Fall 12-19-2017

Food Waste in the United States: Issues, Ethics, and Solutions

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HON 4998

19 December 2017

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1. Introduction

One-third of all food produced for human consumption is lost or wasted globally (Gustavsson et al. 1-37). I begin the present paper by comparing the amount of food wasted in the US to the amounts wasted by different societies around the world, and discussing the reasons why food is wasted, and the consequences it has for our society in terms of resource consumption and production of pollution. Next, I argue why it is unethical for people in our society to continue wasting food at the present rates. Finally, I discuss practices that society could change or adopt to reduce the amount of food wasted, and to deal with food that is wasted more effectively.

2. The State of Food Waste in the United States

What is the global extent of food waste?

According to a report published by the United Nations Food and Agriculture Organization in 2011, roughly one-third of all food produced for human consumption by weight is lost or wasted globally, amounting to 1.3 billion tons per year (Gustavsson et al. 1-37). However, the problem is not evenly distributed between the world's societies.

Food losses in North America and Europe are 280-300 kg per person per year, which is about one-third of the edible food produced in those regions, while in sub-Saharan Africa and South/Southeast Asia, food losses were 120-170 kg per person per year, which is also about one third of the edible food produced in those regions. However, in North America and Europe, people waste 95-115 kg per person per year at the consumer level, which is more than 10 times the rate in sub-Saharan Africa and South/Southeast Asia, where the figure is only 6-11 kg per person per year. While more than 40% of food losses in developing countries occur at the post-harvest and processing levels of the food supply chain, more than 40% of the food losses in industrialized countries occur at the retail and consumer levels. The food losses at the consumer level in industrialized countries comes to about 222 million tons per year, which is almost as high as the total net annual food production in sub-Saharan Africa, at 230 million tons (Gustavsson et al. 1-37).

Kummu et al. considered only the crops grown to be used directly for human consumption, excluding animal feed, crops for industrial use, and seeding, and disregarded meat production. They converted their total food production figures in terms of weight into figures in terms of kcal of nutritional energy, and found that 24% of the produced food calories are lost or wasted in the food supply chain. North America and Oceania (where Oceania includes Australasia, Polynesia, Micronesia, and Melanesia) had the largest per capita food supply losses at 1,334 kcal per person per day, while South and Southeast Asia had the lowest at 404 kcal per person per day. These regions also feature the highest and lowest food losses relative to total food production, with North America and Oceania at 32% and South & Southeast Asia at 18%. Today, there are about one billion people in the world who are malnourished, and as the population increases and the climate changes, food security becomes a more and more pressing

issue (Kummu et al. 477-489). The authors investigated a minimum loss scenario, which took the lowest loss percentage achieved by any world region for each step of the food supply chain, and applied that percentage to all other regions of the world. The authors found that, in this scenario, food losses would be approximately half their current value, and the saved food could feed one billion people. Agricultural losses could be reduced globally by 47%, and consumptive waste could be reduced by 86% (Kummu et al. 477-489).

Where, why, and how much food is wasted in the United States?

The United States consumes the most calories per capita of any nation, is the second most obese nation in the world, and, at retail price, accounts for nearly $166 billion in wasted food each year. As much as 40% of America's food is wasted due to inefficient production and consumer habits (Hickey and Ozbay 1-6). In 2012, Americans wasted, on average, 0.615 pounds of food per person per day, which is greater than 35.5 million tons per year (Thyberg et al. 1-7). This is almost 20% more than the amount thrown out in the year 2000, 50% more than in 1990, and is three times as much food as was thrown out in the year 1960 (Ferdman). In 1980, food accounted for less than 10% of municipal solid waste in the US; now, it's well over 20%, which is greater than plastic, paper, metal, or glass waste. There is no statistically significant difference in the rates of food waste between rural and urban populations, or between commercial/institutional waste and residential waste (Thyberg et al. 1-7).

Food is lost and wasted at each stage of the food supply chain, starting at agricultural production sites. Food waste occurs in industrialized nations when food production exceeds demand. Crops are discarded if they don't meet "appearance quality standards" set by supermarkets. Produce is rejected by supermarkets at the farm gates due to specific standards

regarding the weight, shape, and color of crops. These crops are diverted to animal feed or other use, left in fields, or simply thrown out, destined for landfills (Gustavsson et al. 1-37).

Losses occur during food transportation and processing. During processing, different foods are cut and trimmed, and even though trimmings are edible, it is cheaper for food processors to dispose of the waste rather than to reuse it. Food items that are the wrong shape or size due to processing errors, or have damaged packaging, but are otherwise safe and edible, are also discarded. Food can also degrade in inadequate storage facilities or during transportation and become unsafe for human consumption (Gustavsson et al. 1-37).

Retailers provide a wide range of products and brands to meet American consumers' expectations (Gustavsson et al. 1-37). The estimated total food waste in stores in the United States in 2008 was 43 billion pounds, or 10% of the total food supply in the retail sector (Radojko et al. 23-39).

In the United States and other developed countries, consumers waste food because they can. As the fraction of consumers' income spent on food has decreased with time, the amount of food available per capita in retail stores and restaurants has increased, and the amount of food wasted per capita has increased (Gustavsson et al. 1-37). Restaurants serve large portions, and people tend to overfill their plates at buffets (Papargyropoulou et al. 326-336). Retailers package produce and prepared meals in oversized packages to increase sales (Gustavsson et al. 1-37). In the year 2010, 133 billion pounds of edible food at the retail and consumer level went uneaten in the United States, two-thirds of which is attributed to the consumer level. This amounts to 1,249 kcal per person per day. Of this waste, 95% entered landfills (Qi and Roe 1-19).

What are the consequences of wasting food?

Each year, the United States spends over $218 billion, or 1.3% of the GDP, growing, processing, transporting, and disposing of food that is eventually thrown out (ReFED 1-96). Every piece of food produced requires an investment of fresh water, land, fuel, fertilizer, and labor, and is responsible for the pollution and environmental impact caused by the extraction and use of those resources. Every piece of food that is discarded is a waste of those resources, and has further impact due to the energy and space required to dispose of it.

Food production in 2002 in the United States used at least 8,000 trillion BTU. This total energy figure includes the energy used across four production steps: agriculture, consisting of fuel and electricity use, and the energy used to produce fertilizers and other agricultural chemicals; food transportation, including food transportation by truck, water, air, and rail; food processing; and food handling, consisting of energy used for food services and sales, packaging, and residential energy consumption for storing and preparing food. Of these four categories, food handling accounted for the largest fraction of the total energy consumption at 48%. The authors of this study determined the embedded energy in the production of various food types, and the percent of the total food produced of that type that was wasted, and calculated that all the food wasted in the United States in 2007 accounted for 2,030 trillion BTU (Cuellar and Webber 6464-6469). The oil consumption alone for this waste is approximately 300 million barrels, or 4% of the total United States oil consumption in 2003 (Hall et al. 1-6). The two food categories that were the largest consumers of energy at the agriculture level were the meat, poultry, and fish category, and the dairy category, at 778 and 234 trillion BTU respectively, out of a total 1,270 trillion BTU for agriculture in 2010. However, the two food categories that contributed the most to the total energy waste were dairy and vegetables, due to the high energy requirements of dairy

production, and the fact that 32% of dairy products were wasted and 25.3% of vegetables were wasted (Cuellar and Webber 6464-6469).

Agricultural irrigation accounts for 70% of the fresh water use in the United States, and 90% of consumptive water use (Kummu et al. 477-489). Wasted food alone accounts for more than one quarter of all fresh water consumption (Hall et al. 1-6).

Farming practices in developed nations require over-application of synthetic nitrogen and phosphorus fertilizers to ensure crop yields. The necessary quantities of fertilizers containing fixed nitrogen are produced via the Haber-Bosch reaction, which requires a high energy input, and consumes hydrogen gas primarily derived from methane (Dawson and Hilton 14-22). Phosphorus fertilizers are produced by mining non-renewable phosphate rocks from reserves that are expected to last 300-400 years (Dawson and Hilton 14-22). When this nitrogen and phosphorus are introduced to the biosphere, they can accumulate in water sources, causing increased growth of aquatic plants and algae. Algal blooms can deplete the water of oxygen, killing off other aerobic organisms and creating dead zones. Certain algae species produce toxins and allow for the growth of harmful bacteria that make water unsafe. Nutrient pollutants like nitrates can enter ground water, and excess nitrogen compounds in the atmosphere can produced pollutants like ammonia and ozone, which impair breathing and alter plant growth ("Nutrient Pollution"). One study found that as much as 55% of all non-point water pollution is caused by agricultural runoff (Hickey and Ozbay 1-6).

Of all the food thrown out in 2014, 95% of it ended up in landfills (Breunig et al. 1120-1128). According to the EPA, 17% of the mass put in landfills is food waste. When food and other organic materials are sealed in landfills, they undergo anaerobic digestion, producing methane. As a greenhouse gas, methane has 21 times the Global Warming Potential of carbon

dioxide. Despite its effects as a greenhouse gas, and its potential use as a fuel source, 34-51% of landfill methane escapes gas capture systems. It's estimated that landfills in the United States account for 34% of global human methane emissions (Hickey and Ozbay 1-6). Incomplete combustion of food waste in waste incinerators results in the production of dioxins, and other harmful chemicals that are released into the environment (Katami et al. 1062-1065).

3. Discussion of Ethics

I argue that the act of wasting food is unethical, and that our society would benefit if people changed their behaviors. But why is wasting food unethical? What does "unethical" mean? And why does the ethics of food waste even need to be argued? We can first look at reasons why people might not see food waste as unethical.

Some people are unaware of the consequences of food waste. People who are uninformed or misinformed about the effects of food waste either think that it has fewer harmful effects than it actually does, or they don't consider the effects at all. This ignorance is the result of a lack of education on the subject. This is due in part to a lack of formal education about food waste, but also due to a lack of visibility of food waste behaviors, and a lack of visibility of the consequences of these behaviors (Schmidt 53-66). Because people waste food in small bits at a time and store it out of sight, and live far away from food production and disposal sites, people become out of touch with their own wasting behaviors and the wasting behaviors of others in their society, and are distanced from the physical consequences of food waste that occur at production and disposal sites (Schmidt 53-66). A survey of US residents found that those who were more aware of the environmental consequences of their food waste were more likely to feel guilty about it. Feelings of guilt are highly influential over peoples' behavior. Because people are

less likely to waste food when they realize the consequences, the main solution to the problem of ignorance is education (Qi and Roe 1-19).

Other people don't accept facts about the consequences of their actions. When the guilt and responsibility associated with certain facts becomes greater than a person can handle, that person compensates by denying the facts. These people are informed about the physical impacts on the world that their actions have, but choose to deny that they are true, because they don't want to accept that their behaviors are unethical, and don't want to make an effort to change them accordingly (Graham-Rowe et al. 15-23).

So why do I argue that we need to act, and what should convince others to do the same? What is ethical? What guides people when they judge actions as right or wrong? What, in the end, are we trying to do in this world? People seek fulfillment in their lives—redemption—and we do so in as many different ways as there are different people. So how do we know which is the right way to live?

The American pragmatic philosopher Richard Rorty has written about how people seek redemption, now and in the past, and how society should determine its ethical framework. According to Rorty, the narrative of the evolution of how people in Western cultures have sought redemption goes like this: For centuries, humans have followed many different religions. When ancient people asked questions about how the world around them worked, and what they should do with themselves, they turned to their myths for answers. In the West, people found redemption by entering into a relationship with a divine, nonhuman person, or God. But the rise of science replaced religion for people's mechanistic understanding of the physical world, and secular culture began to replace religion, as their source of moral authority, with philosophy, replacing God with Truth. This is the type of truth sought by philosophers like Plato and Kant—

as Rorty describes it, “a natural terminus to inquiry, a way things really are,” and something that “will tell us what to do with ourselves” (Rorty, “Philosophy” 3-28).

But the search for this sort of singular truth has not panned out. Those like Rorty cannot see the inquiry into how humans should live, and what we should make of ourselves, coming to an end, because solutions to old problems always create new problems (Rorty, “Philosophy” 3-28). Ultimately, on my interpretation, there is no real absolute right and wrong that exists out there for us to find. So then how do we make our choices about what to do? If we exist by chance in a meaningless universe, what are we supposed to do with ourselves? There are some thinkers who consider the question “why should we live at all?” to be the most fundamental question of philosophy. Considering the fact that there are humans in this world who have not died by their own hands, what is it that makes people stick around? Each of us finds happiness, excitement, and meaning in different things—we decide what we find meaningful and pursue it.

Rorty describes a type of person he calls an intellectual as one who reads books, visits different temples, studies songs, poetry, and plays, and interacts with other humans and their artifacts in order to explore as many ways of being human as possible—to explore as many meanings as possible. These people are members of what Rorty calls the literary culture, for whom “redemption is to be achieved by getting in touch with the present limits of the human imagination,” and making the acquaintance of as many humans as possible. The human imagination can be extended forever, and these intellectuals live at the edge of it and constantly push its boundaries. They replace the bad, philosophical question of “is it true?” with the questions, “what’s new?” or “does anybody have any new ideas about what we human beings might manage to make of ourselves?” In this literary culture, writings of religion and philosophy are just more genres, interpreted as human attempts to meet human needs. Rorty argues that this

rejection of the notion of the existence of a redemptive truth should not cause feelings of despair, but rather that human self-reliance should be a source of human pride (Rorty, "Philosophy" 3-28).

In a world where people seek redemption through this sort of exploration, how should society look? If we are free to do as we please, and encouraged to consider different ways of living, how should we choose to treat one another? Should we accept that people might go around murdering each other because they want to experience what it's like to be a serial killer? What do we owe to each other in a world with no fundamental rules in which we are free to explore? What are our morals? John Stuart Mill proposed the Greatest Happiness Principle, stating that "actions are right in proportion that they tend to promote happiness, wrong as they tend to produce the reverse of happiness" (Mill 30-36). This means that actions that are morally right are actions that optimally produce the most happiness, in total, from all people, and minimize pain. But what exactly is this happiness, and what does it mean to everyone?

Rorty notes that morals have traditionally been distinguished from prudence in that prudence is what feels natural for us to do—it is prudential to help your family and close friends when they're in need—while morals are things that we ought to do, but which do not come to us naturally, such as giving up some of our family's food so we can send it to needy people on the other side of the globe (Rorty, "Ethics" 1-8). But he says that this view of morality is based on the outdated idea that the "true self" is a nonrelational, cold psychopath who needs to be reined in by moral laws defined externally. He notes that Baier said that "the secular equivalent to faith in God…is faith in the human community and its evolving features." Rorty says, "The trust which holds a family together is Baier's model for the secular faith which may hold together modern, posttraditional societies." If we can all, as individuals, aim to extend the natural,

intuitive love we have for our families to all people and things around us, the word “moral” would no longer have meaning, because there wouldn’t be any way to contrast “moral” actions with those that come naturally.

In an even more general sense, what is it that makes us happy, and why celebrate diversity? Should we only be concerned with human happiness? And why not be selfish, seeking pleasure for yourself before you die, at the expense of the world around you? What actually is life, and perception? Living organisms are organized systems of matter and energy, with high complexity and low entropy, that have the built-in objective of perpetuating themselves. This definition holds from the scale of self-replicating molecules and viruses, to multicellular organisms, to whole societies of those organisms and their technology. The things that make humans the happiest often coincide with the things that promote the goals of living things in general: having security in resources and support from others, rearing new generations or creating new things and seeing them thrive, having the ability to achieve our goals, and exploring and understanding the diversity of the world.

And where does happiness exist, physically? Happiness, and all thoughts, emotions, and other experiences we humans have, seem to exist as a consequence of the physical activity of human brains. Brains are control systems, and they feel happy when their goals are being achieved. But what are brains made of? They are just instances of high complexity, low entropy ordered systems, like other life. They evolved to be control systems, receiving inputs from the senses, and by using cascades of neuron switches, determining outputs in the form of muscular contractions and hormone releases.

So where is consciousness in there? Is it in the cells, or the fundamental particles? Cells divide, rearrange, and die throughout our lives, and the particles they’re made of constantly flow

into the system and back to the environment. The constant thing about a brain is that it is an abstract, organized structure, that allows for the processing of information in order to achieve a goal. The particles and cells and ganglia at a particular instant in time are physical objects that follow physical rules that perform this information processing. Similar information processing, though of lesser complexity, happens inside the nervous system of every animal. In every cell in our bodies, molecular signaling pathways process information and control cell behavior similarly to how a nervous system controls a whole animal, and likewise in every plant cell and every bacterium. Scaling up, even whole societies run in a similar way, with individual humans taking on different roles and exchanging information to achieve larger goals. Getting away from strictly biological cases, electronic or mechanical control systems do the same thing, with machine learning now achieving feats we previously thought only possible with human brains. So do all of these things, like human brains, have some sort of consciousness, and are they capable of happiness?

I suggest that we conceive of ourselves this way, and doing so has important implications. If it were possible to create a perfect physical copy of yourself, down to the molecular structure, and that copy were placed in an exact replicate of your physical surroundings, wouldn't that copy have a conscious experience identical to yours? And if you could create a computer that perfectly simulated your brain's activity, using silicon hardware instead of biological hardware, would it think the same thoughts as you? If your thoughts, memories, and feelings are just instances of certain structures and activity in space, and if similar instances of those structures exist in other people's brains, how is their conscious experience different from yours? Our bodies don't have hard boundaries anywhere in space; we're just areas of organization in a soup of particles that flow between us. A physical instance of one mind in

one place is not isolated from any others. Thinking about the process of death, in which your body's control systems fail, your particles become more and more disordered, and eventually your body simply ceases to exist, consider the fact that other minds live on. They are in the same universe as you, made of the same stuff, doing similar things—so, in that way, how are those physical instances of thoughts and feelings different from the ones you had? How is their being alive different, or separate, from you being alive? In this way, it seems like pieces of what we consider to be ourselves live on after our bodies have died. A reality in which there are no immortal souls to drift off to some afterlife does not necessitate that the light of life switches off at death and that's the end—after our minds break down, many other minds continue.

Happiness comes from achieving the goals of living things. We're all living things together in this society, and in the larger ecosystem. A familial love for all of these living things, together—things with which we are interdependent for the stability of the ecosystem, and with which we share fundamental identity—promotes happiness for everything involved. We can find meaning and fulfillment in exploring and treasuring the great diversity and beauty of all the living things that exist, human or otherwise, and all that they create. And we can go on to create new, exciting, and interesting things. We can further increase complexity, and increase the amount of life, and its health, and create a better-running ecosystem and society that can persist for as long as possible into the future. We should choose to live because we are alive; we can create happiness by allowing ourselves and everything else to live, exploring those things, and sharing our fundamental kinship with them.

In a society based on these ideas, people would have a duty to each other, and to sustaining the bigger picture. We would be required to contribute to building a society that met the physical needs of all humans, both present and future, by providing for physical needs in

ways that are sustainable and can last into the future. The most sustainable, least impactful practices to meet human needs are in our own best interest, because they preserve the stability of the whole biosphere, ourselves included. Likewise, we would be prohibited from performing actions that could undermine this stability, and thus undermines ourselves. With our remaining time we would each be able to do as we pleased. Our actions would lead to a society that was purpose-built to give all people the ability to explore, create, and find redemption, free to consider different ways of being human, and different ways of being alive.

4. How Society Can Reduce Food Waste

Social and emotional drivers of consumer food waste.

The amount of food wasted per capita in developed countries has increased over the past decades, coinciding with the migration of people from rural to urban settings, and a decrease in the fraction of household income spent on food (Priefer et al. 156-165). Thus, food supply chains have grown longer and more complex, and people are more distanced from the food production process, resulting in about 40% of food losses in the US taking place at the consumer level today (Gustavsson et al. 1-37).

Peoples' behaviors and choices are influenced in large part by moral norms and social norms, which are the behavioral expectations of one's own morals, and the expectations of important other persons, respectively (Schmidt 53-66). People experience guilt when they don't conform to social or moral norms, and this guilt is a strong driver of behavior (Qi and Roe 1-19). Consumer behavior is driven by a desire to avoid experiencing guilt, and to avoid other negative emotions, such as frustration due to inconvenience, or shame (Graham-Rowe et al. 15-23).

A survey of US residents investigated what practical benefits households thought they might lose if they reduced the amount of food they wasted, how much guilt consumers associated with food waste, and whether households thought they could be doing more to reduce food waste. The majority of respondents indicated that they feel guilty when they throw out food, and the respondents that indicated they were aware of the environmental consequences of food waste were more likely to feel guilty (Qi and Roe 1-19). In the UK, people overbuy to minimize the inconvenience of shopping again, and to fulfill the desire to provide abundant, healthy food. Survey respondents said they don't see food waste as a real problem, or that it is inevitable (Graham-Rowe et al. 15-23).

One way to change people's social norms regarding household food waste is to make the habits of the households around them more apparent. Currently, food waste behaviors are not very visible; people waste food in small bits at a time, store the waste in trash cans or dumpsters mixed with other materials, and place it outside where it is quickly removed by trash collection services. Therefore, people have a poor sense of how much food they themselves are wasting, and know even less about societal averages (Graham-Rowe et al. 15-23). One successful intervention to the similar problem of excessive electricity consumption has been used by energy companies, wherein the companies report a household's energy consumption to the household, and compare it to the local average energy consumption, or compare it to a socially-endorsed target value. This method has been shown to reduce the energy consumption of high-consuming households by bringing their consumption towards the average levels. A similar system could be useful in reducing household food waste, although implementing a system that measures and reports food waste has more practical barriers than the system that monitors energy consumption (Qi and Roe 1-19).

Another factor that influences peoples' behaviors is education. A survey of consumers in Romania found that shoppers who planned out their meals for the week, and those who were more skilled in food preparation and storage, tended to waste less food (Stephan et al. 375-381). Similar results were found by a survey of UK households (Graham-Rowe et al. 15-23). Educating people about how to properly store and cook food, and to plan their meals, reduces waste. A study found that commitment and goal-setting measures, such as signing online petitions or pledges to perform specific behaviors in a fixed period of time, are effective for changing people's behaviors. Specifically, these interventions effectively improved avoidance of impulse purchases, discarding excessive amounts of food, and immediate discarding of expired food (Schmidt 53-66). An educational intervention that provided each participant with a personalized list of recommendations, based on each participant's response to a questionnaire, was more effective than interventions that gave extensive, generalized lists of recommendations. General lists make people feel overcharged and less motivated by the irrelevant information, so targeted education is more effective (Schmidt 53-66). UK consumers reported that they experience guilt when they waste money or utility, or when they "don't do the right thing." Educating people about the consequences of food waste to make them feel guilty is an effective way to influence their behavior, so it is a tactic that should be incorporated into waste reduction efforts. However, it should be used sparingly as too much guilt can drive people to compensate and avoid responsibility by denying the relationship between waste and its environmental impacts (Graham-Rowe et al. 15-23).

Behaviors resulting from undervaluing food.

As average household incomes have increased in developed countries, so has per capita food waste. At the beginning of the twentieth century, the average European household spent

50% of its income on food; today, households in the EU spend only 10-20% (Priefer et al. 156-165). The Swiss WWF advocates abolishing all subsidies for food and introducing higher, cost-covering prices. The German Scientific Committee on Agricultural Policy advocates for the elimination of reduced Value Added Tax (VAT) rates on food, as they represent indirect subsidization. They argue that any hardships caused by increases in food prices due to this change would be offset by targeted governmental income support, financed by the increased tax revenue. Experts from environmental groups suggest imposing different VAT-rates according to the environmental impacts of different food items. High tax rates could be placed on meat, dairy, and convenience foods, and lower rates on less environmentally damaging foods like fruits and vegetables. In addition to removing subsidies on food to increase its price, the cost of food waste disposal could also be increased. Pay as You Throw schemes determine the cost of waste disposal based on the weight, volume, or frequency of disposal. Countries that use Pay as You Throw systems for waste disposal tend to have better waste management performance in terms of decreasing waste generation and increasing recycling (Priefer et al. 156-165).

Waste from restaurants and the hospitality sector.

Restaurants and the hospitality industry are notorious for serving large portions that customers don't finish. Restaurants could introduce more tiered portion sizes to their menus, or decrease their maximum portion sizes and offer refills if customers want more (Priefer et al. 156-165). Case studies of restaurants have shown that buffet-style food service leads to greater amounts of avoidable waste than serving food a la carte. Buffet-style service creates lower amounts of preparation waste, due to economies of scale, but much higher amounts of waste due to leftovers. The specific amount of waste created at buffet-style restaurants that cater to large crowds is dependent on the number of people who attend each day, which is highly variable. The

restaurant case study found that, of all the food entering the restaurant, 30% left the restaurant as food waste; of that, 17% was thrown out during food preparation, 7% was uneaten food on customers' plates, and 6% was thrown out as buffet leftovers. Of this waste, only 44% was determined to be unavoidable waste resulting from food preparation, while the remaining 56% was avoidable. Because buffets must ensure that every customer has access to the same variety of food as every other customer, they prepare more food than the customers will consume. Improving communication between the people who handle restaurant bookings and those who prepare the food can help restaurants to prepare more appropriate amounts of food (Papargyropoulou et al. 326-336). Buffets that have eliminated trays, requiring customers to carry a smaller number of dishes at a time and forcing them to pace themselves while eating, and buffets that have stopped allowing customers to fill their own plates, instead receiving portions from staff, saw a decrease in the amount of food they wasted. One change buffets can make is to replace their "all you can eat" policies with a "pay by weight" policy. These changes have been shown to reduce the amount of uneaten food on customers' plates (Priefer et al. 156-165).

Misunderstanding food freshness.

Consumers often don't understand the meaning of date labels on food items. Date labels typically come in the form of "use-by" dates or "best-by" dates. Consumers often interpret both as the date after which food is spoiled and inedible. However, this is only the definition of use-by dates; best-by dates are not related to food safety and are not set by law, but instead are dates after which the product is no longer at peak freshness, based on conservative estimates. Retailers often don't sell products after their best-by dates, to limit product liability, but this is overly precautious. Retailers could offer price discounts for products near their best-by dates, which could easily be integrated into barcode checkout systems. Alternatively, best-by dates could be

removed altogether to avoid confusion with use-by dates, preventing waste (Priefer et al. 156-165).

Clarifying the meaning of food date labels would be especially effective for changing the behavior of high income households, which are the households most likely to dispose of food for the purpose of preserving freshness. A survey of US residents found that 70% of respondents agree that throwing away food after the package date reduces odds of foodborne illness, and nearly 60% agree that some food waste is necessary to ensure meals taste fresh. There was a positive association between perceived benefits of throwing away uneaten food and increasing household income. Meanwhile, it was found that people who immigrated to the US from developing countries wasted less food and were more likely to feel guilty about food waste (Qi and Roe 1-19). Interventions that could target high income households include educating them about food date labels, food storage, and how to determine when food is no longer fit for consumption.

Gleaning food waste.

In 2014, 17.4 million households in the US were classified as food insecure. People receiving food assistance tend to lack micronutrients in their diets, and are more likely to be obese. Food redistribution programs divert edible food, including unharvested crops, or waste from retailers or buffets that would otherwise end up in landfills, to people in need. The main barriers to the success of these program are the lack of strong networks to provide the infrastructure for food redistribution, and the unpredictability of food donations and volunteer availability (Lee 40-52). In Europe, one barrier is concern over the legal consequences of accidentally donating spoiled food, but the US enacted the Good Samaratin Act, which limits the liability of people who donate food in good faith (Priefer et al. 156-165). However, while

donations and volunteers can help these organizations provide food to those in desperate need, food redistribution systems do not fix the structural problems of society that cause poverty and food waste, and the use of people in poverty to recycle food should not be institutionalized (Macdiarmid et al.).

Shipping and storage.

The increased distance between consumers and farms in the last decades has increased the length and complexity of the food supply chain, which increases the risk of losses (Papargyropoulou et al. 326-336). Opening alternative channels for agricultural products, by cutting out the middlemen and having farmers sell directly to consumers, could increase efficiency. Systems like this have gained popularity for their other advantages, including their ability to foster community, preserve local food production, revitalize urban economies, and protect the environment. These distribution systems can help prevent food waste by reducing the distance between farmers and consumers, thus reducing the length of the food supply chain and losses, and making the production process and seasonal limits of farming more visible to consumers, which encourages sparing and responsible handling. The system also avoids losses due to wholesale retail, specifically losses caused by agreements with retailers that force farmers to overproduce and reject substandard products (Priefer et al. 156-165). Such distribution systems can be achieved with farm shops, farmers markets, delivery of vegetable boxes by subscription, mail-orders, producer cooperatives, and solidarity purchasing groups.

Fruits and vegetables that do not meet shape, size, or color standard are thrown out. In 2008, the EU repealed market standards on various fruits and vegetables to try and increase sales of nonstandard products, but these repeals had little effect. One reason was that the trading sector had an interest in maintaining standards because they provide an objective yardstick that

facilitates business relations between producers, manufacturers, and retailers. Additionally, many logistical processes in place are not mechanically designed to handle nonconforming products due to size and shape differences (Priefer et al. 156-165). Markets can be developed for these substandard products, however. Some farms invite gleaning operations to remove the substandard products from their fields to redistribute them (Lee 40-52). Sales from farmers directly to consumers can cut out standards set by retailers (Priefer et al. 156-165). Alternatively, consumers could convince retailers that they are willing to buy nonconforming produce (Gustavsson et al. 1-37).

Alternative forms of waste disposal.

In the year 2009, 97% of all food thrown out in the US was disposed of in landfills (Vanham 1-16). However, food waste can be utilized as a low- to no-cost feedstock to produce various materials or recover energy. Food waste can be used as the sole microbial feedstock for production of methane, hydrogen, ethanol, enzymes, organic acids, bio polymers, and bioplastics. It can also be used as animal feed, or incinerated to produce electricity. The market value of these products ranges from $60 per ton biomass for electricity, to over $1,000 per ton biomass for enzymes (Kiran et al. 389-399).

Ethanol produced from food waste is in high demand as a feedstock for the production of ethylene, with a demand of over 140 million metric tons per year. A pilot study at Kumamoto University and the Hitachi Zosen Company showed that 60 L of ethanol could be produced from 1 ton of municipal solid wastes, while the residual byproducts could be used for biogas production, which is primarily methane. In Finland, ST1 Biofuel built a network of seven ethanol plants, converting various kinds of wastes into ethanol, with a total annual capacity of 11 ML. Hydrogen gas, which is used as a feedstock in many chemical processes, can be produced from

food waste. While hydrogen gas production from food waste is not economically viable on its own, it can be used in combination with other food waste disposal processes to increase the value extracted. One option is a three-stage process for production of hydrogen and methane: photofermentative bacteria can partially digest food into lactic acid, which is then fed to other bacteria that convert it into hydrogen, while the byproducts are used to produce methane. This process recovers 41% of the original energy in the food as hydrogen, and 37% as methane, which, when used to produce electricity, has a yield of 1146 MJ per ton. The fat in food waste can be converted into fatty acids and biodiesel via direct transesterification by various oleaginous microorganisms. Alternatively, food waste can be used as feedstock for microalgae, which can produce biodiesel (Kiran et al. 389-399).

Methane can be produced via anaerobic digestion (AD) of organic materials. Anaerobic digesters are vessels that take in organic material, such as food waste, as feedstock, and combine it with water and anaerobic microorganisms, which digest the feedstock and produce methane when in the absence of oxygen. Methane can be extracted continuously and used as fuel, and once all the feedstock is digested, the remaining material can be dried and used as compost. If state-of-the-art AD technology was used to dispose of all the world's food waste, and all the extracted methane was used to produce electricity, 824 MW of power could be produced globally (Kiran et al. 389-399). In 2009, there was only one medium-scale AD used to dispose of food waste in the US, while Europe had over 120. These facilities produce about 110 cubic meters of biogas per Mg of feedstock, with a methane content of 45-73%, and produce 0.33 Mg of digested solids per Mg of feedstock (Levis et al. 1486-1494).

Aerobic composting (AC) is a process that stabilizes organic wastes by controlled aerobic degradation. There are nearly 300 AC facilities in the US, 80% of which take in less than 5,000

Mg of food waste per year, while fewer than 30 facilities take in over 50,000 Mg per year. The product of AC is compost fertilizer, which the facilities can sell. They can also take the solid digestate byproduct of AD facilities and use it to make compost. Most facilities sell their compost in bulk to organic farms or landscapers, especially to be used for erosion control. In 2009, all the food waste AC facilities in the US were able to sell all of their compost (Levis et al. 1486-1494).

When used correctly, AC and AD have fewer greenhouse gas (GHG) emissions than landfills. The implementation of carbon taxes or cap-and-trade systems would promote the utilization of technologies that reduce GHG emissions, such as AC and AD. Landfills are the second largest anthropogenic source of methane emissions, where methane is created from the anaerobic degradation of food waste and leaks out to the environment. AC releases the carbon in food waste as carbon dioxide, which is a much less potent GHG than methane. While AD produces methane, the methane is captured and burned, converting it into carbon dioxide. When AD methane is burned to produce electricity, it offsets the use of fossil fuels, replacing them with a carbon-neutral alternative (Levis et al. 1486-1494).

The major limitation of AD and AC facility operation is the difficulty of obtaining pure feedstock. Most of the facilities currently in use obtain their food waste feedstock from industrial, commercial, and institutional sources, which are able to sort their waste more easily than households. Most municipal solid waste, even from well-informed communities that request that people separate their waste types, are heavily contaminated with glass or plastic, the presence of which make the compost produced from these materials unusable. At some facilities, when contaminants are found in the feedstock, the facility asks the waste generator to come to the facility and separate out the contaminants; otherwise, the waste is returned to the waste

generator (Levis et al. 1486-1494). A study of Swedish households investigated the importance of convenience and social norms in promoting separation of waste in households. The study found that distribution of information-containing leaflets caused no change in the degree to which households separated their waste types, but the installation of food waste collection bins in people's households resulted in a large and lasting increase in the degree to which households separated their waste (Bernstand 1317-1323). This type of intervention could be used to increased household separation of waste to increase the feedstock purity for AD and AC facilities.

Another alternative to landfills is waste-to-energy (WTE) by incineration. These facilities can burn waste to produce heat, which is used to produce electricity. A lifecycle assessment comparison of landfilling, AC, AD, and WTE shows that many factors influence which of the choices is best for waste disposal—the optimal choice in terms of global warming potential (GWP), smog formation potential, and other factors, is highly dependent on the specifics of the facility operation, feedstock composition, and what form of energy production the facility offsets. However, in almost all scenarios, it was beneficial to divert food waste from landfills to AC, AD, or WTE. AD typically performed better than AC in terms of GWP, except in the case where the electricity produced by AD offset electricity produced by a methane-burning generator. The scenario in which all waste was diverted to a WTE facility that produces electricity had an equivalent GWP to scenarios involving AD (Hodge et al.).

5. Conclusion

Food waste is a global problem that waste resources and damages the environment, with effects all across society. To continue with the status quo is unethical, and as one of the largest contributors to the problem, the United States and its people should make an effort to increase

awareness of the problem and concern for its consequences, and to find better ways of dealing with food waste when it does occur.

Works Cited

Bernstand, Anna. "Household food waste separation behavior and the importance of convenience." *Waste Management*, vol. 34, 26 April 2014, pp. 1317-1323, DOI: 10.1016/j.wasman.2014.03.013. Accessed 7 February 2017.

Breunig, Hanna, et al. "Bioenergy Potential from Food Waste in California." *Environmental Science and Technology*, vol. 51, 10 January 2017, pp. 1120-1128, DOI: 10.1021/acs.est.6b04591. Accessed 17 May 2017.

Cuellar, Amanda and Michael. E. Webber. "Wasted Food, Wasted Energy: The Embedded Energy in Food Waste in the United States." *Environmental Science and Technology*, vol. 44, 21 July 2010, pp. 6464-6469, DOI: 10.1021/es100310d. Accessed 7 February 2017.

Dawson, C.J. and J. Hilton. "Fertiliser availability in a resource-limited world: Production and recycling of nitrogen and phosphorus." *Food Policy*, vol. 36, 2011, pp. 14-22, DOI: 10.1016/j.foodpol.2010.11.012. Accessed 30 September 2017.

Ferdman, Roberto. "Americans throw out more food than plastic, paper, metal, and glass." *The Washington Post*, 23 September 2014, https://www.washingtonpost.com/news/wonk/wp/2014/09/23/americans-throw-out-more-food-than-plastic-paper-metal-or-glass/?utm_term=.c476401ce689. Accessed 7 February 2017.

Graham-Rowe, Ella, et al. "Identifying motivations and barriers to minimizing household food waste." *Resources, Conservation and Recycling*, vol. 84, 13 December 2013, pp. 15-23, DOI: 10.1016/j.resconrec.2013.12.005. Accessed 17 May 2017.

Gustavsson, Jenny, et al. “Global food losses and food waste – Extent, causes, and prevention.” *FAO*, 2011, pp. 1-37. www.fao.org/docrep/014/mb060e/mb060e00.htm. Accessed 17 May 2017.

Hall, Kevin, et al. “The Progressive Increase in Food Waste in America and Its Environmental Impact.” *PLoS One*, vol. 4, no. 11, November 2009, pp. 1-6, DOI: 10.1371/journal.pone.0007940. Accessed 15 September 2017.

Hickey, Michael and Gulnihal Ozbay. “Food waste in the United States: A contributing factor toward environmental instability.” *Frontiers in Environmental Science*, vol. 2, 28 November 2014, pp. 1-6, DOI: 10.3389/fenvs.2014.00051. Accessed 19 May 2017.

Hodge, Keith, et al. “Systematic Evaluation of Industrial, Commercial, and Institutional Food Waste Management Strategies in the United States.” *Environmental Science and Technology*, vol. 50, 7 July 2016, DOI: 10.1021/acs.est.6b00893. Accessed 19 May 2017.

Katami, Takeo, et al. “Formation of Dioxins from Incineration of Foods Found in Domestic Garbage.” *Environmental Science and Technology*, vol. 38, no. 4, 2004, pp. 1062-1065, DOI: 10.1021/es030606y. Accessed 30 September 2017.

Kiran, Ersa, et al. “Bioconversion of food waste to energy: A review.” *Fuel*, vol. 134, 6 June 2014, pp. 389-399, DOI: 10.1016/j.fuel.2014.05.074. Accessed 17 May 2017.

Kummu, M., et al. “Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use.” *Science of the Total Environment*, vol. 438, 1 November 2012, pp. 477-489, DOI: 10.1016/j.scitotenv.2012.08.092. Accessed 7 February 2017.

Lee, Deishin. "Combining two wrongs to make two rights: Mitigating food insecurity and food waste through gleaning operations." *Food Policy*, vol. 68, 12 January 2017, pp. 40-52, DOI: 10.1016/j.foodpol.2016.12.004. Accessed 19 May 2017.

Levis, J.W., et al. "Assessment of the state of food waste treatment in the United States and Canada." *Waste Management*, vol. 30, 19 February 2010, pp. 1486-1494, DOI: 10.1016/j.wasman.2010.01.031. Accessed 19 May 2017.

Macdiarmid, Jennie, et al. "Down with food waste." *BMJ*, 22 March 2016, DOI: 10.1136/bmj.i1380. Accessed 17 May 2017.

Mill, John Stuart. "Utilitarianism." *Ethics across the Professions: A Reader for Professional Ethics*, edited by Clancy Martin et al, 2010.

"Nutrient Pollution: The Problem." *United States Environmental Protection Agency*, https://www.epa.gov/nutrientpollution/problem. Accessed 30 September 2017.

Papargyropoulou, Effie, et al. "Conceptual framework for the study of food waste generation and prevention in the hospitality sector." *Waste Management*, vol. 49, 21 January 2016, pp. 326-336, DOI: http://dx.doi.org/10.1016/j.wasman.2016.01.017. Accessed 17 May 2017.

Priefer, Carmen, et al. "Food waste prevention in Europe – A cause-driven approach to identify the most relevant leverage points for action." *Resources, Conservation and Recycling*, vol. 109, 17 March 2016, pp. 155-165, DOI: 10.1016/j.resconrec.2016.03.004. Accessed 17 May 2017.

Qi, Danyi and Brian E. Roe. "Household Food Waste: Multivariate Regression and Principle Components Analyses of Awareness and Attitudes among U.S. Consumers." *PLoS One*, 21 July 2016, pp. 1-19, DOI: 10.1371/journal.pone.0159250. Accessed 19 May 2017.

Radojko, Lukic, et al. "Retail Food Waste Management." *Management and Research Practice*, vol. 6, no. 4, 2014, pp. 23-39, www.econpapers.repec.org/article/rommrpase/v_3a6_3ay_3a2014_3ai_3a4_3ap_3a23-39.htm. Accessed 17 May 2017.

ReFED. "A Roadmap to Reduce U.S. Food Waste by 20 Percent." 2016, pp. 1-96, https://www.refed.com/downloads/ReFED_Report_2016.pdf. Accessed 30 September 2017.

Rorty, Richard. "Philosophy as a Transitional Genre." Pragmatism, critique, judgment: essays for Richard J. Bernstein, The MIT Press, 2004, pp. 3–28, mitpress.mit.edu/sites/default/files/titles/content/9780262524278_sch_0001.pdf.

Rorty, Richard. "Ethics Without Principles." *EurAmerica*, vol. 24, no. 1, March 1994, pp. 1-8.

Schmidt, Karolin. "Explaining and promoting household food waste-prevention by an environmental psychological based intervention study." *Resources, Conservation and Recycling*, vol. 111, 23 April 2016, pp. 53-66, DOI: 10.1016/j.resconrec.2016.04.006. Accessed 17 May 2017.

Stephan, Violeta, et al. "Avoiding food waste by Romanian consumers: The importance of planning and shopping routines." *Food Quality and Preference*, vol. 28, no. 1, April 2013, pp. 375-381, DOI: 10.1016/j.foodqual.2012.11.001. Accessed 7 February 2017.

Thyberg, Krista, et al. “Quantification of Food Waste Disposal in the United States: A Meta-Analysis.” *Environmental Science and Technology,* vol. 49, 9 November 2015, pp. 1-7, DOI: 10.1021/acs.est.5b03880. Accessed 19 May 2017.

Vanham, D. “Lost water and nitrogen resources due to EU consumer food waste.” *Environmental Research Letters*, vol. 10, 12 August 2015, pp. 1-16, DOI: 10.1088/1748-9326/10/8/084008. Accessed 17 May 2017.