Gutsy Gardens

Implementing Soil Education Programs via Community Gardens in Worcester, MA

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Abstract

Community gardeners in Worcester, MA have limited access to soil education. Through interviews and surveys, we identified a lack of soil education materials in Worcester community development corporations. Based on the recommendations of these organizations, we created a pamphlet and flyer to better educate gardeners of Worcester. We designed these materials to be visually appealing and easy to comprehend. We gave these educational materials to the Regional Environmental Council, where they were distributed to local Worcester community gardeners.

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- The Regional Environmental Council (REC)
- Worcester Common Ground (WCG)
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Executive Summary

Urban soil, soil disturbed by human activity, exists across the globe due to increased urban development. Urbanization leads to severe soil pollution as a result of residential, industrial, and commercial activities (Igalavithana et al., 2017). Urban soils can become highly contaminated with heavy metals and toxins through industrial waste and urban runoff. Contaminated soils produce contaminated crops, which can be poisonous to people growing food in an Urban Green Space (UGS).

A UGS is an area dedicated to improving city aesthetics and biodiversity (Konijnendijk, et.al., 2013). Local residents use these spaces, specifically community gardens, to grow organic foods. The Regional Environmental Council, a community development corporation (CDC) in Worcester, runs and operates 62 community gardens in Worcester (Regional Environmental Council, n.d.). Worcester Common Ground, another CDC in Worcester, manages community green spaces, which include community gardens on Newbury St, Worcester and Castle St, Worcester. These community gardens are usually divided into plots for different residents to plant their crops of choice. Preliminary soil preparation is performed by the REC to ensure the soil of each plot is clean enough to begin planting. However, the gardeners of these organizations do not receive education about this process, nor many of the beneficial processes of maintaining soil health.

There is a lack of soil education available to community gardeners of Worcester CDCs. The REC and WCG provide educational workshops to their gardeners each season; however, these workshops are only done per request of the gardeners. In recent years, the REC has conducted one soil health education workshop, with minimal effectiveness. The goal of this project was to develop educational models for teaching local community gardeners about soil quality and health.

Our methods to establish a soil education model were broken up into four objectives. Our original projects, as mentioned, had a focus on fertilizers and educational trails. From this, we decided to formulate our new project around soil and education. Through interviews and independent research, we found a notable gap in soil education available to gardeners in Worcester. Second, we analyze the feasibility of educational models, and decided on creating a pamphlet, a flyer, and a packet. Third, we describe which topics to tackle with our educational materials which we identified through a qualtrics survey.

Through our Qualtrics survey we learned about the demographics of local gardeners, their previously existing soil knowledge, and their topics of interest. We translated the survey into English, Spanish and Albanian. Of the 27 people who took the survey, 88.9% took it in English, 7.4% took it in Albanian, and 3.7% took it in Spanish. Also, 78% surveyed were women and 41% were over the age of 41. We found the average number of years gardening was 6.13 years, yet over 60% of people rated their soil knowledge as below average. We found 94% of the participants in the survey were interested in learning more about soil. Topics of interest we found through this survey include: nutrients, sustainable gardening, pH, microbes, fertilizer, cover cropping, and soil test results.

We took the information learned about each educational model and recommendations we received from our interviews, and decided to make a soil testing flyer, a pamphlet about basic soil care practices, and an informational packet about in depth soil care practices. We made recommendations on how to create an educational poster and a science experiment to implement into schools for future efforts.

The soil testing flyer focuses on teaching gardeners the importance of soil testing and the basics of interpreting test results. It gives a key to help them understand their test results, and recommendations of crops to grow based on their soil's pH level. *The Roots of Soil Care* pamphlet gives an overview on topics like cultivation, cover cropping, compost, soil testing, microbes and nutrients. It also explains the importance of healthy soil and gives links and QR codes leading to additional materials to learn more about soil. One of the links and its respective QR code leads to *Digging Deeper into Soil Care*, our informational packet, which further expands upon each of the topics described in the pamphlet. Gardeners willing to learn about soil beyond the introductory material offered in the pamphlet would benefit from this packet.

We found a lack of comprehensive soil education provided for Worcester based community gardeners. Three groups demonstrated interest in enhancing soil education programs: community development corporations, community gardeners, and educators. We determined a pamphlet and a flyer would be the most effective educational models for presenting soil information in a clear and concise manner.

The *Roots of Soil Care* pamphlet offers an introduction to soil health for both beginner and advanced gardeners. The Soil Test Flyer provides gardeners with introductory information on the importance of soil testing and the basics of interpreting soil test results. Our additional information

packet, *Digging Deeper into Soil Care*, provides more information for gardeners interested in soil knowledge beyond the introductory material offered in the pamphlet.

After completing our educational materials, we contacted our original sponsors from Puerto Rico, Para la Naturaleza and the Departemento de Recursos Naturales y Ambientales. In an email to them, we attached all of these educational materials. Para la Naturaleza is currently working with community gardens in Puerto Rico. They responded and informed us our materials included interesting topics for them to teach and they could be useful for future workshops.

We recommend the pamphlet, *The Roots of Soil Care*, be distributed to community gardeners at start of season, and the packet, *Digging Deeper into Soil Care*, be distributed to gardeners who express interest in further information. The Soil Test Flyer should be distributed to gardeners along with their soil test results at the end of the harvesting season as a guide for how to read those results. We also recommend schools with access to gardens expand their soil health curriculum in the future, using educational posters and hands-on experiments to allow students to apply classroom knowledge to the real world.

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0.0 Preface

This group consists of members from two previous groups scheduled to complete IQP projects in Puerto Rico. Due to the tragedy of Hurricane Maria, it was deemed unsafe to complete our projects in Puerto Rico, so our new group emerged in Worcester. One group focused on utilizing an invasive catfish species biomass as an organic fish fertilizer. The other group focused on developing an educational trail for students to learn from outside of the traditional classroom setting. From these projects, we decided to combine our past research by creating a project based on community learning and agriculture. This lead us to the project idea of working together to make a community garden soil education program in Worcester to assist community development corporations in teaching their gardeners of the importance of healthy soil.

We chose to direct our focus to this garden because this is a project applicable throughout the world. This project has the potential for implementation anywhere, noting changes in climate and which crops would be able to grow best in their respective environments. We hope the inclusion of soil education materials for community gardeners in the Worcester area can help illuminate the feasibility of using these gardens to help educate gardeners about the importance of soil maintenance. We contacted our original Puerto Rican sponsors in hope that they can also use this project to benefit their community.

1.0 Introduction

Healthy soil and urban green spaces are beneficial to the overall quality of life for individuals in a city. Urban green spaces (UGS) are spaces within urban areas dedicated to promoting biodiversity and improving city aesthetics (Konijnendijk, et.al., 2013). Urban soils within these spaces are at constant risk of pollution through various sources in a city environment. Urban soil is any soil disturbed by human activity, usually connected with construction and urbanization (Craul, 1991). Industrial waste, urban runoff, and citizen waste are all contributors to this global issue. Pollution of urban soils drastically reduces the quality of life and harms the environment (Aydin & Akyol, 2015). A major issue with the contamination of urban soils is the decline in horticulture, the science of gardening. Contaminated soils, usually containing heavy metals, produce contaminated crops which can be poisonous to individuals of a neighborhood. In order to mitigate this issue, soil health needs to be emphasized in UGS, specifically community gardens. Overall, healthy soil is an essential component of a healthy environment, and is the foundation for sustainable horticulture (Gregorich, 1995).

Over 150 years ago, Worcester, Massachusetts was mainly an industrial city and center of manufacturing (Kellogg, 2016; Worcester Historical Museum, n.d.). This time spent as a major manufacturer left a legacy of lead deposits in its soil. As a result, when an interest of urban farming within the city sparked, a significant amount of the soil was poisoned (Kellogg, 2016). Factories, both large and small scale, have been found as possible sources for soil pollution (Möller et.al., 2005). Consumption of these toxins from the air and soil in turn affects the health of citizens. Attempts to remove the toxins by applying chemicals to the soil cause heavy metals to seep into the groundwater, polluting the water supply instead of the soil (Kellogg, 2016).

Currently, community development corporations like the Regional Environmental Council (REC) are working to incorporate urban green spaces, such as community gardens, into the Worcester area to improve the health and environment of Worcester communities (Regional Environmental Council, n.d.). The REC works to promote community leadership and provide the community with access to healthy, affordable food. Similarly, Worcester Common Ground (WCG) is a non-profit community development corporation (CDC) composed of land trust residents, concerned citizens, housing advocates, and community leaders . WCG staff and their residents worked together to promote and develop permanent and sustainable improvement in the

neighborhoods of Central Worcester through affordable housing, community activism and economic development (About WCG, n.d.).

The REC and WCG both have educational programs included in their work to promote healthy soil farming practices. The REC has educational workshops based on the needs of the gardeners. According to Chris Humphrey, gardens coordinator of the community garden program, there is a gap in the soil education for gardeners. Gardeners of the Worcester community do not have sufficient knowledge on the importance of soil health, which is essential to growing crops continuously without external nutrients or additional labor. The gardeners within the REC and WCG programs would benefit from additional educational programs to teach them of this critical aspect to gardening.

In completing this project, we developed educational models for teaching local community gardeners about soil quality and health. To accomplish this goal, we established four objectives that led to the successful development and implementation of these education models. These objectives are as follows:

Objective 1: Develop our problem by researching community gardens, educational programs within community gardens, and the main limitations to these programs to identify spaces for improvement.

Objective 2: Analyze different educational models to find most effective approach to educating our target demographic on soil quality and health.

Objective 3: Identify educational goals by surveying current community gardeners and garden educators to gauge interest in soil education programs/science projects.

Objective 4: Incorporate educational content into established materials.

2.0 Background

2.1. Community Gardens

Community gardens are plots of land dedicated to growing food for local people. They also help improve city aesthetics and promote biodiversity. Community gardens are often put in urban settings where there is less access to plots of fertile land compared to rural areas (Wakefield, 2007). These gardens are gaining popularity throughout the United States and the world as a whole, and the benefits and limitations are becoming more prevalent.

2.1.1. Physical and Mental Health Impacts

As community gardens gain popularity throughout the United States, the health benefits become more pronounced. Nutrition is vital to living a long healthy life, and community gardens provide a great source of nutritional fruits and vegetables. In West Hollywood, 5 school community gardens were established (Dickinson, 2003). Among the 338 students in gardening and educational workshops, fruit and vegetable consumption increased 10% and physical activity increased 6% (Dickinson, 2003). Community gardens also improve people's physical activity, while decreasing the risks of obesity, cardiovascular and cerebrovascular disease, diabetes, colorectal cancer, and osteoporosis (Lee & Maheswaran, 2011; Konijnendijk, et.al., 2013).

Mental health benefits have been observed in developed community gardens all across the world. Several studies have observed psychological benefits of urban green spaces and urban gardens (Ward, Parker, & Shackleton, 2010; Forsyth, 2003; Chiesura, 2004; Tyrväinen et al., 2005). According to the University of Copenhagen's *Benefits of urban parks* synthesis, research trends suggest urban parks and community gardens have lead to an increase in self reported mental health (Konijnendijk, et.al., 2013). Individuals in urban spaces with higher amounts of green spaces reportedly feel higher levels of social support and less loneliness in their neighborhoods (Lee & Maheswaran, 2011). Residents' mental health is improved by showing decreased rates of depression, improved mental functioning, reduced stress, and rejuvenation (Lee & Maheswaran, 2011; Konijnendijk, et.al., 2013; Ward, Parker, & Shackleton, 2010).

2.1.2. Societal and Environmental Impacts

In 2015, 12.7 percent of households in the United States were food insecure for at least some portion of time throughout the year. Food insecurity refers to when a household has limited access to adequate food due to a lack of money and other resources (Hanson & Connor, 2014;

Rose & Oliveira, 1997; Mangini, 2017; Pinstrup-Andersen, 2009). To combat food insecurity in low income areas, community gardens have been implemented alongside other food and nutrition assistance organizations in urban areas (McCullum et.al., 2005). Community-based participatory research projects have shown community gardening projects lead to an increase in food security, demonstrated by participants skipping fewer meals and expressing less concern for how they would acquire food (Sharpe et.al., 2017; Carney et.al., 2012; Krasny & Tidball, 2009).

In Toronto, Canada, participants in community gardens have increased access to food and better nutrition, increased physical activity, and strengthened bonds amongst neighbors (Wakefield, 2007; Dickinson, 2003). The garden of focus in the Toronto study included men, women, and children who would weed, water, and harvest the crops in the garden (Wakefield, 2007). The garden also served as a social gathering location because gardeners would prepare dinner with their crops, as well as share with other members (Wakefield, 2007). Language barriers were not an issue, as hand gestures were enough to allow communication between the neighbors. Community gardens also provide an opportunity for immigrant populations to preserve their culture through food (Wakefield, 2007). Additionally, communities grew closer because they were able to spend more time with their neighbors and share tools and growing strategies with one another (Wakefield, 2007).

In Detroit, where 400 to 500 new community gardens were built from 2002-2012, communities felt stronger bonds in their neighborhoods (Charles, 2012). Members of these gardens felt safer upon becoming more familiar and friendly with their neighbors (Charles, 2012).

From the environmental side, the implementation of community gardens in urban areas lead to carbon sequestration, erosion control, storm water runoff management, and air, water, and soil purification (Konijnendijk, et.al., 2013; Ward, Parker, & Shackleton, 2010). Some environmental problems faced by community gardens include the quality of the area, as well as the climate of the land. Both air and soil pollution affect the quality of food produced. In most cases, preliminary steps are taken to ensure the safety of the soil in community gardens (Wakefield, 2007). Because community gardens are primarily located in urban areas, urban soils are of concern when deciding to implement a community garden.

2.2. Urban Soil

The World Health Organization (2014) reports over 50% of the world's population resides in urban areas, and about 15% of the world's total food produced for consumption comes from urban agriculture (USDA, 2012). However, residential, industrial, and commercial activities can lead to severe soil pollution in urbanized areas (Igalavithana et al., 2017). These activities introduce a number of foreign materials into urban soil such as wastewater from homes and vehicle smokes, which alter the original structure and function of urban soil (Igalavithana et al., 2017). Due to their improper chemical and biological properties, urban soils are not always suited for horticulture (Igalavithana et al., 2017).

Generally, urban soils contain a high bulk density, low nutrient and organic carbon content, low biological activity, and higher concentrations of toxic trace elements, most commonly, lead and zinc (Attanayake, 2014; Igalavithana et al., 2017; Szolnoki, 2013). Heavy metals in soils may pose a potential health risk for humans (Attanayake, 2014; Igalavithana, 2017; Chauhan & Mittu, 2015). Because soil pollution affects the quality of food produced in community gardens, community gardeners must take preliminary steps to ensure the safety of the soil (Wakefield, 2007). According to Wakefield (2007), produce from community gardens show similar quality to produce from supermarkets.

2.2.1. Importance of Healthy Soil

Soil acts as a critical component of horticulture, as most plants depend on soil to grow. Soil quality links horticultural conservation management practices with achieving major sustainability goals (Doran, 2000). This means successful sustainability practices result in higher soil quality. Gardeners can determine soil quality based on the abundance of microorganisms in the soil (Doran, 2000). Some of these microorganisms, like bacteria, cycle nitrogen; whereas fungi in the soil get more nutrients and hold water for plants in exchange for carbon (Chauhan & Mittu, 2015). Other nutrients, such as nitrogen, limestone, calcium, and magnesium exist in healthy soil because of decaying organic matter. These nutrients help improve the condition of the soil and increase the capacity for the soil to grow plants (Chauhan & Mittu, 2015). Over time, through unsustainable maintenance practices, the concentrations of these nutrients and organisms decrease. As a result, gardeners use fertilizers in horticulture to enhance the activity of these microorganisms to help plant growth (Igalavithana et al., 2017).

As observed in Toronto, participants living adjacent to community gardens maintained the gardens more frequently than participants located farther away (Wakefield, 2007). Driven mostly

by volunteer gardeners, community gardens often experience limited maintenance. Without proper maintenance, the soil in community gardens can erode and lose vital nutrients.

2.3. Education

Educating the public on the importance of soil health can promote the maintenance of healthy soil. Kim et at., (2014) suggests collaboration with organizations to develop a central location where gardeners can access information on soil could have the largest impact. Both unconventional learning techniques and place-based learning techniques can effectively teach a diverse audience.

2.3.1. Soil Education in Community Gardens

Community garden organizations, like the Regional Environmental Council (REC) in Worcester, MA, use educational programs and gardening workshops to teach users the benefits of growing organic food (Regional Environmental Council, n.d.). However, these programs often neglect the importance of soil health, restricting gardeners from understanding a critical aspect to growing food. Garden Mosaics, an educational program in urban community gardens across the United States, looked to tackle this issue starting with school children in New York and Pennsylvania (Krasny & Tidball, 2009). Prior to working on the garden, the researchers asked students what a garden needs to grow and thrive. After working on the community garden, 88% of the students included at least one new feature of a garden needed for it to thrive. Students observed the connection between the health of the soil and what can grow in that location (Krasny & Tidball, 2009). After discovering these results, the youth of Philadelphia made recommendations to gardeners to improve the soil, and arranged for free compost delivery to the garden to improve soil quality (Krasny & Tidball, 2009).

Ranjan Datta started a community garden in Saskatchewan, Canada to provide fresh vegetables for 6 months of the year to local residents (Datta, 2016). The garden facility included at most 56 families, around 200 people with over 40 children, representing over 20 cultures (Datta, 2016). In addition to food production, the garden educates children about different cultures as well as the relationships between plants and insects (Datta, 2016). Despite learning about plant diversity and growing food, the program did not teach the children about the importance of soil health. Even when gardening education programs brought up concepts about soil health, many children in the programs struggled to understand concepts of soil quality and importance (Doyle & Krasny, 2010).

To properly maintain community gardens, gardeners must consider soil quality, and programs like Garden Mosaics to remedy the lack of knowledge in the youth community pertaining to gardening. Our group identified a lack of soil education as a gap in community gardens in Worcester. Currently, local gardeners struggle to grasp the soil education models in place, which poses the challenge of creating a more appealing soil education system. Using techniques mentioned by Krasny and Tidball (2009), we hope to further develop the educational programs of the REC and other community gardening organizations to teach people of the importance of soil health in agriculture in an easy-to-understand manner.

2.3.3. Place-Based Learning in School Gardens

Place-based learning refers to the promotion of learning about the unique aspects of the surrounding community. With place-based learning, educators work to impact communities, increase student and teacher engagement, and boost academic outcomes by allowing students to connect their learning to communities and the world around them (Getting Smart, n.d). Students use the core material they learn in the classroom and apply it to the communities surrounding them. Educators often establish this connection through outdoor hands-on activities and community service projects (Kaiser & Goodlaxon, 2013). Students become more involved in their learning because it specifically relates to their community's local culture and environment. Additional benefits place-based learning can provide include energizing teachers, transforming the school culture, and encouraging students to become more involved in the environment and become active citizens (PEEC, 2007).

One example of place-based learning occurred in Tucker Elementary school through the University of Michigan-Flint"s University Outreach program. A kindergarten class began a food garden in which they grew peppers and radishes, and even harvested eggs because students typically did not know where their food sources came from (Discovering PLACE, n.d). The students then visited the Harvesting Earth farm in their local neighborhood to see a larger version of their garden lab and learn more about the actual source of their food (Discovering PLACE, n.d.). This experience allowed the students to first learn some of the simple techniques of gardening in their own classroom setting, and then apply this knowledge to a real life scenario in their own community. A similar experiment on soil education could be added to school curriculum. Students can perform simple soil testing experiments in their classroom or school garden, and then visit local community gardens to see effective soil health practices.

2.4. Worcester, MA

Worcester, Massachusetts contains community gardens throughout the city. Since the city is a post-industrial wasteland, these gardens have potential toxic soil issues (Igalavithana et al., 2017).

2.4.1. Existing Community Gardens

The two largest organizations in Worcester, MA which oversee community gardens are the Regional Environmental Council (REC) and Worcester Common Ground (WCG). The REC has created 62 community gardens, and Worcester Common Ground built two well-known community gardens, and implemented a bioshelter just south of Highland street.

2.4.1.1. Regional Environmental Council

The REC is a grassroots environmental and food justice organization located in Worcester, Massachusetts consisting of staff members and volunteers (Regional Environmental Council, 2017). They work together to provide Worcester with a number of programs including Urban Garden Resources of Worcester (UGROW), YouthGROW, farmers markets, and Worcester Regional Food Hub. UGROW promotes community gardens as a way to create food security and a greater sense of community within local low-income Worcester neighborhoods. Currently, UGROW has created 62 community gardens in Worcester, and 23 of these gardens are school gardens (UGROW, n.d.; Community Gardens, n.d.). YouthGROW employs low income high school students with leadership positions involved in urban horticulture (YouthGROW, n.d.). The REC also hosts farmers markets once a week, and three days a week they have "Veggie Mobile," where they deliver fresh vegetables to residents in remote areas of the city (Greenslit, 2013). The Worcester Regional Food Hub is a collaboration with the REC and the Worcester Regional Chamber of Commerce. They enhance sustainable agriculture of Worcester through the promotion of healthy eating and strengthening the production-to-distribution of local small acre farmers (Bolstering Our Local, n.d.). Overall, the REC facilitates and develops programs for the community to utilize to strengthen relationships between neighborhoods and address environmental issues.

2.4.1.2. Worcester Common Ground

Worcester Common Ground (WCG) is a non-profit community development corporation (CDC) composed of land trust residents, concerned citizens, housing advocates, and community

leaders (About WCG, n.d.). “The mission of WCG is to promote and develop permanent and sustainable improvement in the neighborhoods of Central Worcester through affordable housing, community activism and economic development” (About WCG, n.d.). The WCG mainly works to provide low to middle income residents with affordable housing. However, WCG often pairs with other community based organizations to cater to their residents needs. These needs often include increasing public safety, youth education, resident recreation, and neighborhood business development (About WCG, n.d.). For example, the WCG partnered with students of Worcester Polytechnic Institute (WPI) and YouthBuild Worcester to create a Bioshelter for the Piedmont Neighborhood (“Worcester common ground, WPI,” 2017). The WCG also manages other community green spaces, including the community gardens on Newbury St, Worcester and Castle St, Worcester. These community gardens provide the residents with a space where they can establish a greater community bond and create a feeling of ownership and accomplishment.

2.4.2. Educational Programs

The Regional Environmental Council and Worcester Common Ground both implement gardening education into their organizations. However, their educational workshop curriculums do not focus on soil health.

2.4.2.1. Regional Environmental Council

As previously explained, the REC manages two main types of community gardens: school gardens target children, and community gardens target the general public. Teachers and students primarily use school gardens during the school year. The REC offers general garden education ideas to educators, and educators implement what they can into the school curriculum. Some schools also conduct educational activities within the gardens to provide the students with a hands-on way to learn about gardening. However, the REC only suggests topics to implement in school curriculums. The needs of garden users structure the educational programs for community gardens. The garden managers within the REC survey the gardeners once a season about what they want to learn and plan workshops based off of those results.

For example, the REC collaborated with the Worcester Public Library to hold a beginners gardening workshop for adults. They also held a rain garden workshop and a pest management workshop, one of the more requested workshops. In regard to soil health, the REC offered a workshop to explain the importance of maintaining soil health, but they do not perform this program regularly. In addition, the REC performs soil tests for garden users, explains the results,

and gives users suggestions, but gardeners do what they want with this information (Humphrey, Informational Interview, 2017).

2.4.2.2. Worcester Common Ground

Similar to REC, WCG's gardens have an individual focus on the residents. Residents tend their garden on their own time. The staff of WCG manages the gardens by providing their residents with a plot of land and some basic gardening supplies. On occasion, WCG hosts events for residents to broaden their gardening skills such as the Piedmont Pride Petunia Planting Event. WCG partnered with the Mustard Seed, a local Worcester soup kitchen, to plan the event for residents to socialize and learn how to plant petunias in their yard. However, WCG does not hold many educational events or classes to teach residents about sustainable gardening techniques. WCG does not have enough space to conduct such events. WCG hopes the opening of the Bioshelter will provide more space to hold events and classes for their residents. Overall, WCG is supportive of, and open to any educational and skill enhancing programs they can provide for residents involved in their community gardens (Gilmore, Informational Interview, 2017).

3.0. Methodology

Because community gardens in Worcester, MA currently lack comprehensive soil education materials, we set out to establish practical materials to teach people of the importance of soil health. This presents a challenge because community gardeners with limited soil knowledge struggle to grow and harvest plants at an optimal level in these community gardens. The goal of our project is for community development corporations, schools, and local ungoverned community gardens to develop an educational model for soil education to be implemented.

To accomplish this goal we developed a series of project objectives which are detailed below, along with research methods we used to meet each objective. The next several sections go into further detail on each objective.

Objective 1: Develop Our Problem

Objective 2: Analyze Educational Models

Objective 3: Identify Educational Goals

Objective 4: Incorporate Educational Content

3.1. Developing Our Problem

For our first objective we worked to develop our problem by gathering information about community gardens, educational programs within community gardens, and the main limitations to these programs to identify spaces for improvement. For our initial information gathering process we targeted two main groups: community development corporations (CDCs) and local community gardeners. For each of these groups we performed semi-structured interviews with their leading representatives.

We opted to use semi-structured interviews for our initial information gathering process because semi-structured interviews are more open ended, with a general script to guide the process (Bernard, 2017). This open ended structure allowed us to shift the direction of the interview based on the information given to us by our interviewee, thus helping us narrow down our objective to one tangible goal.

3.1.1. Community Development Corporations (CDCs)

We decided to research community development corporations (CDCs) in Worcester because they often work to promote and support community development through providing services and programming. Specifically, we contacted CDCs with community gardens to learn

more about their community gardening services and programs they provide. We gathered information from two major CDCs: the Regional Environmental Council and Worcester Common Ground.

3.1.1.1. Regional Environmental Council

We initially reached out to the Regional Environmental Council (REC) because they are the largest organization in Worcester providing community garden services and programming. REC also works very closely with our target demographic: people in Worcester who are involved with community gardens. Our initial goals in working with REC were to learn more about general community garden management, and to get an idea of what type of programming REC provides. From there, we looked to find a gap in their educational materials we could fill. First, we held a semi-structured interview with Christopher Humphrey, the UGROW & Social Entrepreneurship Coordinator for REC. We began this interview with a list of established questions, though we allowed the order of our questions to flow with the conversation. Notes from this interview were used to guide our problem statement and the remainder of our methods. See Appendix C for initial interview questions.

3.1.1.2. Worcester Common Ground

Additionally, we contacted Worcester Common Ground (WCG) because they work closely with their residents to improve the neighborhoods of Central Worcester, MA through affordable housing, and community and economic development, our interest being their development of community gardens. WCG targets the area from Piedmont St. to Highland St. and Main St. to Park St. largely consists of low income residents. Therefore, WCG focuses mainly on providing affordable housing to their residents, with their community gardens not being a primary focus. Originally, our goal was to learn of their marketing efforts, who they market to, and how they market for both their community gardens, in general, as well as any educational gardening programs they provide. We contacted WCG and were referred to Ellie Gilmore, the Community Organizer for WCG. From there we scheduled a semi-structured informational interview, and created a list of questions to base the interview off of. This list of questions is located in Appendix A. Notes were taken during the interview to help establish any gaps in their marketing techniques. While this interview was helpful, the focus of our project had shifted shortly after the interview took place. As a result, we emailed Ellie back to explain the change in our project goal and to ask if she could send us any information and materials about their educational garden programs. Her

response helped us to further identify the gap in soil quality and health lessons within community garden educational programs.

3.1.2. Local Schools

We also looked into local school community gardening programs because these types of programs are often used in curriculums as an unconventional learning environment. Chris Humphrey referred us to Eliza Lawrence, the School Garden Education Coordinator for REC. We called Eliza to set a time for a rendezvous. We conducted a semi-structured interview with Eliza to obtain more information about soil education in school gardens, and the list of guided questions for the interview is located in Appendix D. Notes were taken during the interview to record any information to help us identify a gap in soil education in schools, and to help us create the most effective educational platform to portray the material to children.

3.1.3. Local Community Gardeners

Input and information from local community gardeners is vital to completing this project, as they are the target demographic for our educational materials. Local gardeners also have direct experience with their community's gardens, giving them inside knowledge and expertise on what is lacking in their respective gardens. We contacted community gardeners through three different avenues:

1. Community development corporations as a bridge to reach their gardeners,
2. Local school garden programs as a bridge to reach the educators,
3. Community gardeners who work separately from both CDCs and schools.

To learn more about individually owned community gardens, we reached out to Joseph Cullon, a WPI faculty member who establishes his own community gardens throughout Worcester. Again, we conducted an interview with him to learn about his experience with community garden education. The interview questions are located in Appendix B.

3.2. Analyzing Educational Models

A variety of educational models were researched to determine the most effective platform in which to portray our data. Posters, pamphlets, videos, and science projects were considered. These were chosen as they are popular methods of displaying information. We analyzed each model for effectiveness of implementation, based on the demographic chosen, which will be later discussed.

3.2.1. Poster

The purpose of a poster is to communicate ideas in a stimulating way to provoke thought and discussion (Shelledy, 2004). Infographics lay out the material in a visual way are effective as they can be understood by a variety of people with different cultures and first languages. Overall appearance as well as the ease of finding key pieces of information and results determine this evaluation (Hess et al., 2009). A few factors involved in creating an effective poster are displaying the information clearly, effectively using empty space, and constructing the poster out of the proper material. When creating the design for a poster there should be many visuals to engage the viewer and a flow the viewer can easily follow through the poster (Stuckey and Hoyer, n.d.). Empty spaces on the poster will help create this flow for the viewer. Although posters should contain a lot of information, it should be structured spread out enough so it does not overwhelm the viewer (University of Guelph Teaching Support Services, n.d.).

3.2.2. Video

Many studies have shown technology in general enhances learning, but videos specifically can be a very effective tool when used properly (Kay, 2012; Allen & Smith, 2012). Correctly implementing videos can break up the monotonous routine of a classroom setting and offer an alternative perspective to a topic. Using the video as a refresher not an introduction to topics is the most effective method of implementation. This allows students to work throughout the video to stay engaged, and allow students to reflect on what they have watched and learned once the video is complete (BBC Active, 2010).

3.2.3. Pamphlet

Pamphlets, short easily digestible booklets, focus on a single subject matter and are often educational in nature (Carter, 2014). Pamphlets are written for the common person, and tend to lack excessive technical vernacular, this makes pamphlets easier to read. In addition, as an educational resource, they can be as eye catching as a poster, but more portable such that the reader is able to reference them at any time. Some things to keep in mind when designing the pamphlet are ways to catch the reader's attention, the long-term effectiveness of the pamphlet, the organization of the information, and the validity of the information being presented (Pennisi, Gunawan, Major, Winder, n.d.). The layout of the pamphlet must also be decided on. This can be

decided depending on how much information is being included and the best way to organize that information (Maddox, 2015).

3.2.4. Science Project

The science project as a form of practical learning has been a staple in American education for decades (Loewus, 2015). It has been shown by completing science projects, children learn more about the scientific process by having to go through the scientific method. This can develop more of an interest in the subject, especially if it is competitive (NCSU, n.d).

To design a science project, an objective for the experiment must first be established. With this, a hypothesis must then be formed based on the objective and the general information known about the experimental design (Shuttleworth, 2009). The next step is creating the experimental design. This is done by deciding an independent, dependent, and control variable and determining an experimental process to agree with the initial objective of the experiment (Helmenstine, 2017). The experimental design and process can be used to collect data and draw conclusions about what is being tested.

3.2.5. Large Scale Implementation

Each of these proposed platforms has the capability of being implemented to our target audience, and on a larger scale. We will look at how each platform can be implemented into a community garden and school in a general sense, and then specifically once we find actual locations with which we would like to work. We will do this by working with representative from both community gardens and schools and conducting semi-structured interviews to see what would be the most beneficial way present the information.

We will also consider the limitations each platform presents. For example, many people do not have access to the internet, making it difficult to create a platform for them to view. As of 2016, 16% of US citizens ages 50-64 years old and 41% of US citizens 65 years old and older did not have access to or regular use of the internet (Anderson & Perrin, 2016). Household income and lack of general knowledge from older generations have led to this lack of internet usage (Anderson & Perrin, 2016). This is a possible limitation for any platform involving the internet. We will find out the limitations of each platform by conducting further research into the specific ethnicities and demographics of Worcester community gardens and schools.

3.3. Identify Educational Goals

In order to develop educational material about soil health and quality, first, we will research our target audience's goals for soil education and thoughts on current educational programs. Next, various platforms we could potentially use for displaying our information will be considered. Finally, the feasibility and limitations of implementing each platform on a large scale are discussed.

3.3.1. Target Audience

We will look further into the demographics of each of these target audiences to determine how we can best communicate our information to them. For schools, we will contact the schools who work with the REC and send them a survey to find out what kind of information they teach about soil and their personal experiences with community gardens. We will use this information to get an idea of what kind of curriculum is currently in place for soil education and how we can improve upon it. For community gardeners, we will send out a similar survey to find out what resources community gardeners typically have available, their initial knowledge of soil, and their willingness to receive soil education. We will be polling from both community gardens that work with organizations, such as the REC, and individual community gardens that are not affiliated with any organizations.

3.3.2. Qualtrics

To develop this survey, we used Qualtrics, a data collection software used for market research, customer satisfaction, and research data collection. With Qualtrics, we generated a multi-track survey that guided members from different groups through a series of questions. For example, educators and local community gardeners were given different questions based on their experience. Additionally, in Qualtrics we were able to generate reports based on the quantitative statistical data we gathered, detailed in the results section. See Appendix for the full survey.

We chose the route of internet-based survey because this format is time effective and can reach a wide range of people very quickly (Bernard, 2017). One drawback of using this format is not everyone has access to the internet. To combat this issue, we will work with our contacts within each group to have them bring devices, such as smartphones, tablets, or laptops to their garden centers to ensure local gardeners have the opportunity to fill out the survey. We will also take

language limitations into account by working to have several versions of our survey in the main languages spoken by Worcester residents: English, Spanish, and Albanian.

The survey responses were obtained through both digital and physical means. We emailed the survey to contacts within the REC and Worcester Common Ground, who then distributed the survey to the gardeners of the area involved in the community gardens. The survey was also downloaded onto a tablet and brought to YouthGrow community garden volunteer hours, where volunteers completed the survey. Finally, the external device was brought to the YWCA farmers market, which is run by the REC. The garden coordinator of the REC, Christopher Humphrey, has distributed this survey out to the directors of the different community gardens in Worcester. These coordinators distributed the survey to gardeneers within their respective community gardens. Additionally, the survey was sent to Ellie Gilmore of WCG to distribute to her WCG staff members involved in community gardening, as well as residents who utilize community gardens. Finally, Joe Cullon distributed the survey to the "renegade gardeners" who work with him at his personal community gardens. The collected data was coded and analyzed using Qualtrics.

3.4. Incorporating Educational Content

In our final objective we conducted further research on the management of healthy soil and on soil additives such as fertilizers to determine which methods work best for urban soils. Then we implemented this knowledge into our educational model of choice.

3.4.1. Soil Education

We plan to search through a number of databases and sources to determine the most helpful information for community gardeners who will help improve their gardening skills through broadening their soil knowledge.

3.4.2. Fertilizer Education

Again, we plan to search through a number of databases and sources to learn more about the differences between organic and inorganic fertilizers, how and when they should be applied, and which type of soil additives are the most beneficial for urban gardeners. Once this information is obtained we will determine the most helpful and relevant information to be implemented with the model.

4.0. Community Development Interviews

We interviewed staff members of the Regional Environmental Council (REC) and Worcester Common Ground (WCG) as well as a local community gardener. We identified a gap in educational programs and materials provided by community gardens. The trends observed include a lack of soil education, a list of needed soil education topics, and an interest in sustainability.

4.1. REC Community Garden Coordinator - Chris Humphrey

Our team interviewed the Community Garden Coordinator of the REC, Chris Humphrey. During our interview with Humphrey, we learned about the gap in community garden education, specifically soil health and soil maintenance education. We learned the garden users typically maintain the REC community garden plots. The REC staff provides a managerial role and will assist when there are not enough gardens, or when putting the plots to rest at the end of the growing season.

The REC provides the garden users with compost from the city, and sends out soil tests to the UMass Soil and Plant Tissue Testing Lab when requested by garden users. Staff members of the REC interpret the soil test results to the gardeners, but it is up to the gardeners to tend to the soil needs on their own.

The REC has some educational materials containing soil health such as a Gardening 101 book and has held a workshop on soil. However, the available soil education materials are technical and difficult for casual gardeners to understand.

The REC surveys the gardeners of what programs they would like at the beginning and end of each gardening season. Their survey results usually show gardeners are interested in workshops detailing how to plant specific foods or pest control, instead of soil health. There is noticeably a gap in soil education for the REC community gardens.

Humphrey stated, once gardeners get their soil test results and they are interpreted by the REC, the gardeners do not understand how to read the test results or what should be done with the information received from them. Humphrey suggested a handout gardeners could take home and digest on their own time would be helpful. We took those recommendations into consideration and created a flyer on how to interpret soil test results and what to do with the soil based on the results, which can be found in the section titled “Deliverables”. Mr. Humphrey also stated, visuals and

materials to be implemented into their educational workshops would be beneficial to both the gardeners and the REC to pursue a more educated group of gardeners.

4.2. REC Garden Education AmeriCorps MA Promise Fellow - Eliza Lawrence

Eliza Lawrence conveyed to us, there is a gap within soil education in school gardens, and the topics students would benefit most from are soil pH, soil nutrients, and microbial health. Lawrence provided us with current REC educational materials, and USDA soil education packets aimed towards children. It was found that there is room for a garden curriculum at the kindergarten and primary school level. However, not at the middle and high school level, because teachers already have limited time.

4.3. WCG Community Organizer - Ellie Gilmore

At the time of this interview, our research question was: is there a gap in the marketing techniques for community gardens? Gilmore stated the main issue WCG has is being able to contact garden users. WCG often posts on social media, but many of their gardeners do not check social media accounts frequently or do not have access to social media at all. WCG also calls and visits their gardeners, but the gardeners do not always respond. However, most community gardens have extensive waitlists such that they cannot afford to attract more gardeners. Projects to build more community gardens are often slow for logistical reasons and weather conditions, so the idea of developing marketing techniques for community gardens was scrapped.

We adapted our research to target the gap in education for community gardens. In an email to Gilmore, we inquired about WCG's current educational materials and programs for community gardens, specifically in relation to soil health. Gilmore mentioned, WCG would be interested in more soil health educational materials. Gilmore stated, "many of the technical aspects of gardening can be lost, especially for those who are new to the process." Residents tend to their garden plots on their own time while WCG takes on managerial responsibilities. WCG holds garden workshops for residents and sends out surveys to see what garden topics the residents would be most interested in, with regard to gardening, plants, and nature. The topic of soil health, however, is commonly overlooked.

4.4 The Renegade Gardener - Joseph Cullon

We interviewed a local community gardener, Joseph Cullon, to obtain a perspective from a gardener's point of view. Cullon works with a friend of his to identify vacant lots in low income

neighborhoods and turn them into community gardens. One of the biggest issues he has seen is community gardeners often do not know what to do with soil and how to maintain soil health. Oftentimes, Cullon sees gardeners over fertilize and burn their plants. Cullon has also seen a language barrier issue. Some gardeners cannot read instructions and labels, become frustrated and leave the garden. Cullon mentioned pH, soil tests, and nutrients would be helpful topics to include in soil education. We were advised to learn more about how the REC's sustainability practices. Cullon also recommended we read the Journal of Soil Science and research soil science departments at agricultural colleges when establishing content for our soil educational materials.

5.0. Qualtrics Results

From our Qualtrics survey, we identified the following topics as most prominent: nutrients, sustainable gardening, pH, microbes, fertilizer, cover cropping, and soil test results. The survey was conducted and distributed over a three week period, with 27 total responses.

5.1. Demographics

The survey was translated into the three main languages spoken by the Worcester community: English, Spanish, and Albanian. However, 88.9% of survey responses came from people whose primary language was English which contradicts the demographic of Worcester. 35.8% of people in Worcester are speakers of a non-English language (DataUSA: Worcester, MA, 2015).

78% of responses came from women. At the YouthGrow garden, however, there was an even split between men and women to whom the survey was distributed.

The age range of survey responses was more evenly distributed, with responses from people aged 18-65+. Nearly 60% of these responses came from individuals between the ages of 21-30 and 41-65. The full distribution of ages is included in Table 1.

Table 1

Age Range	Number of Responses	Percent of Responses
18-20	5	19%
21-30	9	33%
31-40	2	7%
41-65	7	26%
65+	4	15%

Another demographic was the type of individual surveyed, either a gardener, an educator, or other. The survey was blocked into three categories depending on the individual's response to this question. Of the 27 responses, there were 8 educators, 10 gardeners, and 9 “other,” which consisted of volunteers, interns, and community organizers.

5.2. Soil Knowledge and Interest

The soil knowledge and interest portion of the survey provided us with information including the average years gardening among the participants, their knowledge of soil health, and their interest in soil education programs. Overall, the average years gardening was 6.13 years. However, people did not believe they had a firm knowledge of soil health. As seen in Figure 1, over 60% of participants had a below average knowledge base of soil health.

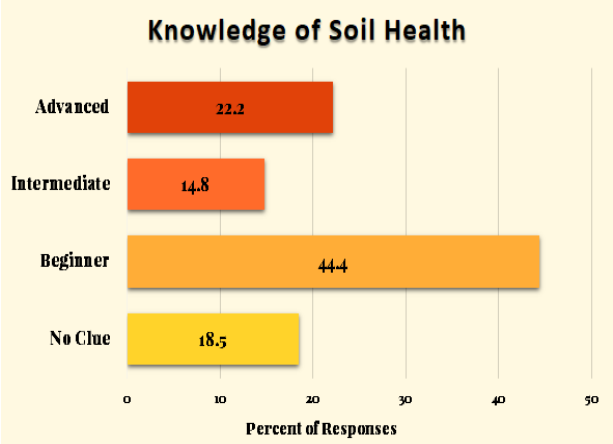


Figure 1

Figure 2, consequently, depicts the high interest in soil education programs, with over 94% of participants having interest in learning more about soil through educational programs. From this, we created educational materials that would be inviting to read, as well as informative of the key concepts of soil health.

5.3. Topics for Learning

The results displayed interest in the following topics: microbes, soil testing, pH, sustainable gardening, nutrients, cover cropping, and fertilizer. An infographic illustrating the distribution of interests can be found in Figure 3. The data reveals, however, most gardeners do not fertilize. REC and WCG informed us that compost is provided for their gardeners so we covered the topic of composting as opposed to general fertilizers, which would not be as applicable to their gardeners. The results of this section of the survey directed our focus for the topics to cover in our educational materials.

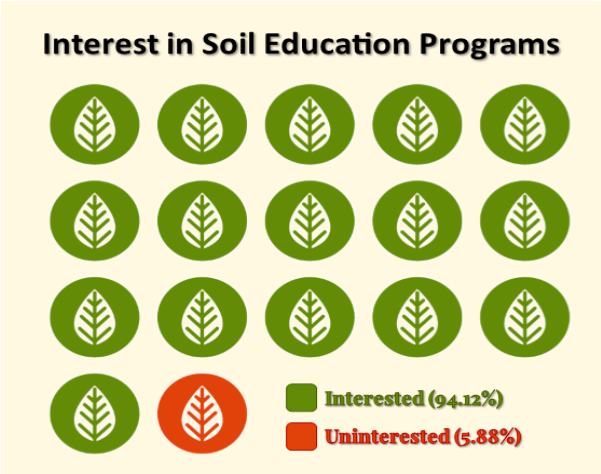


Figure 3

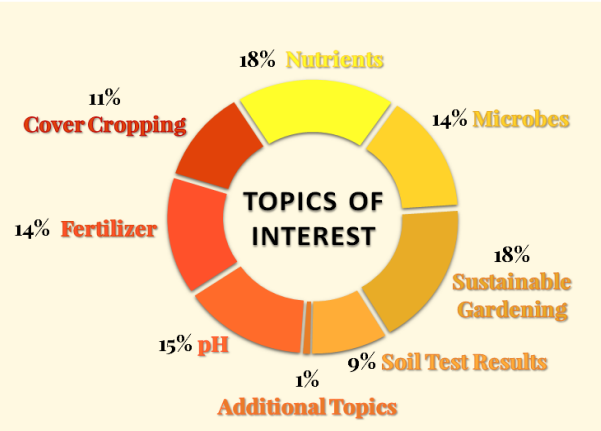


Figure 2

6.0. Educational Model Analysis

As stated above in Methods section 3.2, we created a pamphlet, a packet, and a flyer. REC and WCG found pamphlets would be useful to their gardeners because pamphlets can display substantial amounts of information in a visually appealing way. Our pamphlet provides an overview of topics gardeners were interested in and wanted to learn more about. The pamphlet links to a document we authored for gardeners to refer to if they are interested in learning more about the topics in the pamphlet. We added a link and QR code onto the pamphlet leads to the packet, making it easily accessible. A QR code is a code consisting of black and white squares which leads to a URL or other information, able to be read by a smartphone application (example Figure 6). Finally, we designed a soil testing flyer. This flyer covers only one topic, it includes a detailed overview and larger visuals, such as a soil test key and a pH scale.

7.0. Deliverables

Our final educational materials consisted of a flyer about soil practices, a pamphlet about basic soil care practices, and an informational packet about in depth soil care practices. The flyer and pamphlet were our materials of choice because Humphrey stated handouts with visuals would be most helpful to the gardeners. We designed these materials with the goal of making them both informational and understandable to a wide range of gardeners regardless of skill level and prior knowledge.

The topics covered in our educational materials were determined through our interviews. Chris Humphrey, Eliza Lawrence, and Joe Cullon provided us with the most important topics of soil care. We took those topics and compiled them into a question on our Qualtrics survey, and chose the most popular topics based on those results. Topics of interest we found through this survey include: nutrients, sustainable gardening, pH, microbes, fertilizer, cover cropping, and soil test results. We researched each of these topics, and compiled the information into the *Digging Deeper into Soil Care* packet. We then condensed the information into concise sections for *The Roots of Soil Care* pamphlet. Strictly soil testing information was included in the *Beginner's Guide to Soil Testing* flyer.

We used an earthy color scheme combined with simple icons to make our materials aesthetically appealing while also informative. We consulted Jessica Baer, an Instruct Technology Specialist with Worcester Polytechnic Institute's Academic Technology Center, throughout our design process to ensure our materials met our established goals.

7.1. Soil Test Flyer

Our soil testing flyer focuses on informing gardeners about the importance of soil testing and the basics of interpreting soil test results. The front of the flyer details what is included in soil test results and how to interpret this information. The back gives the reader examples of how they can improve their garden based on the results they receive.

The front of the flyer is broken into three sections. The first section has an infographic explaining why gardeners should test their soil. The second section explains some of the commonly tested nutrients in soil. Nitrogen is the most popular of these nutrients, but is not included on this flyer because a distinct soil test is needed for nitrogen. Some of the commonly tested nutrients on generic soil tests are phosphorus, potassium, calcium and magnesium (UMass Extension, 2014).

The third section is a standard soil test key used by the University of Massachusetts Amherst's Center for Agriculture, Food and the Environment. This is a generic key, used to read soil test results by listing nutrient categories and their corresponding interpretations.

The back of the flyer displays a soil pH scale, showing which pH levels are considered acidic, neutral, alkaline, and highly alkaline for soil. This scale explains what it means to be acidic or highly alkaline, as well as recommends amendments to make your soil more neutral. Below this scale, examples are given of plants that grow well in acidic, alkaline and neutral soils. It then gives similar examples for slightly acidic and alkaline soil. This can be used by farmers to maximize their crop production based on their soil pH. See Figures 4 and 5.

The information found on this flyer about interpreting soil test results came from University of Massachusetts Amherst's Center for Agriculture, Food and the Environment's website. Many organizations, including the REC, use UMass's Center for Agriculture, Food and the Environment to perform their soil tests. Therefore, he soil testing key on the flyer will line up with soil test results the gardeners receive.

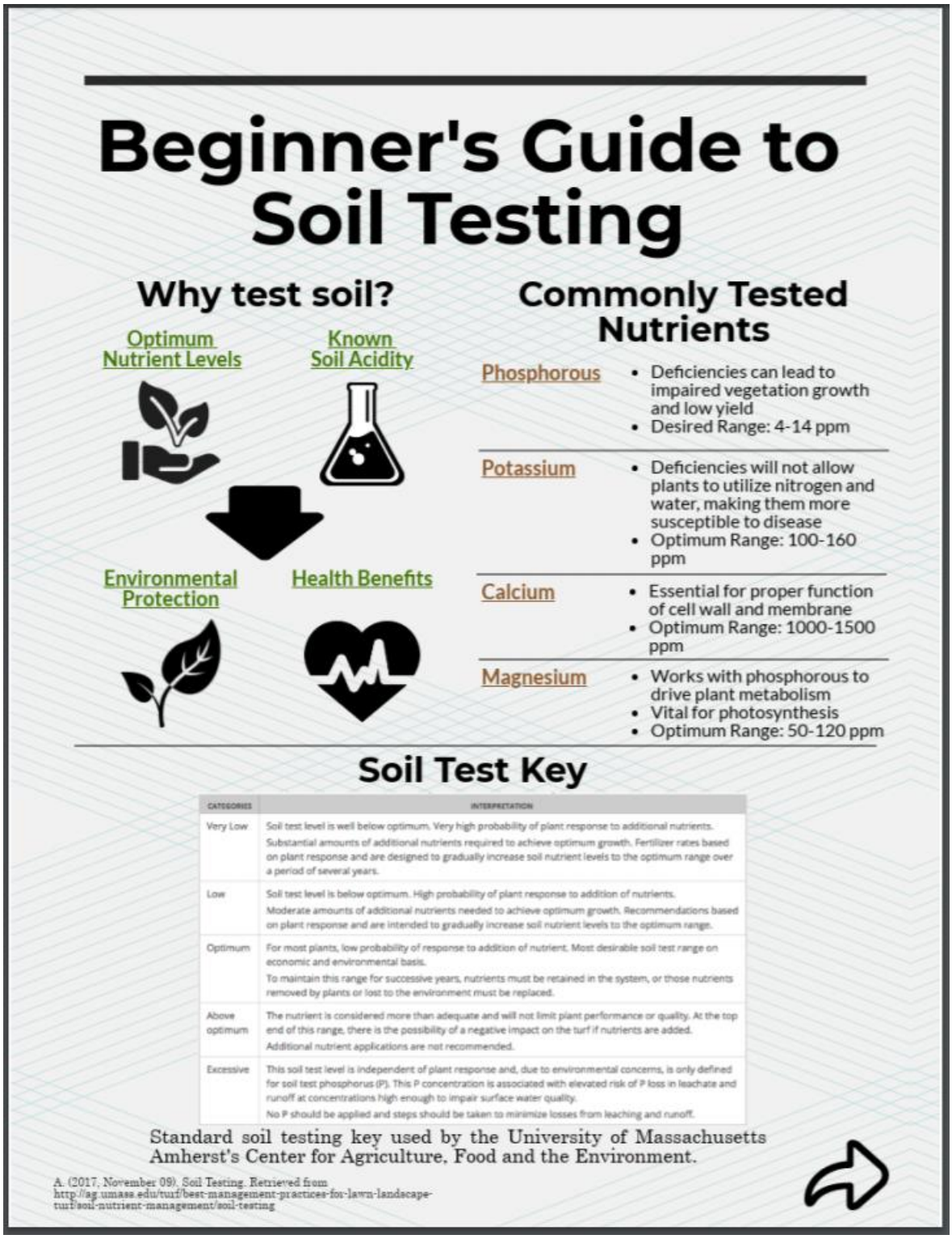

Beginner's Guide to Soil Testing
Why test soil?
Optimum Nutrient Levels
Known Soil Acidity
Environmental Protection
Health Benefits
Commonly Tested Nutrients
Phosphorous
Deficiencies can lead to impaired vegetation growth and low yield
Desired Range: 4-14 ppm
Potassium
Deficiencies will not allow plants to utilize nitrogen and water, making them more susceptible to disease
Optimum Range: 100-160 ppm
Calcium
Essential for proper function of cell wall and membrane
Optimum Range: 1000-1500 ppm
Magnesium
Works with phosphorous to drive plant metabolism
Vital for photosynthesis
Optimum Range: 50-120 ppm
Soil Test Key
CATEGORIES
INTERPRETATION
Very Low
Soil test level is well below optimum. Very high probability of plant response to additional nutrients.
Substantial amounts of additional nutrients required to achieve optimum growth. Fertilizer rates based on plant response and are designed to gradually increase soil nutrient levels to the optimum range over a period of several years.
Low
Soil test level is below optimum. High probability of plant response to addition of nutrients.
Moderate amounts of additional nutrients needed to achieve optimum growth. Recommendations based on plant response and are intended to gradually increase soil nutrient levels to the optimum range.
Optimum
For most plants, low probability of response to addition of nutrient. Most desirable soil test range on economic and environmental basis.
To maintain this range for successive years, nutrients must be retained in the system, or those nutrients removed by plants or lost to the environment must be replaced.
Above optimum
The nutrient is considered more than adequate and will not limit plant performance or quality. At the top end of this range, there is the possibility of a negative impact on the turf if nutrients are added.
Additional nutrient applications are not recommended.
Excessive
This soil test level is independent of plant response and, due to environmental concerns, is only defined for soil test phosphorus (P). This P concentration is associated with elevated risk of P loss in leachate and runoff at concentrations high enough to impair surface water quality.
No P should be applied and steps should be taken to minimize losses from leaching and runoff.
Standard soil testing key used by the University of Massachusetts Amherst's Center for Agriculture, Food and the Environment.
A. (2017, November 09). Soil Testing. Retrieved from http://ag.umass.edu/turf/best-management-practices-for-lawn-landscape-turf/soil-nutrient-management/soil-testing

Figure 4

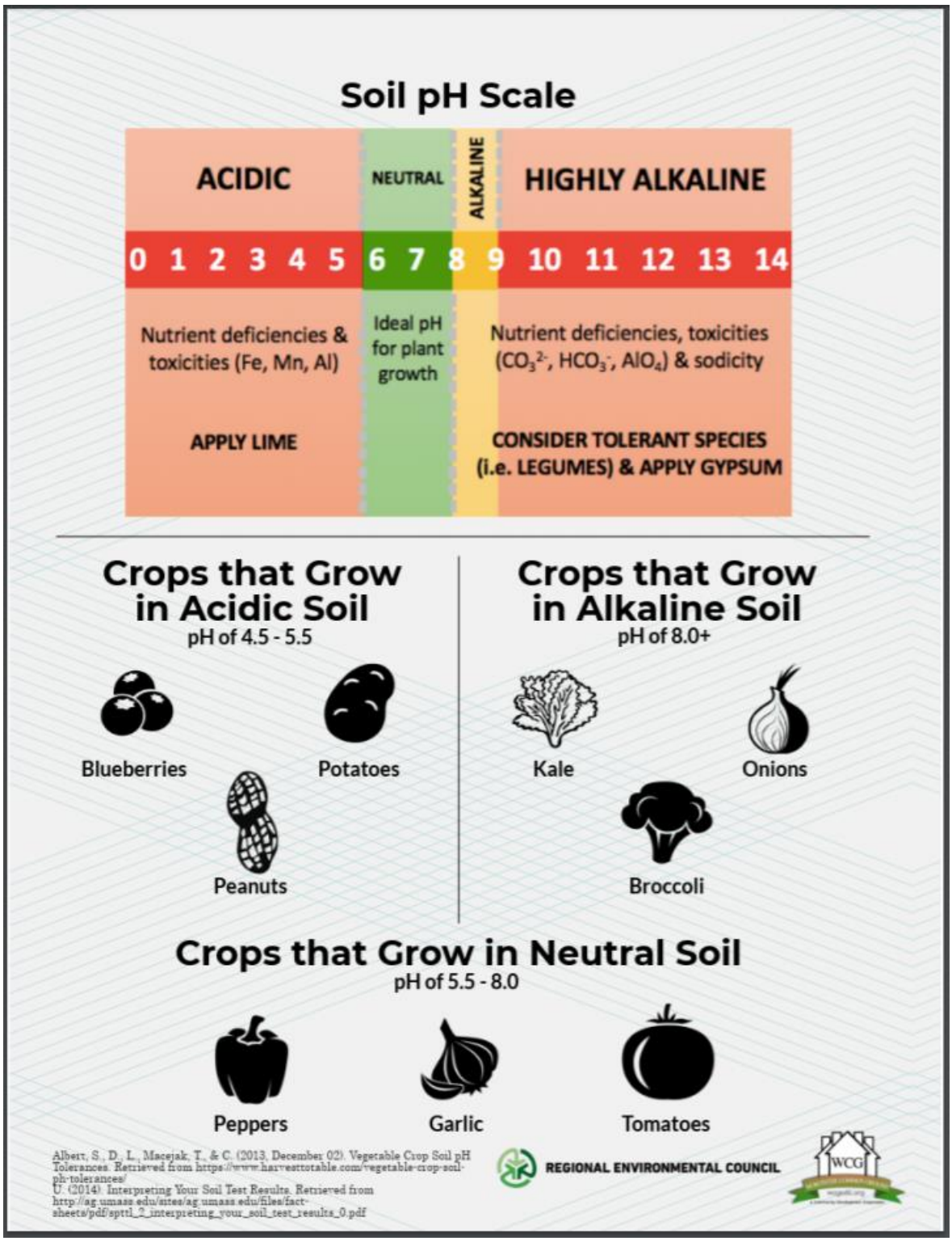

Soil pH Scale
ACIDIC
NEUTRAL
ALKALINE
HIGHLY ALKALINE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Nutrient deficiencies & toxicities (Fe, Mn, Al)
APPLY LIME
Ideal pH for plant growth
Nutrient deficiencies, toxicities (CO_3^{2-}, HCO_3^-, AlO_4) & sodicity
CONSIDER TOLERANT SPECIES (i.e. LEGUMES) & APPLY GYPSUM
Crops that Grow in Acidic Soil
pH of 4.5 - 5.5
Blueberries
Potatoes
Peanuts
Crops that Grow in Alkaline Soil
pH of 8.0+
Kale
Onions
Broccoli
Crops that Grow in Neutral Soil
pH of 5.5 - 8.0
Peppers
Garlic
Tomatoes
Albert, S., D., L., Macejak, T., & C. (2013, December 02). Vegetable Crop Soil pH Tolerances. Retrieved from https://www.harvesttotable.com/vegetable-crop-soil-ph-tolerances/
U. (2014). Interpreting Your Soil Test Results. Retrieved from http://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/sptl_2_interpreting_your_soil_test_results_0.pdf
REGIONAL ENVIRONMENTAL COUNCIL
WCG

Figure 5

7.2. The Roots of Soil Care Pamphlet

Our first pamphlet design split our topics into three sections, one for each flap; however, our initial design was riddled with inconsistencies. After consulting Jessica Baer, we switched to a collaborative software and split our inner panels into four sections.

The first section, "Just Getting Started?" is a reference for people just starting their gardens. The main topic discussed in this section is cultivation and its importance. The next subsection goes over which times are most beneficial for cultivating. The last subsection includes an infographic depicting an ideal digging method. Cultivation is a preliminary step taken before someone begins gardening, which is the reason for titling this section.

The second section, "How's Your Soil Doing?" notes the importance of soil testing, and what soil tests can reveal about your soil health. We added this section to teach gardeners of the existence of soil tests, and the positive effects tests can have on their garden. Soil tests can be conducted either at the beginning or end of growing season to check nutrient levels which is important information for any gardener to understand. This section touches on soil pH levels and how it affects crops.

The third section, "What's in Your Soil?" goes over the three main nutrients nitrogen, phosphorus, and potassium. This section describes what each of these nutrients does for plant growth. It also describes what microbes are, and how to maintain a healthy microbial balance within your soil. This section was named to alert gardeners of the contents of their soil, and the different effects each nutrient can have on crop growth. This section plays off of the "How's Your Soil Doing?" section by expanding on nutrient information.

Finally, "Did Somebody Say Soil Protection?" explains the concept of cover cropping and composting to protect soil, and how to utilize these techniques in your garden. Cover cropping and composting are effective techniques to protect soil during the off season of growing, hence the catchy name of this section.

The inside flap of the pamphlet provides a general definition of soil. It also includes a list of keywords used throughout the pamphlet, along with their definitions. These were included for gardening beginners, to avoid any confusion of terms.

The back of the leaflet has two QR codes, the first of which leads to the USDA guide to community gardening, and the other leads to an additional information packet we created to further

explain the topics covered in the pamphlet. There is also a section on the back of the pamphlet titled “Why Soil Health is Important,” which mentions the benefits of sustainable gardening.

See Figures 6 and 7.

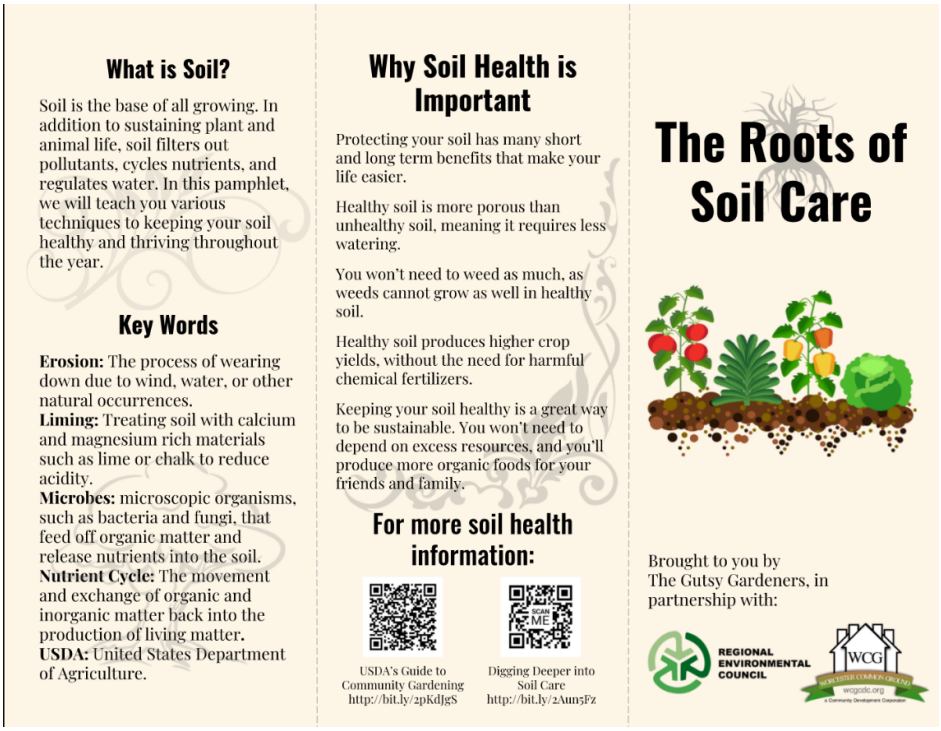


Figure 6

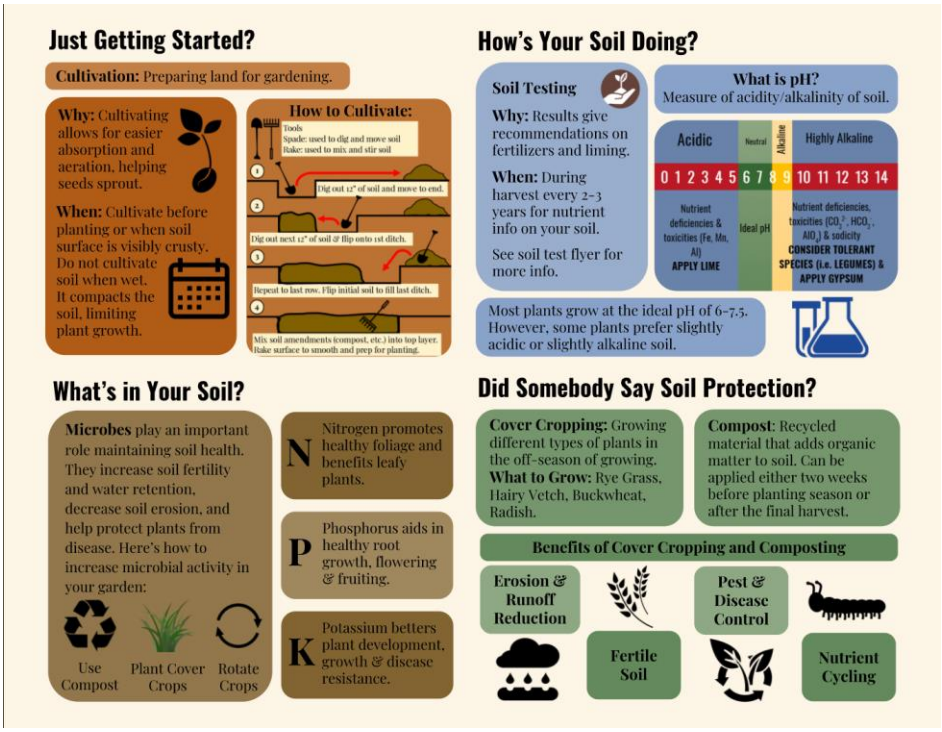


Figure 7

7.3. Digging Deeper into Soil Care - Additional Information Packet

Our additional information packet, *Digging Deeper into Soil Care* further expands upon each of the topics described in the pamphlet. This educational packet targets gardeners interested in soil knowledge beyond the introductory material offered in the pamphlet. We composed the information to be in-depth and well rounded, focusing more on content than visual appeal. The packet follows the same section headers as *The Roots of Soil Care*, with more background and guiding practices in each section. The packet concludes with a list of additional resources readers may cite for more information. See Figure #. (Full packet in Appendix)

Digging Deeper into Soil Care

How to be a gutsy gardener

Keywords

Cultivation: The process of preparing soil for the raising of crops

Erosion: The process of wearing down due to wind, water, or other natural occurrences.

Horticulture: The science of growing fruits, vegetables, flowers, or any other plant.

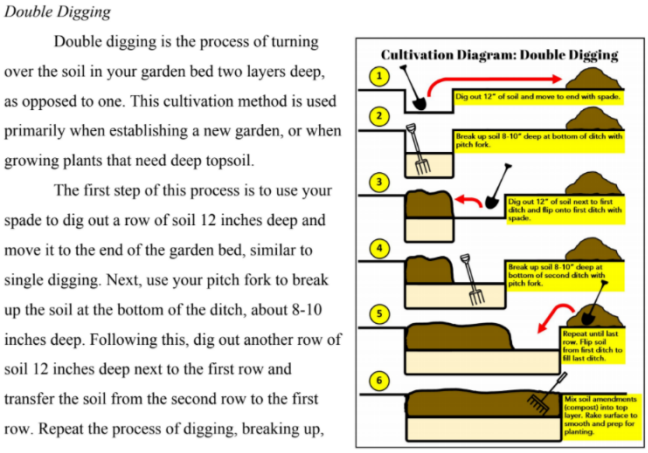
Liming: Treating soil with calcium and magnesium rich materials such as lime or chalk to reduce acidity.

Microbes: microscopic organisms, such as bacteria and fungi, that feed off organic matter and release nutrients into the soil.

Nutrient Cycle: The movement and exchange of organic and inorganic matter back into the production of living matter.

Sustainability: Creating and maintaining conditions under which humans and nature can exist in productive harmony to support present and future generations.

Figure 9



Double Digging

Double digging is the process of turning over the soil in your garden bed two layers deep, as opposed to one. This cultivation method is used primarily when establishing a new garden, or when growing plants that need deep topsoil.

The first step of this process is to use your spade to dig out a row of soil 12 inches deep and move it to the end of the garden bed, similar to single digging. Next, use your pitch fork to break up the soil at the bottom of the ditch, about 8-10 inches deep. Following this, dig out another row of soil 12 inches deep next to the first row and transfer the soil from the second row to the first row. Repeat the process of digging, breaking up,

Figure 8

7.4. Educational Materials Distribution

After meeting Jessica Baer to review the aesthetics of the soil test flyer and the soil care pamphlet, we reviewed the content of the materials with Humphrey. He was ecstatic with the results. Humphrey requested 500 copies of the flyer, 500 copies of the pamphlet, and 20-40 copies of the *Digging Deeper into Soil Care packet*. He brought the materials back to his office to be reviewed by his program director who agreed they look "really great!" He only suggested we put the REC logo on the front of the pamphlet. We added both the REC and WCG logos to the bottom of the pamphlet and the flyer. We printed the requested amount of copies through the Print Shop at WPI.

We emailed our finalized materials to Ellie Gilmore at WCG, and asked if she has any interest in implementing these materials into their educational programs. Gilmore did not request for us to print any copies for her.

These materials were sent to our former sponsors in Puerto Rico, Para la Naturaleza and the Departamento de Recursos Naturales y Ambientales (DRNA) via email. We attached the finalized materials to the email and asked if there was interest in the implementation of these materials or if they knew any other organizations who would benefit from them in Puerto Rico.

Para la Naturaleza is currently working on community gardens in Puerto Rico to aid in hurricane relief. They have been assisting in sustainable agricultural efforts and have begun the process of reforestation of natural habitats (Para la Naturaleza, n.d). They have done this both by setting up a donation center to provide funding to communities in need, as well as providing labor assistance to local ecological farmers and community gardens. Para la Naturaleza is also creating new educational materials and workshops to teach local communities of sustainable habits to assist in their rebuilding. We hope these educational materials will come in handy for the agriculture of Puerto Rico.

Figure 10

8.0. Conclusions and Reflection

Based on interviews with community development corporations, we found there is a lack of comprehensive soil education in Worcester based community gardens. Through surveying community development corporations, community gardeners, and educators, we found that these groups have interest in a soil education program. Specifically, they have shown interest in topics of nutrients, sustainable gardening, pH, microbes, fertilizer, cover cropping, and soil test results. We created a soil test flyer with introductory information on soil testing, the *Roots of Soil Care* pamphlet with a quick introduction to soil care, and the *Digging Deeper into Soil Care* packet with more detailed information about soil care.

Completing this IQP in B term posed an interesting challenge to our group. The harvest season for crops in Worcester closes around the end of November. We believe there would have been more volunteers if this project was completed in the spring, at the beginning of the growing season. However, we still were able to gather ample information from the volunteers and gardeners at this time.

We considered additionally working with school gardens; however, we believed our efforts would be more impactful with community garden groups. According to Eliza Lawrence, school garden coordinator of the REC, budget issues within the schools would have made it difficult to ensure there was necessary funding to consistently implement a science experiment on a long term basis. We also did not feel we had the time to design and test a science experiment to the point where it could be implemented into a school curriculum. We hope a future IQP will expand our work within local schools.

Once we finished creating our final deliverables we contacted our original sponsors from Puerto Rico, Para la Naturaleza and the Departamento de Recursos Naturales y Ambientales, and sent them our materials. We were able to hear back from Para la Naturaleza, who is currently working with community gardens, that our resources included interesting topics for them to teach and could be useful for their future workshops.

From our research, we found two educational materials as the most effective for schools: a poster and a soil based experiment. We recommend schools with access to gardens expand their soil health curriculum in the future using these models. For both the poster and science project, important topics to cover include (but are not limited to): pH, microbes, nutrients, and crop rotation. The poster should be strategically created with eye-catching visuals to illustrate complex

concepts in a simple manner (refer to the 'Deliverables' section). Lawrence mentioned creating a table for students that tracks which crops are planted each year would also be beneficial. The poster should be put up in middle schools and high schools due to the more complicated material. A soil based experiment would also be beneficial for students as it would provide a form of both unconventional and place-based learning. It will allow students to use their creativity and learn how to apply classroom knowledge to the real world. These projects can be completed by a future IQP team in either A or D term.

This Interactive Qualifying Project experience has tested our group's ability to be flexible in a fast-paced learning environment. We have adapted to many challenges throughout the past two terms, while maintaining a positive attitude. Despite hardships, we continued our project to the fullest extent, creating three deliverables to help make an impact in both the Worcester community, as well as for Puerto Ricans committed to rebuilding efforts. We hope this project can have a lasting effect on the gardeners of Worcester, and help spark an agricultural movement in the strong-spirited citizens of Puerto Rico.

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Appendix

Appendix A: Ellie Gilmore semi-structured interview questions

Ellie Gilmore:
Worcester Common Ground
Community Organizer

Goal of interview: Find out how Common Ground Markets there efforts. Who, what, where, when, why of marketing. Successes and failures

We are a group of students from WPI that are on the Puerto Rico project team. Unfortunately, due to the event of Hurricane Maria we are no longer able to complete our project in Puerto Rico so we are now completing it in Worcester. Currently, we are in the process of developing a new project focusing on the marketing of community gardens in Worcester for the Puerto Rican community. We plan to assess the current marketing strategies of community garden organizations with the goal of developing an adaptable marketing technique, able to be adjusted to various demographics.

Question 1: We know your organization has partnered with WPI in the past. Have you yourself worked with WPI students before?

Question 2: We saw that you just had the ribbon cutting ceremony for the Bioshelter Project. How'd that celebration go?

Question 3: How have your projects impacted the Worcester community?

Question 4: In general, what types of projects do you market for to the public?

Question 5: Who is the target demographic for your marketing?

Question 6: What methods have worked well in the past? In addition, what methods have not been as effective?

Question 7: How have your marketing strategies changed in past?

Question 8: Do your current community gardens have any components where participants are educated about nutrition, agriculture, health, etc.?

Question 9: If not, would this be something that you would be interested in?

Appendix B: Joseph Cullon semi-structured interview questions

Dr. Joseph Cullon:
Community gardener
Interesting guy
"Strangely fascinating man" (the most fascinating man in the world)

Goal for Interview: Learn more about how residents interact with community gardens and any gaps, particularly educational gaps.

Question 1: What's been your experience with community gardening in Worcester? How do you get into these gardens?

Question 2: How much support is provided to you by the organization in the garden? How much time per week do you spend tending to your garden?

Question 3: Have you experienced any of the gardening educational programs put on in Worcester, either by the REC, Common Ground, or another organization? What were they? Did they seem suitable for children?

Question 4: In your experience, what topic do CG educational programs focus their energies on?

Question 5: In contrast, what topics could CG educational programs focus their energies on more?

Question 6: How do you rate the importance of soil quality in your gardening on a scale from 1-10?

Question 7: If you could change anything about the community gardening scene in Worcester, what would it be?

Question 8: Did your gardens focus on soil health, and how to test soil quality?

Appendix C: Chris Humphrey semi-structured interview questions

Chris Humphrey:
REC
UGROW & Social Enterprise Coordinator

Goal for Interview: Learn about garden management, program types, educational workshops.

Question 1: What is your role in the REC? / What are your responsibilities in the council?

Question 2: How does the REC manage community garden plots? How much maintenance work must users of the plot do? / do all of the gardens have the same plotting system?

Question 3: What do you do to prepare the soil for the plot? And do you provide users with soil/fertilizer or must they obtain it themselves? What types of soil/fertilizers do you use? organic/inorganic?

Question 4: How do you rate the importance of soil quality in gardening on a scale from 1-10? Explain why you chose that rating.

Question 5: We know that the REC provides educational programs through UGROW. What programs/classes do you hold? Who can attend? What demographic do your educational programs target?

Question 6: How are the school gardens different from general community gardens? What do you teach the kids at the gardens vs what do you implement into their curriculum?

Question 7: Does the REC teach users about the importance of soil health? Specifically, children.

Question 8: How are your educational programs structured? Do you hold classes or have you implemented educational materials into the gardens themselves?

Question 9: Do you believe that there is any gap in the education programs?

Question 10: What have you done to evaluate your educational programs?

Appendix D: Eliza Lawrence semi-structured interview questions

Eliza Lawrence:
REC
Garden Education AmeriCorps

Goals for Interview: evaluate current soil education in schools, discover gaps in soil education in school curriculum, ask about the best topics, platforms, and ages for educational materials

1. **How was the meeting to review curriculum?**

2. **Do the REC curriculum recommendations usually get integrated into the classroom? If so, how?**

3. **Are there any current soil education materials being implemented with REC school gardens? Are any of those science experiments?**

4. **What gaps do you see with these programs?**

5. **Would a soil-based science experiment complement the curriculum? Which soil topic would be best to design an experiment around?**

6. **How much should we simplify the curriculum? I.e., how much should we assume the children already know?**
   a. **age/grades**

7. **Can we have access to other education materials from the schools?**

Appendix E: Qualtrics Survey Questions

Introduction: We are a group of students from Worcester Polytechnic Institute (WPI), and we are in the process of completing our Interactive Qualifying Project (IQP). Our goal is to create an educational model about soil health and soil quality to be implemented into local community gardens in Worcester, MA. With this survey, we hope to gain more insight about soil education in Worcester community gardens and Worcester schools. In addition, we hope to hear the public's opinions on what soil health and soil quality topics they would like to learn more about.

What language do you speak? Que idioma hablas? çfarë gjuhe flisni?

- o English (1)
- o Spanish (2)
- o Albanian (3)

Age?

- o 0-20 years (1)
- o 21-30 years (2)
- o 31-40 years (3)
- o 41-64 years (4)
- o 65+ years (5)

Gender?

- o Male (1)
- o Female (2)
- o Other (3) _____

Which title best describes you?

- o Gardener (1)
- o Educator (2)
- o Other (3) _____

Other

How much experience do you have with gardening?

0 3 6 9 12 15

How would you rate your knowledge of soil health?

- o No clue (1)
- o Beginner (2)
- o Intermediate (3)
- o Advanced (4)

How would you rate the importance of soil in gardening?

Not Important Very Important

0 1 2 3 4 5 6 7 8 9 10

What topics do you think would be useful to cover in a soil education program? Select all that apply

- ▢ pH levels (1)
- ▢ Fertilizer (2)
- ▢ Cover cropping (Crop cycling) (3)
- ▢ Nutrients (Nitrogen, Phosphorus, Potassium) (4)
- ▢ Importance of bacteria and microbes (5)
- ▢ Sustainable growing (6)
- ▢ How to read soil test results (7)
- ▢ Other (8) _____

Educator

What school do you teach at?

_____

How frequently do you utilize your school's community garden?

- o Never (1)
- o Once a year (2)
- o Once a semester (3)
- o Once a month (4)
- o More than once a month (17)

What topic(s) do you teach in the community garden?

_____

Is soil health included in your cirriculum?

- o Yes (1)
- o No (2)

How much experience do you have with gardening?

Years

0 3 6 9 12 15

How would you rate your knowledge of soil health?

- o No clue (1)
- o Beginner (2)
- o Intermediate (3)
- o Advanced (4)

Do you think your students would benefit from a soil education program?

- o Yes (1)
- o No (2)

How do your students learn best? Select all that apply

- ▢ Posters (1)
- ▢ Videos (2)
- ▢ Hand-outs (3)
- ▢ Hands-on Experiment (4)
- ▢ Other (5) _____

What topics would be helpful to cover in a soil education program? Select all that apply

- ▢ pH levels (1)
- ▢ Fertilizers (2)
- ▢ Cover cropping (Crop cycling) (3)
- ▢ Nutrients (Nitrogen, Phosphorus, Potassium) (4)
- ▢ Importance of bacteria, microbes (5)

- Sustainable Gardening (6)
- How to read soil test results (7)
- Other (8) _____

Gardener

Which community garden(s) are you a part of?

_____

How long have you been a part of this garden?

- 0-1 years (1)
- 1-2 years (2)
- 2-3 years (3)
- 3-4 years (4)
- 4+ years (5)

How much experience do you have gardening?

Years

0 3 6 9 12 15

Are you aware of any education programs provided by your garden?

- Yes (1)
- No (2)

Have you attended any of these programs?

- Yes, which ones? (1) _____
- No (2)
- N/A (3)

How would you rate your knowledge of soil health?

- Far above average (1)
- Somewhat above average (2)
- Average (3)
- Somewhat below average (4)
- Far below average (5)

Are you satisfied with the size of your crops?

- o Yes (1)
- o No (2)

Have you had problems with your crops wilting?

- o Yes (1)
- o No (2)

How often do you fertilize?

- o Never (1)
- o Everyday (2)
- o Once a week (3)
- o Once a month (4)
- o Once a season (5)
- o Once a year (6)

What fertilizer do you use?

- o N/A (1)
- o Chemical (2)
- o Compost (3)
- o Other (4) _____

Do you think you would benefit from an education program about the importance of soil quality and health?

- o Yes (1)
- o No (2)

What soil health topics would you be interested in learning more about? (Select all that apply)

- ▢ pH levels (1)
- ▢ Fertilizers (2)
- ▢ Cover Cropping (Crop cycling) (3)
- ▢ Nutrients (Nitrogen, Phosphorus, Potassium) (4)
- ▢ Importance of bacteria and microbes (5)
- ▢ Sustainable Gardening (6)
- ▢ How to read soil test results (7)

- Other (8) _____

All

How did you hear about the survey?

_____

Spanish

¿Edad?

- o 0-20 años (1)
- o 21-30 años (2)
- o 31-40 años (3)
- o 41-64 años (4)
- o 65+ años (5)

Género

- o Masculino (1)
- o Feminino (2)
- o Otro (3) _____

Qué título te describe mejor?

- o Jardinero (1)
- o Educador (2)
- o Otro (3) _____

¿De qué jardín(s) comunitario(s) formas parte?

_____

¿Cuánto tiempo has sido parte de este jardín?

- o 0-1 años (1)
- o 1-2 años (2)
- o 2-3 años (3)
- o 3-4 años (4)
- o 4+ años (5)

¿Cuánta experiencia tienes en jardinería?

0 3 6 9 12 15

¿Conoce algún programa educativo proporcionado por su jardín?

- o Sí (1)
- o No (2)

¿Ha asistido a alguno de estos programas educativos?

- o Sí, cuales? (1) _____
- o No (2)

¿Cómo calificaría su conocimiento de la salud del suelo?

- o Principiante (1)
- o Intermedio (2)
- o Avanzado (3)

¿Está satisfecho con el tamaño de sus cultivos?

- o Sí (1)
- o No (2)

¿Has tenido problemas con la marchitez de tus cultivos?

- o Sí (1)
- o No (2)

¿Con qué frecuencia fertilizas?

- o Nunca (1)
- o Todos los dias (2)
- o Una vez por semana (3)
- o Una vez al mes (4)
- o Una vez por temporada (5)
- o Una vez al año (6)

¿Qué fertilizante usas?

- o No Aplica (1)
- o Químico (2)
- o Compost (3)
- o Otro (4) _____

¿Crees que te beneficiarías de un programa educativo sobre la importancia de la calidad y la salud del suelo?

- o Sí (1)
- o No (2)

¿De qué temas de la salud del suelo estarías interesado para aprender más?

- ▢ Niveled de pH (1)
- ▢ Fertilizante (2)
- ▢ Cobertura de cultivos (ciclo de cultivos) (3)
- ▢ Nutrientes (Nitrógeno, fósforo, potasio) (4)
- ▢ Importancia de bacterias y microbios (5)
- ▢ Jardinería sostenible (6)
- ▢ Cómo leer los resultados de la prueba de suelo (7)
- ▢ Otro (8) _____

¿En qué escuela enseña?

_____

¿Utilizas el jardín comunitario de tu escuela?

- o Sí (1)
- o No (2)

¿Con qué frecuencia usa el jardín?

- o Nunca (1)
- o Una vez al año (2)
- o Una vez por semestre (3)
- o Una vez al mes (4)
- o Más de una vez al mes (5)

¿Qué tema(s) enseña en el jardín comunitario?

_____

¿La salud del suelo está incluida en tu plan de estudios?

- o Sí (1)
- o No (2)

¿Cuánta experiencia tiene en jardinería?

0 3 6 9 12 15

¿Cómo calificaría su conocimiento de la salud del suelo?

- o Ningún conocimiento (1)
- o Principante (2)
- o Intermedio (3)
- o Avanzado (4)

¿Cree que los estudiantes se beneficiarían de un programa de educación sobre el suelo?

- o Sí (1)
- o No (2)

¿Cómo aprenden mejor sus estudiantes? (Seleccione todas las que correspondan)

- ▢ Póster (1)
- ▢ Vídeo (2)
- ▢ Folleto (3)
- ▢ Experimento práctico (4)
- ▢ Otro (5) _____

¿Qué temas serían útiles para cubrir en un programa de educación sobre el suelo? (Seleccione todas las que correspondan)

- ▢ Niveles de pH (1)
- ▢ Fertilizante (2)
- ▢ Cobertura de cultivos (ciclo de cultivos) (3)
- ▢ Nutrientes (Nitrógeno, fósforo, potasio) (4)
- ▢ Importancia de bacterias y microbios (5)
- ▢ Jardinería sostenible (6)
- ▢ Cómo leer los resultados de la prueba de suelo (7)
- ▢ Otro (8) _____

¿Cuánta experiencia tienes en jardinería?

0 3 6 9 12 15

Q53 ¿Cómo calificaría su conocimiento de la salud del suelo?

- o Ningún conocimiento (1)
- o Principante (2)
- o Intermedio (3)
- o Avanzado (4)

Q54 ¿Cómo calificaría la importancia de la salud del suelo en la jardinería?

No importante Muy importante

0 1 2 3 4 5 6 7 8 9 10

¿Qué temas serían útiles para cubrir en un programa de educación sobre el suelo? (Seleccione todas las que correspondan)

- ▢ Niveles de pH (1)
- ▢ Fertilizante (2)
- ▢ Cobertura de cultivos (ciclo de cultivos) (3)
- ▢ Nutrientes (Nitrógeno, fósforo, potasio) (4)
- ▢ Importancia de bacterias y microbios (5)
- ▢ Jardinería sostenible (6)
- ▢ Cómo leer los resultados de la prueba de suelo (7)
- ▢ Otro (8) _____

¿Cómo se enteró de la encuesta?

_____

Albanian

Mosha

- o 0-20 vjet (1)
- o 21-30 vjet (2)
- o 31-40 vjet (3)
- o 41-64 vjet (4)
- o 65+ vjet (5)

Gjinia

- o Mashkull (1)
- o Femër (2)
- o Tjetër (3)

Cili titull ju përshkruan më se miri?

- o Kopshtar (1)
- o Edukator (2)
- o Tjetër (3) _____

Cili kopsht (ët) e komunitetit jeni pjesë e?

_____

Sa kohë keni qenë pjesë e këtij kopsht?

- o 0-1 vit (1)
- o 1-2 vite (2)
- o 2-3 vite (3)
- o 3-4 vite (4)
- o 4+ vite (5)

Sa përvojë keni me kopshtarinë?

0 3 6 9 12 15

A jeni në dijeni për ndonjë program edukativ të ofruar nga kopshti juaj?

- o Po (1)
- o Jo (2)

A keni ndjekur ndonjë nga këto programe arsimore?

- o Po, cilet (1) _____
- o Jo (2)

Si do ta vlerësonit njohurinë tuaj për shëndetin e tokës?

- o Unë nuk kam njohuri (1)
- o Fillestar (2)
- o I ndërmjetëm (3)
- o I përparuar (4)

A jeni i kënaqur me madhësinë e të lashtave tuaja?

- o Po (1)
- o Jo (2)

A janë perimet tuaja të dobta?

- o Po (1)
- o Jo (2)

Sa shpesh jeni fekonduar?

- o Asnjehere (1)
- o Çdo ditë (2)
- o Një herë në javë (3)
- o Njehere ne muaj (4)
- o Sapo një sezon (5)
- o Një herë në vit (6)

çfarë plehërimi përdorni?

- o nuk aplikohet (1)
- o kimik (2)
- o përzierje plehrash (3)
- o tjetër (4)

A mendoni se do të përfitoni nga një program edukimi për rëndësinë e cilësisë së tokës dhe shëndetit?

- o Po (1)
- o Jo (2)

Çfarë tema të shëndetit të tokës do të interesoheni për të mësuar më shumë? Zgjidhni të gjitha ato që vlejnë

- ▢ Nivelet e pH (1)
- ▢ pleh (2)
- ▢ Mbulimi i të lashtave (Çiklizmi i kulturave) (3)
- ▢ Ushqysit (azot, fosfor, kalium) (4)
- ▢ Rëndësia e baktereve dhe mikrobeve (5)
- ▢ Kopshtari e qëndrueshme (6)
- ▢ Si të lexoni rezultatet e provës së tokës (7)
- ▢ Tjetër (8) _____

Në cilën shkollë mësoni?

_____

A shfrytëzoni kopshtin e komunitetit të shkollës suaj per të mbjelle perime te ndryshme?

- o Po (1)
- o Jo (2)

Sa shpesh përdorni kopshtin?

- o Asnjehere (1)
- o Një herë në vit (2)
- o Një herë në semestër (3)
- o Një here ne muaj (4)
- o Më shumë se një herë në muaj (5)

Çfarë temash ju mësoni në kopshtin e komunitetit?

_____

A përfshihet shëndeti i tokës në kurrikulën tuaj?

- o Po (1)
- o Jo (2)

Sa përvojë keni me kopshtarinë?

0 3 6 9 12 15

Si do ta vlerësonit njohurinë tuaj për shëndetin e tokës?

- o nuk ka njohuri (1)
- o Fillestar (2)
- o I ndërmjetëm (3)
- o I përparuar (4)

A mendoni se studentët do të përfitonin nga një program i edukimit të tokës?

- o Po (1)
- o Jo (2)

Si i mësojnë nxënësit më të mirë? [Zgjidh të gjitha ato që vlejnë]

- ▢ Afishe (1)
- ▢ Video (2)
- ▢ Pamflet (3)
- ▢ Mësim praktik (eksperiment) (4)

- Tjetër (5) _____

Cilat tema do të ishin të dobishme për t'u mbuluar në një program të edukimit të tokës? (Zgjidh të gjitha ato që vlejnë)

- Nivelet e pH (1)
- Pleh (2)
- Mbulimi i të lashtave (Çiklizmi i kulturave) (3)
- Ushqysit (azot, fosfor, kalium) (4)
- Rëndësia e baktereve dhe mikrobeve (5)
- Kopshtari e qëndrueshme (6)
- Si të lexoni rezultatet e provës së tokës (7)
- Tjerër (8) _____

Sa përvojë keni me kopshtarinë?

0 3 6 9 12 15

Si do ta vlerësonit njohurinë tuaj për shëndetin e tokës?

- Unë nuk kam njohuri (1)
- Fillestar (2)
- I ndërmjetëm (3)
- I përparuar (4)

Si do ta vlerësonit rëndësinë e shëndetit të tokës në kopshtari?

E pa rendesishme Shume e rendesishme

0 1 2 3 4 5 6 7 8 9 10

Cilat tema do të ishin të dobishme për t'u mbuluar në një program të edukimit të tokës? (Zgjidh të gjitha ato që vlejnë)

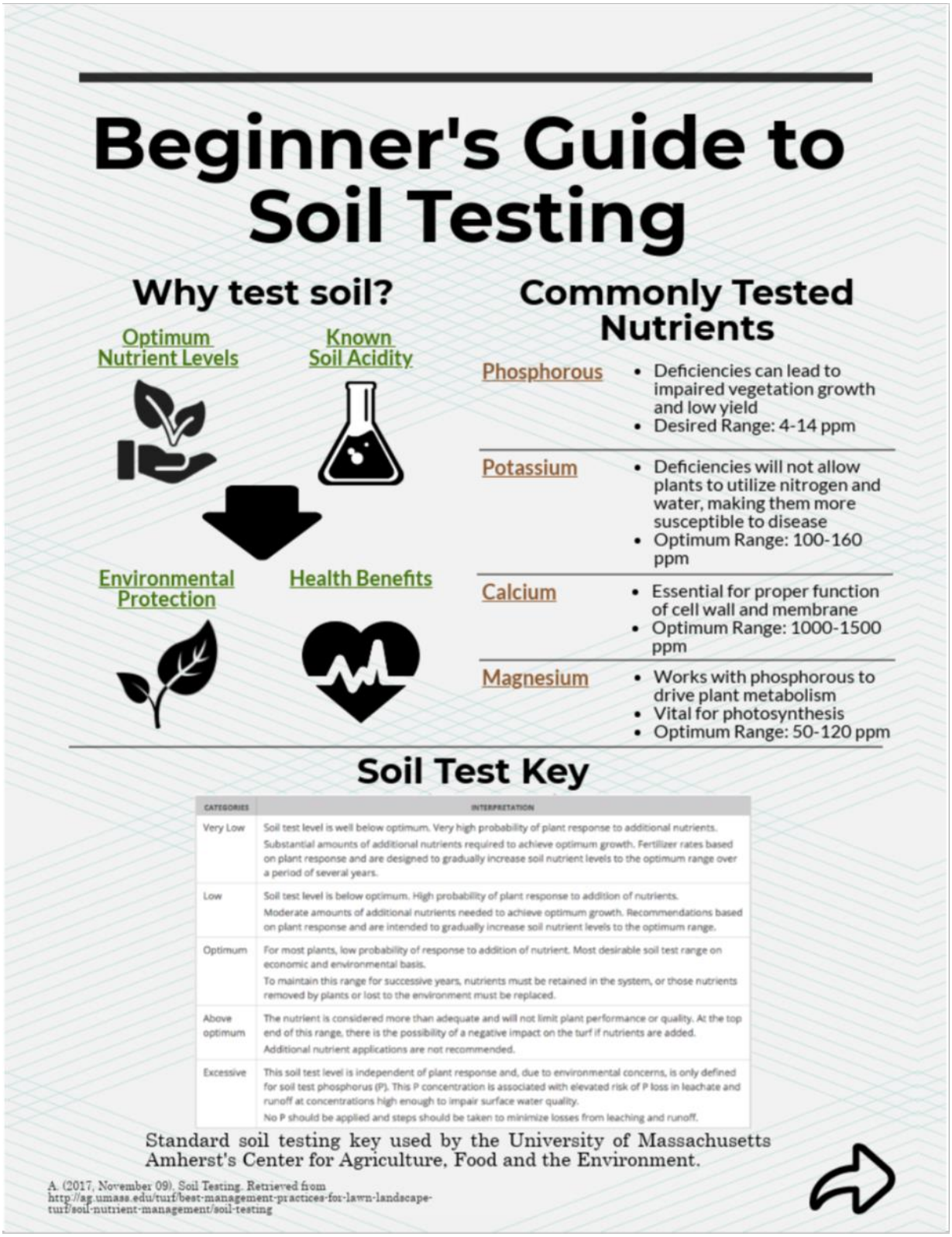
- Nivelet e pH (1)
- Pleh (2)

- ▯ Mbulimi i të lashtave (Çiklizmi i kulturave) (3)
- ▯ Ushqysit (azot, fosfor, kalium) (4)
- ▯ Rëndësia e baktereve dhe mikrobeve (5)
- ▯ Kopshtari e qëndrueshme (6)
- ▯ Si të lexoni rezultatet e provës së tokës (7)
- ▯ Tjetër (8) _____

Si keni dëgjuar për këtë studim?

_____

Appendix F: Beginner's Guide to Soil Testing

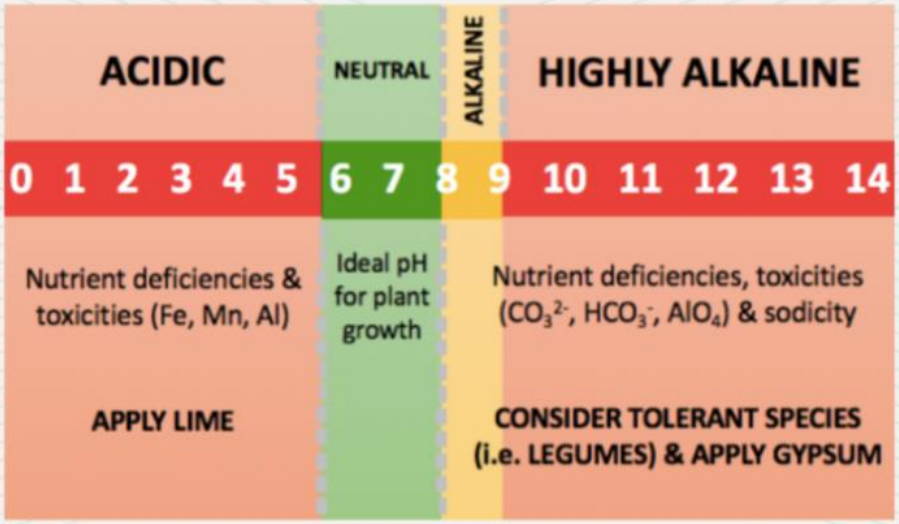


CATEGORIES	INTERPRETATION
Very Low	Soil test level is well below optimum. Very high probability of plant response to additional nutrients. Substantial amounts of additional nutrients required to achieve optimum growth. Fertilizer rates based on plant response and are designed to gradually increase soil nutrient levels to the optimum range over a period of several years.
Low	Soil test level is below optimum. High probability of plant response to addition of nutrients. Moderate amounts of additional nutrients needed to achieve optimum growth. Recommendations based on plant response and are intended to gradually increase soil nutrient levels to the optimum range.
Optimum	For most plants, low probability of response to addition of nutrient. Most desirable soil test range on economic and environmental basis. To maintain this range for successive years, nutrients must be retained in the system, or those nutrients removed by plants or lost to the environment must be replaced.
Above optimum	The nutrient is considered more than adequate and will not limit plant performance or quality. At the top end of this range, there is the possibility of a negative impact on the turf if nutrients are added. Additional nutrient applications are not recommended.
Excessive	This soil test level is independent of plant response and, due to environmental concerns, is only defined for soil test phosphorus (P). This P concentration is associated with elevated risk of P loss in leachate and runoff at concentrations high enough to impair surface water quality. No P should be applied and steps should be taken to minimize losses from leaching and runoff.

Standard soil testing key used by the University of Massachusetts Amherst's Center for Agriculture, Food and the Environment.

A. (2017, November 09). Soil Testing. Retrieved from http://ag.umass.edu/turf/best-management-practices-for-lawn-landscape-turf/soil-nutrient-management/soil-testing

Soil pH Scale

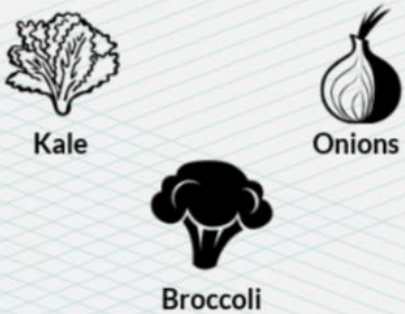


Crops that Grow in Acidic Soil

pH of 4.5 - 5.5

Crops that Grow in Alkaline Soil

pH of 8.0+



Crops that Grow in Neutral Soil

pH of 5.5 - 8.0

Albert, S., D., L., Macejak, T., & C. (2013, December 02). Vegetable Crop Soil pH Tolerances. Retrieved from https://www.harvesttotable.com/vegetable-crop-soil-ph-tolerances/
U. (2014). Interpreting Your Soil Test Results. Retrieved from http://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/spttl_2_interpreting_your_soil_test_results_0.pdf

REGIONAL ENVIRONMENTAL COUNCIL

Appendix G: The Roots of Soil Health Pamphlet

What is Soil?

Soil is the base of all growing. In addition to sustaining plant and animal life, soil filters out pollutants, cycles nutrients, and regulates water. In this pamphlet, we will teach you various techniques to keeping your soil healthy and thriving throughout the year.

Key Words

Erosion: The process of wearing down due to wind, water, or other natural occurrences.
Liming: Treating soil with calcium and magnesium rich materials such as lime or chalk to reduce acidity.
Microbes: microscopic organisms, such as bacteria and fungi, that feed off organic matter and release nutrients into the soil.
Nutrient Cycle: The movement and exchange of organic and inorganic matter back into the production of living matter.
USDA: United States Department of Agriculture.

Why Soil Health is Important

Protecting your soil has many short and long term benefits that make your life easier.

Healthy soil is more porous than unhealthy soil, meaning it requires less watering.

You won't need to weed as much, as weeds cannot grow as well in healthy soil.

Healthy soil produces higher crop yields, without the need for harmful chemical fertilizers.

Keeping your soil healthy is a great way to be sustainable. You won't need to depend on excess resources, and you'll produce more organic foods for your friends and family.

For more soil health information:

USDA's Guide to Community Gardening
http://bit.ly/2pKdJgS

Digging Deeper into Soil Care
http://bit.ly/2Aun5Fz

The Roots of Soil Care

Brought to you by
The Gutsy Gardeners, in partnership with:

REGIONAL ENVIRONMENTAL COUNCIL

WCG
WORCESTER COMMON GROUND
wcgcdc.org
a Community Development Corporation

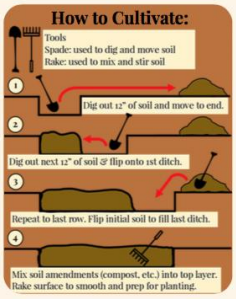
Just Getting Started?

Cultivation: Preparing land for gardening.

Why: Cultivating allows for easier absorption and aeration, helping seeds sprout.

When: Cultivate before planting or when soil surface is visibly crusty. Do not cultivate soil when wet. It compacts the soil, limiting plant growth.

How to Cultivate:



How's Your Soil Doing?

Soil Testing

Why: Results give recommendations on fertilizers and liming.

When: During harvest every 2-3 years for nutrient info on your soil.

See soil test flyer for more info.

What is pH?
Measure of acidity/alkalinity of soil.

Most plants grow at the ideal pH of 6-7.5. However, some plants prefer slightly acidic or slightly alkaline soil.

What's in Your Soil?

Microbes play an important role maintaining soil health. They increase soil fertility and water retention, decrease soil erosion, and help protect plants from disease. Here's how to increase microbial activity in your garden:

Use Compost | Plant Cover Crops | Rotate Crops

N Nitrogen promotes healthy foliage and benefits leafy plants.

P Phosphorus aids in healthy root growth, flowering & fruiting.

K Potassium betters plant development, growth & disease resistance.

Did Somebody Say Soil Protection?

Cover Cropping: Growing different types of plants in the off-season of growing.
What to Grow: Rye Grass, Hairy Vetch, Buckwheat, Radish.

Compost: Recycled material that adds organic matter to soil. Can be applied either two weeks before planting season or after the final harvest.

Benefits of Cover Cropping and Composting

Appendix H: Digging Deeper into Soil Care Packet

Digging Deeper into Soil Care

How to be a gutsy gardener

Keywords

Cultivation: The process of preparing soil for the raising of crops

Erosion: The process of wearing down due to wind, water, or other natural occurrences.

Horticulture: The science of growing fruits, vegetables, flowers, or any other plant.

Liming: Treating soil with calcium and magnesium rich materials such as lime or chalk to reduce acidity.

Microbes: microscopic organisms, such as bacteria and fungi, that feed off organic matter and release nutrients into the soil.

Nutrient Cycle: The movement and exchange of organic and inorganic matter back into the production of living matter.

Sustainability: Creating and maintaining conditions under which humans and nature can exist in productive harmony to support present and future generations.

Importance of healthy soil

Soil quality is directly linked to the quality of crops harvested. Preliminary steps are taken to ensure the quality of the soil prior to the implementation of a community garden. Soil is a critical component to the community garden, as all plants depend on soil to grow. Soil quality is a major link between the agricultural conservation management practices and achieving major sustainability goals. This means that successful sustainability practices result in higher soil quality.

Just getting started?

Fundamentals of Cultivation

The word "cultivation" refers to the process of preparing soil for raising crops, with the goal of attaining optimum fertility. In simpler terms, to cultivate is to break up soil layers.

Cultivating can have both short term and long term benefits, depending on how regularly you do it. In the short term, when you cultivate, you allow for deeper plant root penetration, which leads to improved growth. After all, plant roots don't grow *in* the soil - they grow *in the spaces between* soil clumps. By cultivating, you also increase pore spaces in the soil, allowing the soil to "breathe" and exchange important gases like nitrogen, carbon dioxide, and oxygen (see "What's in your soil?" for more info). With deeper soil aeration, your plants expend less energy growing, leading to faster growth and maturation. In addition, cultivation helps knock back annual weeds, reducing the amount of time you spend weeding your garden. (It's worth noting that stirring soil can stimulate the germination of weed seeds in the soil bank, so they do come back later. Cultivation just keeps you a step ahead of this cycle.)

In the long term, annual cultivation can lead to long term prosperity in your garden. The process of cultivation becomes easier the more often you do it. If you cultivate your garden bed before the start of each season, you can establish a long term structure that will benefit plant growth every year.

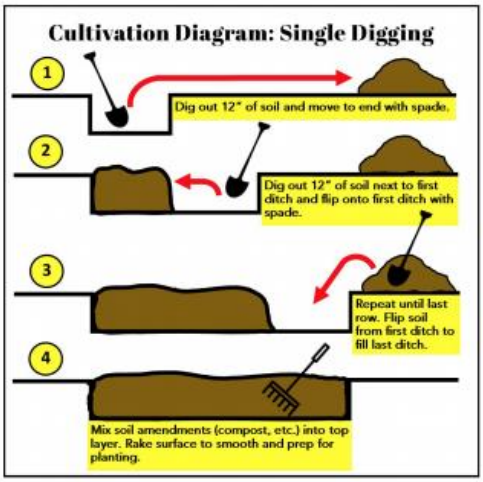
How to cultivate

There are a few different methods you can use to best cultivate your garden bed, depending on your soil and what you're planting. The main tools for cultivation are a D-handle spade, a pitch fork, and a metal bow rake. Described below are the most common methods.

Single Digging

Single digging is the process of turning over the soil in your garden bed to the depth of a single spade blade. The first step of this process is to use your spade to dig out a row of soil 12 inches deep and move it to the end of the garden bed. Next, dig out another row of soil 12 inches deep next to the first row. Transfer the soil from the second row to the first row. Repeat the

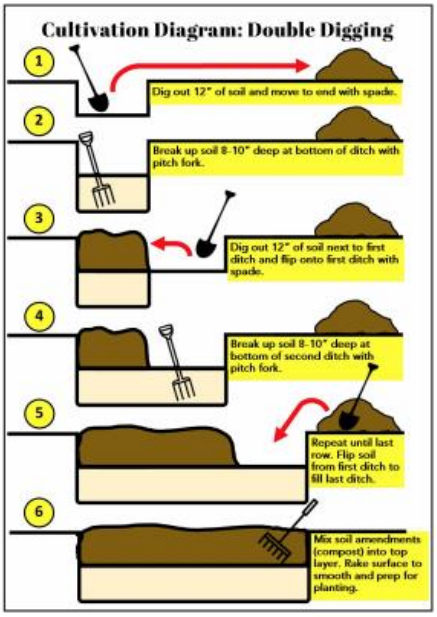
process of digging and transferring soil until you reach the end of your bed. Once you reach the end, transfer the original row of soil onto the last row. Finally, mix any soil amendments, like compost or mulch, into the top layer of the soil. Smooth out the surface with your rake, and you're ready to start planting! (See diagram for visual).



While initially time consuming, single digging a garden bed helps your plants immensely, especially if they have more shallow roots. The more often you single dig your garden bed, (for example, once a year) the easier the process becomes the next year.

Double Digging

Double digging is the process of turning over the soil in your garden bed two layers deep, as opposed to one. This cultivation method is used primarily when establishing a new garden, or when growing plants that need deep topsoil.



The first step of this process is to use your spade to dig out a row of soil 12 inches deep and move it to the end of the garden bed, similar to single digging. Next, use your pitch fork to break up the soil at the bottom of the ditch, about 8-10 inches deep. Following this, dig out another row of soil 12 inches deep next to the first row and transfer the soil from the second row to the first row. Repeat the process of digging, breaking up,

and transferring soil until you reach the end of your bed. Once you reach the end, transfer the original row of soil onto the last row. Finally, mix any soil amendments, like compost or mulch, into the top layer of the soil. Smooth out the surface with your rake, and you're ready to start planting! (See diagram for visual)

Tilling

Tilling is a controversial topic, as it does superficially improve gardening practices in the short term. When you till, you will notice that your seeds will germinate easily, but the amount of weeds, pests, and rocks will keep increasing. This is because tilling destroys soil structure, creating hard pans that will have to be fractured the next year. The process of tilling removes rocks and established roots from the area which makes it so that soil erodes easily. As a result, every planting season will turn up more and more rocks, and the topsoil will perpetually thin. For some purposes, such as large-scale farming, the benefits of tilling outweigh the disadvantages as tilling is easy, fast, and effective in the short term at covering large areas. However, on a horticultural scale, tilling is more expensive and damaging than its alternatives.

What's in your soil?

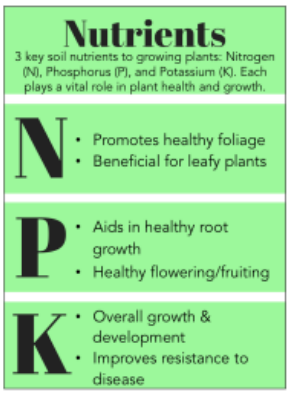
Microorganisms

Soil is is made up of four main components. It is 45% minerals, 25% water, 25% air, and 5% organic matter. Organic matter in soil is vital to maintain healthy soil because it serves as food for microorganisms. Microorganisms can be classified as bacteria, fungi, algae, and protozoa, and they are the key contributors to the decomposition of organic matter. Over time, microorganisms break down organic matter into an inorganic form and release excess nutrients into the soil where they are easily accessible to plants, which increases soil fertility. In addition, microorganisms have a wide range of benefits including: improved soil structure, less toxic soil, protected crops from pests and diseases, soil erosion reduction, and increased water retention.

The more organic matter soil has, the more microorganisms there are. A few ways to increase organic matter content of soil are to use compost, to plant cover crops, and to rotate crops. These methods are discussed in further detail later on. There are also a number of practices that decrease the organic matter content of soil. Typically, these practices are caused by human activity. Repetitive tilling of soil disrupts the natural biota that resides in the soil by unearthing and burying microorganisms. Over fertilization also decreases organic matter in soil as it can kill and burn the vegetation. In addition, if the soil is stepped on too often, the compaction can kill the microorganisms living in the soil.

Nutrients

The main nutrients that are present in soil and aid plant growth are nitrogen, phosphorus, and potassium, which are explained in the graphic to the right:



Soil testing

Why

There are five main reasons why soil testing is important. The first is to know the nutrient levels of soil. This is necessary because of the 17 essential nutrients needed you grow, 15 of them come from soil. When you receive the results on nutrient levels you will also get fertilizer recommendations based on those results. The second reason is to know the acidity of your soil. Similar to nutrient levels, knowing the pH of your soil will give you an idea of the lime requirements. The third reason is soil tests also identify areas with excess nutrients that can cause pollution. These areas with excess nutrients can be harmful to the environment, and identifying them is the first step to correcting them. The fourth reason to test your soil is to ensure you are only buying the necessary amendments. The only way to know whether your soil truely needs fertilizer or liming is by examining the test results. By knowing what amendments are truly needed you can avoid unnecessary spending. Finally, soil tests can also have positive health impacts by identifying if there are elevated levels of lead or other toxins.

When

The optimal time to test soil is directly in the fall during harvest after crops are removed. It is important to sample at the same time each year so results can be compared with one another. Having a consistent sampling time ensures that the results will not vary for another reason other than a change in soil quality. For very sandy soils, tests should be taken every 1-2 years. For crops grown in all other soils, tests can be taken every 2-3 years.

Understanding Results

A few commonly tested nutrients in soil tests are phosphorus, potassium, calcium and magnesium. Each of these nutrients has a specific function within soil. Below is a standard soil testing key used by the University of Massachusetts Amherst's Center for Agriculture, Food and the Environment and its interpretation.

	VERY LOW	LOW	OPTIMUM	ABOVE OPTIMUM	EXCESSIVE
P, ppm[a]	0 - 1.9	2 - 3.9	4 - 14	14 - 40	>40
K, ppm	0 - 49	50 - 99	100 - 160	>160	-
Ca, ppm	0 - 499	500 - 999	1000 - 1500	>1500	-
Mg, ppm	0 - 24	25 - 49	50 - 120	>120	-
a. ppm = parts per million					

Sample soil testing key

CATEGORIES	INTERPRETATION
Very Low	Soil test level is well below optimum. Very high probability of plant response to additional nutrients. Substantial amounts of additional nutrients required to achieve optimum growth. Fertilizer rates based on plant response and are designed to gradually increase soil nutrient levels to the optimum range over a period of several years.
Low	Soil test level is below optimum. High probability of plant response to addition of nutrients. Moderate amounts of additional nutrients needed to achieve optimum growth. Recommendations based on plant response and are intended to gradually increase soil nutrient levels to the optimum range.
Optimum	For most plants, low probability of response to addition of nutrient. Most desirable soil test range on economic and environmental basis. To maintain this range for successive years, nutrients must be retained in the system, or those nutrients removed by plants or lost to the environment must be replaced.
Above optimum	The nutrient is considered more than adequate and will not limit plant performance or quality. At the top end of this range, there is the possibility of a negative impact on the turf if nutrients are added. Additional nutrient applications are not recommended.
Excessive	This soil test level is independent of plant response and, due to environmental concerns, is only defined for soil test phosphorus (P). This P concentration is associated with elevated risk of P loss in leachate and runoff at concentrations high enough to impair surface water quality. No P should be applied and steps should be taken to minimize losses from leaching and runoff.

Soil testing key interpretation

A soil's pH is a measure of how acidic or alkaline the soil is. This is important because certain nutrients are less available when the pH is too low or high. If you find that your soil is within the pH range of 4.5 to 5.5 (acidic), you should try planting blueberries, potatoes and peanuts. Similarly, if your pH is above 8.0 (highly alkaline) you can try kale, onions and broccoli. In neutral soils with a pH between 5.5 and 8.0 peppers, garlic and tomatoes will grow well.

Cover cropping and composting

Cover Crops

Cover cropping is growing different types of plants to suppress weeds, control diseases and pests, and help build and improve soil fertility and quality. Cover crops are planted when you are not growing any crops, used to prevent soil erosion and keep soil healthy year-round. Cover crops add nitrogen and other nutrients such as potassium and phosphorus to the soil, while reducing water runoff, which keeps these essential nutrients in the soil. Different types of crops can be planted with different intentions:

- Nutrient Scavengers: Annual ryegrass, Radish, Winter cereal rye, Oats
- Nitrogen Producers: Crimson clover, Hairy vetch, Austrian winter pea, legumes

When ready to grow crops again, the cover crops can be cut down and used as compost to add additional nutrients to the soil prior to growing.

In the long term, cover cropping has numerous benefits to the plot of land. Cover cropping increases the productivity of soil, which makes it much easier to grow food. Additionally, the number of pests in the soil is decreased, as cover crops provide food and habitats for the beneficial predators of the soil during the off-season. Water filtration is increased as a result of long term cover cropping. The increase of water filtration decreases the amount of runoff from watering or other natural occurrences. This prevents nutrients from being washed out of the soil, keeping a strong soil biodiversity.

Compost

Compost adds organic matter to soil when it is slowly broken down by microorganisms. This improves soil's physical, biological, and chemical composition by providing benefits to gardens including:

- protection against soil erosion
- increased soil fertility
- increased microbial activity
- improved water and nutrient retention

There are couple times of the year that compost can be applied to gardens, and these methods are described in the graphic below:

SPRING

Compost can be applied to garden beds 2 weeks before the planting time in the spring.

SUMMER

If there is a limited amount of compost, compost can be applied sparingly using the side-dress method. This is typically done in late spring to early summer.

FALL

Compost can be applied to garden beds in late fall. If this method is used, after compost is spread it should be covered with a winter mulch, such as chopped leaves, to protect the compost.

WINTER

If compost is applied in the fall, the winter months allow time for soil organisms to work compost into the soil. There is no wrong time to apply compost. Both times provide the soil with the same benefits.

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