COLGATE UNIVERSITY CAMPUS FOREST OFFSET PROJECT ANALYSIS

Andrew Bianco, Felix Dalstein, Julia Feikens, John Post, Leda Rosenthal, Josh Winward

ENST 390 – Colgate Campus Forest Offset Team
December 2017

1. Executive Summary

Colgate University has committed to carbon neutrality by its bicentennial, 2019. While Colgate's *Sustainability and Climate Action Plan* (2011) and *Bicentennial Plan for a Sustainable and Carbon Neutral Campus* (2016) have allowed the university to make great strides in mitigating and avoiding GHG emissions, Colgate is expected to have a significant level of unavoidable net emissions due to ongoing operations (~8,961 MTeCO2[1]). Meeting the ambitious target of carbon neutrality cannot be reached without the use of carbon offsets to counteract the unavoidable emissions. Carbon offsets can be generated through a wide variety of projects that reduce, avoid, or sequester GHG emissions. Colgate has the option of either buying offsets generated by other organizations from the voluntary market or developing an offset generating program of its own. One offset project model is forest sequestration, which entails the protection, management, and enhancement of forests to sequester and store more GHGs, generating carbon offsets for the university.

Higher education has long overlooked the role of campus forests as potential carbon sinks to offset campus emission. Colgate is among the first higher education institutions to actively promote the importance of sustainable forest management and advance the role of forests in meeting GHG targets. From Colgate's 2013 study, the campus forest covers ~1,069 acres, contains 165,491 tons of stored carbon, and sequesters an additional 1,578 tons of carbon per annum. With such an extensive natural asset, Colgate has decided to further investigate the methods for utilizing its forest for further carbon sequestration and/or carbon offsets. Preliminary estimates suggest that the forest project could offset 9,000 MTeCO2 per year for 9 years (fully offsetting the expected emissions in 2019).

This research aims to answer four questions to determine if and how Colgate can use their forested land to reach its bicentennial goal: *(1) Is Colgate's forest a viable option for generating carbon offsets to help the university reach carbon neutrality? (2) If so, which existing forest offset protocol is most appropriate when considering variables such as Colgate's financial and temporal constraints, high-quality offset standards, public relations and acceptability, and others? (3) Can Colgate undertake this project using internal resources or does it make more sense for Colgate to hire an external consultant to help with project development, implementation, and ongoing management? (4) If all else is achievable, how should Colgate allocate the offsets generated (e.g. retain the offsets or sell a portion of them to generate revenue), and what potential revenue can be brought in for Colgate?*

Colgate has participated in forest-based offset programs since 2012, when it started a 15-year commitment with Patagonia Sur. The university funds the reforestation of 430 acres that will generate 5,000 carbon credits for $50,000 per year. Beyond this, several of Colgate's peer institutions have developed on-campus forest offset programs, which have proved to be financial and environmental assets. It is for these reasons that forest carbon offsets are viable for Colgate to pursue.

There are several third-party protocols that define and verify the quality of forest carbon offset projects. For Colgate's land, an offset project would likely follow the American Carbon Registry Improved Forest Management (ACR IFM) protocol. Choosing the ACR IFM protocol, and getting offsets verified and issued by ACR, allows Colgate to market any extra offsets generated. Alternatively, the university may work with Second Nature to adopt an 'Innovative Offset' or

[1] Estimated FY 2019 net emissions before the use of additional offsets, see Table 2

'Peer-Review' protocol, which would be closely modelled after the ACR IFM protocol. Choosing an 'Innovative Offset' or 'Peer-Review' protocol could expedite the development process. However, 'Peer-Review' protocol limits usable offsets at 30% of total emissions and, therefore, would not allow us to use the total number of offsets generated by the Colgate forest. In practice, these projects would largely entail the same level of monitoring and management, but would not generate an equivalent number of offsets. Furthermore, 'Peer-Review' protocol would forego the option to sell extra offsets on the voluntary market.

Beyond Colgate's current forest management and monitoring practices, pursuing a forest carbon offset project requires a variety of third-party verifications, applications, and other bureaucratic work. Colgate may choose to contract a project developer such as TerraCarbon to expedite the development process (1 to 2 years from proposal to accreditation). Colgate may also choose an in-house development process to avoid extra cost, possibly increasing the development period (3 to 5 years from proposal to accreditation).

While Colgate has several possible project scenarios, one thing is clear: pursuing an on-campus forest carbon offset program would be cheaper than purchasing offsets off of the voluntary market if Colgate chooses the ACR IFM option. Voluntary market offsets can be purchased for ~$6 to $8 per ton, whereas offsets produced by Colgate's forest project in the ACR IFM scenarios would cost an estimated $3 to $4 per ton. Going through Second Nature, offsets would cost $5.5 to $8 per ton. Over the course of 9 years, Colgate would have to spend between $376,450 and $778,651[2] to purchase the necessary amount of offsets, off the voluntary market to reach neutrality. Conversely, if the university pursued a forest carbon offset project using the ACR IFM approach, it would only spend between $242,036 to $327,156[3] over the same period for the same number of offsets. Consequently, this research concludes that Colgate could greatly benefit from further developing a forest offset project. Even in the case of Second Nature scenarios, where an additional $199,644 to $330,355 would have to be paid on supplementary offsets, the on-campus carbon offset project could be justified.

In short, from a financial standpoint, the offsets generated from Colgate's Forest will most likely be more cost effective than acquiring offsets off the voluntary market. From a public relations standpoint, the issuance of offsets for a successful program will reflect objective verification of the university's commitment to environmental stewardship and a sustainable mode of operation—especially with Second Nature. Hence, this analysis advises Colgate to develop an on-campus forest carbon offset project.

[2] See Table 12: Net Present Value of Future Offsets
[3] See Table 13: Estimated Benefits and Costs of Pursuing Campus Forest Offset Project

2. Table of Contents

3. List of Figures & Tables

4. Acknowledgements

Dr. Steven Bick, Certified Forester of Northeast Forests LLC at Colgate University

Jack Byrne, Director of Sustainability Integration at Middlebury College

Rick Klotz, Assistant Professor of Economics at Colgate University

Andy Pattison, Assistant Professor of Environmental Studies at Colgate University

John Pumilio, Director of Sustainability at Colgate University

Scott Settelmyer, Managing Director at Terracarbon LLC

David Shoch, Director at Terracarbon LLC

Bob Turner, Associate Professor of Economics and Environmental Studies; Chair, Department Of Economics at Colgate University

Christopher Wells, Senior Advisor to the President; Assistant Dean for Administrative Advising at Colgate University

Ruby Woodside, Innovative Services Manager at Second Nature

5. Definition of Terms

Term	Definition
MTeCO2	Metric Tons of Carbon Dioxide Equivalents
Greenhouse Gasses (GHGs)	Gasses released into the atmosphere derived from the combustion of fuel, use of refrigerants, decomposition of waste, and other sources.
Carbon Offset (or Carbon Credit)	One MTeCO2 of reduced, sequestered, or avoided emissions
Gross Emissions	Total measurable and estimated MTeCO2 emitted
Net Emissions	Total measurable and estimated MTeCO2 emitted less carbon offsets
American Carbon Registry (ACR)	A carbon offset program responsible for registering and verifying carbon offset projects (in line with ACR protocols) to issue carbon credits to compliant offset projects
Improved Forest Management Protocol (ACR IFM)	Protocol developed by American Carbon Registry that entails active forest management (such as increasing tree density and removing diseased trees) to increase carbon sequestration and stock that exceed baseline practices.
Avoided Conversion Protocol (CAR AC)	Protocol developed by the Climate Action Reserve that entails the prevention of privately owned forested land conversion to non-forest land use.
Climate Action Reserve (CAR)	A carbon offset program responsible for registering and verifying carbon offset projects (in line with CAR protocols) to issue carbon credits to compliant offset projects
Compliance Market	Offsets sold through the California Climate Registry. Offsets sell for $10-$12 per MTeCO2
Voluntary Market	Market for carbon offsets that exists outside compliance markets to enable businesses, NGOs, and individuals ability to buy carbon offsets.
PAVER	Five widely followed criteria that an offset must satisfy; Permanence, Additionality, Verifiability, Enforceability, Real
Permanence	The GHG reduction of a potential offset project must last in perpetuity and GHGs cannot be re-released into the atmosphere
Additionality	The GHG reduction of a potential offset program would not occur in a business-as-usual scenario and is motivated by the offset market
Verifiability	The GHG reduction of a potential offset project must be verifiable with data and regularly monitored by qualified third-parties
Enforceability	An offset credit can only offset 1 MTeCO2 and must be retired after its first use
Real	An offset must represent a 1 MTeCO2 reduction and cannot be quantified through false accounting methodology
Scope 1 Emissions	Emissions directly produced and emitted by sources owned or controlled by an institution
Scope 2 Emissions	Emissions associated with the consumption of energy that was produced outside of an organisation

Scope 3 Emissions	Emissions indirectly associated with business operations from source not owned or controlled by the respective company
Bluesource	A Carbon offset company which works with institutions to develop projects and secure offsets. Bluesource keeps all offsets developed by said project, gives the institution the first option to buy back their offsets for a discounted price, and sells the rest on the voluntary market splitting the profits with said institution.
TerraCarbon	A leading environmental advisory firm which develops carbon offset projects to help fund forest and wetland conservation.
Second Nature Carbon Commitment	Formerly the American College & University Presidents' Climate Commitment (ACUPCC); a commitment by institutions of higher education to strive for carbon neutrality and to educate and lead in climate action. Requires Colgate to follow Second Nature's Principles of High Quality Offsets for the use of any carbon offsets
Second Nature Peer-Reviewed and Innovative Carbon Offsets (PRICO)	Peer-reviewed ● Generated credits can only apply to Scope 3 emissions and only up to 30% of gross emissions ● Monitored through a peer-to-peer network for third-party review ● Must comply with reputable protocols (e.g. ACR IFM or CAR AC) ● Provides hands-on educational opportunities for students ● Fosters development of small scale projects ● Reduces risk of developing new registered protocol Innovative ● Generated credits can only apply to Scope 3 emissions and only up to 10% of gross emissions ● More experimental ● Must outline which offset principles apply, which don't Must include a transition plan for more rigorous verification
Carbon Reserve Tonne (CRT)	Represents one metric ton of carbon dioxide equivalent emissions reduction or sequestration (CO2e)
Net Present Value	The current monetary value of a future asset or liability. Present value is found through discounting future values to give more weight to present or near-term values.

Table 1: Definition of Terms

6. Introduction

6.1 Research Overview

Colgate recognizes the need for carbon offsets to serve as a near term amelioration for unavoidable carbon emissions and cites the utility and necessity of carbon offsets in the *Sustainability and Climate Action Plan* (2011) and *Bicentennial Plan for a Sustainable and Carbon Neutral Campus* (2016). Carbon offsets or carbon credits are a measure of the amount of carbon dioxide equivalents (MTeCO2) reduced, sequestered, or avoided, and are used to offset GHG emissions elsewhere. Colgate University's Carbon Offset Working group is currently evaluating the costs and benefits of the various available offset programs, and have been tasked to:

- Place a high value on academic and research opportunities that go hand-in-hand with an offset program.
- Consider community-based and/or local investment options.
- Invest in high-quality offsets that are either third-party certified or have direct and measurable carbon and community benefits.
- Evaluate all options for socially responsible, community-based, economic, and environmental co-benefits[i].

In line with Colgate's above framework, this research aims to evaluate the feasibility and recommend steps toward developing an on-campus forest carbon offset program. Colgate University has 1,059 acres of forested land around its campus, which, if managed in compliance with specific third-party standards and recording methods, could produce a significant number of carbon offsets for the university to either use internally or sell through the voluntary market to generate revenue. This program would likely satisfy all four aforementioned responsibilities of the Carbon Offset Working Group, while also partially or completely offsetting Colgate's unavoidable emissions in the near-term. To evaluate the course of action in respect to the potential on-campus forest offset project, this research investigates and offers potential solutions to four key questions.

(1) *Is Colgate's forest a viable option for generating carbon offsets to help the university reach carbon neutrality?*
Carbon offsets come in a wide variety of forms but can be generally classified into two groups: projects that reduce or avoid emissions, and projects that sequester free GHGs from the atmosphere. Both forms of offset programs are currently being pursued by Colgate, in accordance with the Sustainability and Climate Action Plan (2011) and Bicentennial Plan for a Sustainable and Carbon Neutral Campus (2016). If done correctly, these plans have the potential to utilize Colgate's forest as a carbon sink in order to achieve carbon neutrality.

(2) *If so, which existing forest offset protocol is most appropriate when considering variables such as Colgate's financial and temporal constraints, high-quality offset standards, public relations and acceptability, and others?*
There are a variety of third-party protocols that have been established to ensure the quality and honesty of forest management and reporting. This study investigates three potential protocols to efficiently verify, register, generate, and (if necessary) market Colgate's carbon offsets. These protocols lay out very specific guidelines for forest management, and the choice of protocol may affect the costs of development and operations as well as the quality and quantity of offsets generated from the Colgate campus forest.

(3) *Can Colgate undertake this project using internal resources or does it make more sense for Colgate to hire an external consultant to help with project development, implementation, and ongoing management?*
Considering the complexity of the potential protocols, project development can be both costly and time consuming. Colgate's campus forest offset program only makes practical sense when it is cost effective and would ideally be executed before the university's 2019 neutrality goal. Colgate has already generated a sizable inventory and analysis of its campus forests, but third-party organizations may prove crucial for project development, protocol compliance, and general expediency.

(4) *If all else is achievable, how should Colgate allocate the offsets generated (e.g. retain the offsets or sell a portion of them to generate revenue), and what potential revenue can be brought in for Colgate?*
Assuming the project is possible and appropriate for Colgate, the university has to decide on how it will use its offsets. The most probable case is that the university retains all offsets to achieve neutrality. If the chosen development strategy generates more offsets than necessary for reaching neutrality, the university can sell extra offsets to bring in revenue. Due to the size of our forest, unless the university decreases gross emissions below the current estimate of 14,000 MteCO2, there will likely not be extra offsets to sell.

6.2 Sustainability at Colgate

Colgate University's commitment to teach and practice sustainability effectively began in 2008, when the university became a signatory of the American College and University Presidents' Climate Commitment (ACUPCC)[4]. In Colgate's *Sustainability and Climate Action Plan* (2011), it pledged to become carbon neutral by 2019, the university's bicentennial.[ii] The university has since produced the *Bicentennial Plan for a Sustainable and Carbon Neutral Campus* (2016) which outlines specific programs for reaching this goal. Colgate's mission to become carbon neutral emphasizes its commitment to the environment and ensuring its students become strong leaders and thinkers through their education.

The majority of the programs created for emission reduction at Colgate have been in-house, and centered on upgrading to sustainable, energy efficient technology. In addition, projects like the Green Bikes Program and No-Idling Policy have been implemented in order to encourage more sustainable behavior amongst students, faculty, and staff while also lowering university emissions. The Green Bikes Program, for example, creates an eco-friendly transportation alternative to using cars on and across campus while promoting physical health for students. One project in particular, Colgate's Forest Sequestration Project, stands out from the others. The university currently subtracts the amount of carbon sequestered by our forests, 1,578 MTeCO2 annually, from our total emissions. To avoid double counting, this reduction cannot be accounted for in addition to a campus forest project. If Colgate pursues a verified offset program, the credits generated will reflect both the annual sequestration rate and the total stored carbon.

Currently, Colgate is involved in a 15-year offset investment with Patagonia Sur's reforestation project. The university supports nearly 430 acres of indigenous trees within the Patagonia Sur Nature Reserve, located in Valle California, which is in the Palena region of southern Chile[iii]. In

[4] Now the Second Nature Carbon Commitment (See Table 1)

turn, Colgate receives 5,000 MTeCO2 per annum. However, these offsets will cease upon the agreement's end in 2027.

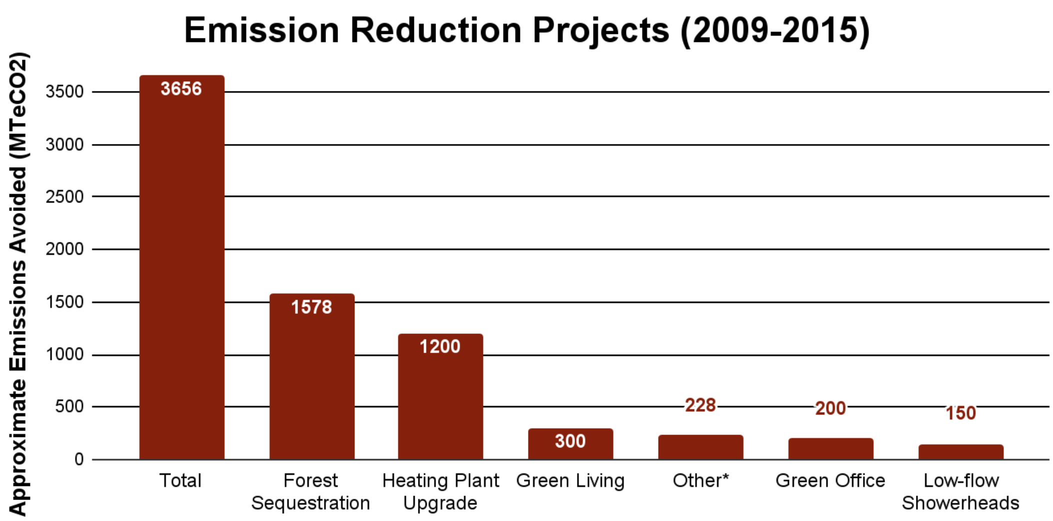

Figure 1: Colgate has taken several concrete steps to reduce its gross carbon footprint, and has mitigated 3,656 MTeCO2 since the baseline year of 2009.
[1]*Other Programs: Geothermal Energy Chapel House (~50 tons), Lighting Upgrades (~40 tons), Fume Hood Monitoring (~35 tons), Onsite Pre-consumer Composting (~20 tons), Reforestation of 2 acres (~20 tons), No Idling Policy (~10 tons), Green Bike Program (~10 tons), Washer & Dryer Upgrades (~10 tons), Solar Thermal Energy (~9 tons), Reduced Mowing (~6 tons), Electric & Hybrid Vehicles (~5 tons), Improved Recycling (~5 tons), Trayless Dining in Dining Hall (~5 tons), Recycled Paper Purchasing (~3 tons)*

Colgate's current emission trajectory, as well as the fact that the university will be constructing additional buildings, reveals that carbon neutrality will not be possible through sustainability projects alone. As Figures 2 and 3 illustrate, the variability of emissions within the three scopes prevent such drastic emission decrease within the time remaining until 2019. Furthermore, increases in construction on campus and the rise in Colgate's logistic emissions, found in Figure 3, reflects the near impossibility of the university's carbon goal while university air travel, employee commuting, campus construction, etc. continue. Consequently, offsets will be necessary for Colgate's carbon neutrality goal.

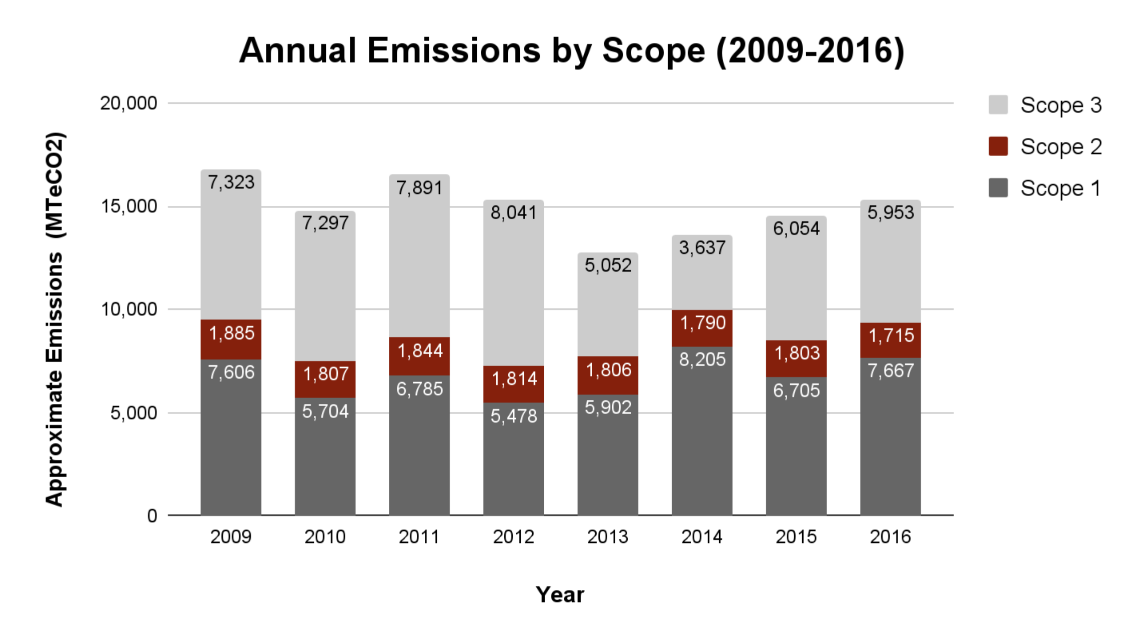

Figure 2: Colgate's annual emission scope is reducing; however, with the increasing rates of recent years, total carbon neutrality from in-house reductions alone is becoming less feasible.

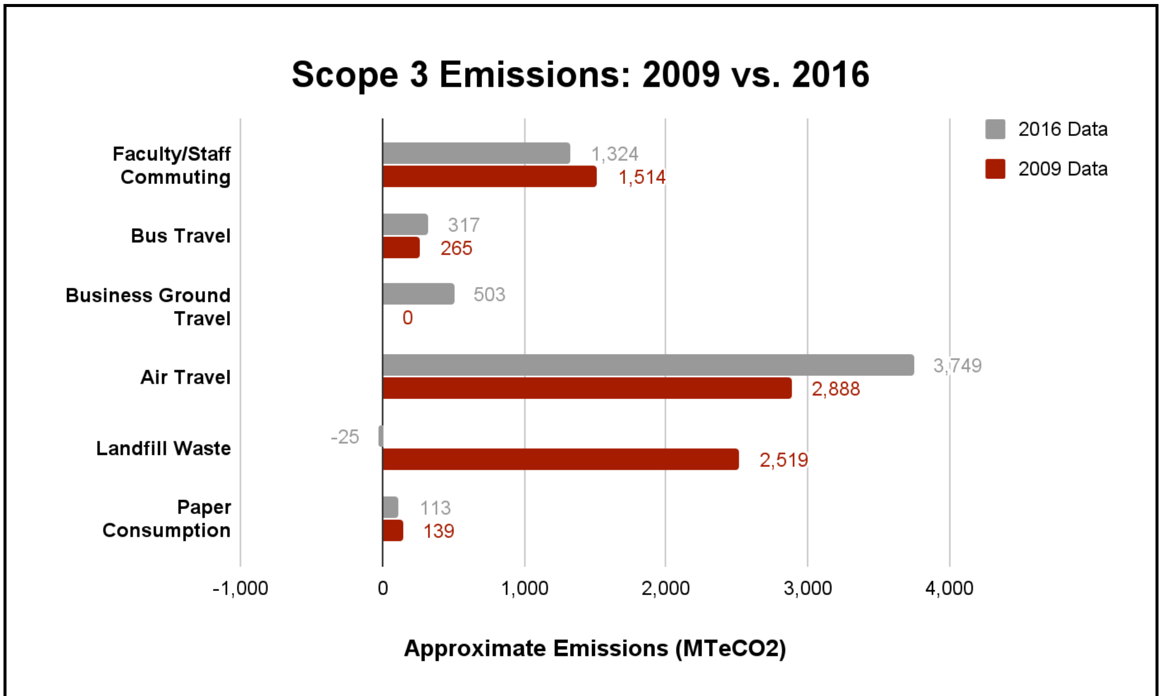

Figure 3: Scope 3 emissions are the hardest to control, due to the overall variability and, in the case of Colgate, increasing rates of travel.

NOTE:
While generally working towards carbon neutrality, there have been instances where Colgate has not followed their guidelines. One example is the remodeling of Stillman: all major new constructions and renovations of buildings should be LEED certified; however, the recent renovation for the Stillman dormitory did not achieve LEED certification. These inconsistencies, while perhaps not major, do impact the overall progress of Colgate's commitment to sustainability and overall carbon neutral goal.

Year	Gross Emissions (MTeCO2)	Net Emissions (MTeCO2)	Offsets (MTeCO2)
2009 (Baseline)	16,815	16,806	9
2010	14,807	14,807	0
2011	16,520	16,520	0
2012	15,333	10,219	5,114
2013	12,759	4,374	8,385
2014	13,631	5,263	8,368
2015	14,562	7,984	6,578
2016	15,361	8,783	6,578
2019 (Estimate)	13,961[1]	8,961[2]	5,000[3]

Table 2: Annual Gross Emissions, Net Emissions, and Offsets
[1]*Due to the variability of Heating Degree Days (HDD) from year to year, values for projected gross emissions FY 2019 vary from 13,139-13,961 MTeCO2. This study uses the highest value in the range to produce a conservative cost-benefit analysis.*
[2]*Net emissions before use of additional or proposed offsets - value will be zero if carbon neutrality is achieved.*
[3]*Offsets from the Patagonia Sur forest offset program, Colgate has a binding investment and will continue to receive 5,000 carbon credits for $50,000 per annum ($10 per MTeCO2)*

6.3 Peer University Case Studies

6.3.1 Case Study 1: Middlebury College

Recently Middlebury College received a notable amount of attention for their ability to meet their goal of achieving carbon neutrality (Fig. 4). They achieved this goal through a combination of drastically reducing their emissions and utilizing carbon offsets. In 2008, Middlebury incorporated a biomass gasification plant which allowed them to replace 1 million gallons of #6 fuel oil with carbon neutral woodchip gasification. By 2016, this plant allowed Middlebury to reduce their carbon emissions by ~50%. While the use of woodchips as a “clean” fuel source is often a controversial topic with regards to whether or not woodchips are actually carbon neutral, according to the Greenhouse Gas protocol, “carbon emissions are counted when trees are cut, not when they are burned”[iv]. Thus, biomass gasification is a carbon neutral fuel source if and only if the growth rate of a forest is greater than the rate at which trees are being harvested. As such Middlebury commissioned a study by the Vermont Family Forest and the Biomass Energy Resource Center which discovered significant net growth and availability of forests in Vermont and New York to provide biomass. In fact, the 21,000 tons of biomass burned by Middlebury per year represent only 1% of the net growth of the forests indicating that woodchips can be a readily available and renewable fuel source. Due to Colgate’s proximity to Middlebury Colgate would also be able to source trees from the same forests which have been shown to support agroforestry and biomass utilization to reduce our own fuel consumption as well[5].

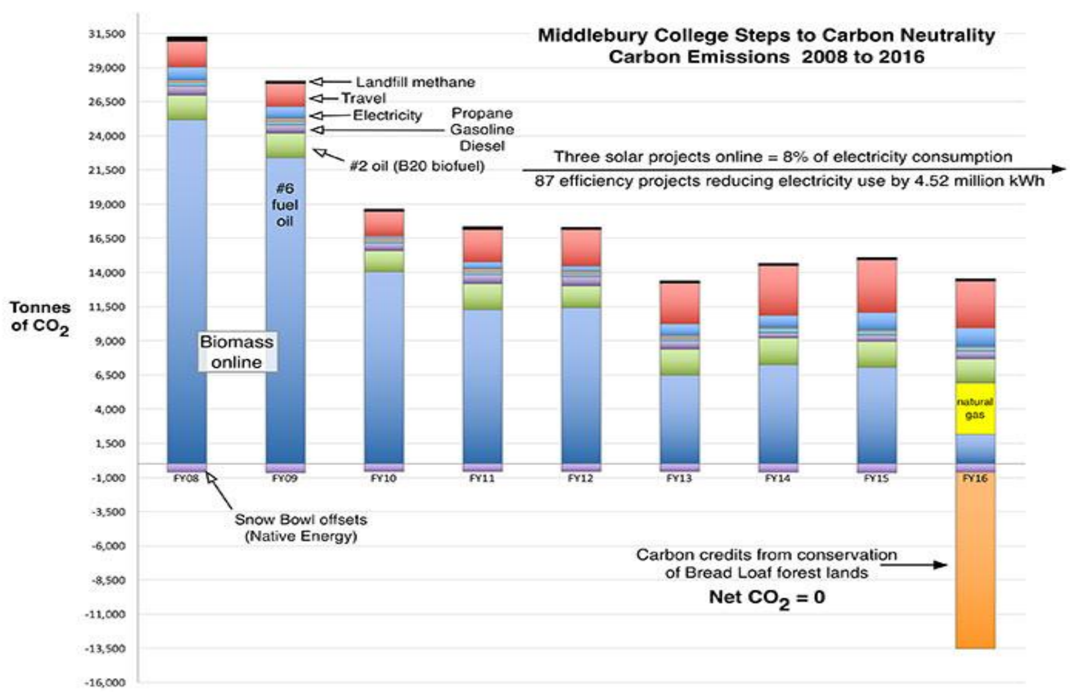

Figure 4: Middlebury’s timeline to carbon neutrality shows the drastic decrease in consumption after the switch from fuel oil to biomass as well as a further decrease in fuel oil after the switch to natural gas. Given the drastically decreased consumption this graph shows that Middlebury was able to offset the rest of their carbon footprint solely through their Bread Loaf offsets in FY16.[v]

However, even with the biomass gasification plant Middlebury was still tasked with offsetting 12,905 MTeCO2. In order to meet these offset goals, Middlebury looked to their Bread Loaf Forest, a forested portion of their satellite Bread Loaf campus, as a fast and cost effective means to completely offset their remaining carbon emissions. Middlebury worked in coordination with the Vermont Land Trust to place an easement on the land so that it would stay a managed forest in perpetuity. To ensure that Middlebury met the PAVER requirements Middlebury developed this project with the help of Bluesource and followed the ACR IFM protocol. Middlebury was then able to claim the credits from this forest as a carbon offset as they were preventing the potential deforestation of their Bread Loaf Forest and ensuring the

[5] See Ecological Benefits (Section 8.3)

improval of the forest stock and health beyond business as usual practices. Timing was incredibly important with respect to this project, after the easement was placed on the land Middlebury only had one year to complete the project and claim the carbon credits otherwise these offsets would not have been seen as additional. After the easement was in place, Middlebury registered their project with Bluesource and hired third party verifiers to quantify the amount of carbon sequestered in the forest. The total amount of carbon that was sequestered by the forest was roughly 25,000 MTeCO2 per year for the first six years. After the initial six years the number of carbon offsets available to Middlebury drops to 7,000 MTeCO2 per year representing the amount of carbon sequestered each year by the forest not the avoided harvesting credits.

Since Middlebury only needed to offset 12,905 MTeCO2 per year to mitigate their total carbon emissions, the rest of the carbon credits were sold through Bluesource to reduce the net cost of the project. Bluesource retains all offsets issued by ACR, and gives Middlebury the option to buy back up to 15,000 offsets per year at $10 per per offset. Bluesource splits the profits from offsets sold, 60% to Middlebury, 40% to Bluesource, effectively giving Middlebury a 40% discount on their own offsets giving them a net cost of $6 per offset. The remaining credits not purchased by Middlebury are sold on the voluntary market for $10 per offset. It is impossible for Middlebury to have an exact figure for how much they stand to profit as they do not know how much carbon they will need to offset in the future. However, conservative estimates show that Middlebury would earn anywhere between $250,000-$400,000 through selling their excess offsets. While these numbers will constantly be in flux due to the uncertainty of Middlebury's exact future carbon offset needs, this projects demonstrates that, by using their own forest, they were effectively able to profit from achieving carbon neutrality.

The potential of using a forest to offset carbon is almost identical to the situation Colgate is currently in, which makes Middlebury a prime case study on which to base Colgate's potential offset model. However, there may be issues regarding the economies of scale relating to the size of our forest. Colgate's forest is roughly half the size of Middlebury's (1,059 acres compared to Middlebury's 2,100), and only needs to offset ~9,000 MTeCO2 while Middlebury had to offset 12,905 MTeCO2. After speaking with Bluesource they are not interested in our project since there are not enough potential carbon credits available for a project of our scale to be profitable to them as demonstrated by the CBA below. While Colgate's forest may be smaller and the revenue generated may be lower than Middlebury's, pursuing an ACR IFM protocol is still a viable option for Colgate as the cost per offset of achieving carbon neutrality through implementing a forest project is still lower than the baseline scenario of simply buying all of the required offsets.

6.3.2 Case Study 2: Duke University

Unlike Middlebury College, Duke University is not yet carbon neutral, but they have made a commitment to achieve carbon neutrality by the year 2024. While comparisons between a university with over 14,000 students and a small liberal arts college may not seem helpful, there is much to learn from Duke's projects. Duke's total emissions far exceed that of Colgate or Middlebury (185,000 MTeCO2 as compared to ~15,000 and ~13,000 respectively), as such Duke's carbon offset programs as useful to inform Colgate's decisions due to the innovation in this field required to offset such a large amount of carbon.

Understanding that their goal of achieving carbon neutrality will not be possible without the use of carbon offsets, Duke University founded the Duke Carbon Offsets Initiative (DCOI) in 2009 to explore different carbon offset and sequestration programs. Since Duke is such a large university with a much larger budget for carbon offset projects than Colgate University, Clarkson University, and Middlebury College, they could have simply purchased the necessary carbon offsets. However, the DCOI did not believe this was the best solution as there would be no co-benefits associated with such a plan. Instead, Duke became the first university in the country to implement an offset bundling strategy. Offset bundling is the practice of combining marketable low cost offsets which represent real and permanent reductions and pairs them with university led projects with high co-benefits to the surrounding community. For example, given a budget of $50,000 to invest in carbon offsets:

> The institution could (1) choose to invest only in innovative projects and potentially yield a few offsets at a high cost but with numerous co-benefits, (2) choose to invest in low-cost 3rd party offsets with a measurable climate impact but few local co-benefits, or (3) the institution could choose to bundle and achieve both goals, with a targeted cost per offset in mind. With the goal of keeping the total cost per offset at $10 and an internal budget of $50,000, Duke could invest in 5,000 3rd party verified offsets at $2.00 each and secure $40,000 for an innovative project with direct co-benefits to the university and community.

Thus, the university secures 5,000 guaranteed carbon offsets as well as producing effective change in their own local community.[vi]

After deciding to acquire carbon offsets through bundling, Duke University partnered with Urban Offsets in 2016 to reduce emissions through urban forestry, thus providing benefits to local cities as well as the university. Urban Offsets is an offset organization which aims to provide carbon offsets through the planting of trees in cities. Rather than focusing on global emissions reduction such as the Patagonia Sur offset program currently utilized by Colgate University, Urban Offsets aims to reforest urban areas local to the university organizing the project. For example as of 2017, with the help of Urban Offsets, Duke University has planted 40 trees in Wilson, North Carolina, and intends to plant 400 trees in 5 cities across North Carolina and Arizona. This program not only provides offsets for Duke as well as increasing the green-space in cities, but also allows the university to use tree planting projects as a learning opportunity for students.[vi] While this may be relevant and feasible at a university set in an urban environment such as Duke university this would not have as large of an impact at a school such as Colgate. This is due to the fact that Colgate is already in a rural agrarian area surrounded by trees and not lacking in green-spaces, thus the potential value added through planting 40 trees in Hamilton, NY would not be as great as in Wilson, NC.

6.3.3 Case Study 3: Clarkson University

Clarkson University represents a third case study closely related to Colgate with respect to pedagogical value. Clarkson University is in position similar to the one that Colgate was in a few years ago. Clarkson currently needs to offset roughly 17,000 MTeCO2 in order to meet their 2025 carbon neutrality commitment. However, since Clarkson does not have significant tracts of forested land that could be protected and used as an emissions mitigation measure, their offsets have to be acquired using a different method. Clarkson's solution to this is two fold. First, they plan on increasing the efficiency of their heating and electricity by partnering with renewable energy companies in efforts to reduce gross emissions. Additionally, Clarkson will use carbon offsets to offset the rest of carbon emitted.[vii]

Clarkson's carbon offset program is quite similar to the Colgate's own Patagonia Sur project. Both projects provide verified offsets to the institutions, in addition to providing pedagogical value. Clarkson's Uganda forest offset program brings business and ecology students over to Uganda to teach the locals about each species of tree and plant and about agroforestry practices. After learning about each specific species and proper agroforestry techniques, the local community members are taught to map out their own farms to determine the optimal location to plant their trees. This program simultaneously educates local community members on why each plant and tree is being chosen, as well as teaches students about the offset project and local culture. Additionally, many of these trees are provided through micro-loans, which gives business students an opportunity to learn financial component of forest offsets.

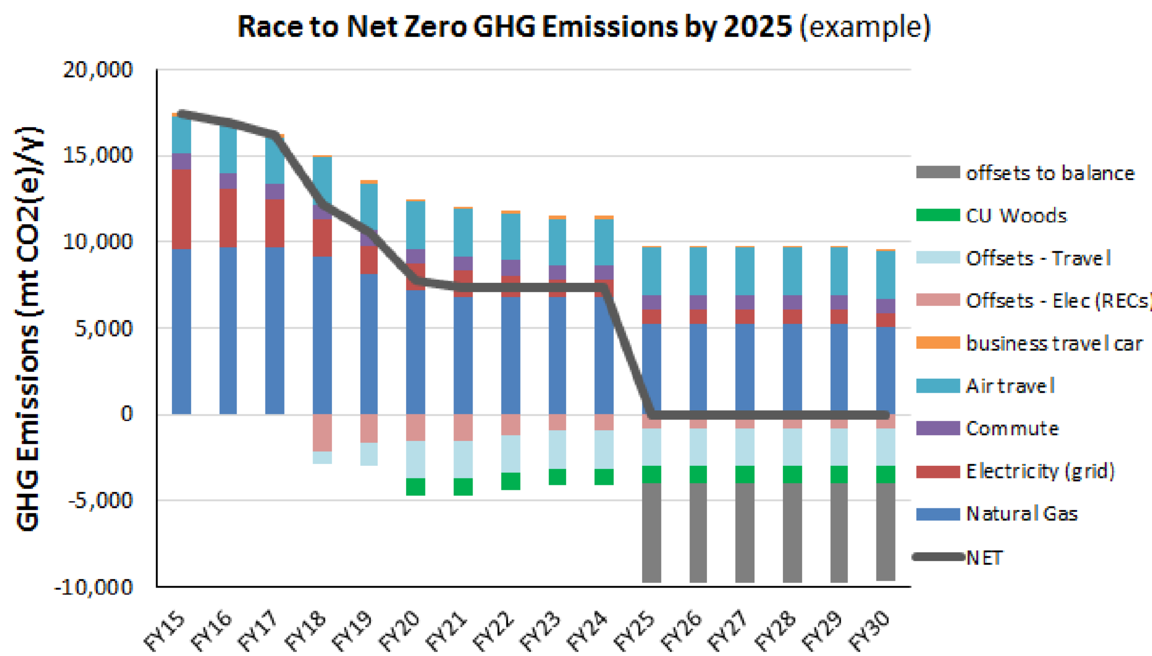

Figure 5: Clarkson's projected emissions for the next 13 years shows an expected decrease in GHG emissions over the next 5-10 years and demonstrates that once their offsets from Uganda come online in FY25 they should be enough to fully offset their carbon footprint.[vii]

As it currently stands, Clarkson has 10,000 trees ready to be planted in Uganda. Although the offsets are not currently validated (likely 5 to 10 years before the project is verified and can generate usable offsets (see Fig. 6)), this is a promising start for Clarkson.[vii] Given that Colgate's Patagonia Sur project includes 13,000 trees, offsetting 25,671 MTeCO2, Clarkson can likely expect to receive 19,746 MTeCO2 from their 10,000 trees - enough to meet their offset goal.[6] These projects show that reforestation in foreign countries can often be an efficient mode of developing real carbon offsets. However, while such projects do not provide the local benefits that a project such as Duke University's will, they do provide a substantial number offsets and pedagogical value that benefit the school and students.[viii]

[6] Footnote: number based on interpolating from colgate's returns. 25,671/13,000*10,000

7. Viability of Forest Carbon Offsets

7.1 Offset Protocols and Markets

7.1.1 Voluntary Offset Market

The Voluntary Offset Market, or Voluntary Environmental Programs (VEPs) encourages the mitigation of emissions for businesses, individuals, and other organizations that are not required to reduce their carbon footprint. Unlike the compliance market, VEPs promote encouragement for offsets rather than forcing compliance through mandations.[ix] This program is only one of several approaches to voluntary offsets. However, it is seen as the most favorable among US companies, for reasons discussed below. This market has become very popular, to the degree that in the late 1990s over 13,000 businesses were participating in VEPs[x], including offsets from either the Clean Development Mechanism under the Kyoto Protocol or in the voluntary market. VEPs consist of various programs that promote emission mitigation that goes beyond required regulations.[xi] These requirements from the mandatory market included placing emission limits on regulated companies, and enforced said organizations to procure permits, install various mitigation equipment, and follow various procedures such as those for disposing hazardous waste.[xii] However, these mandations became hard to follow due to their rigorous and costly nature.[xiii] Consequently, VEPs were designed to be more flexible and open so that mitigation of emissions could both be easier and more efficient.

Over recent decades, VEPs have become the most popular choice for purchasing offsets within the US for a variety of reasons. For example, it promotes positive reinforcement for mitigating emissions through reducing requirement penalties and rewarding companies that reduce their carbon footprint.[xiv] In addition, the voluntary market is considered less costly due to the fact that companies do not need to set up programs or buy equipment as required in the compliance market.[xv] The lack of regulations within VEPs further emphasize innovative means of emission mitigation, creating more offset opportunities. Companies that are active in VEPs not only receive offsets but they also identify themselves as proactive and invested in reducing carbon emissions overall, which bolsters their reputation as a forward-thinking business.[xvi]

The voluntary market does not come without limitations. As offsets from the voluntary market are not mandatory, their trading volumes are smaller due to the fact that their demand comes from only voluntary buyers. In contrast, demand in the compliance market is created by regulatory instruments.[xvii] There are also no established rules and regulations within the voluntary market, unlike the compliance market where all measures are given specific guidelines. Consequently, there may be some concern that businesses push for VEPs in order to avoid such strict measures in order to hide their lack of sustainable development.[xviii] Furthermore, the voluntary market in general may not generate as much of an impact as the compliance market due to the fact that there are no overall regulations for businesses.[xix] Nevertheless, due to the low cost of these respective carbon credits, the voluntary market serves as a positive testing field for new procedures, methodologies, and technologies that may later be included in regulatory schemes.

Colgate's involvement within the voluntary market reflects its commitment to reduce its carbon footprint while not being required to do so by the federal government, which prevents the university from entering the compliance market. Thus, the university's use of the VEP proves that the institution is willingly and soundly committed to its bicentennial goal of carbon neutrality.

PAVER Definition	
Permanence	Emission reductions or removals are permanent if they are not reversible; that is, the emissions can't be re-released into the atmosphere.
Additional	Activities that would have happened without such incentives are business-as-usual and do not represent new emission reductions.
Verifiable	Credible offset programs require that emission reductions be monitored and regularly verified by an independent, qualified third party.
Enforceable	One credit can only credibly offset one ton of CO2e emissions; as a result, it must be tracked and it must be possible to enforce its ownership and use in order to avoid double counting.
Real	GHG offsets must represent one ton of CO2e greenhouse gas emissions reduced or sequestered as a result of an activity undertaken for the purpose of reducing emissions.
Table 3: Definitions of PAVER[xx]	

7.1.2 PAVER: Definition and Importance

PAVER is an acronym that explicates five essential components for carbon offset credits in order to ensure integrity[xxi] in terms of environmental quality. Its existence is necessitated due to the lack of consistent regulation in the offset market, posing an issue of legitimacy for the entire offset market. First and foremost, it is challenging to get consistent baseline metrics since they measured by firms themselves (for the purposes of this report, the firm refers to Colgate)[xxii]. Furthermore, due to the fact that offsets are inherently definitional, it is important to follow PAVER guidelines to ensure the production of high quality offsets that can be recognized by an accredited offsets registry program.[xxiii]

Baseline emissions, or determining business as usual levels of emissions, is inherently challenging due to the aforementioned lack of consistent regulation. However, firms also have the ability to adjust their baselines (which are private information) which amplifies the challenge of obtaining offset legitimacy for all participants in the offset market. The latter also leads to "asymmetric information" issues in the carbon offset market, where asymmetric information is the difference in baseline estimates from firms and the emissions cap set by regulators.[xxiv] Adverse selection and moral hazard are the key asymmetric information issues (which will be explained using Colgate-specific examples in the following paragraph).

While Colgate elected to become carbon neutral by 2019, in theory, it is also at risk of becoming at fault of asymmetric information issues. For example, it would be possible for Colgate to inflate its baseline emission levels for Sector 3 emissions and essentially claim that it is creating offsets that would have happened anyways, which is also known as additionality, and is a component of adverse selection. The moral hazard issue is when firms profit from offsets, which also stems from the fact that emissions baselines are inherently challenging to measure[xxv]. Moral hazard is most relevant to Colgate in the sense that it is cheaper for Colgate to buy offsets, which reduces the incentive for it to abate. From a purely financial standpoint, reducing emissions is expensive. However, by buying them or creating a remote offset program like the one in Patagonia, the university delays both abatement and investment in low carbon technology, both of which would be a detriment to Colgate's long-term carbon neutrality.

Nevertheless, when considering offsets projects, asymmetric information issues must be considered; it essential that Colgate follows PAVER to combat the offset market's dubious reputation and ultimately ensure the project's legitimacy. For a university like Colgate to participate in the offsets market and create its own offsets, it is essential that they follow a consistent metric to the fullest extent possible, and PAVER is the easiest way to ensure such.

7.1.3 American Carbon Registry Improved Forest Management Protocol

The American Carbon Registry's (ACR) Improved Forest Management (IFM) protocol is designed to quantify GHG emission reductions resulting from forest carbon projects by exceeding baseline forest management practices. This methodology is applicable only on non-federally owned forestland within the US, qualifying Colgate's forest to potentially generate offsets. As of November 2016, Colgate's forests contain 165,491 tons of stored carbon, and sequester an additional 1,578 tons[xxvi] per year. By the end of the crediting period, the project must demonstrate an increase in on-site stocking levels above the baseline condition. In accordance with the ACR's *Forest Carbon Project Standard v2.1*, all projects will have a crediting period of 20 years, with a minimum project term of 40 years.[xxvii]

Carbon Pools	Justification / Explanation of choice	Satisfied by Colgate's current practices?
Above-ground biomass carbon	Major carbon pool subjected to the project activity	Yes
Below-ground biomass carbon	Major carbon pool subjected to the project activity	Yes
Standing dead wood	Major carbon pool in unmanaged stands subjected to the project activity. Project proponents may also elect to include pool managed stands. The pool must be estimated in both the baseline and with project cases.	Yes but would need to expand to all Colgate forests applying as an IFM project
Lying dead wood	Project proponents may elect to include the pool. The pool must be estimated in both the baseline and with project cases.	Yes but would need to expand to all Colgate forests applying as an IFM project
Harvested wood products	Major carbon pool subjected to the project activity	Yes in forests currently engaging in harvest practices

Table 4. ACR[xxviii] carbon pools requiring measurement before project implementation as well as during in order to qualify as an officially recognized Improved Forest Management project.

In order to qualify as an official ACR's Improved Forest Management project, multiple data parameters must be monitored (see Tables 4, 5, 6). ACR IFM projects must record and analyze the state of carbon pools in the project area, see table 4. The project, as well as the sample plot area, must be recorded in order to determine the viability of not only the proposed space but also the overall scale of the project. The tree species and biomass must be determined to properly calculate the amount of carbon sequestered annually by the forest offset. To qualify for the protocol, Colgate must also measure and report the dead wood pool within the project area, in addition to the wood products associated with prior forest management. Colgate already has a strong forest monitoring process in place, making these additions feasible without major expense to the university. Beyond carbon pools, Colgate must also record GHG emissions associated with the offset lands (table 5), as well as any potential leakage sources that may occur over the course of the program within all university owned forests (Table 6).

Gas	Source	Justification / Explanation of choice	Satisfied by Colgate's current practices?
CH_4	Burning of biomass	Non-CO_2 gas emitted from biomass burning	No

Table 5. ACR GHG sources[xxix] which require monitoring during the project term in accordance with Improved Management Protocol.

Leakage Source	Justification / Explanation of choice	Satisfied by Colgate's current practices?
Timber	Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.	Yes

Table 6.[xxx] ACR Leakage sources to be accounted for within the carbon measurement reports of a registered ACR IFM project.

7.1.4 Carbon Action Reserve's Avoided Conversion Protocol

The Carbon Action Reserve's (CAR) Avoided Conversion (AC) Protocol involves preventing the conversion of forestland to non-forest land use by dedicating the land to continuous forest cover at existing or increased stocking levels through a conservation easement or transfer to public ownership. An AC project may involve tree planting, harvesting, and other forestry activities as part of the project activity. The Project Operator must monitor and verify a forest project for a period of 100 years following the issuance of any Carbon Reserve Tonne (CRT) for GHG reductions or removals achieved by the project. Therefore, all forests must undergo an initial site verification to register with CAR, as well as an additional verification every six years to document the progress of the project.

The baseline for AC projects is a projection of on-site forest carbon stock losses that would have occurred over time due to the conversion of the project area to a non-forest land use and must be characterized and projected by the Project Operator, as well as adjusted based on conversion risk. The Reserve requires that an approved third-party verification body verify all reported data and information for a forest project and conduct a site visit for the Verification Period that follows the end of every sixth reporting period following the initial reporting period.[xxxi]

Colgate currently records the status of most necessary carbon pools required to qualify as a CAR AC project so not much additional research would need to be done in that field, see table 7. In order to register the forests as CAR AC projects Colgate would be required to analyze the secondary effect sources of the land beyond what is currently done. Biological emissions both within as well as bordering the project area must be accounted for, as described in table 8, in order to gain recognition as an AC offset.

Carbon Pools / Sinks / Reservoirs	Justification / Explanation	Satisfied by Colgate's current practices?
Standing live carbon (carbon in all portions of living trees)	Preservation and/or increases of standing live carbon stocks and/or soil carbon stocks relative to baseline levels are likely to be a large Primary Effect of Avoided Conversion Projects.	Yes
Standing dead carbon (carbon in all portions of dead, standing trees)	Avoided Conversion Projects may significantly increase standing dead carbon stocks over time. The protocol requires recruitment and retention of dead material, including standing dead wood as a structural element. Minimum volume thresholds are stated to meet Natural Forest Management criteria.	Yes
Carbon in in-use forest products	Included because many Avoided Conversion Projects may significantly change carbon storage in in-use forest products relative to baseline levels.	Yes

Table 7[xxxii]. Carbon Pools which need to be monitored to officially register as a CAR AC project.

Secondary Effect Sources	Justification / Explanation	Satisfied by Colgate's current practices?
Biological emissions from site preparation activities	Biological emissions from site preparation are not quantified separately, but rather are captured by measuring changes in included carbon reservoirs (soil carbon, where applicable).	No
Biological emissions from clearing of forestland outside the Project Area	Avoided Conversion Projects may cause land-use pressures to shift to other forestlands, causing biological emissions that partially negate the benefits of the project.	No
Biological emissions from decomposition of forest products	CO2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years	No

Table 8. Carbon Sources[xxxiii] monitored throughout the project term to qualify as a registered CAR AC project.

7.1.5 Urban Offset's Community Carbon Projects[xxxiv]

With the interest in reaching carbon neutrality gaining support among universities, many look towards investing alternative forms of carbon sequestration to offset emissions. Urban Offset's Community Carbon projects (CCP's) focus on implementing tree-planting initiatives in local cities and communities in exchange for verified carbon credits. In an attempt for universities to reach their climate commitments, the Urban Offsets Registry provides a way to positively impact local communities, while simultaneously sequestering enough carbon to offset Scope 3 emissions. Whereas many forest sequestration projects are based internationally and remain disconnected from the everyday workings of the university, the Urban Offsets Registry promotes a tangible and highly visible option to help reach carbon neutrality. By implementing a local forest tree-planting program, it provides research opportunities to both students and faculty. At the same time, it strengthens the relationship between Colgate and the community.

For every tree planted, the CPS provides 10 certified carbon credits from participating in high-quality Climate Action Reserve and Verified Carbon Standard projects. The credits are transferred within 30 days of the purchase and count towards offsetting scope 3 emissions. The trees planted in Community Carbon projects require lifetime care and maintenance which provides the opportunity to continue supporting the program each year to receive the same benefits as well as additional credits. Community Carbon projects can be supported and funded by anyone, making them highly accessible and versatile.

Community Carbon projects organized by Urban Offsets require Planting Partners to provide on-the-ground planting and maintenance for the program. Planting Partners are classified as municipalities and nonprofits, whose urban foresters, arborists, master gardeners, and experts who agree to follow industry best care practices for existing tree inventories. The planting season usually runs from October through April, providing volunteer and educational opportunities for students, faculty, and community members. Planting Partners are responsible for maintaining the health of the trees for the full project term, which is typically 40 years. The goal is to keep at least 85% of the trees alive for the full term, while replacing those that die.

A tree inventory is complete 30 days after planting by approved arborists and foresters using software designed by Urban Offsets. The inventory is taken annually in order to ensure that each planted tree has been accurately accounted for and planted properly. Every tree is verified by a neutral third party, according to Second Nature's Peer Validation Standard. Verification begins 12 months after the first inventory, continuing in its fifth year and every 5 years thereafter throughout the life of the project. While the trees grow, Urban Offsets purchases verified offsets for immediate counting towards neutrality at ~$5 to $8 per ton.

The Urban Offsets CCP's place focus on a high level of transparency in order to reduce risk exposure and avoid double counting, unaccredited projects, and general greenwashing. When investing in Urban Offsets' program, 10% of the money goes towards carbon credit purchasing, 20% to a scholarship fund, 20% is in support of the Urban Offsets Community Carbon Registry, and 50% goes towards tree care and maintenance.

While implementing Urban Offsets may be an interesting option for Colgate moving forward, it is not within the scope of our project analysis. Urban Offsets do not address what action should be taken towards managing Colgate's forested lands, and instead provides an interesting additional way to offset university emissions. However, since other protocols considered take place over longer periods of time and would expectedly take, at minimum, a year to put into action, Urban Carbon Offsets may provide a tangible solution in the short-term for lowering Colgate's environmental impacts. By supporting the tree planting practices throughout the town of Hamilton, as well as on campus, Colgate could promote cooperation with the local community in addition to creating research opportunities for students and faculty. This project, however, often relates more directly to urban centers where the differences in tree cover,location, and addition of green spaces would be more significant, as opposed to the small rural landscape surrounding Colgate. The Urban Offset Registry's CPP may provide the university with quick carbon offsets, while also promoting local community involvement. On the other hand, it will likely not achieve the necessary scale required on its own to fulfill Colgate's carbon neutrality goals.

7.1.6 Second Nature Peer-Reviewed and Innovative Offset Protocol

Second Nature is an organization that works with institutions of higher education to increase sustainability and long-term leadership projects by making bold commitments to combat climate change. Due to stabilized markets, an increased interest in small-scale and local offsets, new work in forest-based offsets, and rapid growth of on campus renewables, a need for high quality offset guidance is necessitated, making Second Nature's new pathways to carbon offsets extremely exciting.[xxxv]

Scope 3 offsets can now be offset by a peer-reviewed process. When developing these new protocols, up to 30% of scope three emissions can be offset by peer-reviewed offset projects or up to 10% of the total campus emissions[xxxvi] using innovative guidelines. In the case of peer-review offsets, Colgate would be able to generate up to 4,188 carbon offsets for sector 3 emissions (4,188 is 30% of the offsets the forest is expected to create). While this means that some generated offsets would not be viable, the educational co-benefits may still make this option worthwhile. Table 9 illustrates Second Nature's definition of peer-reviewed and innovative offsets.

While peer-reviewed and innovative offsets are more lenient than third-party offsets protocols in general, peer-review versus innovative guidelines have a variety important implications when deciding which guideline to follow. For Colgate University's goal to achieve Carbon Neutrality by 2019, Second Nature's "Peer-Review Guideline" seems most feasible, as PAVER requirements are fulfilled completely, fulfilling Colgate's mission to "invest in high-quality offsets that are either third-party certified or have direct and measurable carbon and community benefits".[xxxvii] As mentioned earlier, by following PAVER guidelines, offsets would pass accredited third-party verification, meaning they can be used effectively to offset Scope 3 emissions. Additionally, the opportunity for hands-on learning that comes with peer-review guidelines will benefit students in the long term as they are more prepared to enter sustainability-related careers, become well-versed with carbon offsets, and gain managerial skills that are transferable to any career.

Offset Credit Characteristics	Peer-Review	Innovative Offsets
PAVER requirements	Fulfill Completely	Fulfill most, provide pathway to PAVER
Accredited 3rd	Would pass	Would not pass

Party Verification (such as ACR)		
Marketability	Non-marketable; but goal to be same quality	Non-marketable
Institutional & educational co-benefits	Reinforce academic mission and community benefits. The value of engagements from students may be enough to outweigh the extra effort.	Reinforce academic mission and community benefits. The value of engagements from students may be enough to outweigh the extra effort.
Table 9: Peer Review vs. Innovative Offsets, differing features of the carbon offsets generated under a modified version Second Natures PRICO protocol.[xxxviii]		

While Second Nature protocol is similar to ACR or IMF standard protocols due to the fact that peer-review projects still require formal accreditation for offsets to count in Sector 3 emissions, it's academic co-benefits would make this process worthwhile as they align extremely well with Colgate's academic mission. After speaking with Ruby Woodside, the Innovative Services Manager at Second Nature, it seems that Colgate is an excellent candidate for peer-review offsets protocol.[xxxix] Second Nature will be able to guide Colgate through the accreditation process. According to Ruby Woodside, it is possible that within one year the university would have a fully functional offsets program. If Colgate were to pursue a the offsets project with Second Nature, the necessary steps are as follows:

1. Identify registry and protocol
2. Second Nature will select 2-3 reviewers with expertise/interest in this area, generally, these would be university's doing similar projects with an extensive forestry program.
3. Share the project description with reviewers in an iterative process.

As noted, if Colgate chooses to work with Second Nature, offsets could be verified within the first year, however, this would be dependent on the protocol selected, and the accreditation process that the third-party selected would entail. Although the timeline is uncertain, Ms. Woodside believes Colgate has the capability to shepherd the first-ever peer-review offset program at an American university[xl]. Being a leader in this cutting-edge offset protocol would set Colgate apart from its peers as an innovator in sustainable campus operations.

7.2 Project Scenarios

7.2.1 Pursuable Scenarios

The development of this project could take a myriad of different forms. Table 4 shows 10 possible project scenarios that could be pursued. The project development strategy includes 3 key decisions that impact the cost, time, and quality of carbon offsets programs. The first decision that must be made is choosing offset verifier and issuer; this would either be a traditional voluntary credit issuer (ACR or CAR) or a non-traditional issuer (Second Nature). After making this decision, the most appropriate protocol must be selected (IFM, AC, or Innovative). Lastly, the university must decide if the outlined project will implemented by a third-party developer (such as TerraCarbon or Bluesource) or through in-house efforts.

Step 1: Verifier	ACR or CAR (Voluntary)				Second Nature (Peer-Review)					
Step 2: Protocol	ACR IFM		CAR AC		ACR IFM		CAR AC		Innovative	
Step 3: Developer	Third-Party	In-House	Third-Party	In-House	Third-Party	In-House	Third-Party	In-House	Third-Party	In-House
Scenario:	**A**	**B**	C	D	**E**	**F**	G	H	I	J

Table 10 : Breakdown of 10 Pursuable Project Scenarios

For the first decision, there is no clear preliminary preference. Hence, that decision must be advised by the cost-benefit analysis. The second decision allows for some scenarios to be dispatched. The CAR AC protocol can be safely taken out of the discussion, as it is the least applicable of the three for Colgate's intentions. Above all, the issue of additionality makes this protocol inappropriate CAR AC projects must be developed on forested land that had a provable risk of being deforested, which is not the case with the majority of Colgate's campus forest, as explained further in the opportunity costs section (Section 8.2). Therefore, Scenarios C, D, G, and H can be dismissed from the cost-benefit analysis.

Additionally, innovative guidelines do not fulfill PAVER, which makes their benefits limited when compared to its alternative, peer-review guidelines. Peer-review guidelines have the same educational co-benefits, in addition to allowing Colgate receive third party accreditation and ultimately to offset carbon emissions from sector 3. Therefore Scenarios I and J can be dismissed.

8. Cost-Benefit Model

Having identified the immediately preferable project Scenarios (A, B, E, and F), a more in-depth cost-benefit analysis must be used to determine the most likely outcome of each. Our model aims to include a comprehensive and robust set of trade-offs for the project, and attempts to assign best-guess monetary values to unquantifiable costs and benefits. Costs associated with this project include the various research and development fees, monitoring and operation costs, verification costs, transaction costs, and opportunity cost. Benefits include carbon offset generation, educational value, ecological value, and boosting the image of the university.

Several of the aforementioned factors are not easily quantifiable in terms of dollar values; ecological and campus promotion value. Further research is needed to place economic values on the items below, using evaluation methods such as the contingent valuation method[xli], travel cost method[xlii], or hedonic pricing method[xliii], where applicable. Due to time considerations, we did not conduct these in this analysis. Nonetheless, these measures are of importance and may turn out to be the deciding factor that justifies the project in terms of its benefits outweighing the costs. Although we are not placing exact dollar values on these research components, they will be accounted for. After our final calculations, we will either find that the project proves profitable or unprofitable. If the project proves unprofitable, for instance, then ecological and campus promotion value must provide monetary benefits that are at least as high as the project is net negative. In short, if the project's costs outweigh the benefits by $15,000, for example, then the monetary value of ecological and campus promotion value would have to be at least $15,000 to justify the development of the project. On the other hand, if the benefits exceed the costs, ecological and campus image value will simply stand as an additional argument in favor of an on-campus carbon offset project.

8.1 Discounting

Money today and money tomorrow are not equivalent in value; that is, receiving a dollar today is more desirable than receiving a dollar tomorrow, or a year from now. When comparing costs and benefits of a proposed project over an extended period, the time component of money must be accounted for. Such an extension of prior analysis allows for comparison of both the magnitude and timing of the potential costs and benefits.[xliv] Discounting, thus, permits us to analyze the benefits in current dollar values [xlv]regardless of when they occur; considering that a campus forest project would likely span a 9-year period, discounting is critical for assessing the present value of the costs and benefits. For this analysis, the present value of future offsets generated and present value of future costs of ongoing monitoring & operations must be calculated through discounting. Tietenberg and Lewis (2014) highlight several examples that illustrate the importance of discount rate, including a tidal power project analysis in which the United States and Canada came up with contradictory conclusions because Canada used a discount rate of 4.125% whereas the United States calculated the costs and benefits using a 2.5% discount rate. Their discussion suggests that while discounting, in general, is important, the size of the discount rate is just as crucial.

To properly weigh the time variable of the offsets generated over the course of this project, the benefits and costs must be calculated in terms of their present value through discounting. Factors that involve discounting in the scope of this project are project monitoring costs, annual verifier fees, and the value of generated offsets over the 9-year period. Instead of identifying a single discount rate for our analysis, we chose to analyze the benefits and costs using multiple discount rate scenarios, the lowest being 1 percent and the highest being 7 percent. Betters (1988) and Boonyanuphap (2013) state that, as specific discount rates are generally hard to justify, it is better to use a range of discount rates, rationalizing our approach. Osborne and Kiker (2005) represent an example of applying a range of discount rates in relation to benefits obtained from carbon offsets in their Guyana case study.

In line with prior research, the Colgate Finance Office does not work with a specific discount rate either but rather decide the rate on a case-by-case basis.[xlvi] Using a high discount rate means that initial costs and benefits of a project are weighed more heavily in the analysis[xlvii]. On the other hand, working with a low discount rate increases the weight placed on future costs and benefits[xlviii]. Hence, working with a range of gives us the flexibility of assessing multiple scenarios and outcomes. The discussion of the importance of discount rates suggest that its value can not be 0, as no discount would be applied in such a case. This justifies this analysis' minimum discount rate of 1 percent. On the other side, a discount rate of 10 percent is too high and rarely used in economic analysis.[xlix] Thus, we believe that having the highest discount rate be 7 percent is more appropriate for discounting. In addition to discount rates of 1 and 7 percent, we will apply two intermediate ones, 3 and 5 percent, to ensure the analysis is as comprehensive as possible. Tables 11, 12, and 13 reflect the results of the discounting model on the time dependant variables. For all discounting calculations, it was assumed that costs in the first year would occur in the beginning of the year such that the discounting factor would not apply in year 1. Hence, discounting would, technically, commence in year 2.

8.2 Costs

Research & Development costs
The majority of the costs for any of the project's scenarios will be made up of research and development costs (R&D). In terms of a carbon offset project for Colgate University, R&D costs would include expenditures for project design and development, verification fees, as well as project monitoring. Our cost-benefit analysis relies on preliminary projections from TerraCarbon as they are the best-guess estimates for the R&D costs that would be accumulated in terms of Colgate's carbon offset project.[l] Since these costs likely won't differ considerably between each of the project's scenarios, illustrated in Table 10, we will work with TerraCarbon's cost estimates for the remainder of the analysis.

Most of the research has already occurred. On the other hand, if a carbon sink project were to be implemented, a lot of development costs would accrue. For instance, for $15,000, TerraCarbon would conduct a sensitivity analysis, providing a cost-comparison assessment between peer-review and third-party project development. This would be an investment in the project as it would lower project initiation costs. Furthermore, their estimates suggest that $75,000 to $125,000 would have to be spent on project design. This involves forest inventory, baseline modeling, as well as all documentation that is required. Project design further demands a third party to validate and audit the process. This would add an additional $40,000 to $50,000 to project design cost. Hence, total costs of project design would fall in between $115,000 and $175,000.

Another aspect of the verifier fees are costs of activation and retirement. The activation fee for a carbon offset is $0.15 per MTeCO2. Retiring carbon offsets will cost $0.02 per MTeCO2. Multiplied by the number of offsets Colgate's forest could supply, these costs would accumulate to $1,350 and $180, respectively. Furthermore, account opening fees, annual account fees, and project eligibility screening add additional expenditures to the project. In total, and over the 9-year period, these costs will be $6,516 to $7,356.

Following the project design and implementation, monitoring costs will be incurred. Per monitoring event, which typically occur every 2 to 5 years, $15,000 to $25,000 would have to be expended on calculating carbon credits, updating field inventories, etc. Similar to project design, third-party verification of monitoring, in the form of an audit of the monitoring results, is required. Thus, another $20,000 to $30,000 per monitoring event would be added to overall development costs. Since the project design costs would be incurred at the time of the project's implementation, such costs do not have to be discounted. However, as project monitoring happens multiple times in the 9-year period in which carbon offsets would be generated, monitoring costs will be discounted. In our analysis, we assume that there will be 3 monitoring events; one at the start of the project, one after 4 years, and a last one after 8 years. Doing the calculations for monitoring costs every 4 years is reasonable based on them typically being every 2 to 5 years. If monitoring events, in fact, occur more often than every 4 years, there will be additional costs incurred that would have to be accounted for by Colgate University. Taking the averages of both project monitoring and third-party verification of monitoring adds up to $45,000 for monitoring, which is the value we used to calculate costs over time. Depending on the discount rate, $105,520.69 to $129,800.86 will accumulate due to project monitoring over 9 years.

Hence, the total R&D costs of this project will roughly accumulate to a minimum of $242,036 and a maximum of $327,156 over 9 years, in accordance with the TerraCarbon Improved Forest Management project development.

Opportunity Costs
Buchanan (2008) defines opportunity costs as "the evaluation placed on the most highly valued of the rejected alternatives or opportunities, or the loss of other alternatives when one alternative is chosen". Thus, in application to this study, opportunity costs are the costs of forgoing other potential uses for the Colgate forest, such as timber harvesting or converting the land to make room for more university buildings. Opportunity costs in relation to the on-campus carbon offset project would be de minimis. Colgate has just recently taken away land to construct new buildings and extend a parking lot. Hence, the possibility of future construction plans is low. In fact, Christopher Wells assured us that there are currently no plans of using the forest otherwise. Additionally, for every tree that was taken away due to the new constructions, Colgate planted a greater amount of trees in return[li], suggesting that similar measures would be taken if some of the forest were in some way converted into a different land use in the future. This means that instead of losing trees, Colgate would actually gain trees in total if there were to convert forest land. Ultimately, opportunity costs are worth mentioning but are negligible in terms of this cost-benefit analysis.

Transaction Costs
While accrediting or selling carbon offsets, additional costs are incurred during such transactions. Transaction costs are all the costs associated with arranging an exchange of goods and services[lii]. For instance, these costs are accumulated because of the time it takes to meet, negotiate, and implement a project, in addition to contracts that are needed to exchange property rights as well as register and monitor offsets. Thus, in relation to this project, transaction costs would include the time it takes to draw up contracts with a third party in order to verify the university's carbon credits, for example. While costs would certainly accrue, it is difficult to ascertain how much the total dollar value of these costs would be. In terms of this project, it is likely that transaction costs would be larger if the university would pursue a third-party consulting protocol instead of an in-house or peer-to-peer one, because of a greater number of meetings, contracts, time, etc., that would come with a third-party project. A peer-to-peer project could be implemented more rapidly.

To illustrate this, Middlebury College represents a good example. They used a third party consulting process in which Bluesource recommended two individual third party verifiers who examined the forest to determine the value of the land and how much carbon these forests would sequester.[liii] After this point, Middlebury worked with the Vermont Land Trust in order to place an easement on the land so that it would never be anything other than a forest. These processes involve negotiations and take a long period of time. For example, the process of placing an easement on the land and verifying their forest took Middlebury roughly one year[liv]. Given that Colgate does not have the option of working through Bluesource and are not a far along in our process as Middlebury was the amount of time would likely be greater than one year indicating that pursuing a third party verification option would incur a large transaction cost compared to peer-to-peer. After talking with Middlebury's director of sustainability, Jack Byrne, we discovered that the exact cost of having a third-party verifier was proprietary information. Thus, it is difficult to determine this project's exact transaction costs.

Additional Offsets Purchased:
This type of cost only applies in the Second Nature scenarios (E and F) as ACR IFM protocol would allow the university to use all of the offsets generated by the forest. In the former case, only Scope 3 emissions can be offset and may not exceed than 30% of gross emissions.[lv] Hence, if the Second Nature scenario were chosen, Colgate would have to purchase an additional 4,773[7] offsets to achieve carbon neutrality by 2019. Based on price per offset, this would require expenditures in between $28,638 and $38,184 per year, and $199,644 to $330,355 over the project's lifetime. As no additional offsets would be required in the ACR IFM scenario, based on 2019 emission projections, this value is $0 for Scenarios A and B.

8.3 Benefits

Offsetting Colgate's Carbon Emissions
Most importantly, an on-campus carbon sink project would allow for the generation of carbon credits to offsets the university's emissions in order to achieve the 2019 carbon neutrality goal. This would save Colgate money that would otherwise have to be spent on acquiring offsets, such as in the baseline scenario ones highlighted in Table 11. That is, it will save Colgate money if on-campus offsets turn out to be cheaper than the baseline scenarios. Preliminary estimates have concluded that Colgate's forest offers 9,000 carbon credits per year for 9 years, serviceable to offset the university's estimated carbon footprint in 2019.

Value of Generated Offsets
For the purposes of the cost-benefit analysis, the value of the generated offsets will be measured in terms of their monetary value. The revenue of the sold offsets is the most appropriate monetary valuation of the generated offsets. Offsets can be marketed between $6 and $8 per ton. Using the projected achievable offsets, the value of this project would range from $54,000 to $72,000 per year. Hence, over a 9-year period, this would accumulate in between $386,450 and $642,920 of revenue, using the ACR IFM protocol. In Scenarios E and F, going through Second Nature, the university would only be able to offset Scope 3 emissions and may not offset more than 30% of gross emissions[lvi]. Thus, Colgate would only be able to use and sell 4,188 offsets, translating into a monetary value of $175,175 to $289,866 over 9 years.

Educational Value
If the Carbon Offset project were to be implemented, Colgate University would receive educational benefits for, mainly, its Science Department. While this would require both faculty and student interest, having a yearly class dedicated to carbon inventory or monitoring, for instance, would be a beneficial outcome. Similarly, students working for the Sustainability Office would likely benefit from the additional work associated with on-campus carbon offsets. It is important to note, however, that educational benefits would also be obtained if, instead of offsetting carbon on campus, invested in a different, off-campus project in a developing country.

The best example for why educational value must be included in this assessment comes from Colgate's Patagonia Sur Offset project. Currently, Colgate is paying $50,000 per year for 5,000 annual offsets[lvii]. This means the university is paying $10 per carbon offset credit. In comparison, Colgate could be purchasing carbon credits from the voluntary offset market for $6 to $8 dollars. Hence, Colgate is paying $2 to $4 dollars more on offsets than technically needed,

[7] Estimated 2019 net emissions (8,691) - offsets generated by peer-reviewed case (4,188)

if we were purchasing credits from the voluntary offset market. Multiplied by 5,000 offsets per year, this suggests that Colgate is spending an extra $10,000 to $20,000 on carbon offsets, implying that there are additional benefits obtained from implementing a project like the Patagonia one instead of merely buying credits from the voluntary offset market. In terms of the Patagonia project, such benefits include local economy improvements, as well as the pedagogy associated with using the Patagonia offset project as a learning and teaching tool. In January, 2018, Colgate is offering an extended study trip to Patagonia for the first time. Colgate students and faculty will be able to have first hand experience with our own carbon offset forest. In the spring of 2016, Professor of Biology and Environmental Studies Tim McCay and director of sustainability John Pumilio visited the forest to review the ongoing reforestation project. It was during this visit to Patagonia that they realized that the region, forest, and offset project promised an experience rich in learning and research. Thus, Colgate is now offering a half credit course for students to go and conduct independent research projects in Patagonia so that students can get first hand experience and knowledge of the carbon offset forest. Additionally, students will actively help plant trees to reduce Colgate's carbon footprint and go on multi-day excursions to gain some exposure to the impacts that climate change has on social and cultural issues in the local area.

This is similar to the pedagogical values associated with Clarkson University's Uganda carbon offset project. Clarkson University is using this project to not only offset their own carbon footprint but also to use this as a pedagogical opportunity for their business and ecology students. These students are able to travel to Uganda on an annual basis where they are able to conduct long term research projects aimed at teaching the local community members about microfinance, sustainability, and agroforestry. These students partner with business students from a local university in Uganda to teach the community members about how to farm sustainably, which plants to use, and how to set up their own farms so that they can integrate planting trees into their land use planning. The Patagonia project demonstrates carbon offset projects like Colgate's and like Clarkson's are not simply about buying trees in a foreign country and claiming the credits. These projects provide opportunities to teach people about sustainability and affords students at these respective universities an opportunity to conduct research and learn to teach.[lviii]

Carbon offsets have and continue to provide significant educational opportunities directly at the university, specifically in the context of working with and understanding how our offsets positively impact the university's mode of sustainability. This project is merely one example of that. Additionally, in the future, a Colgate class could be offered on carbon offset monitoring. Students would be able to learn about proper forest management by conducting research in and monitoring the health of Colgate's local offset forest. Monitoring events would occur several times throughout the project. By including monitoring and forest management in the syllabus of a course at Colgate, monitoring costs for maintaining our offset forest may potentially be reduced while students and faculty attain educational benefits.

From the Patagonia example, it seems apparent that Colgate is willing to spend an additional $10,000 to $20,000, at least in part, on academic opportunities that result from carbon offset projects. Thus, we can confidently place a dollar value on the educational benefits. Part of the $10,000 to $20,000 in the Patagonia case count toward local economic and other potential benefits, meaning that educational value does not account for the entire amount. However, in comparison to the Patagonia Sur project, more students would benefit from the educational experience in the case of Colgate's potential carbon sink. Furthermore, establishing a carbon sink on campus will likely have small effects on the local economy and Hamilton community, less so than in Patagonia, of course. Ultimately, it is reasonable to leave the monetary value for education and the additional benefits that come with it at $10,000 to $20,000.

Ecology

One of the factors that is difficult to quantify in monetary terms is the benefits to biodiversity within and surrounding the Colgate University forest. According to the New York State's Department of Environmental Conservation, forests are home to 80 percent of terrestrial biodiversity. Using the forest to offset some of our carbon emissions and, thereby, not converting it into a different kind of land use will benefit various animal species such as squirrels, birds, earthworms, bacteria, and numerous others whose lives are enhanced by trees and forest land. Norborg Carter (2017) suggests that removing plant species like trees from forests has severe negative impacts on the survival of species that are dependent on trees for food, nesting, cover, etc. For instance, he points to owl populations being threatened when many mature trees are cut down in a single forest[lix]. Furthermore, Carter (2017) states that even removing old logs or brushes can harm animal populations in similar ways.

The Middlebury offset project in their Bread Loaf Forest is an excellent example to the positive consequences of forest offsets. By working with the Vermont Land Trust, Middlebury moved to ensure the area would be a forest in perpetuity, thus ensuring it could neither be used in the Biomass gasification plant nor ever used in any other way where trees would be removed, thus ensuring the integrity of the forest, and its diverse ecosystem, would remain for future generations to enjoy. Consequently, Middlebury's project ensures that the ecosystem and species that live in the Bread Loaf Forest would not be negatively impacted by the institution, thus, establishing an environmental stronghold on the property.

As forests are an important contributor to biodiversity, various economists and researchers, such as Black et. al (2010) and Chavas (2009), have tried to put a monetary value on biodiversity. On the other hand, Conniff (2012) argues against the idea of putting monetary values on ecosystem services like biodiversity, disliking the fact that it allows for ecosystems to be bought and sold which decreases the weight of intrinsic value placed on the environment. Moreover, Conniff (2012) does not believe that the true value of nature and its species could ever be truly assessed, which, in his mind, put the natural world at an even greater risk of destruction. Hence, Conniff (2012) would support our idea of not putting an exact dollar value on the biodiversity benefits that would likely be obtained by our project. These benefits will likely be of little magnitude because, as discussed above, opportunity costs of the land are low as there is little incentive, at least currently, to convert the land or remove large parts of the forest. One method of extending the value of biodiversity in Colgate's forest could be to loosely follow Clarkson's Uganda project, in the sense that students learn about the species of the trees that the Clarkson project plants and the importance of agroforestry.[lx] Again, while Clarkson is planting trees and Colgate's potential offset program will not do this, such lessons will need to be altered to fit their respective scenario. However, this plan could prove useful in generating more and varied value to the forest itself.

Campus Image Promotion

Repeatedly, Colgate University can be found amongst the College campuses that are rated most beautiful in the United States. Most recently, the Princeton Review ranked Colgate as the number one university in that category in 2015[lxi]. There are various reasons why Colgate received this award. While not the top factor, Colgate's trees and forest lands, including the Darwin trails, are certainly one of reason why Colgate consistently finishes in the upper part of this ranking. It is reasonable to assume that being awarded with such a high ranking makes

Colgate attractive to High School students, those applying to universities, as well as faculty members that may want to come teach at the university, while also promoting Colgate's image as environmental stewards to other universities. These factors push Colgate's administration to maintain and support the beauty of both the campus and surrounding forest. In addition to making the university more attractive to students, faculty, and staff, these forests significantly benefit the Hamilton community. Similar to students, Colgate's forested land and trails provide spaces for Hamilton residents to walk, hike, and enjoy nature, generating a connection between the campus and community through appreciating the environment. Hence, this space serves as an example of how institutions and local communities share both the benefits and responsibility for ensuring the environment around them is healthy. Thus, Colgate's ranking reflects not only the beauty of the campus but also its mission to benefit the Colgate as well as the Hamilton community as a whole.

Apart from the Princeton Review, the Sierra Magazine recently ranked Colgate in the top 15 of the most sustainable schools in the United States, praising Colgate's sustainability efforts such as the 13 Days of Green and the community garden[lxii]. It is likely that such a ranking attracts students interested in environmental sciences and sustainability. What is also probable is that Colgate's ranking in Sierra Magazine would improve even further if Colgate were to implement an on-campus carbon offsets project in efforts to reduce the university's footprint. Without doubt, it would be better for marketing and image promotion than one of the alternative outcomes, in which Colgate would merely use its wealth to buy itself out of the problem by purchasing offsets. However, the latter option would still help Colgate achieve its carbon neutrality goal, which, in turn, may still look good in the public's and magazine's eyes. While it is difficult to quantify these benefits, it is still important to discuss campus promotion benefits that can be obtained by this particular or other similar projects as Colgate continuously strives to demonstrate leadership among the educational institutions of America. However, the ultimate value for these benefits will likely not be too impactful on the overall analysis.

8.4 Permanent Conservancy

Going into permanent conservancy would mean that Colgate's forest would forever be set aside, eliminating the risk of it being converted. As above-mentioned, Middlebury has set a great example of becoming carbon neutral by converting their forest into a verified carbon sink and placing their forested lands in permanent conservancy. This same potential exists for Colgate. It would cost roughly $7,000 to place an easement on the land. Transaction costs, such as the time it takes to implement, 1 year in Middlebury's case[lxiii], are also involved. However, as a local land owner Colgate would receive a 25% rebate on local land taxes each year. Additionally, Colgate would be able to write off a tax deductible donation in the range of $300 and $500 per acre of land conserved which would help to mitigate costs as well.

As the Carbon Offset Working Group as already noticed, the implications of permanent easement, discussed below, have to be carefully considered. Additionally, John Pumilio has noted that the university's forested lands may not have to be put into permanent conservancy at all, as this process can sometimes be restrictive.[lxiv] Pursuing permanent conservation easement before the entire projected has been designed would be ill-advised. Our analysis hopes to advance the carbon offset project as a whole, and to potentially offer more insight into the idea of going into permanent conservancy.

With the help of Professor Rick Klotz, Colgate University Economics Department, we have identified some of the implications of permanent easement.[lxv] As discussed above, the opportunity costs of this project are minimal. There is no major demand for land in upstate New York, especially not in Hamilton. Furthermore, Colgate University neither has an incentive to convert its forested land into more buildings or other infrastructure nor do they have a reason to sell the land. From this standpoint, going into permanent conservancy does not present a problem. However, if there may not be a need to go into permanent conservation easement in order to implement this project, we would not advise the university to do so. Permanent conservation easement offers no additional benefits. On the other hand, it does not come without concerns and severely limits flexibility.

Risks of the forested land being harmed in a certain way, although they are rather low, have to be considered when making this commitment. For instance, what if an invasive species gets introduced to Colgate's forest, and harms the ecosystem, trees especially? What if climate change causes older trees to die off in the future? What if there is a forest fire? While these seem unlikely, they could potentially, and significantly, alter Colgate's forest and affect its ability to offset carbon. Thus, if the forest were to be put into permanent conservancy, it is important to consider how strict its management would be in relation to keeping the offsets. Would they hinder forest health management? For example, would carbon forest management allow for trees to be taken away if one of the above-mentioned threats were to endanger the overall state of the forest? Would new ones have to be planted immediately to compensate for the harvest? Would additional fees be involved? These questions are important ones to consider when thinking about the implications of permanent easement. If not at all necessary, it is wise to not place Colgate's forest land into permanent conservancy.

9. Cost-Benefit Analysis

9.1 Baseline:

The baseline scenario to which we are comparing the on-campus carbon sink options to is buying all necessary offsets from the voluntary offset market for \$6 to \$8 per MTeCO2. A further alternative would be expanding the university's Patagonia Sur Project, for \$10 per MTeCO2. According to Table 2, Colgate estimates suggest that in 2019, the university's net emissions will amount to 8,691 MTeCO2. For simplicity, this number was rounded up to 9,000 in our analysis. Table 11 illustrates the total cost of the four baseline scenarios over the 9-year period. These would be Colgate's expenditures if they were to simply buy carbon offsets off of the voluntary market instead of pursuing an on-campus project.

Baseline Scenario: Alternatives to Campus Forest Carbon Sink		
Offset Acquisition Method	**Cost per year**	**Total Cost[1]**
Cost of purchasing 9,000 offsets for \$6/MTeCO2	\$54,000	\$376,450 - \$467,190
Cost of purchasing 9,000 offsets for \$7/MTeCO2	\$63,000	\$439,191 - \$545,055
Cost of purchasing 9,000 offsets for \$8/MTeCO2	\$72,000	\$501,933 - \$622,920

Cost of expanding Patagonia Sur project for $10/MTeCO2	$90,000	$627,416 - $778,651

Table 11: Depicts the non-campus carbon offset options available to Colgate University in order to achieve carbon neutrality by 2019. The dollar values in the first 3 scenarios are the potential costs of buying one carbon credit off the voluntary offset market. Low and high total cost estimates are depicted.
[1]Future costs discounted using offset discount model (Table 12)

9.2 Offset Valuation:

9.2.1 Net Present Value of Future Offsets

As previously mentioned, discounting is critical for measuring the present value of future costs and benefits. Table 12 shows the range of possible values of future offsets, in terms of current dollars, for Colgate. All values are discounted over the course of the 9-year project term, and illustrate different discount rates and offset prices that are realistically possible. The values calculated describe the baseline scenario costs (ie. the cost of buying offsets on the voluntary market). The values also provide an equivalent monetary valuation of offsets that could be generated by Colgate's forest project. Using the estimated range due to price and discount rate, the calculated final costs and benefits reflect the project outcomes in several economic environments.

Net Present Value of Future Offsets

		Discount Rate (Annual)			
		1%	*3%*	*5%*	*7%*
Price of Offset	*$6*	$467,190.6	$433,063.4	$403,013.5	$376,450.1
	$7	$545,055.7	$505,240.6	$470,182.4	$439,191.8
	$8	$622,920.8	$577,417.8	$537,351.3	$501,933.5
	$10[1]	$778,651	$721,772.3	$671,689.2	$627,416.8

Table 12: Net Present values are discounted over the course of 9 years at various discount rates and price per offset. [1]Cost of expanding Patagonia Sur

9.2.2 Estimated Final Benefits and Costs:

Using the costs and benefits discussed in the Cost-Benefit Analysis Model, and the net present values calculated in Table 12, the following Table depicts the project's results.

Estimated Benefits and Costs of Pursuing Campus Forest Offset Project		
	ACR (A, B)	Peer-Reviewed (E, F)
Total Benefits	**$386,450 to $642,920**	**$185,175 to $309,866**
Offsets Generated (value if sold)[1]	$376,450 to $622,920	$175,175 to $289,866
Educational Value	$10,000 to $20,000	$10,000 to $20,000
Ecological Value	Not quantified	Not quantified
Campus Promotion Value	Not quantified	Not quantified
Total Costs[2]	**$242,036 to $327,156**	**$441,680 to $656,711**
TerraCarbon Sensitivity Assessment	$15,000	$15,000
Total Project Design Costs[3]	$115,000 t0 $175,000	$115,000 to $175,000
Verifier Fees	$6,516 to $7,356	$6,516 to $7,356
Monitoring and Operations[4]	$105,520 to $129,800	$105,520 to $129,800
Additional Offsets Purchased	$0	$199,644 to $330,355
Net Present Value of Project[5]	**$59,294 to $400,884**	**-$471,536 to -$131,814**
Cost per Offset	**$3 to $4**	**$5.5 - $8**
Savings in comparison to Baseline Scenario	**$49,294 to $380,884[6]**	**-$66,870 - -$36,450[7]**

Table 13: There is a fairly large range in the costs and benefits due to variables of offset price, discount rate, and fees of third-party developers

[1] *Values are analogous to the avoided cost of purchasing offsets on voluntary market (Tab. 11).*

[2] *Total Costs are analyzed based on preliminary TerraCarbon estimates.*

[3] *Include third-party verification of project design, ~$40,000 - $50,000 of total project design costs*

[4] *Total project monitoring and operations costs are assumed to be $45,000 per monitoring event ($20K for someone like TerraCarbon + $25K for third party monitoring).*

[5]NPV of the project do not account for ecological and campus promotion value.
[6]Calculated by subtracting costs of cheapest baseline from costs of most expensive ACR IFM scenario ; and most expensive voluntary market baseline minus cheapest ACR IFM scenario
[7]Savings calculated by subtracting costs of generating 4,188 forests offsets from costs of purchasing 4,188 offsets on voluntary market

10. Results and Discussion

The prior section outlined the costs and benefits that would be associated with an on-campus carbon sink project at Colgate University. Table 13 illustrates that the project's benefits outweigh its costs in relation to the ACR IFM scenario. It would be much cheaper for Colgate to implement this project and use the generated carbon offsets to counterbalance the university's carbon footprint than to do so by buying offsets from the voluntary offset market. This is evident when comparing the ACR IFM project's total cost, found in Table 13, to any baseline scenario depicted in Table 11, as the former is less costly than the latter. This holds true for any dollar value of offsets ($6 to $8) as well as any discount rate (1% to 7%). On the other hand, for the peer-reviewed case, costs outweigh the benefits, making its net present value negative. The main reason for this is the extra costs that would accumulate due to Colgate having to buy 4,773 additional offsets to meet the university's carbon neutrality goal. Due to additional costs, not every peer-reviewed scenario would be cheaper than every possible baseline scenario. However, a peer-reviewed project could still be justifiable. While the monetary value of educational benefits may be underestimated, an on-campus carbon sink project comes with additional benefits such as ecological and campus promotion value that are not explicitly accounted for in the cost-benefit analysis.

Over the 9-year period, 81,000 carbon offsets are generated by the Colgate forest. In the ACR IFM scenario, total costs of the project are estimated to be in the range of $242,036 to $327,156. Thus, each carbon offset would be generated for a price of $3 to $4[8]. Evidently, this would be much cheaper than buying offsets for $6 to $8 on the voluntary market or expanding the Patagonia Sur project for $10 per offset. The cost per carbon offset in the peer-reviewed scenario ($5.5 to $8) are in line with the voluntary market ($6 to $8).

In the meantime, these offsets would generate a value in between $376,450 and $622,920, if Colgate were to sell all of them on the voluntary market. Choosing the ACR IFM protocol would allow Colgate to market any extra offsets generated. Selling offsets, however, would be inadvisable. It has been established that carbon offsets are required in order to meet the university's 2019 carbon neutrality goal. Given the fact that it is cheaper to generate offsets on campus than it is to buy them on the voluntary market, it would not make sense to sell these. However, if Colgate achieves its goal of becoming carbon neutral in 2019 without using all of the offsets generated by an on-campus carbon sink project, the remaining offsets could certainly be sold on the voluntary market. This would generate financial profit and offset some of the costs associated with this project's implementation. As was the case at Middlebury, what the potential revenue from selling these offsets would be is difficult to predict. However, if Colgate continues its efforts in reducing emissions through its various programs illustrated in Figure 1, it may be the case that projected emissions for 2019, 8,691 MTeCO2, are an overestimate. For instance, if the university could manage to reduce its emissions back down to 2015 levels of 7,984 MTeCO2, then Colgate would have 1,000 carbon offsets leftover to sell if the on-campus carbon

[8] Total cost of project development divided by the total number of offsets generated

offset project were developed. Using the ACR IFM protocol, we could sell these offsets for $6 to $8 on the voluntary market, generating revenue of $6,000 to $8,000. Such revenue would immediately counter costs required to verify this project ($6,516 to $7,356). If Colgate were to choose a peer-reviewed protocol, selling leftover offsets would not be possible.

The highest estimated costs of the ACR IFM project scenario came out to $327,156. Even with this generous prediction, the project's benefits would still outweigh its costs (by $59,294), as total benefits are predicted to be at least $386,450. Hence, the ACR IFM project would prove to be unprofitable from a strictly economic standpoint only if total costs would end up exceeding a value of $386,450. This is because it could be possible to buy offsets from the voluntary market for $6. Using a 7% discount rate over 9 years, purchasing such offsets would cost $376,450. Such a scenario would be cheaper than implementing an on-campus carbon offset project if the costs of such an undertaking would somehow accumulate to ~$400,000, which is unlikely. On the other hand, a baseline scenario may be cheaper in comparison to a peer-reviewed project such as Scenarios E and F. This is because either of those scenarios may cost up to $656,671, which is more expensive than 13 out of the 16 baseline scenarios. However, if Scenarios E and F would only end up costing $441,689, the lowest amount we calculated for the total costs of Scenarios E and F, only 3 baseline scenarios would turn out to be cheaper.

Ultimately, by choosing the ACR IFM protocol, savings in comparison to the baseline scenarios would fall in the range of $49,294 and $380,884. These savings are calculated by subtracting the costs of the cheapest baseline scenario from the costs of most expensive ACR IFM scenario ($376,450.1 - $327,156), and the most expensive voluntary market baseline minus cheapest ACR IFM scenario ($622,920.8 - $242,036). For a peer-reviewed project, such savings would be negative, in the range of -$36,450 and -$66,870; suggesting that baseline scenarios are cheaper than peer-reviewed projects. To arrive at these numbers, one subtracts the costs of generating 4,188 campus forests offsets from the costs of purchasing the same amount of offsets off of the voluntary market (for example, $175,175 - $242,045 = -$66,870).

It is important to emphasize the additional benefits obtained through an on-campus offset project. As explained in detail in prior sections, a carbon sink undertaking at Colgate would yield ecological and campus-promotional benefits for the institution. Our ACR IFM case analysis produced results highly in favor of an on-campus forest carbon sink project. Subsequently, supplementary advantages, such as the two mentioned above, further justify the project's implementation by adding further value. Conversely, in the peer-reviewed Scenarios E and F, these values would have to provide increased benefits equivalent to at least $36,450 (possibly up to $66,870) to counterbalance the negative savings (in comparison to baseline scenarios). It is difficult to ascertain whether or not this could potentially happen. However, a peer-reviewed project development could still be justifiable. As discussed above, a peer-reviewed project could potentially be cheaper than several baseline scenarios, even without accounting for benefits such as ecology and campus image which counterbalance the lost savings in the peer-reviewed case. An on-campus carbon sink project would always be cheaper than any baseline scenario if Colgate were to choose the ACR IFM route.

Ultimately, we recommend that Colgate moves forward with this project, in the best way it sees fit, as forest carbon offsets represent a viable option for the university in the quest to meet its 2019 carbon neutrality goal. While there is a variety of possible scenarios, an ACR IFM project development stands out as the most cost-effective and advisable option for Colgate.

11. Conclusion

11.1 Research Motivations

Colgate University's bicentennial goal of reaching carbon neutrality by 2019 is a powerful testament to it's commitment of environmental stewardship and ensuring its students are progressive thinkers and future leaders. While its carbon footprint has been reduced from multiple projects, such as its Green Bikes Program, the university's rising GHG trajectory, due to its increase in construction and scope 3 emissions, signify that this goal cannot be met with projects alone. Therefore, carbon offsets that reduce, sequester, or mitigate Greenhouse Gas (GHG) emissions elsewhere, are necessary for Colgate to achieve carbon neutrality. The university is currently sequestering ~1,500 MTeCO2 through its own forest, and is involved in the Patagonia Project in Chile which provides Colgate with 5,000 carbon credits annually until 2027. Colgate's forest is a strong candidate for additional carbon offsets, and could be the solution for achieving the university's goal. Other on-campus offset projects from Middlebury University, among other institutions, proves that this project is theoretically possible, and cost calculations in this report signify that the forest offset project has the potential to be profitable, both in reimbursing its overall cost, potentially generating future revenue for the university.

11.2 Research Results

(1) Is Colgate's forest a viable option for generating carbon offsets to help the university reach carbon neutrality?
● From preliminary estimates and calculations, the university's forest is large enough to generate the carbon offsets needed to for net neutrality for 9 years ● After taking into account all expenses for project development and operations, the offsets generated through an ACR IFM offset forest project would be far less expensive than simply buying offsets off of the voluntary market ● Even though costs are higher for in the peer-reviewed scenarios, going that route can still be justifiable ● If Colgate reduces gross emissions below 14,000 MTeCO2, extra offsets could be sold on the open market, when choosing the ACR IFM scenarios (A, B)
(2) If so, which existing forest offset protocol is most appropriate when considering variables such as Colgate's financial and temporal constraints, high-quality offset standards, public relations and acceptability, and others?
● The ACR IFM protocol is the most appropriate forest management protocol for Colgate. ● The university may choose to fully follow the ACR IFM, but may also decide to adapt the protocol as an Innovative Offset project. ● Traditional ACR IFM allows the university to market extra offsets whereas an innovative project would not. ● Colgate's forest does not meet the requirements CAR AC because Colgate does not have any plans to convert forested land. ● Urban Offsets provide an innovative solution of creating offsets while simultaneously providing benefits to the local community. However, they are most useful in urban areas which lack green spaces and foliage unlike rural central New York.

(3) Can Colgate undertake this project using internal resources or does it make more sense for Colgate to hire an external consultant to help with project development, implementation, and ongoing management?
● Colgate likely has the resources and funding to proceed with internal project development, but this process may take 3-5 years ● Several external consultants can be hired to expedite development process (1-2 years) ● Undertaking project using internal resources may create additional educational value as student researchers can participate in periodic forest monitoring ● Third-party consultants advertise their services will reduce total project cost, so it is not clear if there is a significant difference in development and operation costs between in-house or third-party scenarios
(4) If all else is achievable, how should Colgate allocate the offsets generated (e.g. retain the offsets or sell a portion of them to generate revenue), and what potential revenue can be brought in for Colgate?
● Generated offsets will be cheaper than purchasing from the voluntary market in the most cost-effective scenario (ACR IFM) ● Offsets should therefore be retained to achieve/maintain carbon neutrality ● Extra offsets (if traditional ACR IFM pursued) can be sold on the voluntary market to generate income for the university ● In theory, if all offsets were sold, forest would generate a net revenue of \$59,294 to \$400,884 over life of project (see Tab. 13) ● In a peer-reviewed scenario, only 4,188 of the offsets generated by the forest would be usable. Consequently, Colgate would keep those while having to purchase another 4,773 offsets off of the voluntary market to meet its carbon neutrality goal
Table 14: Key Findings and Answer for Research Questions

11.3 Final Recommendation

This research suggests that Colgate should pursue an on-campus forest offset project. From a financial standpoint, the ACR IFM Scenarios A and B would be the most cost-effective way to implement this operation and achieve carbon neutrality by 2019. In this case, the cost of generating offsets on campus would be far less expensive than buying offsets off of the voluntary market or expanding the Patagonia Sur project (\$3 to \$4/offset compared to \$6 to \$8/offset) which represent the baseline scenarios in this analysis. For a peer-reviewed project, cost per offset (\$5.5 to \$8) would reflect voluntary market prices.

Beyond the monetary motivations behind pursuing this project, the intangible benefits also offer strong motivation for pursuing this project. By achieving and maintaining carbon neutrality through responsible forestry practices, Colgate can publicly prove its commitment to a sustainable mode of operations. Moreover, success in developing an on-campus offset project will help guide other institutions in overcoming similar challenges.

Beyond this analysis, two key decisions remain for the university. First, administrators must decide how the offsets should be verified, affecting the marketability and quantity of offsets. While it is not clear if the project will generate offsets in excess of Colgate's needs, having the option to sell offsets may prove valuable if the university reduces gross emissions during the lifetime of the project. This would only be an option if Colgate decides to go the ACR IFM route such as in Scenarios A and B. Second, the university must decide if it will contract third-party consultants to aid in project development. Colgate likely has the means to keep the project in-house, but consultants may be prefered if the expedited development period is valuable to the school

11.4 Research Limitations

While this analysis suggests that a forest carbon offset project could offer significant benefits to Colgate (in regards to its carbon neutrality mission, public image, and commitment to environmental stewardship), there are still uncertainties that the university may face should they decide to develop this project further. One uncertainty of this project is the cost-estimation. Colgate's forest offset project has a relatively large estimated cost range between $242,036 and $327,156. These numbers are in-line with most professional estimates; however, due to the fact that these costs are on a case-by-case basis and that they do not include possible unanticipated expenses, this range is merely an estimate and may not reflect the final price Colgate will have to pay for implementation and maintenance.

In addition, estimated generated offsets could vary and, thus, change our calculated benefits and cost per ton. When compared to Middlebury's project (in which 2,000 acres of forestland generate 25,000 offsets per year), an estimate of 9,000 credits per year is a conservative and realistic forecast for Colgate. Until this project is verified, however, this value is still subject to change. Another potential concern is that the time frame of the project is uncertain. Due to the complexity of the project, and multiple phases of third-party verification required, Colgate's forest offset project development could take longer than anticipated due to unforeseen challenges.

If this project is pursued, Colgate must be prepared to purchase offsets from the voluntary market in the event that the forest project is not completed before 2019. However, even if that is the case, the timing will neither affect the quality of the project nor diminish the value of Colgate's investment in a sustainable mode of operations. Third-party consultants may expedite the project's development, as demonstrated by Bluesource's contribution to Middlebury University's project. While consulting firms such as TerraCarbon and Bluesource claim that investing in their services will reduce the overall net cost of the project, the variability in projects specifics suggest that a reduction in net costs is not guaranteed. These factors must be taken into consideration by the university as it debates and, if approved, moves forward with utilizing its forest as offsets for carbon neutrality.

12. References

American Carbon Registry. (2016). *Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands*.

Betters, D. R. (1988). Planning optimal economic strategies for agroforestry systems. *Agroforestry Systems*, *7*(1), 17–31. https://doi.org/10.1007/BF01890467

Black, J., Milner-Gulland, E., Sotherton, N., & Mourato, S. (2010). Valuing complex environmental goods: Landscape and biodiversity in the north pennines. *Environmental Conservation, 37*(2), 136-146. doi:http://dx.doi.org/10.1017/S0376892910000597

Boonyanuphap, J. (2013). Cost-benefit analysis of vetiver system-based rehabilitation measures for landslide-damaged mountainous agricultural lands in the lower northern thailand. *Natural Hazards, 69*(1), 599-629. doi:http://dx.doi.org/10.1007/s11069-013-0730-y

Borck, J. C. & Coglianese, C. (2009). Voluntary environmental programs: assessing their effectiveness. *Annual Review of Environmental Resource, 35*, 305-324. doi: http://dx.doi.org/101146/annurev.environ.032908.091450

Buchanan, James (2008), "Opportunity Cost," in *The New Palgrave Dictionary of Economics*, 2nd ed., ed. Steven N. Durlauf and Lawrence E. Blume, New York: Palgrave Macmillan, http://www.dictionaryofeconomics.com.

Bushnell, J. (2010). "The Economics of Carbon Offsets," National Bureau of Economic Research.

Cacho, O. J., Marshall, G. R., & Milne, M. (2005). Transaction and abatement costs of carbon-sink projects in developing countries. *Environment and Development Economics*, *10*(5), 597-614. doj: doi:10.1017/S1355770X05002056

Chavas, J. (2009). On the productive value of biodiversity. *Environmental and Resource Economics, 42*(1), 109-131. doi:http://dx.doi.org/10.1007/s10640-008-9206-z

Climate Action Reserve. (2017). *Climate Action Reserve Forest Project Protocol*. Los Angeles: Climate Action Reserve.

Conniff, R. (2012). What's Wrong with Putting a Price on Nature? Retrieved from http://e360.yale.edu/features/ecosystem_services_whats_wrong_with_putting_a_price_on_nature

Colgate Sustainability Office. (2016). "Bicentennial Plan for a Sustainable and Carbon Neutral Campus, 2017-2021." Colgate University.

Goodward, J. & Kelly, A. (2010). Bottom Line on Offsets | World Resources Institute. [online] Wri.org. Retrieved from https://www.wri.org/publication/bottom-line-offsets.

Darnall, N. & Carmin, J. (2005). Greener and Cleaner? The Signaling Accuracy of U.S. Voluntary Environmental Programs. *Policy Sciences, 38*(2/3), 71-90. Retrieved from http://www.jstor.org/stable/4532654

Norborg Carter, K. (2017). How to Maintain Biodiversity in the Forest's Ecosystems. Retrieved from https://sciencing.com/maintain-biodiversity-forests-ecosystems-13436.html

Osborne, T., & Kiker, C. (2005). Carbon offsets as an economic alternative to large-scale logging: a case study in Guyana. *Ecological Economics*, *52*(4), 481–496. https://doi.org/10.1016/j.ecolecon.2004.06.003

O'Reilly, K. (2017). The Top 20 Coolest Schools. Retrieved from https://www.sierraclub.org/sierra/cool-schools-2017/top-20

Pasinella, B. (2016). "Peer Reviewed and Innovative Carbon Offsets" presentation. Retrieved from www.secondnature.org.

Pirikiya, M., Amirnejad, H., Oladi, J. & Ataie Solout, K. (2016). Determining the recreational value of forest park by travel cost method and defining its effective factors. *Journal of Forest Science*, 62: 399-406. doi:10.17221/12/2016-JFS

Pumilio, J. (2017). "The Bicentennial Plan: ENST 390". *Colgate University's Sustainability and Climate Action Plan Update*

Rivera, J., & de Leon, P. (2004). Is greener whiter? voluntary environmental performance of western ski areas. *Policy Studies Journal, 32*(3), 417-437. Retrieved from https://search.proquest.com/docview/210560800?accountid=10207

Second Nature. (2017). Carbon Management & Greenhouse Gas Mitigation - Second Nature. [online]. Retrieved from http://secondnature.org/wp-content/uploads/Carbon-Markets-and-Offsets-Guidance-1.pdf

Svokos, A. (2015). The Most Beautiful College Campuses In 2015, Ranked By Princeton Review. Retrieved from https://www.huffingtonpost.com/2014/12/28/beautiful-college-campuses-2015_n_6374822.html

Tietenberg, T., & Lewis, L. (2014) *Environmental and Natural Resource Economics* (10th ed.). Routledge.

Urban Offsets Registry. (2017). *How It Works*. -Urban Offsets Registry. [online] Available at: https://registry.urbanoffsets.co/howitworks

Venkatachalam, L. (2004). The contingent valuation method: a review. *Environmental Impact Assessment Review,* 24(1), 89-124. doi: 10.1016/S0195-9255(03)00138-0

Waltert, F. & Schläpfer, F. (2010). Landscape amenities and local development: A review of migration, regional economic and hedonic pricing studies. *Ecological Economics*, 70(2), 141-152. doi: 10.1016/j.ecolecon.2010.09.031

[i] From “The Bicentennial Plan: ENST 390,” by J. Pumilio, 2016, *Colgate University’s Sustainability and Climate Action Plan Update,* p. 46. Copyright 2017 by Copyright holder.

[ii] From “The Bicentennial Plan: ENST 390,” by J. Pumilio, 2016, *Colgate University’s Sustainability and Climate Action Plan Update,* p. 5. Copyright 2017 by Copyright holder.

[iii] From “The Bicentennial Plan: ENST 390,” by J. Pumilio, 2016, *Colgate University’s Sustainability and Climate Action Plan Update,* p. 45. Copyright 2017 by Copyright holder.

[iv] From “Carbon Neutrality Reached,” by Bluesource, 2017. Retrived from http://www.bluesource.com/2017/01/04/carbon-neutrality-reached/. Copyright 2017 by Copyright holder.

[v] From “Carbon Neutrality: Making Neutrality a Reality,” by Middlebury Univerisity, 2017, *Sustainabilty*. Retrived from http://www.middlebury.edu/sustainability/our-commitment/carbon-neutrality. Copyright 2017 by Copyright holder.

[vi] From “Urban Forestry Carbon Offset Protocal 2.0,” by Duke University, 2017, *Duke Carbon Offset Initiative*. Retrived from https://sustainability.duke.edu/sites/default/files/urbanforestprotocol.pdf. Copyright 2017 by Copyright holder.

[vii] From "Clarkson’s Race to Zero – Climate Action Planning” by Clarkson University, 2016, *Clarkson Climate Action Plan.* Retrieved from: http://internal.clarkson.edu/green/docs/CAPNov.2016.pdf Copyright 2016 by Copyright holder.

[viii] From “Uganda Carbon Offset Program,” by Offset Network, *Offset Projects*. Retrived from http://offsetnetwork.org/uganda-carbon-offset-program/. Copyright by Copyright holder.

[ix] From “Greener and Cleaner? The Signaling Accuracy of U.S. Voluntary Environmental Programs,” by N. Darnall & J. Carmin, 2005, *Policy Sciences,* 38 (2/3), p. 71-90. Copyright 2005 by Copyright holder.

[x] From “Voluntary environmental programs: assessing their effectiveness,” by J. C. Borck & C. Coglianese, 2009, *Annual Review of Environmental Resource,* 35, p. 305-324. Copyright 2009 by Copyright holder.

[xi] From “Greener and Cleaner? The Signaling Accuracy of U.S. Voluntary Environmental Programs,” by N. Darnall & J. Carmin, 2005, *Policy Sciences,* 38 (2/3), p. 71-90. Copyright 2005 by Copyright holder.

[xii] From “Voluntary environmental programs: assessing their effectiveness,” by J. C. Borck & C. Coglianese, 2009, *Annual Review of Environmental Resource,* 35, p. 305-324. Copyright 2009 by Copyright holder.

[xiii] From “Voluntary environmental programs: assessing their effectiveness,” by J. C. Borck & C. Coglianese, 2009, *Annual Review of Environmental Resource,* 35, p. 305-324. Copyright 2009 by Copyright holder.

[xiv] From “Greener and Cleaner? The Signaling Accuracy of U.S. Voluntary Environmental Programs,” by N. Darnall & J. Carmin, 2005, *Policy Sciences,* 38 (2/3), p. 71-90. Copyright 2005 by Copyright holder.

[xv] From “Voluntary environmental programs: assessing their effectiveness,” by J. C. Borck & C. Coglianese, 2009, *Annual Review of Environmental Resource,* 35, p. 305-324. Copyright 2009 by Copyright holder.

[xvi] From “Greener and Cleaner? The Signaling Accuracy of U.S. Voluntary Environmental Programs,” by N. Darnall & J. Carmin, 2005, *Policy Sciences,* 38(2/3), p. 71-90. Copyright 2005 by Copyright holder.

[xvii] Pumilio, J. (2017, Oct 27). Personal Interview.

[xviii] From “Is greener whiter? voluntary environmental performance of western ski areas,” by J. Rivera & P. Leon, 2005, *Policy Studies Journal,* 32(3), p. 17-437. Copyright 2004 by Copyright holder.

[xix] From “Voluntary environmental programs: assessing their effectiveness,” by J. C. Borck & C. Coglianese, 2009, *Annual Review of Environmental Resource,* 35, p. 305-324. Copyright 2009 by Copyright holder.

[xx] From “Bottom Line on Offsets,” by J. Goodward & A. Kelly, 2010, *World Resources Institute,* 35, p. 305-324. Retrieved from https://www.wri.org/publication/bottom-line-offsets. Copyright 2010 by Copyright holder.

[xxi] From “Bottom Line on Offsets,” by J. Goodward & A. Kelly, 2010, *World Resources Institute,* 35, p. 305-324. Retrieved from https://www.wri.org/publication/bottom-line-offsets. Copyright 2010 by Copyright holder.

[xxii] From “Bottom Line on Offsets,” by J. Goodward & A. Kelly, 2010, *World Resources Institute,* 35, p. 305-324. Retrieved from https://www.wri.org/publication/bottom-line-offsets. Copyright 2010 by Copyright holder.

[xxiii] From “The Economics of Carbon Offsets,” by J. Bushnell, 2010, *National Bureau of Economic Research.* Copyright 2010 by Copyright holder.

[xxiv] From “The Economics of Carbon Offsets,” by J. Bushnell, 2010, *National Bureau of Economic Research.* Copyright 2010 by Copyright holder.

[xxv] From “The Economics of Carbon Offsets,” by J. Bushnell, 2010, *National Bureau of Economic Research*, p. 6. Copyright 2010 by Copyright holder.

[xxvi] From “FY 2016 Colgate University Greenhouse Gas Inventory Report,” edited by J. Pumilio, 2016. Copyright 2016 by Copyright holder.

[xxvii] From “Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S.

Forestlands," by J. Bushnell, 2016, *National Bureau of Economic Research.* Copyright 2016 by Copyright holder.

[xxviii] From "Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands," by J. Bushnell, 2016, *National Bureau of Economic Research.* Copyright 2016 by Copyright holder.

[xxix] From "Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands," by J. Bushnell, 2016, *National Bureau of Economic Research.* Copyright 2016 by Copyright holder.

[xxx] From "Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands," by J. Bushnell, 2016, *National Bureau of Economic Research.* Copyright 2016 by Copyright holder.

[xxxi] From "Climate Action Reserve Forest Project Protocol," 2017, *Climate Action Reserve.* Copyright 2017 by Copyright holder.

[xxxii] From "Climate Action Reserve Forest Project Protocol," 2017, *Climate Action Reserve.* Copyright 2017 by Copyright holder.

[xxxiii] From "Climate Action Reserve Forest Project Protocol," 2017, *Climate Action Reserve.* Copyright 2017 by Copyright holder.

[xxxiv] From "How It Works," 2017, *Urban Offsets Registry.* Retrieved from https://registry.urbanoffsets.co/howitworks. Copyright 2017 by Copyright holder.

[xxxv] From "'Peer Reviewed and Innovative Carbon Offsets' presentation," by B. Pasinella, 2016, Retrieved from from www.secondnature.org. Copyright 2016 by Copyright holder.

[xxxvi] From "'Peer Reviewed and Innovative Carbon Offsets' presentation," by B. Pasinella, 2016, Retrieved from from www.secondnature.org. Copyright 2016 by Copyright holder.

[xxxvii] From "The Bicentennial Plan: ENST 390," by J. Pumilio, 2016, *Colgate University's Sustainability and Climate Action Plan Update,* p. 46. Copyright 2017 by Copyright holder.

[xxxviii] From "'Peer Reviewed and Innovative Carbon Offsets' presentation," by B. Pasinella, 2016, Retrieved from from www.secondnature.org. Copyright 2016 by Copyright holder.

[xxxix] Woodside, R. (2017, Nov 10). Personal interview.

[xl] Woodside, R. (2017, Nov 10). Personal interview.

[xli] From "The contingent valuation method: a review," by L. Venkatachalam, 2004, *Environmental Impact Assessment Review,* 24(1), p. 89-124. Copyright 2004 by Copyright holder.

[xlii] From "The Determining the recreational value of forest park by travel cost method and defining its effective factors," by M. Pirikiya, H. Amirnejad, J. Oladi & K. Ataie Solout, 2016, *Journal of Forest Science,* 62, p. 399-406. Copyright 2016 by Copyright holder.

[xliii] From "Landscape amenities and local development: A review of migration, regional economic and hedonic pricing studies," by F. Waltert & F. Schläpfer, 2010, *Ecological Economics,* 70(2), p. 141-152. Copyright 2010 by Copyright holder.

[xliv] From "*Environmental and Natural Resource Economics*," by T. Tietenberg & L. Lewis, 2014*,* 10. Copyright 2014 by Copyright holder.

[xlv] From "*Environmental and Natural Resource Economics*," by T. Tietenberg & L. Lewis, 2014*,* 10. Copyright 2014 by Copyright holder.

[xlvi] Smith, A. L. (2017, Nov 7). Email Conversation.

[xlvii] From "*Environmental and Natural Resource Economics*," by T. Tietenberg & L. Lewis, 2014*,* 10. Copyright 2014 by Copyright holder.

[xlviii] From "*Environmental and Natural Resource Economics*," by T. Tietenberg & L. Lewis, 2014*,* 10. Copyright 2014 by Copyright holder.

[xlix] Turner, B. (2017, Oct. 26). Personal Intreview; Klotz, R. (2017, Nov 3). Personal Interview.

[l] From "Colgate Forest," by Colgate Univerity, 2017, *Colgate Forest*. Retrieved from from https://sites.google.com/a/colgate.edu/carbon-offsets-working-group/2019-offset-options/colgate-forest?pli=1. Copyright 2016 by Copyright holder.

[li] Pumilio, J. (2017, Sept. 14). Class discussion (with approved permission).

[lii] From "Transaction and abatement costs of carbon-sink projects in developing countries,"O. J. Cacho, G. r. Marshall, & M. Milne, 2005, *Environment and Development Economics, 10*(5), p. 597-614. Copyright 2005 by Copyright holder.

[liii] Byrne, J. (2017, Nov 13). Personal Interview.

[liv] Byrne, J. (2017, Nov 13). Personal Interview,

[lv] From "Carbon Management & Greenhouse Gas Mitigation," 2017, *Second Nature*. Retrieved from from http://secondnature.org/wp-content/uploads/Carbon-Markets-and-Offsets-Guidance-1.pdf*.* Copyright 2016 by Copyright holder.

[lvi] From "Carbon Management & Greenhouse Gas Mitigation," 2017, *Second Nature*. Retrieved from from http://secondnature.org/wp-content/uploads/Carbon-Markets-and-Offsets-Guidance-1.pdf*.* Copyright 2016 by Copyright holder.

[lvii] From "The Bicentennial Plan: ENST 390," by J. Pumilio, 2016, *Colgate University's Sustainability and Climate Action Plan Update.* Copyright 2017 by Copyright holder. Reprinted with permission.

[lviii] From "Uganda Carbon Offset Program," by Offset Network, *Offset Projects*. Retrived from http://offsetnetwork.org/uganda-carbon-offset-program/. Copyright by Copyright holder.

[lix] From "How to Maintain Biodiversity in the Forest's Ecosystems by K. Norborg Carter, 2017, *Sciencing*. Retrived from https://sciencing.com/maintain-biodiversity-forests-ecosystems-13436.html. Copyright 2017 by Copyright holder.

[lx] From "Uganda Carbon Offset Program," by Offset Network, *Offset Projects*. Retrived from http://offsetnetwork.org/uganda-carbon-offset-program/. Copyright by Copyright holder.

[lxi] From "The Most Beautiful College Campuses In 2015, Ranked By Princeton Review," by A. Svokos, 2015, *Huffington Post*. Retrived from https://www.huffingtonpost.com/2014/12/28/beautiful-college-campuses-2015_n_6374822.html. Copyright 2015 by Copyright holder.

[lxii] From "The Top 20 Coolest Schools," by K. O'Reilly, 2017, *Sierra*. Retrived from https://www.sierraclub.org/sierra/cool-schools-2017/top-20. Copyright 2017 by Copyright holder.

[lxiii] Byrne, J. (2017, Nov 13). Personal Interview.

[lxiv] Pumilio, J. (2017, Oct 27). Personal Interview.

[lxv] Klotz, R. (2017, Nov 3). Personal Interview.