WHAT AND WHY AGRICULTURE CHANGED:

A COMPREHENSIVE SUMMARY COMPARING THE AGRICULTURAL PRACTICES OF B.C.E. FARMERS AND CONVENTIONAL AGRICULTURE

HONORS THESIS

Presented to the Honors College of
Texas State University
in Partial Fulfillment
of the Requirements

for Graduation in the Honors College

by

Cody R. Brown

San Marcos, Texas
May 2017

WHAT AND WHY AGRICULTURE CHANGED:

A COMPREHENSIVE SUMMARY COMPARING THE AGRICULTURAL

PRACTICES OF B.C.E. FARMERS AND CONVENTIONAL AGRICULTURE

by

Cody R. Brown

Thesis Supervisor:

_____

Ken Mix, Ph.D.
Department of Agriculture

Second Reader:

_____

Alice LeDuc, Ph.D.
Department of Agriculture

Approved:

_____

Heather C. Galloway, Ph.D.
Dean, Honors College

What and Why Agriculture Changed: A comprehensive summary comparing the agricultural practices of B.C.E. farmers and conventional agriculture

By. Cody R. Brown

Abstract

Agriculture is considered one of the most integral sciences used today. As the human species evolves, so do the methods of agriculture. The implications and consequences of farming practices have always been present; however, the issues discussed differ over time. The available resources, technology, land, labor, methods of production and population have changed through the course of the extensive history of cultivating land. The detailed differences between B.C.E. and conventional agriculture are vast and they differ in almost every area of their production practices. Conversely, common ground can still be found when concerning the basic principles of agriculture. The world today has become much more globalized than a B.C.E. farmer could have even imagined and the implications of this on agriculture are broad and should be of concern.

Introduction

Agriculture, in its most basic definition, is the science of farming. The Latin roots of the word agriculture is broken down into two parts: *agre* (field) and *cultura* (growing, cultivation). The importance of agriculture has never changed; however, the actual practices have changed significantly over time. Marcus Porcius Cato was born in 234 B.C.E. just south of Rome and he never creates a concrete definition of farming for he is conflicted between what it means to farm as a lifestyle versus farming for mere profits. Marcus Terentius Varro was another fellow Roman farmer born in 122 B.C.E. who also wrote about farming and described agriculture as an art, but not only an art, for it is as much a necessary practice as it is an art. This was some of the first literature written in Latin and is one of the reasons the literature is still in print. Now, some 2,200 years later, agriculture has transformed from a personal endeavor, for life or for profit, into a global machine dedicated to increasing output. The approach to operating an agricultural farm has remained rather unchanged over time. Modern and B.C.E. agriculture both agree that the choosing of the land, labor, production and proper equipment are of utmost importance to the success of a farm. However, a distinction has yet to be made between the specific actions and consequences of these processes. By comparing early agriculture practices with conventional farming methods, we can compare what, where and why the agricultural production system has changed.

Discussion

Regardless of the era, or the producer, time has proven that the selection of the land is of high concern. It is understood that land is a finite resource that has taken thousands of years to develop and sustain life, both human and smaller biota. The health of a soil not only attributes to the surrounding environmental factors during its creation, but also the anthropogenic effect of human manipulation; a great example of this human impact was displayed in the Dust Bowl of the early 1930's. In Cato's *On Farming* he claims that generally the healthiest land is at the root of a mountain facing south, because it tends to have a variety of land formations (Cato &Dalby, 1998). Cato continues to describe suitable land and many common environmental externalities are discussed: pleasant weather is preferred (not liable to storms), land must be self -sustaining, located near a water supply and sizeable town. The town not only offered a market for products to be sold and purchased, but also offered a source of labor for the farmer to utilize. Cato's final mention of land worth purchasing was a land that was varied, located in a prime position and a minimum size of one hundred *iugera (*approximately 50 acres). The reasoning behind these criteria was that a typical farm of the time was versatile and varied in its production. Cato established that his farm land must be able to provide for the following items, in this order: vineyard (the main crop of his farms), irrigated kitchen garden (vegetables), willow wood stock (for weaving together carrying baskets and vine supports), an olive grove (supplemental income), a meadow (resilient to

weather, requires little investment and guarantees a return each year in pasture and hay), a grain field, a plantation of trees, a fruit and nut orchard and lastly a stand of acorn wood (to feed oxen and pigs) (Cato & Dalby, 1998).

Varro delved deeper into the science behind what made a land appealing for cultivation, explaining how the land created the parameters for what was most suitable to be farmed. He began by firstly separating land into four simple categories: flat, hilly, mountainous and mixed. Varro furthered his point by explaining that the elevation of these land formations directly affected the climate on that land and thus the method of cultivation. The following inferences were made by Varro: the lower the land, the hotter and heavier the air became which was more suitable for the cultivation of corn, poplars, willows, almonds and figs. Similar assumptions could be applied to higher land which is a cooler with lighter air that creates an environment suitable for firs, pines, arbutus and oak. Varro summarized by grouping corn crops to plains, vineyards to hills and wood production to mountains. Varro acknowledged that each variety of land had its benefits and disadvantages by season. Summer was most beneficial to mountainous districts for the air was still cool enough to permit the cultivation of trees and the gathering of green fodder as a natural mulch. Winter was best for hilly land because grass was still present in the meadows and trees could be pruned more easily. In general, a land of slight slope was better than flat land for the purpose of drainage, which prevented the land from becoming swampy, murky and eventually unproductive. (Varro & Storr-Best, 1912).

Both Cato and Varro mention the importance of purchasing land near a city, road, or river. This was for ease of transport to the markets which was driven by supply and demand. It still holds true today that supply and demand are driving factors of agriculture production; however, advancements in technology have decreased the importance of being near a city. This can be attributed to advancements in the transportation sector and the addition of large export demands that have allowed producers to not be limited to producing solely for a local market. The United States Department of Agriculture projects that the United States will export 136 billion worth of agriculture products alone for the fiscal year of 2017 (Jiang et al. 2017). The Economic Research Service stated that in 2013 crops and crop products accounted for 22 percent of total exports in the United States (Jerardo, 2017). This increased demand from international trade was not a considered variable during the times of Cato and Varro; it was not possible with the technology of the time to transport efficiently overseas. Because a producer can still be profitable without being located near a city, the amount of land that is considered for purchase has increased (larger plots of land are available further from urban areas) and the production of secluded land has become vital to conventional agriculture.

The analysis of Cato and Varro's methods of choosing land has shown that land was treated as a highly valued commodity during the Roman era. Their way of looking at the land was from a holistic approach and their land criteria revolved around the work it would take to operate in a self- sustaining

fashion; alluding to Cato's mention of promoting self- sufficiency, attaining a diverse source of profits, and thereby reducing marginal expenditures (Cato & Dalby, 1998). Today, conventional agriculture is not centered around the sustainability of the land, in general farming is done by large corporations rather than by an individual farmer and their family; therefore there is no longer a direct connection with the land. The Food and Agriculture Organization reported in 2014 that large conventional farms accounted for 65% of total land used agriculturally (FAO, 2014). One glaring difference is the amount of land that is sought out for purchase; conventional farms in the United States are on average 178.4 hectares (440 acres) in size (Deininger & Byerlee, 2011). This is a stark comparison to Cato's 50-100 acres. Varro did however mention the measurement of a *centuria* which translates into a perfect square approximately 133 acres and four of these in a quadrant was known as a *saltus.* However, this land was allotted only to individuals of the State and not generally used for agriculture (Varro & Storr-Best, 1912).

After the selection of the land, a labor force must be assembled to carry out the production of the farm. During the B.C.E. era freemen were occasionally hired for the important farm work; however, slaves were the common source of labor. Cato nor Varro list any specific race, or type of person that they would deem a slave; Cato focuses more on the basic needs for your labor force whereas Varro does take the time to list the most desired traits when buying a slave or hiring a freeman. Cato suggests the following labor force for 120 acres planted in

olives: manager, manageress, five laborers, three ox herds, one donkey driver, one swineherd and one shepherd making a total of 13 persons (Cato & Dalby, 1998). A vineyard of 50 acres required more labor: manager, manageress, ten laborers, one oxherd, one withy-cutter and one swineherd making a total of 16 persons (Cato & Dalby, 1998). Varro acknowledged and supported the labor force that Cato suggested and elaborated on the specifics of a purchased laborer. Varro claimed that freemen were to be hired and paid when an important task on the farm needed to be completed, such as tilling the field, harvesting a crop, or building a structure. The economy of a surrounding area would have influenced a farmer's choice of hiring for labor or purchasing slaves; it was better to use hired labor over slaves in an unhealthy district (Varro & Storr-Best, 1912). An ideal laborer could withstand hard work, was no younger than twenty-two years old, and neutral in spirit (not timid or excessively extroverted). An overseer, or manager, should be able to read and write, slightly educated and well versed in farm work for he must lead by example and bolster the morale of the work force through his words and not his whip. (Varro & Storr- Best, 1912). B.C.E. farmers calculated that a hired person for tilling should be able to plow eight *iugera* (roughly five acres) in forty-five days; four days per *iugera* and thirteen days for bad weather and sickness (Varro & Storr- Best, 1912). Farmers of B.C.E. understood worker satisfaction and though the word "slave" carries a negative connotation in the twenty-first century it does not always imply a poor lifestyle for a farm slave in certain historical contexts. Varro discussed this issue

when he spoke about the laborer's enthusiasm for work increased when they were rewarded, not given unachievable tasks and not severely punished. All workers, slaves and freemen alike, lived on the farm property and were provided food, water and clothes (Varro & Storr-Best, 1912). Their labor force was versatile. A group of strong men could tend the entire diversity of the farm; the garden, the vines, the presses, the mills, the animals, the planting and the harvesting.

A much different employee environment has been cultivated over the course agriculture's evolution and today a farmer's most important piece of equipment is not always the laborer. The 2012 Farm Census created by the United States Department of Agriculture quantifies the largest labor investment not to be human labor, but machine equipment. 295,331 farms in the United States have equipment costs between $30,000- $50,000 with a production value of $10,931,730. Furthermore, a total of 43,127 farms have equipment which costs over $1,000,000 with a total value of $74,005,308. The largest contributors to this statistic are trucks and self-propelled tractors that operate in the grain and bean industry (Vilsack & Clark, 2014). When discussing the human workforce that actively participates in the Unites States agriculture sector a contrast can be seen between B.C.E. in the aspect that farm labor is now paid for, however their living conditions are not generally provided for. The Economic Research Service published a study on Immigration and Rural Workforce that presented information collected by the U.S. Department of Labor's National Agricultural

Workers Survey (NAWS), which revealed that forty-eight percent of crop workers were not legally authorized to work in the United States (Hertz & Zahniser, 2017). These migrant workers are paid an average of ten dollars an hour and it is no longer a common practice to house workers on the farm. Instead, laborers, must pay for their own housing, clothes, and food. One of the worst aspects of hiring migrant workers is that the employer is not required to offer health insurance and/or follow labor laws because the worker is not a documented citizen. This leaves the laborer unprotected and vulnerable to be exploited. Because of the increased use of farm equipment, a worker's job satisfaction and health may not be considered vitally important to the success of the farm. A stark contrast can be seen from the better working conditions that were considered standard during B.C.E. are no longer the standard of today's society.

Conventional farming has dramatically increased the size of the average farm in the United States, thus the general selection of crop and crop production systems have changed. B.C.E. farms required a more diverse realm of needs which led to a more diverse production of crops. It was common for a farmer of that time to grow what was required in the totality of the production system. This included not only the growing process, but also storage and processing; grapes and olives were turned into oil and wine via on-farm structures and equipment. This also included things such as food crops to feed the farmer's family and all the housed workers, willow for the utility of weaving baskets, a

wood stock for building and heat energy and pasture land as feed for the livestock (Cato & Dalby, 1998). Vineyards of wine grapes and/or groves of olives were the common cash crop of these farms, but were not the only crop produced on the property; this is known as a polyculture production system. Varro supported Cato's advice of increasing diversity and goes into further detail in his chapter on crops. The decisions of what and where to grow were usually determined by the layout of the land; for not everything can be sown on rich land, and some crop cannot grow on poor land. It is better to plant crops per their needs so that one does not need to augment with additional inputs (Varro & Storr-Best, 1912). Varro made the distinction between what was to be farmed for the utility of the farm (food and willow), what was to be farmed for profits (grapes for wine or olives), the incorporation of orchards and flower gardens for the beauty and productiveness of the farm were all inseparable (Varro & Storr-Best, 1912). Varro described growing shrubbery for wicker weaving, wood for timber and bird capture, hemp, flax, rushes and esparto grass for oxen shoes and rope (Varro & Storr-Best, 1912). Crop selection and production were centered around sustainability, and tended to be local and independent. Today a much different environment of crop selection and production has arisen from the globalization and division of agriculture.

Food in the twenty-first century can now be shipped to anywhere from anywhere which has fundamentally changed the supply and demand of the market. A producer is no longer demanded to offer a variety of product because

products can be imported and gathered at the grocery store. Therefore, crop selection is no longer based around only the local markets, but the global markets. Advancements in transportation, equipment mechanization, the improvement of crop varieties, and the development of agrichemicals have led to the adoption and preference of monoculture agriculture (Altieri, 1998). One of the greater contributors to this shift in agriculture was specialized farm equipment. The development of crop specific farm equipment has influenced producers to produce one crop that is specific to their equipment, thereby making them very efficient. This may not seem like a large determinant because a producer could simply have more equipment for more crops; however, this farm equipment entails such a high investment that it is not financially profitable to diversify, therefore it is not recommended in conventional agriculture (Altieri, 1998). The USDA Economic Research Service reports that the United States is now the largest producer/ exporter (in order) of corn, soybean, wheat, cotton and hay. Conversely, the United States in 2013 imported 20% of the 120 billion pounds of food products consumed by Americans (Jerardo, 2017). Because agriculture is becoming more globalized, the selection of crop for a conventional farm is also influenced by a global perspective of comparative advantage. The term comparative advantage is defined as being able to produce a commodity more efficiently than the counterpart (Rhodes et al., 2007); in this case, other countries. The topography and climate in the United States gives us the comparative advantage in the production of grain and soybean products (thus

we export) but does not afford us the ability to efficiently produce more tropical commodities such as bananas and other tropical fruit (thus we import). A consequence of these market variables is the driving factor for crop selection is now centered around profitability of the market rather than the sustainability of operations.

The differences between B.C.E. and conventional agriculture are vast and differ in almost every area of their production practices; as one may assume when concerning the amount of time and innovation that has passed between the two. Despite the many differences, the two methods of farming begin with the practice of tilling the land to be used in production. Cato instructed tilling the land twice and then apply manure before planting any crop (Cato & Dalby, 1998). The tilling then was done manually with yokes of oxen on much smaller fields; whereas modern farms till using large equipment that can handle exponentially more land area. Varro refers to an *iugum* as being the amount of land that one yoke of oxen can plough in one day and is equal to about 57,600 square feet, or less than two acres (Varro & Storr- Best, 1912 line 36:2). Cato specified the proportions and priority of manure application: half of it to be carted to fields where fodder will be sown, a quarter laid around trenched olives and the remaining manure was kept for the pasture or where ever else it was needed (Cato & Dalby, 1998). Varro understood that manure increases the fertility of the soil and referred to animal dung as the greatest use of an animal besides its strength for ploughing (Varro & Storr- Best, 1912). Both Varro and

Cato advised keeping and collecting manure in large heaps, divided into two piles, and protected from the sun with twigs and branches to keep the sun from sucking out the goodness that the Earth requires (Cato & Dalby, 1998 and Varro & Storr-Best, 1912). Farms of this era heavily relied on the use of animals for fertilizer and power. Cato provided the approximate number of animals needed on a 120-acre plot to be: three yoke of oxen (2-4 each), three asses for carrying dung, one extra ass, one swine herd and 100 head of sheep (Cato & Dalby, 1998 pg. 54:10).

Research concerned with the effects of using animal manure as a fertilizer has found that dung from animals increases nutrient availability and organic matter within the soil. In the first edition of Animal Manure Recycling: Treatment and Management, edited by Sven G. Sommer, manure has not only been shown to replace depleted soil nutrient but also increase plant production (Sommer et al. 2014). Animal manure not only supplements nutrient levels but also increases the amount of carbon compounds in the soil which increase soil aggregation, water infiltration and microbial vigor. However, only seventeen percent of cornfields and six percent of soybean fields (the largest crop fields in the U.S.) receive animal manure as fertilizer. This is largely attributed to the lack of on farm manure and the cheap prices of synthetic fertilizers (Gardiner & Miller, 2008).

Alongside the use of animals and their manure, Cato and Varro incorporated supplemental crops not for harvest but for nutrient replenishment,

a practice known today as cover cropping. Varro wrote that some things should be sown "with a view", not for immediate profit but to aid in next year's harvest; explaining further that they should be cut down and left to improve the soil (Varro & Storr-Best, 1912). Varro provided a list of ideal plants for this purpose: lupins, beans, clovers, and *legumina* (legumes). Diversification and utilization was of importance during this era as was choosing the appropriate site for each planting which was done all over the farm. The moist, dry, shady and sunny areas of the farm were all planted with different varieties of plants (Varro & Storr-Best, 1912). Cato referred to cover crops as legumes that feed cereals and included: lupin, beans and vetch. Plants that were grown as a good source of manure were: straw, lupin, chaff, beanstalks, pods, holm-oak and oak foliage (Cato & Dalby, 1998). The benefits of cover cropping were not only evident during B.C.E. (before scientific experimentation). The Sustainable Agriculture Research and Education's third edition of *Managing Cover Crops Profitably,* says that the practice of cover cropping is known to cut fertilizer costs, improve yields by enhancing soil health, prevent soil erosion which, conserves soil moisture and protects water quality (Bowman et al. 2007). Legume cover crops convert nitrogen gas from the atmosphere into soil nitrogen that plants can use, a process known as "nitrogen fixing". The incorporation of legumes into a cover crop blend can eliminate the need to add external nitrogen inputs; the crop planted after a cover crop used 30-60 percent of the nitrogen the legumes added back to the soil in the previous rotation (Bowman et al. 2007). In regards to soil health,

cover crops increase water infiltration, relieve compaction, add organic matter and enhance nutrient cycling. The roots of any plant hold soil in place and reduce the erosion caused by wind and rain. By reducing water runoff, cover crops are helping prevent the pollution of water caused by sediment and nutrient leaching out of the soil. The range and scope of cover cropping can be increased by enhancing the diversity of the cover crops chosen for use (Bowman et al. 2007).

The transition into conventional agriculture was aided by the introduction of synthesized chemicals and their use as fertilizers, herbicides and insecticides due to the excess stockade of chemicals left over from WWII. Conventional agriculture does not generally use manure as a fertilizer; a large contributor to this is the division of our agriculture system. The separation of crop and animal production has led to the need of external (off-farm) inputs because manure is not readily available for use on the farm. Cows, pigs and chickens are now largely being produced via intensified production methods. For cattle and pigs, this process takes place on feed lots, and chickens are often confined to small cages. Confining greater numbers of animals indoors and further separating production operations from agricultural land will only exacerbate the environmental problems already posed (Steinfeld et al. 2006). These animals raised intensively are not grazed but rather fed a processed grain such as corn. Because of this, producers of corn harvest every bit of plant out of the soil for feed processing and leave nothing behind for the soil and its beneficial

inhabitants. In 1920, the total number of animals "on farm" in the United States was estimated to be twenty-five million. That number dwindled to a mere five million by 1954. The incorporation of chemicals along with the division of agriculture aided in shifting the overall focus towards increasing outputs by any means possible. Without the use of manure, the plant essentials of nitrogen, potassium and phosphorous must be met with synthetic fertilizers.

Harry A. Curtis published in Foreign Affairs that in 1922 the United States alone was consuming six million tons of fertilizers and imported around thirty-five million dollars' worth of raw material for the synthesis of agrichemical fertilizers (Curtis, 1924). The United States Department of Agriculture reports that the U.S. peaked in chemical fertilizer use in 1981 at twenty-four million tons. Government policies reduced consumption by six million tons after the introduction of Payment-in-Kind programs, since 2004 this number has shot back up due to the surge in corn production. American farmers have continued to use approximately twenty-two million tons since 2011 (Nehring, 2016). Corn production accounts for forty percent of U.S. fertilizer consumption; this is attributed to seed advancement by companies such as Monsanto that have developed favorable yield responses to high nitrogen fertilizers. Innovations such as these increased the total use of solid urea (46-0-0) which has the highest nitrogen by weight when considering solid fertilizers and the U.S. now imports fifty percent of total nitrogen demanded by its agriculture system (Nehring, 2016). In 2012, the National Census of Agriculture reported a seventy percent

increase in the purchasing of chemicals since 2007. During the same time frame the United States saw a thirty percent increase in farms changing their legal status to "corporation" or "industrial" while "family farms" saw a ten percent loss and "partnerships" suffered a loss of twenty percent (Vilsack & Clark, 2014). Conventional agriculture shows no sign of slowing down its use of chemical fertilizers and is becoming more corporate.

The practices of conventional agriculture have been reactionary because their production system is dependent upon the use of chemical fertilizers to produce a crop yield. Because the soil health is being depleted through the practices of conventional agriculture, the chemicals are combatting the symptoms of this consequence. However, the continued use of agrichemicals has reared some consequences of its own such as soil erosion. The problem of soil erosion is twofold: a displayed loss in productivity and sediment pollution. As mentioned earlier, one of the earliest displays of this was the Dust Bowl of the 1930's and since that time the United States has spent more than thirty billion dollars on erosion control and yet the methods have remained unchanged (Gardiner & Miller, 2008). The heavy and continuous use of synthetic fertilizers has been linked to the three and a half tons of soil loss per hectare annually across the southwestern United States. The loss of topsoil is the largest polluter of sediment and nutrients in lakes and rivers (Larsen et al. 2014). The settling and deposition of fertilizers into waterways is the process known as nitrification, and is the starting point of many environmental problems such as the algae

blooms in the Gulf of Mexico from water runoff depositing phosphorous out of the Mississippi Delta. The large amount of manure that is accumulated by intensive animal raising is not being relocated and used by farms, and is becoming a large contributor to pollution found in waterways due to runoff and poor management practices (Thorne, 2007).

The harmful side effects of soil health loss leading to erosion have not gone unnoticed. The Unites States initiated the Soil Conservation Act of 1935 along with the creation of a branch of the Department of Agriculture known as the Soil Conservation Service (SCS). The issue became of greater concern in 1970 due to the heavy use of agrichemicals. The National Environmental Policy Act, signed into law by Franklin D. Roosevelt mandated that all federal agencies document and report their impact on the environment. The Soil and Water Resource Conservation Act of 1977 which authorized and required the USDA to monitor and report the soil and water health of non-federal lands so that conservation strategies may be improved. In 1994, the Soil Conservation Service became known as the Natural Resource Conservation Service (NRCS) and expanded their impact by providing financial assistance to landowners that strive to protect natural resources through conservation practices (NRCS, 2017). In 2003 the Conservation Effects Assessment Project (CEAP) was created to quantify the benefits of conservation practices (NRCS, 2017). The consequences of conventional agriculture are being addressed, and yet, the methods of production system have remained unchanged costing the United States billions

of dollars annually. The United States Department of Agriculture's 2017 Budget Summary reports a need for $151 billion dollars in 2017; the largest portion of this money ($126 billion) is allocated for mandatory programs required by law such as crop insurance and nutrition assistance programs (USDA, 2017).

Conclusion

The research has indicated that conventional agriculture is costing the United States billions of dollars to sustain the current methods of production. The integral value of the land that was instilled in a B.C.E. farmer has been replaced with profits and outputs by any means necessary. Agriculture has been divided into compartments that have become highly specialized through the proliferation of farm equipment designed specific to one crop with the ability to plant, harvest, and process. The United States industrialization of agriculture has increased the use of synthetic chemicals, and decreased the diversity of production and damaged soil health. These farming practices have displayed harmful environmental consequences such as the contamination of waterways and a loss of three and a half tons of topsoil per hectare annually. A depleted soil health does not only affect farmers. The countless system of interactions that involve the soil are vital to sustaining many forms of life. The damage done to the soil by conventional agriculture has not gone unnoticed, the United States has initiated a multitude of agencies and services meant to calculate and observe these harms, yet the actual methods of production have not changed. We are waging a war against our soil while simultaneously paying to sustain

destruction. Farmers of B.C.E. could not logically or profitably continue to operate sustainably if they had not understood the systems of production. These farmers understood that agriculture is not a linear process, but a cycle. Farming was a function of acting preemptively, such as using cover crop to supply nutrients for the proceeding crop. Unfortunately, these lessons have largely been lost on American farms today, where the production of crops depends on reactionary measure to the consequences of its own unsustainable actions.

References

Altieri, M. A. (1998). Ecological Impacts of Industrial Agriculture and the Possibilities for Truly Sustainable Farming. Monthly Review, 50(3), 60. doi:10.14452/mr-050-03-1998-07_5

Bowman, G., Cramer, C., & Shirley, C. (2010). Managing cover crops profitably. College Park, MD: SARE.

Cato, M. P., & Dalby, A. (1998). Cato on farming: a modern translation = De agricultura. Totnes: Prospect.

Curtis, H. A. (1924). Fertilizers: The World Supply. Foreign Affairs, 436-445. Retrieved April 4, 2017.

Deininger, K., & Byerlee, D. (2011). Rising Global Interest in Farmland. doi:10.1596/978-0-8213-8591-3

Gardiner, D. T., & Miller, R. W. (2008). Soils in our environment. Upper Saddle River: Pearson.

Hertz, T., & Zahniser, S. (2017, February 3). Immigration and the Rural Workforce. Retrieved April 10, 2017, from https://www.ers.usda.gov/topics/in-the-news/immigration-and-the-rural-workforce/

Jerardo, A. (2017, January 26). Export Share of Production. Retrieved March 24, 2017, from https://www.ers.usda.gov/topics/international-markets-trade/us-agricultural-trade/export-share-of-production/#exportshare

Jiang, H., Carver, J., & Cooke, B. (2017, February 23). Outlook for U.S. Agriculture Trade. Retrieved March 24, 2017, from http://usda.mannlib.cornell.edu/usda/current/AES/AES-02-23-2017.pdf

Larsen, E., Grossman, J., Edgell, J., Hoyt, G., Osmond, D., & Hu, S. (2014). Soil biological properties, soil losses and corn yield in long-term organic and conventional farming systems. Soil and Tillage Research, 139, 37-45. doi:10.1016/j.still.2014.02.002

Natural Resources Conservation Service. (n.d.). Retrieved April 05, 2017, from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/about/history/?cid=nrcs143_021392

Nehring, R. (2016, November 6). Fertilizer Use & Markets. Retrieved April 04, 2017, from https://www.ers.usda.gov/topics/farm-practices-management/chemical-inputs/fertilizer-use-markets/

Rhodes, V. J., Dauve, J. L., & Parcell, J. L. (2007). The agricultural marketing system.

Sommer, S. G., Christensen, M. L., Schmidt, T., & Jensen, L. S. (2013). Animal manure recycling: treatment and management. Chichester: Wiley.Scottsdale, Ariz: Holcomb Hathaway.

The State of Food and Agriculture 2014. (2014). Retrieved March 24, 2017, from http://www.fao.org/3/a-i4036e.pdf

Stienfeld, H., Gerber P., Wassenaar T., Castel V., Rosales M., de Haan C. (2006) Livestock's Long Shadow: Environmental Issues and Options. Rome: Food and Agriculture Organization of the United Nations

Thorne, P. S. (2007, February). Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards—Searching for Solutions. Retrieved April 05, 2017, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817701/

Varro, M. T., & Storr-Best, L. (1912). On farming: M. Terentii Varronis rerum rusticarum libri tres. London: Bell.

Vilsack, T., & Clark, C. Z. (2014, May). 2012 Census Publications. Retrieved April 04, 2017, from http://www.agcensus.usda.gov/Publications/2012/