

10-2010

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Development of agroecology based garden system and educational
program at Grand Valley State University

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Abstract

This study was part of a twelve- week project to introduce agroecology growing principles and educational models at the Community Garden on the campus of Grand Valley State University in Allendale, Michigan. This project was set up to be a demonstration for the further development of the garden space as an area for agroecology focused education, extension, and outreach. To accomplish this, three areas of change became essential components to developing a garden space that can serve as a living laboratory, demonstration area, and outdoor classroom. The first project goal was to develop and create a demonstration garden plot that would include diverse growing models in order to explore the best land management practices for small- scale community garden growing. The second project goal was to develop an agriculture education program that would include preschool students, K-12 students, and university students. These programs would be instrumental in introducing students to the diverse topics in agricultural education and to present the opportunity to experience working in outdoor fieldwork that adheres to ecologically aware principles. The third project goal was to use sustainability as a measure of the quality of our garden management while determining how to assess the environmental, resource consumption, and economic impacts of our garden. The purpose of this twelve- week project was to initiate a preliminary project to expand research and education in the future at the community garden site. The purpose of this paper is to provide a summary of the work that was done throughout the summer as this project was sponsored by the Undergraduate Research Council at Grand Valley State University as part of the Student Summer Scholars (S³) grant program.

Introduction

The Community Garden of Grand Valley State University was established in 2008 by a group of students who examined regional environmental problems in a philosophy class and were challenged to identify and then provide solutions to the most pressing of these environmental issues. The students recognized that a rapid phenomenon was taking place in West Michigan as well as throughout the country. Suburban development was increasing and spreading, small family farms were disappearing and being replaced by large industrial enterprises, food was a commodity that was purchased not grown, and few students had the knowledge or resources to learn about how to grow food in traditional, small-scale, and sustainable ways. Their solution was to raise awareness of local food issues and agriculture by developing a garden space that could be utilized by students, staff, and faculty as a place for learning about 21st century environmentally conscious, small-scale agriculture.

Since the inception of the community garden, students at Grand Valley State University have managed to lease a one- acre plot of land on a country road just south of Grand Valley State University's Allendale campus. The property that the garden lies on has been farmed as a rotating soybean and cornfield for a number of years. The goal of the garden planners was to manage the community garden by adhering to organic principles and exploring holistic and integrated approaches to dealing with soil quality, pest management, water usage, plant selection, and plant productivity. In 2008 and 2009, the garden was set up primarily for students to manage individual plots. Though garden participation is high in the spring and throughout the summer it dwindles. This lack of participation has been attributed to three factors. The first is that there is limited knowledge and resources in the areas of agricultural sciences among university students, faculty, and staff. The second is that the soils are in poor shape and crop yields have been low each year. Lastly, the models for growing are impractical and monogamously square plots that have led to increased crop failure, disease, and pest intrusion. In order to increase participation in the community garden and provide a reasonably enjoyable experience for garden plot owners it was realized that changes

had to be made in the structure of the garden, the availability of resources, and the management of the land. With these changes it was expected that we could increase plant productivity by providing alternative growing models and experiment with the addition of sustainable education, soil amendments, and water supply methods. It is the intention of this study to explore these changes so that the community garden can become a valuable, viable feature of community and academic life at Grand Valley State University.

Literature review and key concepts

The driving force behind this study is the idea that agriculture is one of the most precious, subjective, complex, and extraordinary ecological innovations within the history of mankind. It is widely recognized that one of the very basic things humans need to survive is food. It is less recognized however, that the source of food comes from two very important resources: land and labor. This is what agriculture is and what agriculture depends on. Though agriculture has been mechanized, industrialized, institutionalized, and commercialized, it remains one of the most constant processes by which we live. The difficulty is that agriculture as we know it in the 21st century contributes to degradation of the environment by way of swallowing up ecologically diverse landscapes, stripping the soil of nutrients, and consuming vast amounts of precious water and harmful chemical agents. Then there is the food industry, which is a reflection of our agricultural practices. Because our food industry is linked to our diets, and our diets are linked to our health, and our health is related to our individual well being, and our individual well being is related to our communal well being, it seems necessary to realize that our capacity for changing the way we do agriculture can change the way we live. There is a rise in responsible and ecologically conscious growing methods which call for less dependence on chemical inputs, greater crop diversity, conservation of water and soils, and integrated management programs to deal with pest and diseases. Some of these measures are characterized as organic, some are characterized as sustainable, others are characterized as “just going back to the way it used to be” – meaning pre industrial, pre monocrop, and pre commercial

farming. These measures can be summarized as being part of an agroecological production system. Agroecology is the environmentally and socially sensitive approach to agriculture and one that focuses on the ecological sustainability of the garden production system (Altieri, 1989). Agriculture within the system of agroecology seeks not only to manage the target crop but also the other resources that are important in production systems such as soil, water, land, and nutrients. Locally developed agroecological knowledge is fundamental to the progress of ecologically sensitive farming systems (Altieri, 1989). With a focus on sustainable solutions the combine modern innovation with traditional and cultural wisdom, it is possible to create a reformed agrarian perspective about how food should be grown and land should be managed and creating a garden space that is reflective of these principles.

Objectives

The general objective of this project was to demonstrate an agroecology- based program while utilizing the space of Grand Valley's already established community garden. The goals of this program are the following:

- a) Create a garden demonstration plot that includes a diverse array of garden models to demonstrate best land and resource uses, increase crop yields, promote diverse small growing systems, and explore traditional and cultural growing models to be duplicated in the following years based on success
- b) Develop pre K-12 educational programs to be conducted at the garden to increase participation at the garden, integrate garden field visits at a younger age, and introduce ecologically conscious growing methods to students
- c) The third project goal was to use sustainability as a measure of the quality of our garden management while determining how to assess the environmental, resource consumption, and economic impacts of our garden

Specific research questions that will be explored will include determining which garden models were successful in demonstrating small- scale ecological production systems and can be used for further comparative analysis. We are interested in developing educational programs to increase agroecological knowledge among young students and those students at the university level who have an interest in agricultural sciences. We are also interested in applying the fundamental principles in sustainable farming so as to take into consideration and balance environmental, social, and economic interests.

Methodology

The primary methodological approach to this project was demonstration and observation to conclude qualitative data results. This project began in February 2010 and adjourned in September 2010. Analysis and assessment of the results of this project were based on how effective our techniques were for implementing agroecology educational programs, constructing and maintaining various growing models, and the extent to which we offered sustainable solutions to these challenges. Each component of this project was assessed using qualitative data results, which we would hope will serve as the preliminary step in developing needed quantitative data in further research. The impact of educational outreach was assessed through student visit evaluations. The degree to which we used sustainability as a measure of the quality of our work was assessed through the projection of how the methods we enacted this year will be improved upon or utilized for the next growing year. The success of the garden demonstration plots was determined based on overall observations of characteristics of the crops and the uses and limitations of the growing models. It should be noted that there are a number of factors that determine agricultural crop production, and we did take into account the effects of management and care, the soil quality, climatic influences, pests and diseases. With that understanding, these models are representative and will serve as starting points for further research.

Description of study area

The Grand Valley State University community garden sits at 4329 Luce Street in Jenison, Michigan on one acre of previously industrialized agriculture land that has been farmed on a rotating yearly basis of corn and soybeans. The farm is surrounded by rural residential properties. The garden site lies at latitude: 42.95, longitude: -85.89. The site is one mile southwest of campus on a low traffic paved road. To the east of the site is the Wesley House, a home that serves the Methodist student population at Grand Valley State for small gatherings. The other buildings on the site include a garage and a shed that is used by the community garden crew for tools and equipment. The climate can be classified as temperate with well-defined seasons. The garden site is 20 miles east of the Lake Michigan shoreline. Because of its proximity to Lake Michigan the area has a slightly higher than average number of cloudy days due to the condensation from water vapor from Lake Michigan (“Climate for Grand Rapids”, 2007). Average percentages of sunshine hours are in the 50 percentile range in April and May and reach a high of 64% in July before dropping down again in August (“Climate for Grand Rapids”, 2007). Average precipitation from April to August is between 3 and 4 inches and average temperatures in April are in the 50’s and reaching a high of low 70’s in the months of June, July, and August.

Soil quality studies completed in 2009 by Grand Valley student and founding garden member Sarah Chartier revealed that the garden soils were comprised mostly of sand (47%) and clay (39%) particles and the remaining 14% was comprised of silt (Chartier, 2009). The Natural Resource Conservation Service Ottawa County Soil Survey (OCSS) suggested that the first 7 inches of soil on the site was sandy loam followed by a clay loam from 7 – 60 inches. The soils are also believed to be poorly drained Kawkaalin from a glacial till parent material (Natural Resource Conservation Service, 2009). The 2009 soil analysis conducted by extension services from Michigan State University indicated that the garden area had low levels of phosphorous (24 ppm (P) and moderate potassium (161 ppm K) and magnesium (232 ppm Mg) levels and an adequate amount of calcium (1794 ppm Ca) (Chartier, 2009).

Summary of results

Part I. Garden Models

The 2,000 sq. foot garden plot we utilized for our demonstration site lies in the southeast corner of the one-acre community garden space. The garden space is bordered by Luce Street to the south, the Wesley House property to the east, individual plots to the west, and a floral garden to the north. Sunlight coverage is full sun from morning until late afternoon in all but the northeastern most corner of the garden, which is partially shaded due to a large oak tree that lies just outside of the fence on the Wesley House property. The garden plot was measured at 45 sq. feet by 45 sq. feet and was divided into four sections. In the center of the plot is a Native American herb wheel modeled after traditional Native American medicinal wheels found in the northwest United States and Canada. The four sections were separated by 2 foot wide walking paths which were mulched with recycled woodchips from the Facilities Department waste dump site on Grand Valley's campus. A small drainage ditch was dug along the southern most path and the western most path and flowed south towards the ditch that lies along Luce Street. The upper left (northwestern) most section and lower right (southeastern) most section experienced extreme flooding before these drainage ditches were installed. The garden map can be referenced in the Appendix, (**Figure 1**).

Keyhole Gardens

The keyhole garden is a productive, small garden model that is ideal for condensed spaces. Three keyhole gardens were built at the garden site in the upper left corner (northwest). The keyhole garden is circular, with a path cut out in the middle so that it forms a "C" shape (**Figure 2**). This shape is ideal for allowing gardeners to walk into the circle and plant and weed without trampling plants. The keyhole garden was built using old salvaged bricks around the perimeter creating a 7- foot diameter. The space was filled with

compost from facilities dumpsite and horse manure from a nearby farm. There are many benefits in the keyhole garden including the layering of organic composts that contributes nutrients in the soils. The shape of the garden contributes to a low maintenance system by re-nourishing the soil through compost and retaining moisture, which cuts down on labor time spent weeding and watering. The low cost design provides readily available materials and the bricks around the garden retain heat which protect plants in early stages of development. The keyhole gardens were planted by preschool students from the Children's Enrichment Center and include tomato varieties, onions, lettuces, basil, and sweet peppers. The tomato plants and basil saw the greatest success and highest yields, while the sweet peppers, onions, and lettuces suffered low yields and did not fare well. One mistake included that we did not add the compost pile to the center of the keyhole garden which functions to replenish nutrients to the garden plants.

Potato Stacks

There has been much discrepancy in the past years about whether or not to allow the growing of potatoes on community garden plots. This adversity to potato growing is due in part to two factors, the first being that it is believed that potato crops leach the soil of proper nutrients and the second is that potatoes are especially prone to disease and pests and therefore are discouraged as a beneficial plant within the garden. While there is no past evidence that potato crops of such small quantities will leach the soil, there is resistance among those who adhere to organic practices of implanting a crop with known difficulties in managing disease. The potato can be very finicky to grow, because of pest and disease problems. One method for encouraging healthy and somewhat isolated potato crops is the potato stack model. The potato stack model is a cultural practice that uses cylinder columns stuffed with layers of straw and soil to mound potato spuds in a vertical column for ease of growing. Potatoes are grown from seed pieces- the well-known "eye" of the potato and not actual seeds and therefore require a bit more spacing when planting. Potato seed pieces can be planted 10 – 12 inches apart (University of Illinois Extension, 2010). The potato stack model we used was placed in the upper left (northwest) area of the 2,000 sq. foot garden

demonstration plot. Three cylinders were formed using recycled chicken wire creating three “tubes” which were 2.5 feet deep and 1 foot wide (**Figure 3**). A layer of straw was placed on the bottom of the cylinder as bedding, and then a layer of organic soil (bagged from Allendale Hardware) was applied. In between the layers three to four potato spuds were planted. Potato spuds were donated by the non-profit organizations Our Kitchen Table and the Greater Grand Rapids Food Systems Council at their annual plant giveaway in Grand Rapids, Michigan. The potatoes were a Michigan disease-free white-skin variety however the specific variety is unknown. The straw is an ideal planting material for potatoes because it smothers weeds, locks in moisture while insulating the developing plants from excess moisture and heat which can lead to rapid potato rot, and protects young potato plants from turning green from the sun. The straw also acts as a mulch to keep the soil moist (Healy, 2010). This method also is a no-till, no dig method for harvesting a large potato crop. Sprouts grow quickly when planted in straw, and when the green sprouts begin to poke through the cylinder encasement it is advisable to cover the emerging plants with more straw. It is important to isolate potatoes from other plants such as cucumbers, pumpkins, squash or tomatoes as these vegetables are prone to *mosaic virus*, and keeping them apart helps to prevent the virus from spreading from one vegetable type to the next (University of Illinois Extension, 2010). Tomatoes can also catch potato blight so isolating potatoes is important in preventing cross infection. Potatoes can be planted in early spring so long as the soil is dry and relatively warmed, moist soils can lead to seed rot early on. Potatoes were planted in mid June, which yielded a late crop. Potatoes were harvested in mid September and were one of the most successful crops, yielding thirty small, white-skinned, golden centered, disease free, baby potatoes ranging in size from 2 to 4 inches. This method will certainly be replicated in the 2011 growing season as an efficient, minimal space usage, and low input model for potato growing.

Container gardening

Container gardening is a space and time efficient method of gardening that is ideal for urban environments or unfavorable soil conditions, poor drainage, or condensed spaces. Container gardening

was modeled through the use of six recycled plastic drums that were placed in the upper part of the southwest section of the garden. These cylinder containers were filled with a mixture of organic purchased soil and compost from the facilities waste site. The six drums were planted with a variety of sweet and hot pepper varieties. Because the southwest section of the garden was prone to flooding, the 12 – 16 inches of additional soil prevented crops from becoming waterlogged. The containers held moisture relatively well. Holes drilled at the bottom of the drums allowed for proper drainage of the soils. The pepper plants were from Countryside Gardens greenhouse in Allendale, Michigan and were planted in mid June by students in the Environmental Studies 480 Practicum in Sustainable Agriculture course. The pepper plants showed excellent health aside from wilting as they received full sunlight. The yield for the pepper plants was high and harvest continued into October.

Companion Planting

Companion planting is a practice that recognizes the symbiotic relationships that exist among plants and is a fundamental principle of agroecology. Complementary plantings typically include pairing legume crops that are nutrient enriching and nitrogen fixing such as soybeans with nutrient demanding and vigorous crops such as corn (Snapp, 2008). Scientific research supports some claims of the benefits of companion planting, but most models are based on historical observation and cultural tradition.

We modeled two systems of companion planting. One such system is a Native American traditional planting systems called the Three Sisters, which has seen a revival since permaculture gardening has gained attention in recent years. The three sisters are corn, beans, and squash and were staples of the Native American diet and also one of the most successful agricultural system innovations in the domestication of food crops. The structure of the system allows for beans, through their symbiotic association with a type of root bacteria to fix nitrogen from the air into a form that plants such as corn can use (“Growing Garden Companions”, 2003). Therefore, the beans provide the nutrients that corn demands while the corn provides a natural trellis for pole beans to grow on. The leaves of the squash plant protect

the stalk of the corn at the base as well as the roots, stunt weed growth, and keep the soil temperature cool. The Three Sisters system was planted in the lower left (southwest) section of the garden. Eight rows of corn was planted at 6 inches apart and rows were spaced one foot apart. Beans were planted at every other corn plant, and squash was planted at intervals of four. Each row had therefore 22 corn seeds, 11 bean seeds, and 4-5 squash plants. This model was unsuccessful and yielded only a small amount of bean plants. The corn plants had little growth and the squash plants never flowered. The failure of these crops can be attributed to four likely factors which include: (1) severe flooding of this section of the garden in May and June before the drainage ditch was dug in late June, (2) spacing plants too close together, (3) a dry climatic conditions throughout August, and (4) insufficient soil nutrients to support a corn crop. Late planting of the corn crop in late May might have also contributed to the weak development of the corn, which reached a maximum height of four feet. We would like to try this model again in 2011, with key differences being that the crops will be spaced and soil will be mounded. This model will also be irrigated through a drip irrigation system which is in the process of being developed at the community garden utilizes rain barrels.

The second model of companion planting was demonstrated in the upper left (northwest) section of the garden by planting varieties of tomatoes, peas, and marigolds together along a small string fence (**Figure 4**). Marigolds are a flowering plant that are known for keeping the soil free of harmful nematodes and are scented serving as a pest deterrent. This model produced a successful yield of cherry, Roma, and grape tomatoes, which were purchased as seedlings from Countryside Greenhouse in Allendale. The peas were planted by seed and showed healthy early growth, yet they became withered during the month of July and yielded no harvest.

Intercropping

Intercropping is the practice of growing of two or more crops in close proximity on a farmland to promote interaction between them (Sullivan, 2003). Intercropping is an important method of planting in

agroecology and sustainable gardening in that it mimics natural plant communities while creating a closed ecological system in which the nutrients of one plant contribute to the nutritional needs of another plant in a cyclical input and output system (Sullivan, 2003). Intercropping illustrates principles that can be used to improve the resilience of crops and enhance the efficiency of agricultural systems (Snapp, 2008).

Intercropping protects plants from transmittable disease and discourages pest damage by limiting heterogeneous crops patches. This method recognizes the need to create crop systems when planning ecologically sensitive and sustainable gardens. Intercropping is based on diversity and integration and encourages cooperation rather than competition among plants (Snapp, 2008). Most intercropping models are based on large scale agriculture, while small scale garden or farm intercrop planting is more often related to companion planting. We did however experiment with intercropping in the upper right (northeast) corner of the garden (**Figure 5**). This section of the garden was planted with a layout of mounded rows with a 6 inch rise, spaced 1 foot apart. This layout is called strip cropping or row cropping. The two furthest east rows were planted with eggplant seeds, the middle three rows were planted with heirloom carrot varieties, and the three west rows were planted with cauliflower, kohlrabi, and eggplant seedlings from Countryside Greenhouse gardens. This area experienced pest damage as the expansive foliage proved to be attractive to rabbits, beetles, and slugs. A two-foot high chicken wire fence was erected in mid-June and the surviving plants continued to develop throughout the summer, though most of the plants had suffered from severe enough damage that they did not yield fruit. The eggplants seeds never grew more than 2 inches, likely due to the lack of sunlight as this section of the garden is partly shaded by a large oak tree through most of the morning and early afternoon sun. Carrot varieties showed moderate yields with tubers reaching no more than 3 inches in length, nevertheless over 60 baby carrots were harvested in a relatively high yield. The development of the carrots likely suffered from inadequate spacing between plants. The mounded row cropping worked well for root vegetables such as the carrot and will likely be repeated in spring 2011 garden planning.

Raised garden beds

A raised garden bed system is built on top of existing soil and is comprised of a frame filled with either the incorporation of the existing soil or added soils. Raised beds are ideal for small scale growing operations for several reasons. According to The Ohio State University Extension services “Raised Bed Gardening Fact Sheet” compiled by Pete Lane (n.d.) these benefits include:

- Accessibility: raised beds are elevated making labor easier and allowing individuals who suffer from physical discomfort when gardening an alternative to kneeling
- Soil quality: added soil and compost can provide an alternative to growing in the garden’s natural soils, and soil is less compacted and drains better in a raised bed system
- Low maintenance: raised beds are less prone to rapid weed development and retain water moisture better than ground implanted gardens decreasing labor time
- Higher yields: Plants are planted in beds in at greater densities because raised beds do not require space between rows because all walking, harvesting, and cultivating is done outside of the perimeter of the bed (Lane, n.d.)

The raised beds were built in the lower right (southeast) corner of the garden plot where they received partial shade in the early morning (**Figure 6**). Beds were constructed from landscape lumber and filled with a combination of store bought organic soils from Allendale TrueValue Hardware in Allendale, Michigan and compost from the Facilities Department waste dump site. The two long raised beds were planted with pepper, tomato, and herb seedlings from Countryside Greenhouse in Allendale. The two short raised beds were direct seeded with lettuce, spinach, and mixed green varieties. All beds thrived throughout the summer and showed early signs of healthy development. Lettuces were harvested in succession throughout July and August. Peppers were harvested throughout July and August, and tomatoes were harvested throughout August and September. The raised bed model was the most successful model in the garden demonstration plot and will likely be repeated in the 2011 growing season.

Square foot garden

The square foot garden is an urban garden model that uses on average 20% of the space that a conventional row garden requires (Square Foot Gardening, n.d.). Square foot gardens are arranged in a 4 ft.x 4 ft. grid. The square foot gardening method was developed by engineer and weekend gardener Mel Bartholomew in 1981. Bartholomew's method emphasized space saving, labor saving and water saving, biodiverse and intensively planted areas (Bartholomew, 2005). The square foot garden is ideal for poor soil conditions as it requires the addition of several soil supplements. The square foot garden is layered with a combination of organic materials called "Mel's Mix". This combination includes by volume of one third of decayed Sphagnum "peat moss", one-third expanded vermiculite and one-third blended compost. Because the model uses soil additives, it has been shown to be successful in diverse geographic regions throughout the world (Bartholomew, 2005). Maintenance is modified for easy access to all sides of the garden, and regular watering and weeding are not needed. Soil remains loose and does not become compacted through trampling and therefore water conservation is a key feature of this model. This garden model is relatively expensive as it requires the purchase of vermiculite, which can cost up to \$19.00 per each 2 cu. feet bag, Sphagnum "peat moss" which can cost up to \$8.00 per 2.2 cu. feet bag, and the purchase of wood to create the garden box. However, costs may be saved in regards to water usage and plant purchases as Bartholomew stresses that this model for growing provides just enough and never excess crops. Two square foot gardens were constructed on the lower right (southwest) most section of the garden (**Figure 7**). These gardens were bounded by rope creating a 16 sq. foot grid area. We did not purchase the recommended ingredients for Mel's mixture due to budget limitations, so we instead opted for a combination of store bought soil and compost. Grids were planted with peppers seedlings that we had started from seed along with squash seedlings. Plants showed normal beginning growth but were stunted by early June and failed to yield a harvest by September. This can be attributed to lack of nutrients in the soil along with poor seedling health when they were transplanted. We would like to build at least one square foot garden using the proper materials for the 2011 growing season.

Vertical growing

Vertical growing is a form of traditional and permaculture growing. The word "permaculture" was first used in 1978 by Bill Mollison, an Australian ecologist, and one of his students, David Holmgren. It is based on the joining of the concepts of "permanent agriculture" or "permanent culture" (Diver, 2002).

Permaculture is a food production system that is designed with specific regards to integrating both human and natural environments into a stable ecological system. Trellising is an important feature of permaculture growing, and though the vertical growing model is not part of a complete permaculture system it is a cultural practice that was explored in this project. This application of permaculture used space efficiently to support climbing crops such as pole beans. A teepee like structure was created out of wood pieces found at the Facilities department dump site and was placed in the upper left (northwest) section of the garden space in the middle of the keyhole gardens (**Figure 8**). The teepee structure was held together by twine and was placed on a mound of compost and soil that rose about 7 inches off of the ground. Pole bean and wax bean seedlings that were grown from seed were planted around the structure. Plant health was moderate and the yield was moderate. Less than one pound of beans was harvested from this structure. Plants showed signs of nutrient deficiency early on in their growth and development. This was most likely due to unhealthy seedling growth. For 2011 we plan to layout the beginning stages for a permaculture garden system.

Native American Herb Wheel

The Native American herb wheel was one of the most aesthetic and artistic expressions of the cultivation of crops in the garden. The model for the Native American herb wheel is derived from the mysterious medicinal wheels that have been found in Alberta, Canada and the state of Wyoming. The herb wheel is a reminder of the connection between the natural world and the human world and the interrelatedness of these two domains on Earth. It is projected that the use of the medicine wheel were for shamanistic ritual healing using the remedies from a myriad of domesticated plants (Lockhart, 1983). The herb wheel is a form of ethnobotany studies which examine the relationship between people and cultures and plants.

Particularly, ethnobotany is the study of how people of a defined culture and region use indigenous plants (Veilleux and King, n.d.) The Native American herb wheel is traditionally planted as a ceremonial and meditative ground space with specific regard to animism and directional orientation. The garden is shaped like a wheel, with one inner circle interlaid within another larger circle with spokes dividing the wheel into four sections, which represent the four cardinal directions. Crops planted within these sections follow a specific pattern as towards symbolism of color, time of day, time of year, lifelines, and animal symbolism. The Native American wheel was laid out using stones previously pulled out of the garden and was formed in the center of the garden space as a focal point. The wheel was planted not according to traditional native layout, but rather served as a general herb garden with the intention of attracting pollinators through the fragrant mix of herbs, spices, and wildflowers. Basil, Sage, thyme, marjoram, lemon balm, lavender, parsley, rosemary, chamomile, curry, oregano, and cilantro were all planted within the garden. The herbs did well and produced moderate yields while basil produced high yields. As the herbs went to flower, increasing numbers of birds and butterflies could be seen in the garden creating a harmonious synergy throughout the garden. The herb wheel model will be introduced as part of a permaculture garden model in the future.

These garden models served as the outdoor laboratory for the summer where the comparative analysis of these systems could be assessed and understood. The components of the garden models are summarized and condensed on **Table 1** in the Appendix. Table 1 demonstrates the principle that guides the garden model, whether it was based on cultural, traditional, ecological, permaculture, or urban garden systems. Table 1 also provides a comparative analysis of the health, crop yields, and maintenance of the varying models and includes the list of the vegetables planted within each system.

Part II. Agroecology Education

From May to August 2010, over fifty students in preschool through twelfth grade were introduced to the garden through day field trips, and eight university students participated in the practicum “Sustainable Agriculture” offered through the Environmental Studies Department taught by Dr. Edwin Joseph. These educational and experiential programs were the first of their kind to be offered to students in the campus community and were an integral part of this project’s success in demonstrating the feasibility to teach agriculture education at a non-land grant institution. When describing the importance of agricultural education among youth, H.M. Hamlin (1962) stated the value of agricultural education in public institutions:

There are two ways of viewing the public interest in agricultural education. One arises from concern about making agriculture an efficient industry...The other emphasizes agricultural education as a means of developing good American citizens and good human beings...there can be no compromise between these approaches. Education must emphasize human and social values; agriculture must be made a mean of attaining these values (Hamlin, 1962).

This principle of using agricultural education to encourage human and social values tied to environmental and food systems sciences guided the agroecology focus of the program that was developed for pre -12 students at the garden.

Children’s Enrichment Center, preschool students

The Children’s Enrichment Center of Grand Valley State University is a campus day care program for children of students, staff, and faculty at Grand Valley as well as the surrounding community. Ten students ranging in ages from 4 to 9 visited the community garden as part of a day fieldtrip. The students at the center are familiar with discussions about healthful foods and taking care of the earth, these are key ideas that center Director Sharelle Arnold stresses in the day- to- day classroom activities and lessons. The student group visited the garden in early June on the same day that students in the Grand Valley high school preparatory program TRIO Upward Bound visited the garden for a service project day. The pairing of the two student groups proved to be complimentary as students were able to work in groups that

encouraged one-on-one tasks and collaborative learning while integrating different age groups. One of the goals of the community garden has been to make it a multi-generational work area where individuals who are novice and experienced, older and younger, can engage in food production. There is extensive research to show the benefits of introducing younger students to garden activities in their school curriculum. Of these benefits the greatest are the educational integration of the natural sciences, social sciences, and math. Also, the garden experience is capable of inspiring environmental stewardship and an increased awareness of where food comes from. Gardening introduces youngsters to healthful lifestyles and outdoor physical activities, which may encourage eating habits that include fresh vegetables and fruits at a young age (Ozer, 2006). Children's Enrichment students toured the community garden and learned about the keyhole garden, which is a form of permaculture gardening. The students planted seedlings from Countryside Greenhouses of Allendale, Michigan and also seedlings that I had started in the keyhole garden plots. The goal was to plant pizza and salad gardens. After talking about the ingredients that go in a pizza and salad and what special toppings students enjoyed, they hand planted onion sets, bell peppers, three varieties of tomatoes, lettuce, and basil. Student asked questions like "Can we plant a pepperoni plant?" "Or how about mushrooms?" We discussed how pepperoni was made and what special growing conditions were necessary for mushrooms to grow. Faculty and staff mentors read library books to the children after they had planted the gardens. After reading a book about sunflowers, the children planted sunflowers in cups. It was explained to them that these flowers would be sold at the Grand Valley Farmer's Market on Wednesdays on campus. Students also painted garden signs with vegetables on them to place in their gardens. The following week, I visited the students at their daycare center and we painted terra cotta pots to put their sunflowers in. The students later visited the Farmer's Market and were able to see their pots for sale. We planned on students coming back to the garden to harvest their foods to make pizzas and salads. However, the keyhole gardens saw little success and the light yield of tomatoes was not ready for picking until well into September. The assessment of the Children's Enrichment Center participation are summarized here, students learned:

- a. The location and function of the community garden on campus

- b. How different growing models contribute to an ecological system that mimics diverse systems found in nature
- c. To share in intergenerational learning by partnering with high school and college students along with faculty members of the university
- d. How the concepts of creativity and literature are complimentary to nature-based and garden activities
- e. The Farmer's Market is a component of the community garden and represents a stage in the food production and consumption cycle
- f. How to select plants and carefully plan out the plantings for a pizza and salad garden. The importance of hard work and patience in outdoor service learning. Students understood that some factors that determine garden health cannot be controlled

The students and staff at the Children's Enrichment Center showed an overwhelming interest in being involved with a garden program beginning in the spring of 2011. The focus of this garden program will be on planting a successful pizza and salad garden and using the garden to support ecological lessons learned in the classroom. Students will be engaged in projects both at the Children's Enrichment Center as well as at the community garden so that they may learn of the versatile ways and environments in which food is grown. General concepts will focus on healthful eating and introduction to new vegetables.

Allendale Christian School, 6th Grade Students

Eighteen sixth grade students from Allendale Christian School visited the community garden in May. The lesson plan for the day was on soils and soil composition. Students were given a tour of the garden and were introduced to the varying garden models. We discussed how the community garden was positioned within an agricultural field of soybeans. We discussed the differences in small scale multi-crop growing and monocrop mechanized agricultural growing. The project for the students was to learn about how to collect a soil sample and study the results of the soil sample to learn about the soil composition and analyze the nutrient quality. Students split up into five groups and went to five different sites near the garden, which included a spot within the 2,000 sq. foot demonstration garden, the northwest most corner

of the community garden, an adjacent grassy field, the corn/soybean field behind the garden, and a forest area across the street. We discussed how the different locations would affect the soil quality and what students might expect to find. Students were supplied with soil probes, soil data sheets, and soil result sheets. Soil data sheets helped students use sensory skills to describe the soil types they were seeing. Questions such as “How does your soil sample feel”? And “Does the soil feel sticky when moist”? Students became familiarized with the soil classification pyramid, (**Figure 10**). Students used the probes to collect a small handful of soil. This soil was then brought back to a gathering space where students tested soil nutrient levels of potassium, phosphorous, nitrogen, and pH levels. Students used soil-testing kits from the Grand Valley State geography department to measure the levels of these nutrients based on a color reactor chart. Students then examined and compared the results of their tests. It was determined that only the pH test levels could be accurately read due to outdated tablets which measured the potassium, phosphorus, and nitrogen levels. Students learned about remediation and soil amendments, which could correct the deficiencies in soils over time. The assessment of skills, concepts, and educational experience of the Allendale Christian School visit are as follows:

- a. Students were introduced to a campus community garden, its uses, and its function
- b. Students learned about the importance of soils and soil nutrient levels, students learned how to identify characteristics of soils
- c. Students were engaged in hands-on fieldwork learning in cooperative teams
- d. Parents were able to supervise and assist students in figuring out how to use outdoor science lab equipment, students learned how to use soil probes and collect soil samples
- e. Students learned to record data and then analyze soil sample test results
- f. Students presented their group findings to their peers and discussed the differences and variability of their results

Allendale Christian School faculty are interested in continuing to bring their 6th grade students to the community garden if structured learning modules are available. One parent from the group works

with visual and hearing impaired adolescents and adults and is interested in bringing her students to the garden for a sensory learning fieldtrip.

TRIO Upward Bound, 9th grade students

TRIO Upward Bound is a college preparatory program for high school students in inner city Grand Rapids. Students participate in TRIO Upward Bound on a volunteer basis and are typically minority students from low- income families who struggle in school and stay with the TRIO Upward Bound program from the 9th – 12th grade. TRIO Upward Bound is a yearlong program that offers mentoring and advising, service learning trips, and college planning. During the summer, students live on the Grand Valley Allendale campus in dorm housing and take courses, go on field trips, and do community outreach and service learning trips. TRIO 9th grade students go on a series of field trips. In 2009, TRIO 9th grade students came to the community garden twice. For 2010, twenty-five 9th grade students had three field trips to the garden. These visits were set up to be three- hour educational and fieldwork service trips. The method for developing field visits was based on an awareness of the student learning process that is based on a model of agricultural education outlined in the study *Agricultural Education* by Glenn Z. Stevens (1967). Stevens found that his development of a four- part teaching model led to productive development of skills among his high school students. The elements of the teaching model include: (1) identification and definition of the problem situation and the specific goals which are determined to be purposeful, (2) formulation of a plan of action with an understanding of the approved agricultural practices to implement these actions, (3) the execution of the plan through guidance of student activity in their individual and group experience projects, and (4) periodic self- evaluation of results through understanding and or observing outcomes. This four- part teaching model allowed us to focus on the importance of purpose, planning, execution, and evaluation of the effectiveness of agricultural education at the high school level (Stevens, 1967).

The first student visit in early June was not reflective of the Steven's teaching model as it had not yet been explored. The first TRIO visit was in conjunction with the Children's Enrichment Center visit first visit. Most TRIO students were involved in helping to weed the existing garden plots, till a large area that was to be planted, and water existing crops. Students toured the garden and learned about the origins of the community garden and the purpose that the garden served as an outdoor classroom setting. In general, the day was structured yet not educational. Five students were able to work with Children's Enrichment Center preschool students, and these students seemed to have a more fulfilling experience than their peers according to their fieldtrip evaluations, which were given to them at the end of their visit. TRIO student Lyric Hoffman stated that what she liked best about her first visit was working with the preschool students. She stated "I enjoyed working with the kids because I felt like a role model" (L. Hoffman, student evaluation, June 18th 2010). Students like Shontierra Parks who spent the day weeding did not have as enjoyable experience. Shontierra Parks stated that she "Didn't like anything because I felt it was just an introduction so I didn't experience much. I didn't like pulling weeds because I want to learn how to garden not pull weeds" (S. Parks, student evaluation, June 18th, 2010). Though students generally complained about the physical or environmental conditions of the workday, a number of students recorded that they felt they were helping the community or helping people by lending a hand in the garden, one of the key concepts we sought to instill in the students by demonstrating the importance of their individual work. After the first visit, a more structured schedule was established. This schedule included an orientation activity, discussion and educational lesson, and fieldwork activity.

On the second student visit on June 24th the lesson was centered on Integrated Pest Management (IPM) strategies. A course module was developed and students spent time during their orientation activity observing animal behavior and pest damage to crops in the garden. Students were assigned readings to help them understand that Integrated Pest Management (IPM) strategies were ecologically beneficial because they avoid the use of chemical pesticides and herbicides and encourage natural pest control through mechanical and biological methods. Students gathered in small groups to discuss their readings

and to discuss their observations of pest damage in the garden. Key lessons learned in our group discussion were:

- a. Understanding when an animal becomes a pest
- b. Setting a threshold for when it is appropriate to deal with a pest
- c. Harmful effects of chemical pesticide use on ecosystem and human health
- d. Identifying preventative measures to protect the garden from pests
- e. Different pest management strategies to control and mitigate crop damage

Students were involved in an activity in small groups where they created spice sachets to hang around the garden fence posts, create egg spray mixtures to apply to plant foliage, and create a liquid fence barrier that was sprayed along the perimeter of the garden. Students worked in small groups and ingredients were supplied to create these integrated pest management strategies. The spice sachets contained mixtures of offensive smells such as cayenne pepper, lemon juice, pepper, and garlic. The sachets were made of cheesecloth and tied every ten feet along the garden posts (**Figure 11**). The egg spray was made of eggs, garlic, and water and was applied to plants to protect foliage from being nibbled by creating a rotting smell (**Figure 12**). The liquid fence contained a mixture of Tabasco hot sauce, garlic, citrus, and pepper. These recipes are meant to either frighten or offend animal pests and the students learned that these measures could aid in the prevention of primarily deer and rabbit garden pests (**Figure 13**). We did not test these measures as part of a trial experiment but it is recommended in 2011 that a number of test plots be set up to demonstrate the feasibility of integrated pest management strategies through comparative analysis.

On the final garden visitation date on July 16th 2010, students were engaged in composting activities. The student's goals for the day were to help us prepare our compost beds for our newly built compost bin system and construct a worm bin for the process of vermicomposting. The orientation activity had students reflect on what the word "*compostable*" meant and where composted items came from. Students

discussed in small groups what their daily usage of recycled, waste, and compostable materials was. Our group discussion focused on these key concepts:

- a. Understand what compost is, where it comes from, and why it is used in the garden
- b. Understand how compost is made and what inputs and maintenance is needed to ensure the proper balance of nutrients
- c. Learn how to make their own compost from materials found around the campus and outdoors

Students worked in three groups. One group collected raw materials such as grass clippings, leaves, weeds and vegetation, food waste, and woodchips and layered these materials in our one sided wooden compost bin. Food waste was retrieved from Grand Valley's Campus Dining and consisted of waste from TRIO student's meals from the previous days (**Figure 14**). Another group was involved in creating a lasagna layered compost mixture from some bought and some scavenged materials. The lasagna-layered compost is meant to generate heat and provide a perfect amount of nitrogen rich and carbon rich nutrients to create a perfectly balanced compost (**Figure 15**). The project plan for the lasagna compost was derived from John Biernbaum of Michigan State University department of Horticulture in his "Compost Quick Course". The third group of students worked to build worm bins for vermicomposting, which is the process of creating compost by worms. The project plan for the vermicomposting bin was from the book by Mary Appelhof, *Worms Eat My Garbage: How to Set Up & Maintain a Worm Composting System* (Flower Press, 1982). Using 20 gallon tubs, students prepared beds for the common worms used in composting, *Eisenia Foetida*, otherwise called red worms. Students in all three groups created posters to present to the group explaining the process for creating their composts and how their compost systems should be maintained. From this composting course:

- a. Students witnessed the food cycle by using food waste to supply nutrients for their compost systems
- b. Learned about the fundamentals of composting including space and resource requirements
- c. Demonstrated their learning by creating posters to share with peers and teachers

- d. Understood the different forms of compost that are used at the garden including commercially produced compost, animal manures, and compost from facilities dump sites

The TRIO visits were one of the most important programs we were able to establish over the summer. Planning meetings contributed to the success of these visits and students showed increased levels of interest and participation in the second and third visits. Student's experiences and learning were assessed through field trip evaluations, which asked questions such as "What did you like best about your garden field trip"? "Did you enjoy working independently or in small groups"? "Were you able to interact with the garden staff during your visit"? As well as specific questions about the material and lessons taught during each visit. Overall, students enjoyed the hands on aspect of the field visits and enjoyed the collaborative group work. Most students wrote that they were interested in creative projects at the garden, which included building new garden models, making signs, and creating pest management strategies. Students also showed a strong interest in fieldwork that included general labor such as weeding, raking, and watering plants. Most students were adverse to the physical conditions of their visits which included complaints about the heat, dirt, and walking to and from the garden. The outcomes of the TRIO student participation are as follows:

- 25 new 9th grade students were introduced to the garden and were able to make recommendations about what they would like to do in the future at the garden
- Students worked in small groups and were engaged in observation, interpretive readings, discussions, and collaborative group work
- Students learned about integrated pest management, composting, local food resources, ecologically conscious garden management, and organic gardening
- Students became familiar with different garden growing models

As a result of the success of the TRIO Upward Bound visits this summer, TRIO Director Arnie Smith Alexander has decided that the community garden will serve as the incoming freshman fieldtrip site for the entire summer and will consist of five consecutive visitations in which specific workshops will be

taught and a youth agriculture program will be developed which will allow TRIO students to plant their own gardens in early spring and manage them throughout the summer.

Part III. Sustainable systems in agroecology

Due to the fact that sustainability as component of our research was ingrained in the garden model systems as well as the basis of the composition of our agricultural lessons, it should be stated that the full extent of the sustainable measures that were taken in completing this project are not completely nor fully realized and therefore it is proposed that this section be simply a summary of the most important measures we took to adhere to an agroecological principle of sustainable growing. Below are listed some of the actions that we took and it is recommended that these factors be considered for future studies in increasing sustainable features of the community garden area.

- Bought primarily organic and heirloom seeds from regional seeds retailer, Menard's
- Bought seedlings from Countryside Greenhouse in Allendale, Michigan
- Utilized compost from Facilities Department waste dump site, along with woodchips
- Purchased 300 sq. feet of SPURT commercial compost which is processed from Campus Dining food waste at Grand Valley eating facilities
- Used no chemical fertilizers or pesticides on garden area
- Implemented Integrated Pest Management (IPM) strategies throughout the garden
- Reused old building materials including salvaged wood, bricks, and stones
- Constructed one bin and two bin compost systems (**Figure 16**) along with students in Environmental Studies 480 Practicum in Sustainable Agriculture course and taught fundamentals of composting to TRIO students
- Set up vermicomposting system that utilizes worms as agents in decomposition of organic materials

- Conserved water through limited irrigation, integrated water conservation designs in our demonstration models, and installed six rain barrels to serve as a rain collection and drip irrigation system for the future (**Figure 17**)
- incorporated urban garden models which can be replicated in areas not suited for agriculture and also introduced traditional and cultural garden models to expand the options for independent or community growers
- Demonstrated non-mechanized agriculture methods
- Contributed produce to the GVSU summer and fall Farmer's Market on campus (**Figure 18**)
- Set up small agri-business with Grand Central Market of downtown Grand Rapid, Michigan

It was realized throughout the summer that any one of these measures could benefit from a complete, thorough, and narrow study of their application at the community garden, and it is a hope that these emerging sustainable measures will encourage a new group of Grand Valley students to explore the multifaceted opportunities to study agricultural sciences and agroecology systems.

Discussion

The process of creating agroecological growing models along with an educational program was one that was multifaceted and often multidirectional in purpose, goals, and outcomes. The discovery that agriculture is both an art and a science was fully realized within the six months that this project began and was completed. In a sense, this project remains incomplete in that it was a necessary stepping-stone towards acquainting Grand Valley State University with the feasibility of using the community garden as a site for agriculture extension, education, and outreach. The university sits in the middle of the largest growing region in all of Michigan, and a region that is the 11th largest growing region in the country. Agriculture is as much a feature of the community as it is neglected by it. Perhaps that is because it is easy to drive past fields and open land and consider this space to be “unproductive” or lacking in function. Our garden demonstration models have the potential to show the community that 21st century

agriculture doesn't have to look like the "empty" fields that line the highways and byways of West Michigan. Agriculture can come in many different forms; it can be condensed, portable, high efficiency, boxed in, contained, upright, laid out, etc. One of the main goals of this project was to show that the largest consideration for agricultural productivity is not space, but management of space and resources. Agriculture does not need to be expensive or time consuming; we can create highly productive agricultural systems without using wasteful amounts of land, resources, and inputs.

The limitations to this project were largely in part due to lack of experience and knowledge of agricultural sciences, mechanical and management errors, and the influence and unpredictability of climatic conditions. The climatic conditions were perhaps the most challenging aspect to this project and largely affected the productivity of the garden modeling component of this project. The growing season was outlined as being between the months of April and September. The last frost freeze date recorded in 2010 for Grand Rapids, Michigan was May 5th, 2010. The first fall frost is expected to be October 8th, 2010 (Farmer's Almanac, 2010). Weather patterns for the growing season in 2010 were marked by extreme periods of precipitation and an early frost freeze date. On April 2nd, temperatures reached above 80^oF and dropped to the low 40^oF by the following week. There were many days of precipitation with a total of 3.74 inches for the month of April (History for Grand Rapids, Michigan, 2010). May 2010 was characterized by record highs in the 90's and severe storms, which dropped 3.8 inches of precipitation throughout the month. June was cooler than May with temperatures averaging in the 70's. Extreme storms continued throughout June and over 8 inches of precipitation flooded the garden throughout the month. July had a number of thunderstorms and cloudy days with mean temperatures in the mid 80's. There were 4.66 inches of precipitation throughout the month. The month of August was dry and sunny, with consecutive days reaching temperatures in the mid 80's. Only 1.74 inches of precipitation left a number of crops damaged and parched. Harvesting continued into September where temperatures were cool and averaged in the mid 70's with 2.8 inches of precipitation (History for Grand Rapids, Michigan, 2010). Teaching youth how to cultivate food in sustainable ways is one of the surest measures of food security

we can promote in the 21st century. Based on the response from children at the pre- kindergarten to college students, there is a place for agricultural studies in schools, and there is a need to reconnect students to land based and ecological learning that is hands on and service oriented. The benefits of service and experiential learning opportunities were highlighted in the Summer/Fall issue of the Grand Valley State University College of Education publication *Colleagues*. This issue publication was focused on the impact that service-learning opportunities can have on school communities. Because service learning is linked to engagement, students show a higher interest in learning and are focused on goal setting, being responsible for the management of their time and projects, attain new social and group work skills, and learn problem solving strategies (Billing, 2010). The community garden project proved to be a perfect integration of the principles of service learning, as demonstrated by the TRIO Upward Bound students. TRIO Upward Bound Director Arnie Smith Alexander decided in August 2010 to make the community garden the summer project for all incoming freshman to the TRIO program beginning in June 2011. Plans are underway among the Sustainable Community Development Initiative and the Community Garden Council to secure grant funding to support such a program for TRIO students. It is by developing a continuous cycle of education, instruction, and learning that we can encourage a re-emergence of agricultural interest at Grand Valley State University and introduce principles of agroecology education across campus.

Plan for Dissemination

This project was presented at the SENCER (Science Education for New Civic Engagements and Responsibilities) Summer Institute in Asheville, Tennessee held July 29th – August 2nd 2010. I participated in a student panel “Students as Partners in Change” and presented a poster entitled “Agrarian Education”. I will be giving a poster presentation on agroecology growing models at the East Lakes Division Association of American Geographers Conference which will be held in Grand Rapids, Michigan October 23rd and 24th, 2010. For the 11th Annual Conference of the Americas, which will be held November 4th – 6th at Grand Valley State University I will be discussing agroecological education as

a part of the theme “*Creative Agents of Change: Facing Challenges in our Communities*”. In April 2011, I will be a student presenter at the 2011 Student Scholars Day held at Grand Valley State University.

Acknowledgements

I will be forever grateful for the opportunity I had to do this summer project as an undergraduate student and for that I thank the Undergraduate Research Council and the Student Summer Scholars program. I was fortunate to have the oversight of Dr. Edwin Joseph as my faculty mentor for this project. He was instrumental in accomplishing many of these projects and meeting the demands of realizing our joint dream to build an agriculture program at Grand Valley State University. Levi Gardner, who served as the garden operations manager is not only the brains but also the muscle behind what has become one of the best efforts I have seen by an individual to bring about change through hard work and integrity towards a cause. He was responsible for overseeing, correcting, and encouraging me in my lack of expertise, experience, and knowledge in the agricultural sciences. The staff at the Facilities Department of Grand Valley was a willing taskforce behind some of our greatest work projects and material needs. Bart Bartles, Norman Christopher, and Andrea Marz of the GVSU Sustainable Community Development Initiative for their support of this project and their commitment to developing agricultural education resources for our university. Dr. Kin Ma and Dr. Elena Lioubimtseva and Dr. Kin Ma of the geography department for serving as my academic and extended mentorship support network throughout the seven months that this project was a part of my life. Professor Julia Mason for her guidance. Sharelle Arnold and Lauren Zeman of the Children’s Enrichment Center, Arnie Smith Alexander and Danielle Palmer of TRIO Upward Bound, and Gretchen van Heulkeum of Allendale Christian School for their willingness to allow their students to be our guinea pigs for the programs we began and their commitment to partner with the community garden for future garden education programs. Heather Holt for allowing us to use the Wesley House. And finally a thanks to my friends Amanda Moore, Andrew Reid, and Claire Harrison who are all Grand Valley students and who wanted as desperately as I did to take the classroom outside and learn through mistakes, which is an embarrassing and ever humbling way to get an education.

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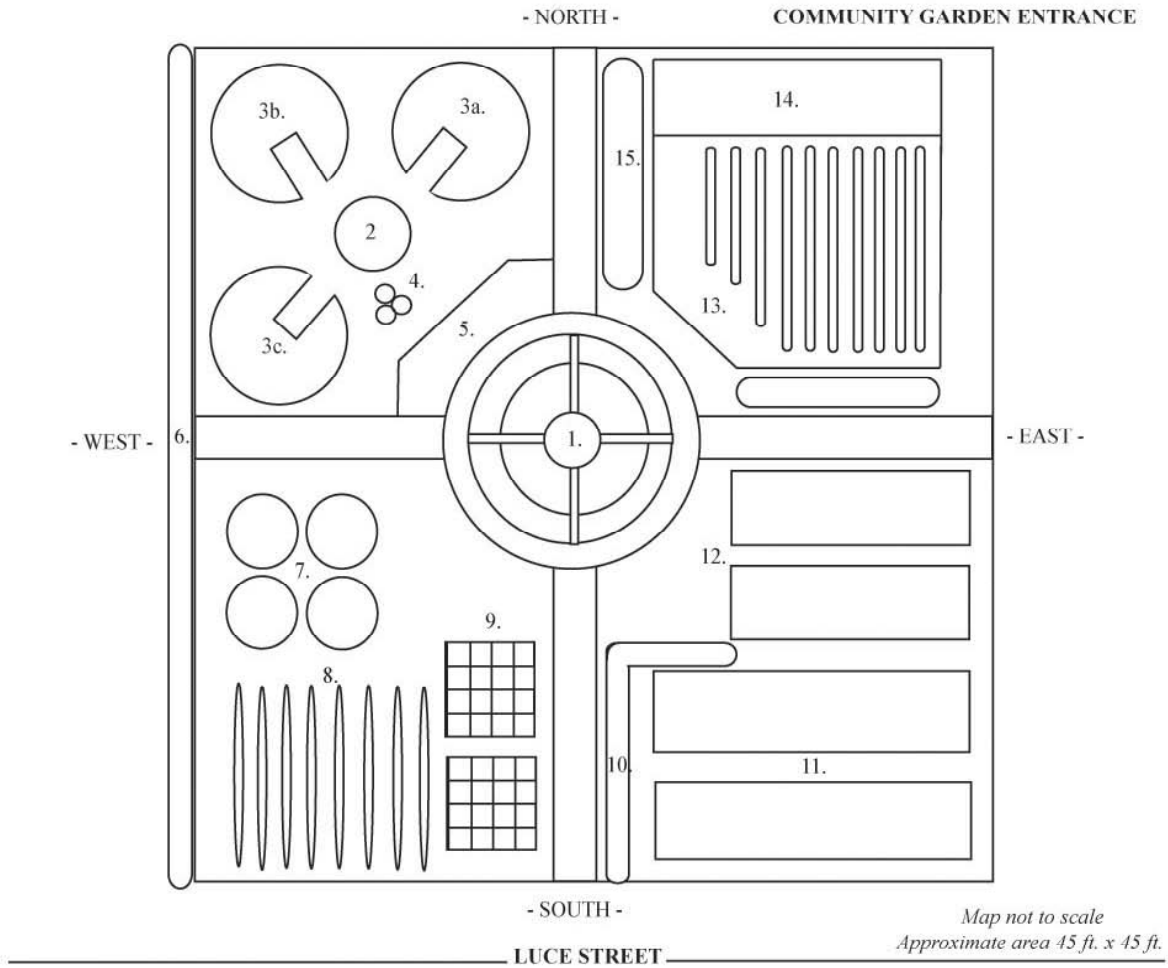
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Appendix

Figure 1.

GARDEN DEMONSTRATION PLOT
 Grand Valley State University Community Garden
 4539 Luce Street, Jenison Michigan



Key	
1. Native American Herb Wheel	8. Corn rows
2. Bean pole	9. Square foot gardens
3a. Keyhole pizza garden	10. South retention ditch
3b. Keyhole salad garden	11. Long raised beds
3c. Keyhole fruit garden	12. Short raised beds
4. Potato stacks	13. Mixed mounds
5. Companion planting area	14. Fallow area/ compost pile
6. West water retention ditch	15. Companion planting
7. Container gardens	

Figure 2.

Aerial view of community garden. Keyhole gardens in lower left corner of photo



Photo by Levi Gardner (2010)

Figure 3.

Potato stack planting in straw, supported by chicken wire fencing



Image retrieved from <http://www.instructables.com>

Figure 4.

Companion planting: tomatoes, marigolds, peas



Photo by Kendall Gilbert (2010)

Figure 5.

Intercropping: row cropping, cauliflower, eggplant, kohlrabi



Photo by Kendall Gilbert (2010)

Figure 6.

Raised bed gardens within the demonstration plot



Photo by Kendall Gilbert (2010)

Figure 7.

Square foot garden



Photo by Kendall Gilbert (2010)

Figure 8.

Vertical “permaculture” growing model



Photos by Kendall Gilbert (2010)

Figure 9.

Native American Herb Wheel



Photos by Kendall Gilbert (2010)

Figure 10.

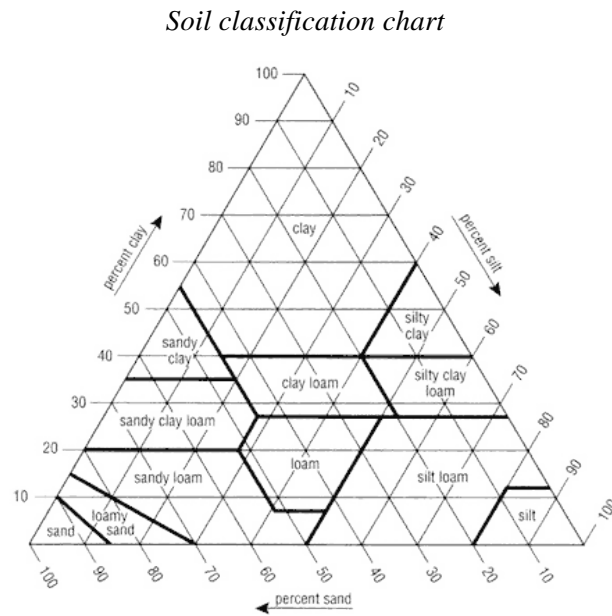


Image retrieved from http://www.organicsecure.org/articles/soils_primer.php?continued=yes

Figure 11.

TRIO student hangs spice sachets along fence line



Photo by Kendall Gilbert (2010)

Figure 12.

TRIO student sprays plant foliage with egg spray



Photo by Kendall Gilbert (2010)

Figure 13.

Student prepares liquid fence mixture



Photo by Kendall Gilbert (2010)

Figure 14.

Student dumps food waste into one bin compost system



Photo by Kendall Gilbert (2010)

Figure 15.

Students prepare a straw layer for the lasagna layered compost system



Photo by Kendall Gilbert (2010)

Figure 16.

Two bin rotating compost system



Single bin system



Photos by Kendall Gilbert (2010)

Figure 17.

Rain barrel collection system at the community garden, along the Wesley House



Photos by Edwin Joseph (2010)

Figure 18.

Selling plant seedlings at the Grand Valley Farmer's Market in June



Photo by Andrea Marz (2010)

Kendall Gilbert and Professor Edwin Joseph on the farm



Table 1.

Garden Models, Comparative Analysis

<i>Garden Model</i>	<i>Plants</i>	<i>Health</i>	<i>Yields</i>	<i>Maintenance</i>
Raised bed (ecological, urban)	- Sweet and hot peppers - Lettuce - Spinach - Tomatoes	Excellent health, few signs of pest or disease damage	Lettuces- high Tomatoes- high Peppers – moderate	Excellent water conservation, ease of labor, few weeds, high costs to construct
Potato stack (cultural, traditional, ecological)	- Potatoes	Good health, no signs of pest or disease damage	High yields of relatively small potatoes	Excellent water conservation, few weeds, ease of labor, low costs to construct
Native American herb wheel (cultural, traditional)	- Herbs	Good health, some signs of nutrient deficiencies	High yields of herbs	Poor water conservation, many weeds, low costs to construct, but labor intensive
Square foot garden (ecological, urban)	- Peppers - Herbs - Squash - Tomatoes	Poor health	No yield	Few weeds, low cost to construct, but labor intensive
Container gardens (ecological, urban)	- Hot peppers	Good health, few signs of pest or disease damage	Moderate yields	Few weeds, good water conservation, low cost to construct
Companion planting (traditional, cultural, ecological)	- Corn, beans, and squash - Tomatoes, peas, marigolds	Poor health, poor drainage, signs of nutrient deficiencies	No yield	Few weeds, poor water conservation
Intercropping (ecological)	- carrots - cauliflower - kohlrabi - tomatoes - eggplant	Limited growth, poor health, signs of pest and disease damage	Moderate yield carrots and tomatoes	High maintenance, many weeds, requires precision in planting and management
Keyhole garden (permaculture)	-lettuce -tomatoes - onions - basil	Poor health, many weeds,	No yield	Poor drainage, labor intensive to construct
Vertical growing (permaculture)	- green and yellow wax beans	Moderate health, signs of pest damage and nutrient deficiencies	Moderate yield	Few weeds, poor water conservation, uses space efficiently

