Understanding Students' Perception of Food Waste Recycling Programs and Likelihood of Adoption of Composting Programs on Auraria Campus in Denver, CO

Elaine Hunt, May 2018

University of Colorado – Denver

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Abstract.

As global populations continue to increase, so too does the demand on resources. It is largely for this reason that a growing number of researchers are focusing their efforts on understanding why more than 30% of food produced in the US ends up in landfills, without having ever reached a human stomach. These wasted food products not only represent an enormous quantity of wasted resources and energy, but also are responsible for an estimated one-third of all methane emissions in the US. We know that methane molecules are up to twenty-five times more powerful at trapping heat in Earth's atmosphere than carbon dioxide. Coupled with statistics as alarming as one in eight people in the US going hungry each day, a need to address the food waste issue is becoming increasingly clear. In recent years, the number of cities and communities across the country have begun examining their waste management practices in an attempt to curb greenhouse gas emissions and to contribute to a more sustainable future. Some of these programs have been successful, while others have struggled to maintain their goals. In this study we examine the perception of food waste recycling programs of students on Auraria Campus in Denver, Colorado as well as their likelihood to adopt a residential composting program. Through understanding some of the behavioral patterns behind waste production, we hope to offer a basic framework upon which composting and recycling services may build programs that will stay successful in the long-term, as we transition into a greener society.

I. Introduction.

Reducing the production of organic municipal solid waste (MSW) results in a variety of social, economic, environmental and ethical impacts (Sakaguchi, L., et al., March 2017). MSW can be defined, in the US, as garbage or rubbish in the UK and refers to everyday items that are discarded by the public. MSW can also refer, specifically to food waste. For the purposes of this study, the term food waste (FW) will be utilized. The rate of FW production in the US is currently at an all-time high, having increased in the last fifty years by nearly 50% (Hall, 2009). The Center for American Progress estimates that the average US citizen produce an average of 7 pounds of waste, per day. In the US alone, this means a phenomenal 390 million tons of trash is produced each year (Kasper, M., 2013). Current literature suggests up to 21.4% amount of that trash destined for landfills is comprised of wasted food (USDA, 2015). And although there are various points throughout the food production chain where waste is an inevitable end-product, we now know the main source of food waste production comes not from producers, farmers or distributers, but from consumers (USDA, 2015). The current figure, as estimated by the United States Environmental Protection Agency (EPA), stands at 40% of purchased food in the US that ends up in landfills (USDA, 2010). This is akin to purchasing ten bags of groceries and then dropping four of those bags on your way home and simply not picking them back up.

The wasted food products that eventually find their way to landfills not only contribute to an enormous quantity of wasted resources and energy, but also is responsible for an estimated one-third of all methane (CH_4) emissions within the US (USDA, 2010). The increasing production of CH_4 emissions plays a significant role in altering the temperatures of our planet. Without regard to climate change's causes, anthropogenic or otherwise, we know the physical and chemical properties of greenhouse gases (GHG), such as CH_4, contribute significantly to the increase of our global average temperatures, both on land and at sea (Jiang, X., et al, 2018). The same natural systems that create what is a livable climate on Earth will become increasingly compromised should the production of CH_4 and CO_2 continue to grow (Kirk-Davidoff, 2018; Schuiling, R.D., 2016). Many countries and communities around the world, concerned with reducing their carbon footprint and reducing GHG emissions have turned to more efficient waste management practices in attempt to create a more sustainable world (Bees, A., December 2017; Chien-Bong, C., et al., December 2017; Morris, J., et al., April 2017). These programs, that include composting and food waste recycling programs, are showing promising results in the reduction potential of GHG emissions. An estimated 72% of GHG emissions have shown to be the direct result of the diversion of food waste to landfills (Chien-Bong, C., et al., December 2017).

As the popularity of 'going green' and general interest regarding the implementation of climate change mitigation tools and preparedness measures has increased, so too has the number of cities and universities across the US that have begun adopting 'greener' waste disposal methods, in addition to their current recycling and waste disposal efforts. Many of these endeavors, however, have not been initially successful, as some programs have lacked adequate program education or sufficient infrastructure to enable long-term success (Sanders, J., 2011). This study aims to address some of the social aspects of these conflicts; asking students on Auraria campus what they know about composting as a concept, how much food waste they produce and whether they currently do

or potentially would participate in a FW recycling or composting program, should one be available to them either at home or on their university campus.

In addition to gaining a better understanding of students' current perception of composting, another goal of this study is to offer a more depth view into some of the characteristics that make contemporary composting and food recycling efforts successful, and which characteristics have made them unsuccessful. In examining perception of composting and food wastage that students on the Auraria Campus in Denver, Colorado have, we hope to lay some basic groundwork for future studies to begin addressing some of these social issues that plague current composting efforts in metropolitan areas across the country and in communities around the world. As a side-benefit of this study, we also hope to be able to investigate some of the social and behavioral patterns that have created a mindset of the 'throw-away culture,' in which it is socially and economically acceptable to encourage a 'disposable' mentality with regard to not only our food, but to a majority of consumer products in the US today.

II. Background.

A. Social Implications of Food Waste in America.

Present literature indicates that much of the organic waste being produced in the US should not be viewed as simply uneaten food that could have fed a hungry stomach, but also as wasted energy and wasted resources (Kibler, K., et a., April 2018; Mohareb, E., et al., December 2017; Qi, D., et al., October 2017). Hereafter, for the purposes of this study, this paper will utilize the USDA Economic Research Service's estimation of 31% of the food produced in the US is destined to be wasted, before ever reaching a human stomach, though some estimates are as high as 40% (USDA, 2015). If we then use the USDA's GDP total contribution by agricultural and food production industries in the US from 2015, $992 billion, then the estimated annual food waste in the US amounts to over $300 billion. Simply put, in 2015, a grand total of $300 billion was essentially thrown into landfills by American households (USDA, October 2017). In the same year, according to the World Hunger Education Service, approximately one in every eight households in the US faces food insecurity (WHES, 2016).

When addressing the issue of food waste, it is impossible to discuss such a topic, in a country where over 38 million individuals deal hunger each day, without acknowledging the levels of inequality that exist among food accessibility across income levels. Most cities across the US are able to provide some kind of food assistance program, through either federally funded welfare such as food stamps, or through local options such as soup kitchens and food pantries. Soup kitchens in the US began appearing as early as the 1920s when the effects of economic crisis penetrated communities throughout the country (SSA, 2018). Today, a network of more than 58,000 food pantries serve millions of hungry individuals, many of which run on purely donation-based food programs. In an effort to address the needs of hungry Americans and to divert wasted food from landfills, the EPA has implemented an official step in their food-waste hierarchy specifically addressing the needs of those individuals. Figure 1 shows the official Food Recovery Hierarchy, created by the US Environmental Protection Agency (EPA). Although an intricate framework of welfare options is available, many Americans still struggle to obtain sufficient

caloric intake and there are surprisingly large areas of the US suffering from the effects of food-deserts (EPA, 2018).

Highest on the hierarchy are steps through which food retains the majority of energy by attempting to target the root of food waste production and eliminate the issue from the source. The first step, source reduction, is the most difficult to implement as it involves the participation of individuals engaging in lifestyle changes that are less conducive in food waste creation. This step requires individuals to make a choice to change the way that they life; these changes are often viewed as inconvenient and time consuming. Feeding people is the next preferred method of food-waste-to-landfill-diversion; this can be achieved either through donations to soup kitchens and food pantries or to employees of restaurants and grocery stores. When the food is no longer suitable for human consumption, the next attempt is to provide this food as animal feed. The following step, industrial use, is comprised primarily of attempts by alternative energy research and development to convert the oils and organic matter present in food waste into biofuels. Composting appears relatively low on the food recovery hierarchy; this is important to note. Though the process of composting provides a healthy and organic way to which we can provide more nutrients to our gardens and soils, it becomes less efficient when a larger picture of the process is obtained.

As aforementioned, an estimated $992 billion is invested in agricultural and food production industries in the US. Still under the assumption that 31% of that is wasted, annually, feeding that food, so-to-speak, into composting programs is a grossly expensive and wasteful approach to fertilizing our gardens. The final destination for food waste, if all other steps fail, is to arrive in a landfill. This, unfortunately, is the ultimate fate of the majority of food that is wasted in the US (USDA, 2015). It is also important to be aware of some of the differences between the numbers and statistics used to describe the food waste patterns in the US. The differences are subtle but powerful. To summarize these succinctly, 31% food produced in the US is wasted, that is, 31% of the US food supply is wasted each year; FW is the single largest component of contemporary landfills; landfills are currently the third largest contributing sources of CH_4 due to their high FW content; 21.4% of MSW is comprised of food (USDA, 2015).

Understanding why food waste is created in the first place, is an element of the equation that severely lacks awareness and is rarely addressed in the conversations and research that surround the production of food waste in the United States. Literature exists suggesting an increase in food production has led to a surplus of food in developed countries like the US, however no correlation has been proved to exist between a surplus of food and the rate at which food is wasted ((Papargyropoulou, E., et al., August 2014). It is largely for this reason that understanding the psychology behind our obsession with a ‘throw-away’ culture is difficult to quantify, difficult to measure and difficult to study that the majority of food-waste-to-landfill-diversion efforts are focused primarily on how to handle the food waste, once it is produced, rather than attempting to transform the way that Americans think about food and the ease at which they can throw it ‘away.’

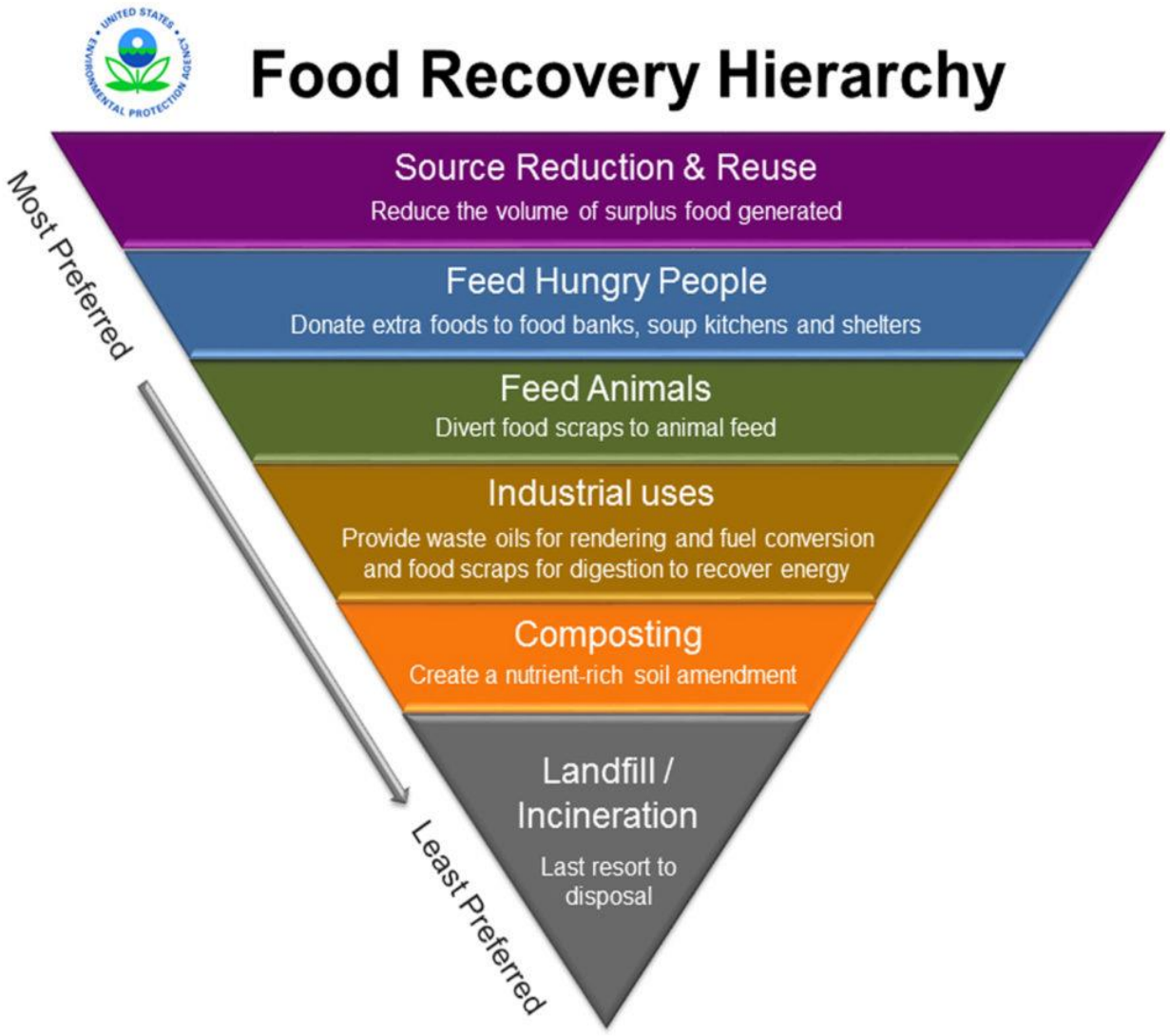


Fig. 1 demonstrates the six ways through which the EPA attempts to recover food that has been or will be discarded. These steps range from most preferred method of landfill diversion at the top to the least preferred methods at the bottom (Source: EPA, 2018).

B. Physical Consequences of Food Waste.

The food waste that ends up in landfills across America's landscape not only represents a severe lack of resourcefulness and alludes to a severe attitude of wastefulness among Americans, but it also contributes to a devastating proportion (about 25%) of methane (CH_4) emissions donated to our atmosphere, on behalf of the United States (EPA, April 2016; Geislar, S., October 2017). A large majority of climate-change research and common public knowledge centering around greenhouse gas (GHG) emissions focuses on CO_2 emissions but the damage that is done by CH_4 is significantly more damaging to our atmosphere, on a short-term timeline. At the rate that it is being emitted into our atmosphere can have monumental effects on global average atmospheric temperatures and sea-surface temperature (SST); which, in turn, effects a variety of natural systems on our planet.

CH_4 molecules are estimated to be at least twenty-five times more effective at trapping heat than carbon dioxide in our atmosphere throughout their lifetime (Jiang, X., et al., 2018). This means, on a time scale of 100 years, one hundred CH_4 molecules that find their way into our atmosphere can have the effect of two-thousand CO_2 molecules during the first 100 years of those molecules lifetime in our atmosphere. Greenhouse gases play an integral role in the warming of our atmosphere, enabling what is known as the greenhouse effect. Described simply, the greenhouse effect refers to the process that occurs when molecules of a GHG enter the atmosphere and essentially block long-wave radiation from leaving our planet, that normally would leave. The more GHG molecules in the atmosphere, the stronger their ability to 'trap' heat within the atmosphere, leading to an exponentially increasing temperature on Earth (Jiang, X., et al., May 2018).

Through the successful implementation of composting and food recycling programs, a significant portion of current CH_4 emissions can be eliminated (Bees, A., et al., December 2017). It is with this hope that cities across the country have adopted various waste reduction practices and recycling programs in attempt to curb GHG emissions and to address the enormous amount of resources that are rotting in landfills (Cerda, A., et al., January 2018; Chien-Bong, et al., December 2017; Geislar, S., October 2017; Morris, J., et al., April 2017). In addition to this, there are a considerable amount of resources wasted not only in throwing food away, but in regard to every aspect of the production, delivery and purchase of that food; going all the way down to the farmers' fertilizer to the delivery truck driver's fuel, to the water used to grow that food.

C. Composting in the United States.

Many conflicts have arisen in past attempts to implement FW recycling and composting programs in cities (Arastoopour, H., et al., June 2012; Blondin, S., et al., June 2015; Kibler, K., et al., April 2018; Martin W., et al., January 2018; Sakaguchi, L., et al., March 2017; Qi, D., et al., October 2017). But current literature suggests that perhaps these conflicts can be avoided if a careful and thorough approach is utilized during the implementation process (Sakaguchi, L., et al., March 2017; Qi, D., et al., October 2017). Some of these conflicts include (but are not limited to): lack of education for the program, lack of public awareness about what composting is, a lack of proper infrastructure and, perhaps most importantly, a growth in what is becoming a normalization of the 'throw-away' and disposable culture. Other reports suggest that, although education for the programs and willingness to participate in them has been successful, utility costs of the composting process have played a role in whether an organization or business decides to keep the composting program in place (Sanders, J., et al., 2011; Szczepanski, M., 2017).

Early municipal solid waste (MSW) steam recycling processes faced similar obstacles in their initial phases, as the demand for recycled material was also developing as a viable alternative to simply purchasing new materials. One must also consider the processing capacity of a city's recycling facility to manage the amount of incoming food waste (Blondin, S., et al., June 2015; Cerda, A., et al., January 2018; Kibler, K., et al, April 2018). In 2010, the city of Denver was forced to abandon their initial curbside composting pilot program due to the higher-than-estimated overall cost of operation; as a result of receiving significant quantities of material to process (MIT Sloan, 2014). In addition to these points, concerning any recycled product, the need for consumers

who choose to purchase and use the recycled output is a necessity for any successful recycling program. The efforts involved with the implementation of composting programs are oftentimes co-operated with schools and universities as a means to educate not only on the process and reasons composting programs are beneficial, but in educating why it is an important step in becoming a greener society within which we can build an infrastructure that combats climate change and creates a healthier future for generations to come (Arastoopour, H., June 2012; Blondin, S., et al., June 2015; Costello, C., July 2017; Kibler, K., et al., April 2018).

In spite of initial turbulence, there are a number of cities, who have been successful in their implementation of composting and FW recycling programs; San Francisco, Seattle, Sacramento, Raleigh and Boulder, to name a few. Increasing amounts of legislation and political pressure have led cities to start considering ways to reduce their contribution of food to landfills (Geislar, S., October 2017). In US cities and states that have yet to adopt some type of food recycling system or composting program, schools have been large driving forces in the process of gaining public support of such agendas (Arastoopour, H., et al., June 2012; Costello, C., July 2017). And although there are many obstacles throughout the development of city-wide composting programs, observational study has an important role in influencing both public awareness of our food waste epidemic, as well as informing city officials and politicians of potential legislation in the future.

In the summer of 2017, a study was conducted by the University of Missouri (MU) to document the generated waste at the MU football stadium and to gain a better understanding of some of the ways to move towards a more zero-waste lifestyle. The report found that over 47 metric tons of waste was generated that year, from their football stadium alone; where the majority of said waste came from food preparation and where 24% of what was sent to landfills was food waste (Costello, C., October 2017). The idea of reducing the wasted food that is produced in a system, however, is only part of the equation.

Many researchers have begun focusing their efforts on ideas of food conservation and food waste prevention (Thyberg, K., et al., August 2017). This idea mirrors the current direction in many recent diet trends that have begun moving away from what are known as ‘high impact foods’ (i.e. beef) and is thought to have been influenced by the public’s increased awareness and understanding of resource and climate implications of the systems that currently provide our food (Kibler, K., et al., April, 2018). And although these trends benefit aspects of our food production systems, knowledge surrounding the attitudes and behavioral patterns that drive the production of food waste is still relatively small (Sakaguchi, L., et al., March 2017). It is this characteristic that calls for more action on behalf of legislation and more in-depth research addressing the current behavioral patterns and driving forces of food waste production in America.

D. Contemporary Waste Reduction Efforts.

In 2015, in an effort to obtain target 12.3 of the UN Sustainable Development Goals, the USDA and EPA unveiled what was the first-of-a-kind attempt to lower food waste production by 50% by 2030 (USDA, 2015). In addition to these efforts, there is an existing infrastructure of organizations and educational efforts that strive to promote the ideas of being a greener society through reducing waste output. The US Compost Council (USCC), founded in 1990 is currently the only national

organization in the nation whose focus surrounds encouraging education, development and growth of the composting industry. The USCC works together with the Composting Council Research and Education Foundation (CCREF) to establish standards, generate training materials for industry partners and offer education to professionals and to the public through a variety of sources included their official magazine, BioCycle. But, like many things in contemporary life, in order for something to become ultimately successful, it needs to make economic sense.

In 2017, a study produced in the Journal of Cleaner Production, examined the effects of monetary incentives offered to restaurants who prevented food waste in Berkley, California. Their report found that, in the restaurants investigated for the study, 65% of them were measuring the food waste that they produced, and that 84% of them utilized composting bins as a means to dispose of the food waste that was produced (Sakaguchi, L., et al., March 2017). It should be noted, however, that this study was conducted in an area of the US that is known for having a more progressive outlook on their environmental impact and ways to combat those impacts. But the report also found that many restaurants were still dealing with an abundance of uneaten yet edible food, and that the most frequent approach to disposing of that food was to give it away to employees. And although technically, this falls under the second tier of the food waste hierarchy (feeding hungry people), what the EPA is referring to when describing 'hungry' people typically constitutes people who struggle to find food and those are not so often employees of restaurants. Three-quarters of the restaurants in this study admitted to avoiding donating that food because of 'legal liability' (Sakaguchi, L., et al., March 2017). This fear of legal liability pertaining to food that was donated on someone's behalf is another feature of our food waste production that is severely misunderstood. Edible food that is donated either by an individual or by a company or organization sits outside of legal liability in what is known as the Good Samaritan Act. In 1996, President Clinton passed a law called the Bill Emerson Good Samaritan Food Donation Act (US GPO, October 1996). This piece of legislation protects anyone who, in good faith, donates food, from any legal or criminal liability, if for any reason the food should spoil and potentially cause harm to anyone who received it as a donation. But many restaurants and grocers, fearing damage to their profits, avoid the possibility altogether by refraining from donating food entirely.

E. The science of composting.

Applying spent organic material as fertilizer is a concept that dates back to as early as 12,000 years ago (UoI, 2018). It was not until the 1900's that German scientist Justus von Liebig discovered that plants could benefit greatly from certain chemical elements; nitrogen (N), phosphorus (P) and potassium (K). Through the application of highly concentrated chemical fertilizers, farmers and gardeners quickly adopted the new and efficient practice as a means to expedite their plant growth, food production and profits while reducing labor costs and production time. But what chemical fertilizers don't do is improve the structure of the soil or the soil's ability to obtain water and nutrients.

Organic compost material, when added to soil provides slow-release nutrients into the soil and plants, making it extremely difficult to over-fertilize with natural materials such as compost. Whereas, with chemical fertilizers, prolonged use can lead to a fundamental alteration of the soil's chemistry, changing the pH levels and disturbing a variety of microbial systems and eventually

leads to an inability of the soil to uptake nutrients and, in some cases, even sufficient water intake. The benefit of chemical fertilizers is short term and does not replenish any of the necessary elements into the soil that are taken up by plants throughout their growth cycles. And because most chemical fertilizers are highly potent, there is a significant chance of overfertilizing which not only causes damage to the plant, but to the life of the soil and the ecosystems within it. To add insult to injury, the fertilizer industry contributes enormously to the production of CO_2 and takes a significant amount of energy in order to produce. We now turn to some of the many benefits of using organic, naturally occurring materials to fertilize our soils.

Compost adds a variety of nutrients back into the soil, including the three major components of healthy soil (N, P and K) but also provides a multitude of micronutrients including manganese, copper, iron and zinc. These micronutrients are similar to vitamins and minerals that humans need and are necessary and only helpful when applied in small doses. These play an integral role in maintaining long-term soil health and in passing this health along to the plants that grown in it. The so-called 'slow-release' action of compost is precisely what makes it such a valuable resource, and it is partly for this reason that chemical fertilizers are unable to completely provide for plant and soil health.

The fact that food waste and other organic materials that go into compost all decompose at varying rates, this ensures that the soil is obtaining nutrients for a much longer period of time than any chemical fertilizer. In addition to this, because compost is providing the soil with healthy amounts of nutrients and chemicals that are found naturally, this creates an encouraging atmosphere for earthworms and other invertebrates that signify a healthy soil make-up. This is of vital importance with regard to growing plants that eventually provide us with food and maintaining resource abundance.

F. Composting and food waste in the Denver area.

The city of Denver and surrounding areas currently have a variety of food waste diversion, food recovery and composting efforts in place. These include the Denver Food Rescue, We Don't Waste, Produce for Pantries, Denver Yard Harvest, Food Rescue Alliance, Foraged Feast, Denver Inner City Parish, the Colorado Food Recovery Network, Scraps, Be Zero and several others. In addition to these endeavors, in the fall of 2017, Denver completed its' implementation of a city wide curbside compost pick up program which now offers composting services to all residents within the city of Denver for $10 per month. The city also offers a variety of courses, seminars and training programs in order to provide Denver residents with a better understanding of composting, how to compost and how to use compost material in their backyards or gardens. In 2015, city residents provided more than 5,000 tons of organic waste to the composting program, diverting an estimated total of nearly 5,000 metric tons of CO_2 emissions from going into our atmosphere, or comparable to removing more than 12,700 cars from the roads (The Denver Compost, August 2017).

In attempt to remedy their unsuccessful composting program in the past, the city has provided its' residents with a large supply of educational and reading material on its' website. The pages provide residents the opportunity to learn how to reduce household food waste,

in addition to other composting tips and suggestions. This program is available to all city of Denver residents who live in single family homes, which accounts for only a portion of city dwellers. In fact, the program is not available to any building with more than seven units in it. This is what spurred the creation of Scraps, a local bike-powered composting service dedicated to creating a greener planet. Scraps not only works to keep food out of landfills, they do so without having to drive diesel trucks while doing it. Then, a little further north in the city of Boulder, a woman named Andrea Sanders founded her local non-profit, Be Zero, in 2015, and offers a wide range of educational resources and services including seminars, workshops and lectures with the goal of teaching others how to reduce their waste production and lighten their carbon-footprints (via BeZero.org).

In addition to Denver's food waste recycling and composting efforts, Colorado is home to one of the largest composting organic recycling businesses in the country, A1 Organics. Their efforts divert over 350,000 tons of organic waste from landfills in Colorado each year (A1 Organics, 2018). Within the city of Denver, there are also several other companies who offer their services, aiding in the diversion of food waste to landfills; including Alpine Waste & Recycling services and even includes a bicycle operated composting serviced called Scraps. And although there are a variety of options for Denver residents to reduce and recycle their food waste, researchers estimate that more than 20% portion of US landfills are comprised of organic waste that has the potential to be recycled into compost (EPA, 2018).

The Auraria campus is also involved with a few different composting efforts in partnership with AHEC, Denver Urban Gardens (DUG) and student-run clubs from the universities on the campus. DUG currently has implemented a pilot program within the Tivoli Food Court. Some of the waste diversion efforts implemented by another university on Auraria Campus, Metropolitan State University (MSU) was able to earn recognition by the EPA's Achievement in the 2014 Food Recovery Challenge. The current efforts on campus have been spread across the three main institutions that called Auraria Campus home (University of Colorado Denver, Metropolitan State University and the Community College of Denver). The tri-institutional campus has discussed the possibilities of merging efforts, not only for waste reduction, food waste recycling and composting programs but with regard to many affairs on campus in an attempt to streamline some of these efforts that tend to get lost or prove unsuccessful because of lack of integration and participation from students on campus.

III. Methodology.

A. Survey and Survey Location.

The specific location and demography of this survey were selected for several reasons. The most significant of those reasons was for time considerations and for lack of funding. The data collection was carried out on Auraria Campus and although the students were not required to state which school they were affiliated with, students on this campus all attend either the University of Colorado Denver (UCD), Metropolitan State University (MSU) or the Community College of Denver (CCD). All participants in the survey must have been enrolled as a student on Auraria Campus, though not all have declared majors; and their ages range from 18-79 years old, with an average age of 24 years old. A total of 23 questions were given to participants, who were selected

at random. Students were simply asked if they were willing to participate in 'a survey.' Through this approach, it was the goal to avoid any bias that might be created from asking students if they were willing to take a survey about composting or an environmental survey. The content of the survey aimed to understand the likelihood of adoption of composting programs on Auraria Campus in the city of Denver.

The responses of the survey assist in providing insights into potential success of future composting programs and offer suggestions to potential conflicts in contemporary composting and FW recycling efforts that might render a program unsuccessful. Section I covers background and demographic information including major, age, gender, whether or not they are a first-generation student and if they rent, own their home or live with their parents. Section II covers questions regarding the student's background in environmental issues, asking whether they have taken an environmental science course, if they recycle at home, if they compost at home (and if so, whether they participate in a program or if they use the compost at home themselves), and if they pay for their waste and recycling services (as a part of or separate from their rent). Section III includes questions pertaining to the individual's current participation in composting and food waste recycling efforts, whether a part of an official pick-up program, or when not at home. Section IV includes a series of questions that attempt to gain an understanding of the perception of composting and to test some general knowledge of how composting works and why it is useful. The survey ends with two open ended questions; the first asking the student to describe the amount of food waste created during their last meal, and the second asks the student if there is anything they would like to add to their knowledge about composting.

B. Data.

The data collected from the survey was obtained on campus and through the University of Colorado student portal email, Canvas. The survey itself was structed and designed by Elaine Hunt with the assistance of Dr. Deborah Thomas, chair of the Geography and Environmental Sciences department. Before initiating the data collection, both Hunt and Thomas submitted an application to the Colorado Multiple Institutional Review Board (COMIRB) requesting permission by the board for Hunt's human subject research survey to be conducted on campus. Hunt completed the required online training courses and obtained approval from the committee to proceed with the research (Approval ID COMIRB Protocol 18-0386). Participants were each required to accept the terms and conditions of participating in this survey and were provided with contact information for Dr. Thomas, should they have any questions pertaining to the extent that their information would be used in this study. Participant's personal information such as name, home address, phone number and email were not disclosed in the data collection.

The survey used in this study was created via Survey Monkey and was distributed to participants on an iPad. The questions selected for use in the survey include a variety of questions pertaining to some aspects of the participant's demographic background, their current understanding of food waste in the US and general knowledge about what composting is and why it is beneficial. In addition to these attributes, the survey intended to grasp an understanding of each participant's likelihood to compost in the future, either through participation in a city-wide collection pick up (e.g. Denver's curbside collection program) or for use on their own property.

The questions were comprised of multiple choice, true/false, text box entries in which each participant was able to type their response, as well as a series of questions distributed on a Likert scale.

C. Limitations.

For reasons largely relating to lack of funding and amount of time allotted for research in an undergraduate thesis study, limitations were inevitable. The overall scope and direction of this project was adjusted several times, to account for accessibility to conduct the human-subject survey. For these reasons, the number of survey participants was a significantly limiting factor. Without introducing any bias or predetermination of outcome, it was decided to select survey participants at random. A large portion of the data collection occurred in the cafeteria of the Tivoli Turnhalle. Students were often rushing to class, or quickly getting lunch and few had time to stop and participate in the survey. The ones who did choose to participate in the survey have the potential to represent only a portion of the student population on Auraria Campus. It should also be noted that Denver one of the most educated states in the nation, according to the US Census Bureau and has been ranked as the state with the lowest obesity rate (US Census, 2016). These are all qualities to be taken into consideration when addressing any survey of human population, in understanding the survey's role in the larger context. Should time or funds not have been an issue, it was the original goal to engage in a case study in which a series of households, of varying income levels, would participate in a food-waste tracking activity. Each household was to be given a scale, a food waste container and a journal to document not only the amount of food waste that was produced but also the content of that waste. Through the analysis of the food-waste tracking program, the hope was to understand more about patterns of waste production across varying income levels, and to begin documenting some of the behaviors and mindsets that lead to food waste production. And although these were elements of the study that ultimately were not incorporated into this report, understanding some of the mechanisms at work amongst students is a viable and important step in addressing the food waste issue in America.

As with any survey that involves public opinion or individual perception, when posed with particular questions, in a survey format, the likelihood of a participant answering in a certain way may be influenced by the simple fact that they are being asking that question. For example, by asking students if Auraria Campus or if the City of Denver have composting programs, they are more likely to answer yes, regardless of if they are actually aware of a given program or not, due to the fact that this is a question in a survey about composting that is taking place on Auraria Campus and in the City of Denver. Taking this into consideration is another important step in understanding the outcomes of this study.

C. Summary of Conclusions.

The results of the survey are discussed at length in the following section. But a brief description of some of the overarching themes will be discussed here. Students on Auraria Campus demonstrate an understanding of FW production as well as some general awareness pertaining to what composting is, how it can be used, why it is useful. A large majority, about 85% of students recycle at home, while only 34% of students compost at home. An interesting trend, however, developed among students who do not compost at home; 74% of those students are interested in

participating in a composting program, should one be available in their neighborhood. Similarly, nearly 80% of the same students who do not currently compost at home are willing to pay for a composting program at home, but nearly 90% of those students are unaware if there was one in their home neighborhood. Based on the zip codes provided by each participant, relating to their home address, the majority of students do in fact have a composting program available to them. This denotes a potential insufficiency in promoting and educating about the city-wide collection program offered by the City of Denver. Regarding Auraria Campus's composting program, slightly more than half (51.22%) of students do not know whether Auraria participates in a composting program. It is important to consider that not every building has composting receptacles on campus, most of them are currently housed in the Tivoli Turnhalle. This suggests that at least half of the students who are on Auraria Campus either do not go to the Tivoli building or are not aware that there are composting receptacles on campus.

IV. Results.

1. Survey Participant Demography.

This section details the findings of the survey, comprised of 23 questions aimed at understanding student's knowledge and perception of composting. A total of 40 students participated in the survey, each student begins the survey by stating their major in school. Table 1 demonstrates the variety of majors amongst the participants in this study, and the number of participants that belonging to each major. The largest group is comprised of students with undecided or 'undeclared' majors.

Some majors demonstrate students' residence at the University of Colorado – Boulder, while these students may be on Auraria Campus one or more classes throughout the week. The second question addresses each student's potential bias in participating in a survey about composting by asking if they had ever taken an environmental science course; to which 60% of students have done. A series of questions that followed aimed to understand more about the demography of the participants. As demonstrated in Figure 2, students describe whether they are a first-generation student, gender, age, and whether they own/rent or live with their parents (labelled as 'Living Status' in Fig. 2). Just over 26% of the students are first-generation students. The survey collected data from nearly half female and half male participants and found that a total of 41% of the students are renters, while another 41% live with their parents, and about 17% own their home. And as a final piece of demographic information, Figure 3 shows age ranges of the survey participants. After establishing some background information on each student, the survey moves into Section II and examines their current waste efforts. The environmental awareness of students on Auraria Campus was of interest for this study and was briefly examined in asking students whether or not students had ever taken an environmental science course during the college career. This characteristic seems to have an effect on if a student participates in recycling efforts off-campus. Trends suggest that if a student has taken at least one environmental science course, they are more likely to recycle at home while they are about half as likely to compost at home. Inversely, the trends suggest that if a student has not taken an environmental course, they are less likely to participate in recycling efforts. These trends can be seen illustrated in Figures 4, 5, 6 and 7.

Table 1. Majors of student participants in the composting survey.

Major	# of Students	Major	# of Students
Anthropology	1	GIS Certificate	1
Architecture	1	History	2
Associate of Arts	1	International Studies	2
Biology	1	Law	1
Chemistry	2	Math	1
Criminal justice	1	Political Science	1
Economics	1	Psychology	1
Education	2	Public Health	1
Engineering	2	Sociology	1
English	3	Undecided	5
Environmental Sciences	2	Urban studies	2
Geography	4		

Figure 2 - Three variables of demographic background of the participants.

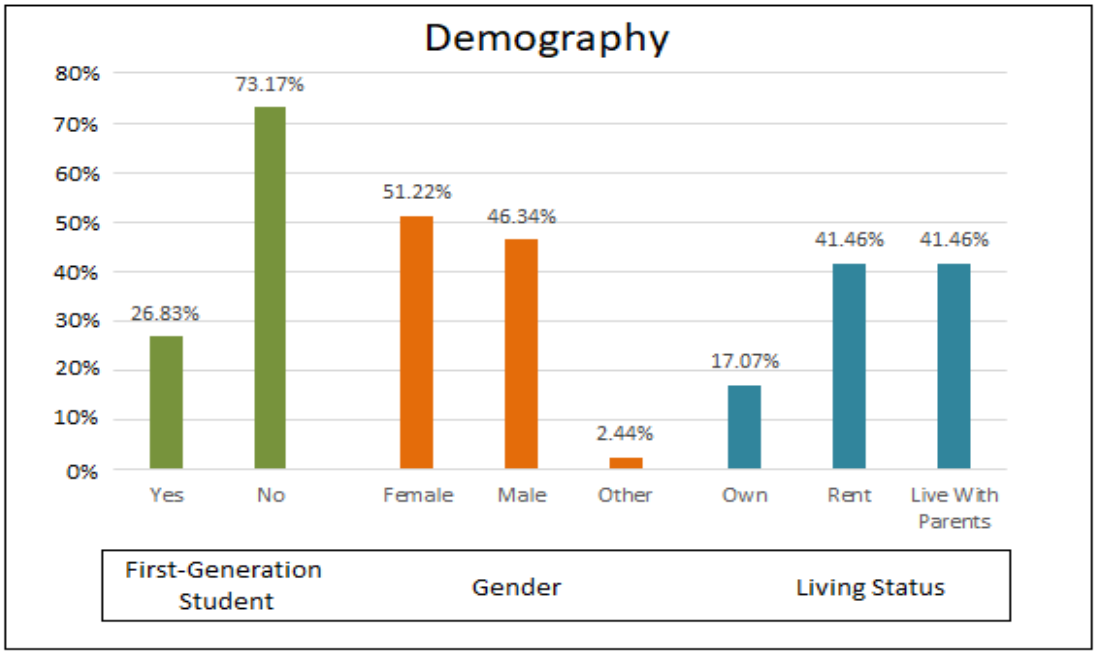
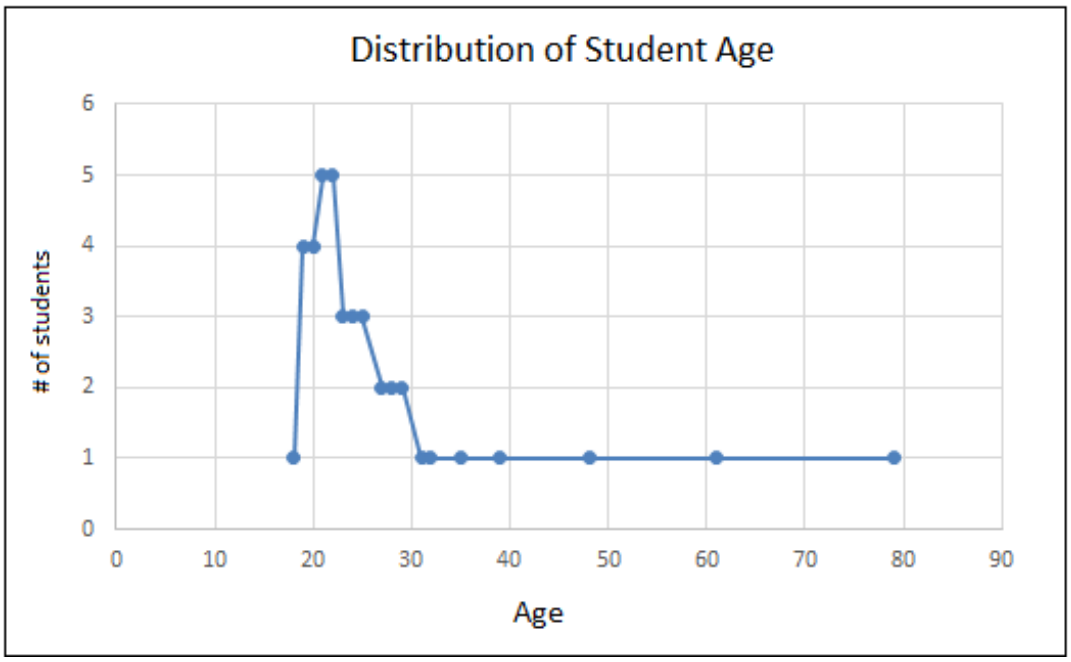


Figure 3 - Demonstrating the distribution of age among participants.



2. Composting and Food Waste Knowledge.

The second portion of the survey gauges each participant's knowledge surrounding the production of food waste in the US as well as basic knowledge pertaining to composting. The report finds that only 48% of students are aware that Auraria Campus has a composting program, while almost 61% know that the city of Denver has a composting program. Based on conversations that occurred throughout the survey process, as well as comments left in the final section of the survey, reasons for students' unawareness of the composting program on Auraria Campus included: not seeing composting bins, not having time to separate the organic items from items that either needed to be sorted into recycling or landfill receptacles, not understanding what can and cannot be composted, and some students admitted they never knew there were any composting bins on campus at all. The compost bins present on campus have been distributed in select locations and do not exist in each building of the tri-institutional campus.

Through an almost unanimous answer, all but two students were aware that composting and food recycling can reduce household waste up to 50%. Students also show a significant awareness of the rate of current estimated food waste in the US (according to the EPA's estimation of 35% of all food produced in the US is destined for landfills) with more than half of the participants selecting 35% as the amount of food waste production.

Figure 8 shows what students believe can and cannot be composted. This question was in regard to what materials have the potential to be broken down through a food recycling method such as composting, as distinguished from asking them to list the materials that can be composted in their yard at home. The difference between these two statements may seem trivial, but many

backyard or DIY compost practices do not have the capacity or ability to handle certain organic materials like dairy products and meat. Specifically in Colorado, it is oftentimes very difficult to obtain the necessary temperature in an outdoor composter necessary for breaking down meat, bones and some dairy products. Figure 9 compiles answers from the Likert scale portion of the survey. Students were asked to rate each of the statements with ratings ranging from "Strongly Agree" to "Strongly Disagree." Table 2 lists the statements each of the participants was asked to rate, and following in Figure 9, their answers are compiled into a bar graph that coordinates with Table 2's statements.

Figures 4 through 7 – Cross comparison between whether students have taken an environmental science (ENVS) course and whether they participate in recycling or composting efforts at home.

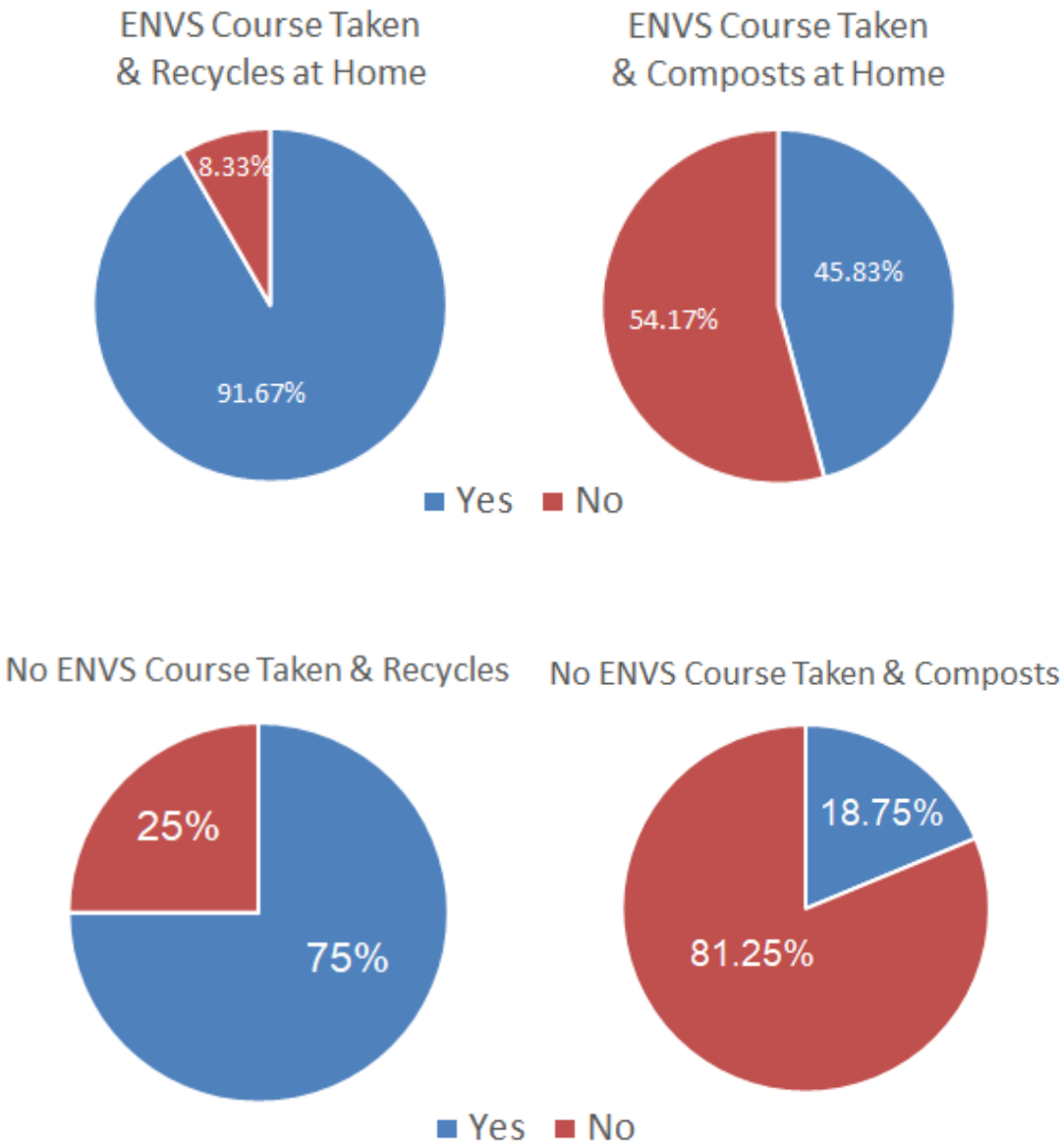
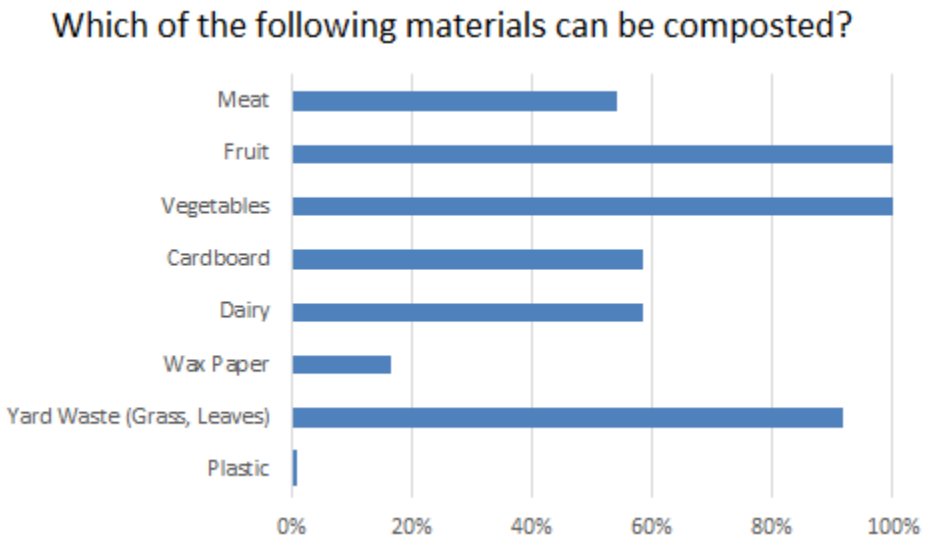


Figure 8 - Percentages of students that believe a given material has the potential to be composted.



3. Likelihood of Adoption.

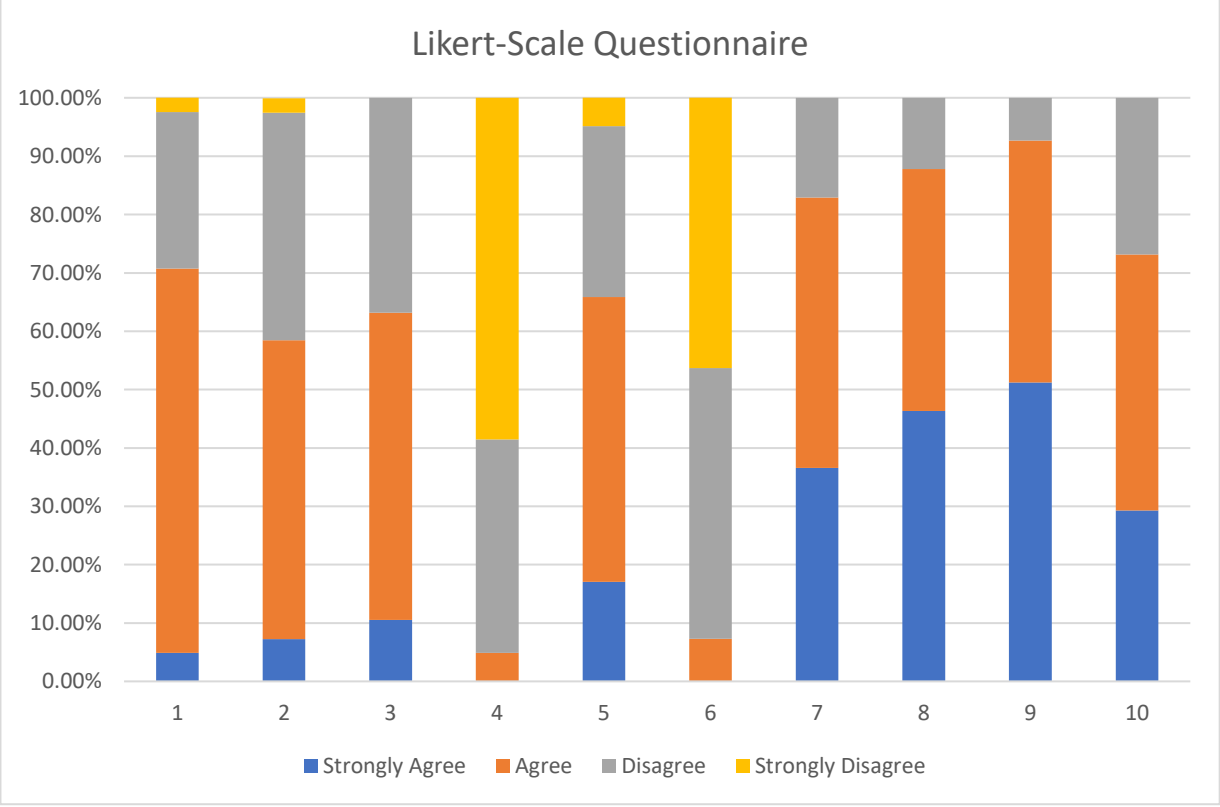
This section examines the participants' current knowledge of composting and tested their awareness of food recycling programs that are available both on Auraria Campus and in Denver. Participants were asked if they pay for their own waste and recycling services, and then whether they recycle or compost at home. The results show that all participants who compost at home, recycle at home as well, however the majority of those who compost at home, do not currently participate in a composting program. A question that followed this aimed to understand in what ways in which the participant engages in food recycling practices. Those who compost at home were able to describe their composting efforts in a text box and answers excluding participation in a city program (in Denver or in Boulder) revealed the participants use the composted organic material in their yard or garden. A cross examination between living status (own, rent, or with parents) and whether or not the participant pays for waste and recycling services demonstrates that those who identified as homeowners are more likely to pay for waste management services as a separate service; versus participants that either rent or live with their parents, who tend to either not know whether their waste management services were paid for or if it was included in the rent that they pay each month. These trends are documented in Figures 9 and 10.

Among students who either identify as renters or live with their parents who also they pay for waste and recycling services as separate from their rent, the survey report found 100% of these individuals recycle at home, but only 30% compost. Similarly, 100% of students who identified as homeowners (who tended to be more likely to pay for waste management as a separate service) also recycle at home. But this trend diverges when comparing the number of students that compost at home who identified as homeowners which came to over 70%. Another trend was noted in comparing students who have taken environmental course in their college careers, versus those who have not. Students who have taken an environmental science course are more likely to recycle at home and are more than twice as likely to compost at home (as demonstrated in Figures 4-7).

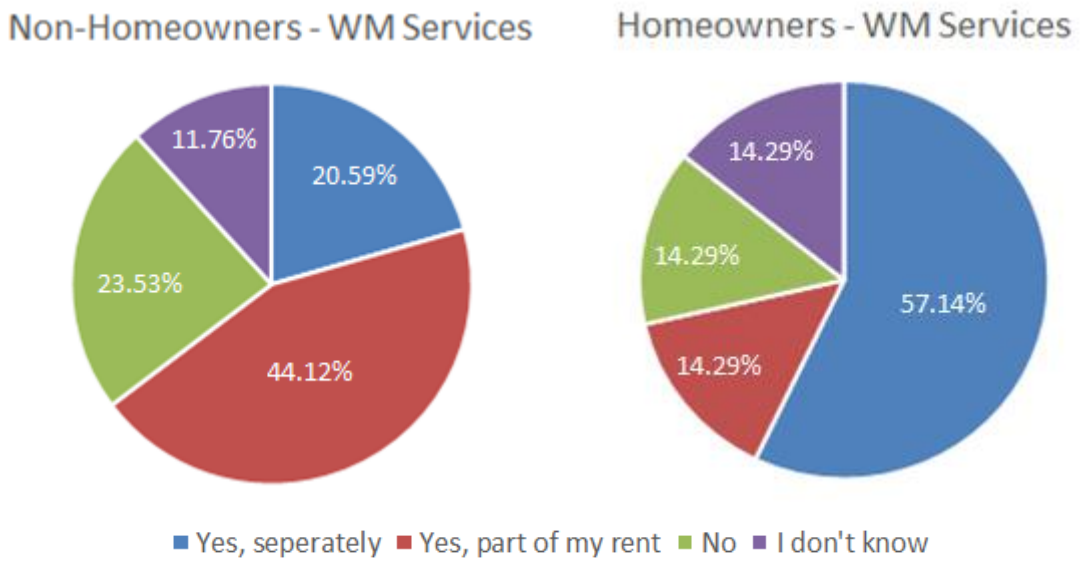
Table 2 – Likert Scale Questionnaire.

1.) Participating in a composting program is easy and free.
2.) Composting smells (bad).
3.) Composting is messy.
4.) Composting does not significantly reduce waste.
5.) I do not mind storing food waste in my kitchen.
6.) Food waste cannot be used once it is thrown away.
7.) I compost if I see a composting bin (when not at home).
8.) I would be interested in participating in a composting program at home.
9.) I would participate in a composting program, if it were free.
10.) I would participate in a composting program at home for $10/month.

Figure 9 – Shows results for Likert-scale questionnaire. Statements have been condensed to numbers 1-10 and coordinate with those in Table 2 (above).



Figures 9 & 10 – Showing the waste management (WM) services by non-homeowning students and students who identified as homeowners; as either paid for as separate from rent, part of rent, not paid by the student or the student does not know.



V. Discussion.

The current patterns of food waste production in the United States will have catastrophic implications for future generations if effective and long-term mitigation measures are not implemented (Bees, A., et al., December 2017; Chien-Bong, C., et al., December 2017; Kibbler, K., et al., April 2018; Mohareb, E., et al., December 2017; Ranieri, L., et al., January 2018; Sakaguchi, L., et al., March 2017; Qi, D., et al., October 2017). Current literature suggests that anywhere from 35-50% of the food that is produced in the US is eventually sent to landfills. The term 'wasted food,' in this context, does not account for the inevitable side-product of food production itself, rather it refers to edible food; food that is fit for human consumption, that ends up in landfills without having been eaten. Many communities around the world seek to reduce food waste as it, "deprives hungry people of nutrition, depletes resources and accounts for substantial greenhouse gas emissions," (Qi, D., et al., October 2017).

Research has shown that a significant portion (nearly half) of what constitutes American landfills is recyclable (paper, aluminum, plastics) or compostable (organic materials) (Ranieri, L., et al., January 2018). This trend has surmounted to an alarming proportion of CH_4 gas emissions that the US is responsible for. It is believed that the CH_4 gas emitted from landfills comprises nearly one quarter of all CH_4 emissions in the US (Geislar, S., October 2017).

Over the last few decades, communities and universities across the country have begun adopting more sustainable approaches to waste management and recycling practices as the concern of climate change grows (Qi, D., et al., October 2017). With growing concern surrounding climate

change and the myriad of ways through which it has begun to manifest on our planet, city planners and government officials are increasingly under pressure to contribute towards a more sustainable future. Reducing the amount of food that goes into landfill is one way that we can address several aspects of our current economy and waste infrastructure that have allowed for such a significant loss of resources. This, in turn, will have numerous advantages both for the environment and those who live within it (Blondin, S., et al., June 2015; Cerda, A., et al., January 2018; Kibler, K., et al., April 2018; Oh, J. et al., August 2017; Sakaguchi, L., et al., March 2017; Thyberg, K., et al., August 2017).

A large body of literature exists which argues for the benefits of food waste reduction as well as general waste reduction (Bees, A., et al., December 2017; Chien-Bong, C., et al., December 2017; Oh, J., et al., August 2017; Kibler, K., et al., April 2018; Morris, J., et al., April 2017; Qi, D., et al., October 2017; Sakaguchi, L., et al., March 2017). The main obstacle that plagues research surrounding the production of food waste, however, is the difficulty in quantifying its' driving factors (Kibler, K., et al., April 2018; Sakaguchi, L., et al., March 2017). A significant amount of research has been produced that examines some of the ramifications of extreme levels of food waste production in the US; yet the causes of food waste production remain poorly understood and sparsely documented (Kibler, K., et al., April 2018; Sakaguchi, L., et al., March 2017).

This study looks at some of the behaviors and attitudes surrounding contemporary ideas of composting and waste production. About half of students believe that composting is messy and smells bad. A large majority of students also admit to either not realizing there was a composting program on Auraria Campus or having difficulty in participating in it because they either do not have enough time between lectures and course work to educate themselves on what can be composted and to take the time to separate the different variables of their own waste. Beginning to understand why people think a certain way about waste and food recycling is an integral step in being able to design composting programs that are effective and that are successful long-term. There are many aspects of studying the behavior patterns at the root of food waste production in the US that cannot be addressed as easily as other aspects of the food waste issue. But by documenting what obstacles people face when dealing with food waste, we can begin to lay a basic framework for understanding how to address them in the future.

VI. Next Steps.

As a result of this report, perhaps we can now begin producing tangible suggestions for organizations and individuals who wish to implement effective and long-term food waste mitigation efforts. Institutions such as Auraria Campus have a significant amount of information available to them through the number of people who work and study on campus. Future survey work could offer valuable insight into some of the more intricate reasons why food waste is produced. As it currently stands, food waste research is more often focused on the other end of the problem; dealing with the waste, once it is already produced. This is an approach that might be more accessible in the short-term, but does not actually address the real reasons as to why the US has such an extreme problem with producing food waste. Some studies have suggested that, by addressing the root of the problem, the overall amount of waste that is eventually produced will be

much lower (Sakaguchi, L., et al., March 2017). This would, in turn, have effects on the processing capabilities of current commercial scale composting infrastructure; another issue that plagues potential success of contemporary composting efforts. Some examples of the changing the focus on food waste issue from the front end include; changing the way we think about food, resizing portions to reflect not only a healthier size for us but for our planet, improving restaurant and food producers' efficiency by increasing measurement protocols and by staying informed with current local legislation and donation options (Sakaguchi, L., et al., March 2017).

There are also ethical ramifications to consider; when nearly one in eight Americans goes hungry every day and when there are more than 815 million people around the world who suffer from food insecurity, there are significant conflicts with throwing away nearly half of the food that is produced in our country (WHES, 2018). Current waste trends in the US have severe consequences on resources that we take for granted like water and accessibility to essentially any food we like; regardless of season or location. These actions are beginning to show negative effects on other areas of our environment as well, in the air that we breath, in the ecosystems that sustain life on this planet, in the atmosphere that protects us and in the water that we drink. Diverting food waste from landfills is only one part of a system with many moving parts. But composting could be a step in the right direction. It is important to note, however, that composting is not the answer. This paper and many others examine aspects that can be quantified, attributes that can be measured and analyzed, but to solve an issue as enormous and as complex as food waste, behavioral driving factors must be considered. The social patterns that have created the current mindset of the 'throw-away' culture has affected our ability to see value in resources that are poured into the food that we eat and the products that we consume. A sustainable future will require a radical shift in the way that we think about resources, the way that we think about food and how much of those things we throw away; wherever 'away' might be.

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