failure rate among the planted trees. On the other hand, tree planters would require little instruction and produce identical, and most importantly accurate, holes in which to plant the saplings. Additionally, tree planters would only cost $8.32 per tool more than shovels, so it is at no major financial cost.

**Recommendations**

We recommend that Colgate implement a pilot reforestation project in the spring of 2012 with the following attributes:

- On a one-acre area of land above the old ski hill
- Planting approximately two hundred and fifty black locust saplings
- Utilizing student, staff, and faculty volunteers to plant this acre during a tree-planting event in the spring
- Using planting bars to facilitate the tree planting and tree tubing to protect the sapling from deer
- At the end of the pilot project, observing the survival rate and any improvements that can be made for future projects
- Ideally, reforesting approximately two acres of land each year starting in the 2012-2013 school year

**Conclusion**

A local reforestation project has many benefits in the social and environmental realms. Through this project, a greater awareness for sustainability can be nurtured as well as provide something real and tangible for the Colgate University community to participate in. The environmental benefits, as have been discussed, are many. The primary purpose, though, is carbon sequestration in order to help Colgate achieve carbon neutrality by 2019. Our thorough research through interviews and literature reviews has enabled us to recommend a specific tree species, recommend a location for a local reforestation project, and provide a thorough protocol to insure our project is legitimate.

This project can also be used as a guideline for future reforestation plans not only by Colgate University, but for other academic institutions and entities as well. It can ultimately serve as a protocol for local reforestation projects both nation and worldwide. We believe our findings will play a crucial role when Colgate University begins its reforestation project in the spring of 2012.

**Bibliography**


**Appendix**

Appendix I
Calculation of CO2 Sequestration

**Sugar Maple**
Source: http://green.hope.edu/Brooks%20Midstates%20conference%20poster%20w%20kgm%20edits%20%281%29.pdf

611.7 kg/hectare year * 1 hectare/2.47 acres*1 metric ton/1000 kg*100 years = 24.77 metric tons
[Initial value provided from source]
Red Pine and White Spruce
Source: http://www.cinram.umn.edu/publications/landowners_guide1.5-1.pdf
Given 5 year increments of CO2 sequestered up until 20 years, used last value for remaining 80 years (assumed 100 years until carbon saturation)

Red Pine
5(2.68 + 3.38 +3.5+3.5) + 80(3.5) = 345.3 metric tons

White Spruce
5(1.28 + 1.28 + 1.4 + 2.56) + 80(2.56) = 237.4 metric tons

Black Locust

Used base information of trees that reach a maximum height of 60ft and a trunk diameter of 18 inches

From the source, we were given height of a Black Locust at 10 years, 25 years, and 40 years. In determining the other yearly values, a linear growth rate was applied and reached a maximum at 40 years. For diameter, we set the maximum, mature diameter at 40 years to coincide with mature height. Then, linear growth rates were applied to the earlier years.

The formula offered by the Trees for the Future source was used for calculating sequestration rates:

1. Determine the total (green) weight of the tree.
   \[ W = 0.15D^2H \] (or \(0.25D^2H\) if diameter is < 11 inches)
   \[ W = \text{Above-ground weight of the tree in pounds} \]
   \[ D = \text{Diameter of the trunk in inches} \]
   \[ H = \text{Height of the tree in feet} \]

   Including roots, multiply by 120%

2. Determine the dry weight of the tree: multiply the green weight of the tree by 72.5%.
3. Determine the weight of carbon in the tree: multiply the dry weight of the tree by 50%.
4. Determine the weight of carbon dioxide sequestered in the tree: multiply by 3.6663
5. Determine the weight of CO2 sequestered in the tree per year: divide the weight of carbon dioxide sequestered in the tree by the age of the tree.

250 trees per acre, therefore:
Multiply value from (5) by 250
Convert to metric tons
X lbs Carbon * 1 metric ton / 2204.62 lbs =
Metric tons carbon sequestered of 1-acre plot for that given year

<table>
<thead>
<tr>
<th>Years since planting</th>
<th>Diameter (inches)</th>
<th>Height (feet)</th>
<th>CO2 sequestered that year (metric tons)</th>
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