WASTE NOT, WANT NOT: RECONCEPTUALIZING WASTE AS A RESOURCE AT CORNELL UNIVERSITY

A Project Paper

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ABSTRACT

Alongside a growing movement for “green” campuses, which are primarily classified as sustainable for their dedication to reducing greenhouse gas emissions, universities around the globe have increasingly focused attention on diverting food waste from landfills. Among the most common forms of waste diversion are recycling and composting. However, cross-contamination between waste streams, as well as the operational activities associated with composting, pose a significant hindrance to the effectiveness of this waste diversion method. Cornell University, while possessing an award-winning, on-campus compost facility and several sustainability incentivization programs, has yet to conduct a life cycle analysis of their food waste system. As Cornell University has announced their intention to become carbon neutral by the year 2035, an in-depth look at inefficiencies in this waste stream is all the more urgent. Therefore, the life cycle analysis presented in this study has quantified the amount of campus waste currently being redirected from landfills, as well as the amount that would need to be successfully diverted in the future to achieve carbon neutrality. While investigating the process by which food waste is diverted on campus , this study has identified key challenges to implementing a carbon-neutral strategy for waste diversion, along with suggestions for innovative solutions. These challenges are primarily contamination, transportation, operational activities and methane emissions at the compost facility, and inefficient reuse of waste. Based on this life cycle analysis presented here, it has been concluded that Cornell University is currently on-track to meet their goal of carbon neutrality by 2035. However, major changes will have to be made to campus waste streams for the continued success of this objective.

BIOGRAPHICAL SKETCH

Ellen Nevers is a candidate for the MPS in International Development, concentrating in International Agriculture and Rural Development. She graduated with a dual degree from Boston University in French Studies and Chinese Language and Literature with a specialization in linguistics. After completing her undergraduate degree, she worked on farms in Northern France, the Karoo National Park in South Africa, Northern Thailand, and the North Island of New Zealand serving as a translator and farmhand. These experiences led her to pursue a Master's degree in the field of agriculture. Her interests include sustainable farm management, waste management, and the use of compost for bioenergy.

This report is dedicated to the Cornell faculty and staff who generously offered their time to the creation of this project.

ACKNOWLEDGMENTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

It is the purpose of this life cycle analysis to determine the efficacy and productiveness of Cornell's current waste production, management, and diversion to answer the following question: How far is Cornell University from having a carbon-neutral food waste stream and what would it take achieve this goal by the year 2035?

Scope and Intent of Study

A life-cycle analysis (LCA) is "a tool that can be used to evaluate the potential environmental impacts of a product, material, process, or activity" (EPA, 2017). This assessment treats food waste as a product *produced* by Cornell University (either through food preparation or consumption) and has tracked the waste through initial disposal, transport, maturation, and re-use. Only food waste produced and managed by Cornell University will be included in this study.

Research Implications

In 2013, Cornell released a Climate Action Plan, detailing their goals and commitments to improving sustainable practices on campus. One of the goals is as follows: "Expand compost collection on campus to include campus events and small generator locations, such as office spaces and residence halls" (Cornell University Campus Sustainability Office, 76). However, if current waste streams are operating inefficiently, the expansion of such programs would be ineffective. For example, if high contamination rates within compost bins cause them to be directed to a landfill rather than reused for landscaping, local farms, or even energy, the resource potential is wasted. Currently, research is being conducted in Cornell's Department of Chemical Engineering for the conversion of food waste to energy via biogas. Considering that, "Campus energy needs account for nearly two-thirds of Cornell's carbon dioxide footprint, and even more of Cornell's total carbon footprint when upstream methane leakage is included," reconceptualizing waste as an energy resource could prove a crucial step in achieving carbon neutrality by 2035. Therefore, an in-depth analysis of the food waste life cycle at Cornell University is essential to guide the implementation of a sustainable, yet cost-effective, plan to reduce carbon emissions on campus.

Data Collection Methods

Both quantitative and qualitative data were collected to determine the efficiency and sustainability of Cornell University's food waste stream. Quantitative analysis included yearly waste production in pounds, transportation costs and distances, as well as compost facility energy use--all information which was readily available, but not yet synthesized, in mandated reports produced by Cornell University. In addition to the collection of these figures, semi-structured interviews were conducted with campus dining staff, compost-facility management, and members of student-run, waste-diversion clubs. These interviews have provided insight into the *perceived* efficiency of food waste operations on campus and investigated the undocumented expertise of those working closest to this waste stream.

CHAPTER 2

HISTORY OF COMPOSTING: AT CORNELL AND BEYOND

In 1972, the Stockholm Declaration called for institutes of higher education to lead the way in sustainable organizational practices. This declaration, "focused on finding ways in which universities, their leaders, lecturers, researchers, and students can engage their resources in responding to the challenges of balancing between the human quest for economic and technological development with environmental preservation" (Tiyarattanachai and Hollmann, 2016). As a result, implementations of sustainability programs on university campuses significantly increased (Grindsted and Holm, 2012).

In addition to the Stockholm Declaration, a book titled *Limits to Growth* was published in the same year by a team of MIT researchers, which urgently called for a reduction of global non-renewable resource consumption. The book presented a model of current non-renewable resource trajectories, factoring in population, agricultural and industrial capital, and the availability of arable land. It concluded that, "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity" (Meadows et al., 1972). Thus, in both the academic and public sphere, a growing interest and concern for sustainability was underway.

As this movement gained momentum (with a growing number of prospective students were paying attention to campus sustainability) universities were incentivized to "go green" and act as innovators in the field of environmental sustainability. In particular, many universities have engaged in Green Campus initiatives since the Universitas Indonesia (UI) developed the UI GreenMetric World University Ranking in 2010 as means of comparing university sustainability. The measurement ranks universities on the basis of six categories: setting and infrastructure, energy and climate change, waste management, water usage, transportation, and environmental education (Universitas Indonesia, 2015).

Waste management, one of the six categories factored into the GreenMetric ranking, has proved to be a particularly common strategy for higher education institutes to improve their score, as it is a relatively low-cost option. Cornell University, in particular, has wholeheartedly adopted a focus on waste management; the campus is unique in that it features its own on-campus composting facility. As figures 2.1 and 2.2 demonstrate, composting began at Cornell in 1992 with the construction of its on-site composting facility. It was originally created to manage manure and bedding waste from the College of Veterinary Medicine. Since then, it has expanded to include more waste streams across campus -- from food waste to construction waste. Today the composting facility sits on four acres and has received awards from the U.S. Environmental Protection Agency for the compost quality (Schwarz and Bonhotal, 2009).

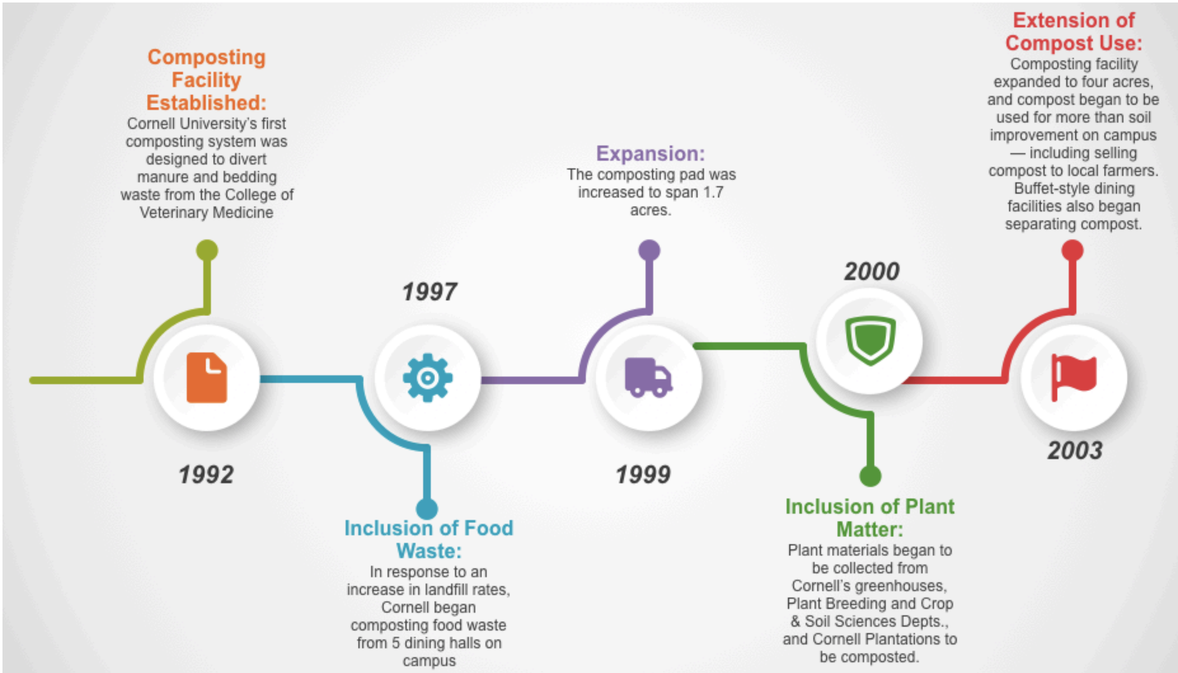

Figure 2.1

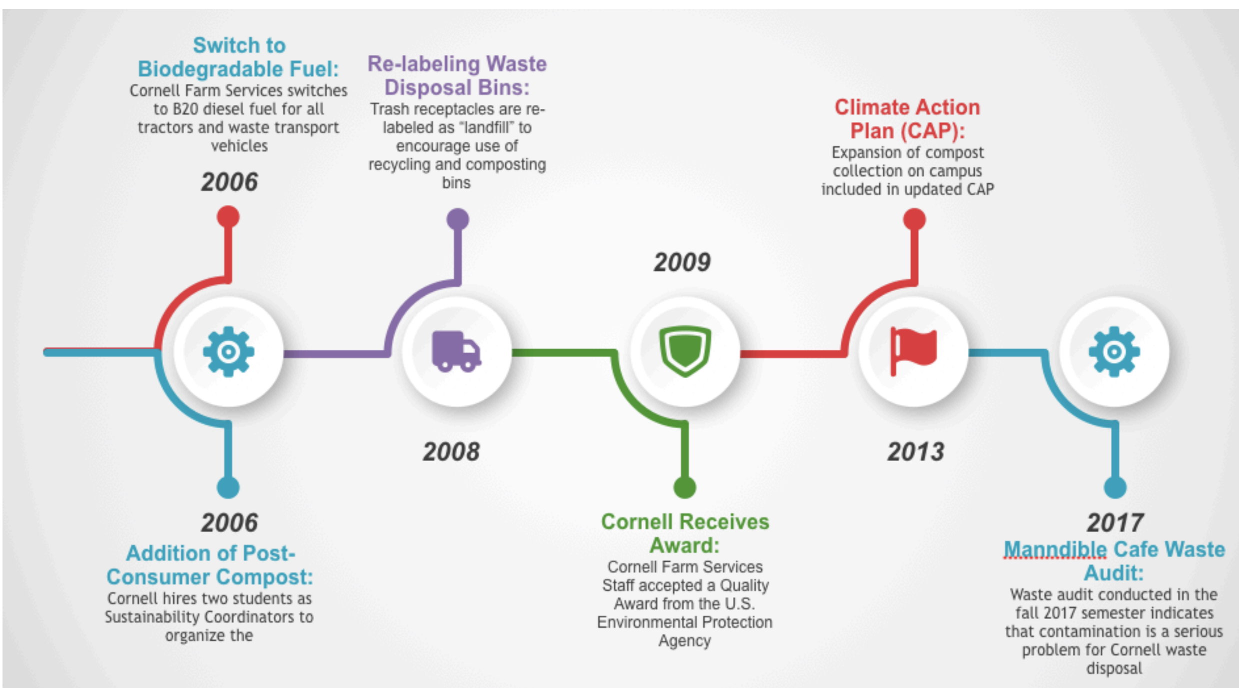

Figure 2.2

CHAPTER 3

LITERATURE REVIEW

Pertinent research on the study of compost waste streams tend to focus on one step of the waste life cycle--either disposal, management, or the implications/aftermath of waste on a given environment. Thus, this literature review has been divided into three sections to provide an overview of publications researching each stage of the life cycle. First, this report synthesizes the literature on environmental stewardship, particularly on university campuses. Many studies in this field have indicated that universities, as model communities in the sphere of sustainable innovation, play an important role in setting a standard for eco-friendly waste management practices. This section of the review will cover literature exploring what fosters a community of stewards to engage and improve food waste programs. Second, a summary of the successes and challenges of current campus waste management systems will be provided, which will provide the basis for a life cycle assessment of Cornell University's food waste. Finally, current research on the environmental, economic, and social impacts of food waste will be investigated to further elucidate the importance of sustainable food waste management.

Universities as Model Communities and Current Strategies for Campus Composting

University campuses hold a unique position on the global stage. They are oftentimes seen as model communities -- a place where innovation is tested and perfected before being adapted by groups at large. It is for this reason that universities have the opportunity and responsibility to serve as examples of sustainability, pushing the world towards environmental activism by being a model of efficient, ecological practices. One pivotally important way campuses can minimize their environmental impact is through the reduction of pre and post-consumer food waste. According to a publication by the National Resources Defense Council (NRDC), in 2012, "getting food to our tables eats up 10 percent of the total U.S. energy budget, uses 50 percent of U.S. land, and swallows 80 percent of freshwater consumed in the United States. Yet, 40 percent of food in the United States today goes uneaten" (Gunders, 2012). Additionally, the Journal of Hunger and Environmental Nutrition emphasized the growing need to address the problem of food waste in a recent article published, stating, "Food waste is a global problem with enormous implications for food security, biodiversity, water shortages, water quality, land degradation, and greenhouse gas emissions, to name a few" (Rajan et al, 2017).

Thus, food waste is not merely a problem because of its contribution to landfill waste -- although this is also a growing concern considering that, "landfills have become the third largest source of CH4 emissions in the United States and have accounted for 18% of the total methane emissions there" (US EPA, 2015). In the United States, " food wastes represented ~2% of the annual energy consumption (2030 ± 160 trillion BTU) in 2007, with nearly half of this resulting from food handling alone" (Rajan et al, 2017). The following infographic, published by the NRDC, also demonstrates the scale and scope of the problem; there is an enormous amount of time, money, energy, and water behind the waste.

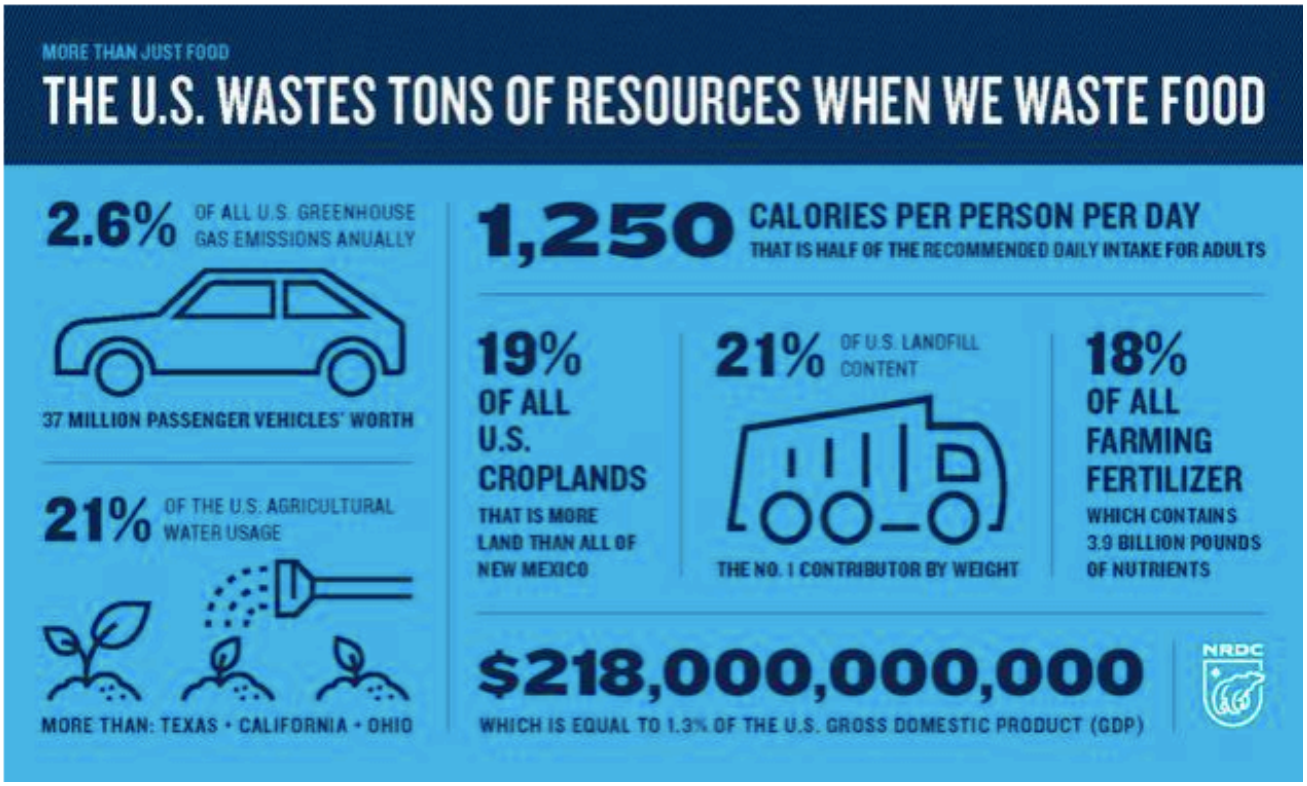

Figure 3.1 (NRDC, 2017)

The above chart provides some startling statistics about the daily caloric loss due to food waste. Given the paradoxical situation in the United States in which food insecurity and food waste exist side by side, finding a solution to current waste management inefficiency is all the more urgent; food waste is not merely an environmental hazard, but is also a moral problem. The USDA estimates that 17.3 million people live in food deserts, defined as urban communities that live more than one mile from access to healthy food (from a grocery store or other large vendor); in rural communities, a food desert is defined as a community that lives more than ten miles from access to healthy food (USDA ERS, 2017). Due to the prevalence of food deserts, "in the United States, 5.6%–14.5% of Americans were deemed food insecure in 2013, and as much as 40% of all food available to Americans was wasted in 2009" (Rajan et al, 2017). A study published in the Journal of Hunger and Environmental Nutrition researching the "greening" of Canada's University campuses, states, "wasting food in a community with high rates of hunger is a moral, social, and environmental failing". They describe the food waste that is often produced on university campuses as "the most egregious of food wastes" because they are "edible and prepared foodstuffs… with large embedded energy (e.g., food product– and cooking-related energy and emissions), labor time and cost, environmental impact (e.g., water use), and social impact (e.g., land use)" (Rajan et al, 2017).

Evidently, efficient and sustainable waste management systems would significantly improve environmental, economic, and social repercussions of food waste. University campuses, as models for other universities and communities around the globe, would serve as an ideal place to experiment with innovative waste management strategies. Because of their unique position, "universities play a critical role in developing environmentally sustainable policies, becoming climate neutral, and educating and graduating environmentally responsible students" (Babich and Smith, 2010). Furthermore, an assessment of the successes, failures, and challenges of these innovative solutions is critical to understanding and adopting best practices for waste diversion and reuse. Therefore, this review examines current strategies adopted by various universities and organizations while also seeking to understand how effective each strategy is for the community they seek to engage in sustainable waste disposal practices.

Environmental Stewardship Beyond the Campus

Literature on environmental stewardship investigates many different variables that foster community conservational activism. Quantitative studies most commonly cite the impact of demographic, socio-physical, and cost-benefit variables on the involvement and commitment level of community members to environmental causes. On the other hand, qualitative analyses tend to refer to notions of power structures, sense of place, place attachment, and cultural landscapes to explain what fosters a community of environmental stewards.

Studies that have attempted to find correlation among demographic groups and environmental activism have largely found weak correlations at best. It has generally been reported that, "associations between pro-environmental behavior and demographic variables tend to be weak and are inconsistent from study to study, which is not surprising considering the different ways research is designed" (Van Liere & Dunlap, 1991). In terms of socio-physical factors, an analysis conducted on 51 stewardship-related studies, "found a positive correlation between responsible environmental behavior and the variables of: knowledge of issues; knowledge of action strategies; internal locus of control; attitudes; verbal commitment; and an individual's sense of responsibility" (Hines et al, 1987). Additionally, "a positive attitude towards the neighborhood has been found to be correlated positively with active membership in a neighborhood organization" (Wandersman et al., 1987).

Finally, when quantitative analyses investigate cost-benefit as a variable of community participation in environmental programs, research generally indicates that, "most people rationally calculate the costs and benefits associated with taking part in organizations and will not join unless their membership in the organization will bring benefits they would not otherwise have obtained" (Donald, 1997). "Benefits", in this body of literature, refers to a variety of perceived returns on investment, including material benefits (e.g. property values), increased political influence, personal growth, personal enjoyment, increased profile in the community, friendship with other members, family bonding, sense of contribution and helpfulness, sense of providing a useful service to the community, and increased responsibility (Wandersman et al., 1987; Ordubhegian, 1993; Schahn & Holzer, 1990). Thus, it would appear that advertising potential benefits of participating in sustainability initiatives would increase participation and responsiveness.

Researchers in the field of public planning have also found that environmental planning programs have been more successful when they provide, " flexibility to allow innovation and accommodation in the planning process." It was observed that, " community partners have great success completing projects they themselves initiate" (Shandas and Messer, 2008). This indicates that community participation operates in a sort of feedback loop. Participation in ecological initiatives leads to better, more successful initiatives, which in turn leads to increased participation.

Evidently, the existence of community groups, perceived benefit from being part of such groups, and democratic decision making all positively influence the effectiveness of environmentally-friendly initiatives. However, the piece of the puzzle that's missing is how these communities are formed in the first place. Manzo and Perkins (2006), in their research on place attachment as it relates to community participation, assert that,

> *"The sharing of a common neighborhood space by diverse groups does not inevitably lead to a sense of community; therefore it is essential to understand the diverse meanings that a neighborhood holds for its residents in order to create successful places (Loukaitou-Sideris 1995). Such an understanding can also help foster action on the part of all parties who have an emotional stake in a place (Lukas, 1985). This is critical because urban neighborhoods are shaped by an array of cultures as residents express their identity spatially, through the creation of vernacular (i.e., culturally-*

sensitive, locally-based) architecture and through their use of space. Such practices can build a sense of community and create new attachments to place."

Research in this vein cites that having an "emotional stake" in a place requires a public space around which groups can gather. For example, "community gardens are heterogeneous environments that integrate environmental restoration, community activism, social interactions, cultural expression, and food security. This is because they, "provide a context for learning that addresses multiple societal goals, including a populace that is scientifically literate, practices environmental stewardship, and participates in civic life" (Krasny and Tidball, 2017). Thus, it may be important that Cornell University continues to create spaces on campus which could foster this kind of civic engagement and shared sense of community ownership.

Challenges to Composting and Strategies to Overcome Them

Despite the obvious benefits of composting, implementing a compost-based waste management system is not without its challenges. The often-cited quantitative analysis of Kean University's in-vessel composting system compared the suitability of in-vessel composting versus landfill waste management systems. In-vessel composting in a composting method by which waste in matured in some kind of building or container, as compared to letting compost mature outside. The study reported that, " composting food wastes in an in-vessel composter when compared to typical disposal means by landfilling, had lower impacts in the categories of fossil fuel, GHG (greenhouse gas) emissions, eutrophication, smog formation and respiratory effects; whereas, it had higher impacts in ozone depletion, acidification, human health impacts, and ecotoxicity" (Mu et al, 2017). This report confirmed that the composting system provided many environmental benefits to the community.

However, it also confirmed some of the common ramifications of implementing a composting system -- the possible risk it poses on human health. When a closed-loop waste management system is used (meaning that the waste, i.e. compost, is reused as fertilizer to grow crops that are once again served by the university), a higher standard of compost sanitation must be achieved to mitigate potential health risks of using compost waste as fertilizer for future food (Burton, 2016). Kean University currently manages this issue by using the in-vessel composter exclusively for, "pre- consumer wastes that are discarded before the consumer use stage, because the compost is going to meet the requirement of organic farms and using post-consumer waste increases the potential to contaminate the compost. (Mu et al, 2017).

The final challenge that recurred in the literature on current, compost-based university waste management systems was odor. The Kean University LCA addressed this issue, stating that, "although the odor of in-vessel composting is much lower than other composting technologies, it would still rise complains from students. Especially, the in-vessel composter is usually located close to student cafeterias where food wastes are collected. Adding an equipment to control odor could be a choice, but this will increase the investment" (Mu et al, 2017). Other studies addressed the problem of food waste order by freezing compost or by immediately removing the food waste and transporting it to a composting facility off-campus (Saer et al, 2013; Booth and Anderson, 2016; Sharp, 2002). However, not all universities have the option to quickly remove their food waste from campus. Urban universities face even greater challenges in creating an agricultural composting system because their urban locations may limit their access to finding a farm (or other user) to which they can send their compost. This affects the environmental and economic efficiency of the composting system because, "if the university transports compost to farms located in other regions, impacts will increase accordingly" (Mu et al, 2017).

Environmental, Economic, and Social Implications of Food Waste

The Environmental Protection Agency defines compost as, "organic material that can be added to soil to help plants grow" (EPA, 2017). Composting is an intriguing solution to campus waste diversion because it uses waste as a resource rather than a product to be removed and diverted to a landfill where it will serve to further purpose. However, composting also requires active community understanding, engagement, and participation in order to function as an effective solution. Several waste audits and life cycle analyses have been conducted in recent years on waste management systems on university campuses, indicating the growing interest in investing in campus sustainability initiatives. In general, these studies have found composting to be a highly effective and sustainable waste diversion technique in terms of environmental, economic, and social impact. However, determining the appropriate equipment and infrastructure required to carry out a campus food waste composting system, from the literature, appears to be a recurring problem. Additionally, cross-contamination due to lack of community education on how to use the composting system and lack of environmental stewardship have been noted as barriers to carrying out successful composting systems.

—> ***Environmental Impact***

Several researchers at Kean University, having recently conducted a life cycle analysis of an in-vessel composting system on campus, noted that, "a composting system provides many benefits towards achieving sustainability such as, replacing fertilizer use, increasing the quantity of produce sold, and diverting organic wastes from landfills" (Mu et al, 2017) The United States Environmental Protection Agency has also echoed this sentiment, asserting that, "amongst all of the diverting technologies, composting is the method recommended the most, because it is able to reduce waste disposal in landfills, while simultaneously recycling organic materials by converting them into a beneficial product" (US EPA, 2009). In terms of environmental benefits, studies have shown that, "applying compost to the soil may increase the carbon storage capacity within the soil, which reduces GHG emissions into the atmosphere" (Saer et al., 2013). Hence, the literature confirms that producing compost waste is by and large preferable to producing landfill waste. However, implementing an environmentally sustainable and effective composting system is not without its challenges.

The Kean University waste audit reported that, in many cases, "the nutrients levels of vegetables derived from compost differ from regular vegetables" (Capilano University Sustainability, 2013). The audit reported that, "the ammonium content in compost taken right out of the composter is too high to grow plants". As a result, the university was forced to store the compost for an additional 20 days, "to further decompose before it can be applied on the soil at Liberty Hall Farm at KU". This was problematic because, "the total weight loss from fresh food scraps to compost for land use is between 50% and 70%, depending on the amount of time allotted" (Mu et al, 2017). Thus, the amount of fertilizer that could be created from the university's food waste was significantly reduced.

Additionally, due to the problem of nutrient differences between vegetables fertilized with compost and those fertilized with other materials, "university cafeterias or high-end restaurants may hesitate to accept those vegetables which have been fertilized using campus compost" (Mu et al, 2017). This report confirmed some of the common ramifications of implementing a composting system -- the possible risk it poses on human health. When a closed-loop waste management system is used (meaning that the waste, i.e. compost, is reused as fertilizer to grow crops that are once again served by the university), a higher standard of compost sanitation must be achieved to mitigate potential health risks of using compost waste as fertilizer for future food.

—> *Economic Impact*

As previously touched upon, discarding edible food does not only waste environmental resources, but economic ones as well. The economic losses of food waste could be minimized if food waste was, instead, seen as a potential resource. Organic wastes, "are typically the heaviest component of a waste stream, thereby costing the most money to dispose of, and have the highest potential to emit greenhouse gases, once buried in a landfill," (Diaz et al, 1993). The NRDC estimates that the aggregated total cost of organic waste disposal in landfills is 218 billion dollars, which is roughly equivalent to 1.3% of the U.S. Gross Domestic Product (GDP) (NRDC, 2017). However, the disposal of organic materials does not inherently need to be wasteful. For example, the production of food that is ultimately wasted account for approximately 18% of total fertilizer use across the U.S, which contains almost four billion pounds of nutrients (NRDC, 2017). Imagine, however, that food waste was diverted from landfills and, instead, composted to be recycled back into the supply chain as fertilizer for future crops. In this scenario, sustainable management of food waste would not only reduce greenhouse gas emissions and save valuable, non-renewable resources, but also alleviate enormous agriculture-related costs.

—> Social Impact

As previously stated, there exists a paradoxical situation in the United States in which food insecurity and food waste exist side by side. Studies conducted by the NRDC suggest that "food saved by reducing losses by just 15 percent could feed more than 25 million Americans every year at a time when one in six Americans lack a secure supply of food to their tables" (Rogers, 2012). Evidently, there is an urgency to address unequal distribution of resources across the United States and globally. By restructuring current waste management systems to view food waste as a resource rather than a product meant for complete disposal, the environmental, economic, and social costs of food waste could be mitigated.

Implications

Food waste is a complex, but crucial, issue that is gaining attention on the global stage. It is a rapidly growing problem that presents environmental, economic, and social risks. Because food waste is integrally tied to a food, water, and energy nexus, it poses an enormous threat to the sustainable use of non-renewable resources. However, the problem of food waste is not without solutions. Informed by this body of literature, the following life cycle analysis will seek to investigate how Cornell measures up to their own goal of achieving a carbon-neutral campus by 2035. This research on Cornell University's food waste management system will advise how best to move the university towards this ultimate goal.

CHAPTER 4

OVERVIEW OF LIFE CYCLE ANALYSIS

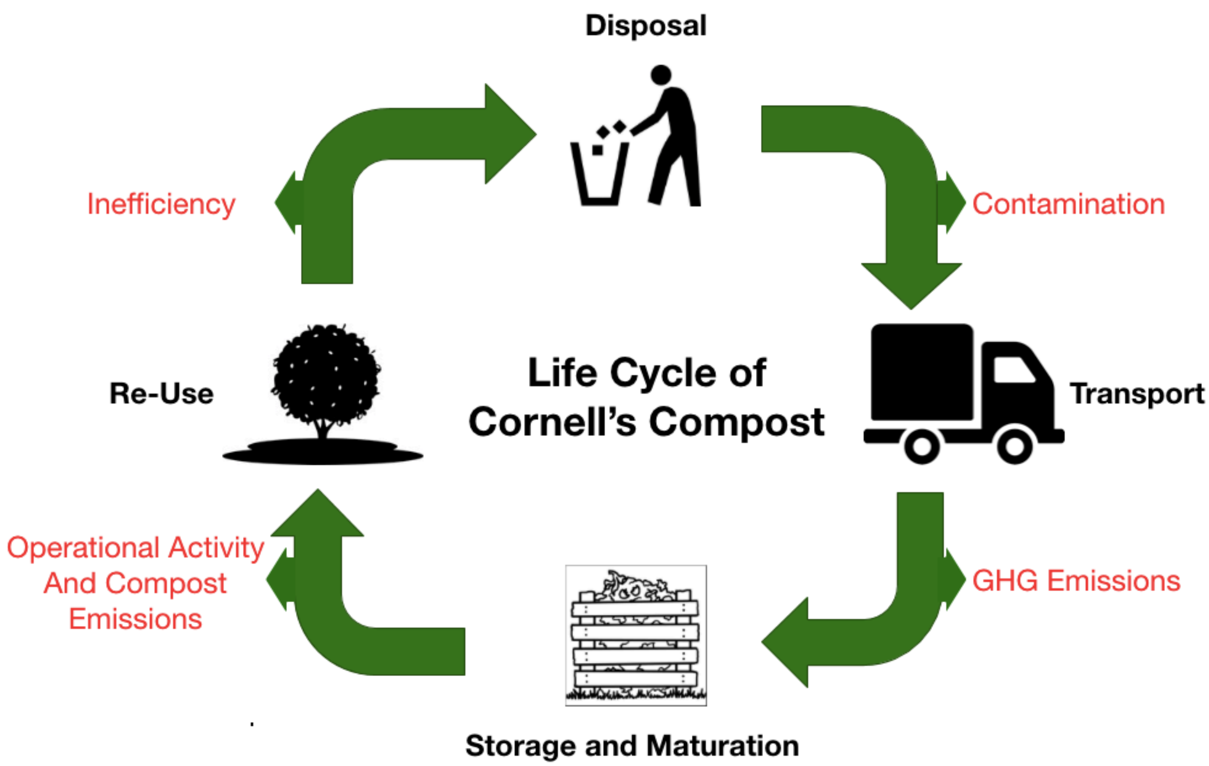

Figure 4.1

The diagram above demonstrates the course that this life cycle analysis will take as it follows the four main steps of waste management on campus. Similar to the concept of food miles, which tracks the energy and greenhouse gas emissions associated with the transportation of an item from producer to consumer, this life cycle analysis will treat waste as a product produced by Cornell University--beginning at initial disposal of said waste--and following it through storage/maturation and ultimate re-use. At each step of this life cycle, there are ways that food waste could be further maximized as a resource and ways that carbon emissions could be eliminated or counteracted. These “leaks” of efficiency in the life cycle are indicated in red on the diagram. Solutions for improvement for each leak will be suggested as this report reviews each stage of the food waste lifecycle.

CHAPTER 5

STEP ONE: DISPOSAL OF FOOD WASTE

Cornell Dining Facilities offers students 27 separate dining locations. Of these twenty-seven facilities, there are ten All-You-Care-to-Eat dining halls, eleven sit-in or grab-and-go cafes, two food courts, two convenience stores, one food truck, and one ice cream bar. Pre and post-consumer food waste is managed differently across these various styles of dining facilities (Cornell Dining, 2018). Pre-consumer food waste includes, "all food waste and compostable paper and plant-based products being composted during preparation and cooking before being served to customers. This would include all produce, dairy, and meat trim loss and any other food products that would not be eaten or salvaged" (AASHE, 2012). Post-consumer food waste, alternately, consists of non-consumed food scraps and compostable paper products disposed after being served to the consumer.

At the All-You-Care-to-Eat locations, pre and post-consumer food waste is handled entirely by paid dining staff. This significantly minimizes the risk of compost contamination--the greatest threat to inefficiency in the compost life cycle. According to Mary Harrington, head of the Washington State Department of Ecology, "the physical contaminants of most concern to composters are the Big Three: Plastics, glass and produce stickers". When these contaminants enter the waste stream, they pose a threat to the quality of compost produced; therefore, many compost facilities will not accept compost with an observable amount of contamination. Harrington, thus, emphasizes that compost contamination can be best prevented at the source by having trained sorters dispose of compostable products (2015).

Cornell University's All-You-Care-to-Eat dining facilities follow this suggestion by having students place reusable dining trays on a conveyor belt; food scraps are then washed and sorted into compost bins. This process is described by Extension Support Specialist Mary Schwarz and Director of the Cornell Waste Management Institute Jean Bonhotal as follows,

> *"Students need only bring their plates to the dish collection area where CU staff scrape the remains into a trough which leads directly to the pulper. The pulped scraps then travel down a pipe from the dish room to a dewatering machine. Once dewatered, the solids are collected in 32-35 gallon yellow plastic barrels on casters and the water goes down the drain. Note that food scraps can be composted whole or pulped but this system was in place before composting. Pre-consumer food scraps and other compostables are also collected in the yellow plastic barrels and wheeled down to the loading dock for pick-up by Farm Services. The cans are washed by CU staff with a can washer. The custodians who bring the barrels down to the loading dock police them for items that do not belong. If they see something that does not belong, they will take care of it. If it becomes consistent, or there is too much to take care of, they will bring it to the manager's attention and it will be discussed at the daily staff meeting." (2009).*

However, the 17 other retail-style dining facilities on campus do not follow this model. Instead, students are provided with three waste disposal bins: compost, recyclable, and landfill. Waste is then sorted by the individual consumer, oftentimes with the guidance of charts hung above each bin to indicate the appropriate disposal method for packaging and food products sold at this facility. Beginning in 2006, Cornell University began hiring two Student Sustainability Coordinators per academic year to, “have awareness campaigns at the dining halls for a week at a time to help teach patrons what is compostable and what is not. There is also extensive signage above the stations” (Schwarz and Bonhotal, 2009). However, not all retail-style dining facilities currently provide a compost disposal bin and, therefore, food waste must be discarded with the landfill refuse.

Despite the improvement of signage during the 2017 academic year, contamination still appears to be a significant problem at these sites.

During a waste audit conducted at Mann Library during the spring semester of 2017--prior to the intervention of improved signage--it was observed that there was significant contamination between waste bins (as demonstrated in figure 5.1).

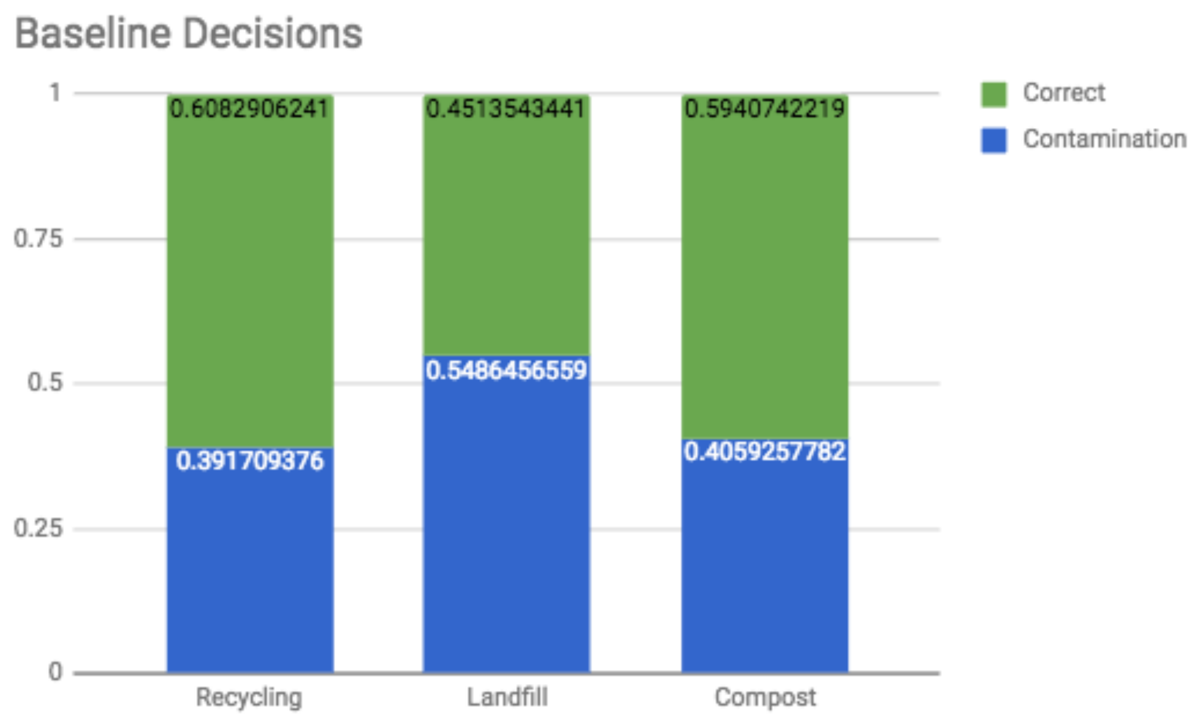

Figure 5.1

The audit reported that more than 40% of the products disposed of in the compost bin were non-compostable. In an attempt to improve cross-contamination between bins Waste Not Want Not sustainability club, who conducted this waste audit, posted detailed signs with pictures of goods/packaging that belong in each respective disposal bin. The assumption of this strategy was that the high rate of contamination was due to a lack of knowledge around what did or did not qualify as a compostable goods, rather than a lack of concern for the environmental consequences of cross-contamination. After displaying the improved signage in Mann Library, the Waste Not Want Not team conducted a post-intervention audit in the fall semester of 2017. The results are displayed in figure 5.2.

Figure 5.2

The baseline and post-intervention data show an 19% decrease in compost contamination, indicating that access to knowledge via improved signage might be an important strategy in decreasing cross-contamination across other grab-and-go/cafe-style dining areas. However, at 22% post-intervention, the problem of compost contamination was by no means eliminated. This might suggest that lack of knowledge about compostable goods may not be the only factor contributing to this problem. Further research would need to be conducted to identify consumer views on composting on Cornell's campus.

Percent Contamination at Lobby Waste Station

	Baseline	Post Intervention	Difference
Recycling	39%	22%	17%
Landfill	55%	45%	10%
Compost	41%	22%	19%

Figure 5.3

Therefore, while the most recent sustainability report published by Cornell University through STARS (Sustainability Tracking, Assessment, and Rating System) indicates that 6,934.13 tons of material was composted in 2015, the amount of *high-quality, usable* compost remains unreported (STARS, 2018). This calls into question the validity and representativeness of Cornell University's claim that 75.03% of waste was diverted from landfills and incinerators in 2015. This percentage measures the amount of waste that was collected and transported to Cornell campus' compost facility, but not the percentage that was ultimately repurposed for landscaping, farming, or other purposes.

Additionally, although the amount of food waste collected from the year 2014 to 2015 increased by approximately 300 tons, the reported percent of diverted waste slightly *decreased* from 76% to 75% (Facility and Campus Services, 2017). This indicates that policy changes did not in fact improve compost collection, but merely that *more* waste was produced in general; the percent of waste composted remained the same relative to that increase. Furthermore, the percent of diverted waste takes into account both recycling *and* composting initiatives, which raises the question: how much is campus composting contributing to waste diversion and what could be done to improve the amount and quality of compost being collected?

According to Felix Blanco, a Sustainable Campus Student Outreach Coordinator, "Data up until June 2016, shows that post-consumer compostable materials collected at Cornell Dining locations are regularly rejected and put into landfills at rates up to 50% because compost collections were contaminated with non-compost materials" (2016). In an attempt to decrease the instance of contamination, Tompkins County (in conjunction with the Cornell Campus Compost Facility) changed their policy to discontinue accepting plastic and paper service-ware in compost bins. It was reported that, "The goal of this change is to increase usable material in the composting process by decreasing contamination… With these new, simpler guidelines, Cornellians will decrease the rejection levels of compost collected by Farm Services because we will decrease the high rates of contamination at those areas" (Blanco, 2016). The following infographic was created to accompany this change in hopes of simplifying the composting process (and therefore reducing contamination) for members of the Cornell community.

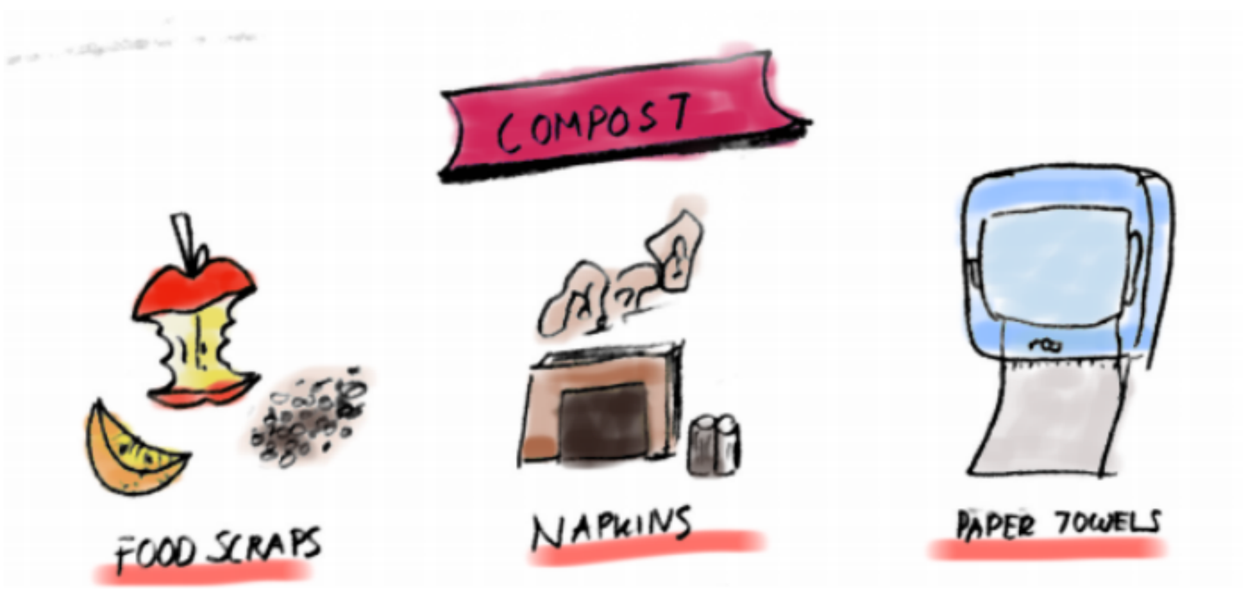

Figure 5.4

However, as results from the 2017 Mann Library waste audit indicate, contamination levels are still quite high despite this policy change implemented in August of 2016. In fact, the Waste Not Want Not team reported that plastic and paper service-ware was one of the top three contaminants of the compost bins being audited (Waste Not Want Not, 2017). Thus, despite the effort to simplify and raise awareness about compostable goods, confusion still persists around what is and is not compostable.

Solutions for Improvement: Preventing Contamination

As inefficiencies at the beginning of the waste stream impact the rest of the compost life cycle, it is important to minimize risk at step one: disposal. Mary Harrington from the Washington State Department of Ecology emphasizes preventing contamination at the source of the waste stream in figure 5.5.

6 Steps To Clean Compost

Figure 5.5

In order to achieve clean compost from initial disposal she recommends, "Working toward cart color consistency [which] will reduce confusion and contamination. This consistency, along with clearly visible signs and volunteers to answer sorting questions, improves diversion and contamination reduction at special events" (2015).

Expanding upon this recommendation, the suggestions presented in this analysis are explained by the acronym S.A.V.E., as demonstrated below in figure 5.6.

Figure 5.6

Currently, Cornell lacks consistency among the color, style, and shape of their compost bins across campus. Hence, the **S**tandardization of compost bin appearance, as well as increasing the number of compost bins on campus, is one suggested action to decrease contamination. Similarly, consistent signage with images of commonly-disposed items posted above compost bins have proved to be an effective method for contamination reduction (Waste

Not Want Not, 2017); this strategy, currently being utilized outside Manndibles Cafe at Mann Library, could be expanded to dining facilities across campus.

However, as the Manndibles Waste Audit demonstrated with a post-intervention contamination rate of 22%, knowing where and what to compost is not a complete solution to the problem of contamination. Thus, **A**wareness of the consequences of contamination. Patrons must be sufficiently motivated to compost, which may stem from a deeper understanding of how composting diverts negative environmental impact.

Third, **V**olunteers to help guide consumer sorting would provide accountability and assistance to patrons of special events on Cornell's campus. Although having a volunteer to answer sorting questions at every compost bin on campus would not be a feasible solution, utilizing a volunteer at events where a large amount of waste might be produced in a short amount of time could prove highly beneficial. Additionally, **E**ducation through awareness campaigns run by Student Sustainability Coordinators could be expanded to include all dining facilities at the start of each semester.

CHAPTER 6

STEP TWO: TRANSPORTATION OF FOOD WASTE

Cornell Farm Services currently manages the food waste from the 11 on-campus, all-you-care-to-eat dining facilities. Five days a week, Monday through Friday, compost bins are collected by a farm services staff member and transported to the composting facility approximately thirteen miles from the farthest campus dining facility on north campus. The collection process is explained by the director of the Cornell Waste Management Institute, Jean Bonhotal, as follows:

> *"Prior to starting off on the pick-up, the truck is lined with six to eight inches of bedding material consisting of sawdust and horse manure. This material is built into a dam at the rear of the truck bed to prevent liquid leaving the truck. The dump truck they use has a lift onto which the yellow "compostables" barrel is strapped and the contents are dumped into the truck. The first run on Mondays, in which they pick up from 7 of the 11 dining halls and retail facilities, takes about an hour and a half and yields around 3.5 tons of organics. This is unloaded at the compost site next to the end of the windrow where a pile of sawdust, straw and chips (carbon source) is ready for later mixing. The second run takes approximately one hour and yields around 2.5 tons for a total of 6 tons of food and compostable items." (Schwarz and Bonhotal, 2009)*

Based on the weight and frequency of compost collection described by Bohotal, the total carbon emissions per day can be calculated--as demonstrated in figure 6.1. Since the farm services collection truck must make two runs to collect the food waste from all eleven dining facilities, it effectively travels the 13 miles from the compost facility in Dryden to north campus (the dining facility located farthest from the facility) four times per day. Two of these trips are taken with a nearly empty load and two with a 3.5 and 2.5 ton load of food waste, respectively. The additional weight affects the estimated miles per gallon the standard class VI dump truck utilized by Cornell farm services; this decrease in expected miles per gallon is considered in the calculation.

	Total Distance (mi)	Weig ht (lbs)	(~) Miles Per Gallon	C02 Emissions Per Gallon (lbs)	Total CO2 Emitted (lbs)
First Run - Out	1.3	14,40	15	22.38	1.940
First Run - Back	1.3	21,40	13	22.38	2.238
Second Run - Out	1.3	14,40	15	22.38	1.940
Second Run - Back	1.3	19,40	14	22.38	2.078
Total	5.2	-	-	-	8.196

Figure 6.1

Thus, using the distance, adjusted miles per gallon, and CO_2 emissions per gallon (as reported by the U.S. Department of Energy), the total CO_2 emissions from food waste transportation can be derived. As figure 6.1 shows, the calculations conclude that 81.96 pounds of CO_2 are emitted per day at this step in the waste stream. Over the course of a calendar year, at a compost collection rate of five days a week, the transportation of food waste would emit 21,309.6 pounds, or about 10.65 tons, of CO_2 per year. However, in an inventory report publish in 2017, Cornell reported that campus activities produce approximately 212,000 tons of CO_2 each year; food waste transportation, then, accounts for a mere 0.00005% of campus carbon emissions.

Solutions for Improvement: Sustainable Biodiesel Fuel

Since 2006, Cornell switched their fleet of farm service vehicles from using diesel fuel to B20 biodiesel fuel. B20 diesel, "consists of 20 percent biodegradable fuel made from soybean or canola oil, a renewable resource that reduces particulate emissions by 17 percent while increasing engine life" (Lang, 2006). Although biodiesel does not reduce the amount of carbon emissions released during use, carbon is absorbed during the growing process of this alternative fuel. Hence, the carbon emission is offset by plant carbon absorption, making it a more sustainable option (as demonstrated in figure 6.2).

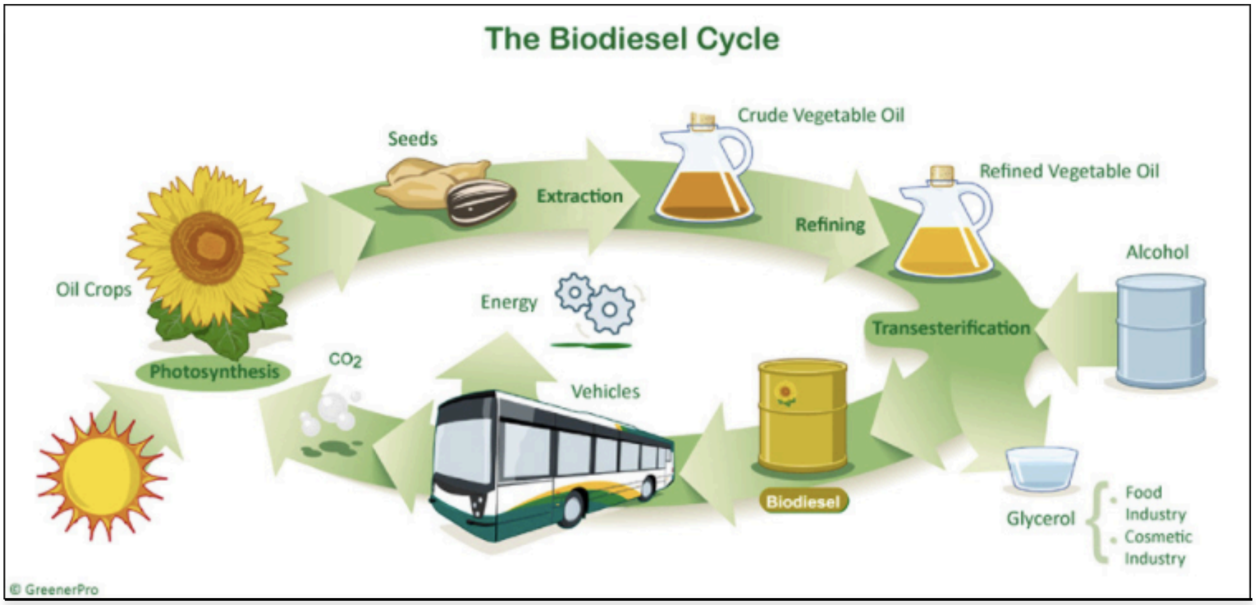

Figure 6.2 (Alternative Energy News, 2018)

However, land change plays a significant factor in the overall sustainability of biodiesel fuel. For example, if forest land is cleared in order to create arable farmland on which to grow oil crops, any carbon emissions offset is exiguous because, "the amount of greenhouse gas emissions from deforestation is so large that the benefits from lower emissions (caused by biodiesel use alone) would be negligible for hundreds of years" (UK Department for Transport, 2008). Currently, due to the number of middlemen involved in the supply chain for B20 diesel, it is unclear where the fuel supplied to Cornell University is coming from and whether or not the oil crops are being farmed on land that has not suffered deforestation. Biodiesel fuel has immense potential as a carbon neutral transportation method, if produced sustainably. Thus, further research would need to be conducted to assess the sustainability of the B20 biodiesel used at Cornell as well as the validity of a claim to carbon neutrality at this phase of the waste stream.

CHAPTER 7

STEP THREE: STORAGE AND MATURATION OF FOOD WASTE

Cornell University processes compost from 60 different waste streams. This includes, "4,000 tons of animal bedding and manure from research and teaching facilities, 300 tons of plant debris from campus greenhouses, orchards and farms, 800 tons of food scraps and organic kitchen waste from Cornell dining halls and small eateries, and other waste streams, such as building-specific compost collection programs and special events". In total, Cornell Farm Services, " turns 5,000 to 7,000 tons of organic waste annually into high quality compost" (Cornell University Agricultural Experiment Station, 2018). The question, then, that concerns this life cycle analysis is, what energy output is required to store and mature campus compost and what is the quantity of carbon emissions released in this process?

For the composting process to begin, first, "the waste is piled in sequential long heaps, called windrows". The farm supervisor of Cornell's compost facility, Bill Huizinga, estimates that there are approximately eight windrows on-site at any given time, which are each around, "seven feet tall and the length of a football field" (Huizinga, 2018). Photos of these windrows can be seen in figures 7.1 and 7.2.

Figure 7.1

Figure 7.2

Each windrow is matured for approximately nine months--after which they are ready to be reused (for purposes that will be more thoroughly discussed in *Step 4: Reuse*). From April to November, windrows are turned bi-weekly. In the winter months between December and March, heaps continue to be turned, although much less frequently. If the compost piles are frozen or there is a significant amount of snow coverage, they cannot be turned. Turning resumes once the snow/ice has cleared and the Frontier F18 industrial turner (as pictured in figure 7.3) can once again fit over the windrows (Huizinga, 2018).

Figure 7.3

The contents of each windrow varies depending on the intended use of the compost. Approximately half of the windrows are composed solely of waste from the College of Veterinary Medicine and Cornell Dining Facilities. "There's a lot more red tape around this kind of waste," Bill Huizinga reported during a visit to the compost facility. Contamination remains a significant problem from these waste streams and, thus, this compost is not re-used or sold. These waste streams are combined and left to mature in separate windrows on one assigned part of the compost site. They are repurposed for "land use", meaning they are distributed around non-agricultural lands on Cornell's campus to fertilize and mix with the soil. Therefore, although the waste is not reused, it is reintegrated into the environment rather than disposed of in a landfill.

The remainder of the windrows at Cornell's composting facility are composed of, "wood chips, leaves, manure from Cornell farm services, and other organic wastes" (Huizinga, 2018). The end product of these windrows is, "used for campus landscaping, university experimental farms, and sold to local landscape companies" (Cornell Dining, 2018). One windrow is dedicated entirely to the composting of wood chips and leaves, as this is mixture is used by Cornell's Botanical Gardens for planting (Huizinga, 2018).

The composting process requires, "consistent aeration and mixing of the organic materials... [this] speeds up the composting process and helps to regulate moisture levels" (Cornell University Agricultural Extension Station, 2018). However, much of this process occurs organically and requires minimal human intervention. In terms of equipment and carbon emissions, the composting process requires very few resources and contributes only marginally to greenhouse gas emission. Mr. Huizinga reported that only himself and two farm service assistants are responsible for the management of the compost facility. The team of three successfully produces quality compost with only one Frontier F18 Compost Turner and "about a half-dozen farm vehicles", such as dump trucks and small loaders, for collecting and distributing campus waste onto the windrows (Huizinga, 2018).

In a comparative study between landfill and compost pile particulate matter emissions -- which are the sum of all organic and inorganic, solid and liquid particles suspended in air many of which are hazardous -- it was found that, "Greenhouse gas emissions from waste decomposition are considerably higher for landfills than composting." One central reason for this disparity is the high rate of C4 emissions (methane) from landfills, "which has a GWP [global warming potential] 25 times that of CO_2." Although compost also generates C4, the organic matter contains aerobes, which, "are most densely located throughout the upper layer of the compost." It is in this layer that C4 is then captured and utilized by these microorganisms (Lou et al, 2009). Thus, a sort of self-regulation of methane emissions occurs within the compost windrows that does not take place in a landfill, making the composting process more environmentally sustainable overall. This observation is remarked on in the same comparative study between landfill and composting sites, stating,

> *"This brings about the fundamental difference between landfilling and composting – landfilling, together with its mitigation strategies are often reactive measures in environmental protection, seeking to remediate harmful effects it has caused. Conversely, composting adopts a more proactive approached, with an objective to prevent or minimise such negative impacts in the first place" (Lou et al, 2009).*

However, despite the relatively low greenhouse gas emission of composting sites when compared to landfills, compost maturation is not a carbon-neutral process. So, what could be done to achieve carbon neutrality at this stage in the food waste life cycle at Cornell University? The next section, *Solutions for Improvement*, will discuss some innovative strategies for offsetting carbon emissions on composting sites.

Solutions for Improvement: Minimizing Greenhouse Gas Emissions

The body of research investigating greenhouse gas emissions from composting facilities point to four main strategies for emission reduction. These strategies are presented in the following infographic (figure 7.4).

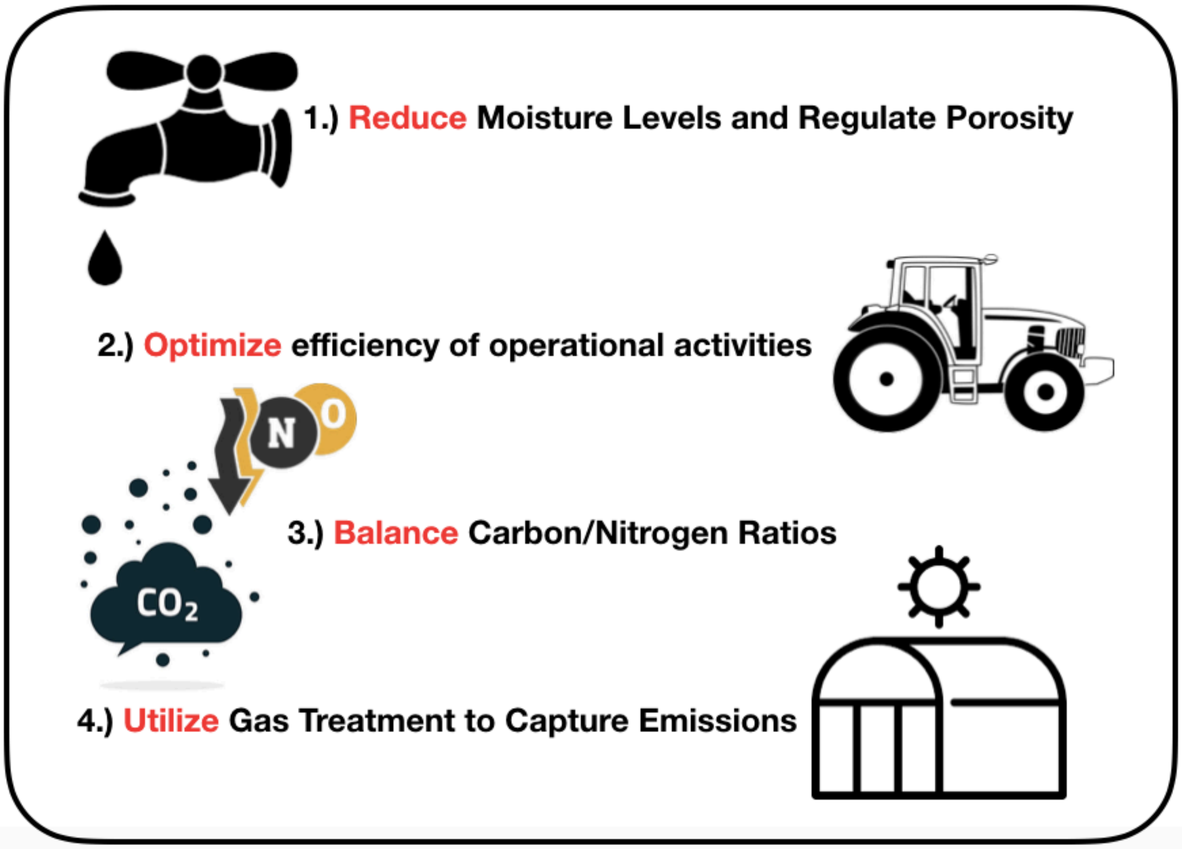

Figure 7.4

The first recommended strategy for proven greenhouse emission reduction is the reduction of moisture content in compost piles. It has been discovered that, "wastes with...high water content have a great potential for generating GHG emissions both during the storage and the composting process" (Lou et al. 2009). This is because high water content increases the likelihood that anaerobic pockets will be formed in the compost pile. These pockets, then, fill with C4 as the waste inside the compost windrow (which have a higher-temperature environment than the waste at the surface of the pile) degrade. When the compost is subsequently turned, these pockets of highly-concentrated methane are released into the atmosphere (Lou and Nair, 2011; Colon, 2012; Tamura and Osada, 2006). Therefore, it is important to maintain a low moisture content so that C4 is evenly distributed throughout the pile, allowing it to more easily be reabsorbed by microorganisms rather than released back into the atmosphere (Lou et al., 2009).

Research has identified that manure and other biosolids, in particular, “have a poor structure and an excess of water content and require the use of a bulking agent” (Lou et al., 2009). This is consistent with the observations of the staff at Cornell’s Compost Facility. Mr. Huizinga commented that the compost site stopped processing manure from Cornell’s dairy farm in 2016 exactly for this reason: cattle manure increased the moisture content of the compost, increasing methane emissions and decreasing overall compost quality (2018). Cornell’s compost facility also manages excess moisture in their compost by placing windrows on a slope. At the bottom of this slope, “Any water and nutrient runoff from the compost facility is captured in two large collection ponds and is either returned to windrows when they are too dry, or pumped to pastureland that serves as a bio-filter to uptake water and nutrients” (Cornell Farm Services, 2018). One of these two collection ponds is pictured below (Figure 7.5).

Figure 7.5

Typically, overly wet compost requires the supplementation of bulking agents to be ground and mixed into the windrow. These are, "operations that require energy that again contribute to GHG emissions" (Lou et al., 2009). This leads to the second recommendation for emission reduction: optimizing efficiency of operational activities.

A paradox exists in the field of compost site management. On the one hand, research studies have observed, "lower N2O and CH4 emissions in turned piles than in static systems" (Lou et al, 2009; Lou and Nair, 2011; Colon, 2012; Tamura and Osada, 2006). This information would indicate that the best practice would be to continue regularly turning compost windrows to ensure proper aeration. However, on the other hand, it has also been observed that, ““The CO2 that contributes to GHG emissions is generated by composting facilities as a result of operational activities” (Lou et al., 2009). Thus, there is an ideal balance which must be determined to ensure the highest compost quality and aeration while also minimizing operational use of CO2-emitting equipment. When assessing environmental impact of a composting site, it is important to be remember that, “The operational activities can contribute to GHG of composting process more than the decomposition process itself” (Lou and Nair 2011).

Therefore, although the Cornell Composting Facility previously turned compost piles weekly, the decision has been made in the last two years to turn each pile bi-weekly instead. This cuts down on diesel fuel costs and, subsequently, greenhouse gas emissions (Huizinga, 2018). It is the recommendation of this analysis that compost piles continue to be regularly tested to optimize the use of operational activities.

The third recommendation is to ensure an even carbon-to-nitrogen ratio within each compost windrow. Compost research has indicated that, “co-composting of complementary wastes,” is ideal to, “obtain a balanced initial mixture with a balanced porosity and biodegradable C/N [carbon-to-nitrogen] ratio” (Lou et al., 2009). The reason behind the necessity for a balanced carbon-to-nitrogen ratio is similar to the reason a low moisture content is desirable: this prevents the build-up of carbon or nitrogen pockets within the compost pile. A high carbon content will not be reabsorbed by microorganisms in the compost pile and, thus, are ultimately released into the atmosphere (as is the case with a high nitrogen content). Therefore, a C/N balance should significantly reduce the greenhouse gas emissions of the subsequent composting process.

Lastly, this analysis recommends that Cornell consider the creation of a *closed-system composting site*. This is a site in which composting piles are inside closed buildings with a gas management system. Closed-system composting facilities, "present much lower environmental impact because process emissions are not released to the atmosphere" (Lou et al., 2009). This strategy is the most promising in terms of achieving carbon neutrality for Cornell University's composting site. While the other strategies minimize the risk of methane and carbon dioxide emissions, this approach (when working as intended) essentially eliminates emissions by trapping them before they are ever released into the environment.

CHAPTER 8

STEP FOUR: REUSE OF FOOD WASTE

Up until 2003, Cornell Farm Services primarily used compost waste, "to supplement nutrients on field crops (field crops are tolerant of composts that are 3/4 finished) and to generally improve the soil as well as for research in compost quality and use." The food waste and veterinary hospital manure are still composted separately and used primarily for this same purpose -- for fertilization of Cornell's agricultural fields (Cornell Farm Services, 2018). The remaining compost is, "managed for sale and used in research" (Schwarz and Bonhotal, 2009). However, in 2003, due to a significant increase in landfill fees, "A decision was made to use more compost on campus and to sell some locally. In order to produce stable, mature compost, the pad was enlarged to the current size of 4.0 acres" (Schwarz and Bonhotal, 2009). Today, although most compost is re-purposed for use on Cornell grounds (i.e. for landscaping, planting at the botanical gardens, and research purposes), Cornell continues to sell compost to local farms and private research groups (Huizinga, 2018).

Solutions for Improvement: Renewable Bioenergy Initiative

Organic wastes, rather than being a *source* of carbon emissions, have the potential to be reconceptualized as the *solution*. The Cornell Composting Facility Site Director reported that currently all compost (except contaminants found within compost piles which are removed and disposed of) is reused either for fertilizer, land cover, planting, or research--nothing is wasted once it reaches the compost site (Huizinga, 2018). However, as Cornell continues to strive to reach their goal of carbon neutrality by 2035, they are looking for innovative strategies for preventing and/or counteracting carbon emissions produced as a result of campus activities. Organic waste could play a much more active role in reducing greenhouse gas emissions, rather than contributing to them.

Compost could be a tool to achieving carbon neutrality through the creation of biogas. Biogas is a gaseous fuel, most commonly methane and carbon dioxide, which is created through the fermentation of organic matter. It is, "considered to be a renewable fuel as it originates from organic material that has been created from atmospheric carbon by plants grown within recent growing seasons" (Clarke Energy, 2017). As heating and electricity are the largest contributor to greenhouse gas emissions at Cornell University, utilizing waste already produced on campus as a potential energy source is a promising, sustainable solution. In fact, the use of bioenergy--including biogas--as an energy source has already been outlined as a prospective strategy in Cornell's Climate Action Plan published in 2013 (as seen in figure 8.1 below).

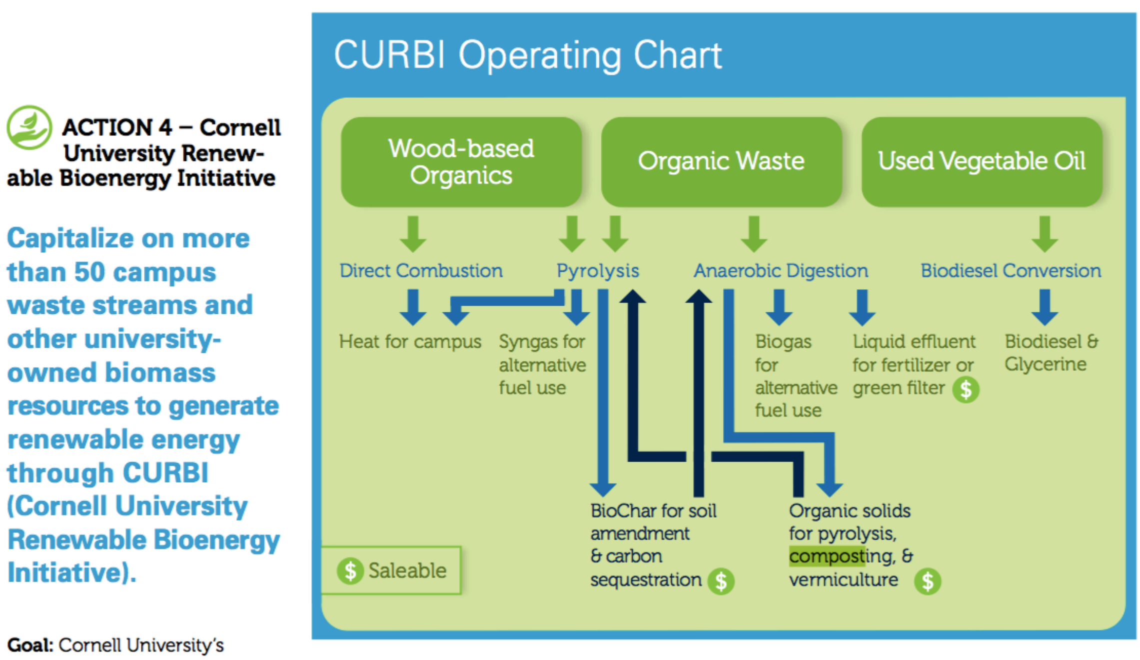

Figure 8.1

Although the implementation of this bioenergy initiative would require some upfront costs, such as the purchase of an anaerobic digester to convert waste to electricity, figure 8.1 presents a few methods for the recovery of these costs. Cornell University sees potential in the re-sale of bioenergy to local buyers, which could be used to cover the startup and operating costs of this system.

This recommendation makes both environmental and economic sense for the university. Not only would this allow the institution to save money by reducing the amount of electricity purchased from the grid, but the university would *earn* money through the sale of bioenergy. Therefore, it is the suggestion of this analysis that alternative uses for food and other organic wastes be explored. If Cornell University employs its waste as a resource, it will have more tools at its disposal to achieve carbon neutrality on campus.

CHAPTER 9

CONCLUSION

In many ways, Cornell University has a model food waste stream. Since the creation of the composting site in 1992, the university has successfully diverted an impressive thousands of tons of waste per year from landfills. However, as has been demonstrated throughout this report, there are several areas for improvement at each step of the waste life cycle: disposal, transportation, storage and maturation, and reuse. These recommendations are all the more urgent in the wake of a push to achieve carbon neutrality on campus by 2035. As figure 9.1 below indicates, Cornell is on a promising trajectory to meet this goal by the proposed date. However, many improvement will still have to be made to campus operations before this goal is met, including compost facility operations.

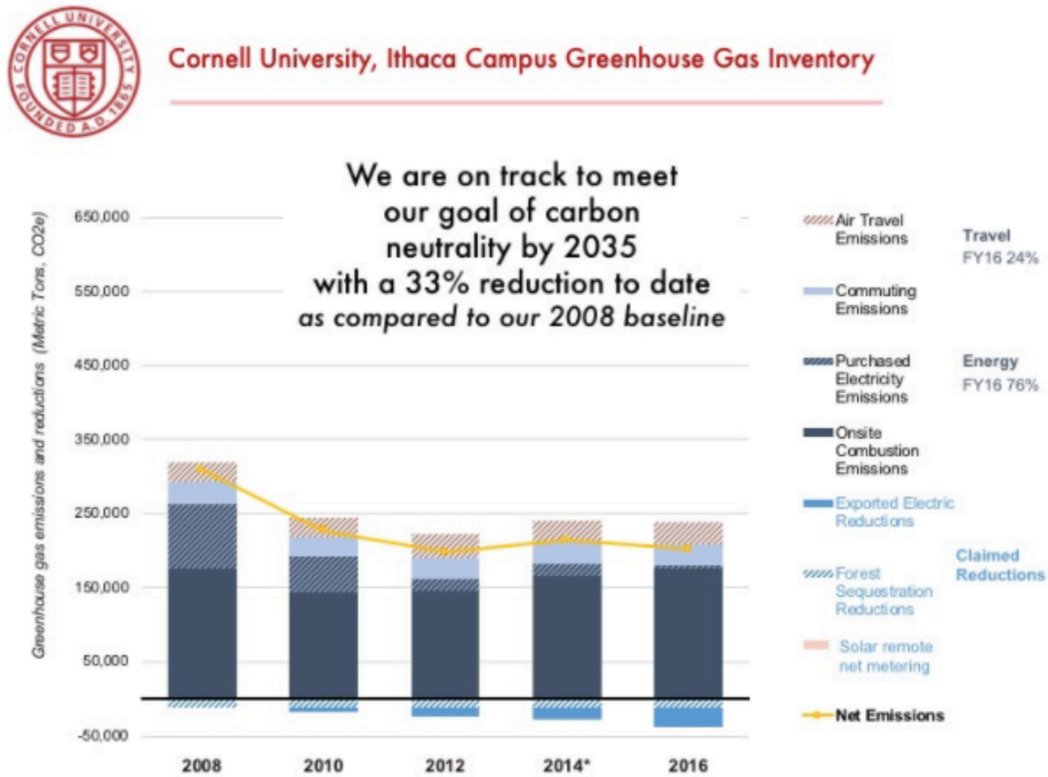

Figure 9.1

The key recommendations outlined by this life cycle analysis address four main sustainability concerns at each step in the life cycle. These concerns are contamination at initial disposal, GHG emissions from the necessary transportation of food waste, GHG emissions from the compost itself and the operational activities required to maintain the compost site, and, lastly, inefficiencies in the way that waste is currently being reused.

To address the first problem of contamination, this study has suggested the university S.A.V.E. (standardize bin appearance and signage, increase awareness of the consequences of contamination, employ volunteers to help guide consumer sorting, and educate to improve self-sorting results). Second, while the university has already mitigated the emission of GHGs due to waste transportation, a return to the use of sustainable biodiesel fuel is recommended to further eliminate detrimental carbon emissions. Regarding the third concern--GHG emissions due to lack of proper compost aeration and inefficient operational activity--this study has proposed four solutions to minimize compost-facility-related emissions: reduce moisture levels of compost piles and regulate porosity, optimize efficiency of operational activities, balance the carbon-to-nitrogen ratio within windrows, and utilize gas treatment to capture emissions. Finally, to better utilize waste on campus as a potential resource, this analysis advocates for the benefits of converting waste into electricity and heat via bioenergy.

Cornell University continues to make necessary changes to campus activities in order to eliminate, or in some case counteract, carbon emissions. Although Cornell's compost waste stream is not currently carbon neutral, utilizing the aforementioned recommendations could allow this facet of campus activity to attain carbon-neutral status. Such steps will bring the university that much closer to achieving its goal by 2035.

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