Summer 8-5-2016

The Relationship Between Agriculture And The Environment

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THE RELATIONSHIP BETWEEN

AGRICULTURE AND THE ENVIRONMENT

by

Elise N. Volz

A capstone submitted in partial fulfillment of the requirements for the degree of Master of Arts in Education: Natural Sciences and Environmental Education.

Hamline University

Saint Paul, Minnesota

Summer 2016

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To my students, thank you for allowing me to teach you this curriculum so that I may grow and develop as an educator. I have learned so much from your feedback. Thank you to my Capstone Committee for taking time out of your busy schedules to support me throughout this project.
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CHAPTER 1

Introduction

Stretch. Reach. Put the paddle in the water. Now pull it back along side your body and repeat. I learned this motion in a canoe at my grandparents’ cabin on an overcast day when I was seven. This skill and technique has served me well over my lifetime. I have enjoyed peaceful paddles across countless lakes in the Boundary Waters Canoe Area Wilderness (BWCAW). My heart has raced as we have foregone the portages and taken on the fury of rapids, both with and against the current. I have dug deep to help paddle to safety in the face of wind and waves that would have even the most experienced canoers racing for the nearest shore. Little did I realize that this simple motion, this skill, would be the theme to my capstone process.

My research question is a stretch of my wildest imagination. I was raised in the timbers of northern Minnesota. I had never been around agriculture, never thought about its pros and cons, and now in the scope of this capstone is a topic that is suddenly very important to me. Within my reach is a better understanding of the area I will call home for the rest of my foreseeable future. So I am going to put the paddle in the water and pull it so that I may began to propel and drive my curiosity and research forward as I develop and analyze a curriculum that teaches about the interconnectedness and interdependence of agriculture, the environment, and society.

Views From A Deerstand
Five years old. That is how old I was when I got my first bow and arrow, and to this day it is still my favorite birthday present I have ever gotten. This rudimentary bow and arrow symbolized my beginning in one of the most practiced and revered outdoor activities my family does, bowhunting. The passion for bowhunting started long before I was born, with my grandpa and his friend Father Cassian. It has been passed down to my father and uncle’s generation, and now to my cousins’ and my generation. It is a way that I began to build my bond with nature on my own and with the people that I care for the most deeply.

Bowhunting has always been a way for me to connect with nature. I cannot count the number of times I have sat in the deer stand just observing the scenery around me. I watch the song birds flit among the treetops searching for food, the woodpeckers hammering away on rotten tree trunks searching for a tasty morsel, and if I am really lucky, I will be able to hear an owl hooting in the distance or feel the beat of a bald eagle’s wings as it flies over me. Then there are the squirrels. They are quick to trick the senses into thinking there is a whitetail behind me. The way they rustle the fallen leaves searching for the coveted acorn and move with uncanny agility as they scurry from place to place. These actions are enough to get me to turn around searching for what is not there. All of these moments are trumped by those heart-racing times when the whitetails are around my deer stand. There are intense moments where I have gotten to watch and listen to the crashing of antlers as two bucks fight and the more calm moments as a doe and her two fawns graze the snow covered underbrush in search of food. All of these moments mesmerize me and create a sense of wonder within me. It has been moments
like these where I yearn to learn more about these fascinating creatures, their habitats, and the processes that connect the woodland communities.

Environmental Mentors

Throughout my childhood and even into adulthood, four of my favorite environmental teachers have been my grandpa, dad, and two uncles. These men have demonstrated the best type of teaching, leading by example. There are countless times when I have been with these teachers, whether it was hunting, fishing, or just going for a walk through the woods where I have come away with more knowledge and appreciation for the outdoors. My Uncle Kent has taught me more about plant and tree identification just from walking through the woods than I have ever learned in any of my course work. I remember walking down the dirt road from my grandparents’ cabin when I was in seventh grade. Every time we came to a tree, fern, or wildflower, Uncle Kent pointed out each species’ distinguishing features and said the common and scientific name. Then twenty paces further down the trail he would hold a leaf in his fingers and ask me to identify it. It is from walks like these and the many conversations huddled around the wood stove at the hunting shack where I first learned phrases like “population management”, “ethics”, and “healthy environment”. It is moments with these teachers that got my heart deeply invested in caring for our environment as it centered around places that were dear to my family and me. These four men laid the foundation for my interest in proper care for the environment.

The Northwoods

Five channels. That is all we had for television choices when I was growing up. I lived for the opportunity to go to a friend’s house and watch, well really anything that I
was not privileged enough to get on my measly five channels at home. At the time, I thought my childhood was so deprived of entertainment and the basic rights of any child. I was not in the know of what was happening on the latest and hottest television show, and I felt like an outsider at lunchtime conversations at school. What I know now, is that the deprivation of television knowledge led me to a vast awareness of nature and passion for being immersed in nature.

Instead of sitting in front of the television set with my five channels, when I would get home from school my sisters and I would venture outside. Stepping out the back door of my parents’ house brought me to nature’s front door. I grew up in a ten acre spruce tree forest in Bemidji, Minnesota. I remember the day we moved into that house vividly. My dad told my sisters and I that we could not complain about being bored until we had named all of the trees on the property. In an effort to call his bluff, we headed out with a notebook in hand and began naming the trees. To this day, you can hear Bear Claw come up in an occasional conversation.

Those ten acres did not stop there, my parents’ property shared a boundary with state land where the spruce forest continued and the places to find adventure seemed to stretch forever. During the summer my sisters and I would pack our backpacks with binoculars, rope, whistles, and of course snacks, and head out to the woods to find new adventures. We would make our rounds to the deer stands that we used in the fall. We would imagine the thirty-point buck walking out in that perfect spot. With binoculars pressed to our faces, we would scan the distance for signs of wildlife. One of our favorite spots was the beaver pond where, if the water was low enough, we could walk all the way across the beaver dam to the other side.
One of my favorite adventures in those woods took place on a bitterly cold winter night. In the name of family bonding, my dad, mom, sisters, and I strapped on snowshoes and went for a walk in the woods. In complete silence, Dad started in the front of the Wolf pack, leading us down the trails that I knew even in my sleep. As we got a little farther into the woods, he started to veer off the path onto fresh sparkling snow. As the branches got thicker and started smacking my face, I could not help but think my dad was crazy. Just as I was about to say something we broke free from the tangle of branches and entered a clearing. Here were had a perfect view of the night sky, and just as I looked up I could see the dancing shimmer of the aurora borealis. The red curtains of light played across the night sky in graceful, sweeping motions that captivated the five of us; a new found respect and wonder was found for frigidly cold winter’s nights.

I could go on and on describing how the passion for the outdoors has been imprinted on my heart since my childhood. However, it is more than just my childhood memories that drive my fondness for the environment. I realized that one of the biggest ways that my appreciation for the environment was strengthened was when I become removed from my parents’ forest. This happened when I graduated from highschool and ventured to southern Minnesota for college and eventually my career and relationship.

The Southern Plains

The first thing I noticed when I moved to southern Minnesota was the wind. The wind was always blowing, it seemed like it never stopped. Then one day I realized something was missing, something that I had grown up with, something that I had taken for granted for all those years in Bemidji. The trees. Those green, luscious evergreens
that blocked the wind and sun were not to be found in southern Minnesota. My landscape had changed. I had traded trees and crystal clear lakes for a landscape dominated by farmland and algae infested ponds and lakes. Mile after mile, section after section of plowed land dotted with bodies of water covered in a slimey green sludge was my new home. This was an insurmountable loss, what was I to gain in this seemingly barren land?

As a junior at Minnesota State University, Mankato, I met one of my best friends and little did I know at that time, one of the greatest influences of my environmental ways of thinking. Merissa was not in the teaching program, however, she and I shared a passion for ecology, and we met in a lake ecology course where we were vastly outnumbered by the males in the room. To say we became fast friends may not be telling the whole truth, but we quickly learned to respect each other for each other’s strengths and weaknesses. It was through this respect that an unbreakable friendship formed.

It is to Merissa’s credit that I married my husband. It was on a whim that I decided to take her recommendation and go on a blind date with one of her high school friends from Blue Earth, MN. Luckily for her, Travis and I have been mostly inseparable ever since. When we first started dating I had a teaching position in a small town in central Minnesota. I was back among the trees and closer to my family. It took two years for him to convince me to make the move to the seemingly barren land without trees of southern Minnesota. I found a full-time teaching position at an incredibly small school where I currently teach every kind of science required for high school graduation in the state of Minnesota. It was here that I became immersed in a culture of agriculture and an altogether different view on the environment from my own.
Working and living in the heart of an agricultural area, I started to see how agriculture is a necessity to our livelihoods. I began to benefit greatly from farming, and I will continue to for the rest of my life. I did not see a problem with this until I was talking with Merissa about her day at work. Merissa works for the county soil and drainage department for Faribault County. She sees first hand the negative environmental effects of farming: the unnatural movement of water, the contamination of water, the loss of topsoil, and the destruction of natural habitats, specifically wetlands. On that particular day, Merissa said that she had been talking with a landowner who was very interested in restoring one of his low lying fields that flooded every spring into a wetland. She asked him why he was willing to pursue this, his response was, “I keep asking myself, what is my legacy?” Talking with Merissa, I began to realize that despite the benefits and requirement of agriculture it is not without its consequences.

Furthering My Education

It was this conversation that really developed my interest in potential solutions to the environmental crisis caused by conventional agricultural practices. However, it was not until I started the Natural Sciences and Environmental Education program at Hamline University that I realized I was going to take this curiosity any further. There have been two stand out moments throughout the courses of my training at Hamline. The first was the Environment and Society course that I took the summer of 2014, taught by Tracy Fredin. Tracy had a guest lecturer join our class, Dr. Christie Manning. Dr. Manning presented information regarding the psychology of sustainable behavior, and her message was about how to positively influence people to change their behavior, specifically regarding environmentally friendly habits. Her message was full of easy steps to invite
behavior to change and filled with a positive undertone that has stuck with me. From Dr. Manning’s lesson I have gleaned that if conventional farming practices are going to shift to more sustainable techniques, the change is most likely going to happen in a few generations from now. It is going to start when my students inherit the family farm.

The second stand out moment I have had throughout my courses at Hamline was during the fall semester of 2015. I took Mike Link’s course, History of the Environment. One of the assignments in this course required us to do a literature review of some kind of environmental work. I chose to focus my attention to Rachel Carson’s book, *Silent Spring*. *Silent Spring* is an exposé of the dangers that exist because of the chemicals used in agriculture practices. The purpose of these chemicals can range from demolishing unwanted bugs and plants that grow and steal nutrients and space from the desired crops to spraying whole communities so that pesky insects will not infuriate the residents. It went into detail about the dangerous of these chemicals to both the biotic and abiotic factors of the environment and humans. Carson presented scary statistics and warnings about the unknown long term effects of this chemical. All the while she was warning of the dangers of these toxins, she was able to offer biologically friendly ways to combat the unwanted pests in farmers’ fields. It was her words that resonated with me that there are environmentally friendly ways to have a successful agricultural operation.

Perhaps my most personal reason for wanting to investigate sustainable farming practices is because Travis works with these toxic chemicals. Every summer he helps to drown the environment with poisons that kill nature’s pollinators and natural species. He handles these dangerous toxins, inhales these dangerous toxins, and perhaps even gets unknowingly coated with these dangerous toxins. I struggle with this immensely. One
day he too will inherit the family farm, and I do not want to stand on the sidelines and watch my husband make choices that are harmful to the environment. I want to be able to knowledgeably and effectively communicate that there are different and profitable approaches to farming that do not harm the environment. I want my children and grandchildren to not only inherit healthy land, but also the values, responsibility and ethics that accompany sustainable agriculture practices. If I can accomplish this I will be proud of my legacy.

Conclusion

My family has an ideal place for teaching younger generations about the environment, and as a result, from a young age I have been immersed in its beauty on land and water. It is through those experiences that I have been able to create a connection with nature. This connection is built on respect, passion, and awe and follows me regardless of where I live. My deeply rooted respect for the environment is the reason that I maintain a level of concern for its health and sustainability and seek to increase education and knowledge among my students as I develop a curriculum that allows my students to discover the intertwined relationships between agriculture, the environment, and society.

The following chapter will highlight the concerns of conventional agricultural practices and the effect on the environment with a focus on the effects on soil health, water quality, and health effects towards humans. Sustainable agriculture techniques are based on the ideology maintaining the health of the environment so that agriculture can continue to be a successful enterprise. Sustainable agriculture techniques include crop rotation, the use of cover crops, and naturally occurring insecticides and herbicides.
Concerns surrounding sustainable agriculture include decreased profitability due to smaller yields. A detailed look at these facets of agriculture will also take place in the following chapter.

In addition to investigating the relationship between agriculture techniques and the environment, the next chapter will discuss various curriculum development methods. The methods that will be discussed are the Tyler Model, Taba Model, Saylor, Alexander, and Lewis Model, the Olivia Model, Understanding by Design Model. This investigation will serve as the foundation for my reasoning behind choosing the Understanding by Design Model to develop my Agriculture, the Environment, and Society curriculum.
CHAPTER 2

Literature Review

Introduction

Since the use of synthetic chemicals began in the 1950s (Luoma, 1989) there has been rising concern regarding the effects to the environment and human health. As a result of this concern, there has been a push to develop a more sustainable approach to agriculture. Those who are proponents of conventional agricultural techniques believe that sustainable agriculture provides an ethical dilemma because there are food shortages throughout the world. These farmers view it as their duty to have high yields, so that they may help feed as many people as possible (Nature, 2004). Those that are against conventional agricultural methods believe that those practices are detrimental to the environment and are not sustainable, believing that if conventional agricultural practices remain the dominant farming method, over time, there will be decreased yields (Nature, 2004). It is this profit based mentality that drives me to investigate how much my students know about sustainable agricultural practices and if their attitude towards sustainable techniques change after learning more about sustainable agriculture.

In order to highlight a need for change in agricultural mentality, this chapter looks at both agricultural techniques with a specific focus on how each method interacts with the land and the consequences of those actions. The chapter concludes with an investigation of five curriculum development methods. The analysis of curriculum development methods provides a backbone for selecting an appropriate one to use in the development of Agriculture, the Environment, and Society curriculum. This curriculum
will be used to teach students conventional and sustainable agricultural techniques and the effects of agriculture on the environment.

Conventional Agriculture Defined

Conventional agriculture can be defined as a method of agriculture that relies heavily on the use of fossil fuels, pesticides, and synthetic fertilizers (Luoma, 1989; Middleton, 2013; Kontopoulou, Bilais, Pappa, Rees, and Savvas, 2014). This technique has been employed since the 1950s (Luoma, 1989). Middleton (2013) describes conventional farming as creating a monoculture and warns that growing a single crop species over a large area is detrimental to the biodiversity of the area and can increase the habitat for agricultural pests.

Conventional agriculture techniques observe the separation of livestock and crops. This disconnect between the livestock and crops can create a build up of manure at the sites where the livestock are raised (Middleton, 2013).

Sustainable Agriculture Defined

Sustainable agriculture can be known by many other terms including organic farms, healthy farms, and agro-ecological agriculture (Luoma, 1989). Sustainable agriculture is associated with a range of techniques such as those employed by the Amish to agricultural options that incorporate the use of large implements (Luoma, 1989). One of the programs associated with sustainable agriculture is the National Organic Program Standards (NOPS). One of goals of NOPS is “to increase and sustain soil organic matter through reduced tillage and sufficient organic matter inputs” (Bellows, 2005). Europe defines organic farms as those that do not use chemicals, hormones to increase growth, antibiotics, or genetically modified organisms. Additionally, these organic farms may
use mechanical weeding devices such as ridge-tillers and rotary hoes to help reduce the need for chemical herbicides (Luoma, 1989; Puech, Poggi, Baudry, & Aviron, 2014).

Regardless of the title or the country, these farms have similar goals. The goals of sustainable agriculture are to produce affordable foods so that the United States and others around the world may be fed and sustained, to be a feasible agriculture technique for farmers so that they may sustain a comfortable way of life, and to be focused on maintaining the health of the environment by sustaining maximum soil health and the health of the surrounding areas (Middleton, 2013). Middleton (2013) suggests completely abandoning the conventional agricultural systems and creating a new, more sustainable system. The goal of the new systems needs to recognize that farms need to be "multifunctional, regenerative, biodiverse, and interconnected with the natural and human landscape." (p. 7-8).

In order to achieve a sustainable farm, farmers need to focus on agricultural techniques that support the health of the environment. These techniques include using biological pest control, using compost and manure as natural fertilizers, and maintaining soil health through crop rotation and cover crops (Kontopoulou et al., 2014). Middleton (2013) also suggests producing a variety of crops, farming livestock and crops together, and using cover crops.

Sustainable agriculture calls for farmers to begin to focus on the landscape as a whole, and see there is immense value in the untilled land surrounding the farmland. These areas house many pollinators and natural pests that can help decrease the reliance of chemicals, additionally there is an abundance of life in the untilled areas, which helps increase the biodiversity of the area (Middleton, 2013). Benton, Vickery, and Wilson
(2003) found that when the landscape exhibited a heterogeneous mixture of species, the overall biodiversity of the area increased.

As farmers grow more varieties of crops and then rotate the location of these crops each year, this helps decrease soil loss and can reduce the dependence of chemicals. One sustainable technique modeled from the agricultural techniques of the Central American Indians is to grow different species in the same field and alternate rows with the different species (Luoma, 1989). An example of this is to plant corn, squash, and beans in alternating rows. The corn provides a natural framework for the beans to grow. The beans replace nitrogen to the soil through a the process of nitrogen-fixation done by the microbes, *Rhizobum* in the roots of the beans (Kontopoulou et al., 2014). The squash provides vegetation that blankets the ground, reducing soil erosion (Luoma, 1989). A more common sustainable practice is to alternate rows of corn and sugar beets or rye and soybeans. Luoma (1989) suggests that crop rotation should include years where no crops are planted in a field. This provides time for the rate of soil fertility to increase quickly, which will compensate for the lost profit during the “soil building” (Luoma, 1989) year.

Raising livestock and crops together benefits the farm because the manure can be used to fertilize the crops. Grazing pastures have been shown to reduce soil erosion, store carbon, and provide habitat for pollinators. Finally cover crops, such as rye, clover, and hairy vetch, when planted between growing seasons can decrease soil erosion, add nutrients to the soil, and decrease pests and weeds. Cover crops can make the farm less susceptible to the detriments of draught (Middleton, 2013). Larsen, Grossman, Edgell, Hoyt, Osmond, and Hu (2014) found that planting cover crops in between growing seasons increased the amount of nitrogen in the soil.
Middleton (2013) recognizes that some farmers may be leery to make switches from conventional agricultural techniques. Cover crops usually require start up money, and those crops will not be sold for profit. Middleton (2013) also points out that taking tilled land and removing it from the farming operation will reduce the farm's short-term profit. In order to minimize profit loss, it is important to initially find a compromise between the two agricultural methods, and it is recommended that farmers make the shift from conventional agriculture to sustainable practices gradually and refrain from completely removing chemicals from use initially (Luoma, 1989). Gabriel and colleagues (2009) found that farmers are more likely to make the switch to sustainable agriculture if other farms in the area have already made the switch. Puech and colleagues (2014), found a similar trend and concluded that the agricultural technique of one farm is related to the overall techniques of the area.

Due to the nature of sustainable agriculture, its crops and techniques can change yearly. It is these changes that help increase yields and decrease runoff. The changes in crops and methods can help increase the organic matter found in the soil which in turn can help diminish the proliferation of weeds (Nature, 2004).

Agriculture and Pest Control

Organisms must consume energy in order for them to grow and survive. This remains true even for organisms that humans may not want to grow and survive. These organisms are deemed pests. In the realm of agriculture, pests are known to damage plants and reduce yields. Conventional farmers have turned to the use of chemical pesticides to curb the effect of various agricultural pests. Pesticides are used to prevent pests from physically damaging the crops (Batie, 2001). While sustainable agriculture
turns towards a technique, integrated pest management, that reduces the need for pesticide application and embraces nature’s natural enemies (Calvert et al., 2008)

Conventional Pest Control Techniques

Conventional farmers choose to use inorganic chemicals as pesticides for various reasons. Pesticides is a general term used to describe various chemicals used against an assortment of agricultural pests. Pesticides include herbicides, insecticides, fungicides, and other less common chemicals. Between 1996 and 2007, 63% of the overall monies spent on pesticides were allocated to the purchase of herbicides, including growth regulators. Insecticides accounted for 21% of the overall monies spent on pesticides, fungicides accounted for 10%, and the remaining 7% were the less common chemical group (Epstein, 2014).

One of these reason farmers choose to apply pesticides is government policy. Many conventional farmers receive federally subsidized crop insurance. One of the components of this insurance requires farmers to demonstrate best practices, which translates to the use of pesticides (Epstein, 2014). Corn growers in the mid-west United States that have crop insurance spent 21% more on pesticides than those farmers without crop insurance. Those farmers, also infected 63% more acreage with insecticides than those without the federally subsidized crop insurance (Epstein, 2014).

When analyzing the overall costs associated with agriculture, pesticides are relatively inexpensive (Epstein, 2014). From the 1980s until present, the costs of fuels, seeds, fertilizers, and farm labor has increased twice as fast as the cost of pesticides (Epstein, 2014). The overall trend for pesticide cost has increased since 1951. In 1951, pesticides accounted for 0.9% of the overall farming costs, in 1964, 1.3%, and in 1998
5.0%. In 2010, the percentage of the overall farming costs that was attributed to pesticides had dropped to 3.9% (Epstein, 2014). The global pesticide market averages $31 billion dollars per year (Batie, 2001).

Looking at the mass of chemicals purchased in 2007 the breakdown among the different categories looks like this. 200 million kilograms of herbicides and growth inhibitors were purchased, 29 million kilograms of insecticides, 20 million kilograms of fungicides, 60 million kilograms of fumigants and nematicides, and 88 million kilograms of sulfur and other miscellaneous chemicals were purchased. The total cost on these chemicals was $7.9 billion dollars (Epstein, 2014).

Despite their relatively inexpensive nature as a means to control agricultural pests, pesticides are not without their downside. The negative effects of chemical pesticide use can harm the environment and be detrimental to human health. Synthetic chemicals can be responsible for polluting water resources, the air, and soil (Luoma, 1989). According to Epstein (2014), the honeybee population is decreasing. The culprit of this decline is still unknown, but pesticide use is being looked into as one of the major components. When conventional agricultural fields are inundated with pesticides, the target pests are not the only species that absorb the chemicals. Plants can absorb these chemicals through the soil, stems, and leaves, without damage to the plants. However, when those plants get consumed by other organisms it can be deadly (Epstein, 2014).

In 1979, the Environmental Protection Agency (EPA) banned 1,2-dibromo-3-chloropropane (DBCP). DBCP is water soluble and was shown to contaminate groundwater near where the chemical was being used. The effect in humans of consuming the contaminated groundwater was sterility (Epstein, 2014). Methyl bromide
(MB) was another chemical that required government intervention. MB was shown to contain chemicals that are responsible for decreasing the protective ozone layer in the atmosphere (Epstein, 2014).

According to Calvert and colleagues (2008) those who work in agriculture are at greater risk for pesticide exposure. This exposure can occur from mixing pesticides, loading pesticides into devices that disseminate the chemicals, applying pesticides, re-entering areas that have been inoculated with pesticides too soon after application, experiencing contact from pesticide drift, and not following the instructions on the label (Calvert et al., 2008). Luoma (1989) points out that not all synthetic chemicals are harmful to the environment and the health of humans and even these good chemicals can become detrimental to the environment if they are not used properly, according to the label instructions.

Acute pesticide poisoning includes symptoms such as headaches and dizziness, blurred vision, nausea and vomiting, and skin irritations. There are much lower incident rates of upper respiratory and chest pains (Cavert et al., 2008). Calvert and colleagues (2008) researched the incident rates of various forms of acute pesticide poisoning and drew these conclusions. Females are more likely to experience acute pesticide poisoning than males. This may be because, of the females surveyed only 27% of them used personal protective equipment (PPE) when handling pesticides compared to the 40% of the males surveyed. PPE use has been shown to decrease nervous system irritation, aggravation of the gastrointestinal system, and respiratory problems, while it does increase episodes of eye and skin agitation (Calvert et al., 2008). Calvert's research concluded that "...despite strengthening the Worker Protection Standard for Agriculture
Pesticides in 1995, agriculture workers continue to have an elevated risk for acute pesticide poisoning." (pg 893).

The 2004 National Agricultural Workers Survey found that agriculture workers are ten times more likely to experience acute pesticide poisoning than Calvert's (2008) research (US Department of Labor, 2014). In 2005 the Bureau of Labor Statistics Survey of Illness and Injuries examined the prevalence of injury and illness among farming (farms with less than ten workers were not included), fishing and forestry. The survey found that there was a yearly injury rate of 5.7% and a yearly illness rate of 0.4%. Three percent of the yearly illness rate was attributed to poisonings.

The effect of more long-term exposure to pesticides needs more examination, but a few generalized conclusions can currently be drawn. Prenatal exposure to organophosphate insecticides can cause brain abnormalities and decreased cognitive development in children, neonicotinoid insecticides can decrease immunity, and occupational or environmental exposure to organochlorine, organophosphates, and pyrethroids can cause a decrease in sperm counts (Epstein, 2014).

As a result of the required decrease of MB, the use of the chemical dichloropropene has increased. According to the EPA, this chemical is likely to cause cancer in humans. Chloropicrin and Metam potassium use is also increasing with the government regulation on MB (Epstein, 2014).

Perhaps the greatest known insecticide to be governmentally banned is dichlorodiphenyltrichloroethane, better known as DDT. DDT is an organochlorine insecticide that was shown to be very effective at removing insect pests from agricultural areas, cities, and decreasing the threat of deadly human diseases by killing insect vectors.
However, in 1962, Rachel Carson wrote *Silent Spring*, which highlighted the dangers of DDT and other synthetic chemicals to humans and other organisms that were not the intended target (Epstein, 2014). This expose initiated the process for banning the use of DDT.

To help monitor the risks associated with the exposure to agricultural pesticides, in 1974 the EPA developed the Worker Protection Standard for Agricultural Pesticides (WPS). The goal of this program was to help reduce the exposure of agriculture workers to pesticides. However, later analysis of the program indicated that it was not working, and in 1992 it was revised. The revisions included education of workers and handlers of pesticides, prohibiting workers from entering an inoculated area for an extended amount of time after inoculation, including more agricultural occupations, and changes to what information is required on the manufacture labels. The final aspect of the revision prohibits employers from punishing employees who follow the rules and regulations spelled out in the WPS (Calvert et al., 2008).

*Sustainable Pest Control Techniques*

Since one of sustainable agriculture’s goals is to be conscientious of the health of the environment, those that embrace sustainable agriculture shy away from the use of pesticides and inorganic materials. These farmers employ a pest management technique of incorporating natural biological enemies of the pests into the agricultural landscape (Calvert et al., 2008).

This technique was used as early as 1873 with the introduction of the Vedalia beetle (*Rodolia cardinalis*) in California to help destroy cottony cushion scale (*Icerya purchasi*) (Batie, 2001). Since 1961, the microbe *Bacillus thuringiensis* (Bt) has been
registered as a pesticide with the United States Environmental Protection Agency. Bt is being used as a natural insecticide because it is found naturally in healthy soils (Batie, 2001; National Pesticide Information Center [NPIC], 2015). Insect larva will consume the toxin, and the toxin will activate when it reaches the gut of the larva. This causes the insect to perish due to infection or starvation, which can occur within hours of ingestion or may take as long as weeks (NPIC, 2015).

Bt is environmentally friendly because it only becomes activated when the environment is basic, such as found in the gut of insect larva. If Bt is introduced to an acidic environment, such as the human gut or most soil types, it is quickly and easily broken down (NPIC, 2015).

The global market for biological pest management practices is $700 million each year (Batie, 2001). In the United States, there has been legislation to support integrated pest management systems or the reduction in pesticide use has been in the works since 1987. In 1987 Iowa politicians supported the implementation of a tax on pesticides and other chemicals used in the agricultural sector. This tax help boost Iowa’s state revenue $1.3 million (Luoma, 1989). At about the same time, Senator Wyche Fowler from Georgia proposed the Farm Conservation and Water Protection Act. This legislation would allow sustainable farmers to receive some of the same federal crop subsidies as their conventional agricultural counterparts (Luoma, 1989).

**Agriculture and Soil**

One of the common resources between conventional agriculture and sustainable agriculture is soil. Both techniques rely on the characteristics of soil and the resources found within this natural entity. Fred Krischenmann states that “Soil is not a factory, it’s
an organism.” (Luoma, 1989). Both conventional agricultural techniques and sustainable techniques have different effects on soil health.

**Conventional Techniques and Soil**

Conventional agricultural techniques interact with the topsoil through two ways, chemical interactions and tillage. The use of synthetic chemicals and tilling the land are both responsible for the reduction in soil microbe populations (Leite et al., 2010). When crops are inoculated with chemicals, excess and/or mis-applied chemicals may reach the soil. When this happens, the chemicals can kill microbes in the soil and decrease organic matter within the soil (Luoma, 1989).

Chemicals that sit on the soil surface is susceptible to runoff. This means that during heavy precipitation events excess water flowing over the land will carry soil particles with chemical residue on them into nearby bodies of water (Larsen et al., 2014). According to the United State Environmental Protection Agency (EPA, 2010) agriculture runoff is the leading cause of water pollution. It is estimated that one-third of all soil and nutrient runoff is deposited into a nearby water source (Kok et al., 2009).

The second way conventional agriculture interacts with the soil is through physically breaking the soil by tilling the land. This is done by turning over the soil with the use of heavy machinery. This process helps break up the topsoil and allows seeds to be more easily integrated into the soil (M. Lore, personal communication, April 8, 2015). Along with making the soil more penetrable for plant germination, tilling the land helps to disturb the soil and increase the decomposition rate by increasing the amount of soil exposed to oxygen (Bot & Benites, 2005).
Even though loosening up the topsoil can be a benefit for conventional farmers, it also is responsible for increasing topsoil erosion. As the particles are no longer bound tightly together or protected by the organic matter that can blanket the soil, tilling makes it easier for wind and water to pick up and move soil particles (Kok et al., 2009).

*Sustainable Techniques and Soil*

Sustainable agricultural practices may or may not include tilling the land. However, conservation tilling must have 30% of the surface covered in leaves and other organic litter as this reduces the potential for topsoil erosion (Larsen et al., 2014). Not only does leaving organic matter on the soil’s surface help decrease erosion, it is also a preventive measure against runoff and the contamination of bodies of water (Apezteguíz, Izaurralde & Sereno, 2009; Bollag, Myers & Minard, 1992; Lal, 2004). Organic matter left in the fields helps to increase infiltration of water into the soil, and it increases the ability of the soil to retain that water (Shepherd, Harrison & Webb, 2002; Williams & Petticrew, 2009).

Another technique that sustainable farmers employ to maintain soil health is the application of compost and other natural fertilizers. Compost promotes soil health by (Marianari, Masciandaro, Ceccanti & Greggo, 2000; Fernández-Luqueño et al., 2009) increasing the pore space which allows roots to more easily penetrate deeper into the soil (Marianari et al., 2000). This allows the roots to become more massive (Fernández-Luqueño et al., 2009). The application of compost also allows water and other gasses to flow more freely in the soil. This extra movement of water and gases stimulates decomposition. Larsen and colleagues (2014) completed an investigation comparing plots that were tilled and not tilled. Through their research, they found that in the plots in
which there was organic compost applied and no tilling took place, the soil contained more organic matter than plots that were treated with compost and tilled, conventionally fertilized and tilled, and the control plot. With the increase of organic matter, Larsen and colleagues (2014), also noted that there was an increase in carbon in the soil. Areas that received organic fertilizer and were not till had 14.34 g of carbon per kilogram of soil, whereas, plots that received conventional fertilizer and were tilled had 6.80 grams of carbon per kilogram of soil (Larsen et al., 2014). Similar observations were completed by Kontopoulou and colleagues (2012), and they hypothesized that the increase in carbon in the soil was likely due to the use of manure as a fertilizer and the planting of cover crops for multiple consecutive years. The plots that experience conventional agricultural techniques the soil experienced a greater loss in carbon, Larsen and colleagues (2014), suggests that this is due to increased runoff.

Agriculture and Greenhouse Gas Emissions

Regardless of the agricultural method, Smith & Martino (2007) report that agriculture is responsible for emitting between 10% and 12% of the world’s total greenhouse gas emissions. The most concerning greenhouse gases emitted through agricultural processes are nitrous oxide ($\text{N}_2\text{O}$), methane ($\text{CH}_4$), and carbon dioxide ($\text{CO}_2$) (Schulze et al., 2009). In addition to $\text{N}_2\text{O}$ being a greenhouse gas, it also tears apart the $\text{O}_3$ molecule that composes the ozone layer in the atmosphere (Ravishankara, Daniel, & Portman, 2009). Animal and crop productions are responsible for 70% of the yearly emission of $\text{N}_2\text{O}$ and 33% of the $\text{CH}_4$ emissions (Mosier et al., 1998; Mosier, 2001).

Sustainable agricultural practices employ the use of organic fertilizer in the form of compost and manure (Larsen et al., 2014) The use of organic fertilizer increases the
rate in which organic matter is decomposed, and this process increases the rate in which 
\( \text{N}_2\text{O} \) and \( \text{CO}_2 \) are released into the atmosphere (Kontopoulou et al., 2012). Increasing the 
amount of organic material in the soil increases the levels of carbon found in the soil 
(Drinkwater, Letourneau, Workneh, van Bruggen & Shennan, 1995; Gattinger et al., 2012). Kontopoulou and colleagues (2012) found that when sustainable agricultural 
practices were employed \( \text{CO}_2 \) emissions measured at 2645 kg/ha versus 2199 kg/ha when 
conventional agricultural practices were used. In terms of \( \text{N}_2\text{O} \), conventional agricultural 
techniques emitted 455 g/ha, whereas sustainable techniques yielded 363 g/ha of \( \text{N}_2\text{O} \), 
while the levels of \( \text{CH}_4 \) were not affected by the agricultural method (Kontopoulou et al., 2012).

**Agricultural Yields**

Historically, the goal of agriculture was to provide enough food for a family to 
make it through harsh winter months. However, in today’s economy and global market, 
agriculture is focused around high yields and high profits. To help increase yields both 
conventional and sustainable agriculture turn to fertilizers. Conventional agricultural 
methods focus on the use of synthetic fertilizers to return nitrogen and other nutrients to 
the soil, while sustainable agriculture methods employ the use of organic fertilizers 
(Larsen et al., 2014).

Some crops, such as various bean species, are capable of supplying nitrogen to the 
soil because of a symbiotic relationship with nitrogen-fixing bacteria on their roots. In 
conventional agriculture, it was noted that the number and size of the root nodules 
produced by the bacteria was significantly lower than in fields where sustainable 
agricultural methods had been used (Kontopoulou et al., 2012). When conventional
agricultural practices were used, 30 days after bean seeds were planted, the total nitrogen in the soil was higher than in the fields where sustainable agricultural practices had been demonstrated. This difference in nitrogen levels between the two different agricultural methods disappeared when the soil was sampled 85 days after planting due to the increase in the number and size of the root nodules on the roots of the bean plants in the sustainable agricultural fields (Kontopoulou et al., 2012).

Despite fields farmed with sustainable techniques being able to eventually compensate for the decreased quantity of nitrogen during the early stages of plant development, this lag time in nitrogen availability can negatively affect overall yields (Seufert, Ramankutty & Foley, 2012). Sustainable agricultural techniques rely on the nitrogen already found in the soil. However, this nitrogen is not available for plants to access until it is further broken down by soil organisms. The rate of this decomposition depends on the rate of mineralization of the organic litter found in the soil. This in turn can decrease the yield potential (Seufert et al., 2014). Kontopoulou and colleagues (2012) suggest that in order for sustainable agriculture to produce competitive yields, nitrogen must somehow be supplied to the plants during the early stages of plant development.

Since sustainable agriculture techniques refrain from the use of heavy tilling and pesticides, competition for the soil’s resources can factor into the overall yield. In fields that were tilled and conventional agricultural techniques, such as pesticide use, were employed the overall yields were eight times greater than fields that had been farmed using sustainable agricultural techniques. In those fields where only tilling and no pesticides were used, the overall yields were five times greater than the fields in which
sustainable practices were used (Larsen et al., 2014). This difference in yields is likely due to competition for resources from weed species as those fields where no pesticides were used the total weed biomass was significantly higher (Larsen et al., 2014).

Those proponents for sustainable agriculture argue that even though the initial biomass of the crops may favor conventional farming techniques research indicates that agricultural method has minimal impact on the dry weight of a harvested crop (Kontopoulou et al., 2014). In green bean pods the initial mass after harvest was 5.50 kg/m$^2$ in those crops that were farmed under conventional techniques. When sustainable techniques were used the initial mass of the pods was 3.67 kg/m$^2$. When both harvests were allowed to dry, the differences in pod mass between the cropping systems had diminished (Kontopoulou et al., 2014).

**Agricultural Methods Conclusion**

Conventional agriculture and sustainable agriculture have two different fundamentals. Conventional agriculture focusses on the profitability of the agriculture craft. The degradation of soil and water quality due to the use of synthetic pesticides and fertilizers and the increase in greenhouse gas emissions are ways that conventional farmers are harming the environment for the sake of the bottom dollar. The physical health of the farmers and those that live and/or work near agricultural areas are also compromised by conventional agricultural techniques.

Sustainable agriculture promotes a broader spectrum approach to agriculture. Instead of focusing on the instant profit, those that choose to farm sustainably factor in soil health and the biodiversity of the area in order to promote a healthier ecological landscape through the agricultural process. Sustainable agriculture focusses on using
nature to help promote the growth of crop plants through the use of manure and integrated pest management systems. The belief of sustainable farmers is the decrease in profit is an initial setback as the health of the ecosystem improves as synthetic poisons are removed from the system, so will the profitability of sustainable agriculture.

**Curriculum Development Models**

In order to effectively reach the young minds of students, teacher need to design curriculum that meets the needs of the students, incorporate the required topics, acquire or develop materials that enhance learning experiences, and have a solid grasp of the content (Graff, 2011). Curriculum development is a process that allows decisions to be made in order to develop effective classroom programs. The process of curriculum development allows for revisions within the programs as needed based on indication from continuous evaluations (Olivia, 2008). There are countless curriculum development models that provide a framework for developing and implementing curriculum. Often times, these models are general and do not offer solutions for precise problems. Using curriculum development models increase efficiency and productivity of the curriculum design and implementation process (Olivia, 200).

Curriculum development models began to take hold during the modernist era. The fundamental thinking of this era was that life was a mechanical process within a stable universe (Hunkins & Hammill, 1994). This transferred to curriculum development models that were defined by their categorical nature and taken out of context. The goals of modern curriculum development were separate from the experiences used to achieve the goals of the curriculum (Hunkins & Hammill, 1994).

*John Bobbitt*
John Bobbitt was one of the first to develop and integrate learning objectives into curriculum development. The objectives were determined by the needs to the students (Hunkins & Hammill, 1994). In 1918 he penned a book, *The Curriculum*, about curriculum development during the modern era and how the process of developing curriculum was not specific to an age group or subject area. He embraced a scientific and modernistic approach to education and thought of curriculum development as a form of science. In his book he argued that the components of curriculum could be identified (Hunkins & Hammill, 1994).

*Tyler Rationale*

Following in Bobbitt’s path was Ralph W. Tyler. Tyler too, supported the modernistic view of curriculum development and in 1949 wrote the book, *Basic Principles of Curriculum and Instruction*. This book introduced a curriculum development model known as the Tyler rationale. The focus of the Tyler rationale is the process for creating educational objectives. Tyler believed that educational objectives were developed from gleaning information from three sources: the learners, life outside of school, and the subject matter (Olivia, 2008).

According to Tyler’s rationale, once curriculum developers have come up with a multitude of educational objectives, the developers must apply two filters to each of the objectives. The first of these filters is the educational and social philosophy filter. Each of the objectives to pass through this filter must align with the values and beliefs of the each school. The second filter is the psychology of learning filter, objectives that pass through this filter need to be appropriate for the cognitive growth and development for the demographic of the students at hand (Olivia, 2008).
Once the pool of objectives has been screened through the two filters, those that remain are written in such a way that they will communicate what the student will do and the behaviors they will demonstrate. Once the objectives are solidified, Tyler proceeds to describe how curriculum will be selected, organized, and evaluated. These processes receive less attention than the development of educational objectives (Olivia, 2008).

Proponents of the Tyler rationale appreciate its application to any content area. They view curriculum that is developed in accordance with the Tyler rationale will be sequential and effectual and there will be control over the curriculum (Hunkins & Hammill, 1994). Opponents of the Tyler rationale believe that it does not require the various components to be reliant on one another. They also are of the opinion that the process is too procedural and lacks individuality (Olivia, 2008).

**Hilda Taba**

A colleague of Tyler’s, Hilda Taba, also took the modernistic-scientific approach to curriculum development. Taba authored the book *Curriculum Development: Theory and Practice*, which was published in 1962. Taba believed that the process of developing curriculum is a sequential process (Hunkins & Hammill, 1994). Perhaps the biggest advancement with Taba’s model is that she argued that teachers need to be involved in the curriculum development process (Hunkins & Hammill, 1994; Olivia, 2008).

Taba’s curriculum development process is composed of a five step process, each step is to be completed before progressing to the next step (Hunkins & Hammill, 1994). The five steps include producing pilot units, testing experimental units, revising and consolidating, developing a framework, and installing and disseminating new units (Olivia, 2008). Within the first step, producing pilot units, Taba has a seven step process
that include assessing the needs of the students, creating objectives, choosing the content, arranging the content, determining what to use for learning experiences, arranging those learning experiences, and finally evaluating the curriculum (Hunkins & Hammill, 1994).

Post-Modern Era

The focus of curriculum development shifted during the post-modern era. Now curriculum centered around play, chance, process and performance, and participation rather than purpose, certainty, finished products, and distant proximity from the process. This new era recognized that there was no single method of curriculum development that would work for the ever changing world, and therefore, many ideas and processes were necessary rather than just a few (Hunkins & Hammill, 1994). The post-modern curriculum development era paid attention to relations and connections made within the learning rather than the learning process, a more holistic approach was taken (Hunkins & Hammill, 1994). Curriculum development embraced uncertainty because many decisions made in the curriculum development process were designed partially because of “human experiences” (Hunkins & Hammill, 1994). This was fundamentally different from the modern era of curriculum development in that chaos was accepted (Hunkins & Hammill, 1994). Three models that embody the post-modern viewpoints are the Saylor, Alexander, and Lewis model, the Olivia model, and the Universal Backwards Design (UbD) model.

**The Saylor, Alexander, and Lewis Model**

The Saylor, Alexander, and Lewis model consists of three steps. Like the Tyler rationale, the first step is to outline educational objectives. The educational objects in the Saylor, Alexander, and Lewis model need to be placed into one of four categories: personal development, social competence, continued learning skills, and specialization
(Olivia, 2008). Once the educational objectives have been placed into the appropriate
category the curriculum is designed. Learning experiences are created from each of the
categories, and the curriculum designer determines the sequence for presenting each
learning experience (Olivia, 2008). From the curriculum design step, Saylor, Alexander
and Lewis, like Taba, encourage teachers affected by the curriculum to develop
instructional strategies to best convey the educational experiences (Olivia, 2008). The
final step to the Saylor, Alexander, and Lewis model is evaluation. This evaluation needs
to evaluate if the goals outlined in the first step were met, in addition they suggest
evaluating the evaluation process (Olivia, 2008).

The Olivia Model

Peter Olivia developed a curriculum model that includes planning and operational
phases. The ten components of the Olivia model allow for the development of
curriculum as well as instructional materials. The Olivia model can be used for
developing school wide curriculum (Olivia, 2008).

In Component I of the Olivia model, the curriculum developer describes his/her
educational philosophical and psychological beliefs and what he/she views as the purpose
of education. This process parallels Tyler’s screens (Olivia, 2008). Component II of
Olivia’s model assesses the educational needs of the community and students. It also
investigates the requirements of the content. Components III and IV identify specific
educational goals and objectives based on the values identified in the first component
(Olivia, 2008). The fifth component involves the organization and implementation of the
curriculum, and components VI and VII allow for more the curriculum to become more
specific to the grade level and the subject matter being taught (Olivia, 2008). Once the
The final curriculum development model to embrace the post-modern views on curriculum development is the Understand by Design (UbD) model that was developed by Grant Wiggins and Jay McTighe. Following in similar fashion to the Tyler rationale, Saylor, Alexander, and Lewis model, and the Olivia model, UbD also begins the curriculum development process by determining educational objectives (Graff, 2011; Hendrickson, 2006; Jones, Vernette, & Jones, n.d.). Wiggins and McTighe title their first stage “Desired Results” (McTighe, n.d.). The second stage, “Evidence” is where the curriculum developer, who is encouraged to be a teacher, will determine what evidence students will create or do in order to demonstrate mastery of the educational objectives (Graff, 2011; Jones et al, n.d., McTighe, n.d). The final stage of UbD is developing the actual lesson plan. In this stage teachers create learning activities to convey the desired information to the students (Graff, 2011; Jones et al., n.d.; McTighe, n.d.).

Perhaps the biggest emphasis within UbD is to create a curriculum in which students not only acquire knowledge, but the students can transfer that knowledge to a larger context (Graff, 2011; Hendrickson, 2006; McTighe, n.d.).
activities developed within the third stage are encouraged to be inquiry-based experiences that are aligned with the educational objectives of the first stage (Hendrickson, 2006). The use of inquiry-based activities allow the students to come to their own conclusions and develop their own opinions (Hendrickson, 2006). Teachers are used as a guide through these processes to help students make connections that further allow them to transfer their new found knowledge to a broader spectrum (McTighe, n.d). Teachers also serve as a guide as they monitor for student misconceptions (Hendrickson, 2006). The use of formative assessment is encouraged in order to catch misconceptions early on in the learning process. Formative assessments should remain ungraded and can be done through simple teacher observations, teacher conversations with students, worksheets, and student journal entries (Hendrickson, 2006).

Curriculum Development Conclusion

The Tyler rationale, Saylor, Alexander, and Lewis model, Olivia model, and UbD model begin with looking at curriculum development in general and work towards specific entities within their own designs. The Taba model is more inductive in that it is initiated with the development of materials which then leads to generalizations. All of these models have specific starting points followed by sequential processes that describe what needs to be done (Olivia, 2008).

Despite the details and sequences laid forth by these various models, there is no one model that will develop all of the necessary steps to creating curriculum because the process is complex and new unforeseen events and details appear with each new curriculum development process (Olivia, 2008). Developing curriculum is much more than knowing the content and state standards, the process of developing sound curriculum
also requires curriculum developers to take into account the students that will be using
the curriculum (Graff, 2011). Not only do curriculum developers need to be aware of the
student demographics, it also behooves them to understand the role society will play in
the development of their curriculum (Hunkins & Hammill, 1994). With all of these
variables being input into curriculum development, those that take on this task must
realize, “There is no master curriculum plan that we can generate for all times. Master
plans are illusions.” (Hunkins & Hammill, 1994).

**Agricultural Education**

Agricultural education is not something that is new to the academic scene. Since
the mid-1980s agroscience has taken hold in various academic realms (Thoron & Myers,
2008). This hybrid science can take one of two approaches to mixing science and
agriculture education. The first of these approaches is to embed the agriculture into the
science curriculum (Thoron & Myers, 2008). The second tactic is to inlay the science
fundamentals within the agriculture curriculum (Thoron & Myers, 2008). This second
approach is viewed as the best method to sustain agriculture education in schools (Thoron & Myers, 2008).

Borsari (2001), believes that agriculture education has taken a pause, and it is not
embracing a progressive mentality that aligns with the changing environment. The goal
of agriculture education needs to focus on regaining a semblance of homeostasis between
the environment and agriculture (Borsari, 2001). In order to achieve this homeostatic
relationship, agricultural education needs to have a solid foundation and understanding of
the many facets of ecology at play in agriculture (Duncan & Navarro, 2008). Laying this
foundation allows students to develop an emotional connection that stems the need for
change (Duncan & Navarro, 2008). Students who feel disconnected or have had adverse experiences with the content are less likely to embrace sustainable agricultural education (SAE) curriculum (Duncan & Navarro, 2008).

Another benefit of focusing on the complete ecological system in SAE is the positive, long-term benefits that are experienced by agricultural communities (Borsari, 2001). In order to develop a successful SAE curriculum, there needs to be focus on three aspects of curriculum development. The first of these is that the curriculum must align with the requirements of the students, the second area of focus is integrating relevant and up-to-date industry concepts within the curriculum, and lastly, creating assessments that are functional for both the students and the district (Thoron & Myers, 2008).

Agroscience allows the goals of SAE to be integrated into the curriculum through the use of inquiry-based learning activities that allow students to develop their own thoughts and opinions through hands-on laboratory investigations and activities (Thoron & Myers, 2008). Duncan & Navarro (2008) also indicate that demonstrations, hands-on activities, and agriculture experiences are productive ways of teaching agriculture education. A successful SAE curriculum will expose students to various farming techniques, struggles, and solutions from a global perspective in order to help cultivate and diversify the students’ thinking and perspective (Borsari, 2001). Finally, SAE needs to have clear terms and definitions so that it can easily differentiate between conventional agriculture and sustainable agriculture (Borsari, 2001).

At the secondary level, science and agriculture classes have begun to pique student interest, however, when these students look for SAE curriculum at the college level, they are left empty handed (Borsari, 2001). The challenge with developing and
implementing an SAE curriculum at the college level is due to many colleges and universities receiving funding from large agrochemical and food industry companies and often times an SAE curriculum will not align with the agenda of these substantial donors (Borsari, 2001).

Conclusion

Students, especially those immersed in an agricultural landscape, need to be educated about these two very different agricultural techniques. Prior to educating students about the difference between conventional and sustainable agriculture, it is important to assess what the students’ current thoughts are regarding the subject matter. Once a baseline of knowledge has been established, it is important for the curriculum to maintain an unbiased approach, this allows students to develop their own thoughts, opinions, and draw their own conclusions. Lastly, it is important to assess if there has been a gain in student knowledge and a shift in personal opinion as a result of the knowledge gained.
CHAPTER 3
Methodology

Introduction

The purpose of this study is to determine if learning about the relationship among agriculture, the environment, and society influence student opinions regarding sustainable agricultural practices. The study will consist of two parts, an action research component and curriculum development. The first part of the study will be completed through quantitative research with the help of pre and post-surveys. The surveys will allow me to measure if student knowledge and opinions regarding conventional agricultural and sustainable agriculture have changed throughout the course of learning the developed curriculum. Both Mills (2014) and Creswell (2014) indicate that surveys are a valid quantitative method for obtaining data.

The second focus of this project is to develop a SAE curriculum that provides students with learning experiences that will allow them to demonstrate their independence by formulating their opinion regarding conventional and sustainable agricultural practices. Understanding by Design is a curriculum development theory that focuses on providing students with learning opportunities so that they may draw their own conclusions (McTighe, n.d.).

Thoron & Myers (2008) indicate that 32% of agriculturally related occupations will require some type of science degree. The curriculum developed will provide students with the tools to make connections between the environment and the agricultural landscape. It will also promote the development of and foster student ability to solve
problems and work with others to achieve a common goal. These are skills that are desired by employers (Thoron & Myers, 2008).

Location of the Study

Rural southern Minnesota is a hub of agricultural activity. Schools located in this area are full of students who come from families with strong agricultural backgrounds. Glenville-Emmons High School (GEHS) is no exception to this norm. It is fairly common for students to miss school because their help is needed during planting, harvesting, farrowing or calving seasons.

GEHS is located less than ten miles north of the Minnesota-Iowa border, in the town of Glenville, Minnesota. Glenville has a population of 642 citizens. The school is surrounded by agriculture fields and the town is home to Glenville Grain, a local grain elevator business. An ethanol plant, POETS, is located just outside of town.

GEHS is home to all seventh through twelfth grade students in the district. It is a single section school. Over the past two years the district has seen a decrease in class size at the high school level, while the elementary class sizes remain stable. Throughout my career with this district, the graduating class sizes have averaged 20.3 students per year. The largest graduating class has been 29 students and the smallest has had 10 students receive their diplomas.

The most well participated in extracurricular activity is FFA. FFA is an organization that is open to students in eighth, ninth, tenth, eleventh, and twelfth grades. Activities of the organization revolve around many facets of agriculture. Students form teams and compete with other FFAs across the state for various titles and state
recognition. Membership fluctuates with our student population, but FFA captivates roughly half of the total student population at GEHS.

Participants

I have chosen to use my own students for this project. Agriculture plays a major role in some aspect, either directly or indirectly, of all of my students’ lives. Part of my mission as a teacher is to develop students who are well rounded and have an understanding of the connections and implications of human actions and the environment.

I will implement Agriculture, the Environment, and Society in my tenth grade biology class, the graduating class of 2018. This class is comprised of 17 students, ten boys and seven girls. Of these seventeen students, three of them (all males) are on individualized education plans (IEPs). Two of the male students are upperclassmen, one is a junior and the other is a senior. This class was chosen because it is one of the larger classes in the school and the curriculum of tenth grade biology provides a nice fit for a sustainable agriculture unit. The Minnesota State Science Standards for biology require students learn about the relationship among various communities and how the communities interact (Minnesota Department of Education, 2009).

Methods

Before I could begin to collect any student data, I obtained permission from the district to implement new curriculum into the tenth grade science class (Appendix A). In addition, approximately two weeks prior to the Agriculture, the Environment, and Society curriculum being taught, a letter was sent home to the parents and guardians of the students who would be participating in this unit. This letter provided the adults responsible for the students’ well being a opportunity to consent to or decline permission
for their student’s data to be used in the data collection process of this project (Appendix B).

In order to investigate if students’ knowledge and opinions of conventional and sustainable agriculture changed throughout the course of this unit, I needed to determine how much the students knew about conventional and sustainable agriculture and their current opinions regarding each. Questions on this survey (Appendix C) focused on four categories. The first category looked at the relationship of that student to agriculture. Questions were centered around how much agriculture directly influences the livelihood of the individual students. From there the questions fell into one of three categories, student awareness of conventional and sustainable agricultural definitions, students’ ability to identify conventional and sustainable agricultural practices, and student opinion of conventional and sustainable agriculture.

Once the baseline information has been gathered students were taught an approximately two-week unit *Agriculture, the Environment, and Society*. This unit was created so that students could understand how agriculture has changed over time, the different agricultural techniques associated with both conventional and sustainable agriculture, how agriculture affects soil health, and the importance of agriculture to their community. The unit also looked at the financial feasibility of switching from conventional agricultural methods to a more sustainable style of agriculture. Students investigated these topics through direct instruction, local interviews, and inquiry based activities. The unit culminated with students creating a fictional farm that integrates farming practices that the student felt best suits the balance between profitability and
environmental concern. The students were asked to base their farms on the information gathered throughout the unit.

The final aspect of the study will be to give the students a post-survey (Appendix D). The purpose of this final survey is to gauge if the knowledge and opinions of those who participated in the unit have shifted, and how the opinions have changed based on the information they may or may not have learned throughout the course of the unit. Questions on this survey will be similar to those questions asked on the initial survey. The main difference between the pre and post-survey was that the post-survey also asked questions regarding the effectiveness of various components of the unit.

The pre-survey and post-survey were disseminated using Google Forms. This mechanism was be used for three reasons. The first is that it is familiar to my students. My second reason for selecting Google Forms is that it is very user friendly for both the creation of the questionnaires and completion of the surveys. Lastly, it also provides an organized spreadsheet of the data collected from each of the questionnaires, make the analysis of the data easier.

**Curriculum Development Theory**

Understanding by Design (UbD) is a curriculum development method that emphasizes the ability for students to make connections with the main concepts and then transfer what they have learned to other aspects of the education and areas of their life (McTighe, n.d.). This process allows students to independently make meaning of the curriculum, and teachers are viewed more as coaches rather than disseminators of supplies and activities. UbD allows student understanding to be demonstrated through
six different areas: explanation, interpretation, application, changing point-of-view, empathy, and self-assessment (McTighe, n.d.).

UbD takes a backwards approach to curriculum development. Through three stages, the curriculum developer creates a curriculum that provides learning opportunities and focus on the “big picture”. The first stage is to determine the desired results of the curriculum, stage two investigates what evidences will be produced in order to determine if the curriculum goals were achieved, and the final stage is to create the learning plan (Graff, 2011; Jones et al., n.d.; McTighe, n.d.).

In the first stage the curriculum developer defines the goal of the curriculum. This stage defines knowledge and skills the students will gain from the instruction. Essential questions are written, long-term goals are defined, and student connections and meanings are determined (McTighe, n.d.). The second stage of UbD is the evidence stage. Here, the curriculum developer defines the items that the students will create and do in order to demonstrate that they have made connections and are making meaning of the curriculum. The final stage is to develop the learning plan (McTighe, n.d.). This stage focuses on designing activities and engaging experiences for the students so they will be able to accomplish the desired results outlined in the first stage (McTighe, n.d.).

I used the process of UbD to design the Agriculture, the Environment, and Society curriculum. First, I determined that my goal of the curriculum was to introduce students to two agricultural practices and identify student opinion about both methods. These essential questions came through in both surveys. The second stage of UbD requires the curriculum developer to determine how the students will demonstrate they have made larger and personal connections to the material. The evidences of connections made can
be seen in detail in the full lesson plans (Appendices E-J). The final requirement of the UbD process is to develop a complete learning plan for the curriculum. I used this stage to complete my unit with detailed lesson plans furnished with PowerPoint presentations, student worksheets, class activities, and a final project, again these components can be seen in Appendices E-J.

Conclusion

This project employed pre and post-surveys to determine if student knowledge and opinion about the relationship among agriculture, the environment, and society changed after learning about conventional and sustainable agricultural techniques, the various effects agriculture has on the environment, and communities drive agriculture. A six-lesson unit was implemented and students learned about the differences between conventional and sustainable agriculture, the relationship between the agriculture and the environment through direct instruction, inquiry activities, and research activities. The finale of the unit allowed students to create a hypothetical farm to demonstrate the student's awareness of the different agricultural practices and the reasons for these different practices.

The final component of this project was to analyze the data from the pre and post-surveys. This was done by graphing the data and analyzing any trends. Additionally, a summary of the data regarding components of the curriculum was explored in order to determine strengths and shortcomings of the Agriculture, the Environment, and Society curriculum. These results will be discussed in depth in the following chapter.
CHAPTER 4
Results

Introduction

This chapter will summarize the findings from the pre and post-surveys and discuss the student rated effectiveness of various components of the curriculum. Of the seventeen students in the tenth grade biology class, fifteen were surveyed. One student did not return the consent form, and one student was absent the day of the pre-survey so the student did not complete the post-survey in order to maintain consistency.

The first section of the survey was used to gauge the students connection to agriculture. They were asked to indicate if their immediate family relied on agriculture as a primary source of income for the family and if their extended family relied on agriculture as a primary source of income. Of the students surveyed 20% of the students’ immediate families rely on agriculture as a primary source of income for the family, while 60% reported that their extended family rely on agriculture as a main source of income for the family.

The second part of this section on the survey asked students to indicate their involvement in the family agricultural operation. Of the students that answered yes to questions about their family’s involvement in agriculture, 45.5% of students indicated that they rarely help with agricultural activities, and 9.1% stated that all of their spare time was devoted to helping with the agriculture operation.

The second and third sections of the survey focused on student knowledge of conventional agriculture and the techniques it uses and sustainable agriculture and its techniques. The fourth section of the survey asked for student opinion regarding which
method of agriculture the student felt was best for raising crops. The following provides a breakdown of data obtained for each of these sections.

**Conventional Agriculture Analysis**

There were four questions on the pre-survey pertaining to conventional agriculture.

- How would you rate your knowledge of conventional agricultural practices?
- If asked, how confidently could you accurately define conventional agriculture?
- How knowledgeable are you of the various techniques used in conventional agriculture?
- Based on your current knowledge regarding conventional agriculture, would you say it is the best way to raise agricultural crops?

Students used a Likert-type rating scale to indicate the degree with which they most agreed or disagreed to the statements, a one indicated the least amount of connection to the statement of question. A five indicated a strong connection with that statement or question, while a one indicated no connection with the statement or question.

When I analyzed the results of the surveys I looked at each question and quantified into a percent those that had selected a one or a two into a single group and those that had selected threes, fours, or fives into a second group. This was done for each question on the surveys. These groups will be referred to as the lower group and the
higher group, respectively. Simplifying the scale into these two groups allowed me to more easily identify any trends the data would present.

When asked to rate their knowledge of conventional agricultural practices on the pre-survey, 53% of students identified with the lower group and 46% identified with the higher group. The post-survey saw an increase of 46.8% of those students who more closely identified with higher group. This trend can be seen in Figure 1 where the pre-survey results are higher on the lower end of the spectrum and the post-survey results are higher on the high end of the spectrum.

![Student Knowledge Of Conventional Agricultural Practices](image)

Figure 1. Student responses on the pre and post-survey regarding their knowledge of conventional agricultural practices.

The question was rephrased to ask how knowledgeable students were regarding the various techniques of conventional agriculture, 60% of students on the pre-survey indicated that they had little knowledge regarding these practices and 40% felt they were fairly knowledgeable when it came to the techniques of conventional agriculture. On the post-survey all students felt they had a working knowledge or even felt very knowledgeable about the techniques used in conventional agriculture. The students’
increase in knowledge is shown in Figure 2. Again, the pre-survey shows a higher percentage of student relating to the lower numbers on the Likert-type scale, while the post-survey indicates students more closely relating to the higher ratings on the Likert Scale.

Figure 2. Student responses on the pre and post-survey regarding their knowledge of conventional agricultural techniques.

Students were asked how accurately they could define conventional agriculture. On the pre-survey, 73.3% of students indicated that they could not accurately define conventional agriculture, while 26.7% of students were confident in their ability to accurately define conventional agriculture. After the *Agriculture, the Environment, and Society* unit was taught, 93.3% of students felt they could accurately define conventional agriculture. Figure 3 shows the shift in student knowledge from the pre-survey to the post-survey.
The final question on the surveys regarding conventional agriculture asked students, if based on their current knowledge of conventional agriculture, they thought conventional agriculture was the best way to raise agricultural crops. On the pre-survey, 6.7% of students felt that conventional agriculture was not the best way to raise crops, while 93.4% thought it was the best way to raise crops. On the post-survey, there was a 13.5% drop of students who felt that conventional agriculture was the best agricultural practice for raising crops. Figure 4 shows the decrease in those students who felt conventional agriculture was the best method for raising crops. The decrease was in those that selected a three on the Likert-type scale rating.
Figure 4. Student responses on the pre and post-survey regarding if conventional agriculture is the best agricultural practice for raising crops.

Sustainable Agriculture Analysis

On the pre-survey, the sustainable agriculture questions mirrored the conventional agriculture questions.

- How confidently could you define sustainable agriculture?
- How knowledgeable are you of the various techniques used in sustainable agricultural practices?
- Based on your current knowledge regarding sustainable agriculture, would you say it is the best way to raise agricultural crops?

I used the same low and high groupings in order to analyze the data for this set of questions.

When asked how accurately students could define sustainable agriculture, 73.3% felt they could not do so and 26.7% felt they could somewhat confidently define sustainable agriculture. On the post-survey, there was a 66.6% increase in the number of students who felt fairly confident in their ability to accurately define sustainable agriculture.
agriculture. Of those students who felt fairly confident with their ability to define sustainable agriculture, 13.3% of students indicated that they were very confident in their capability to define sustainable agriculture. Figure 5 shows the increase in student ability to define sustainable agriculture after being taught the *Agriculture, the Environment, and Society* unit.

![Student Ability to Define Sustainable Agriculture](image)

Figure 5. Student responses on the pre and post-survey regarding their ability to define sustainable agriculture.

On the pre-survey, when it came to the question about student knowledge of techniques used in sustainable agriculture, 73.3% of students related with the lower group, and 26.7% felt they could relate to the higher group. On the post-survey, those that could related to the higher group increased 66.6%. Again, 13.3% of students were very confident in their ability to identify sustainable agriculture techniques. Figure six shows that the students were not confident in their knowledge of sustainable agricultural techniques prior to being exposed to the *Agriculture, the Environment, and Society* unit. Additionally, it shows that after learning the material student confidence in their knowledge of sustainable agriculture had increased.
Figure 6. Student responses on the pre and post-survey regarding their knowledge of sustainable agricultural techniques.

The final question asked students if they felt sustainable agriculture was the best way to raise agricultural crops. On the pre-survey, 20% of students felt that sustainable agriculture was not the best way to raise crops, while 80% of students felt it was the better choice for raising crops. The post-survey indicated that there was a 6.67% drop in students who felt sustainable agriculture was the best option for farmers. Even though there was a decrease in those in the higher group, there was a shift among the higher group. On the pre-survey, 83.3% of students in the higher group rated themselves low in the group, 16.67% rated themselves in the middle of the group, while 0% rated themselves as strongly agreeing that sustainable agriculture is the best way to raise crops. On the post-survey, 27.3% of students in the higher group rated themselves low in the group, 45.5% rated themselves in the middles of the group and 27.3% rated themselves as strongly agreeing with sustainable agriculture as the best option for raising crops. Figure 7 depicts the shift in student thinking.
Figure 7. Student responses on the pre and post-survey regarding if sustainable agriculture is the best agricultural practice for raising crops.

**Curriculum Development**

The second component of the post-survey was questions regarding different aspects of the *Agriculture, the Environment, and Society* curriculum. Students were asked three questions regarding nine components of the unit. The questions followed the following format.

- How much did (name of assignment/activity/lecture) increase your knowledge of how agriculture and the environment are connected?
- How much did (name of assignment/activity/lecture) increase your knowledge of sustainable agriculture?
- How much did (name of assignment/activity/lecture) increase your sense of community connections?

The assignments of the unit that were looked at included, “Looking at Change in Agriculture, Food Systems, and the Environment, “Connections”, and “Farm Interview”. The lectures that were included on the post-survey were, “Sustainable Agriculture
PowerPoint”, “Soil PowerPoint”, and “Full Circle Farm PowerPoint”. The class activities/discussions that were analyzed were, “Sustainable vs Conventional Class Activity”, “Agricultural Cost Analysis”, and the “Final Project”. These components represented various teaching techniques, and they catered to different learning styles.

In hopes of getting the best results on this part of the post-survey, I included an image of the unit component to help the students better remember the component being asked about. A second way that I tried to help students remember the components of the unit was that on the post-survey, the components were asked about in the same order in which they were used in the unit lessons.

Curriculum Analysis

*Looking at Change in Agriculture, Food Systems, and the Environment Assignment*

This particular assignment was designed to demonstrate how agriculture, food systems, and the environment have changed over the course of time. Students were asked to go home and interview people from three time periods, 1940s, 1980s, and the present. The results from the survey indicated that the majority of students (93.3%) felt this assignment helped them understand how agriculture and the environment are connected. There was also indication from the survey that this assignment somewhat increased student sustainable agricultural knowledge and the students’ sense of community, with 73.4% of students being placed in the higher group for each of these categories. Figure 8 depicts these trends.
Figure 8. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community on the assignment Looking at Change in Agriculture, Food Systems, and the Environment. Connections Assignment

The process of farm to table is not as simple as one might imagine. There are many facets to this process, growing, transporting, and selling food, that many people overlook and are unaware of. This assignment allowed students to construct a web of connections among multiple facets of going from farm to table. Figure 9 shows the results from the survey. When it came to students learning about the connection between agriculture and the environment 86.7% of students felt this assignment helped demonstrate that connection. Seventy-three percent of students felt the assignment helped them gain more knowledge about sustainable agriculture, and 93.4% of students felt this assignment increased their sense of community.
Figure 9. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community on the assignment Connections.

Sustainable Agriculture PowerPoint

This PowerPoint was a form of direct instruction. Students were given the definition of sustainable agriculture as well as examples of various sustainable agricultural practices. All students felt this part of the unit helped them gain an understanding of how agriculture and the environment are connected. Almost all students (93.4%) felt they gained knowledge when it came to sustainable agriculture, and 80% of students felt an increased sense of community after going through this part of the lesson. These results are shown in Figure 10.
Figure 10. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community from the *Sustainable Agriculture PowerPoint*.

**Soil PowerPoint**

This was the second direct instruction PowerPoint of the unit. This lesson focused on the importance of soil and the multiple components of soil. This lesson also presented soil as a community of organisms each of which play an important role in soil health. Figure 11 shows that eighty percent of students felt this lesson helped them gain knowledge in the connection between agriculture and the environment and sustainable agriculture, and 73.3% of students felt an increase in their sense of community.
Figure 11. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community from the Soil PowerPoint.

Sustainable vs Conventional Class Activity

For this portion of the unit, students were paired up and had to take a sustainable agricultural practice they had previously learned about and identify its conventional agricultural counterpart. Once they had the two different methods, they needed to identify pros and cons of each method. The final component to this activity was that each pair had to present their findings to the class and insert their data into a class chart.

Figure 12 helps illustrate that 80% of students thought this assignment helped them gain knowledge about how agriculture and the environment are connected, 86.7% of students felt this activity helped them gain knowledge about sustainable agriculture, and 73.3% of students felt they gained a sense of a community from this activity.
Figure 12. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community from the *Sustainable vs Conventional Activity*.

**Agricultural Cost Analysis**

The *Agricultural Cost Analysis* activity allowed students to see a basic list of costs associated with both sustainable and conventional agriculture. Students were able to add up costs associated with planting, harvesting, and storing crops. Eighty percent of students felt this activity helped them gain knowledge about how agriculture and the environment are connected, 66.7% felt they gained knowledge regarding sustainable agriculture, and 73.3% felt they gained a sense of community connections. These results are shown in Figure 13.
Figure 13. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community from the *Agricultural Cost Analysis*.

**Full Circle Farm PowerPoint**

The *Full Circle Farm PowerPoint* allowed students to see an example of a farm that operates by completely using sustainable farming techniques. This presentation allowed students to make connections between previous lessons within the unit and a real world example. Figure 14 shows that 80% of students thought the PowerPoint helped them gain knowledge about the connection between agriculture and the environment, 93.4% of students felt they gained knowledge regarding sustainable agriculture, and 80% of students felt they gained a sense of community from this presentation.
Figure 14. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community from the *Full Circle Farm PowerPoint*.

**Farm Interview**

The last take home assignment for this unit was the *Farm Interview*. For this, students had to interview a local farmer. Students were given a list of interview questions that ranged from the farm’s history and size, the conventional and sustainable practices used on the farm, and the basics of the farm’s finances. Students were given a weekend to complete this interview. Eighty percent of students felt they gained knowledge regarding the connectedness between agriculture and the environment, 73.3% of students felt this assignment helped them gain knowledge regarding sustainable agriculture, and 63.7% of students felt an increase in their sense of community. Figure 15 shows these results.
Final Project

The last part of the Agriculture, the Environment, and Society Unit was the Final Project. For this project, students worked in pairs to create a hypothetical farm. The students needed to describe their farm’s history, size, location, and agricultural practices used on the farm. Additionally, students needed to explain why they as “farmers” made the decisions regarding their farm that they did. Students were given multiple in-class work days prior to presenting their farms to the class. Figure 16 helps illustrate that 80% of students felt this activity increased their knowledge regarding the connection between agriculture and the environment, 93.3% of students felt an increase in their sustainable agriculture knowledge, and 73.4% of students felt an increased sense of community.
Figure 16. Survey results indicating student awareness of the connectedness of agriculture and the environment, sustainable agriculture, and sense of community on the Final Project.

Conclusion

Through the use of a pre-survey I was able to identify strengths and weakness of student knowledge of conventional and sustainable agricultural. I was able to measure changes in student knowledge from the use of a post-survey. Student growths could then be identified in these areas when comparing data from the pre and post-surveys.

A survey was also used to help measure the usefulness of various curriculum components to the Agriculture, the Environment, and Society unit. This student feedback helped determine strengths and weaknesses of the curriculum. Through the analysis of this data I will be able to identify changes that need to be made in order to strengthen the curriculum for future uses.
CHAPTER 5

Conclusion

Introduction

This project looked at two different components. The first component was to determine how much students learned from the *Agriculture, the Environment, and Society* unit. This unit incorporated various teaching techniques to suit a range of learning styles. The unit also allowed students to draw their own conclusions about the pros and cons of conventional agriculture and sustainable agriculture. The underlying goal of teaching this unit to my students was to increase their awareness of the connections any agricultural decision has on the environment and to make them aware of the many facets to each decision as farmer makes.

The second component of this project was to create an effective unit to teach about conventional agriculture, sustainable agriculture, and the connections between agriculture and the environment. The multiple lessons created and taught in this unit were developed by employing the Understanding by Design (UbD) curriculum development model. This chapter will interpret the results from the pre and post-surveys, look at strengths and weaknesses of the curriculum, and suggest changes to the curriculum for future uses.

Effectiveness of Curriculum

The effectiveness of the *Agriculture and the Environment* curriculum was measured using pre and post-surveys. Data from these surveys was analyzed in chapter four. Factors taken away from these surveys were that students became more confident in their knowledge of both conventional and sustainable agriculture, they were able to
draw connections between agriculture and the environment, and students were also able to recognize the importance of agriculture to their community.

All questions from the pre and post-survey saw some degree of student growth. The two questions that saw a drop in agreement from the pre to post-survey were if students felt that conventional or sustainable agriculture was the best way to raise agricultural crops. Both questions on the post-survey saw a drop in agreeance. My opinion for this drop was that students were thinking along the lines of the potential decrease in profits a farm may see while the farm is in the progress of switching agricultural methods. The question was a very broad question and more detailed questions would be needed in order to gain a better understanding of the students’ true opinions about sustainable agriculture.

The results of these two questions seem to be in conflict with one another. If you no longer believe conventional agriculture to be the best way to raise agricultural crops, then you would expect to find an increase in those that believe sustainable agriculture is the better way to raise crops. It seems to me as though the surveys show that the students felt a degree of confliction between what they had learned over the course of the unit and what they have known their whole lives. As a teacher, it is good to allow students to feel and think about these conflicting viewpoints. It allows them to develop higher level thinking skills and become more well-rounded individuals. This was an unknown benefit of creating and implementing this curriculum in my classroom.

Review of Specific Curriculum Aspects

There are two points of view to the effectiveness of every aspect of curriculum that is implemented in a classroom, the viewpoint of the teacher and the opinions of the
students. For each component of the unit, I reflected on the effectiveness of each PowerPoint, assignment, and class activity. The Sustainable Agriculture PowerPoint, Soil PowerPoint, Conventional vs Sustainable Classroom Activity, the Looking at Change in Agriculture, Food Systems, and the Environment assignment, and the Final Project were all highlights of the curriculum to me for various reasons.

The Sustainable Agriculture PowerPoint was very effective at communicating information to the students about what sustainable agriculture looks like. The slides were to the point and had clear graphics. The Soil PowerPoint had good information, however, the PowerPoint itself was quite lengthy. During this lesson there seemed to be quite a few students who lost interest. A lesson in soil ecology is a crucial component for this unit because it ties the unit into previous units taught in tenth grade Biology. This will be a lesson that is reconfigured for future use. I would also like to add a laboratory investigation regarding soil health into this lesson. For this laboratory investigation, I would have students bring soil samples from their family farms or gardens, this would allow them to find a deeper connection with the activity.

The Conventional vs Sustainable Classroom Activity was an effective way for the students to summarize their learnings from the previous lessons. It allowed them to work in partners as well as the larger group. I also felt that the Looking at Change in Agriculture, Food Systems, and the Environment assignment was a great introduction into how there has been an evolution in the environment and agriculture over the years. It allowed them to see this first hand through the use of an interview with community members. I would add a component to this assignment that has the students summarize their findings so that they can report them more easily to the class.
The Final Project allowed students to use their knowledge to create a hypothetical farm in which the students could implement any agricultural technique they felt would best help the farm achieve its goal. This project was a lesson in goal setting, figuring out the best ways to achieve the set goal while keeping in mind the complexities of the agricultural and environmental dynamics. This project allowed the students to demonstrate the full range of what they learned and the experience the conflicts that today’s farmers face.

I used a survey to allow the students to provide feedback about nine components of the curriculum. Students indicated that all nine components were effective at demonstrating the connectedness between agriculture and the environment, informing about sustainable agricultural practices, and creating a sense of community. Some curriculum components were better at a certain one of these aspects than others and that showed in the results of the survey.

The final question on the survey was an opened ended question that allowed the students to tell me what their favorite part of the unit was and why. The following are assignments that students focused their responses to this question: the PowerPoints, Farmer Interview and Analysis, and the Final Project. Students felt that the PowerPoints were direct, to the point, and easy to follow. The Farmer Interview and Analysis was liked by students because it gave them the opportunity to talk to their family members about farming, increasing their sense of community. Students enjoyed the freedom of the Final Project, and that they were able to draw their own conclusions and explain their opinions.

Challenges Still Ahead and Final Thoughts
Despite the success of many areas of this curriculum, there are still challenges that need to be addressed. The first of the challenges is the amount of classroom time I was able to use in order to implement this curriculum. There are so many requirements that must be met for high school biology, that I was not able to take as much class time as I would have liked for this unit. This limited the amount and specific activities I was able to include in the curriculum. One major downfall due to the time constraints was that I was not able to include any laboratory investigations.

A second weakness of my project was that the curriculum strayed from my initial goal of wanting students to be able to make connections between agriculture and the environment. This goal got sidetracked by having to focus a considerable amount of time teaching the students about the basics of sustainable agriculture. The majority of the students did not have the fundamental knowledge of agriculture in order to begin to make the connections that I desired.

A final challenge of this project was that students have a very limited ability to bring about changes to how the family farm is operated. In their current position, they have almost no financial stake in the agricultural operation, which in turn limits how much their voice gets heard. The concepts that they learned from this unit must stay with them until they become in charge of the family farm or purchase their own land before they would be able to implement agricultural techniques that keep the health of the environment in mind.

Perhaps the most valuable insight I gained through this project was the importance of making connections between the students academics and the life they have outside of the classroom. Students that participated in Agriculture, the Environment, and
Society demonstrated a desire and eagerness to learn. Students who do not normally participate in class were answering questions, sitting alertly, and raising questions when aspects of the curriculum conflicted what they were being taught outside of school. There were many times where I had to regain focus of the students because they wanted to share stories or agricultural techniques that were practiced on their farms.

In the state of Minnesota, students must take a science Minnesota Comprehensive Assessment (MCA) test in tenth grade. This test investigates student knowledge of many areas of science, but it is heavily dominated by biology concepts. This year, the first thing the tenth graders told me about the exam was that it had sustainable agriculture questions on it. This further validated the importance of implementing a form of sustainable agriculture education into my science curriculum.
REFERENCES


May 13, 2015

TO: Human Subjects Committee
FROM: Jerry Reshetar
RE: Capstone Project

To Whom It May Concern,

As part of her Master’s program, Ms. Elise Wolf will develop an approximately two week curriculum that focuses on the connections between agriculture and the environment. This curriculum will address how conventional agriculture techniques and sustainable agriculture techniques interact with the environment. Pros and cons of each method will be analyzed, and students will be encouraged to draw their own conclusions. Additionally, the curriculum will be aligned to the Minnesota State Science Standards for 9th grade science and chemistry.

As superintendent, I give my permission for Ms. Wolf to develop and implement this curriculum in our school.

Sincerely,

Jerry Reshetar
Superintendent
March 15th, 2016

Dear Parent/Guardian,

I am your child’s science teacher and a graduate student at Hamline University in St. Paul, MN. As part of my graduate school studies, I have developed a curriculum that allows students to explore the relationship between agriculture and the environment. The curriculum provides the students with the opportunity to investigate different agricultural methods and techniques and their relationship with the environment. This research is public scholarship. The abstract and final product will be cataloged in Hamline’s Bush Library Digital Commons. This is a searchable electronic warehouse, and the research may be published or used in other ways.

In order to assess the effectiveness of the curriculum and to aid in its development I will be implementing it into the science curriculum throughout the 2015-2016 school year. The curriculum aligns with the Minnesota State Science Standards and your student will still acquire the knowledge and skills outlined by these standards. I have received approval for my study from the School of Education at Hamline University and from the superintendent of Glenville-Emmons School District, Jerry Reshetar.

To help determine strengths and weaknesses of the curriculum I will be using surveys and pre/post-tests to monitor student growth and opinion. There is little to no risk to your child to participate. All results will be confidential and anonymous. The surveys used will not record your child’s name or any other identifying information or characteristics. All students will participate in the curriculum, however, student participation in the surveys is voluntary. There will be no negative consequences if you decide to not have your child participate in the surveys.

If you are willing to allow your student’s data to be used anonymously, please check the “I consent” box. If you do not wish for your student’s data to be incorporated into the results of the surveys please indicate by checking the “I do not consent” box. If you select to not have your student’s data be used in the research he/she will still be required to participate in the lessons as they cover require Minnesota State Science Standards.

If you have any questions or concerns, I would be more than happy to discuss them with you. I can be reached by email at volze@geschools.com or by voicemail at (507) 448-2889.

Please sign and return this form by March 24th, 2016.

Thank you,

Mrs. Elise Volz
Glenville-Emmons Secondary Science Teacher
volze@geschools.com
(507) 448-2889
Keep this full page for your records

I have received your letter about your study regarding an implementation of a unit about agriculture and the environment. I understand that there is little to no risk involved to my child, that his/her confidentiality will be protected, and that I (or my child) may choose to no longer participate at any time.

☐ consent  ☐ I do not consent

___________________________________  __________________
Parent/Guardian Signature  Date
Please return this page to Elise Volz

I have received your letter about your study regarding an implementation of a unit about agriculture and the environment. I understand that there is little to no risk involved to my child, that his/her confidentiality will be protected, and that I (or my child) may choose to no longer participate at any time.

☐ consent  ☐ I do not consent

___________________________________   ______________________
Parent/Guardian Signature                  Date
APPENDIX C

Pre-Survey

Please rate each statement on a scale of 1 to 5.

1. Does your immediate family (Dad, mom, siblings) farm as a source of income for the family?
   Yes No

2. Does your extended family (grandparents, aunts, uncles, cousins) farm as a source of income for the family
   Yes No

3. If you answered “yes” to questions 1 or 2, how involved are you in the farming operations?
   1 2 3 4 5
   Not at all I spend all of my free time helping farm

4. How would you rate your knowledge of conventional agricultural practices?
   1 2 3 4 5
   I know very little Very Knowledgeable

5. If asked, how confidently could you accurately define conventional agriculture?
   1 2 3 4 5
   Very little Confidence Very Confident

6. How knowledgeable are you of the various techniques used in conventional agriculture?
   1 2 3 4 5
   I know very little Very Knowledgeable
7. Based on your current knowledge regarding conventional agriculture, would you say it is the best way to raise agricultural crops?

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8. How confidently could you accurately define sustainable agriculture?

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<td>Very little Confidence</td>
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9. How knowledgeable are you of the various techniques used in sustainable agriculture practices?

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10. Based on your current knowledge regarding sustainable agriculture, would you say it is the better option for raising agricultural crops than conventional agricultural techniques?

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</tr>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
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APPENDIX D

Post-Survey

Please rate each statement on a scale of 1 to 5.

1. Does your immediate family (Dad, mom, siblings) farm as a source of income for the family?
   Yes  No

2. Does your extended family (grandparents, aunts, uncles, cousins) farm as a source of income for the family?
   Yes  No

3. If you answered “yes” to questions 1 and 2, how involved are you in the farming operations?
   1  2  3  4  5
   Not at all  I spend all of my free time helping farm

4. If you answered “yes” to questions 1 and 2, does your family implement any sustainable agricultural techniques?
   1  2  3  4  5
   None at all  Our entire farm is sustainable

5. How would you rate your knowledge of conventional agricultural practices?
   1  2  3  4  5
   I know very little  Very Knowledgeable

6. If asked, how confidently could you accurately define conventional agriculture?
   1  2  3  4  5
   Very little Confidence  Very Confident
7. How knowledgeable are you of the various techniques used in conventional agriculture?

1  2  3  4  5
I know very little Very Knowledgeable

8. Based on your current knowledge regarding conventional agriculture, would you say it is the most feasible way to raise agricultural crops?

1  2  3  4  5
Strongly disagree Strongly Agree

9. If asked, how confidently could you accurately define sustainable agriculture?

1  2  3  4  5
Very little Very Confident

10. How knowledgeable are you of the various techniques used in sustainable agriculture?

1  2  3  4  5
I know very little Very Knowledgeable

11. Based on your current knowledge regarding sustainable agriculture, would you say it is a more feasible way to raise agricultural crops than conventional agricultural techniques?

1  2  3  4  5
Strongly disagree Strongly Agree

12. After learning about the relationship between the environment and agriculture, how concerned are you regarding the status of the environment?

1  2  3  4  5
Not Very Concerned Concerned
13. How much did the “Looking at Change in Agriculture, Food Systems, and the Environment Assignment” increase your knowledge of how agriculture and the environment are connected?

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<td>No Knowledge Gain</td>
<td>A lot of Knowledge Gain</td>
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14. How much did the “Looking at Change in Agriculture, Food Systems, and the Environment Assignment” increase your knowledge of sustainable agriculture?

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<td>No Knowledge Gain</td>
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15. How much did the “Looking at Change in Agriculture, Food Systems, and the Environment Assignment” increase your sense of community connections?

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<td>No Awareness</td>
<td>A lot of Awareness</td>
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16. How much did the “Connections Assignment” increase your increase your knowledge of how agriculture and the environment are connected?

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<td>No Knowledge Gain</td>
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17. How much did the “Connections Assignment” increase your knowledge of sustainable agriculture?

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<td>No Knowledge Gain</td>
<td>A lot of Knowledge Gain</td>
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18. How much did the “Connections Assignment” increase your sense of community connections?

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<td>No Awareness</td>
<td>A lot of Awareness</td>
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19. How much did the “Sustainable Agriculture PowerPoint” increase your increase your knowledge of how agriculture and the environment are connected?

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<td>No Knowledge Gain</td>
<td>A lot of Knowledge Gain</td>
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</table>
20. How much did the “Sustainable Agriculture PowerPoint” increase your knowledge of sustainable agriculture?

1  2  3  4  5
No Knowledge  A lot of Knowledge
Gain  Gain

21. How much did the “Sustainable Agriculture PowerPoint” increase your sense of community connections?

1  2  3  4  5
No Awareness  A lot of Awareness

22. How much did the “Soil PowerPoint” increase your knowledge of how agriculture and the environment are connected?

1  2  3  4  5
No Knowledge  A lot of Knowledge
Gain  Gain

23. How much did the “Soil PowerPoint” increase your knowledge of sustainable agriculture?

1  2  3  4  5
No Knowledge  A lot of Knowledge
Gain  Gain

24. How much did the “Soil PowerPoint” increase your sense of community connections?

1  2  3  4  5
No Awareness  A lot of Awareness

25. How much did the “Sustainable vs Conventional Class Activity” increase your knowledge of how agriculture and the environment are connected?

1  2  3  4  5
No Knowledge  A lot of Knowledge
Gain  Gain

26. How much did the “Sustainable vs Conventional Class Activity” increase your knowledge of sustainable agriculture?

1  2  3  4  5
No Knowledge  A lot of Knowledge
Gain  Gain

27. How much did the “Sustainable vs Conventional Class Activity” increase your sense of community connections?

1  2  3  4  5
No Awareness  A lot of Awareness
28. How much did the “Agricultural Cost Analysis” increase your knowledge of how agriculture and the environment are connected?

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29. How much did the “Agricultural Cost Analysis” increase your knowledge of sustainable agriculture?

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30. How much did the “Agricultural Cost Analysis” increase your sense of community connections?

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<td>No Awareness</td>
<td>A lot of Awareness</td>
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31. How much did the “Full Circle Farm PowerPoint” increase your knowledge of how agriculture and the environment are connected?

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32. How much did the “Full Circle Farm PowerPoint” increase your knowledge of sustainable agriculture?

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33. How much did the “Full Circle Farm PowerPoint” increase your sense of community connections?

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34. How much did the “Farm Interviewt” increase your knowledge of how agriculture and the environment are connected?

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<td>No Knowledge</td>
<td>Gain</td>
<td>A lot of Knowledge</td>
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</tbody>
</table>
35. How much did the “Farm Interview” increase your knowledge of sustainable agriculture?

1 2 3 4 5
No Knowledge Gain A lot of Knowledge Gain

36. How much did the “Farm Interview” increase your sense of community connections?

1 2 3 4 5
No Awareness A lot of Awareness

37. How much did the “Final Project” increase your knowledge of how agriculture and the environment are connected?

1 2 3 4 5
No Knowledge Gain A lot of Knowledge Gain

38. How much did the “Final Project” increase your knowledge of sustainable agriculture?

1 2 3 4 5
No Knowledge Gain A lot of Knowledge Gain

39. How much did the “Final Project” increase your sense of community connections?

1 2 3 4 5
No Awareness A lot of Awareness

40. What was your favorite part about this unit?
APPENDIX E

Agriculture, the Environment, and Society-Lesson 1

Time: 1-50 minute class period

Objectives:

- Students will distinguish between conventional agriculture and sustainable agriculture.
- Students will use critical thinking skills to develop a list of successes and concerns regarding the three legs of sustainable agriculture.
- Students will use interview skills to explain how agriculture has changed in the local area.

Standards:

MN State Standard(s)

- Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument, and skeptical review.
- Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world.
- Science and engineering operate in the context of society and both influence and are influenced by this context.
- People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
- Human activity has consequences on living organisms and ecosystems.
- Personal and community health can be affected by the environment, body functions and human behavior

Materials:

- Presentation: “What is Sustainable Agriculture”  
- Pad of Post-It Notes (1/group of 2)
Lesson Outline:

- Agriculture and the Environment Pre-Survey (5 minutes)
- Introduction: Students will complete a Think-Pair-Share over the topic, “What is agriculture?” (5 minutes)
- Class discussion current agricultural practices (10 minutes)

Talking Points

- What does a typical farming season look like?
- How does the land get work?
- What do farmers do to the land?
- What is the purpose of these agricultural activities?
- Have agricultural practices changed throughout history?
- What has caused these changes?
- Will agricultural practices continue to change? Why or why not?

- “What is Sustainable Agriculture?” presentation (15 minutes)
- Activity: “Thinking Positively, Thinking Critically” (10 minutes)
- Closing: discuss homework assignment, “Looking at Change in Agriculture, Food Systems, and the Environment” (5 minutes)

Resources


What is Sustainable Agriculture?

A three-legged stool of sustainability:
- Environmentally Sound
- Socially Sustainable
- Economically Viable

Environmentally Sound

Socially sustainable

Goals: A desired end
Practices: Actions to achieve a goal

How do you get to goals?

Toward a Sustainable Agriculture

April 16

Environmentally Sound

Preserves the quality of soil, water, and air

Good for families
Supports communities
Fair to all involved
Name: _______________________
Worksheet: Looking at change in agriculture, food systems, and the environment

<table>
<thead>
<tr>
<th>What did they look like then?</th>
<th>in 1940</th>
<th>in 1970</th>
<th>in 2000</th>
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<tbody>
<tr>
<td>Farms</td>
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<tr>
<td>Environment</td>
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<td>Main Street</td>
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</table>

(where did people get their food?)

Mayerfeld, Diane. (n.d.).
APPENDIX F

Agriculture, the Environment, and Society-Lesson 2

Time: 1-50 minute class period

Objectives:

- Students will be able to use the terms: system, ecosystem, agro-ecosystem, and food system.
- Students will develop an awareness of the connectedness among ecosystems, agro-ecosystems and where their food comes from.
- Students will use map skills to analyze where their food comes from.

Standards:

MN State Standard(s)

- Science and engineering operate in the context of society and both influence and are influenced by this context.
- People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
- Human activity has consequences on living organisms and ecosystems.
- Personal and community health can be affected by the environment, body functions and human behavior
- The interrelationship and interdependence of organisms generate dynamic biological communities and ecosystems.

Materials:

- PowerPoint Presentation: “What is a System?” - Paper Plates (1 per student)
- Map Placemats (1 per student)
Lesson Outline:

- Introduction: Students will share their findings from the Lesson 1 homework. (10 minutes)
- "What is a System?" presentation (10 minutes)
- "Menus and Maps" activity and discussion (20 minutes)

Talking Points

- Where do we get our food from?
- Is the general consumer aware of where their food comes from?
- How do we know our food is safe to consume?
- What are some pros and cons of having a global food system?

- Closing: "Food and You" video (8 minutes)
- Homework: “Connections”

References:


An **Agro-ecosystem** is:

- an ecosystem that is
  - managed to produce
  - food or fiber

---

**Ecosystem** is:

- an ecosystem that is
  - the interactions of
    - energy
    - living organisms
    - the physical environment in a
      - geographic location

---

**System** is:

- a regularly interacting or interdependent
  - group of items forming a unified whole

---

**Food System** is:

- the way that food moves
  - from the farm to the consumer

---

**Parts of a Food System**

- Production
- Processing
- Distribution
- Consumption
- Waste management

---

**References**

http://www.cias.wisc.edu/curriculum/index.htm
• “Set the table” by plac student’s seat.

• Then, on their placemat, have the students “map” where they think the food in their meal from. To make things easier for the students you may have the “placemat” show a

•

•

•

•

•

  o We don’t usually know exactly where our food came from, or how it was gro

  o judicial system to ensure the safety of our food, because consumers usually don’t
Name: ___________________________

Critical components of the agro-ecosystem and food system for a single farm:

Counter-clockwise from the top: The farm, solar energy, row crops, pasture, livestock, farm products, food processing facility, retail facility, consumer home, food ready for consumption, compost (waste being converted to a resource), and inside the circle are the farm family and natural environment.

Explain how the elements in the graphic are connected.

Add ecosystem and food system elements that are missing from the graphic, such as fossil fuel energy, water, transportation, and so on. Add the connections and missing items to the graphic. There should be A LOT connections.

What conclusions can you draw from analyzing your diagram?

Adapted from Mayerfeld, Diane. (n.d.).
Agriculture, the Environment, and Society - Lesson 3

Time: 3-50 minute class periods

Objectives:

- Students will describe the connections among the various components of our food system.
- Students will be able to identify characteristics of various soil types.
- Students will be able to distinguish between conventional and sustainable methods for obtaining soil nutrients.
- Students will be able to describe various sustainable agricultural techniques.

Standards:

MN State Standard(s)

- The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.
- Human activity has consequences on living organisms and ecosystems.

Materials:

- Soil Ecology PowerPoint
- Sustainable Agricultural Practices PowerPoint

Lesson Outline:

**Day 1:**

- Discuss conclusions from Day 2 Homework “Connections” (10 minutes)
Talking Points

- Identify how the various components are connected
- Is there information/components that are missing from the graphic?
- Looking at the completed graphic, how would you describe our food system?

- Brainstorm - “What makes soil so important?” (5 minutes)
- Soil Ecology Lecture (30 minutes)

Day 2:

- Brainstorm: “What are examples of sustainable agricultural practices?” (5 minutes)
- Sustainable Practices Lecture (40 minutes)
- Exit ticket: Which sustainable practice seems most easily implemented for a conventional farmer looking to integrate sustainable practices into his/her farming operation? Why?

Day 3:

- In pairs, students will create a comparison between a sustainable vs conventional practice that was discussed yesterday. Once student pairs have completed their section, presentations will be made to the class and a large compare and contrast chart will be made.
- Class discussion regarding the chart

Talking Points

- Which sustainable practice seems most easily implemented for a conventional farmer looking to integrate sustainable practices into his/her farming operation? Why?
- Which sustainable practice seems least easily implemented for a conventional farmer looking to integrate sustainable practices into his/her farming operation? Why?
- What would make converting from conventional agricultural practices to sustainable agricultural practices challenging? Easy?
What major component of farming have we not discussed? (money, finances, economics)

(This assignment will demonstrate students’ knowledge of conventional practices that I have assumed they have knowledge of based on their family history and the area they are from)

References:


What is soil biology?

What role does it play in soil quality?

Soil organisms are involved in nearly every aspect of soil quality:
- Structure/Aggregation
- Humification
- Nitrate Leaching
- Nutrient cycling
- Maceration
- Organic matter
- Decomposition

In order to understand how biology affects our soils - we need to understand a little about the organisms who live there.

Soil is alive...
For example, in 1g of soil:
- >100,000,000 bacterial cells
- >11,000 species of bacteria
Also fungi and larger animals

Who’s there?
Macrofauna: Soil ‘Engineers’

Soil Animals
- Termite
- Centipede
- Pseudoscorpion
- Snail
- Earthworm
- Vole

FIGURE A3: Bioclassification of organisms in decomposing food web by body size. (after Kite, 2012).
Soil animals are important for

1. Decomposition (shredding residues)
2. Mixing soil (aeration)

Who's there?
Mesofauna:
Soil predators, pathogens, herbivores

Microorganisms: Soil process controllers

Soil mesofauna

Fungi
- Filamentous growth
  - Wood degrading
  - Mycorrhizal association

• myco (fungus) + rhiza (root)
  (Symbiotic structure formed by a fungus plus a plant)
Diversity in soil is important for nitrogen cycling.

Relationship to soil quality?
Diversity may be important in response to management

![Diagram showing comparison between reduced tillage and plowed soil]

Figure 2. A comparison of biological, physical, and chemical properties of minimum tillage and plowed soils (from Simmer and Simmer, 1999).

References

Sustainable Agricultural Practices

Elise N. Volz

Where do key nutrients come from?

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Conventional sources</th>
<th>Sustainable sources</th>
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<tbody>
<tr>
<td>Nitrogen</td>
<td>Synthesized from natural gas</td>
<td>Fixed from the air by microorganisms associated with legumes; Manure and compost; blood meal</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Mixed in Florida, Canada, etc.</td>
<td>Manure, compost, bone meal</td>
</tr>
<tr>
<td>Potassium</td>
<td>Mixed in Canada</td>
<td>Manure, compost</td>
</tr>
</tbody>
</table>

Sustainable Practices

• Conserve soil (and nutrients)
  – Minimize tillage
  – Filter and Buffer Strips
  – Strip Cropping
  – Use of grains in rotation
  – Cover Crops

Minimize Tilling

Why do farmers till?

Consequences of Tilling
- Loss of topsoil
- Loss of organic matter
- Loss of soil microbes
- Release of CO2

Filter and Buffer Strips

What are they?
- Strips of natural vegetation
  - Usually grasses

What do they do?
- Slow down runoff
  - Allows for infiltration
  - Reduces soil erosion

Strip Cropping

What is it?
- Planting two or more species in parallel rows within the same field
  - One species is usually susceptible to erosion

Why do it?
- Decreases soil erosion
  - Naturally maintains soil nutrients

Use of small grains

• Use of small grains

Cover Crops

What are they?
• Vegetation that is planted on “open” soil

Purpose
- Slow down erosion
- Increase water retention
- Improve soil nutrients
- Decrease soil availability to weeds
- Increase biodiversity

Use Cover Crops and Legumes

• Maintains a healthy nitrogen level in the soil
Recycle Nutrients
- Use manure and crop residues to fertilize fields
- Compost
- Locally

Crop Diversity
- Plants in the ground almost year round
- Row crops, small grains, perennials
- Restores complex natural plant communities
- High biodiversity = healthy agro-ecosystem

Integrated Pest Management
- Take actions to prevent pests from becoming problematic
  - Use disease-resistant plant
  - Grow healthy crops
- Analyze the environmental factors that benefit the pest
  - Create conditions that are no longer beneficial to the pest

Minimize Transportation
- Decreases use of fossil fuel

IPM (Continued)
- Monitoring
  - Identifying pests that are present
  - Quantity
  - Analysis of action
    - Can the pest be tolerated or does it need to be controlled

Allow Animal Grazing
- Reduces feed costs
- Aerates pasture soil
- Naturally fertilizes soil
- Less energy required to produce meat products

IPM Controls
- Biological
  - Natural enemies
- Cultural
  - Reduce the pests ability to reproduce, spread out and survive
- Mechanical
  - Destroy the pest directly
  - Make environment unfavorable to sustain pests
    - Ex: Trapping rodents, scabs
- Chemical
  - Pesticides

Sustainable Practices for the Consumer
- Buy local foods
- Avoid excess packaging
- Minimize waste
- Eat Lower on the Food Chain
  - Grass fed meat/dairy products
  - 4 lbs of corn to produce 1 lb of pork
  - 10 lbs of corn to produce 1 lb of beef
References

APPENDIX H

Agriculture, the Environment, and Society-Lesson 4

Time: 1-50 minute class period

Objectives:

- Students will be able to compare and contrast sustainable agricultural profitability and conventional agricultural profitability
- Students will be introduced to how government plays a role in agriculture
- Students will be able to identify externalities of agriculture
- Students will analyze cost scenarios of sustainable agriculture and conventional agricultural practices

Standards:

MN State Standards

- People consider potential benefits, costs, and risks to make decisions on how they interact with natural systems.

Materials: - The Economics of Field Crop Production PowerPoint

- Cost analysis assignment sheet (1 per student) - Calculators

Lesson Outline:

- Opening question: “If you were a conventional farmer, what would be your biggest concern in regards to moving to a more sustainable farming operation?”
  (5 minutes)
- The Economics of Field Crop Production PowerPoint (25 minutes)
- Cost Analysis Assignment description (10 minutes)
References:


The Economics of Field Crop Production

Elise N. Volz

Costs of Production

• Land
  — Biggest farming expense
  — Costs determined by neighboring land costs, soil type/quality
  — Sustainable practices can help land maintain value

• Fertilizer
  — Sustainable practices reduce the cost

• Seed
  — Comparative between farming methods
    • Certified organic seeds = spendy
    • Unusual seed species can be expensive
  • Standard genetically modified seeds are also expensive

Yields

• Organic Agriculture
  — No synthetic fertilizers/pesticides
  — During 3-year transition = drop in yields
  — After 3-years yields generally stabilized
  — Food-grade soybeans have a lower yield that feed-grade

Costs of Production Continued

• Pesticides
  — Sustainable farms have a lower cost

• Machinery, Fuel, Repairs, etc
  — Reduced tillage and IPM decrease amount of machine time
  — Growing grains requires special machinery

• Labor
  — Sustainable farmers work is more evenly spread out throughout the year (many crops with different growing seasons)
  — Total labor depends on sustainable farms are still equal to or higher than conventional farms

Yields

• Crop Rotation
  — Yield increases consistently “rotation effect”

Price

• Conservation tillage
  — Little effect on price received for crop

• Certified Organic
  — Higher price for Certified Organic Crops
  — Ex: Organic soybeans and corn receive 50-100% more than the conventional products

• Certified non-GMO
  — GMO = genetically modified organisms

Government Payments

• In WI and IA most government payments go to growing corn and soybeans
• Very little government money goes toward environmental conservation
Related-yet unrelated Costs

• Environmental Damage
  – Pollution (extra water treatments, decline in fish populations)
  – High rates of cancers and birth defects (potentially attributed to agriculture)

• Struggling Farmers
  – US has cheap food (generally speaking, cost has stayed the same the last 30 years)
  – Farmers receive less $5 for their product

Conclusion

• Complex process of determining feasibility of sustainable vs conventional ag practices
• Regardless, agricultural practices must be profitable to the farmer
• Externalities taken into account???

References

Agricultural Cost Analysis

Directions: Table 1 gives a hypothetical overview of costs associated with conventional farming practices. Table 2 gives a hypothetical overview of costs associated with organic farming practices. Analyze the two tables and answer the following questions.

### Table 1. Division of costs in a conventional corn-soybean rotation (one acre).

<table>
<thead>
<tr>
<th>Machinery and Labor (custom rates)</th>
<th>Tenant</th>
<th>Owner</th>
<th>Tenant</th>
<th>Owner</th>
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</thead>
<tbody>
<tr>
<td>Apply nitrogen</td>
<td>$12.80</td>
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<tr>
<td>Chisel plow</td>
<td></td>
<td>$16.90</td>
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<tr>
<td>Tandem disk</td>
<td>14.65</td>
<td>14.65</td>
<td></td>
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<tr>
<td>Field cultivate</td>
<td>14.05</td>
<td>14.05</td>
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<tr>
<td>Plant</td>
<td>19.90</td>
<td>19.90</td>
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<tr>
<td>Cultivate</td>
<td>14.65</td>
<td>14.65</td>
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<tr>
<td>Spray</td>
<td>7.40</td>
<td>7.40</td>
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<tr>
<td>Combine</td>
<td>35.35</td>
<td>34.75</td>
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<td></td>
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<tr>
<td>Haul to storage</td>
<td>13.88</td>
<td>3.85</td>
<td></td>
<td></td>
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<tr>
<td>Dry</td>
<td>28.35</td>
<td>28.35</td>
<td></td>
<td></td>
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<tr>
<td>Haul to market</td>
<td>16.20</td>
<td>4.50</td>
<td>4.50</td>
<td>4.50</td>
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<td><strong>Total</strong></td>
<td><strong>$177.21</strong></td>
<td><strong>$44.55</strong></td>
<td><strong>$130.65</strong></td>
<td><strong>$4.50</strong></td>
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| Nonfield Labor                    |        |       | 1.0 hour @ $15 | $15.00 | $15.00 |

| Crop Inputs                       |        |       | Seed | $57.65 | $57.65 | $27.50 | $27.50 |
|                                  |        |       | Fertilizer and lime | $63.18 | $63.18 | $29.98 | $29.98 |
|                                  |        |       | Herbicide | $17.75 | $17.75 | $13.25 | $13.25 |
|                                  |        |       | Crop insurance | $6.80 | $6.80 | $4.45 | $4.45 |
|                                  |        |       | Miscellaneous and interest | $10.35 | $10.35 | $8.02 | $8.02 |
| **Total**                         | $155.92 | $155.92 | $83.19 | $83.19 |

| Land and Buildings                |        |       | Land charge | $250.00 | $250.00 |
|                                  |        |       | Storage | $15.84 | 15.84 | $4.40 | 4.40 |
|                                  |        |       | Management (10% of other costs) | $38.40 | $38.40 | $23.32 | $23.32 |
| **Total**                         | $400.37 | $466.31 | $256.56 | $342.09 |

| Share                             |        |       | Tenant | 46% | 46% | Owner | 54% | 57% |

| Total Rotation                    | Tenant | Owner | $ per acre | $328.47 | $404.20 |
|                                  |        |       | Share | 46% | 55% |
Table 2. Division of costs in organic production (one acre).

<table>
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<th>Machinery and Labor (custom rates)</th>
<th>Corn Tenant</th>
<th>Owner</th>
<th>Soybeans Tenant</th>
<th>Owner</th>
<th>Oats/Alfalfa Tenant</th>
<th>Owner</th>
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<td>Seed rye</td>
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<td>Management (10% of other costs)</td>
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<td>$12.98</td>
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<td>$12.98</td>
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<td>$380.88</td>
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<tr>
<td>Share</td>
<td>52%</td>
<td>48%</td>
<td>17%</td>
<td>33%</td>
<td>45%</td>
<td>65%</td>
<td>41%</td>
<td>59%</td>
</tr>
</tbody>
</table>

Average Costs for a Corn-Soybean-Corn-Oats-Hay Rotation

- Tenant: $277.45
- Owner: $318.59

Average Costs for a Soybean-Corn-Soybean-Oats-Hay Rotation

- Tenant: $255.90
- Owner: $309.95

Average Costs for a Corn-Soybean-Oats-Hay Rotation

- Tenant: $251.65
- Owner: $310.29

Average Costs for a Corn-Soybean-Small Grains Rotation

- Tenant: $255.96
- Owner: $312.45

Source: Ag Decision Maker File At-18, Organic Crop Production Enterprise Budgets.
Analysis Questions

Analysis of Table 1
1. What was the total farm cost?________________
2. What was the total cost associated with synthetic chemicals? ______
3. What was the total cost of planting? _____________
4. What was the total cost of harvesting? _____________
5. What was the more expensive crop to plant? _________________
6. What was the cheaper crop to plant? _________________

Analysis of Table 2
1. What was the total farm cost? _________________
2. What was the total cost associated with fertilizing? ______
3. What was the total cost of planting? _________________
4. What was the total cost of harvesting? _________________
5. What was the more expensive crop to plant? _________________
6. What was the cheaper crop to plant? _________________

Comparisons
1. Which farm had the greater financial cost?

2. Which farm had the greater profit?

3. Where was there cost savings on the organic farm?

4. Where were there additional costs on the organic farm?
5. Where were there cost savings on the conventional farm?

6. Where were there additional costs on the conventional farm?

7. Taking into account what you know about externalities, which farm has the higher costs? Explain.

Graphics from Mayerfeld, Diane. (n.d.).
Questions developed by Elise N. Volz
APPENDIX I

Agriculture, the Environment, and Society-Lesson 5

Time: 2-50 minute class period

Objectives:

- Students will analyze pros and cons real-life examples of sustainable agriculture.

- Students will analyze a local farm to determine the sustainable practices that occur locally.

Standards:

MN State Standards

- People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.

- The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

- Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.

- Human activity has consequences on living organisms and ecosystems.

- Personal and community health can be affected by the environment, body functions and human behavior.
Materials:

- Full Circle Farm PowerPoint
- Farm Interview Questionnaire (1 per student)
- Farm Interview Analysis (1 per group)

Lesson Outline

Day 1:

- Full Circle Farm Presentation (20 minutes)
  - Have students fill out the Full Circle Farm Handout
- Full Circle Farm Discussion (20 minutes)

  **Talking Points**
  - Identify each sustainable component in Full Circle Farm and classify it under one of the sustainable practices
  - Discuss the feasibility of such a farm
  - What is the underlying goal of Full Circle Farm compared to an underlying goal of a conventional farm

- Assign homework: Farm Interview (10 minutes)
  - Discuss expectations and answer any questions

Day 2:

- Each group will complete a “Farm Interview Analysis” (20 minutes)
- Groups will share their findings with the class (20 minutes)
- Closing (10 minutes): “On the spectrum of sustainable agriculture, where would you place the farm you interviewed? Why?”

“What were farmer’s biggest concerns when it comes to the sustainability of their farm?”

References:

Minnesota Department of Education. (2009). Minnesota Academic Standards Science K-


12AcademicStandards/Science/index.htm
A visit to Full Circle Farm

Operated by Nan Bonfils, Don Adams, and Harold Adams

Full Circle Farm as a Sustainable Agro-ecosystem

Full Circle Farm's Grazing & Grass-based Farming

Full Circle Farm as a Sustainable Local Food System

Grass captures solar energy. Cattle then consume the grass, fertilize the pasture with manure, recycling plant nutrients.

Even in winter when grass is not growing, cows deposit manure to fertilize fields and pastures.

The use of movable electric fence allows cattle to strip-graze the crop while it is still in the field. This saves the fuel and labor of mechanical harvest.
Prairie plantings provide wildlife habitat. These warm season prairie grasses are grazed by cattle in the heat of summer.

Clun Forest sheep, a hardy breed, grow well on forage, and are processed and sold locally.

Steers are processed at the local locker and marketed directly in the community.

Vegetables are grown with organic methods to provide local customers with fresh, farm-ripened produce.

Food scraps from a nearby camp are brought to the farm and composted. The farm recovers the food waste nutrients, returning them to the fields.

Eggs from Red Star hens that are fed organically-grown grain from the farm provide a year-round product.
Towards a Sustainable Agriculture

Woodlands protect water quality, and provide wildlife habitat and firewood to cut and sell to nearby campers.

The farm pond is managed for fishing and recreation. Water is used to irrigate vegetable crops and water livestock.

Full Circle Farm is visited by many people for educational field tours and community picnics.

References

Interview form

This interview questionnaire is designed to provide an overview of the environmental, economic, and social aspects of a real farm. You can use it as a guide for farm visits, and you can edit it to reflect your particular interests or what you already know about the farm. It is important that the farmers know that no specific financial information is needed and that they should feel free to not respond to some of the questions. It is also fine to let the interview progress naturally. If the farmer tells you something interesting about the operation that is not covered in the questionnaire, all the better! Just don’t forget to note down the information.

Part 1: Environmental Considerations

1. What percentage of your farm is in tillable acres?
   ___100% ___75% ___50% ___25% ___none ___don’t care to answer

2. What are the slopes of your tillable acres? (check all that apply)
   ____steep ____moderately hilly ____gently rolling ____mostly flat

3. What are the major soil types of your tillable land? (check all that apply)
   ____sandy ____silt ____loam ____sandy-clay ____mostly clay

4. About how much of your farm would be considered wetland?
   ___100% ___75% ___50% ___25% ___none ___don’t care to answer

5. About how much of your farm would be considered woodland?
   ___100% ___75% ___50% ___25% ___none ___don’t care to answer

6. What is special about your farm’s environment?

7. How much of your land is in pasture?
   ___100% ___75% ___50% ___25% ___none ___don’t care to answer
Part 2. Personal and Economic Considerations.

1. Why do you work on the farm? (check all that apply)
   ___Enjoy the life  ___I grew up on a farm  ___What I know how to do best  ___Other

2. What aspect of the farm operation do you enjoy most (mark with an X), and which aspect do you enjoy least (mark with an O).
   ___Working with the livestock  ___Growing crops  ___Fixing the machinery
   ___Management/planning  ___Recordkeeping/bookkeeping  ___Marketing
   ___Other (fill in) ____________________________

3. What special things do you do to support your and your family’s quality of life?
4. How do you handle periods of increased labor? (i.e. harvest, or lambing)
   ____Hire custom work ____Work long hours by myself ____ Have family help

5. Do you have plans to pass your farm on when you retire?
   ____Yes ____No, no one can afford to take it ____No, no one wants to take it
   ____ No, have not thought about that yet

6. Does the farm support itself? (Show a profit 4 years in 5)
   ____Yes ____No _____ Do not care to respond

7. Which enterprise generates the most net earnings?
   ____Cash crop ____Livestock ____Dairy ____________________ Other(fill in)

8. What percentage of the farm income goes toward paying loans (retiring debt)?
   ____>75% ____Between 50 and 75% ____ Between 25 and 50% ____<25% ____Paid

9. What percentage of the farm income is needed to cover expenses? (i.e. fertilizer, seeds)
   ____>75% ____Between 50 and 75% ____ Between 25 and 50% ____<25% ____Paid

10. Do you work off the farm?
    ____No ____Part-time or occasionally ____Full-time

11. Does anyone else in the family work off the farm?
    ____No ____Part-time or occasionally ____Full-time

12. If you answered yes to questions 10 and 11, how important is health insurance as motivat
    ____A major factor ____A factor, but not the only reason ____Not important
13. Do you hire labor?
   _____ Custom   _____ Occasional   _____ Full-time equivalent   _____ No

14. If you don’t hire labor, why?
   _____ Don’t need help   _____ Can’t afford help   _____ Can’t find help

15. How many farm enterprises are there? (e.g. individual crops, livestock, custom services)
   _____ One   _____ Two   _____ Three   _____ Four   _____ Five   _____ More than five

16. How do you describe your farm size, relative to other farms in the state?
   _____ Small   _____ Medium   _____ Large

17. Do you pay yourself an hourly wage?
   _____ No   _____ Yes, amount (optional)________

18. What percentage of farm income comes from government payments?
   _____ >75%  _____ Between 50 and 75%  _____ Between 25 and 50%  _____ <25%  _____ None

19. Are there constraints that keep you from trying new practices?
   _____ Yes, economics   _____ Yes, time   _____ Yes, lack of information/ideas   _____ No

20. What special things do you do, or plan to do, to improve the economic sustainability of your farm?
Farm Interview Analysis

Who did you interview?

Is this farmer related to you? If yes, what is the relationship?

Did the farmer consider his/her farm a small, medium, or large scale farm?

1. Looking at Part 1 questions 7-9, what (if any) sustainable practices are done on the farm?

2. What sustainable practice was done with the highest percentage on the farm?

3. Looking at Part 2 question 7, what was the most profitable aspect of the farm?

4. Was the farmer required to have other employment (other than farming)? If so, why?
5. Looking at Part 2 question 20, what things does the farmer do (or is the farmer planning to do) in order to improve the sustainability of the farm?

6. Did the farmer seem hesitant to make changes to his/her farming operation?

7. What was the most interesting thing you learned in this interview?
APPENDIX J

Agriculture, the Environment, and Society-Lesson 6

Time: 3-50 minute

Objectives:

- Students will synthesize a fictional farm that takes into account the various lessons of this unit.
- Students will analyze the feasibility of sustainable agriculture based on economic, environmental and community factors.

Standards:

MN State Standards

- Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world.
- Natural and designed systems are made up of components that act within a system and interact with other systems.
- Science and engineering operate in the context of society and both influence and are influenced by this context.
- The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.
- Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.
- Human activity has consequences on living organisms and ecosystems.
- Personal and community health can be affected by the environment, body functions and human behavior.

Materials: Sustainable Agriculture, Putting it all Together Assignment Sheet (1 per student)

Lesson Outline:

- Students will be introduced to the two project options (10 minutes)
- Students will be given time to work on their project (2-3 days depending on schedule)
- Students will present their project/findings to the class.

References:


Objective: To use your knowledge of conventional and sustainable agriculture to create a fictional farm that is best suited to be profitable, environmentally sustainable, and an asset to the community.

Directions: You are a farmer looking to hire laborers to your farm. Your applicant pool has indicated that they will only work for a farm that exemplifies the goals of sustainable agriculture. You are to create a presentation promoting your farm to these applicants. Be sure to take into account profitability, environmental sustainability, and community involvement and explain your reasoning behind your agricultural choices.

Your Applicant Pool is interested in these facts

- Farm Logistics (size, location, soil type, family background?)
- What sustainable practices are done on the farm? Why those practices?
- What conventional practices are done on the farm? Why those practices?
- Are there changes to the current farming operation that you the farmer, would like to change over the next 10 years? Why or why not?
- What is the overall goal of the farm?

Remember, you are trying to woo the best laborers possible. You want to make sure your presentation is well put together with pictures and easy to read slides. The most impressive quality of the presentation will be the presenter's ability to answer the question, “why?”.

Hint...

Before you begin to create your presentation, you need to answer the question, “What is the overall goal of the farm?” From there, you need to make sure all of your farming decisions align with that goal. It is also perfectly okay to not be achieving your farm’s goal, as long as you develop a plan to get there are can discuss why there are issues with meeting your goal.

**Creativity is key to this project**

Adapted from Mayerfeld, Diane. (n.d.).