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Abstract

Greenhouse gas emissions as a result of food production are impacting climate change at an ever-growing rate. If we want to sustain and feed the rapidly increasing human population, be able to improve our health, and ensure nutritious food is accessible to all people, we need to assess and focus on where our food comes from. Michigan (the third largest U.S. apple producer) apples are a contributor to health, food security, culture and economic livelihood. While research shows correlations of decreased cancer and other cardiovascular diseases with the consumption of apples, they have a staggering transportation carbon footprint as a result of being one of the most commonly demanded fruits in the U.S. To understand the impacts, I interviewed, and surveyed different types of apple packing and final retail locations. From the data collected, I roughly estimated the carbon emissions based on distance traveled and found the farm is not always the most cost efficient option for purchasing apples but does decrease food miles traveled. For example, apples from Washington sold in Aldi were the cheapest (generally, there were price differences based on variety) but the highest transportation emissions, where apples sold at Schultz (Mattawan, MI, U.S.) farm had virtually no transportation emissions impact and a low price comparatively. Therefore, a responsible way to consume apples is to purchase in-season produce that was grown in your home-state.

Introduction

Apples to apples, two things that can reasonably be compared. The concentration of greenhouse gases and climate change, two things that can also reasonably be compared. Food production in the world, nation and even just one State all have a big impact on the environment. The way in which we mass produce food is frequently researched and the environmental costs are becoming apparent (Godfray, 2010). However, if we want to be able to sustain and feed the rapidly increasing population of the world, humans are going to have to find ways to change the way food is produced, stored, processed, and transported (Godfray, 2010). The way in which many humans live right now, the Earth will not be able to support our over consumption for much longer; there is a finite amount of resources provided by the Earth (Godfray, 2010).

Malus domestica, the modern domesticated apple, has ancestors that can be traced back to the mountains of Kazakhstan (Pollan, 2001). The history of rapid apple variety expansion often begins with John Chapman (more commonly known as Johnny Appleseed), who is credited with propagating early apples in the U.S.. He arrived with the colonists and was a unique person; a nature-enthusiast, he never wore shoes and slept outside because he was constantly on the move (Pollan, 2001). Chapman, on his journey around the U.S., planted millions of nameless seeds over thousands of miles along the Mississippi River. The vast quantity of apple seeds gave the fruit the opportunity to change and adapt to be highly successful in the New World. Others took care of the apple trees Chapman planted and soon learned how to turn them into cider, an alcoholic drink. In short, the apple thrived in its new North American home (Pollan, 2001).

In the United States today, apples are produced in 32 states as a commodity, and there are more than 7,500 apple producers who collectively use 130 thousand hectares of land. The U.S. is the world's second-largest producer of apples behind China (USApple.org; Accessed 28 October

2019). Michigan is the third-largest state producer of apples in the U.S., behind Washington and New York. One out of every four U.S. grown apples are exported; top markets include Mexico, India, and Canada (USApple.org; Accessed 28 October 2019). Roughly 67% of the U.S. apple crop is grown for fresh consumption and the remainder is processed into products such as apple juice and applesauce (USApple.org; Accessed 28 October 2019).

In Michigan, there are approximately 11.3 million apple trees growing on 14,164 hectares. Most of these apples are grown on family-run farms, and the growers are a part of a rich heritage of apple production (MichiganApples.com; Accessed 28 October, 2019). Apple growers strive to grow high quality apples, but also to meet customer demands. Appearance, flavor and texture are all very important characteristics of an apple. A study has shown that flavor, bruising, blemishes, and crispness were all important aspects to both the grower and consumer (Ricks et. al, 2002).

In the U.S. there is a grading scale for apples, that begins with U.S. Utility, a low quality apple, and peaks at U.S. Extra Fancy (USDA.gov; Accessed 13 November, 2019). This scale helps packers, processors and consumers sort and identify apples against a national standard. According to the USDA, a U.S. Utility apple is mature but not overripe, free from serious deformity, internal browning, internal breakdown, soft scald, freezing injury, and decay. Next in quality is a U.S. No. 1 which meet the requirements of U.S. Fancy grade except for color, russetting, and invisible water core. Then U.S. Fancy which are mature but not overripe, clean, fairly well formed, and free from decay, internal browning, soft scald, freezing injury, internal decay, and broken skin; also free from damage caused by bruises, brown surface discoloration, sunburn, limb rub, scars, disease, insects, bitter pit and some others. Finally, U.S. Extra Fancy are free from every kind of deformity listed above as well as a certain amount of color. A farmer

decides on which variety to grow with consideration to the highest probability of profit and consumer preferences (Yue et. al, 2013).

Apples are a part of Michigan culture, as well as, a big source of income for farmers in the agro-tourism business. Going to the apple orchard, and picking or buying apples is a yearly tradition for many Michigan families. However, many farms do not offer this novelty experience of what is commonly referred to as “You-Pick”, but rather grow their apples for packing and processing. The attraction to “You-Pick” is mostly economical, it can make a farm more well known in the ecotourism industry, and farms are able to charge a flat fee to walk into the orchard, as well as a charge for the apples picked. So, the farm is making more money and expending less energy and resources to pick and transport the apples for sale. While tourists are visiting, there are commonly other attractions and things to buy from the farm (Megan VerHage, personal communication, 18 October, 2019). For example, VerHage’s Fruit and Cider Mill in Kalamazoo, Michigan, offers “You-Pick”, caramel apples and assorted candies, squash and pumpkins, fresh apple cider and fresh donuts, they also have a zip line that for a small fee you can ride over a section of the farm. Through all these activities the farm is bringing in a lot more income as compared to just selling the apples in a market.

Michigan apples are available almost all year long due to a technology called controlled atmosphere; a non-chemical storage process that slows down the maturing process in order to keep the apples fresh (MichiganApples.com; Accessed 28 October, 2019). Post harvest life of fruits can be extended by 50-100% when stored in a controlled atmosphere environment as compared to air at optimum temperature and humidity (Kader, 1994). The oxygen levels are lowered to only one or two percent, much less than the air we breathe which is around 21 percent. The temperature is kept consistent at 0 °C to 2.2 °C but exact conditions are set

according to the variety (MichiganApples.com; Accessed 28 October, 2019). There are monitors to keep the room conditions as consistent as possible, and apples that are visible from outside of the room in order to monitor the apples at all times. The purpose of the controlled atmosphere rooms is to keep the door shut and the room at perfect conditions, the ability to monitor remotely is important and the innovation of technology has greatly increased apple saving (Angela Sommers, personal communication, 15 October, 2019).

“An apple a day keeps the doctor away” is not only an old saying, but it holds some truth. Medical News Today actually ranked apples as number one in a list of the top ten healthy foods (Nordqvist, 2017). Fruit and vegetables have significant preventative effects for a variety of cancers and other health effects such as heart disease (Boyer et. al, 2004). Apples are a significant source of flavonoids, phenolics, and antioxidants these are the bioactive compounds that contribute to the health benefits of apples (Boyer et. al, 2004; Liu et. al, 2005). They are associated with decreased mortality; help prevent chronic disease and slow ageing (Boyer et. al, 2004). An interesting study by Liu et. al (2005) has shown that whole apple extracts prevent mammary cancer in rats, thus apple consumption may be an effective strategy for cancer prevention. Apples are major contributors to phytochemicals in human diets, and apple extracts exhibit strong antioxidants. The findings of Liu et. al (2005) also suggest that there are more health benefits from including whole food in a balanced diet compared to processed or dietary supplements.

On the topic of health benefits of apples Rupasinghe et. al (2013) found in the North American and European diet apples are one of the best sources of dietary polyphenols, which have demonstrated to have many biological effects in the prevention of various chronic diseases. However the peel is an important part of the apple because it contains three to six times more

flavonoids than the flesh; this means the peel contains a greater antioxidant activity. Therefore it is beneficial to consume whole-fruit and not processed concentrates, juices or extracts. In a hospital-based study, colorectal cancer risk was reduced by half when the patient consumed more than one apple a day (Rupasinghe et. al, 2013). Another with 10,054 participants found there was a significant inverse association of apple intake and lung cancer. The role of the apple in preventing cancer is due to the polyphenol components, which have been shown to prevent and reverse the carcinogenic process (Rupasinghe et. al, 2013). Apples contain many polyphenolics including flavonoids, phenolic acids and lignans, which modulate cellular mechanisms related to carcinogenesis (the initiation of cancer formation) (Rupasinghe et. al, 2013).

There is extensive literature on the health benefits of apples and their major source of fiber and good dietary phenolics with antioxidant function (Adyanthaya et. al, 2010). Not only are apples good for your health, but they are easily transportable, for a snack, lunch or travel. Apples can be kept at a variety of temperatures for a short period of time before consumption, which makes them the perfect fruit to grab-and-go.

Apples can only be grown in certain climates, which is a combination of cold winters, a moderate summer and medium to high humidity (harvesttotable.com; Accessed 5 January, 2020). Therefore for the entire country to be able to enjoy apples, larger producers in Washington, New York and Michigan must transport apples all over the country. Emissions from transportation mostly include CO₂ which is currently the largest greenhouse gas in abundance (82%) (EPA.gov; Accessed 28 October, 2019). Increasing concentration of greenhouse gases are bad for the environment and are causing a cascade of devastating effects. The Earth needs a greenhouse gas layer to remain habitable, however due to the industrialization revolution and human activities such as agriculture (Mitchell, 1989), the layer is rapidly becoming too concentrated. This is

causing more heat from the sun to be trapped within the Earth's atmosphere, and global temperatures to rise (environment.gov; Accessed 24, November 2019). Some gases are more effective per molecule at trapping thermal radiation than others, such as chlorofluorocarbons and methane when compared with carbon dioxide (Mitchell, 1989). The climactic result of an increase in the concentration of these gases is an increase in average global temperature. The rise in temperature is changing water vapor content, snow and ice melt, and cloud cover (Mitchell, 1989). The EPA report on greenhouse gas emissions in 2017 says that transportation is the largest emitter at 29% and agriculture contributes 9%. Within the U.S. most food is transported in bulk by trucks on the highway, therefore our diet can contribute significantly to our individual emissions.

Transportation and emission effects can make food that is nutritious, less nutritious due to physiological effects on the produce due to greenhouse gases. When farmers grow greater quantities of product, it does not always correlate with quality. Scientists have shown that plants change when they're grown at higher CO₂ levels (Evich, 2017). These plants are known as "C3", which includes around 95% of plant species on Earth. Elevated CO₂ drives down important minerals like calcium, potassium, iron, protein and zinc but they also pack in more carbohydrates because of the increased transformation of sunlight to food (Evich, 2017). This causes foods such as apples to be less dense in minerals and more rich in carbohydrates.

Produce is also highly sensitive to temperature. About 40% of vegetables never make it to the supermarket shelves due to damage during transit which can be damaged due to improper temperatures, bumping and bruising, and many more. (Vigneault et. al, 2009). There are compatibility standards set forth by the USDA that limits what kinds of fresh produce can be packed and transported together, due to the sensitive nature of produce. They include (1)

required commodity temperature, (2) required relative humidity, (3) emission of physiologically active gases such as ethylene, (4) odor-absorbing characteristics, and (5) modified atmosphere requirements (Risse, 1995). Apples are particularly sensitive to freezing, absorbing strong odors, and produce significant quantities of ethylene, which can bring about premature ripening of other produce such as carrots or lettuce (Risse, 1995).

The concept of “food miles” can help us quantify the impacts during food transportation. Food miles are a measure of how far food travels between the production and final sale stages (Weber, 2007). Although food can travel far during the post production to retail stage, data suggests that the greenhouse gas emissions are concentrated in the production phase, contributing 83% of the average U.S. household carbon footprint for food consumption (Weber, 2007). Weber (2007) also suggests that a shift in dietary habits can be more effective in lowering a household’s greenhouse gas footprint, than buying local with regard to transportation emissions. Engelhaupt (2008) has a parallel argument as well, and states that replacing red meat and dairy with chicken, fish, or eggs for one day per week reduces emissions equal to 760 miles per year of driving. Switching to vegetables instead of any animal product would be the same as driving 1160 miles per year (Engelhaupt, 2008). From the EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks in 2017, transportation was the biggest contributor, at 29%, of greenhouse gas emissions followed closely, at 28%, by electricity.

Research on “food-miles” often comes back to an on-going question of local vs. commercial, but there are so many aspects to take into account that a single definitive answer is not clear on which is better. Taking a closer look at the transportation aspect of local and commercial delivery methods Coley et. al (2008) found, when they compared the carbon emissions from a large-scale vegetable delivery system and a local farm shop system, that if a

consumer drives more than 6.7 km round-trip in order to get their vegetables their carbon missions are likely to be higher than the emissions from a large-scale system taking into account the cold storage, packing, transport to a regional hub and final transportation to the consumer (Coley et. al 2008). This is to say that large-scale can bring the emissions, per pound of apple for example, down so low because they have the processes and volume setup to be extremely efficient. However, this does not take into account packaging and the effects it has on the environment, where as local farm produce is typically not packaged.

Global food waste is a difficult number to quantify, but it is estimated that as much as half of all food grown is unusable due to damage, disease, etc. or it is wasted before it reaches the consumer (Parfitt et. al, 2010; Hooge et. al 2016). While this may be the high end of losses, it is a staggering figure, and some research indicates that household food waste is increasing over time (Hooge et. al, 2016). The increase has been found to begin at 33 kg per year to 52 kg per year from 2004 to 2010 (Porpino, 2016). Porpino (2016) cites the increase in household food waste as a result of the maturing baby boomer population. As their awareness of the value of food has diminished, due to a mentality switch after war time food scarcity to now easily available food, wastefulness patterns have emerged. Respondents from a survey conducted by Hooge et. al (2016) showed that consumer preference for food that is suboptimal played a large role in the food-waste issue. A majority of consumers were willing to purchase a product with suboptimal qualities when a discount was given. Hooge et. al (2016) also found that choosing a food product with deformities was perceived as a way to act environmentally sustainable. Hasselbach & Roosen (2015) found from a sample of 720 German consumers that preference for local or organic food was based on price, animal welfare and sensory appeal or how appetizing food looks. They found that consumers who prefer organic to local food put higher values on the

natural content and animal welfare first then sensory appeal and price second. Meaning those who purchase organic might compromise on looks for the environmental impacts of the food. To summarize, due to high grading standards of food in the U.S. there is a lot of food waste generated before it even reaches the customer; however, customers are willing to purchase food at a lower grade especially those whose intentions are eating more sustainably.

In developing countries, the infrastructure lends itself to poor harvesting/growing and processing techniques that generate food waste due to spoilage from a lack of modern transportation and storage technology (Parfitt et. al, 2010); (Venkat, 2011). These countries also look to the developed countries for symbols of prosperity. Therefore, if the U.S. and other developed countries act as leaders in animal-based protein consumption then developing diets and economies will hopefully follow suite (Beverland, 2014). As for developed countries, the biggest sources of household food waste are food being cooked, prepared or served in too large quantities, as well as, not being used in time. One example of this is food served in school cafeterias, a study found that only about 60% of food served at middle school lunches was consumed (Cohen et. al, 2013). As a result, students were consuming an inefficient amount of calories, fiber, and vitamins. There was also an economic impact for the student/students' family and school. On average, a student wasted \$0.26 a day or \$47.12 annually in food that the student purchased and disposed of as trash that could have been consumed (Cohen et. al, 2013). That may not seem like a lot over a year, but if a family has multiple children in school, even for just the three years of middle school it all adds up, especially for low-income families.

Wasting food does not only imply that the resources are wasted, it also indicates that all the emissions that were a result of the production and transportation of that food are now wasted as well (Scholz et. al, 2014). Globally about 1.3 billion tons of food is wasted yearly, with fruit

and vegetables contributing to 85% of the wasted mass and 46% of the total waste carbon footprint; where as meat contributes to 3.5% of the mass and 29% of the carbon footprint (Scholz et. al, 2014). There are greenhouse gas emissions directly related to the decomposition of food after disposal, but the impact is far more significant in the embedded emissions, which are production, processing, transport and retail (Venkat, 2011). The entire life cycle of food waste needs to be considered to assess emissions.

One way in which individuals can help reduce climate change effects and stop contributing to the oversaturation of greenhouse gases is through their dietary choices. A majority of food's climate impacts are due to other greenhouse gases such as methane (CH₄) (Weber, 2007). A clear trend, no matter how it is measured, suggests that red meat is the most intense emitter of greenhouse gases compared to all other forms of food (Weber, 2007). World Wildlife Fund and Greenpeace Program say that the biggest personal change a person can do to reduce their individual footprint is by reducing consumption of red meat (Beverland, 2014). Engelhaupt (2008) has a parallel argument as well, that replacing red meat and dairy with chicken, fish, or eggs for one day per week reduces emissions greatly and switching to vegetables instead of any animal product would make the impact even more significant (Engelhaupt, 2008). This can be used as an example, of being a conscious consumer and looking at how much of an impact food is, to the degradation of our environment. By making a choice, such as shifting one day per week's consumption of red meat and/or dairy to chicken, fish or a vegetarian diet, it would have the same environmental impact as total localization of food (Weber, 2007). For perspective, driving a 25mi/gal car approximately 12,000 mi/year produces around 4.4 t of CO₂/yr, by shifting totally away from red meat and dairy towards chicken, fish or

a plant based diet reduces greenhouse gas emissions equivalent to driving a car 8100 mi/year (Weber, 2007).

Food, especially fresh and nutritious food, is not always available. This epidemic is referred to as food security. Another common term associated is, food desert. Both labels are referring to cities or neighborhoods that do not have consistent and regular access to affordable fresh and nutritious food (Weatherspoon et.al 2012). The Community Food Security Coalition's definition of food security is that "all persons having access to culturally acceptable, nutritionally adequate food through local non-emergency sources at all times (Short, 2018). Sadler et. al. (2013) states that the design of the human-constructed built environment is a cause of inadequate access to nutritious food and exacerbates malnutrition. Food deserts cannot be mitigated by a single food, but by starting in food deserts with produce or products that are not highly sensitive and easily recognizable might sell better than something that expires quickly and is not common. Apples would be a good example, they have numerous health benefits, are easily transportable and do not expire very quickly.

Black neighborhoods have a disproportionate abundance of fast food locations in comparison to white neighborhoods (Kwate, 2007). In these neighborhoods food security, as well as, proper nutrition are major issues. To quote Kwate (2007), "it is easier to get fried chicken than a fresh apple", this is not only literally accurate but also metaphorically accurate. It is easier to find fast food in neighborhoods that are predominantly black and have low socioeconomic status than fresh produce. This is because there is not adequate access to supermarkets (Kwate, 2007). Fast food restaurants represent a low-price point for eating out, and therefore an association between prevalence of fast food restaurants and low income. This phenomenon has resulted in an association between poverty and obesity due to these low cost,

energy-dense foods. Fast food is notoriously low in many important nutrients but high in calories, fat and cholesterol (Kwate, 2007). Disadvantaged people are the target for these kinds of food and it becomes the only option accessible, then the added-on health effects and costs of health care pile even more on the backs of these people.

Lake et. al (2012) found that shifts in food prices often lead to less healthy food-choices. Healthy food is often more expensive than less healthy food; energy-dense foods with high-sugar and high-fat contents are also usually cheaper than their comparable substitute. Lake et. al (2012) also found that even though overall reductions in consumer spending were decreasing the major fast food companies were seeing an increase in profits. Therefore, climate change causing food prices to increase also has effects on the nutritional quality of dietary intakes of some groups of disadvantaged people. As a result of food insecurity, rising food prices and climate change there are major health effects occurring to the people affected by these issues. Physical inactivity and food consumption are two major factors in the development of obesity (Smoyer-Tomic et. al, 2008). The built environment and where a person lives plays a role in food choices and available food, and research has linked health consequences, such as higher obesity, overweight, and hypertension, to individuals living without a supermarket. Other research has shown a positive association between obesity rates and higher mortality rates, with density of restaurants which include fast food (Smoyer-Tomic et. al, 2008). These effects are disproportionately affecting the low socioeconomic status population and causing adverse health effects which exacerbates one of their issues even more, having no money for medical treatment. Which is why food security and nutritious diets are important to pay attention to.

Apples are a major crop of Michigan, and understanding the environmental impacts that the production, transportation and consumption of apples is important. It encompasses more than

just apples grown in Michigan, but rather apples sold to the general public in Michigan and specifically the City of Kalamazoo.

Methods

In order to understand the impacts that a local fresh produce product has on the environment I collected qualitative and quantitative data. To accomplish this I surveyed and interviewed multiple local businesses that sell apples. These local businesses include:

- VerHage's: a farm
- The Kalamazoo Farmers Market: local farmers market
- People's Food Co-op: a local year-around grocery store
- Aldi: a low price national chain store
- Harding's: a local chain grocery store
- Meijer: a regional chain grocery store

A representative of each type of business that sells apples was important because each type of business acquires apples and transports them in different ways. For businesses where I could speak directly to the farmer, VerHage's and the Farmers Market, I used the following interview questions:

- How do you harvest your apples?
 - Do you sort them after? How?
- How much do you get from a harvest? How many are disposed of?
 - Do you use culled apples for other things?
- What do you transport them in?
- Where are you transporting them? Why there?
- How many do you sell here?
- Is there anything you do to maintain your trees for the future?
- How much do you sell them for?

- Peck, half peck, bushel, half bushel? Per pound?

For businesses where I could not speak directly to the apple grower, such as Hardings, Aldi and Meijer, I used the following questions:

- How long are apples kept on the shelf or rotated?
- How often are new ones shipped in?
- Do you throw any away while stocking?
- Where do you throw bad apples away?
- What type of container do they come in?
- Where do the containers go after the produce is emptied?

I also looked at the apples sold in these grocery stores to find the name of the farm or where they were transported from. All apples, and most fresh produce for that matter, are labeled with a small sticker that contains the price look up (PLU) code, the origin of the produce item, and sometimes its quality such as organic or non-GMO (consumerreports.org; Accessed 14 November 2019). From the stickers, I was able to look at all the different varieties from a variety of locations offered in the stores.

At the interviews, I collected my data by writing down notes while the interviewees were speaking. I asked them the specific questions listed above, but also let them elaborate and add anything that they wanted to share. During the interviews, I took note of prices as well. To compare retailers, price by the pound was the simplest metric to find. In each location, I took note of the prices and names of all of the varieties that they offered. The variety is important because the price varies significantly between them.

To find the price per pound of different varieties I had to use different methods depending on how the retailer packed their apples. Some came by the pound, some in 3 lb. and 2 lb. bags and others in smaller paper bags.

Distance

I used Google maps to calculate the distance in kilometers between the apples point of origin, and the distribution center, and finally the market. The first distance I needed to find was from the farm to a packing facility. As a model I used the farms that Belle Harvest, who share a packing facility with Michigan Fresh, have listed on their website. I found the average distance of all the growers listed, then their distance to the Belle Harvest Facility in Comstock Park, MI. Then for each store that I interviewed, I found their Michigan distribution center and using google maps found the distance from Belle Harvest to their respective locations. Finally, I found the individual distance from the distribution centers to the respective store location on West Main St. in Kalamazoo, MI. Although these numbers are rough estimates, it still provides a general picture of where and how far the apples are moving. For the VerHage's example, I assumed the apples travel zero miles, since they were sold on site. For the People's Food Co-op, I found the name of the farm that they came from; they were shipped directly from the farm to the store.

I was able to find information online indicating how much a standard semi-truck emits per ton mile (Mathers, 2015). Then I was able to find the average weight of a box of apples, and calculated how many would fit on a standard thirty-five-foot refrigerated truck. Then used that weight to calculate the emissions per ton-mile.

- $8'' \times 12'' \times 20'' = 1.109 \text{ ft.}^3$ per bushel box
- 48 apples per box

- 35 ft. average semi = 3489 ft.³ per semi
- 3,146 bushels per 35 ft. semi-trailer
- 1 bushel = 48 lbs.
- Therefore 3,146 bushels = 151,011.7 lbs. = 75.5 tons

Note: I also took note of price and the supplier at Trader Joe's in Kalamazoo, however I did not speak to anyone about their apples.

Results

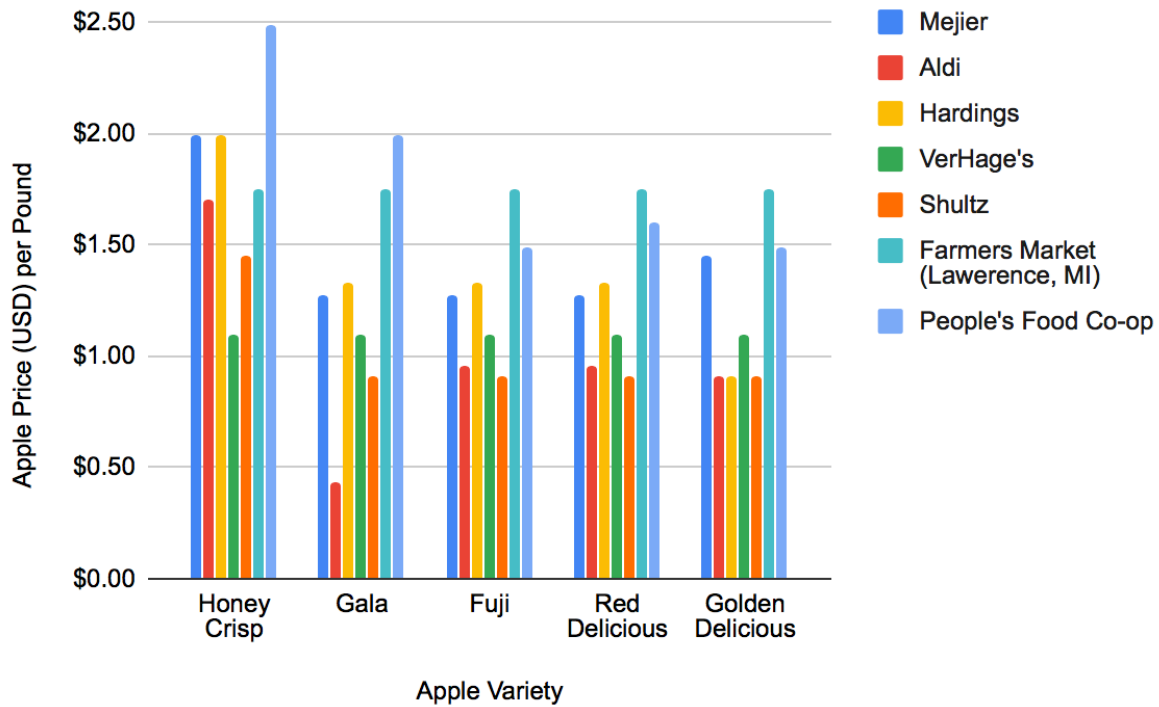


Figure 1. The price of apples per pound based on the retail location when visited*.

*Dates and specific locations referenced in appendix

| | Meijer | Aldi (MI apples) | Aldi (WA Apples) | Harding's | People's Food Co-op |
|---|--------------|------------------|------------------|------------|---------------------|
| Bell Harvest to Distribution Location (miles) | 72.80 | 97.10 | 2484.00 | 19.20 | 0 |
| Distribution to W. Main Location (miles) | 76.60 | 101.00 | 101.00 | 38.60 | 16.50 |
| Farm to Belle Harvest (miles) | 13.08 | 13.08 | 13.08 | 13.08 | 0 |
| Total Distance (miles) | 162.48 | 211.18 | 2598.08 | 70.88 | 16.5 |
| Tons of cargo (all apple) | 75.50 | 75.50 | 75.50 | 75.50 | 0 |
| CO ₂ Emissions per ton-mile(grams) | 1,984,839.43 | 2,579,753.76 | 31,737,885.47 | 865,862.99 | 2,669.7 |
| Metric Tons of CO ₂ | 1.98 | 2.58 | 31.74 | 0.87 | 0.0027 |

Figure 2. The distance of an apple tracked from harvest location to retail location, through distribution sites*, using google maps and the most efficient freeway route. Including the CO₂ emissions as a result, based on weight and distance.

*Apples from Washington in Aldi were estimated from the Missouri Aldi distribution location first.

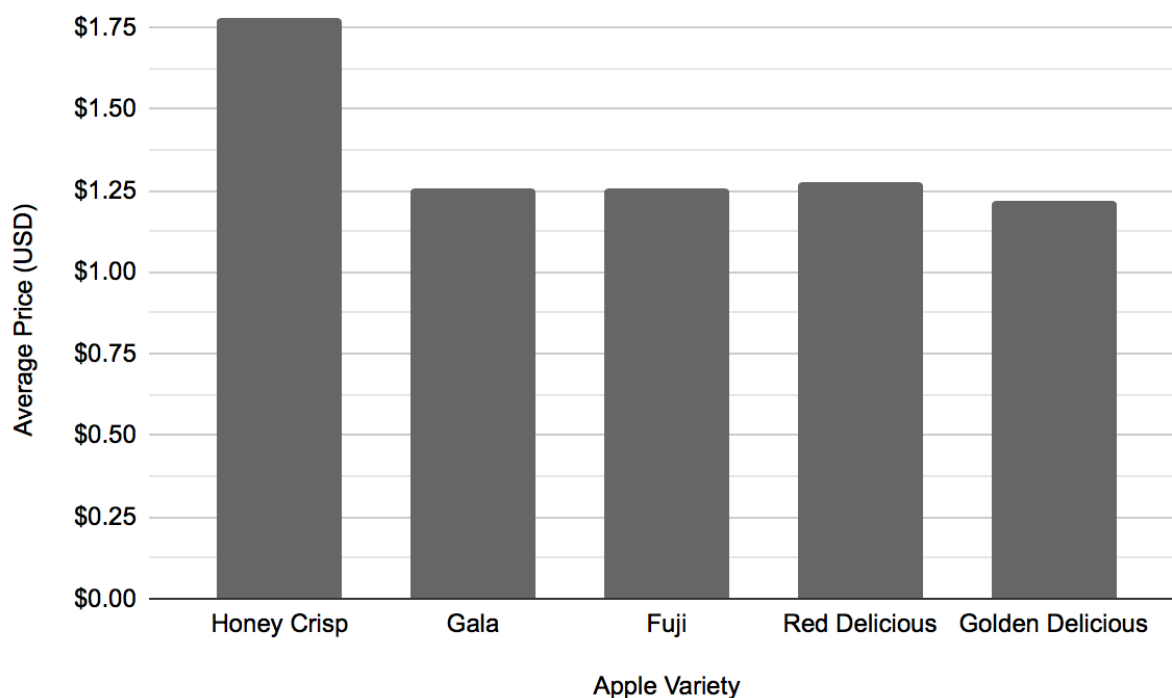


Figure 3. The average price of apples by variety based on data collected from various retail locations.

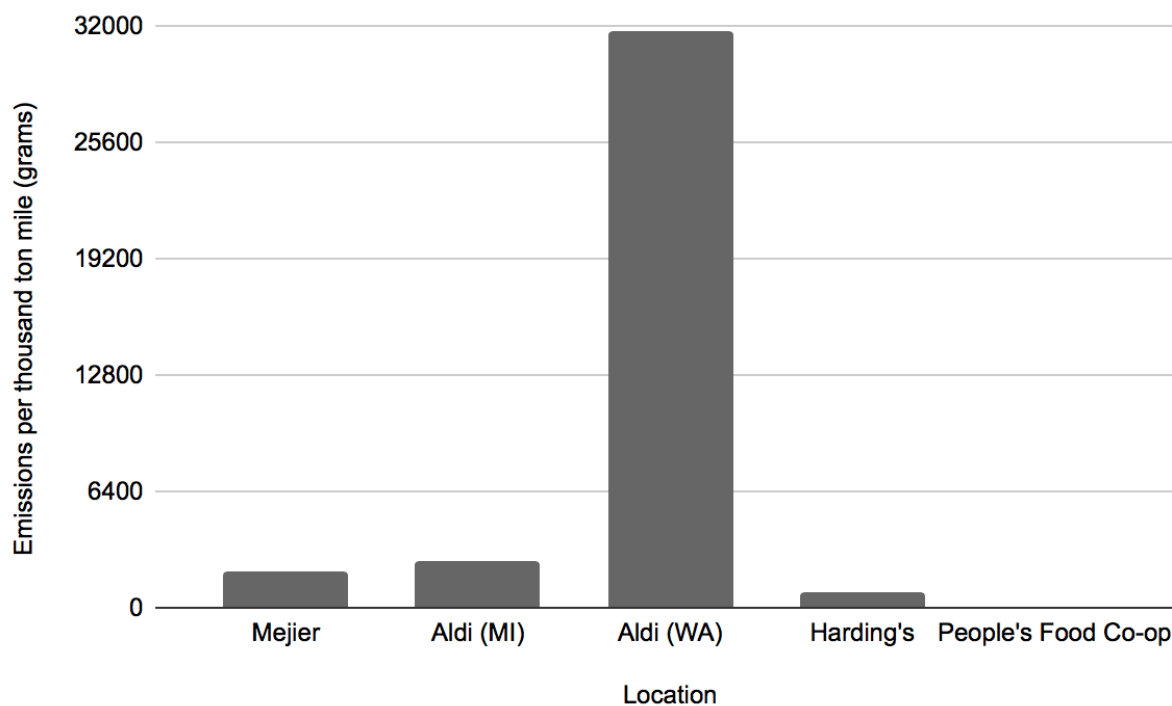


Figure 4. Carbon dioxide emissions as a result of apple transportation by location, represented in thousands of grams per ton mile.

My findings are based on the price of apples per pound and indicate the most expensive apple is Honey Crisp from the People's Food Co-op and the least expensive apple is Gala from Aldi. On average the Honey Crisp variety are most expensive followed by Red Delicious, Fuji, Gala, and Golden Delicious respectively. Since Honey Crisp on average are more expensive than other varieties, the best "deal" on them was at VerHage's Fruit and Cider Mill.

The results based on food-miles indicate that the greatest emitter of CO₂ due to transportation are the apple from Aldi, from both Washington first then Michigan. Followed by Meijer, Hardings, then the People's Food Co-op respectively. Aldi has such high numbers in the transportation because all of their apples go through a distribution center farther away then the others who also use distribution centers. The People's Food Co-op is able to keep their miles low due to the farm bringing their apples directly to the store.

The distribution center for Aldi stores in Kalamazoo, Michigan is a longer distance in comparison to the other stores I choose to examine, however Aldi also purchases a portion of their apples from Washington and because of this they are able to keep their prices at a nationwide minimum but it comes at a high cost to their carbon footprint. The metric tons of CO₂ emitted as a result of the transportation of apples from Washington to Michigan is more than ten times that of all other apples examined in this paper.

Discussion

In my study, Apples provide an example of how transportation vehicle emissions, and other aspects related to food justice can help the increase sustainability of fresh produce. The most startling topic measured in this research was transportation emissions. Emissions are the main degradation agent in the transportation phase of fresh produce (EPA.gov; Accessed 28 October, 2019) , therefore looking for emissions of apples, other fresh produce and food in general has led to the conclusion that there are many aspects of food that should be considered if an individual wishes to eat sustainably. A single person does not have to have a “perfect” lifestyle, and some foods have unavoidable impacts but then one might suggest to avoid those foods. However, going about life avoiding foods is no way to experience the wide variety of flavors available to us. But if food choices were more commonly associated with environmental impacts then climate issues could possibly be mitigated.

With regards to emissions, there is an ongoing debate about how much of an impact buying local truly has. The definition of local is not set in stone, especially with regards to food. How close is “local” referring to? In a survey by Leopold Institute they found that 66% of consumers assumed local food to be grown within 100-miles (DeWeerd, 2009). The 100- mile diet started and spread in popularity after James MacKinnon and Alisa Smith decided to eat food produced within 100 miles of their home (Cosier, 2007). Others have tried similar mileage restrictions in attempt to eat locally and be more conscientious consumers. The biggest difficulty in this type of diet seems to be finding staples, even at local organic stores or Whole Foods (Cosier, 2007). Cosier does not follow the diet anymore, but says she took a lot away from the experience and still incorporates the foods she found during her research, in her diet today.

Eating local does not have to be strict, but if everyone makes a small effort we can make a big impact together.

Pirog, a leading research scientist and associate director of the Leopold Center for Sustainable Agriculture at Iowa State University in the field, warns “Food miles are a good indicator of how far food has traveled. But they’re not a very good measure of the food’s environmental impact.” Transportation emission may, in some situations, be overshadowed by higher energy needs for crop production (Pirog, 2001). Which is why it purchasing locally in-season products yield the least emissions. It is possible to grow many things locally that would not normally survive in this climate, but they require greenhouses or other facilities that are energy intensive to achieve the climate they need in order to grow. For example, when tomatoes grown in Denmark, the Netherlands, and Sweden were compared based on carbon dioxide equivalents per kilogram and consumed in Sweden, Spanish tomatoes were shown to have lower CO₂ equivalents than those produced in Denmark, the Netherlands, and Sweden (Pirog, 2001). This is due to the fact that the climate in Spain was suitable to grow the tomatoes in open-ground whereas in the other countries listed the tomatoes were raised in heated greenhouses. Therefore, eating local is not always the answer to lower emissions, in-season and native to the climate are very important aspects as well.

In addition, from the same study by Pirog et. al (2001), they found that produce in the conventional system traveled an average of 2,443 kilometers whereas locally sourced food traveled an average of 71.7 kilometers to markets in Iowa. Possibly a counter argument to the previously stated findings that local may not always be better. The important aspect to look at is where the food is coming from and if it was in season in that location.

Another counter argument to buying local can be assessed by examining division of labor or comparative advantage. In other words, some countries or places are more efficient at producing certain things than others; this is the reason we trade. When a good or service can be produced for cheaper in another place, then we are most likely to trade rather than producing it ourselves such as Aldi purchasing apples from Washington to sell for cheaper. However, it is not just an economic issue, there are many externalities involved (Lilico, 2008). There are environmental impacts, such as transportation emissions or shore erosion from ships, chemicals used for production or exotic/invasive species, that are not taken into account of the cheaper price of an item that is produced in an efficient facility (Lilico, 2008).

The concept of fair trade has been growing in recognition in the last decade with an increase in food scares or sudden disruption in food consumption habits or the food supply chain, environmental awareness, and interest in healthy sustainable food (Bacon, 2010). To quote Bacon (2010) “Fair Trade is a trading partnership, based on dialogue, transparency and respect which seeks greater equity in international trade, and contribute to sustainable development.” Although Fair Trade does not directly look at environmental impacts there are standards abided by such as restricted use of agrichemicals, water conservation buffer zones around water bodies, and no GMO’s, these can be beneficial for the environment as well as the producers. Fair Trade also has social standards that prioritises smallholder producer cooperatives, child labour restrictions, minimum labor standards, right to collective bargaining and others (Bacon, 2010). With these standards consumers can make conscious decisions that the food or products they are buying were produced and sold fairly.

Referenceable and perspective are important figures that consumers can take into account when making diet and food choices. The amount of resources, or how far food travels, or

nutritional aspects are all important factors. In particular it has been found that on average it takes one liter of irrigation water to grow one calorie of food (Foley, 2011). To go along with that, it takes roughly 9463.5 liters of water to produce one pound of beef from cattle (Cowspiracy.com; Accessed 19 November, 2019), and 66.2 liters to produce one pound of apples (abcwua.org; Accessed 19 November, 2019). These numbers are greatly different but while shopping at the grocery store, it may never cross the consumer's mind. Resources used are important figures to be aware of, even in rough estimates, and so are emission impacts. One pound of apples (roughly three apples) produces 240 grams of CO₂ emissions (terrapass.com; Accessed 20 November 2019), compared to one pound of beef which produces four pounds of greenhouse gas emissions, or roughly 1814 grams (businessinsider.com; Accessed 20 November 2019). There are 240 grams of emissions associated with three apples, so roughly 22.7 apples is equal to 1814 grams of CO₂ emissions (the same as one pound of beef). The average passenger vehicle in the U.S. emits 4.6 metric tons of CO₂ per year (epa.gov; Accessed 19 November, 2019) and on average one acre of new forest can sequester about 2.5 tons of carbon annually (urbanforestrynetwork.org; Accessed 19 November, 2019). One acre of forest could sequester roughly 9,450 apples worth of emissions, but thankfully apple trees do some of their own dirty work and sequester carbon in their woody tissues. But the purpose of these statistics is to illustrate just how big of a conundrum we face in regards to emissions and how much food choice can make an impact.

Other considerations to take into account when assessing the impact of a food to the environment are required refrigeration, materials used for production and a big source of carbon emissions are fertilizers and pesticides used on the farm. Every aspect of a food should be considered when assessing the sustainability or effect on the environment of that food.

When comparing commercially produced foods to locally grown there are some major differences. Currently roughly 35% of the world's crops are used for animal feed, and it takes 30 kilograms of grain to make one kilogram of edible boneless beef (Foley, 2011). By reducing meat consumption, space for agriculture would also decrease as well as more food going towards humans. Globally, humans could gain up to three quadrillion additional calories each year by switching to all-plant diets (Foley, 2011). Food dispersal is related issue, which also ties into food deserts, however an increased food supply could be a step in the right direction towards feeding the growing population.

There are many techniques for increasing crop yield and conserving the soil and land, such as planting in strips. A study was done in Minnesota that showed by combining maize and alfalfa crops by planting one strip of maize followed by three strips the same size of alfalfa, there was no need for fertilizer or herbicide and a dramatic reduction in soil erosion. In the end since the maize strips were narrow they could be planted at twice the normal plant population without being light limited, and the field yielded almost double a typical just maize field (Granstein & Kupferman, 2008). If these techniques were applied to apples, and other fruits and vegetables for that matter, then perhaps we would have a great reduction in food waste at the source.

Another farming technique to increase crop yield is high density planting. Mario Sazo, a fruit Extension specialist with Cornell Cooperative Extension, says that the best growing system for apples is tall spindle like trees with modifications of create a narrower canopy. The results would yield lower labor costs, improve fruit quality and boost pruning and harvest efficiency (Fruitgrowersnews.com; Accessed 12 January 2020). There is research of optimum planting densities and new technology such as over-the-row equipment for spraying, pruning, and harvesting that will allow for trees to be planted closer together. Due to how rapid apple trees can

grow, apple orchards could reach full potential yield in as little as 3-5 years (Fruitgrowersnews.com; Accessed 12 January 2020). Some of the new technology being developed will be solar powered and operated remotely through GPS. With great leaps in our agricultural techniques commercial farming could look a lot different in the future.

Small farms can be more productive and resource-efficient than large-scale monocultures (Altieri, 2008). The contribution of small farms to food security is crucial, especially in rural places. There can be stigma that small farms can be unproductive however, it has been shown that small farms are more productive in regards to total output rather than yield from a single crop (Altieri, 2009). Small farms provide locally sourced food, but also food in a rural area where it might not be easily accessible otherwise.

There are community benefits to buying from a local farmer, for example the money is put back into the local community. A study conducted on 28 fruits and vegetables grown in a group of six U.S. states, with Iowa as the center, based on consumption for these fruits and vegetables if an extra 10% of the produce items were grown and sold in Iowa, it would result in \$54.3 million dollars in sales going towards Iowa farmers (Pirog, 2001).

Food waste is a major issue and poses threats to the environment due to greenhouse gas emissions and wasted resources used in production, processing and transportation (Farr-Wharton et. al 2014). Food waste happens along the food supply chain with the most significant portion of food waste coming from domestic settings. However, domestic food waste is hard to control, it has to be reduced by behavior changes and raising food waste awareness (Farr-Wharton et. al, 2014). Changing consumers habits and behaviors are not easy, consumers are encouraged to purchase food excessively due to exposure of marketing, and processed food is a cheap commodity so consumers stockpile. But the majority of food waste in the household was found

to be comprised of expired or forgotten in storage food (Farr-Wharton et. al 2014). When an individual has food in question, it has been found that a majority of people do not know how to judge whether food is edible or spoiled and therefore discard food they are unsure of (Farr-Wharton et. al 2014). Changing an individual's food practices is multifaceted because food behaviors are influenced by many things such as social norms, attitudes, knowledge, and many others. Everyday consumption practices are motivated by many factors such as convenience, diet, perceived value for money, and social responsibility (Farr-Wharton et. al, 2014).

Research has suggested that food waste now accounts for more than a quarter of the total freshwater consumption (Hall et. al, 2009). In the United States by addressing the oversupply of food, it may help reduce food waste but also the obesity epidemic because there will be less superfluous choices clutters consumer's brains. It may also discourage consumers to purchase less thus hopefully consuming more of what is purchased instead of it going to waste.

Food recovery could be the answer to the food waste conundrum. There are food products that are still just as nutritious, but are not attractive, for the consumer and these get disposed of (Giuseppe et. al, 2014). There are people who have problems fulfilling nutritional needs, and this is where food recovery comes in and mitigates some of the losses. In a world with complete equality some people would not need to eat the leftover or unattractive food, whereas others are determining what is not pretty enough for them to eat. Alas that is not the world that exists today, food recovery enables economic benefits for donors and is seen as a way to manage food that would otherwise be unsaleable and this discarded into a landfill. Food recovery is not always practiced though, due to benefits that are not yet known (Giuseppe et. al, 2014). There are some risks involved and precautions needed for food recovery, such as sanitation and viability of a product after is expiration date. But the effectiveness of policies depends on evidence of

economic benefits (Giuseppe et. al, 2014). A local example in Kalamazoo, Michigan would be the efforts put in by students at Kalamazoo College who volunteer their time for a club entitled “Food Recovery Network”. These students gather and package the leftover food from the cafeteria and then bring it to the local food bank.

However, we would be able to counter the need food recovery systems, if food supply chains were improved then there would be less food going to waste. When supply chains become one hundred percent efficient then there will be no more need for food recovery, however the likelihood of that happening is very small, especially in the next few decades. Therefore, food recovery is important not only to food waste and environmental impacts but also for food scarcity and malnutrition.

Food choice and consumer preference plays a major role in what people buy but also how companies market to individuals. A study by Vermeir and Verbeke (2006) investigated the gap between values and positive attitudes towards sustainable habits and behavioral intention to purchase sustainable products. They found that low perceived availability of sustainable products was the explanation for low intentions to purchase. Sustainable products are those that contribute through their attributes to either economic, social, or environmental goals of sustainable development (Vermeir & Verbeke, 2006). They also noted that consumers with high involvement in sustainable food consumption, are more willing to purchase sustainable products, where as the general public believes that sustainable products are hard to find and their perspective will not be easy to shift (Vermeir & Verbeke, 2006).

A term that businesses use to connect the product to a particular cause in the hopes that the consumer with values associated with that cause will be more likely to purchase the product is called “cause-marketing” (Pirog, 2001). A marketing report indicated that 76% of consumers

would switch to a brand that supports a cause they value (Pirog, 2001). This influential type of marketing may be why people are more willing to purchase higher priced apples from a farm as compared to the low price and closer location of Aldi.

Sage Van Wing, an Oregon-local food advocate, who speaks about food choices and her journey on the radio, said that when she purchases an apple is it not just about the emissions, it is also about how the apples were farmed, how the worker conditions, and other ecological, economic and social factors with a focus on sustainability. She strives for directly interacting with the farmer that grows the food she is going to eat, she says it creates a standard of trust (DeWeerd, 2009).

These ideas and marketing strategies can be used to promote, with the intended audience of the broader public, and lower perceived barriers of sustainable consumption. Emphasizing personal relevance and importance at an individual level, as well as increasing knowledge about product availability will aid in increasing the social stigma of being a sustainable consumer (Vermeir & Verbeke, 2006).

With regard to apples, “choice” is a big question. There are new varieties every year, with different characteristics, and ultimately it comes down to personal choice but there are some characteristics that keep consumers coming back to the same variety. These are called experience characteristics, which are sweetness, tartness, crispness, and juiciness and these drive demand for particular varieties (Yue & Tong, 2011). The objective of a study by Yue & Tong (2001) was to determine if consumers were willing to pay more for Honey Crisp, Sweet Tango, and Zestar compared to other varieties. (For reference, Honey Crisp and Zestar are the parent varieties to Sweet Tango.) They found that consumers were more willing to pay a higher price for a new variety than a more established one because the newer varieties of apples had more of

the desired attributes. Sweet Tango were perceived as improved from both of its parents (Honey Crisp and Zestar), participants responded that the tartness and sweetness was better in Sweet Tango than Honey Crisp, and the crispness and firmness was better in Sweet Tango than Zestar (Yue & Tong, 2011). In almost all of the varieties studied Sweet Tango were consistently ranked the best in all quality attribute categories. Consumers are willing to pay for an apple that has all of the attributes that they want, and especially if the variety is consistent, then the consumer knows exactly what to expect and will repurchase.

Agriculture is the single largest source of greenhouse gas emissions from society (Foley, 2011); one of our main agents of climate change. By slowing and hopefully eventually stopping the expansion of agriculture, it would dramatically decrease environmental damage. These greenhouse gases that are emitted from agriculture are turning back around to hurt production even more, it is a positive feedback loop. Luck et. al (2011) states that under elevated CO₂ levels there is increased photosynthetic rate, and an increase in plant biomass, which could lead to new growths earlier in the season for pathogens to colonize. They also found that the major factors likely to influence plant disease and spread due to climate change are increased CO₂ levels, heavy rains, increased humidity, drought, hurricanes, and warmer winter temperatures.

An example of a major event likely due to climate change was the “Polar Vortex” that hit Kalamazoo, Michigan in February 2019. There were extreme cold temperatures as well as precipitation. As a result VerHage’s Fruit and Cider mill lost a great deal of their apples, across all varieties. Due to this event they sold out of apples about half-way through their busiest season, the weather event not only hurt the apples but also the economic side of their small farm (Megan VerHage, personal communication, 18 October, 2019).

Although extreme weather events can be catastrophic to small farms, they can provide some valuable effects to the environment. Small organic farms can actually have the opposite effect that industrial agriculture has on climate change. Where large scale farms contribute to greenhouse gas emissions significantly, biodiverse small farms can increase the sequestration of carbon(Altieri, 2008). Small organic farmers usually treat their soil with compost which sequester carbon better than soils treated with conventional fertilizers. Research conducted in Malaysia has suggested that the conversion of 10,000 small-to-medium farms converting to solely organic production would be equivalent to taking 1,170,000 cars off the road (Altieri, 2008).

Limitations to this research have been the collection of data for apple transportation, the weight of a produce truck, the price of apples (changes daily), and the research of only one food due to time constraints. If more time was allocated some of these limitations could have adjusted. With regard to the collection of data for apple transportation, rough estimates were able to be calculated to the best of my knowledge on the topics of distribution centers and farm location. Especially the distance that apples from Washington travel to Michigan, then to the Kalamazoo Aldi location. As for the weight of a produce truck, in order to keep the data on topic and simple I was able to calculate the weight of an average size produce truck with apples packed in wholesale cardboard boxes. First I found the size of the boxes, then how many apples on average fit in each, then the average weight of an apple.

As for the price of apples, they fluctuate daily in some locations. In order to keep things more simple, the day I visited each location is the price of the apple that I used for my research as if I was a regular consumer walking into the store on any given day to do some shopping.

Finally, due to the time constraints and the broadness that this topic could entail, I narrowed my research to use apples as a lens in which to study fresh produce and food more broadly.

CONCLUSION

Apples are a very commonly eaten food all over the U.S., they pack a lot of nutritional value, can help bridge the gap between fresh and processed foods, and are able to be easily stored and transported aiding in the accessibility of the fruit. Emissions during the transportation phase of a food are a major factor in the environmental impacts of our diets. But aside from the impacts, we cannot lose sight of the fact that everyone deserves to have fresh food and access to healthy choices.

In review, when choosing an apple, any fresh produce or food in general, it is important to determine where it came from, or ask yourself if it is in season in your region. Food choice and daily habits can have big impacts an individual's contributions towards greenhouse gas emissions. Everyone can do their part to help lower their contributions, and develop more sustainable habits. Sustainable agriculture should be a goal rather than a set of strict guidelines or practices. Having a goal can help us enhance biodiversity, cycle/recycle nutrients and waste, and increase reliance on renewable production inputs. We should be striving to use nature as a model for the ways in which we produce products for our survival (Granstein & Kupferman, 2008).

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Appendix

Belle Harvest and Michigan Fresh

On 15 October, 2019, I visited Belle Harvest, an apple packing facility located in Comstock Park, Michigan. Belle Harvest has recently joined another apple packing company under the name of Michigan Fresh. Their shared facility can now better serve the community as well as the consumers that Michigan Fresh provides for. On my visit, there were many aspects of the apple packing process that I saw as well as got to learn about from Angela Sommers, the director of marketing for Belle Harvest.

Upon arrival, I sat down and talked with Angela about the history of apple production, her own background growing up as the daughter of an apple farmer. Also, what goes on in the packing facilities and the transportation of apples. Belle Harvest has a few locations that pack, ship and store apples. One in Comstock Park that I visited, a second in Belding that deals with a very high volume of product and a third in Wisconsin. A benefit to having multiple locations is that they can collect the apples as well as ship them from closer distances as compared to one large facility. Belle Harvest facilitates around 50 growers, and combined with Michigan Fresh, many more.

Growers from Michigan, as well as surrounding states have the choice of where they bring their apples. There are many factors that can influence their choices of packers. There are fees, rates, and regulations from each packing facility that the grower must decide upon. Once the grower's apples are packed, they get a report card. This report card tells the grower how good their apples were, how many were good quality and size to pack and how many went to processing. The average grower usually sees about a 70% pack on their apples, and it can be as

high as 90%. This tells the farmer how well they are growing their apples, and that 70% of what they sent it can be used for eating apples and the remaining 30% is sent for processing.

In the facility, there are many different stages that an apple can go through. First the apples are brought to the facility in large plastic or wooden crates, they hold a thousand pounds, then they are sorted. This process is done by a water system, the apples are carefully dumped in. They float past workers who manually scan the apples for disease and rot. Then they move on to where they are scanned by a machine that looks at the size of the apple and can also detect physiological disorders. Next the machine sorts the apples by size, and they are dropped off in their respective lanes. Then the apples are dried, they get a coat of food grade wax and then are either packed for sale, or put back in large bins for storage.

When the apples are packed for sale, there are many different styles this can happen in. What determines how they get packed is usually based upon the customer who is buying the apples. Whether it be Walmart or Aldi, or a local school district. Some want them in cardboard boxes that they can use for display, some in individual layers, and others in bags. The apples are also darned with a sticker that has a barcode and label for type of apple and an identifier.

For food safety reasons and traceability, every apple that is packed through the facility can be traced back to not only the farm that it can from but the row in the farm where the apple grew. This is important for identifying pests and disease that can come from the apples. There are very strict guidelines that growers must follow to be able to have their apples packed and sold to large grocery stores and the general public. There are very tight restrictions and pest management and chemical use as well as condition of the plants.

Apples that are packaged for storing are usually done in the same large container that they came in on. They are stacked from wall to wall and ceiling to ceiling, then the controlled

atmosphere room is sealed. The oxygen as well as other things are then extracted from the room to slow the maturity process. The apples are monitored through a small window for freshness and can be kept in this room for many months. This is how we are able to have fresh Michigan apples year around. The packing a sorting is done before the apples are stored so that the quantity, quality and varieties are known to the distributors.

The company could be referred to as a middle man. But they are able to take the apples from many small and local growers and buy their entire crop from them, and then help them get the supplies to the people who want it. They are centralizing the packing as well as distribution of apples, which can help to reach more people as well as keep the costs down.

VerHage's Fruit and Cider Mill

On 18 October, 2019 I visited VerHage's Fruit and Cider Mill in Kalamazoo, MI. I asked them the set of questions that I had thought about previously. At VerHage's they grow all their own fruit. They have about 13 varieties of apples and they do not change variety very frequently. The last major change they made was for the Honey Crisp. They handpick all of their apples, but do use heavy equipment such as tractors for transportation.

All of the apples come in for either cider, or for sale. When they come for cider they are washed and sorted then they are pressed on a machine to make the cider. Their cider is made from a variety of apples. When they are processed for packaging they are graded, with a small machine or by hand. In the past they sold the apples that had fallen to the ground for deer baiting, however there is less demand for deer bate now, so they have recently stopped selling those.

They typically sell out of apples in a season. VerHage's is part of the agro-tourism business. Their farm usually offers, You-Pick for a fee of \$5 plus the quantity of apples that you would like to pick. They also sell cider, caramel apples, fresh donuts, pumpkins and gourds, and

other candies. They also offer a zip line over the field as well as a small barn of farm animals to see. Going to VerHage's is an experience for all ages of people. Going to the apple orchard/pumpkin patch is a traditional activity in Michigan culture. I personally grew up going at least once a year, then making our favorite treats with the baking apple varieties.

The prices at VerHage's are pretty standard in comparison to similar sellers in Michigan. In order to maintain their trees for the future, they fertilize as well trim, and spray for pests. All to insure the best quality apples as well as many as they can grow. This day that I visited, they were sold out of apples. Mid-October is early for them to typically sell-out. However, in 2019 there was an extreme weather event over the Winter, commonly referred to as "The Polar Vortex", as well as a problem with pollinators, like bees, in the spring. Both of these factors lead to a drastic loss of crop for VerHage's. In order to keep their other attractions and bring in customers for the rest of the fall season. They are now purchasing apples from other farms close by, to ensure that they can keep making cider. It is very disheartening to hear about the lost crop, but it is also causing a loss of profits during their peak season.

Meijer

On my visit to Meijer on 28 October, 2019, a large commercial grocery store, I spoke to a produce manager. From the set list of questions that I developed to ask grocery store's I learned that first, apples at Meijer are rotated and sell out every few days. Meijer is constantly restocking their shelves. They receive produce every day from a Meijer distribution center. These deliveries are based on the inventory they already have and the trend of how fast the product has been selling. They do not want to over or understock. If they over stock they are left with lots of apples, for example, that they are not making a profit on and are going to waste since their shelf

life is relatively short. Where as if they understock, they are losing out on profits that they would have otherwise had.

The rotten or leftover apples are donated to local farms for animal feed. The cardboard that is used for transportation is recycled and taken to a paper mill. While I was at the store I took note of the prices as well as variety of apples and their surroundings to observe their marketing tactics. The first thing I noticed is that the apples are on the shelves right when you walk in the door. There are large, bright yellow sale signs on most of the varieties, and they are neatly arranged in divided cardboard separators. Both of these factors make the apples look more desirable to purchase. One of the questions I asked was, how do they determine sales. The response that I got was they base their prices on when competitors have sales as well as in season produce, they put on sale to encourage people to purchase. Another marketing strategy is that next to the apples they had a shelf with other products that go along with apples. Such as, kits with sticks and caramel, caramel and other flavor dip and some baking necessities. This convenience might convince more people to buy more apples because they can make something with them as opposed to just snacking on one plain.

Aldi

Visiting Aldi, there was no produce manager that I could talk to directly. However the information that I did find out, from an employee was that they restock frequently, and always aim to keep the shelves full. From research online I found that they receive their product from a distribution center. They also only sell apples that are prepacked in either 2 lb. or 3 lb. bags. This is for convenience of shipping, stocking and purchasing. This was not surprising to me, because of Aldi's efforts to be as quick as possible.

Another thing that I noticed was that some of their apples are from Michigan and some are from Washington. My logical guess is that they purchase the cheaper option, too keep prices low. Aldi did not have as many varieties as some other grocery stores that I visited, and I would think this is because they only sell them in bulk. People are more likely to buy apples they have already had in bulk, than ones they have not because they don't know what they taste like.

Harding's

I did not speak to anyone on my visit, instead I walked around the produce section and observed the variety of apples that were offered as well as their placement. What I saw was that they offered a few varieties but in different packaging. For example, there were Honey Crisp and Gala for individual sale but no other varieties. There were 3 lb. bags of Fuji, Golden Delicious and Gala. Finally, there were bulk bags sold by the pound of Gala and Fuji as well.

All of the apples were located in the same general area of the store, but there were some that were on the backside of a display and away from the first display that catches your eye. I almost missed them in my observation, and it made me wonder why they put them where they are hard to find. I would think that it might hurt sales, however they were only the 3 lb. bags of the gala and Fuji, which are a very common variety to buy.

Farmer's Market

I visited the Kalamazoo Farmers Market located on Banks Street in Kalamazoo, Michigan, U.S. on 9 November 2019. The market is open multiple times a week from spring until late fall, however Saturday mornings draw the most sellers as well as consumers. On the crisp morning I was there, the apples were plenty in stock. I saw Honey Crisp, Fuji, Golden Delicious, and Johnagold at Deleo's Farm table. They were selling theirs in woden produce containers that are used commonly around the market. Around 5-6 apples fit in a container and

they were selling them for \$5 a piece. A few more tables had a few varieties of apples, the most common were Honey Crisp, Johnagold, Fuji and Gala.

By far the biggest seller was the farmers from Lawrence, Michigan. Stacked behind their table were dozens and dozens of wooden crates filled with apples. They offered 14 varieties including Honey Crisp, Gala, Cortland, Jonathan, and Ida Red to name a few. They were selling them for \$4 a container (about 5-6 apples) or 2 for \$7. So not only did they have the most variety, they were also cheaper than some others around the market.

People's Food Co-op

I visited the People's Food Co-op on Harrison Street in Kalamazoo, Michigan, U.S. on 12 November 2019. When you step over the threshold the apples are presented at chest level in many types of packing styles. There were some apples for sale individually, some in small plastic bags and some larger plastic bags. Upfront there were a few varieties, then a few steps further back in the cold cases were the rest of the varieties. I was surprised to see HoneyCrisp not included in the front display. Most of the apples came from Shultz farm in Mattawan, Michigan however the Granny Smith, which are not grown in Michigan, were from Chile and the Gala were from Watervliet, Michigan.

The price seemed to be high compared to other retail stores, but close to the prices of the farmers' market. I would conjecture this is due to the local farm being a direct seller at the market and the Co-op acting as a middle man.

Appendix (2)

Byers, Michael. (28, October, 2019). Personal Interview.

Sommers, Angela. (15 October, 2019). Personal Interview.

VerHage, Megan. (19 October, 2019). Personal Interview.