ABSTRACT

Through the Lens: A Documentary Photography Project on Sustainable Agriculture in Central Texas

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Sustainability is one of the most pressing global issues that spans disciplines. How can we achieve a level of sustainability in which we no longer harm the planet, and can reverse the damage we have already done? Promoting sustainable agriculture is one central way we must combat global environmental, social and economic issues. Yet, most people are unaware of the mechanisms and processes by which their food is produced. How can we get people to engage in supporting sustainable agriculture if they do not have any sort of knowledge on what it pertains to? As our culture embraces the use of visual images to share information, I believe that photography can be one of the most effective ways to engage people with sustainable agriculture. In this project, I aim to let my photography of several farms around Central Texas to be a voice for sustainable agriculture, showing various processes food production must move toward if we are to become a truly sustainable society.

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THROUGH THE LENS: A DOCUMENTARY PHOTOGRAPHY PROJECT ON SUSTAINABLE AGRICULTURE IN CENTRAL TEXAS

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INTRODUCTION: A REFLECTION

Finding ways to incorporate different disciplines into one, cohesive educational experience has been at the core of my years as an undergraduate. I find purpose and meaning in a wide range of subjects, and I never want the passion I have for one area to compromise my passion that lies in other fields. As both a creative and a scientist-in-training, I believe it is my calling to find imaginative ways to bridge the gap between science, art and storytelling. For my thesis, I undertook a project that I felt could be multidimensional and multidisciplinary. I wanted to take a universally important issue and display information about it in an informative, but creatively engaging way. Using my knowledge as an ecology major and skills as photojournalism minor, I aimed to synthesize a story about sustainable agriculture in Central Texas: a visual story that could not only be aesthetically engaging, but that could also be benefited by discussion of ecological and environmental issues.

A large part of this project was finding my voice to tell this story; a voice that lets the images speak for themselves but is informative where the photographs fall short. I learned a great deal from looking at the work and writing of documentary photographers such as Sebastião Salgado, Donna Ferrato and Antonin Kratochvil, as well as work by scientist-turned-photographers Paul Nicklen and Cristina Mittermeier and the agricultural work of George Steinmetz. These incredible photographers served as inspiration for my own work. One of the most impactful pieces I read while researching successful documentary photographers before embarking on my photographic journey was a piece by Salgado. Salgado emphasized documentary photography's role as a vector linking together multiple parts of life. His words capture the essence of this thesis project beautifully: "You see the whole thing. You see yourself acting, photographing to show something to the other side, to people who did not have the opportunity to be there. And you have the idea of the link between these things. And as a vector it links points of the various concepts of "normal" life" (Light). It is my hope that this project can be a vector for linking people with where their food is produced, allowing those who are willing to bear witness to the beginnings of a sustainable revolution the opportunity to become part of solution to widespread environmental, social and economic issues. As Salgado says, "when you show them, when you discuss the situation with them, they become integrated with the problem, and the problem becomes part of their life" (Light). This is a thesis designed to inspire change, to inspire individuals to pursue a sustainable future starting with the food on their plates.

I would like to thank everyone who has helped me on this thesis journey, especially my advisor, Dr. Clark Baker. I also send special thanks to Johnson's Backyard Garden, World Hunger Relief Farm, Urban REAP and Urban Produce for allowing me to come out and photograph the farms. This project would not have been possible without their willingness to aid me during this project.

CHAPTER ONE

Documentary Photography: Visual Truth

Human beings are visual creatures. The majority of human society experiences the world through images, whether that be primary experience through the naked eye or secondary experience through images created either on film or digitally. Due to the expanding digital age, the secondary method of experience continues to grow in prominence. Photographs are pervasive in print publications, on the internet and on social media networks (Caple). Everywhere people turn, they are met by an environment saturated with images: advertisements on billboards and products, Instagram newsfeeds, Pinterest boards, news articles, and even through motion pictures and television. In all photographic outlets, images aim to satisfy aesthetic desires while acting as informational devices. This pairing, along with the ease of which images can now be made, has brought society to process and share information largely by way of images, thus allowing visual storytelling to become one of the most engaging mechanisms of modern society.

As more and more images are transmitted to the public sphere, the question of the truthfulness of images becomes an important issue to consider. The construct of "seeing is believing" is a result of society's acculturation to determine truth by what it is able to see (Newton). Because so much of what society experiences and engages with visually is not a direct experience, it becomes the responsibility of photographers to give their viewers the best visual truth possible in order to preserve veracity (Newton). Images have been shown to strongly influence people's perceptions of the issues and ideas they represent, so it is critical photographers depict their subjects in a way that mirrors the truth as best they can, allowing individuals to come to informed conclusions about the issues presented to them (Gibson and Zillmann).

The media is often criticized for failing to act as an unbiased platform for sharing information. Sensationalism is blamed by critics for the public skepticism against journalism platforms. This phenomenon dramatizes ordinary aspects of life. It carries a negative stigma by seeking to grab the viewers' attention with exceptional content rather than attract the pure interest of viewers (Kilgo et al.). Yet, for all the skepticism held against the media, humankind has nonetheless become reliant on visual truth, and often seeks images that have inherently sensational qualities because of their emotional appeal (Newton). This poses an interesting issue: how can society accept images as truth in light of manipulative modern culture? The answer lies in the truthfulness of photographers and in how informed the audience is. While all photographers should aim to convey the truth and portray objectivity in their work, it is important for viewers not to engage blindly in the "to see is to believe" construct, but to consider the photographer's reputation, the photographic genre of the images, and outside knowledge on the subject of the photographs in question to determine the veracity of the images (Light). In certain genres of photography, to see is not to believe, and it is important to understand under what construct images were shot when evaluating their truthfulness.

Documentary Photography vs. Photojournalism

Documentary photography and photojournalism can be mistaken as one of the same at the surface as they use the same medium. Yet, the two genres of photography produce inherently different images with disparate messages (Kratochvil and Persson).

Caple defines photojournalism as “the visual reporting of newsworthy events”; photojournalism focuses on the events and issues that grab the public’s attention most. The images taken in this context – inherently dramatic or emotional events – focus on capturing what is obvious and exciting in the moment to viewers. The more extreme such images are, the more exciting they become. This can muddy the truth of an event, as great images running on the front of newspapers or at the top of online articles are often those depicting climatic moments, whether or not those extreme moments truly are accurate depictions of what occurred. What the viewer is left with are images that show climatic moments of events and incidents, compromising the truth for the aesthetic, “attention-grabbing” factor (Caple).

Photojournalism has also come to be defined by immediacy: images offering instantaneous, quick visual information on a subject of peak interest. The immediate transmission of images from camera to publication often leaves a shallow portrayal of the real truth behind the image (Kratochvil and Persson). Such images are concerned primarily with the aesthetic appeal of an image and how effective the image is at evoking strong reactions from its viewers. This leaves viewers with a skewed, incomplete view of the truth, forcing them to make up their minds about the truth behind the image without a full body of evidence (Kratochvil and Persson). Photojournalism absolutely has its place in the sharing of visual information. It is critical for allowing society to quickly gather visual information on current issues, event and situations. However, when really looking to effectively tell a story through a visual medium, when truly wanting to capture an aspect of “life” as it exists in reality, documentary photography offers the necessary well-rounded approach to coming to a fuller understanding of a subject.

The beauty of documentary photography comes from the lack of constraint that comes with the pressure of rapid fire production found in photojournalism. It removes the instantaneous need, allowing for a more retrospective approach to image making. Documentary photography aims to describe what is less obvious; what lies beneath the surface. It explores the grey areas of life left unexplored and unexplained by media sensationalism (Kratochvil and Persson). Images can be made over a long period time or from wide variety of places to constitute a single piece. With this freedom from time constraints, the subject matter can be approached more deeply, more intimately (Light). True documentary photographers are able to resist the pulse of typical news photographs and engage deeply with the subject of their images (Light). It is the story behind the images that becomes the prominent focus when immediacy is no longer important.

An important defining feature of documentary photography is that it aims to remain relevant over a significant period of time. Instead of focusing on what is important or newsworthy at one particular moment, it focuses on what is important over days, weeks and years, or even what may not be important at the present but may hold significant value in the future (Kratochvil and Persson). How does a single event effect a community over a period of time? How does a certain component of society vary across large degree of spatial area? What is the significance of a certain cultural trend and how will the capturing of it as it currently exists look in the future? These are the types of questions that can only be answered by looking at the small, obscure details documentary photography intends to capture.

As a genre with a theme of timelessness, the interpretations of bodies of documentary photography ultimately change and shift over time. Effective documentary photography allows the subject matter to create the images rather than use the camera to create images meant to meet a certain need or evoke an emotional reaction based on the subject matter (Kratochvil and Persson). This allows the interpretation of documentary photography projects to be open ended and allow the viewers to actively participate in the images created. It shows a subject as it exists in real life, without appealing to single melodramatic images that evoke strong emotional reactions. The common maxim in creative writing, “the more specific, the more universal”, is very applicable to documentary photography projects. By piecing together the specific realities of a certain aspects of life, documentary photography allows its subject matter to be universally relatable by diverse peoples over large periods of time. Life is not comprised by single, emotionally heightened, instantaneous moments, but a collection of less consequential moments over time (Kratochvil and Persson). Documentary photography studies those specific aspects of life, finding meaning and importance in the small details that people everywhere can engage with and find common ground in.

Though images created by documentary photographers focus on the small grey areas of life, they, too, are individually meant to be engaging and involve a certain level of emotional appeal in order to be effective. However, unlike photojournalism which creates single evocative images, documentary photography aims to create bodies of images that together tell evocative, engaging stories. Each image is a piece of the story being told, much like chapters in a novel contribute to the full story. A chapter alone may still tell a story, and may still engage the readers’ emotions and intellect, but has a much greater effect when it is taken into consideration of the novel as a whole. The same is true for images within documentary photography projects. Taken out of context as single images, the full story element of documentary photographs is missed. Documentary photography forces the viewer to fully engage with the images, to consider the connectivity and message between multiple images to understand the truth of the story the images strive to convey (Light). By putting the story element in the forefront, documentary photography both widens and elicits the feelings of the viewers (Light). Together, the photographs come together to show a full picture of some facet of life, whatever the subject matter may be.

Exploring sustainable agriculture through the lens of documentary photography offers a way to deeply approach the subject through a visual medium. As complicated, multifaceted topic, the full story of sustainable agriculture cannot be accurately depicted solely through the perspective and immediacy of photojournalism. It requires ample time for the photographer to engage with the subject matter to give adequate attention to the details that would otherwise be disregarded. To understand the full story, seemingly less consequential features need to be part of the project's visual rhetoric. What is not obvious to the naked eye or blatantly noteworthy about sustainable agriculture is critical to coming to a full understanding of what it truly entails. By approaching sustainable agriculture in Central Texas through the genre of documentary photography, this project aims to engage society more deeply with where their food comes from and what the future of agriculture may come to look like, capturing an important transitionary stage in agriculture during the global push toward sustainability.

CHAPTER 2

Sustainable Agriculture

What is sustainable agriculture?

Sustainability is a word that is thrown around quite frequently: sustainable businesses, sustainable use of water, sustainable agriculture, sustainable energy, the list goes on. But what exactly is sustainability? According to Merriam-Webster, the definition of sustainable is "of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged." In the context of agriculture, sustainability is the process of cultivating and harvesting crops in such a way that the environment is maintained to be able to successfully produce crops in the future. The United States Department of Agriculture (USDA) legally defines the purpose of sustainable agriculture with five main parameters as cited in the 7 U.S. Code § 5801:

A) Satisfy human food and fiber needs;
B) Enhance environmental quality and the natal resource base upon which the agriculture economy depends;
C) Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
D) Sustain the economic viability of farm operations; and
E) Enhance the quality of life for farms and society as a whole.

The USDA's sustainable agriculture program is promoted by the National Institute of Food and Agriculture (NIFA). With the broad legal definition of sustainable agriculture provided above as a baseline, some specific areas the program emphasizes include using local resources, practicing soil conservation, utilizing cover crops, conserving water, protecting water quality, using alternative marketing such as community supported agriculture (CSA) programs, practicing integrated pest management (IPM) and growing a diversity of crops ("Sustainable Agriculture Program"). The Food and Agriculture Organization (FAO) is another organization committed to achieving sustainability in the global agricultural sector. The FAO has 5 parameters by which it has formulated as comprehensive approach to achieving agricultural sustainability: improving efficiency of resource use, conserving natural resources, protecting the livelihood of rural communities, improving ecosystem resiliency, and responsible governance procedures ("Sustainable Food and Agriculture"). In order to employ these practices, farmers must creatively integrate traditional skill sets with entrepreneurial thinking (Bhullar and Bhullar). With these general sets of sustainability principles in mind, we will take a look at the threats to global agriculture if such principles are not implemented on a wide scale in the near future.

Threats to the Current Agricultural Model

Modern conventional agricultural practices are under extreme pressure to produce food for the expanding global population in ways that minimize impacts on the environment and conserve earth's precious resources in order to combat a wide array of issues posed to society on a global scale. Food is the bedrock for the survival of any civilization, yet, many people are unaware of just how limited the agricultural system currently is. In the developed world, there are grocery stores on every corner, restaurants lining the streets and refrigerators stuffed with food, one third of which will likely be thrown away and not consumed. Those bombarded with food on every other corner and TV advertisement are blind to the real threats against food production. Yet, with agricultural systems being run like assembly lines and constantly being pushed to meet the exponential growth model, we are creating a disaster. The modern agricultural model has reached a crisis point; a lethal one hidden in the uniform fields of rural farmland, silent against the bustle of everyday life (Wechsler and Speicher).

Agricultural land is defined by the FAO as the "share of land are that is arable, under permanent crops and under permanent pasture" ("Agriculture land"). Arable land is defined as the "land under temporary crops such as cereals, temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow" ("Agricultural land"). Over 90% of this land is currently managed as industrial monocultures, which is an area where one single crop is continuously cultivated, sucking out the biodiversity and health of the ecosystem and requiring a constant input of energy and resources (*Agroecology: Key Concepts, Principles, and Practices).* This type of agricultural model is completely unsustainable. It breaks down the natural ecological processes of the soil, leads to massive erosion and causes overuse of fertilizers, pesticides and water. Why, then, is agriculture adhering to such detrimental practices worldwide?

These destructive agricultural practices arose during the Green Revolution of the 1960s. Agricultural models were built around three principles that assumed earth's resources were unlimited, something we now recognize as absurdly false (*Agroecology: Key Concepts, Principles, and Practices*). These models assumed that "there would always be abundant and cheap energy; the climate would be stable and unchanging; and water would always be available" (*Agroecology: Key Concepts, Principles, and Practices*). Yet, none of these three assumptions have ever been true; the earth is a system of finite resources and variability. The energy system agriculture utilizes – fossil fuels – is nonrenewable and is being consumed at unsustainable rates that compromise the environment. Global climate is experiencing major changes, like rising temperatures, to due various anthropogenic influences. Water is being used faster than it can be recycled back into the environment. The industrial agricultural model is pushing for maximum, exponential yields in a world of decreasing resources, where those decreasing resources face a growing number of threats (Francis and Porter). Arable land alone is being lost at a rate of 24.7 million acres a year due to erosion (Bhullar and Bhullar). Instead of operating in a way that produces the most appropriate food for consumption, modern industrial agriculture is first focusing on how it can make the biggest short term profit and get maximum yields (Wechsler and Speicher).

While there are numerous pressures on agricultural production, here we will focus on just three ways food production is threatened. These three pressures have enormous implications on what the future of food will look like, and are pressures recognized on a global scale. This is not meant to be a comprehensive discussion of each topic, but rather an introductory discourse on the ways the global agricultural system is being threatened by these factors. The three threats to be explored in the following sections are population growth, pollution and climate change.

Population Growth:

The earth now has a population of about 7.4 billion people ("Population Clock"). Reports by the United Nations Department of Economic and Social Affairs project the human population to reach 9.7 billion by 2050 and 11.2 billion by 2100. Estimates project that the global food demand must double by 2050 to meet the needs of this exponential population growth (Tilman et al.). Already, 37% of earth's land area is used for agricultural purposes, and the amount of arable land per person is decreasing

(Bruinsma). As global population rises, the question of how global food demands will be met becomes a major concern. More people means the consumption of more land and resources, land and resources that are by no means increasing and that are being depleted and degraded in a highly unsustainable manner. While current methods of food production have the capability to feed 8 to 10 billion people, the majority of agricultural practices are not sustainable (Tilman et al.). Thus, under current conventional agricultural practices, the earth will be unable to support the projected amount of global population growth.

Global population growth is currently increasing at a constant rate. “Constant rate” might sound like global population is increasing linearly, however, that is not true. Growth at a constant rate over time is called exponential growth (Jiles). Exponential growth follows a “J-shaped” curve. In nature, exponential growth is rare because it cannot continue for prolonged periods of time. Eventually the environment cannot sustain the rapid growth of population: resources run out, disease runs rampant, and space for each individual is simply not enough (Jiles). This “limit” to growth is known as a population’s carrying capacity. Carrying capacity is defined as the number of individuals that a given environment can support indefinitely (Jiles). Because of carrying capacity, populations in nature follow a logistic growth model (an “S-shaped” curve) rather than an exponential growth model. As populations approach carrying capacity, the per capita growth rate decreases as density-dependent factors increase mortality (Jiles). Thus, populations typically will stay just below carrying capacity.

What, then, is the carrying capacity for humans? This questions still remains unanswered. In 1798, Thomas Malthus attempted to answer this question. He hypothesized that human population increases at an exponential rate while food production increases at an arithmetic rate (Butler). However, his theory was incorrect, and global food production continued to match global population growth (Butler). The Green Revolution of the 1960s saw a dramatic increase in crop yields by focusing on producing high yield cereals (*Agroecology: Key Concepts, Principles, and Practices*). However, while this seemed to solve the problem of global food production, the means by which farms were homogenized were a short term solution to a larger issue of long term sustainability. Even the father of the Green Revolution, Norman Borlaug, recognized that the success of the Green Revolution would be no match for the dangers of continued exponential population growth (Butler).

In terms of food production under current practices and technologies, the carrying capacity of mankind is about 10 billion people (Tilman et al.). If global population grows as projected, this probable "carrying capacity" will be reached within this century. This limit also does not consider the rate at which resources are being depleted and the environment is being degraded. If exploitation of resources and land continues at is, global food production will fail to meet the needs of the growing population, degrading the environment to where future generations are unable to adequately feed themselves. Despite how it may seem, the population crisis is not some far off, distant problem of the future. It is a problem of the present; a problem the agricultural industry of today must work tirelessly to solve.

Pollution:

Pollution is not likely something most people would think of associating with agriculture. It is more synonymous with mining, transportation or plastic garbage in the ocean. The sad reality, however, is that agriculture is a major contributor to global pollution. Modern agricultural practices such as the use of synthetic fertilizers, pesticides and fossil fuels are major contributors to global pollution, in effect coming back to hinder the very agricultural processes that played a role in exasperating the situation to begin with.

Unsustainable use of fertilizer is a major threat to the viability of earth's agriculture. Conventional agricultural models use an incredible amount of fertilizer to replace vital micronutrients lost in crop biomass. Because farming systems have become industrialized, homogenization of the environment is viewed as the simplest, most effective way to maintain high production for high profit (*Agroecology: Key Concepts, Principles, and Practices*). Because of this, the ecology of the soil and environment is destroyed. Without the regenerative processes that microorganism communities perform in the soil, industrial farms must resort to dumping massive amounts of fertilizer heavy in phosphorous and nitrogen on crops for continued growth in dying soil (Bhullar and Bhullar).

Agricultural use of phosphorous at current rates is completely unsustainable. The phosphorous cycle has been thrown out of balance: excess phosphorous used on crops is not taken up by the plants, runs off into nearby streams and rivers, eventually flowing out into the ocean and polluting our waters (Childers et al.). Because phosphorous is a limiting nutrient, its presence in excess in water bodies causes eutrophication, the excessive buildup of nutrients in both inland water bodies and in the ocean (Elser). The devastating effects of such pollution is exemplified by the dead zone in the Gulf of Mexico caused by agricultural runoff down the Mississippi River. Currently there is no wide scale implementation of recycling phosphorous lost due to runoff, leaving the human phosphorous cycle open (Childers et al.). Phosphorous is also mined from nonrenewable mineral sources around the world with consumption rates at about 400% greater than during preindustrial times (Elser). If current rates of consumption and waste continues, the peak global phosphorous production from mines could occur as early as 2035 (Elser).

Excess nitrogen applied to crops as fertilizer also has detrimental effects on the ecosystem. As more and more nitrogen is added to the soil, the soil becomes saturated (Fields). At that point, plants are unable to take up any more nitrogen from the soil (Fields). This excess nitrogen is then leached from the soil, running off into rivers and estuarine areas where eutrophication occurs, damaging water supplies and harming the ecosystem (Kramer et al.). When nitrogen leaves the soil, it also takes other vital nutrients with it such as magnesium and calcium (Fields). This leads to destruction of the soil ecosystem vital for sustained agricultural use. Excess nitrogen waste also can take form as nitrous oxide, a potent greenhouse gas with over 300 times the warming effect of carbon dioxide (Kramer et al.). Soil with excess nitrogen becomes inefficient at denitrifying, and thus nitrous oxide can escape into the atmosphere before complete reduction (Kramer et al.).

The United States food system as a whole accounts for 17% of all fossil fuel use ("Agriculture, Energy & Climate Change."). Fossil fuels are used to power farming machinery such as tractors, synthesize chemicals and fertilizers and to transport food around the world ("Agriculture, Energy & Climate Change."). Fossil fuels can account for up to 80 percent of operating costs on farms (Bhullar and Bhullar). Unnecessary transportation of food is a big contributing factor to the agriculture sector's fossil fuel consumption and greenhouse gas emissions. Rather than have locally based food markets, we have created a massive global market that will ship products thousands of miles when the same products are grown locally ("Agriculture, Energy & Climate Change."). Tilling practices used by most conventional-type farms require high use of fossil fuels to power machinery that churns the soil as well as the fossil fuels used to produce chemicals that have to be added to the soil for plant growth (Schmidt). With farms all around the world becoming larger and more industrialized, fossil fuel consumption and greenhouse gas emissions will continue to rise if practices are not changed.

Climate Change:

Climate change poses another major threat to agriculture. With 97% of scientists around the globe at a consensus about climate change, there is no questioning that it will impact the agricultural sector (Cook et al.). Climate change is most notably seen by the worsening of phenomena such as droughts, storms and ocean acidification, sea level rise, melting sea ice, desertification, and by the steady increase of global temperatures (IPCC, 2014 Climate Change 2014: Synthesis Report). It is largely due to anthropogenic influences on the environment: increased use of fossil fuels leading to increased greenhouse gas emissions, destruction of rainforests for agriculture and development, and rapid population and economic growth.

Ironically, agriculture itself is the second largest contributor to climate change (Wechsler and Speicher). The effects of climate change on agriculture are in fact largely driven by the very unsustainable practices used by industrial agriculture in the first place. The reality is most farmers are not changing their agricultural practices due to climate change and are continuing operations as is (Fleming and Vanclay). Industrial farms still use fertilizers excessively, use fossil fuels for farm operations, do not practice water conservation and engage in monoculture systems that emit carbon into the atmosphere rather than sequester it (“Population and Land Degradation - Annexes 1-5”). Soils are estimated to hold up to three times the amount of carbon than plants do, yet, irresponsible management of soils causes the degradation of soil carbon content, increasing carbon dioxide emissions as agriculture become more and more homogenized (“Population and Land Degradation - Annexes 1-5”).

Climate change also has altered the global water cycle. Precipitation types are changing, especially in colder regions (IPCC, 2014 Climate Change 2014: Synthesis Report). Mountainous regions are warming 2 to 3 times the rate of the rest of the globe (Giersch et al.). Instead of snow, colder, mountainous regions are experiencing more rain. This causes the shrinkage of permanent snow packs and glaciers through increased melt, and the preservation of these areas are important for the sustainability global water supply (Giersch et al.). While initial increased melt might lead to a great volume of water available for use, over time there will be less glacier and snowpack regions left to melt to replenish water supplies for agriculture and human consumption (Williamson et al.).

Sustainable Solutions

Getting to true sustainability in agriculture requires viewing the process as an integrated, connected system (Bhullar and Bhullar). It requires embracing agroecology: the implementation of a system based, ecological approach to agriculture that looks at the whole of the farm and production rather than each component separately (*Agroecology:*

Key Concepts, Principles, and Practices). Instead of looking at short term production, an agroecological approach looks at the long term viability of the system from soil health, to water supply, to crop health. Agricultural sustainability requires integrating technological advances with natural processes and understanding what type of inputs and changes to the environment can enhance the agricultural system as a whole. A foundation of ecological principles is absolutely essential for long term sustainability of agriculture that can meet the needs of the global population and also minimizing environmental impact (Tilman et al.). Achieving true sustainability on a widespread scale will be a major challenge, but it is necessary for the vitality of future generations. The following sections will highlight of just a few ways farmers are embracing sustainability and operating from a more agroecological perspective.

Hydroponics:

Hydroponics is the process of growing plants without soil. Instead, plants are grown in a bed of water, often along with some type of sterilized, soilless medium such as gravel, sawdust, sand, vermiculite, or a number of others (Jones). The bed of water is enriched with nutrients tailored to the plants' specific growing needs, allowing for plentiful and abundant yields (Jones). Because it takes place within a greenhouse, hydroponics is considered a type of controlled-environment agriculture (CEA). While hydroponics might be an unfamiliar and seemingly "modern" agricultural technology, hydroponics is in fact not a new concept, but has a rather ancient history.

The idea of hydroponics can be dated back to 562 B.C. during the time of the Hanging Gardens of Babylon, and also to the ancient floating gardens of the Aztecs in Mexico (Stauffer). In the 1st century, Roman Emperor Tiberius was believed to have engaged in a form of CEA by growing cucumbers underneath transparent stones out of their regular growing season (Grattan). In the 1600s, Jan van Helmont experimented with plants to determine the primary source of nutrients taken up by plants (Grattan). With a willow tree planted in a small pot, he observed the tree over the course of five years, finding that while the tree gained 160 pounds, the soil in the pot lost a mere two ounces (Grattan). From such observations, Helmont concluded that the majority of a plant's makeup comes from water, not the soil, one of the essential reasons hydroponics can be such a successful endeavor (Grattan). Experiments continued with Julius von Sachs in the 1860s, who researched growing plants in nutrient solutions rather than soil (Jensen). His work led to the development of basic laboratory techniques for nutrient solutions and led to more scientists studying the nutrient composition and physiology of plants (Jensen).

It was not until 1925-1935 that hydroponics began to be applied to practical commercial agricultural ventures (Jensen). Because soils in greenhouses had to be replenished frequently, scientists began looking into nutrient solution-based options to grow plants. Dr. W. F. Gericke began experimenting with growing tomato plants in a soilless water and mineral solution (Stauffer). He successfully cultivated multiple crops, popularizing hydroponics, and also coined the term (Rorabaugh). The U.S. military even used hydroponic greenhouses overseas during World War II to feed troops on ground that was inadequate for cultivating crops. Since then, hydroponics has become a serious agricultural venture for growing vegetables, especially since the 1980s (Jones). With current rates of environmental degradation paired with growing food demand, many farmers are turning toward CEA hydroponic systems to be able to cultivate crops in spite of pollution, erosion, water shortage and other factors that threaten conventional agriculture.

Hydroponics offers a large number of advantages that can make it a more sustainable option for growing crops than traditional soil agriculture. Inside greenhouses, variables affecting plant growth can be controlled for optimal growth and production (Jones). Growers are able to regulate factors such as temperature, air flow, nutrient availability, pH, light availability and humidity (Jones). This ability to control the majority of growth variables lets growers adjust as needed for optimal yields, something that cannot be done with traditional soil-based agriculture. Another major advantage is the fact that hydroponics can be conducted on non-arable land: land that is unable to support agriculture due to lack of nutrients, pollution, rocky or sand ground, or any other number of confounding factors (Rorabaugh). As arable land is decreasing globally, hydroponics offers a sustainable way to grow crops where soils are inadequate to do so. Other advantages of hydroponics include maximization of land area due to high planting density, less water and nutrient usage, minimized disease, and easier pest control (Jones, Rorabaugh, Jensen).

There are, however, several disadvantages to hydroponics, which is why it is not yet as popular as it could be. The main issue is the upfront expense of installing a hydroponic system (Jones). The typical hydroponic farms cost 600,000 to 1,000,000 dollars per acre on top of the original cost of the land (Rorabaugh). Because they are contained within a greenhouse apparatus, there is the additional cost of heating and cooling the system to maintain optimal temperatures for plant growth, as well as the energy costs of maintaining computer systems and technology involved (Rorabaugh). If the energy source of the hydroponics system is fossil fuels, that also detracts from its sustainability potential.

Aquaponics:

Aquaponics is very similar to hydroponics. It is a combination of aquaculture – the cultivation of captive aquatic animal or plant species in a controlled environment – and hydroponics (Junge et al.). Most often it involves the use of fish in an integrated, sustainable system for crop production. Some say that aquaponics is in fact an even more sustainable option than strict hydroponics because it is a closed-loop system where there is no need for added fertilizers or chemicals for plant growth ("What Is Aquaponics?"). It offers many of the advantages that hydroponics offers, using only one-tenth of the water that traditional soil-based agriculture uses, which is even less than hydroponic systems ("What Is Aquaponics?").

The fish and plants are engaged in a symbiotic, mutualistic relationship: the fish produce waste that the plants uptake as nutrients while the plants filter the water for the fish (Junge et al.). The catch with this seemingly simple set up is that ammonia, a toxic waste product, can build up in the water. Aquaponics systems require the use of bacteria to avoid toxic buildup of ammonia and convert it into usable fertilizer for the plants (Somerville et al.) There are two types of bacteria present in an aquaponics system: ammonia oxidizing bacteria and nitrogen oxidizing bacteria (Somerville et al.) The ammonia oxidizing bacteria convert ammonia into nitrite, and the nitrogen oxidizing bacteria consume the nitrite, turning it into nitrate (Somerville et al.). Nitrate is then taken up by the plants.

Aquaponics is a monitoring-heavy endeavor. Careful watch of the water pH, temperature and dissolved oxygen levels is essential for making sure the system is functioning properly. Improper conditions can result in unwanted bacteria getting into the system (such as denitrifying bacteria) or hypoxic conditions in the fish tank, both of which can lead to damaging the aquaponics crops (Somerville et al.). Like hydroponics, the upfront cost of implementing a hydroponics system can be expensive, but it can be made up for by higher yields and a greater maximization of land area through high density cultivation (Junge et al.).

Organic Farming:

Organic farming is one of the most sustainable agroecological farming models, striving to create biodiversity within the farm by increasing soil microorganisms, cultivating a variety of plants, and encouraging other natural ecosystem functions. It has rose to prominence over the past several decades, with the market for organically grown produce having risen as consumers are slowly becoming more conscious of where their food comes from and what products they desire to put into their bodies. Organic farming strives to be chemical free, prohibiting use of synthetics for pest control and fertilizers, and prohibiting the use of genetically modified organisms (Bhullar and Bhullar). Because of this, organic farmers must operate under a system-based approach, utilizing natural remedies to maintain ecological homeostasis, keeping the system in equilibrium rather than exploiting certain components of the system (Bhullar and Bhullar). The foundation of organic farming lying in the cultivation og biodiversity leads to ecological processes that renew the environment rather than degrade it (*Agroecology: Key Concepts, Principles, and Practices*).

Currently, only 0.9% (about 91 million acres) of the earth's agricultural land area is farmed organically (Bhullar and Bhullar). However, organic agriculture is growing, especially in European countries like Austria, pioneering the way with over 20% of its agricultural land area farmed organically (Bhullar and Bhullar). Globally, the market for organically produced food has increased by 55 billion dollars (Bhullar and Bhullar). As market trends show increased consumer awareness and concerns for health manifesting in food purchases, the organic market will continue to grow as consumers are more willing to pay the higher price for organic products ("Organic Market Overview").

By focusing on natural, holistic solutions for crop production, organic agriculture is able to keep the environment healthy and viable for farming endeavors over the long term. One such holistic approach is biocontrol. Instead of using synthetic pesticides that cause pollution and homogenization of the environment, farmers allow natural predators to take care of pests, keeping ecosystem diversity for long term viability. Releasing natural enemies of pests into crop fields is one of the most prominent mechanisms of biocontrol (Oztemiz). This can be done either by releasing a large volume of predators at one time, or by releasing some during critical times through out the growing season (Oztemiz). Organic practices also encourage natural predators to move into fields on their own, allowing for normal ecosystem functioning.

Soil health is a huge focus of organic farming. Some practices integrated into organic farming to encourage healthy soils are crop rotation, cover crops and composting. Crop rotation is the practice of growing different crops on the same plot of land instead of following a monoculture, single crop model. This allows the soil to recover, and for the next crop to pull out different nutrients to avoid depletion and help farmers avoid soil compaction (Francis and Porter). Cover crops are plants used to help soil nutrition, prevent erosion and keep microorganism community in the soil functioning properly ("Cover Crops"). Especially in organic farms, cover crops can help put nitrogen back into the soil, improving the overall health of the soil and get rid of the need to use synthetic nitrogen fertilizers (Bhullar and Bhullar). Legumes are a popular cover crop because of their high nitrogen fixing abilities ("Cover Crops"). Cover crops also can help soils become more of carbon sinks rather than carbon emitters, offsetting some of the other greenhouse gas emissions induced by farming (Bruinsma). Since cover crops are typically planted during the off season, they can harness solar energy to replace lost carbon in the soil during a time in which it would be unproductive and losing organic matter (Birchmier).

Composting is the process of turning waste organic matter into humus or fertilizer for crops (*Soil Microbial Interactions and Organic Farming*). Soils undergoing frequent cultivation are constantly losing humus, nutrients and organisms ("Population and Land Degradation - Annexes 1-5"). By applying compost to soil, nutrients are put back into the ground where they can be taken up and used to produce crops. This is an effective and natural solution for prolonged vitality of earth's arable land. It is essential to the sustainable agriculture model because it recycles organic matter back into soil instead of wasting it, minimizing the amount of nonrenewable, outside inputs to the system.

Studies have shown that organic farms produce just as much, if not more than, conventionally grown crops over time per acre because of revitalized ecosystem functioning. While the production costs of organic practices can be expensive since it is more labor intensive, the long term benefits on the land, decreased spending on inputs such as fertilizers and herbicides, increased yields, and the saving of water and energy can be enticing incentives for farmers to make the switch to organic.

Community Supported Agriculture

Community supported agriculture (CSA) is one of the most innovative and effective ways for consumers to actively engage in sustainable agriculture. CSA programs are basically a subscription service for fresh produce. The consumer pays the farmer upfront for a share of the harvest, and the farmer delivers the harvested produce to the consumer every week or so. What makes CSA programs sustainable is that the farmer is able to utilize all of the crop yield. Supermarkets increasingly are asking for larger, uniform, blemish free produce (Osmond and Wilson). If farmers strictly sell wholesale to supermarkets, any unqualified produce is lost as food waste. With the CSA model, crops that are too small or too "imperfect" for supermarket sale can be distributed to CSA members. The farmer can give the CSA member two or three broccolis, for example, if they are small instead of having to throw them out if the farmer was strictly selling wholesale to grocery stores (Osmond and Wilson). The CSA model protects the farmer when harvests are not optimal, since subscribers know upfront that they are investing in the farm for better or for worse.

CHAPTER 3

The Photography: Sustainable Agriculture

The following section is the main focus of this thesis project. It consists of photographs taken over the past year of four farms in Central Texas that practice sustainable agriculture. The photographs were shot using a Canon EOS 70D, with a EF-S 18-135mm, f/3.5-5.6 STM lens and were edited using Adobe Lightroom.

Urban Produce

Urban Produce is a small produce operation that has been functioning since 2014 off of 12th Street in Waco, Texas. The entire operation takes place inside one greenhouse, smaller than half a football field. What makes the greenhouse so unique is that it is hydroponic. Urban Produce typically has about 7 employees, and sells its hydroponic lettuce to local restaurants, to the local HEB grocery stores and at the Waco Downtown Farmers Market every Saturday. Here is a glimpse inside of the hydroponic greenhouse, from seedling to harvest.

Figure 1: Lettuce begins to grow in the propagation room before being transplanted to the main greenhouse.

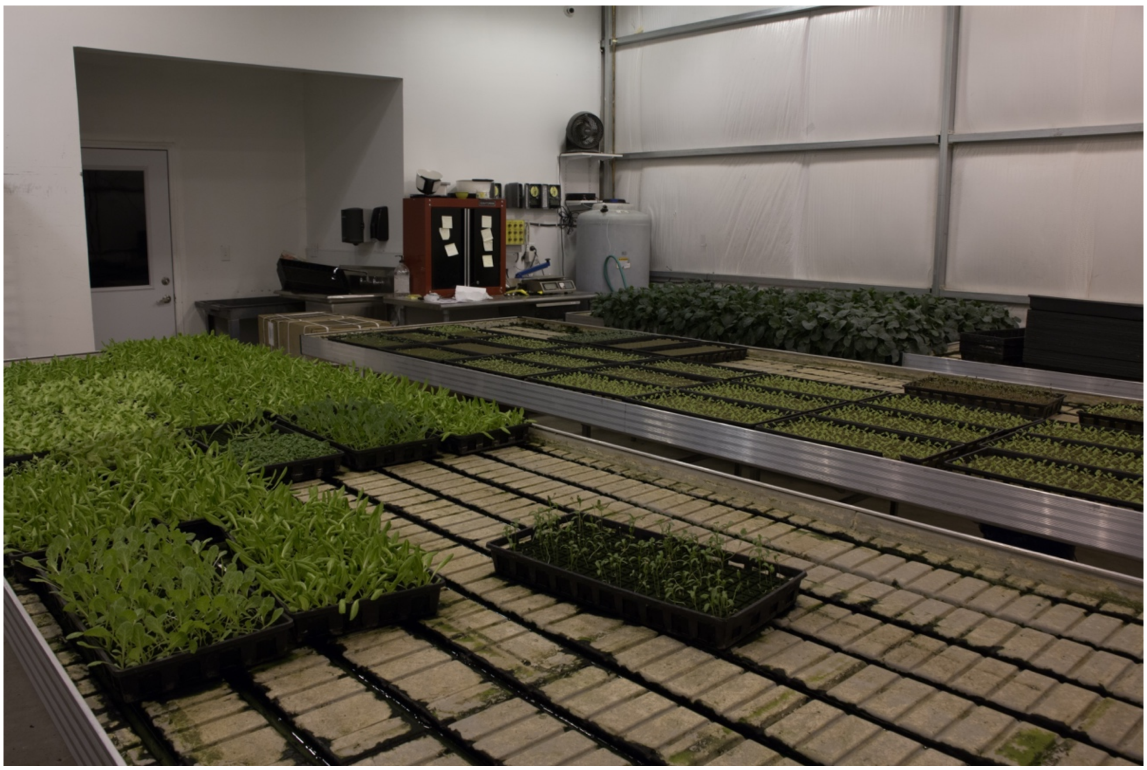

Figure 2: The propagation room is used to seed the lettuce. It offers better climate control to ensure optimal conditions for the lettuce to sprout.

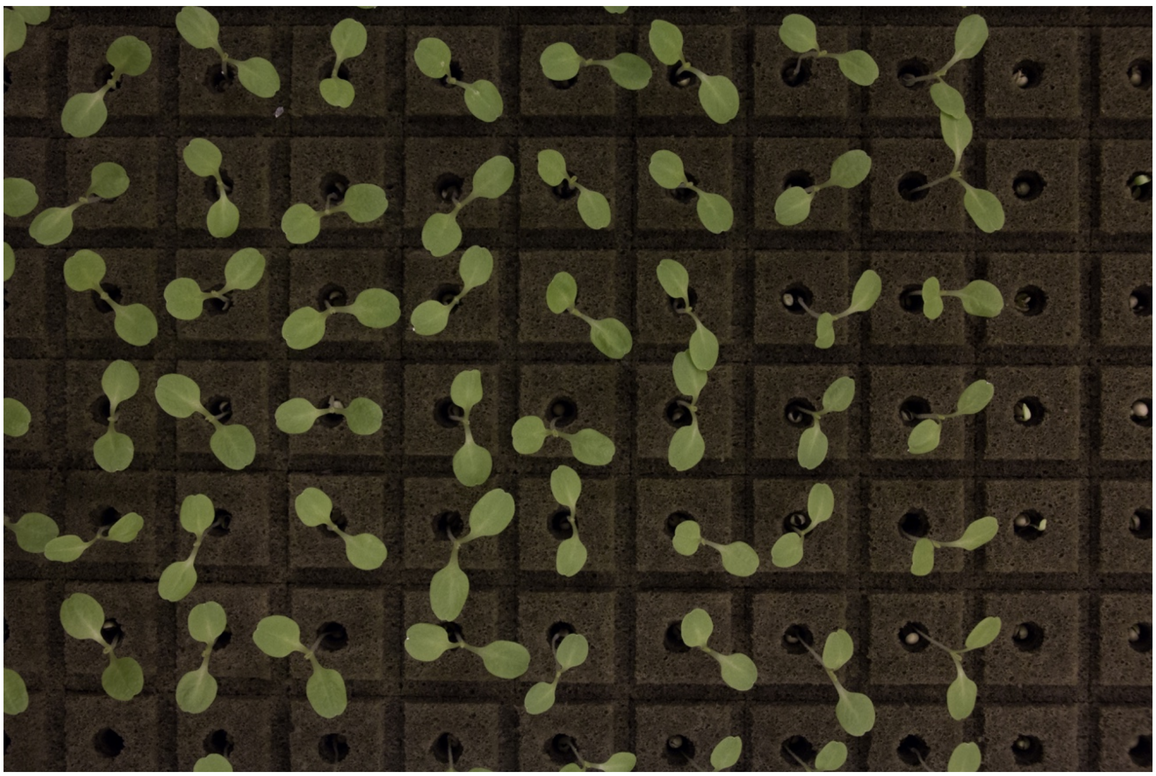

Figure 3: Urban Produce uses Oasis Foam Medium for its lettuce, which is specially designed for hydroponics. The cubes are separated before they are moved into the main greenhouse.

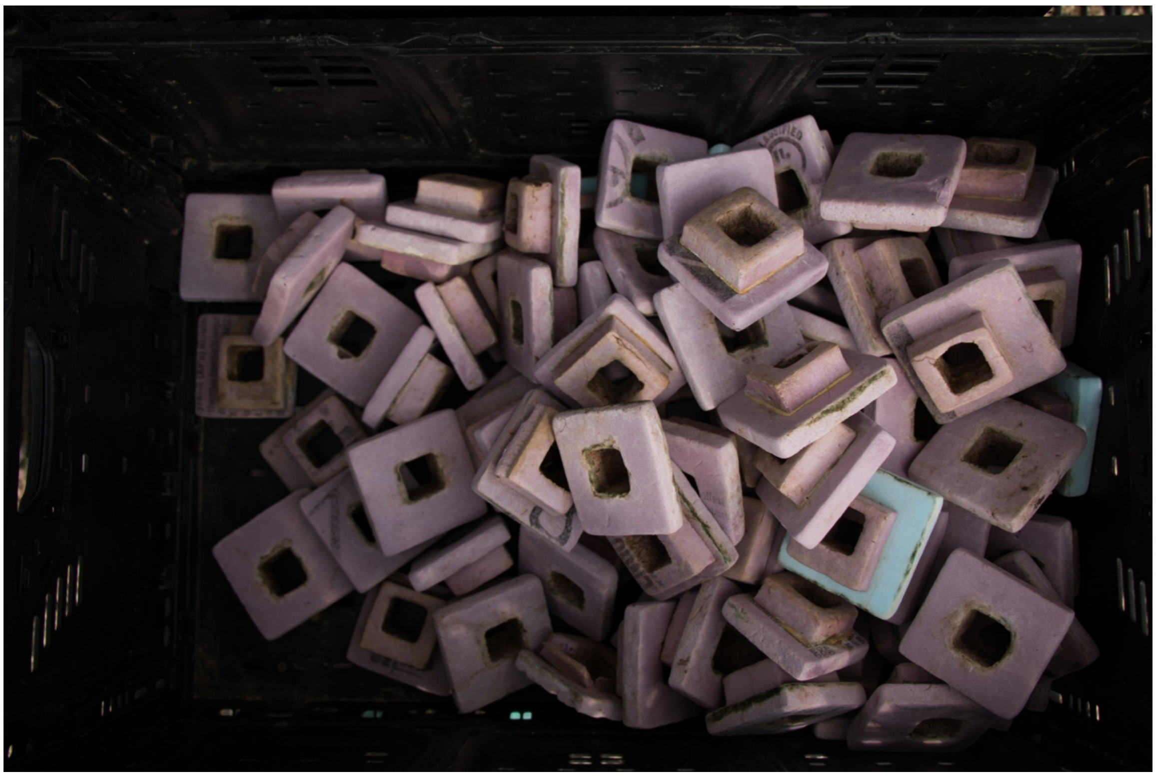

Figure 4: Plastic cells used to hold the young plants and the growing medium inside the main trays in the greenhouse.

Figure 5: Empty floating trays wait for new lettuce plants to be inserted.

Figure 6: Field of floating lettuce trays inside the Urban Produce hydroponic greenhouse. The more mature lettuce plants are towards the far end of the greenhouse. As lettuce plants are harvested and new seedlings are inserted, the trays cycle towards the far end as the plants mature, almost like a slow moving assembly line.

Figure 7: View from the opposite end, with the younger lettuce at the far end of the greenhouse. It takes six to eight weeks for the lettuce to reach harvestable size.

Figure 8: Ventilators at the end of the greenhouse along with fans suspended inside help keep the air fresh to promote lettuce growth.

Figure 9: A young lettuce in its Oasis growing medium and holding cell floating in a foam tray in the greenhouse.

Figure 10: The lettuce roots grow down into the water-nutrient solution instead of soil. An Argus computer system monitors and controls the nutrient levels in the water as well as controls the cycling of fresh water into the system.

Figure 11: Butter lettuce soon to be harvested.

Figure 12: Red Romaine lettuce soon to be harvested.

Figure 13: Lettuce trays are moved and inspected manually to determine which are ready for harvest.

Figure 14: An employee carries a tray of butter lettuce ready to be harvested and prepped for sale.

Figure 15: Employees prep and package lettuce to be sold.

Figure 16: Lettuce is prepped for packaging by rolling up the roots around the remainder of the growing medium.

Figure 17: Leaving the roots on the lettuce allows it to stay fresh for a longer period of time. Urban Produce sells their lettuce at the Waco Downtown Farmers Market, local HEB stores, Happy Harvest and through Sysco.

Figure 18: Urban Produce lettuce being sold at the Waco Downtown Farmers Market.

Urban REAP

Urban REAP – Renewable Energy and Agriculture Project – is a sustainability project by Mission Waco off of North 15th Street in Waco, Texas. Jimmy and Janet Dorrell, co-founders of Mission Waco, began Urban REAP as a solution to many of the environmental issues the earth is facing from a Christian perspective. The project runs on renewable energy, uses an aquaponics growing system, and engages the community in composting. Here is a look at the Urban REAP facilities.

Figure 19: Entrance to Urban REAP facilities behind the Jubilee Market in Waco, Texas.

Figure 20: Urban Reap is powered by renewable energy. The 36 solar panels powering the operation were donated to Urban REAP by the Green Mountain Energy Sun Club.

Figure 21: Rainwater is harvested through a gutter system on the greenhouse and is used as replacement water for the aquaponics system.

Figure 22: Urban REAP engages the Waco community in composting. Participants fill up the blue buckets with compostable material, and Urban REAP processes it into fertilizer for sale as well as for the plants they grow for sale.

Figure 23: Participants in the composting program dump the contents of the blue buckets into a larger grey trash bin, and then scoop sawdust material on top of the compost to help with odor and decomposition.

Figure 24: The Urban REAP composting machine turns compost into natural fertilizer for the garden at the facility as well as for purchase for people in Waco.

Figure 25: Urban REAP sells flowers, herbs and vegetable plants to the Waco community.

Figure 26: Urban REAP rosemary plants grown for sale.

Figure 27: Outside of the aquaponics greenhouse.

Figure 28: Inside of the aquaponics greenhouse facility.

Figure 29: The fish tank holds about 280 hybrid striped bass. The ammonia waste produced by the bass is converted to nitrate by the bacteria grown throughout the system.

Figure 30: Table with young, sprouting produce.

Figure 31: Young Swiss chard and cilantro plants sprouting from the growing medium before they are large enough to be transplanted into the aquaponics tank.

Figure 32: Sprouting kale.

Figure 33: The plants sprouting from the aquaponics growing medium are placed into floating plastic trays where the roots will grow down into the water-nutrient solution.

Figure 34: A volunteer inspecting aquaponics produce. Urban REAP relies heavily on support from volunteers in the community to keep the operation functioning.

Figure 35: A volunteer inspecting produce.

Figure 36: A volunteer prepares aquaponics lettuce for sale.

Figure 37: Produce grown in the Urban REAP aquaponics greenhouse is sold at Mission Waco's Jubilee Market and to local restaurants.

Johnson's Backyard Garden

Johnson's Backyard Garden (JBG) is an organic produce farm just outside of Austin, Texas. The farm began in the actual backyard of the Johnson family off of Holly Street in East Austin in 2004. Since then, the farm has grown into a 1,000 member CSA operation, with around 200 acres of 60 types vegetable grown off of River Road in Cedar Creek, Texas. Here is a look at the farm from seedling to harvest.

Figure 38: Sign at the entrance of the farm.

Figure 39: A grouping of greenhouses are used to seed the crops grown on the farm.

Figure 40: The greenhouses have retractable plastic walls that can be lifted for ventilation when the outside weather is optimal for seedling growth.

Figure 41: The greenhouse allows the farm's employees to monitor and water the seedlings under a more watchful eye, and also control temperature for peak growth.

Figure 42: Plastic greenhouse vegetable cultivation (PGVC) is a growing phenomenon in agriculture. JBG currently has one PGVC structure.

Figure 43: Crops grown under plastic coverings like this consume less water by losing less to evaporation, keep air pollutants out and help prevent erosion.

Figure 44: Lettuce plants soon to be transplanted to grow in the field.

Figure 45: After plants are strong enough, they are loaded up on wagons and taken to empty sections of the field for planting.

Figure 46: Lettuce plants soon to be planted in the field.

Figure 47: Employees planting lettuce seeded in the greenhouse. This tractor moves along slowly, puncturing small holes in the ground so the two seated workers can fill the holes with the lettuce plants.

Figure 48: The farm waters its crops through a drip irrigation system. The water flow is adjusted manually from risers (left). Manual adjustment allows for the farm to adjust water pressure depending on the weather and crop type for minimal water loss.

Figure 49: The water flows out of the riser and into the blue lay flat tube. The water then goes through the black tubing called drip tape.

Figure 50: The drip tape is run the length of field either right at the surface of the ground or just below. Drip irrigation is one of the most efficient irrigation methods in farming, conserving more water than the sprinkler based systems farms often use.

Figure 51: Water trickles out slowly from the drip tape directly into the soil, minimizing water loss to evaporation.

Figure 52: When the drip tape is under the ground, it is often in beds that utilize plastic covering.

Figure 53: Plastic coverings are useful for preventing weeds from growing and taking away nutrients from the crops, and also for reducing evaporative water loss from the soil.

Figure 54: While the plastic coverings are beneficial, use of plastics is a major sustainability issue. Plastics are one of the main pollutants on the planet by toxic buildup in our waters, posing a threat wildlife mistaking plastic products for food, and adding to the global waste dilemma.

Figure 55: There are beds of different vegetables scattered throughout farm as a result of the crop rotation practices of the farm. To keep the soil healthy, the farm is constantly in a rotation of vegetables on different plots of land. The same crop is never grown on the within 2-3 growing seasons.

Figure 56: Cover crops are also grown to enrich the soil and prevent erosion. The appropriate cover crop must be selected depending on what the farmer needs to enhance on the land. Planting cover crops ultimately increases yields and is beneficial to soil health.

Figure 57: As a certified organic farm, JBG can only use biological pest control and fertilizers. The farm cannot spray synthetic chemicals or any type of hormonal treatments on its crops. This benefits the consumer as well as the ecosystem of the farm and surrounding area.

Figure 58: Organic practices allow the ecosystem to function in a more natural way. Lady bugs are beneficial to farmers by eating havoc wreaking insects such as white flies or aphids. They can be effective biocontrol predators.

Figure 59: Even on organic farms practicing sustainability, the consumption of fossil fuels to power large tractors and equipment is still prevalent.

Figure 60: While the farm rotates through 250 vegetable varieties, there are a couple grown in larger quantities for wholesale. Kale is one of the top two crops produced in terms of quantity on the farm. It is used for both the CSA program and wholesale.

Figure 61: Carrots are the other top produced crop on the farm, also sold for wholesale and used in the CSA program.

Figure 62: Lettuce is also produced in high quantity for both CSA and wholesale.

Figure 63: JBG grows some crops in smaller quantities, such as herbs like rosemary, specifically for its CSA members.

Figure 64: Recently harvested radishes are waiting in the field before being washed and stored. Radishes are actually a common cover crop used to help get rid of soil compaction and can also bring out nutrients lost to other crops in the soil because of its long tap root. JBG use radishes in their CSA program.

Figure 65: The packaging and transport area of the River Road farm location. JBG also has a packing shed on Hergotz Lane in Austin, Texas.

Figure 66: An employee moves crates of harvested produce out of the storage shed.

Figure 67: Harvest crops are taken to the Hergotz Lane location where the produce is washed, packaged and cooled for storage. Produce is then shipped for wholesale, packaged into CSA boxes or packaged into crates for sale at farmers markets throughout Central Texas.

Figure 68: JBG sells produce at farmers markets all throughout Central Texas, including the Waco Downtown Farmers Market.

Figure 69: Sweet potatoes for sale at the JBG stand at the Waco Downtown Farmers Market.

Figure 70: JBG delivers its CSA boxes, and also has pickups at farmers markets. They have four sizes of boxes for consumers to subscribe to from individual boxes, small and medium boxes and large boxes suitable for large families.

World Hunger Relief Farm

World Hunger Relief Farm was started in 1976 by Bob and Jan Salley. The farm provides a program for individuals looking to train in sustainable agricultural practices to address hunger and poverty around the world. Interns live on the farm for about a year, producing fresh produce for the Waco community through a CSA program, sale at the Waco Downtown Farmers Market and their new “Veggie Van”. Alumni of the farm have served communities in over 40 different countries, and constantly engage the local community through outreach events on the farm focused on educating the people about sustainable agriculture. Here is a look at the produce production at World Hunger Relief.

Figure 71: Composting is a big part of the sustainable practices on the Farm. Through monitoring the decay of food scraps, cardboard, and other compostable materials, the farm is able to have a nutrient rich medium to add to the soil used for growing crops.

Figure 72: The heat produced as the compost materials decompose help foster the formation of humus: the organic matter, nutrient rich layer of soil most important for plant growth. Humus fosters the growth of vital organisms in the soil that are essential for adequate nutrient uptake by plants.

Figure 73: Compost is taken to the vegetable fields where it is applied to beds soon to be planted or added to growing crops for added nutrition.

Figure 74: The Farm also uses organic approved fertilizers to improve plant growth. Gypsum (calcium sulfate dehydrate) is one nutrient added to reduce soil acidity, reduce aluminum toxicity, reduce erosion, and improve the soil’s overall structure.

Figure 75: Combining fertilizers like gypsum and compost is an essential part of the fertilization process on the Farm.

Figure 76: Farm workers add the compost-gypsum mix to soil beds soon to be planted.

Figure 77: The Farm seeds its produce in a small greenhouse by the entrance of the farm, allowing the plants to grow outdoors when conditions allow.

Figure 78: Squash plants soon to be planted in the newly fertilized soil beds. The Farm practices crop rotation to keep the soil healthy and not leech vital nutrients from the soil.

Figure 79: A farm worker waters recently planted red romaine lettuce.

Figure 80: World Hunger Relief Farm also utilizes drip irrigation to minimize water usage as well as plastic coverings for preventing weeds from growing and losing water to evaporation.

CHAPTER 4

A Sustainable Future

One day, the aerial view of cities around the world could be green gardens and hydroponic greenhouses rather than wasted concrete space, maximizing lost land area for agricultural production. We could see the return of small family farms that support local communities rather than industrial monoculture machines. We could see a restoration of the environment by refraining from excessive fertilizer use by promoting soil health with enhanced crop rotation practices. We could see large scale organic farms that function from an agroecological perspective, working in concert with the environment rather than traditional farms that are constantly battling to subdue normal, ecological flow and diversity. We could see city sponsored composting programs that go back to local farms to be used as natural fertilizer. One day, we could see such realities come to fruition. But these realities can be possible only if we are able to realize what is at stake, and what we must consciously invest in going forward.

These are just four small farms that have taken the leap forward toward sustainable practices. My hope is that this project can raise awareness on some of the threats our agricultural system faces, and show what is being done to combat those threats. By making what people think is mundane beautiful, by providing a glimpse at what the future of our food may look like, I hope, too, that this project can give hope for the future and inspire people to promote and invest in sustainability.

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