Food Self-Sufficiency in the La Plata Region

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Food Self-Sufficiency in the La Plata Region

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Abstract

Our team worked under the Departamento de Recursos Naturales y Ambientales to develop an education program. We created the education program to promote food self-sufficiency in the La Plata region of Puerto Rico. We interviewed local residents and experts to learn about gardening techniques and conducted a growing example to problem-solve gardening in Puerto Rico. The results of the interviews and growing example shaped our education program, which focused on maintenance, debris disposal, fertilization, pest control, and eco-friendly gardening.

Acknowledgments

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Executive Summary

Due to the Jones Act and the island's relatively small size, Puerto Rico imports the vast majority of their food and is extremely reliant on the global agri-food supply chain. The agri-food supply chain is the movement of food from farm to table. This reliance is incredibly dangerous as a single event can cause a break in the supply chain, which can have catastrophic effects. Hurricanes Irma and Maria devastated the small island, cutting them off from their food imports and leaving debris that is still present two years later.

El Refugio de Vida Silvestre del Embalse La Plata (Wildlife Refuge of La Plata) is a wildlife refuge within Lago de La Plata that still struggles with damage from the hurricanes. The refuge is a popular fishing and recreation site for people from many different cities and towns in Puerto Rico. The refuge also hosts several different classes to teach children about fishing and agriculture. The Departamento de Recursos Naturales y Ambientales (DRNA), a government organization, is in charge of protecting the natural resources of Puerto Rico as well as La Plata.

The areas immediately surrounding La Plata were unable to receive food due to the damage caused by the storms. La Plata and the DRNA want to help the community, and by extension, the rest of the island, to become more food self-sufficient, but currently have no method to do so. One method of improving food self-sufficiency involves educating community members about home gardening. An effective education program should cover topics such as the benefits of gardening, implementation of beds, good practices, effective fertilization, and general upkeep of gardens. These topics provide community member with the knowledge to create a garden or provide beneficial practices to existing gardeners.

We completed a series of objectives to achieve our main goal of improving food self-sufficiency for the community surrounding the La Plata Wildlife Refuge by providing educational materials about home gardening, debris disposal, and solutions to local problems. Our first objective determined the extent of home gardening in the community, the challenges, and successes involved with home gardening; along with the locals' preferred method of learning. Additionally, we needed to understand the strategies of debris removal to help the local communities improve their lives after a severe storm. To complete the objective, we interviewed 21 visitors at La Plata. The interviews consisted of a variety of baseline questions to obtain knowledge of local home gardening. Following the completion of our interviews, we digitized them into an Excel spreadsheet for analysis to identify gaps in local knowledge, effective gardening techniques, and preferred method of learning to aid in our education program. Additionally, we interviewed a variety of local experts, farmers, and agronomists in order to obtain information on useful gardening techniques.

Objective two was to determine materials commonly found in local areas that can be used for home gardening. Through the same interviews mentioned in objective one, we gained information on the availability of gardening resources for community members particularly relating to materials available for compost. Part of achieving this objective included discovering what locals had done with their remaining debris from Hurricanes Irma and Maria.

In order to improve food self-sufficiency in the community surrounding the La Plata Wildlife refuge, we used two growing examples to show the importance of soil health and low cost fertilization for the success of gardening. In conducting our growing examples, we hoped to also understand agricultural problems, while at the same time, implementing new potential solutions. Piles of leftover debris in La Plata provided nutrient runoff for the growing example. We planted 60 trees of three species (*Guarea Guidonia, Citharexylum Spinosum, and Cananga Odorata)* in two plots. One plot was with Hügelkultur runoff and the other with compost. For the

second growing experiment we planted 48 Red Oak Lettuce plants and 126 Roma tomato plants in eight garden beds split between two different plots. One plot was designed to not receive any potential Hügelkultur runoff while the other was sloped with the land to receive runoff. Each week we took data on leaves, buds, and sprouts for our trees; height, number of leaves, and yellow leaves for our tomatoes; and number of leaves for our lettuce. Overall health and qualitative observations for all plants were recorded. The data was used to observe how different types of nutrients affect plant growth.

By carrying out our growing examples, we experienced the development of a home garden in Puerto Rico first-hand. Our gardening experience including many aspects of planning, building, planting, and maintaining a garden. Also, it allowed us to test many of the gardening methods that locals and experts recommended during our interviews. The growing example also tested the effectiveness of compost and runoff from debris piles as mediums of plant and garden fertilization. From the growing example data, we concluded that piling debris and allowing nutrients to runoff into gardens is an effective method of debris disposal with an additional benefit of adding some nutrients to the garden. We also determined that because of the poor quality of local soil, compost should be added to home gardens for extra nutrients and healthier plants.

Interviews with visitors of La Plata touched on topics like fertilization, pests, disease, everyday gardening techniques, and preferred method of education. These topics were also discussed in interviews with experts. We found that home gardens were common. Fertilization was used often, but methods varied with mixed results. Additionally, iguanas, rats, disease, and a wide variety of insects posed a threat to home gardens. Through interviews and first-hand experience, we determined that hunting, dogs, traps, naturally grown repellants, and neem oil are effective ways of deterring these pests. Finally, interviewees requested a combination of a hands-on lecture and brochure. The class aspect included a small PowerPoint for visual representation, while the hands-on activity consisted of simple growing activities. The brochure contained gardening techniques along with benefits and other small concepts of gardening. Additionally, we concluded from our interviews that pest control, composting, and eco-friendly practices needed to be emphasized in our education program in order to improve home gardening and food self-sufficiency within the community surrounding the La Plata Wildlife Refuge. We also added information on basic gardening practices and techniques aimed for beginners, such as bed creation, planting, and maintenance, but did not need a greater emphasis within the program due to most interviewees having this basic knowledge.

By spreading this information in Puerto Rico, we hope to make the locals in the La Plata area less reliant on the agri-food supply chain. We believe that by following our objectives and implementing a similar system around the world, people can become more food self-sufficient. The issue of food self-sufficiency is bigger than just Puerto Rico. It extends to all communities. With the implementation of our project on a grander scale, we feel that communities around the world will benefit from more food self-sufficiency.

Recommendations

Based on our time in Puerto Rico and the gathered data, we have constructed several recommendations concerning pests, growing techniques, and debris removal. We hope these recommendations will aid in our ultimate goal of improving food self-sufficiency.

We recommend that locals attempt to use true Hügelkultur. This method of composting allows gardeners to dispose of any remaining debris as well as provide additional nutrients to a garden. True Hügelkultur works best with smaller debris and cannot be properly created with large debris.

We recommend that gardeners with large pieces of debris use La Plata's piling method of Hügelkultur. If gardeners wish to use the piling method, they should use the natural slope of the land to use nutrient runoff. This may provide gardeners additional nutrients if plants are placed downhill from the large piles of debris. La Plata's method of piling hurricane debris is efficient and common in the area.

We recommend that any gardener utilizes traditional compost to help their gardens. The addition of compost will increase the carbon and nitrogen within the soil, therefore helping any plants that are placed in the soil.

We recommend that gardeners living in areas with iguanas hang cans or CDs around their garden bed. This method is a cheap, moderately successful, and non-lethal way of deterring the iguanas.

We recommend that gardeners dealing with iguanas, but do not wish to harm the reptile, use chicken wire to surround and protect their beds. This method was incredibly successful during our four weeks maintaining a garden because there were no more attacks after installing the wire.

We recommend that gardeners that continue to struggle with iguanas take more drastic measures such as either hunt them or use a dog to protect their land. This method not only keeps the garden safe but can lower the total population of iguanas in Puerto Rico. If gardeners decided to kill the iguanas, we recommend that they eat them for a source of healthy, lean meat.

We recommend that gardeners struggling with insects use natural pesticides like neem oil and BT or plant natural repellants like oregano, lemongrass, parsley, citronella, and the neem plant. All of these work towards repelling the pests, but are not guaranteed to kill the insects or entirely repel them.

We recommend that locals reuse materials to build elevated gardens. Following the passing of a hurricane, extensive amounts of debris are present in the affected areas. We noticed empty refrigerators and old tires left on the side of the road. These can easily be repurposed to both remove the debris and provide resources to local families. Elevated beds create a barrier from weeds and pests as well as providing good drainage.

Authorship

Brian Liwo, Brandon Malarney, Jordan Pickunka, and William Roe all contributed in the research, writing, and editing of our final report. The following is a breakdown of the writing contributions of the group.

Brian Liwo contributed to the report by being the principal writer of the methodology and acknowledgments, along with significant portions of the background, results, and conclusions and recommendations. Additionally, Mr. Liwo translated the information given by Jacqueline Seijo into English and our own brochure into Spanish; as well as, organized the tree data.

Brandon Malarney contributed to this paper by drafting the objectives portion of the executive summary along with part of the introduction and part of the background. Additionally, Mr. Malarney contributed to the methods, along with recommendations for Hügelkultur/traditional compost. Lastly, Mr. Malarney was in charge of organizing lettuce data and creating a visual representation for lettuce results.

Jordan Pickunka contributed to significant portions of the background, methods, results, and conclusions. Additionally, Mr. Pickunka was the principal compiler of the La Plata interview data and creator of the recommend PowerPoint and brochure.

William Roe was responsible for notable sections of the background, methodology, results, and conclusions and recommendations. Additionally, Mr. Roe analyzed and created graphs using the tomato data. Finally, Mr. Roe constructed the abstract along with developing the hands-on activities included in the education program.

In addition to writing individual sections of this report, Brian Liwo, Brandon Malarney, Jordan Pickunka, and William Roe all contributed to editing the paper for grammar, content, and overall flow.

Nomenclature

WPI-	Worcester Polytechnic Institute
IGSD-	Interdisciplinary and Global Studies Department (WPI)
SBFSA-	Southern Baja Food Security Alliance
WFP-	World Food Programme
FEMA-	Federal Emergency Management Agency
FAO-	Food and Agriculture Organization
IFAD-	International Fund for Agricultural Development
UNICEF-	United Nations Children's Fund
WHO-	World Health Organization
WWF-	World Wildlife Foundation
NGO-	Non-Governmental Organization
BBC-	British Broadcasting Corporation
ICRC-	International Committee of the Red Cross
DNA-	Deoxynucleic Acid
USGS-	United States Geological Survey
AE-	Adverse Events
USDA-	United States Department of Agriculture
PRDA-	Puerto Rico Department of Agriculture
BT-	*Bacillus Thuringiensis*

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1: Introduction

Severe storms disrupt everyday life due to the catastrophic damage they cause. After storms hit, citizens may lose power, access to food can be limited, large quantities of debris are often left behind, homes can be destroyed, and there may be loss of life. The Caribbean experiences an average of just over six hurricanes each year (Landsea, 2015). The debris left over by these and other severe storms, such as hail, monsoons, typhoons, wildfires, and blizzards, cause lingering problems for people long after they end. These storms can destroy modern infrastructure, cripple power grids, and halt shipping routes. Severe storms can often lead to the break in the agri-food supply chain, which is worsened by the centralization of food due to supermarketization.

Severe storms can cause extensive damage, which may lead to the inability to transport, produce, or properly store food without spoiling. In the past few decades, there has been an extreme shift in the food retail sector throughout the world. Supermarketization, or the shift towards the modern supermarket format to replace traditional marketplaces, has continued to dominate the market, allowing a wide variety of goods to be sold in a centralized location (Rush, 2012). This shift puts stress on globalized food chains and leaves consumers dependent on the success of the 1,500-mile journey from farm to table (FAO, IFAD, UNICEF, WFP & WHO, 2018). When breaks in transportation occur, such as following a severe storm, the agri-food supply chain fails and food shortages can occur (Wang, 2014).

When the food supply chain is disrupted, it is paramount that people receive aid from relief organizations such as the World Food Programme (WFP), International Committee of the Red Cross (ICRC), and Federal Emergency Management Agency (FEMA) (Shah, 2007). Relief often comes in the form of emergency or program food aid, which involves the distribution of free food rations ("Food Aid," 2003). These relief efforts are beneficial at alleviating hunger and food shortages, but do have shortcomings. In 2017, the United States and its territories experienced three major hurricanes within two months of each other causing over $265 billion in damage (Atkin, 2018). FEMA's resources were almost entirely drained and its entire fiscal year budget could not deal with the combined estimated damage of the storms. This caused shortages and delays in relief, including food aid, especially after the third and final hurricane hit Puerto Rico (Einbinder, 2018). Transporting food supplies into a devastated area is an effective method of supporting a community's need for food, but does not help achieve long-term food self-sufficiency. Home gardens may be an effective way to promote food self-sufficiency in the face of severe storms, as well as potentially working to halt the impending food shortage as a result of a temporarily broken food supply chain. For example, in the wake of several large earthquakes in Mexico, the Southern Baja Food Security Alliance (SBFSA) has promoted and taught about home gardening in order to combat the resulting food insecurity ("Fresh Food for All: The Southern Baja Food Security Alliance," 2018). However, some gardeners lack the knowledge and experience to develop climate-specific home gardens and utilize natural resources, especially debris to improve the quality of the garden.

In 2017, Hurricanes Irma and Maria devastated the island of Puerto Rico, creating food shortages throughout the island (Huber, Klinger, O'Hara, 2018). Puerto Rico imports 85% of its food with 15% grown locally. Additionally, the Jones Act requires all Puerto Rican imports to come from U.S. ports (Kenton, 2019). This is dangerous because foreign aid cannot directly unload resources to Puerto Rico. The hurricanes cutoff food imports and destroyed 80% of Puerto Rico's already small crop production (Tank, 2018). Home gardens are not likely to survive should a hurricane make landfall; however, having an established garden is easier than

starting from scratch. After Hurricanes Irma and Maria hit, the area surrounding La Plata Wildlife Refuge was cut off from their food due to debris-covered roads (Personal Communication, 2019). This region is still dealing with the leftover debris, two years later. While every home garden has its plants tailored to that residence, there are several ways that all types of gardens can be improved. Hügelkultur, a type of composting, is a way to clean up debris after severe storms. Also, composting decomposes leftover organic debris to provide nutrients to the soil that can be used for fertilizer. This makes the community more food self-sufficient in years to come, reducing the impact of supermarketization in the case of a supply chain break.

The ultimate goal of our project is to improve food self-sufficiency for the community surrounding the La Plata Wildlife Refuge by providing educational materials about home gardening and solutions to local problems. To understand the problems that locals dealt with, we created a growing example in which we attempted to maintain a garden. By dealing with local issues, we were able to test solutions and gather experience. To create an education program for the community on techniques for improving home gardening, we interviewed local residents to gather information on what is being done with home gardens in the area as well as to determine the locals' preferred method of education. By compiling the information from both the interviews and growing example, we noticed gaps in the resident's general knowledge. We shaped our education program to address these gaps and expand on people's understanding of well-known topics. Understanding the best method of education ensures that our information will be accepted, understood, and utilized by the locals.

2: Background

The global food supply is a complex network that provides sustenance for the whole world (Stone & Rahimifard, 2016). If the supply chain were to break, many people would be left without access to food, which can lead to further problems such as starvation and malnutrition. Severe storms often cause supply chain breaks and create extensive amounts of debris. Home gardening is one strategy to support those who have been cut off from the supply chain by providing the family with a source of food. In addition, there are methods of home gardening that decompose and utilize debris and organic waste to supply the soil with nutrients. By providing a concise collection of basic information on gardening and recommending certain techniques to the community, we hope to promote food self-sufficiency so that in the event of another chain break like the hurricanes of 2017, the people of La Plata will be able to survive until order is reestablished.

2.1: Agri-Food Supply Chain Breaks Down

The agri-food supply chain is the movement of food from production to consumption (Wang, 2014). The chain transforms raw materials to finished products through the assistance of multiple parties. The complex chain must navigate harsh deadlines and ensure cooperation between the aforementioned parties for continued success (Wajszczuk, 2016). As the world continues to become more interconnected, the inner workings of the agri-food supply system become more complex. The increase in variables leads to a more vulnerable supply chain (Stone & Rahimifard, 2016).

2.1.1: Causes of Breaks

For the purposes of this report, we have split the causes of supply chain breaks into three tiers of threat. The lowest threat tier includes transportation logistics. The complexity of transportation logistics alone is enough to cause the agri-food supply chain to stall temporarily. This first tier may result in a certain product not arriving at its destination on time, but will only cause short term lack of access of a certain food product. The second tier includes events such as droughts, disease, pests, and nutrient deficiencies that stress the global food chain in various parts of the world. A second tier break causes supermarkets to be devoid of a particular food but does not cause a total lack of food because imports come from many areas of the world. But the break still requires direct attention to fix. Events causing significant breaks such as economic shock, war, and natural disasters fall into tier three threats. These breaks in the supply chain can last months or even years and effect a widespread variety of food products. Tier three threats require outside aid from relief organizations.

Threat Tier 1

Transportation issues fall into tier one threats. Throughout the world, there are 14 chokepoints' in the global supply chain (Webb, 2017). Even a single choke point can be responsible for a large proportion of a countries food. Three-quarters of Japan's maize and wheat imports pass through the Panama Canal 8,451 miles away (Webb, 2017). With massive distance and continuous flow of huge shipments, it is common for lost and damaged goods as well as delays to occur. This may be an inconvenience for communities who depend heavily upon these chokepoints; however, it is normally a short-term issue that fixes itself once the supply chain returns to normal (Webb, 2017).

Threat Tier 2

Tier two threats cause a lack of access to a specific food product that can be difficult to fix but rarely affect a wide variety of food, typically only affecting the access to a particular food product. These threats are focused around vulnerabilities to the farming system. They include pests, lack of biodiversity in crops, and stressed farmland, caused by a lack of space and quotas that are increasing.

Tier two threats directly affect the farming process, targeting current weaknesses. To better understand why the agri-food supply chain breaks during the second tier, it is crucial to understand the current risks to the farming processes. Some current risks are insects, the lack of pollinators, and reptiles. On average pests are responsible for the destruction of 15% of all crops grown each year (Maxmen, 2012). Devastating pests include desert locust, the western corn rootworm, and the mountain pine beetle. These pests wreak havoc by eating crops, damaging roots, and making produce unable to be harvested. Some pests, like the western corn rootworm are becoming resistant to insecticides, forcing farmers to try experimental chemicals or find another solution (Cock, 2011). Additionally, according to the United States Department of Agriculture (USDA), honey bee populations have drastically suffered over the last 30 years. Many farmers rely heavily on the honey bee to pollinate their crops (Ramaswamy, 2016). In the Caribbean and South America, the green iguana is an invasive species that has become one of the major pests of the area. Without any natural predators, the iguanas are able to reproduce rapidly and without any major control. They devastate small crops and are a major nuisance for farmers (Falcon, Ackerman, Recart, & Dehler, 2013).

Another risk to food production is a lack of biodiversity in crops. With a shift toward industrialized farming, local farmers have begun growing high-yielding varieties of crops. This shift to genetically modified organisms has decreased plant genetic diversity by 75% in the last century. Additionally, 75% of the world's food supply is from only 12 plants and 5 animal species (FAO, 2004). This decrease in genetic diversity is a problem today but is especially worrisome for future generations. Lower genetic diversity leads to vulnerability from droughts, disease, and pests (Kinver, 2014). One well-known example of the dangers of low genetic diversity is the Irish Potato Famine in the 1850s. The Irish potatoes were cloned from a small number brought from South America, leading to little biodiversity. In 1845, a fungal disease ripped through the crops causing a break in the agro-food supply chain ("Consequences of low genetic diversity," n.d.). The lack of biodiversity leaves agri-food supply chains vulnerable to events of drought, disease, pests, nutrient deficiencies, and natural disasters.

Threat Tier 3

Tier three threats cause an overwhelming lack of food for months to years. Supermarketization plays a prominent role in third tier threats due to increased distance from farm to table, which in turn causes low food security. The global trend of supermarketization has shifted crop production away from local communities and towards industrialized farming. Based on United States census information, the amount of farms has dropped from 5.7 million to 1.9 million in 100 years, a decrease of 300%. In the same time, the average size of farms has increased from 146 to 487 acres, an increase of 334% (United States of America, 2018). This trend is found across the world, leaving communities reliant on the globalized food supply chain, rather than purchasing fresh produce at local markets. This increase in distance from farms leads to low food security, leaving communities more vulnerable from tier three threats of economic

shocks, war, and natural disasters than if they accessed local farms or gardens as part of their everyday diet.

During an economic crisis, communities do not have access to farms, gardens, or seeds to grow their own food. An example of an economic shock affecting a place with low food security is the current state of affairs in Venezuela. When the price of oil dropped, Venezuela plunged into its worst economic crisis ever ("Venezuela's worst economic crisis: What went wrong?," 2017). With an inflation rate of over 400%, Venezuela is in chaos. A family of five, who are reliant on the global food chain, needed to collect 1.06 million bolivars to purchase basic goods for one month. That is an increase of 424% when compared to 2016. The state tried to ration food and set their prices, but products disappeared from shops to appear on the black market ("Venezuela's worst economic crisis: What went wrong?," 2017). When Saudi Arabia and Yemen went to war, Saudi Arabia systematically and deliberately destroyed Yemen's means of producing, distributing, processing, and storing food. Their weapons have targeted agricultural land, dairy farms, food processing factories, and food markets (Thornberry, 2018). This lead to the death of 85,000 children due to malnutrition and disease (Thornberry, 2018). Natural disasters also fall into tier three threats for two reasons. First, if a natural disaster were to seriously damage one of the 14 food supply chain chokepoints it could take months to years to return the choke point to its current production (Webb, 2017). Second, natural disasters can damage shipping routes on a more local level. Damaged roads, shipping ports, airports, and train tracks can isolate a community that is reliant on the global food supply chain. Also, severe storms, such as blizzards, cyclones, hail, hurricanes, monsoons, tornadoes, typhoons, and wildfires are violent acts of nature that destroy communities cutting them off from food and leaving debris that can take years to clean. Monsoons and seasonal rains can cause extreme damage due to landslides. High rainfall in the Gansu Province of China caused a landslide that contained five million cubic meters of racing water, dirt, and debris blocking a river and causing even more debris and damage from the extensive flooding (Jun, 2010). Severe storms have a tremendous impact on shipping routes after the event is long gone. Additionally, natural disasters weaken financial and economic resources that leave governments prioritizing areas of relief, leaving poor or isolated communities even more overlooked ("How Recovering from a Natural Disaster Impacts Food Security," 2018).

Agriculture relies on the weather, climate, and water availability. These are easily disturbed by natural events and disasters (Agriculture and Natural Events and Disasters, 2018). Impacts from natural disasters commonly include, contamination of water bodies, increased susceptibility to disease, and destruction of agricultural infrastructure. Natural disasters also affect livestock, when Hurricane Harvey hit Texas, over a quarter of the state's population of cattle were killed (Bloch, 2018). The stress of natural disasters can cause the agri-food supply chain to break.

2.1.2: Response and Effects of Breaks

In response to food supply chain breaks, governments and non-governmental organizations (NGO) work together to supply food and restore order to the affected community. In 2015, a civil war broke out in Yemen between the Houthi rebels and the Hadi government, which caused food insecurity for over 20 million civilians (BBC, 2018). With many citizens starving and food imports at critically low levels, the International Committee of the Red Cross organized relief efforts and provided food assistance to 65,000 citizens (ICRC, 2015). Another relief organization is the WFP. On October 4, 2016, Hurricane Matthew struck the Caribbean

islands of Haiti and Cuba leaving 750,000 people in need of food assistance (Anthem, 2016). The WFP organized food relief efforts that supplied the southwestern town of Les Cayes, Haiti with 100 metric tons of food, 14 tons of rice, pulses, and vegetable oil to Jeremie, Haiti, and 30 tons of high-energy biscuits to both Islands (Anthem, 2016).

However, these responses are not always sufficient such as the economic crisis in Venezuela (Reuters, 2018, Feb 22). In 2017, the country had an extreme food shortage causing citizens to lose an average of 24 pounds in body weight. The combination of poverty and food shortage created a complicated situation for the government and NGOs to solve. As aid slows, the wait times for basic foods like flour take hours (Reuters, 2018, Jan 12). Fed-up Venezuelans created hungry mobs, as large as 1,000 people strong. They ransacked food collection centers and looters plundered state-run supermarket trucks carrying corn. Citizens were hungry enough to pursue cows through fields and beat them (Reuters, 2018, Jan 12). If the food crisis in Venezuela is not solved soon there could be profound lasting impacts. Research has shown that children who are malnourished in their first 1,000 days of life may suffer cognitive and physical impairment (Resilience building, n.d.). While promoting food self-sufficiency will not fix the food crisis in Venezuela, if local communities were food self-sufficient they could have limited the impact of the severe economic and food crisis.

2.2: Home Gardening

Home gardens are small land cultivations on or near households that provide families with direct access to fruits, vegetables, medicinal plants, and herbs (Galhena, Freed & Maredia, 2013). Families with a direct food source increase their food self-sufficiency and sovereignty by reducing dependency on the global food supply chain. Similar food sovereignty practices are seen in Cuba. The Cuban government placed importance on increasing local agriculture by providing citizens with land grants to increase the number and size of small farms. The grants reduced Cuban dependence on food imports by 28%, which saved money and reduced the threat of food supply chain breaks (Reardon & Perez, 2010). The implementation of home gardens within communities can have a similar impact to the land grants in Cuba. Aside from food self-sufficiency, home gardens also provide families with economic, environmental, and health benefits.

2.2.1: Benefits of Home Gardening

Home gardens can improve health conditions through increased nutrition and access to herbal medicines (Galhena, et al., 2013). Populations with food insecurities often consume less food with lower nutritional quality, which often leads to nutritional deficiencies (Marshal, 1998). Vitamin A deficiencies are very common in Africa and China and lead to birth complications for pregnant women and account for 6% to 8% of deaths in children five years old or younger (Galhena et al, 2013). Home gardens help combat nutritional deficiencies by improved access to fruits and vegetables. Also, they provide families with access to medicinal herbs to treat various illnesses and diseases (Galhena et al., 2013). An increase in access to food and medicinal herbs can improve the health of families.

The economic status of families with home gardens tends to improve due to increased income and savings. By consuming homegrown food, families reduce the need for store-bought goods, therefore spending less money on groceries. Additionally, families can save money by cultivating herbal medicines, which can decrease the amount of store-bought drugs (Marshal, 1998). Aside from saving money, home gardens can increase household income by selling

surplus fruits and vegetables. Galhena stated that 60% of Nigerian household income came from the sale of tree crops and livestock. The additional income and the savings from home gardens can pay for education, gardening products and more (Galhena et al., 2013). Therefore, the implementation of home gardens can help increase the economic status of families.

Home gardens are environmentally beneficial due to their biodiversity and ecosystem services. Biodiverse gardens have a large variety of fruits and vegetables, which improves the chance of at least one plant species surviving a disease, drought, or pest infestation that may be wreaking havoc on food staples in the region. Any surviving plants could supply families with food during a supply chain break (Kinver, 2014). Also, home gardens can be environmentally beneficial by providing a habitat and refuge for wildlife, including birds, insects, reptiles, and more (Galhena et al., 2013). The root systems of plants reduce soil erosion and therefore aids in land conservation (Galhena et al., 2013). Home gardens support the environment while improving food self-sufficiency through biodiversity. Enhanced food self-sufficiency helps families overcome a food shortage during an agri-food supply chain break.

2.2.2: Implementation of Home Gardening

To obtain the maximum benefits of a home garden, one must be successfully implemented in a household. *Home Gardening* by Pratibha Trivedi (2014), discusses the operations involved with creating and maintaining a garden. Some important aspects of gardening include location planning, soil preparation, obtaining plant material, planting, watering, feeding, and plant care. When implementing a home garden, its location and size must be determined based on the types of plants or availability of space. Gardens should be large enough to provide plants with adequate growing space. If a family has limited garden space, then multiple plots can be created to meet the needs of the plants.

Once the garden's location is plotted out, the soil must be prepared to support plant growth by supplying adequate nutrients to the plant, retaining moisture, and holding the roots firmly in place (Trivedi, 2014). Soil preparation typically includes digging out hard objects that may block root growth, adding sand and small cement chips to increase subsoil porosity and drainage, and mixing organic or inorganic fertilizer into the topsoil. Fertilizer enrichens soil with various nutrients that are vital for plant growth.

Some common organic fertilizers include manure, compost, wood ash, and charcoal dust, which may be widely available or created at the household for no cost. Aside from nutrient enrichment, organic fertilizers also improve soil porosity and water retention, which are two important qualities for gardening soil (Trivedi, 2014). If organic fertilizers are not available, inorganic fertilizers can be purchased for soil enrichment. An advantage of inorganic fertilizers is that they can be mixed together to match the nutrient requirements of different plants (Trivedi, 2014). These fertilizers are excellent tools for enriching topsoil. Once the soil is prepared, seedlings and saplings can be transplanted into the garden.

If purchasing seedlings and saplings are too expensive, families can germinate their own seeds to save money (Alterman, 2016). Germination is the process of sprouting a seedling from a seed through the absorption of water, passage of time, and exposure to light (Heslop-Harrison, 1999). Germination should take place during the gardening off-season, so seedlings can be transplanted during the growing season (Grist, 2018). The first step is to obtain proper growing containers. Next, place enriched soil into the containers, then push the seeds into the soil and cover them up. The seeds need to be watered and placed in direct sunlight for 15 hours a day to properly grow (Grist, 2018). Growing lights may be used to supply additional light. When the

seeds sprout into seedlings, they should be gradually acclimated to the outdoors over a seven to ten-day span by placing them outside for increasing increments of time (Growing Gardens, n.d.). After acclimation, the seedlings are ready for transplanting.

Transplanting should occur late in the afternoon to prevent dehydration due to direct sunlight exposure (Trivedi, 2014). The first step involves digging a hole in the garden bed, large enough to contain the root system. Next, spread the roots of the seedling to prevent them from tangling or crowding up, then place it into the hole. When placing the sapling into the soil, the first main root needs to be right below or on the surface of the soil otherwise, the sapling may die (University of New Hampshire Extension, 2018). Gradually fill the hole with soil and gently pack it down to remove air pockets (Trivedi, 2014). After transplanting, water the seedlings. Transplanting a sapling is similar to the process for a seedling. As plants grow, they may require staking to support themselves and their produce (Trivedi, 2014). After transplantation, saplings and seedlings require continuous watering, feeding and basic care to thrive. If all of these gardening aspects are successfully completed, families will have their own food source, which is extremely beneficial in the event of a food supply chain break.

2.2.3: Efficiency in Home Gardens

Home gardens can supply families with essential foods; however, not all gardeners know about some beneficial gardening techniques. Yield time along with quantity can be improved upon with proper hydration, fertilization, and plant distribution (Patterson, 2015). Additionally, fertilization techniques can be used to dispose of debris left over from a storm while supplying nutrients to the soil.

Fertilization boosts the nutrients content of the soil, which in turn improves the growth and yield of the plants (Wairegi & Asten, 2010). Two fertilizers include wood ash and compost. Wood ash is obtained through burning wood materials. After a severe storm, large quantities of wood debris can be disposed of through burning. It is a useful, easy, and space efficient disposal method. The wood ash contains large amounts of carbon and has a high alkalinity (Tanner, 2018; Demeyer, 2001). The addition of ash increases soil pH, which is beneficial in tropical climates where soil tends to be acidic (Demeyer, 2001). The ideal pH for gardening soil is 6-7 pH (Boeckmann, 2017).

Composting involves the decomposition of organic material using microorganisms, large bacteria, and fungi to create nutrient-rich soil (Trautman, 1997). Compost is added to the soil during preparation or transplanting. The carbon and nitrogen content of compost is beneficial to plant growth. Carbon is an energy source and building block for cells. Nitrogen is one of the main components used to create proteins, amino acids, and DNA (Trautman, 1997). The ideal carbon-nitrogen ratio of 30:1 effectively supports plant growth and function (University of Florida, 2019). The success of composting organic material depends on the growth of the microbes, which are affected by the physical properties of the compost pile (Trautman, 1997). Debris from storms, garden waste, and food scraps can be used to create a home compost pile. The physical properties are often affected by the method of composting, which include:

Hügelkultur: Mounds are created by removing sod from a patch of ground, placing woody debris into the hole, then covering the wood with the sod. Next, foliage followed by course and fine compost are placed over the mound (Chalker-Scott, 2017). The mound's large surface area can be used to grow plants and is very low maintenance. Hügelkultur disposes of logs whereas other composting methods cannot. Even though Hügelkultur is useful, it is not always an effective method due to its sheer size. The large number of organic layers may prevent

air and moisture from penetrating all the layers of the pile, which slows decomposition rate to 5-6 years (Chalker-Scott, 2017). Also, mounds tend to collapse during decomposition, which can damage any trees or bushes planted in them. Many of these problems can be avoided using other composting methods.

Indore: Created in India during the 1920s, it is performed by piling various organic materials (Misra, Roy, & Hiraoka, 2003). The pile is turned 1-5 times over a 1-6 month period to aerate the material (Miller & Jones, 1995). Aeration quickens the decomposition process while only requiring a minimal amount of work. The Indore method is more time efficient than Hügelkultur, but better methods exist.

Berkeley: Arguably the quickest method of decomposing organic material, it should take 2-3 weeks to complete (Miller & Jones, 1995). It takes place in above-ground stacks or windrows and requires frequent aeration and mixing. Unfortunately, the Berkeley method is labor intensive due to the constant care of the pile, which may not be suitable in certain situations.

Another method of enhancing home gardening involves proper plant distribution. When plants become crowded, they create an excess amount of humidity, which allows powdery mildew, rust, and downy mildew to thrive (10 Ways to Keep Your Garden Healthy, 2014). Also, crowded plants compete for nutrients, water, and light, which slows growth and food production. Properly spaced plants allows for nutrient absorption and proper ventilation. It is necessary for plants to be properly placed and receive sufficient nutrients through fertilization for efficient plant growth to achieve maximum food self-sufficiency.

Lastly, plant hydration is an important aspect of gardening that supports their health and crop production. One method to maintain plant hydration is through watering gardens. Water allows for plants to absorb nutrients from the soil surrounding the roots, but only when properly balanced. Excessive amounts of watering can cause the plant to rot. While underwatering leads to plants shriveling up. For this reason, it is necessary to pay careful attention to the amount of water applied. Watering can depend on the weather, the plant, and its stage of life (Trivedi, 2014). Plants require more water as seedlings, when in bloom or budding, and during the summer. They need less water when matured, bearing fruits or flowers, and during the rainy season. Aside from proper watering, plant hydration can be maintained by retaining soil moisture.

In arid climates or places that experience drought, soil can dry up quickly from intense sun and heat. One way to sustain soil moisture is to create basins around individual plants, garden beds or in a grid-like pattern between sections of plants. Controlling the landscape in this way encourages water to flow down toward the plant roots and retains soil hydration between waterings (Larum, 2018). Another strategy to retain moisture involves placing leaves, grass clippings, wood mulch, or other materials around the plant to prevent evaporation caused by receiving direct sunlight (Larum, 2018). This keeps the roots and soil hydrated for longer while practicing efficient water management. Placing organic material around the plant also acts as a barrier for weeds. Weeds can compete with desirable plants for water and nutrients which can hinder growth and crop yield. Another way to practice efficient water management is drip irrigation, this method provides a constant and regulated supply of water to the plant and is the choice of many plant nurseries, high tech farms, and agricultural centers. This method is being promoted around the world by government organizations to battle water scarcity (Camp, 1998). A unique form of drip irrigation that ensures the soil remains wet is to poke small holes in plastic water bottles and bury them in the soil near plants (Larum, 2018). The bottle should be almost

flush with the ground with the top sticking out of the soil to allow for the bottle to be refilled. The bottles will slowly release water into the ground and can be refilled either when the bottle is empty or at a scheduled time. The community members must be educated on adequate hydration techniques for gardens to be effective food sources.

2.3 Education Methods

There are many methods of educating people about information, such as hands-on activities, tradition classes, and brochures. These methods relay information visually, verbally, and through examples. People retain information differently based on the way it is conveyed. Most people have a preferred method of learning that sticks with them better (Hammond, 2016).

Traditional classes are used by instructors of any kind especially in different levels of academia in various countries to convey different topics. Their teaching style can vary from hands-on activities to lecture-style classes. Lectures are a useful method of educating because they effectively communicate the intrinsic message of a subject based on their instructors' enthusiasm (Advantages and Disadvantages of Lectures, 2019). They allow educators to maximize the value of the learning experience and teach information that could not be obtained otherwise (Advantages and Disadvantages of Lectures, 2019). Furthermore, much can be gained from hands-on based educational methods. Well-designed hands-on activities in the classroom foster connections to real-world situations and increase learner engagement (Hands-on Learning Benefits, 2018). In an article written about the benefits of hands-on learning, the researchers discuss that when students make connections between the concepts in the classroom and concepts in the real world, more parts of their brains are activated and the knowledge gained is more easily transferred to long-term memory (Hands-on Learning Benefits, 2018). This style of teaching and learning also fosters critical thinking and problem-solving skills. These are skills that many employers say they view as high priorities in new hires (Hands-on Learning Benefits, 2018).

In addition, brochures are efficient methods of conveying important information to a population (Carter, 2014). Brochures are a condensed form of information designed to offer a general perspective of a topic. While most people are not aware, brochures are useful especially for health-care professionals when it comes to communicating risk. In 2016, a study indicated just how easy and useful it was for health-care professionals to gain insight on medical procedures from a series of brochures (Bester, 2016). It concluded that distributed educational brochures may be an effective risk minimization strategy to raise health-care professional awareness of new and rare adverse events (AEs). Also, it was found that educational brochures may be effective for sharing information about managing AEs (Bester, 2016). Brochures can be formulated in many ways, such as to contain mostly words or have a focus on photos, diagrams, and other visuals. An issue that comes along with an image heavy brochure is the lack of content, which in some cases can inhibit people’s ability to retain the knowledge (Krow, 2019).

2.4: La Plata Wildlife Refuge & Departamento de Recursos Naturales y Ambientales

In order to have an effective home garden, it must be adapted for the location it is implemented in. The San Juan Project site provides an interesting case study for debris removal following a natural disaster and developing home gardens due to its tropical climate and unique ecosystem. Therefore in order for our education program to be successful, we need to gather information and techniques that are effective in Puerto Rico.

Hurricanes Irma and Maria struck Puerto Rico in September of 2017, causing billions of dollars worth of damage and cost more than 2,900 lives (Guzy, 2018). Hurricane Maria enveloped Puerto Rico, buffeting the island with winds in excess of 150 mph and heavy rainfall. The hurricane was the third most powerful storm to make landfall in the United States and the strongest hurricane to hit Puerto Rico in 80 years. Residents were forced to live through food and water shortages for months after the hurricanes (Huber, Klinger, O'Hara, 2018). 80% of their crop production was destroyed by Maria, 50% of dairy production was lost and seventy percent of poultry infrastructure was ruined (Bloch, 2018). The island's food production was almost entirely halted and areas around Puerto Rico were cut off from the food sources they had grown to rely on.

Our official sponsor is the Departamento de Recursos Naturales y Ambientales (DRNA). The DRNA is a government agency in Puerto Rico that is in charge of 20 state forests, 34 reserves, and 5 wildlife refuges in Puerto Rico (Bigio, 2017). They are charged with protecting, conserving, managing, and maintaining the natural and environmental resources of Puerto Rico (DRNA, n.d.). Recently, they started to promote agriculture in their various project sites. The DRNA is invested in making sure that La Plata continues to heal from the damage caused by Irma and Maria.

We worked at Lago de La Plata (Lake of La Plata) which is located in the Puerto Rican municipality of Toa Alta. The lake was created in 1974 to act as a public water source for multiple municipalities in central Puerto Rico (USGS, 2008). The reservoir is home to El Refugio de Vida Silvestre del Embalse La Plata (Wildlife Refuge of La Plata) which is an important community center that offers several popular recreational services to the locals. The refuge offers shore fishing areas, bird watching, parades, kayaking, canoeing, and other paddle sports ("DRNA reopens the La Plata Reservoir Wildlife Refuge," n.d). La Plata also offers community clinics where managers, such as our point of contact, Marinelly Valentin-Sivico, teach various classes. These outreach programs are central to our project and offer us an opportunity to improve food self-sufficiency.

Because of the impacts of Hurricanes Irma and Maria on the region around La Plata, the DRNA is now aimed at trying to improve climate resiliency of the park and the surrounding communities. A critical aspect of this is food security. As stated by Ms. Valentin-Sivico (Personal Communication, 2019), the food supply chain in the area was almost halted due to damage to roads and producers. The introduction of a robust system of home gardening may help provide a safety net for the La Plata region if another natural disaster were to strike.

Conclusion

Puerto Rico relies heavily on a network of global food supply chains which provides the majority of the communities essential foods. A chain break can bring catastrophic consequences especially if the suffering location is ill-prepared for the threat. Furthermore, a successful method for helping communities become temporarily food self-sufficient is necessary to avoid the ramifications that could follow if the community is unprepared for the cataclysmic event. Home gardening gives people the tools they need to be adequately prepared for food shortages.

3: Methodology

The project goal was to improve food self-sufficiency through local outreach programs that promote home gardening. Our sponsor wanted us to gather data on effective growing techniques, which we shared with the communities surrounding the La Plata Wildlife Refuge through an education program aimed to improve home gardens. Additionally, we supplemented the data with recommendations based on the community's input. To fulfill this goal, we identified three objectives.

Objective 1: Determine the extent of home gardening in the community, the challenges, and successes involved with home gardening; along with the locals' preferred method of learning.
Objective 2: Determine materials commonly found in local areas that can be used in home gardening.
Objective 3: Conduct two growing examples in order to determine the best methods of growing

These objectives guided us to execute the goals of the project and those assigned by the DRNA. We completed these objectives from March 11th to April 30th, 2019.

3.1: Objective 1: Determine the extent of home gardening in the community, the challenges and successes involved with home gardening; along with the locals' preferred method of learning.

To successfully promote food self-sufficiency in the community surrounding the La Plata Wildlife Refuge, it was necessary to know whether locals were utilizing home gardens. Our team selected individuals in La Plata to interview in order to gain an understanding of local home gardening. These interviews were conducted from March 27th until April 17th. People from varying walks of life, professions, and communities come to La Plata. There are four main groups of people who visit La Plata: students, fisherman, gardeners, and other community members. The fisherman come to La Plata for recreation as well as for gathering food for their families. Students are consistently visiting the refuge in order to fulfill their required environmental studies. Gardeners include those who come to work on the small community garden, as well as those who work for a living at the Refuge. Other community members visit to exercise, bird watch, relax, and picnic. The range in population of visitors allowed our team to gather a wide variety of the locals' knowledge.

The interviews consisted of a list of baseline topics and questions accompanied by follow-up questions, as necessary, to accumulate the data needed to complete objective one (Gillham, 2005). The interview questions are listed in Appendices A and B. Also, the interviews provided information on the gaps in the locals' gardening knowledge, which guided our education program. The group conducted our interviews in person with the help of Emmanuell Pagan as our translator, and a note-taker (Gillham, 2005). After the interviews, the group coded the responses in Excel (Gillham, 2005). The gathered information on the community's knowledge, or lack thereof, on home gardening was used to make an education program to improve food self-sufficiency.

Additionally, we acquired information on local gardening techniques, strategies, and implementation by interviewing local community gardeners and agricultural experts. We gathered as much information as possible from experts, as well as locals, to determine any successful gardening techniques the community might not implement in their gardens. By interviewing both sides, we were able to provide the DRNA and communities around La Plata

with more information to improve their home gardens and food self-sufficiency. With the help of our sponsor, we contacted two agro-ecological centers, Josco Bravo and Finca Noa, and two government agents, Jacqueline Seijo and Shirley Cruz, as well as one successful community gardener, Manuel Nieves.

We traveled to Josco Bravo in Toa Alta on April 9th, and Finca Noa in Toa Baja on April 1st. These are two Puerto Rican agro-ecological centers, where we interviewed local agronomists. These agro-ecological centers are large-scale farms with multiple acres which try to minimize their use of unnatural pesticides and tools to produce the healthiest and most organic produce possible. We also interviewed Manuel Nieves, a local, small farmer, on March 29th. We formed questions tailored to the farms to gather gardening knowledge on these topics: composting/fertilization, crop/plant selection, drainage, gardening materials, maintenance, pests/animals, plant placement, watering, and weeding.

Additionally, we traveled to the Servicio de Extension Agricola office in Toa Alta to interview Jacqueline Seijo on April 1st. She has considerable experience and knowledge on teaching classes about gardening to Puerto Ricans of all ages. We also traveled to the entomologist department of the Puerto Rico Department of Agriculture on April 16th to interview Shirley Cruz to obtain information about insects and pesticides.

Aside from understanding the community's knowledge of gardening, it was important to gain information on their preferred method of learning to better execute the education program. We organized the data and presented it to our sponsor who may distribute it to the local community. The classes currently offered at La Plata are mostly for students. However, we have developed our education course to be available for people of all ages in order to have a greater impact on the community. While we interviewed the locals about their home gardens and gardening experience, we asked them questions listed in Appendix A.

These topics and questions were formatted into semi-structured interviews seen in Appendix A for visitors of La Plata and Appendix B for the local gardening experts. One limitation that arose during the interview process was a language barrier. The interviews were conducted in English, which is commonly spoken in Puerto Rico, but the most popular language is Spanish. As mentioned before, we conducted interviews with a translator present to combat this limitation; however, the language barrier still skewed our interview results. The translator may have left out important statements while explaining the interviewees' answers to our questions.

3.2: Objective 2: Determine materials commonly found in local areas that can be used in home gardening.

In order to have a successful home garden, community members need to have access to various materials such as fertilizer, organic materials, seeds, seedlings, saplings, water, space, and gardening equipment, for instance, shovels and gloves. Therefore, we obtained information on the the availability of gardening resources for locals. If the community has any trouble obtaining various gardening resources, it may hinder their ability to become food self-sufficient. We identified the accessibility of these resources through our interviews with locals, experts, and agriculturalists. These interviews were conducted at the same time as the ones mentioned in objective one.

Additionally, our team has worked to identify the organic materials available to be used in composting. Our research has indicated that the method of composting used to fertilize the land does not make a measurable difference in the output of the soil. Ultimately, choosing a

composting method should depend on the materials, time, and workers available to be put into the project. Carbon and nitrogen are two main elements plants need for growth. The organic materials used for composting dictate the proportion of carbon and nitrogen in it (Trautmann & Krasny, 1997). Therefore, the materials chosen to be put in the compost determine the effectiveness of the fertilizer based on the ratio of elements (Trautmann & Krasny, 1997). Scientifically, the perfect ratio of carbon to nitrogen within the composting material will produce the best yield. Given the right time and equipment, we could test the available material to determine if the debris would produce the perfect ratio of 30:1 carbon to nitrogen molecules (University of Florida, 2019). However, due to the seven-week time frame, and our limited resources, we could not test for the golden ratio. Composting also offers a unique way to get rid of any debris. By using the extra organic waste in compost, people can clear debris remaining from the hurricanes or any other disaster.

While we conducted interviews outlined in Appendices A and B, we gathered information on the resources available to the area. By determining the local availability of materials, we made a calculated recommendation to eliminate the debris still remaining from the hurricane, as well as provide a positive effect on the food self-sufficiency in the region. Composting and home gardens may be able to use leftover debris to improve the community.

3.3: Objective 3: Conduct Two Growing Examples in Order to Determine the Best Methods of Growing

To improve food self-sufficiency, our team conducted two growing examples using Hügelkultur runoff and compost. We completed objective 3 over the first six weeks of our project. The purpose of these examples was to experience local problems in agriculture, as well as to test new solutions given to us by the locals, or created by us. The examples had the added benefit of investigating the effectiveness of compost as well as the Hügelkultur runoff from the debris piles created by the La Plata staff.

3.3.1: Removal of Debris Following Natural Disasters

One major component of the growing example involved incorporating debris removal. It was necessary to analyze strategies of debris removal, in order to help the local communities improve their quality of life. La Plata had set up large piles of debris in order to move the leftover leaves, branches, and trees out of the way and let them decompose. Marinelly referred to these mounds as “Puerto Rican Hügelkultur.” We were unable to plant within these large debris mounds as actual Hügelkultur requires. These mounds were not traditional Hügelkultur, but were interesting to study because of their commonness in the community.

3.3.2: Growing Example

Trees

The first growing example involved planting 60 trees of three species. The planting took place over two weeks, from March 4th until March 15th. We planted 20 Guaraguao trees *(Guarea Guidonia),* 20 Pendula trees *(Citharexylum Spinosum),* and 20 Ilan Ilan trees *(Cananga Odorata),* the only non-native species. All of these trees were 4-5 months old when planted. These 60 trees were split into two plots, each having 10 trees of the three species. Plot 1 was planted using traditional compost and Plot 2 was in an area surrounding a large Hügelkultur mound. Traditional compost is defined as compost created by piling food and other organic

waste and letting it decompose. The decomposed material is mixed in the soil to provide nutrients. We created the second plot of land surrounding the “Puerto Rican Hügelkultur” mounds already present at La Plata. We hoped to observe some signs of nutrient runoff from the mounds. We planted 15 saplings, 5 of each species, without compost and in direct line of the supposed runoff. We planted 15 trees with compost in this plot because we did not think that the Hügelkultur runoff would reach every plant, but we wanted to keep all trees healthy.

Additionally, all trees throughout both groups were spaced equally from each other to ensure regularity but also to aid in the weeding and maintaining process throughout the experiment. Once a week, for 6 weeks, we went through each of the two plots and took notes on the number of leaves, buds, and sprouts that the trees had developed. This was the most convenient way to track the growth of the plants. It is also easy to continue on with, as our sponsor wanted the data collection to continue with the aid of local interested students.

A map of each of the two plots can be seen in Figures 1 and 2.

PLOT 1	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	
Row 5	II7	G7	P6	II6	G9	P10	G= Guaraguao
Row 4	G6	P5	II5	G5	P8	II10	II= Ilan Ilan
Row 3	P4	II4	G4	P3	II8	G10	P= Pendula
Row 2	II3	G3	P2	II2	G8	P9	
Row 1	G2	P1	II1	G1	P7	II9	

Figure 1. Map of Plot 1

PLOT 2									
Row 1	II2	G2	P1	II1H	G1H	Hugelkultur		Bed	
Row 2	II5	G5	P3	II4H	G4H	P2H	II3H	G3H	
Row 3	G8	P6	II7	G7H	P5H	II6H	G6H	P4H	P10H
Row 4	P9	II10	G10	P8H	II9H	G9	P7	II8	

H =	Hugelkultur (no compost)
G =	Guaragao
II =	Ilan Ilan
P =	Pendula

Figure 2. Map of Plot 2

Garden Beds

The second growing experiment involved planting Red Oak lettuce and Roma tomatoes. During the week of March 18th, we planted 48 red oak lettuce plants and 126 Roma tomato plants. The spacing between each plant was roughly about a foot each way to ensure proper growth between plants. We created eight garden beds. Four of those beds, labeled A through D, were positioned so they would receive no runoff from the Hügelkultur pile and four, labeled E through H, were positioned in direct line of the runoff we desired to test. Beds A and C received compost but no assistance from the Hügelkultur pile. Beds B and D acted as our control and received no form of growing aid. Beds E and G received only Hügelkultur runoff, whereas beds F and H received a combination of compost and Hügelkultur runoff. A map of the beds can be seen in Figure 3.

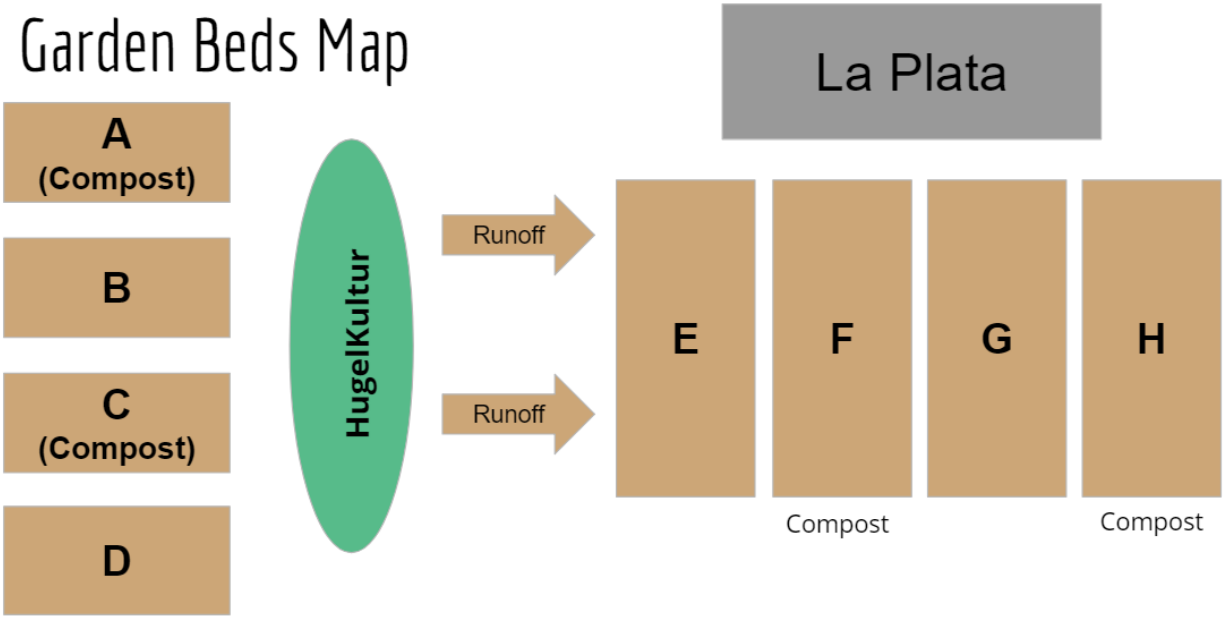

Figure 3. Map of Garden Beds

Every week, we properly maintained each bed. This included daily watering, performed by us on days where we traveled to La Plata and by employees when we were unable to go. For the next five weeks, we took detailed notes on height, the number of leaves, buds, and sprouts, as well as mortality. We also noted of any evidence of pests or disease that a specific plant shows as well as general qualitative observations.

For the tomatoes planted in each bed, the first thing we measured was the height. If the plant stays consistent or starts to trend downward, this could indicate the end of the plant's lifespan. We also took note of the number of yellowing leaves on each plant. Leaves will show signs of yellowing at the beginning stages, but does not indicate certain death. However, leaf yellowing should be noted because it could be a sign of decreasing health. Finally, we took very careful note of the overall health of each individual bed. For the overall health of each bed, we ranked them on a very simple scale of bad, average, good, and healthy. The determination of each category of the scale was based upon visual observations such as how much the plant was drooping, color, and fullness of the plant. We believed that this, along with height, was the best way to analyze the beds in a short period of time.

We planted six lettuce plants in each of the eight beds. We started with 144 lettuce plants, but only 48 were healthy enough to be planted. Every week we used a health scale to analyze the plants. Originally, the lettuce plants were not in good health, so the scale was determined to be on a scale of bad, average, good, and healthy. Visual inspections of each plant’s color, posture, and texture helped determine the plant’s health. Different visual cues such as browning leaves, or droopiness demonstrate a decline in plant health. Most of the data collection is fairly simple and required a ruler or measuring tape to find plant height.

After recording all of this data, we inserted the results into an Excel sheet. We organized the data and began to make connections and conclusions. For the tree data, we created line graphs that indicate the number of leaves, buds, and sprouts per week. This data helped give us a simple understanding of the growth of the plants. The data also helped us to determine the

mortality of the trees, and see any unexpected or sudden growths. We were also tracked and analyzed the growth in height of the tomatoes from March 22nd until April 16th.

4: Results

Through creating our growing example we learned how to plan a garden, build beds, transplant seedlings and saplings, and maintain a home garden in the Puerto Rican climate. We also dealt with iguanas, where we implemented three strategies to protect our gardens against these pests. Our growing example used compost and runoff from the debris pile. We tested both for effectiveness and use in home gardens.

Through interviews with local residents and experts, we have identified gaps in local knowledge, as well as successes and shortcomings of local home gardeners and larger farms. Our interviews with visitors at La Plata touched on the use of home gardens, fertilization, pests, disease, and preferred method of education. We found that many visitors had home gardens but not all used them to grow crops. Fertilization was often used in the garden but with varying methods, some not as effective as others. Iguanas, insects, caterpillars, and fungi were common pests in home gardens. Finally, interviewees requested a combination of a hands-on lecture and brochure for our education program.

4.1: Saplings

In addition to vegetable plots, we created and maintained two plots of 30 trees. Data on each plot was taken weekly. The full table of weekly results for each plot and species can be found at the end of this paper in Appendix C. This data is being archived to allow Marinelly Valentin-Sivico and students visiting La Plata to continue the data collection and the study.

Our first plot was used to show the efficacy of composting to the local communities. By using locally made and organic compost, we were able to successfully plant trees in unhealthy and weed infested land. In fact, the compost example was so successful that it was not uncommon for plants to double in leaf or bud number in just one week. This example showed the effectiveness of home-made compost, acquired from a local farm, even in difficult conditions.

12 plants had no leaves on branches and their branches were dried out, they appeared dead or dying. Through attentive watering, weeding, and observation, 10 of the trees we had considered dead at the beginning of planting ended up returning to life in some fashion. Our sponsor requested that we space out the three species of trees instead of planting them in groups. We also planned out our plots so that the plants were isolated from each other. We mapped out the 30 trees planted with compost in Figure 4 and the 30 trees planted near the Hügelkultur bed in Figure 5. Additionally, the figures show the overall health of the trees, classified with great, acceptable, poor, and dead. This classification system was determined by the overall leaf number on the final day of data collection, April 16th. Of the trees planted in compost, 56.6% were great, 26.6% were acceptable, 13.3% were poor, and 1 tree died. For the trees planted near Hügelkultur, of trees planted with compost, 40% were great, 46.6% were acceptable, and 2 trees died. Of the trees planted with only runoff from Hügelkultur, 46.6% were great, 33.3% were acceptable, 13.3% were poor, and 1 tree died.

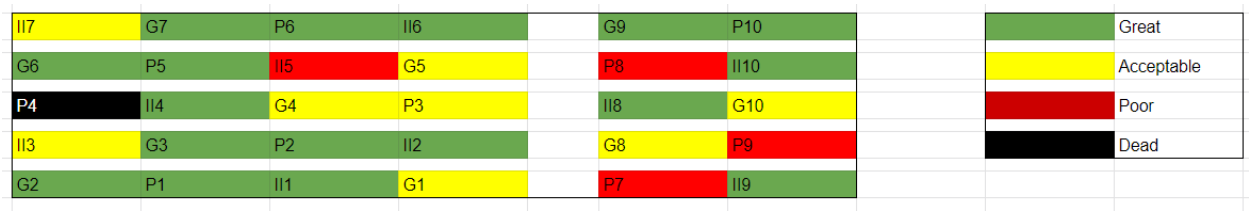

Figure 4. Overall Health of Trees Planted with Compost

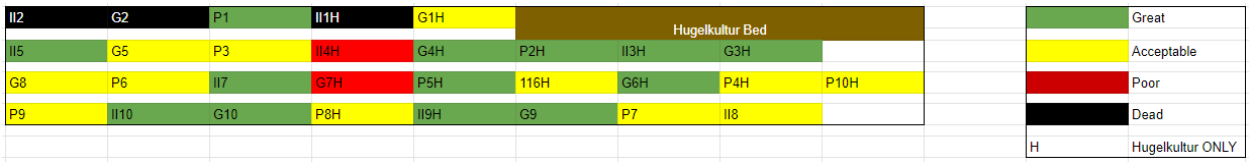

Figure 5. Overall Health of Trees Planted Near Hügelkultur

We did notice that trees grown with just a Hügelkultur influence grew steadily and almost always grew new leaves or buds during one week. Those planted with a combination of Hügelkultur and compost boasted similar results but were more sudden and spiked in growth from week to week. As shown in Figure 6, the "Hügelkultur" graph shows a gradual increase from week to week, but the "compost added" graph in Figure 7 shows a sharp spike from week to week. During the growing experiment, we lost two trees due to outside forces. One Guaraguao was torn up by iguanas in an attempt to make a burrow. The other, Ilan Ilan 2, was accidentally run over by the tractor used by the La Plata staff. This specific tree's progression can be seen in Figure 7.

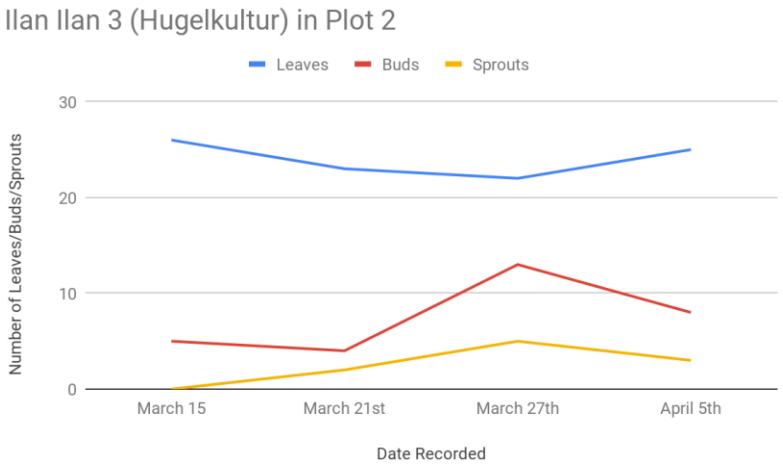

Figure 6. Example of Ilan Ilan Tree 3 Leaf, Bud, and Sprout trends

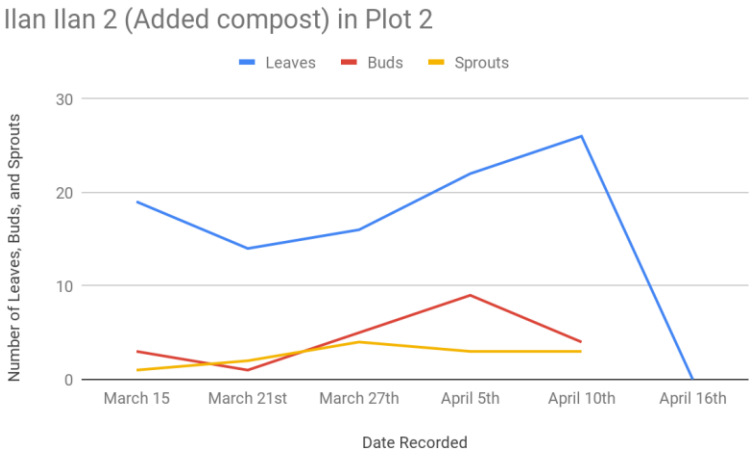

Figure 7. Example of Leaf, Bud, and Sprout Count of Ilan Ilan Tree 2 with Added Compost

4.2: Garden Beds

Along with trees, we created, planted, and monitored eight garden beds (two Hügelkultur, two Hügelkultur + compost, two regular compost, two control) containing two vegetables, red oak lettuce (*lactuca sativa*), and Roma tomatoes (*solanum lycopersicum*). We planted six lettuce plants in each bed (48 total) while the tomatoes varied from 12 to 17 per bed (126 total).

4.2.1: Tomatoes

Fortunately, there were only three tomato plants that did trend downward. They appeared to have been eaten by an unknown animal. In terms of health, Figure 8 illustrates the trend of the health of each bed from our initial data gathering from March to April. As shown in Figure 8, initially no beds were classified as bad. However, there was a plot that was slightly above bad giving it an average rating. This was due to intense droopiness and extensive yellowing. Additionally, Figure 8 also shows an upward trend from March to April. Those plants, considered good and average, made considerable progress and were upgraded to healthy. Figure 8 displays the quantity of healthy plants. We believe plot D, a control bed, downgraded in health after April 5th because it lacked sufficient nutrients.

	March 26th	April 5th	April 10th	April 16th
Plot A	Healthy	Healthy	Healthy	Healthy
Plot B	Good	Healthy	Healthy	Healthy
Plot C	Good	Healthy	Healthy	Healthy
Plot D	Good	Healthy	Good	Good
Plot E	Healthy	Healthy	Healthy	Healthy
Plot F	Healthy	Healthy	Healthy	Healthy
Plot G	Average	Healthy	Healthy	Healthy
Plot H	Healthy	Good	Healthy	Healthy

Healthy
Good
Average
Bad

Figure 8. Tomato Health Scale

After recording our height data we placed it into Excel. To display our results, we averaged the five height growths for each week to show the general trends of change in height for each bed as seen in Figure 9.

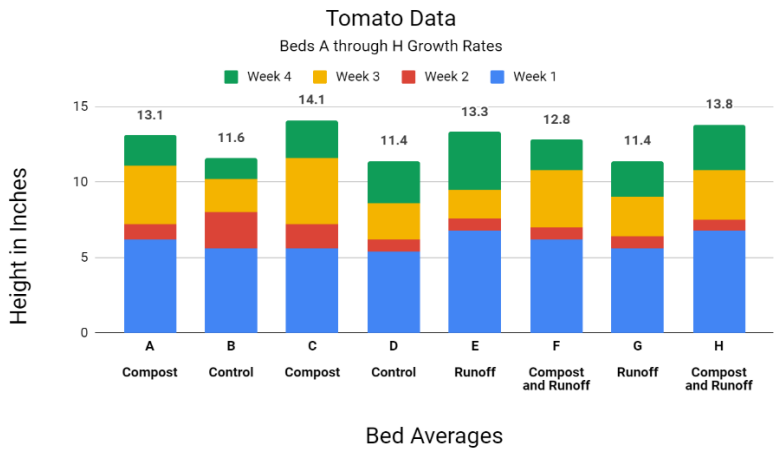

Figure 9. Tomato Growth Rates for Beds A-H

The beds with only compost (A and C) and the beds with compost and runoff from the Hügelkultur pile (F and H) all posted high average heights as illustrated in Figure 9. The two beds that acted as controls (B and D) were significantly shorter when compared to the beds with compost added. The beds that received only Hügelkultur runoff had mixed results. Bed E, located closest to the Hügelkultur pile had growth numbers that were on par with the beds that received compost. However, bed G showed growth that was most similar to the control plots, but visual clues such as the color of the leaves, developing flowers, and plant posture indicates that bed G was healthier than the control beds. The full set of data collected on tomatoes as well as growth charts for individual beds is included in Appendix D.

4.2.2: Lettuce

April data illustrated different information than that of March. Following our April data collection, the survival rate for the lettuce was very low. Fortunately, only one appeared to be eaten or possibly dug up. However, the rest died. Our retention rate for the lettuce was 17 of 48 plants about 35%.

As illustrated by Figure 10, our March 26th data indicated very few plants being on the positive side of the scale. 62.5% were bad, 29% were average, and 8.3% were good. On April 5th, many plants had died but most of the survivors improved. Figure 10 shows the lettuce was 64.58% dead, 8.3% average, 18.75% good, and 8.3% healthy at the time. On April 10th, some plants improved while others regressed. Figure 10 shows the lettuce was 64.58% dead, 6.25% bad, 8.3% average, 6.25% good, and 14.58% healthy. On April 16th, there were slight improvement for some of the plants. Additionally, in Plot G, L2 returned, making the final survival rate 18 of 48 an equal 37.5%. Figure 10 shows the lettuce was 62.5% dead, 2.08% bad, 12.5% average, 8.3% good, and 14.58% healthy. Overall, the lettuce survival rate was not good for our experiment and the remaining lettuce did not have substantial growth. All of the surviving lettuce, except L1 in plot H, remained small. The full set of data collected for lettuce can be found Appendix E.

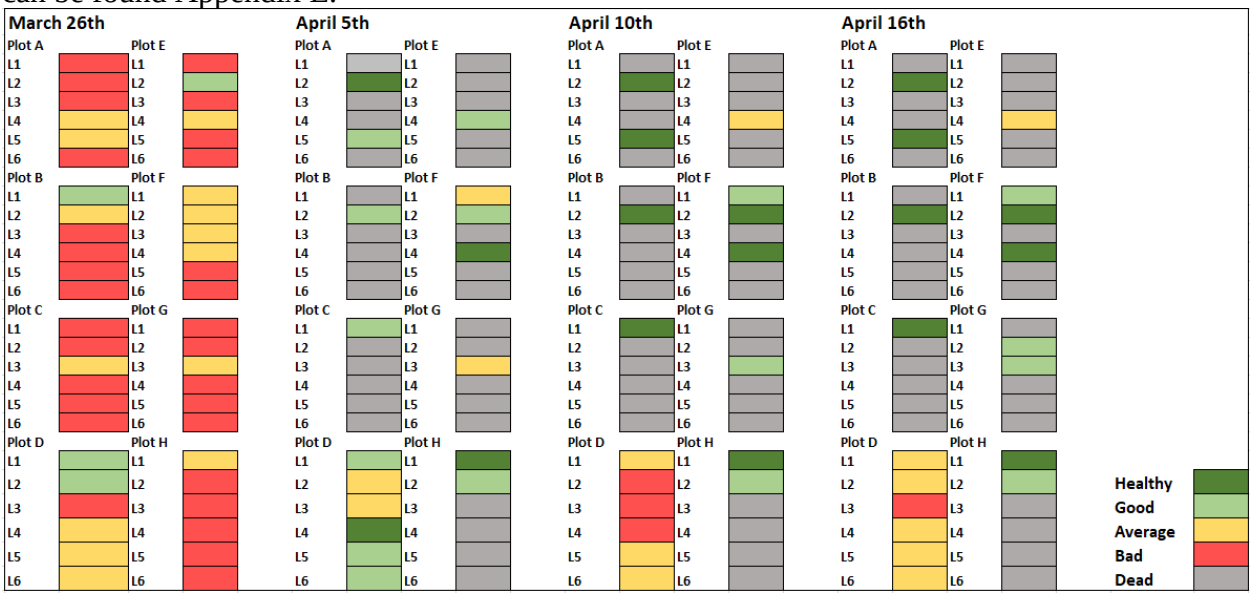

Figure 10. Lettuce Health Chart

Figure 10 indicates the progression of the lettuce health over a four week period. Each bar represents one lettuce plant.

4.3: Pest Control at La Plata

During our time planting in Puerto Rico as well as conducting interviews, we discovered that pests are a major impediment to local gardening. Of the pests at La Plata, one extremely common issue is the green iguana. They are an invasive species with minimal natural predators in Puerto Rico. With nests producing several eggs at a time, the iguana population has become a larger problem than Puerto Ricans anticipated years ago. Iguanas affected our garden beds by creating large burrows in them.

Our interviews with experts provided us with additional knowledge on how to deal with insects, fungus, and other pests; however, this section discusses the methods that we performed in La Plata. For our iguana prevention methods, we tested three concepts. The first concept was creating a barrier of hanging cans around our beds, hoping that the noise and motion from them blowing in the wind, and the shininess would scare them. This method was developed as an adaption of an existing one used in La Plata that involved CDs hung from wire. However, CDs were not available at the creation of our system so we compromised by using available cans. Following the implementation of the cans, only one out of the eight beds showed major damage, four showed minor damage, and three were undisturbed. The severely damaged bed was consistently tampered with, possibly due to buried iguana eggs. CDs were later added to the system, but it appears that it did not make the system any more or less effective than just the cans. We witnessed an iguana detouring around the beds protected by the hanging cans. However, on another occasion, we noticed an iguana run through our beds completely ignoring the cans.

After our interview at Finca Noa, we investigated whether or not natural repellants would be effective. Oregano was highly recommended to stop iguanas and we placed an oregano plant in Bed H in a location that had been moderately attacked by the iguanas. The iguanas did not attack for two weeks following its implementation, but then did attack the bed in close proximity to the plant.

We attempted to reinforce the one bed that was consistently damaged by adding chicken wire around it. We believed that the height and thickness of the wire would dissuade the iguanas from attacking. Chicken wire is also readily available in many hardware shops or online. After putting the chicken wire around the one bed, it received no further damage from iguana attacks.

4.4: Visitors at La Plata

In order to determine the community's knowledge of home gardening, we interviewed 21 visitors at the La Plata Wildlife Refuge. The major findings included the popularity of home gardening, use of fertilizer, issues with pests, methods of debris disposal, and preferred style of learning. The full set of interview responses can be found in Appendix F.

All the participants had some sort of knowledge of gardening. 18 of them had a home garden, but only 14 of the gardens were used to produce food. Three of the interviewees stated they had large plots of crops, which can be considered a farm instead of a small home garden. The home gardens had a wide variety of crops that included tomato, pumpkin, yautia, malanga, plantains, breadfruit, and more. The most popular crop was plantains. Also, three of the interviewees mentioned they raised animals as a food source. In order to maintain their gardens, all the interviewees watered their plants and the majority of them kept the garden beds clean by removing dead material and cutting the weeds. The amount of time spent on maintenance and general upkeep varied greatly from half an hour to seven hours a day.

When asked about using fertilizer in their gardens, only two of the interviewees had no knowledge about it and its benefits. Of the 19 participants who had knowledge about fertilization, 16 of them fertilized their gardens. Four interviewees used inorganic fertilizer within their gardens, yet two of them had compost piles. Person 13 used inorganic fertilizers instead of compost because he did not have enough compost for all of his crops, but wants to switch to compost. Four participants stated that they placed organic materials, such as coffee grounds and fish, in their gardens to supply nutrients to the plants, but they did not have a compost pile. Eight others stated they had compost piles. The majority of these interviewees placed food scraps, manure, or other organic materials into heaps, then left the materials to decompose without aerating the pile or using any other process. Person 15 created a homemade compost bin by cutting holes into a trash bin. Also, during the interview with Person 16, she mentioned a unique method to obtain a nutrient-rich liquid to use for gardening. The participant's mother had a three tier screening system, where vermicompost was added to the top tier, then water was poured onto it. The water washed the nutrients out of the vermicompost resulting in a nutrient-rich liquid that could be added to gardens.

When asked about the difficulties within gardening, the main issues were with pests and disease. One pest that was consistently identified as damaging gardens was the iguana. The participants had a wide variety of methods to deter iguanas, which included killing them, using dogs to scare them off, setting up traps, and putting up chicken wire. Person 17 would kill the iguanas, then either eat them or place the bodies in his compost pile to decompose. Participants also had trouble with caterpillars and other insects eating the leaves and produce on plants within their gardens. Surprisingly, only two of the interviewees used pesticides to kill or deter the caterpillars and other insects. The two insecticides were Neem oil and Malathion. Person 17 would squish the caterpillars whenever he found one. Another common issue participants encountered was fungus, called Citrus Greening, that affects all citrus trees (Marroquin - Guzman, 2012). Person 10 mentioned that Citrus Greening causes the trees to yield poor quality fruit and reduces its life span to just three to four years. Most of the participants that had issues with the Citrus Greening let the fungus take its course, but Person 2 used an unidentified liquid to kill it. As for obtaining materials, only five participants identified having difficulties purchasing either proper gardening tools, seedlings, or seeds. The other participants had no issues with purchasing any other materials. The last problem that three interviewees had was the lack of space for gardening due to living in an urban area. They do not have access to community gardens making it more difficult to find other planting space.

Also, we acquired data on the methods of debris disposal that the visitors used after Hurricane Maria. During our first in-person interview with our sponsor, she informed us that the debris could not be burned, there was no equipment to chip it up, and the wood was not of high-enough quality to be repurposed into timber or other materials. Unfortunately, we did not ask questions on debris disposal for the first four interviews, so data only represents 17 of the interviews. The most popular method, performed by 10 of the interviewees, was to pile the debris in the woods or on the edge of their property, then let it decompose. Some of the interviewees stated they mixed the decomposed material within their home gardens. The number of interviewees who used the decomposed material for gardening is unknown because it was not asked during the interviews and only came up in a discussion. Five people stated that an organization, such as their local church or the government, collected their debris. One unique method used by Person 6 was to use the debris as firewood.

Lastly, we collected data on the education program and the preferred methods of learning for a gardening education program. We discovered that 16 of the interviewees would attend the class if it was available. As for the class structure, Figure 11 demonstrates the community's preference for learning. The biggest emphasis was to develop a hands-on class or activity. Even though the majority of the interviewees could understand English, the program was written in Spanish. If the class was implemented in La Plata, 16 of the interviewees would participate in the class. Surprisingly, many of the interviewees who were participating in Ian's education class were also interested in participating in the education program at La Plata.

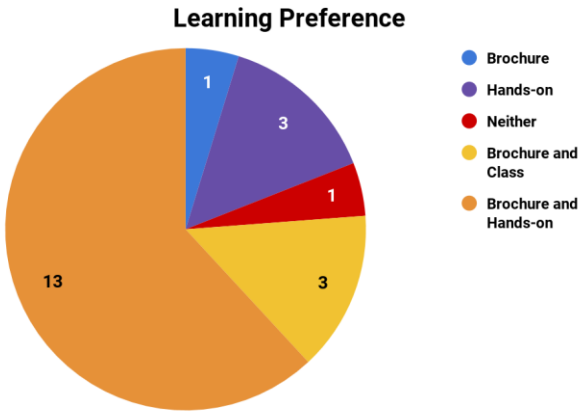

Figure 11. The Interviewees Preferred Method of Learning

4.5: Expert Advice and Opinions

During our time in Puerto Rico, we interviewed five experts that were identified to us by Marinelly Valentin-Sivico or recommended by an interviewee. These experts consisted of farmers, agriculturalists, and state or federal workers. Throughout our interviews with experts, we saw some themes that included the lack of gardening materials, damage from hurricanes, utilization of compost and fertilizer, and difficulties from pests and disease. Aside from the main themes, we gained information on two education programs on gardening.

Access to larger equipment was a universal problem. There was a clear need for tractors and larger equipment like tillers, augers, spare parts, tractor wheels, and other equipment. The Nieves farm wants to expand and grow 4,000 plantain trees. The project is 1-2 years away because they lack the access to machinery to prepare the land and need to install an irrigation system to supply water to such a large plot. Their largest issue appears to the lack of access to necessary equipment, slowing their farm's growth and limiting the activities they can do on a day-to-day basis. In Finca Noa, they have difficulties with obtaining water. They currently have a water collection system but lack a pump and power supply to distribute the water. Additionally, they rely on old equipment and do not have access to replacement parts for their tractor or new farming equipment. Ian Pagan also had issues following Hurricane Maria, where tools were not immediately available for processing debris. Eventually, he was able to borrow a friend's wood chipper to begin the process of turning the debris into compost. Additionally, Ian cannot obtain certain tools in Puerto Rico and has to import a scuffle and colonial hoe from the continental United States. These imported tools are vital to his farm and make weeding faster. Mentioned occasionally was lack of access to seedlings but was not a problem for every farmer. Finca Noa's lack of access to common gardening supplies makes them grow plants from seeds instead of

purchasing seedlings. However, even purchasing seeds can be difficult. Finca Noa orders seeds from Ohio, Iowa, California, and Missouri and purchase enough seeds for 1-3 years.

All farms had many issues caused by hurricanes, including severe damage to established plants and causing future plans for expansion to be put on hold. Farms also had to deal with extreme debris. For the Nieves farm, after Hurricanes Irma and Maria, the normal water supply was lost. The family used water from a nearby stream for their home and farm. The hurricanes destroyed the majority of the farm. They have been rebuilding since, clearing debris with chainsaws and machetes and pushing it to the side. Many of their trees that produce fruits were damaged severely and are slowly recovering. Finca Noa was hit hard by the hurricanes, losing three acres of passion fruit, one acre of peas, 300-400 papaya trees, 85 plantain trees, and 50 melon trees. Additionally, only 30% of their nursery survived. They have begun regrowing by planting passion fruit and a large species of cabbage. Ian Pagan had recently purchased Josco Bravo when the hurricanes hit. The hurricanes made his startup process slower than expected.

Composting and fertilization were also repeated topics during the interviews. Farms and experts gave us a variety of types and methods of fertilization, but the benefits were universally known. The Nieves farm utilized the natural landscape, growing in a valley where there is naturally higher humidity and moist soil. The family mostly buys their compost but also used the rich soil and sand from their spring to supplement the purchased compost. However, the Nieves farm is located on a portion of land with good natural nutrients and they do not use fertilizer often. Finca Noa makes their own compost from debris by cutting trees into small bits and then letting it decompose for 1-2 years. They add horse or cow manure for fertilization and lime powder to protect against diseases. Ian Pagan makes his own compost because he believes the commercial compost on the island is of low quality. To create his compost, Mr. Pagan uses kitchen scraps, garden scraps, and imported chicken, cow, and horse manure from nearby farms for compost on his farm. He also uses debris from storms. Mr. Pagan uses a microorganism spray for his compost to quicken the decomposing process. The microorganism spray is created by collecting natural soil from the woods and mixing in rice, flour, corn, milk, sugarcane, molasses, then incubating the mixture in a dark area for 45 days. The mixture is then strained and applied directly to the compost pile.

Pests and disease were other topics covered in our interviews. The Nieves farm has issues with Citrus Greening, a fungus that grows on avocados, plantains, lemons, and varieties of oranges. They treat the fungus as best they can by removing diseased branches; however, the tree will die. The farm has not found a solution to this disease but gives extra nutrients to the tree to lengthen its lifespan. Additionally, they have issues with rats, which eat seedlings and the fruit of their trees, mainly bananas. At Finca Noa, pests are a severe issue. They have a wide variety of pests including insects, bugs, rats, iguanas, wild pigs, and even monkeys. They deter insects using natural plant repellents such as oregano, lemon grass, parsley, limoncello, cinnamon, citronella, and neem. Additionally, they place these plants strategically around their nursery. They also use an organic insecticide called *Bacillus Thuringiensis*, BT. Rats are also a major pest that eat seedlings in the nursery and gardens. The farm elevated the nursery plants to protect against the rats. The farm has dogs to help with iguanas that like to burrow in the land and monkeys that eat the plantains. Additionally, when iguanas become a larger issue, the farm uses air rifles to hunt them and lower the population. The most significant issue is the wild pigs in the area that will eat plants and cause the largest mess. Their solution is to feed the pigs on the border of the farm so that the pigs do not eat the plants and ruin the ground. Ian Pagan rotates his crops to minimize the impact of pests during the summer and autumn. Mr. Pagan informed us

that winter is the best time to plant vegetables because pests, especially aphids, are more prominent in summer and autumn. Other pests he deals with are cucumber beetles, rats, and iguanas. He uses neem oil to deter the cucumber beetle and aphids. He hunts, sets traps, and owns dogs to minimize the population of rats and iguanas. Additionally, fungi become an issue during the rainy season. Mr. Pagan sprays sodium bicarbonate to kill the fungus and applies nutrient rich microorganisms to strengthen the plant. He sprays the microorganisms on the plants and the soil. Shirley Cruz informed us that common pests for Puerto Rico are fire ants, mealybugs, croton scale, whiteflies, aphids, and snails. Shirley noticed that since Hurricane Maria pests have worsened in Puerto Rico. For home gardens, she recommends using Neem oil or the insecticide, Aramite, to protect against general pests. She also had some specific solutions to individual pests. To deter mealybugs from plants, spray the plant with water and soap. This is not a perfect solution and does not kill the mealybugs, but is a good home remedy with easy-to-access supplies. For snails, sprinkling the dirt with coffee grounds or salt can kill them. Recently, thrips have been causing issues because they affect bananas and plantains. They can be combated by placing bags around the fruit with pesticides for protection. Ms. Cruz also discussed common types of diseases and fungus, including Citrus Greening, Sigatoka, and rust leaf. Citrus Greening was a recently introduced disease to Puerto Rico. There is no cure for this disease; however, she recommends using micronutrients and fertilizer to extend the lifespan of the tree. Sigatoka, another common fungus, grows on plantain leaves and lowers the production of the plantain but the fruit is still edible. Similar to how Sigatoka effects plantain leaves, rust leaf is common among coffee trees. Both diseases are prevented with a fungicide used by large-scale farms but it is not available for home gardening. Shirley told us that a home remedy to diseases and fungus is trimming infected leaves and branches. It is important to place the tainted leaves and branches into plastic bags and to clean the tools using bleach so that spores do not spread.

Lastly, our expert interviews informed us of two established education programs. The first education program, run by Jacqueline Seijo, has different curriculums for children and adults. Both youth and adult classes included information on composting. The adult class has a whole lesson on composting, complete with a PowerPoint and information on carbon and nitrogen, while the youth class provides a less complex overview of composting. For both classes, they use chicken manure compost and a concentrated liquid compost when planting. Both classes planted vegetables, fruits, herbs, and spices. Her youth classes are taught through the local schools, either during 7th or 8th grade. These classes are built around the project-based learning approach with hands-on examples rather than lectures and PowerPoints. The groups prefer the hands-on approach rather than the information-driven lectures and PowerPoints. One hands-on activity that groups participate in is planting in tires filled with dirt for small controlled beds. Another activity is planting in soda bottles for the children to bring home. This activity also promotes gardening in the home. The adult classes are split into 15 different lectures, each with a PowerPoint supplemented by some type of activity. Each lesson takes three hours and two lessons are taught a day. Ms. Seijo told us that it takes the majority of the lessons before long-term learning occurs for a beginner. She also provided us with the PowerPoints that she uses in her adult classes as well as brochures she hands out throughout the 15 lessons. This information was closely analyzed and shaped our education program for La Plata. The second education program, run by Ian Pagan includes three components from January to June. The first is a theoretical session taught in the classroom using PowerPoints, conversation, videos, documentaries, readings, and scientific papers. The second portion is a hands-on practical at his farm where the students develop a vegetable garden. The third session is an independent study

for 50+ hours at a farm that the student chooses and is approved by the program. The school is in its sixth year and has graduated over 250 students. In addition to the main course from January to June, Mr. Pagan hosts a summer course revolving around animal use, mostly oxen, as well as an autumn advanced agricology course. He also hosts many workshops throughout the year. Mr. Pagan believes that the best way to develop a new generation of farmers is through teaching agricology to young people in a sustainable way.

5: Conclusions/Recommendations

By carrying out the project objectives and analyzing the results our team has made conclusions based on our interviews and growing example that shaped our education program and recommendations. The results of our interviews and growing helped shape conclusions on fertilization, debris disposal, everyday gardening techniques, pests, our education program, the effectiveness of compost and Hügelkultur runoff.

5.1: Conclusions

5.1.1: Fertilization

From our interviews with the visitors at La Plata, we learned that only half of the participants utilized compost as a fertilization and waste disposal method. Composting is a very beneficial gardening practice that supports plant growth, therefore gardeners should take advantage of it. Also, composting is an effective method for disposing of debris. Since only half of the interviewees had compost piles, we concluded that composting needed to be emphasized within our education recommendation to improve food self-sustainability. Additionally, the interviewees with compost piles tended to have a hands-off approach and let the pile sit. From our research, we know this method is not the most effective technique. Therefore, we determined that the community also needs education on the benefits of performing simple composting techniques such as aeration. If a gardener does not wish to make compost, they can buy it. Even though compost can be bought, three experts, Carlos, Carmen, and Ian, informed us that it tends to be of low quality. Thus, it is better to teach the community to create their own compost where they can control the organic materials within it. Our research and results both demonstrated that soil health can be overlooked by gardeners, therefore it may be an issue that needs to be addressed in other parts of the world. Furthermore, along with our interviews, we were able to draw significant conclusions from our growing example.

After recording our data from the growing example, we analyzed the growth patterns of the planted trees, tomatoes, and lettuce. We determined two conclusions about fertilization through our use of traditional compost and runoff from Hügelkultur piles.

The first conclusion was that compost is a good way of providing nutrients to plants, allowing them to flourish. The tomatoes were the best plant to draw conclusions from because of their quick growth rates. They showed significant changes to height, size and color and some plants had flower buds during the last week of data collection. Figure 9 in our results shows that on average, tomatoes planted in beds with compost added grew significantly taller than the control plots. Additionally, beds with compost visually looked the healthiest. These plants were fuller, greener and more mature than plants in control beds. This supports the conclusion that using compost enables plants to thrive, which is also backed by our research that indicated compost is an effective method to improve plant health. Unfortunately, it was difficult to draw conclusions from the lettuce and the trees. The lettuce was in such bad health when planted that the plants did not grow a significant amount. Additionally, the surviving lettuce did not show any health trends. The tree plots were difficult to analyze because of the slow growth rate of the trees. However, trees planted with compost would occasionally double leaf or bud number in just one week, showing growth and improvements in health.

The second conclusion is that “Puerto Rican Hügelkultur” mounds provide nutrient runoff that supports plant growth more than typical soil. Bed E was closest to the Hügelkultur pile, directly receiving runoff with no added compost. Bed E grew taller plants than two of the

four beds with compost added. This was illustrated by the tomato data provided in Figure 9 in our results. Bed E also significantly outgrew the two control plots. However, bed G, which also received runoff and not compost, had height growth that was very similar to the control plots. Visually, it was in better health than the control plots but was not as healthy as beds that received compost. This shows that debris runoff was not as effective as compost. Bed E could have grown better than bed G because it was closer to the Hügelkultur pile, indicating that distance could be a limitation for nutrient runoff. Results for the effectiveness of Hügelkultur runoff were mixed; however, it is clear that plants that received this runoff were better off than plants grown in unassisted soil. We were only able to collect data for four weeks. More data on height and fruit yield from future months would draw more concrete conclusions about how these types of fertilization affect different stages of a plant's life.

5.1.2: Daily Gardening Techniques

We concluded that based on our interviews, weeding and watering are important factors for maintaining the overall health of a garden. Additionally, as a result of information obtained in our interview, we understood watering and weeding were essential daily procedures. Also, through our time in Puerto Rico, we learned that elevated beds do not retain water that well. The intense heat and sunlight of the Puerto Rican climate quickly dry the soil within garden beds. Also, according to our research, we learned this to be true in other areas of the world as well. In both tropical climates and areas with extreme heat, hydration becomes difficult and puts strain on crops. Therefore, it can be concluded that devising appropriate watering plans and methods is crucial for steady crop production. Lastly, we also concluded that plants, especially tomatoes need support as they get taller. Depending on the plant, we learned from research our interviews, and personal experiences that certain plants like tomatoes need to be staked for support as they get taller to prevent stalks dropping and snapping. Also, our team concluded that people had some difficulties with obtaining garden materials. While not every interviewee, there was a fair amount that had trouble obtaining materials needed to garden day-to-day. As found from our interviews, one problem Puerto Rico experienced was the inability to obtain tools. A great example was Ian Pagan and Jasco Bravo. Ian had a very well put together farm; however, his resources weren't entirely perfect and he expressed how it would be easier to have a tractor. This is something he is working toward. Depending on the magnitude of the garden, our team understands that materials, especially heavy equipment can be needed. Furthermore, depending on the circumstance we concluded that in order to start, maintain, and have a successful garden, materials of all kinds may be necessary.

5.1.3: Debris Disposal

During the interviews, we collected information on various methods of debris disposal. We determined that piling large quantities is an efficient method of disposal that benefited home gardening. Ideally, community members could shred their debris and use it for composting, but the interviews demonstrated that the equipment is not available. Piling the debris is an option that supports home gardening because the wood will decompose into nutrient-rich material and could provide runoff to plants. Piling debris may not supply plants with as many nutrients as true Hügelkultur, but it is an adequate way to utilize space, save time, and provide some, if any, nutrient runoff for those with limited resources. Also, it can be an effective method of debris disposal for those with limited resources because it is easy to perfromed and requires much less work. One downside to piling is that it provided shelter for iguanas, which may cause problems

if it is near a garden. Piling is a unique method that did not appear in our research. Many of the methods that we researched could not be implemented due to many restrictions, therefore piling is an effective debris disposal method in Puerto Rico. If any other nation or community has similar problems with debris disposal after a severe storm, they may use piling to deal with debris.

5.1.4: Pests

Due to the overwhelming percentage of both our expert and local interviewees dealing with pests, we have come to the conclusion that pests are a major threat to local agriculture. Green iguanas were the most common pest with 11 of our 21 locals, and all three expert farmers we interviewed, citing them as a significant nuisance. Following the interviews, we concluded that there are multiple methods to deal with the iguana. Through the results, we have concluded that dogs, hunting, and chicken wire are effective ways to stop them from attacking garden beds.

Additionally, we drew conclusions on iguana pest control through our experiences with the growing example. We implemented several prevention systems in order to prevent the iguanas from damaging the garden beds. The first system consisted of stringing wire around the beds and hanging cans from the wire, which was moderately successful. We saw the system work, as well as fail. The addition of CDs, later on, did not seem to make a difference in the effectiveness of the hanging can system. We concluded that hanging cans around a garden bed works, but is not entirely reliable. The addition of chicken wire was incredibly effective. After adding the wire to Bed E, the constant attacks stopped almost immediately. We concluded that chicken wire is the best way to prevent iguanas from attacking home garden beds. Following the suggestion from the experts at Finca Noa, we decided to integrate a natural repellant into our garden beds. We planted oregano in Bed H, which received irregular attacks. After planting the oregano, the beds were not attacked for two weeks but then was attacked directly in front of the plant. Therefore, we concluded that the oregano as an iguana repellent is mildly successful.

Our research also showed that iguanas were a prominent pests within Puerto Rico and are invasive in other areas in North and South America. These methods of iguana prevention may be beneficial to gardening in areas where they are an issue. In other parts of the world, barriers similar to chicken wire can be used to prevent larger animals from entering the garden and damaging beds or eating plants (Windbiel-Rojas, 2014).

The second most common pest were insects of various types, including caterpillars, worms, and whiteflies. Parasites, rats, mice, fungus, birds, and even snails are all threats to agriculture. As for insects, crushing and removing them works to stop their effects. Additionally, we concluded that Neem oil is an effective repellent that can deter insects from gardens. Our expert interview with Shirley Cruz was our main source of knowledge on pests. Due to her answers, we concluded that Neem oil is the most effective natural repellant to add to home gardens. By spraying the oil on the plants, it can deter insects and prevent them from spreading fungal or bacterial infections. Insects are common pests throughout the world, but there are different types. While insects vary, natural repellents and insecticides are still two effective ways to deter them. Therefore, other education programs need to determine local insects and how to repel them.

5.1.5: Education Program

Lastly, the interviews revealed some important information on the education program, which we used to deduce several conclusions. We discovered that many of the community

members were interested in participating in a home gardening education program. Due to the willingness to attend the class, we determined that the class would be very beneficial for improving home gardening within the area. Also, the interview data demonstrated that the community members preferred a hands-on class structure with a brochure. Using this data, we concluded that the education program needed a focus on being hands-on while providing a brochure as a take-home reference for gardening methods. Along with our interviews, our research indicated hands-on activities are a useful method of learning. The contents of the education program should be tailored to the environment and climate. Additionally, it can be said in this case, and in others across the world, that hands-on learning is useful for teaching agriculture because it gives first-hand, real-world experience to gardening in that specific location (Chiep, 2013). Even though the community members preferred this structure, we incorporated a PowerPoint presentation because they were used by both Jacqueline Seijo and Ian Pagan. Additionally, our research showed that they are effective methods of conveying information. The PowerPoint needed was short and concise to ensure it was not the main focus of the education program. Similar education programs can be set-up in other parts of the world to educate people on home gardening, therefore improving food self-sufficiency.

Based on the results of the interviews, our team concluded that pest control, composting, and eco-friendly practices needed to be emphasized in our education program in order to improve home gardening and food self-sufficiency within the community surrounding the La Plata Wildlife Refuge. As seen in the results, many interviewees did not use pesticides to prevent insects from eating leaves or crops. Many of them did not use chemical pesticides either. In order to improve plant health and crop yield, we incorporated the benefits of applying organic pesticides and natural repellents to deter or kill the insects within the education recommendations. We also added information on basic gardening practices and techniques aimed for beginners, such as bed creation, planting, and maintenance, but did not need a greater emphasis within the program due to most interviewees having this basic knowledge.

5.2: Limitations

The trees we were presented with at the beginning of our time at La Plata were in varying degrees of health. Many plants of the Pendula (*Citharexylum Spinosum*) species appeared to be dead or close to dead during planting. We were unable to guarantee that each sapling would survive and perform to the best of its ability. We were also unable to perform a control experiment due to the fact that La Plata and the DRNA needed as many trees to survive as possible. Another limitation of these conclusions is the time span of the experiment. This was a limiting factor of both lettuce and tomato, but was especially significant when looking at the trees' gradual growth rates. Also, the compost was created prior to our arrival, therefore we were unsure about the makeup of the compost, which could have negatively influence our growing experiment. Additionally, we would have calculated growth rate on the plants to determine the effectiveness of compost and nutrient runoff, but the health variation, short time frame, and human error made growth calculations too varied to use as an overarching conclusion. We encountered two limitations during interviews due to the need for a translator to conduct some of the interviews. The main limitation was that the translator may have left out important statements while dictating the conversation. Also, requiring a translator for interviews caused scheduling issues where we waited for him, thereby wasting time and slowing productivity.

5.3: Global Issue

Supply chain breaks, lack of gardening knowledge, and food-self sufficiency are problems all across the world. Food is an essential need for people in every part of the world. People depend on food through an imported network, and when that network is cut off, it becomes problematic for people. Supply chain breaks are a real-world problem that is not just central to what we saw in Puerto Rico.

For our project, we concluded that in the event of a supply chain break, a viable option for communities to survive until networks start working again is to implement home gardening. In addition, our project dealt with the problems facing Puerto Rico in the wake of Hurricanes Irma and Maria. However, the project can be applied to more than just Puerto Rico. The program that we conducted, attempting to plant within the local climate, and gathering information from experts in their craft, can be applied anywhere in the world. The basics of gardening are the same all around the world. Watering, weeding, and good soil will lead to a successful plant, regardless of where in the world the seed is planted. However, not all climates are the same, and techniques from local gardeners change all over the world. By gardening in the local area, we were able to come up with our own solutions to local problems that plague the area, like the iguanas. By identifying gardening issues and methods in other parts of the world, new ideas that may not have been considered by locals can be created. By interviewing the experts in the area, we were able to gather information on the tried and true methods that are used in Puerto Rico. By interviewing local experts anywhere in the world, practical knowledge for that area can be gained. If the experience of growing and the local knowledge is combined into an education program, it can be used to teach others how to plant successfully.

By spreading this information in Puerto Rico, we hope to make the locals in the La Plata area less reliant on the agri-food supply chain. We believe following our objectives and implementing this system around the world, can make people food self-sufficient. The issue of food self-sufficiency is bigger than just Puerto Rico. This problem extends to all communities. With the implementation of our project on a grander scale, we feel that communities suffering from breaks will have fewer issues and more productivity in all areas of the world.

5.4: Recommendations

Our team has developed several recommendations that we believe will help make the community surrounding the La Plata Wildlife Refuge more food self-sufficient. We have also developed the framework for an education program that we believe Marinelly Valentin-Sivico can use to further aid La Plata's visitors in home gardening. Our time at La Plata has been extremely beneficial and the conclusions that we have reached during our time there provide an interesting insight into how to set up and maintain an effective home garden in a tropical environment.

5.4.1: Hügelkultur/Traditional Compost

For our example, we decided to test various saplings and seedlings in soil, with and without Hügelkultur compost. After data collection and analysis, our group has decided on a variety of recommendations in terms of the application of Hügelkultur and traditional compost. Traditional composting is still the most effective form of added nutrients. However, our team recommends that those trying to remove debris and obtain the most growth from their respective gardens use true Hügelkultur because planting directly in the mounds will provide more nutrients than runoff.

Additionally, we suggest La Plata's version of Hügelkultur for certain special circumstances. Piling is perhaps more feasible for people with fewer resources that are dealing with extensive amounts of debris and no way of disposal. After Hurricanes Irma and Maria, debris disposal was at the forefront of problems facing Puerto Ricans. Many Puerto Rican citizens used piling as their main method of debris disposal. In the event of a severe storm, piling aids in clearing unwanted debris when resources are limited while also helping gardening. Improved gardening can help people become more food self-sufficient for an extended period of time when the food supply chain is cut off.

If a gardener decides to use the piling method, our team has several recommendations for plant spacing and placement. These gardening practices are necessary for overall health and nutrient runoff. After conducting our experiment, for the lettuce, tomatoes, and trees, our group recommends planting with the natural slope of the land, and downhill from the debris pile in order to provide nutrient runoff to the plants. Also, we suggest planting a foot apart between lettuce and tomatoes, and approximately eight feet apart between trees in order to provide plants with plenty of room to grow especially as they get larger.

Lastly, our next primary recommendation is using traditional compost. For Hügelkultur or piling, if proper spacing and placement is applied, our group recommends the addition of some type of traditional compost. Compost, rich in carbon and nitrogen, is very important for plants and aids in overall growth, especially if the soil lacks nutrients. Compost is very beneficial for overall plant health and should be added to the soil when planting. Additionally, we recommend that gardeners create their own compost because it is very cost effective.

5.4.2: Maintenance/Hydration

After completing our growing example, our group has some final recommendations for our tomatoes, lettuce, and trees. For tomatoes and lettuce, we recommend that they are watered twice a day, every day. Watering will also depend on the amount of rain the area is getting. Tomatoes require a lot of water as we learned from our sponsor. It is our understanding that if you wish to see good growth, proper hydration is imperative. For lettuce beds, we recommend the same system. It is important to water your lettuce well and twice a day. We highly recommend these tasks, for both lettuce and tomatoes, as they are essential for plant health and growth.

Furthermore, we also recommend digging moats around garden beds in order to retain water. These moats will keep beds moist during the dry season. Finally, we also recommend adding leaves around your garden beds in order to retain moisture in the beds. Leaves retain water very well, keep the soil cooler and are another small but effective way to keep beds hydrated.

Lastly, we recommend heavily watering the trees once a day. Trees retain water better than smaller plants but still require daily watering during the drought season. Additionally, we also recommend putting leaves around each individual tree. Just like for the tomatoes and lettuce, leaves are good for anything that needs water and moisture.

5.4.3: Pest Control

Based on the results from the interviews with community members and expert gardeners, we determined that pests were the main issue involved with gardening in Puerto Rico. These pests included insects and iguanas. Additionally, the interviews and previous research provided multiple methods to deter these pests.

5.4.4: Iguanas

Green iguanas are a common pest and major problem. We discovered five methods of deterring iguanas, which are chicken wire, owning dogs, hunting, natural repellents, and hanging cans and CDs. Two main methods, used by both local and expert gardeners, were owning dogs and hunting them. These methods produced the best results, but involve harming iguanas, which may not be appealing to some gardeners. First, we recommend the can and CD method for those seeking an easier and less expensive solution. However, gardeners using cans and CD's should expect only moderate success. Another recommendation is to use chicken wire as a primary deterrent because it has the most success in our gardens. We realize this method is not financially plausible for everyone. We recommend that the ultimate goal for gardeners should be to move towards chicken wire when they can afford it. Gardeners should focus on problem areas then purchase more in the future. If iguanas are damaging a community member's home garden, we recommend they choose one of the five methods listed. If the gardener wants to use natural repellants, then we recommend using oregano.

We also believe that changing the perception of iguanas as inedible may be the best way to curtail the pest's population as a whole. A study in Bonaire and Curaçao showed that lionfish, a notorious, invasive pest, was affected by in "invasivorism," the movement that explores the idea of stopping invasive species by eating them. Lionfish biomass was 2.76 times lower in areas of Bonaire where harvesting is encouraged, than in areas of Bonaire where harvesting is not implemented. Curaçao numbers are even better with lionfish biomass being 4.14 times lower in harvested areas (Snyder, 2017). We recommend that Puerto Ricans try to eat the iguanas. According to National Geographic, their meat is lean and healthy and easy to cook ("Hunting and Eating Invasive Iguanas," 2015).

5.4.5: Insects

Insects were another pest regularly mentioned as affecting the performance of home gardens. Some commonly mentioned insects included flies and caterpillars. Based on the information received from our interviews, we recommend that gardeners use pesticides such as neem oil and *Bacillus Thuringiensis* (BT), and natural repellents that include oregano, lemongrass, parsley, citronella, and the neem plant (Peraz, Bond, Buhl & Stone, 2015). Planting these natural repellents have other uses such as spices and medicines.

5.4.6: Environmentally Conscience Decisions

We recommend that gardens reuse waste or other materials when creating garden beds. When we visited Finca Noa, we discovered some sustainability practices that involved reusing tires and old refrigerators to create raised garden beds. Raised garden beds are beneficial by creating a barrier from weeds and pests, provide good drainage, and less soil compaction (Patterson, 2016). We witnessed these materials abandoned on the roadside, therefore community members have access to them. Re-using these materials helps reduce the waste in landfills while reducing the eyesore of trash on the roads.

5.5: Education Program

In order to teach the local community about important gardening techniques and methods, we suggest that La Plata utilize the example PowerPoint, lecture, and brochure provided in Appendices G through J. If La Plata decides to not use the provided education

materials, we recommend that they still address the common topics of bed creation, seed germination, soil health, composting, transplanting, pest control, eco-friendly gardening, and basic maintenance. Additionally, with Jacqueline Siejo and Ian Pagan's permission, we recommend that La Plata provides information to students about the two gardening classes that they run including contact information and times of classes. Both Ms. Siejo and Mr. Paganhost classes that are held in sessions, which La Plata is not set up for currently.

5.5.1: Lecture and PowerPoint

Following interviews with experts, we learned that it is necessary to provide locals with the basic knowledge and information to fully appreciate the recommendations given. The lecture should be brief enough to not bore younger audience members but detailed enough so that the finer points of gardening will be understood. The experts we spoke with all ran their classes over multiple days; however, the class at La Plata would only be a one-time event. Therefore, the information needs to be substantial enough to be retained by the audience. We recommend that the lecture be roughly 10-15 minutes with a focus on maintenance, debris disposal, fertilization, pest control, and eco-friendly gardening. The group has provided a basic PowerPoint lecture covering the aforementioned topics that we believe would be useful to the local community. The DRNA and La Plata are welcome to use the materials to teach their class and advance local food self-sufficiency.

5.5.2: Hands-On Activities

An important portion of the education program that students will experience at La Plata is hands-on examples. Similar to how we learned that Jacqueline Seijo builds her classes around the project-based learning approach, we have designed three hands-on activities to complement the rest of our education program. These activities are designed to introduce students to common gardening practices and techniques where beginners can develop gardening skills. The three activities are "Bean in a Bag," "Seed in a Cup," and "Planting within a Garden Bed at La Plata." Directions for these activities can be found in Appendices I, J, and K. "Bean in a Bag" is tailored toward allowing the students to see plant growth in a short period through seed germination. Additionally, the "Seed in a Cup" activity was designed to maximize the students' knowledge of plant growth through a small growing example using soil within a cup. Finally, "Planting within a Garden Bed at La Plata." is simply an activity allowing the students to have a first-hand experience of small scale gardening. Each of these activities varies in required materials and purpose, but accomplish our end goal of promoting food self-sufficiency through educating the community. We recommend that La Plata utilizes at least one hands-on activity per education session for both youth groups and adults.

5.5.3: Brochure

We recommend to include a brochure for students to bring home to further their education process. The brochure supplements the PowerPoint lecture and hands-on activity. The brochure can be found in Appendix H. The main limitation with the brochure was that a sizable amount of useful information could not be added to keep it concise and appealing to the reader. Additionally, the brochure was translated from English to Spanish. We used a standard 8.5 by 11-inch piece of paper to create a double-sided, trifold brochure in order to keep the information concise and the printing cheap. It briefly mentions the importance of home gardening and touches on a broad overview of basic gardening techniques. It includes sections on bed creation,

fertilization, compost, transplanting, maintenance, and suggestions for plants to grow and harvest. The brochure goes more in-depth with compost, pest control, and eco-friendly gardening. Hopefully, the brochure will allow the students to look back and refer to specific information that will improve their garden.

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Appendix A - La Plata Visitors Interview Questions

Introduction

?Hablas ingles?

Hello, I am (state names),

We are students from WPI, a college in the United States, who are here to conduct research about home gardening in Puerto Rico. We are interested in learning about how communities utilize home gardens, their gardening strategies, and any difficulties they may have with gardening. If you are willing, can we ask you a few questions?

Questions (In English)

1. Where are you from?
2. What brought you to La Plata?
3. Where do you get your food?
4. Do you have any experience gardening?
5. Do you have a home garden?
    a. Do you grow food or other types of plants in your home garden?
        i. What do you grow?
    b. How do you maintain your garden throughout the season?

.How much time do you spend maintaining your garden?

c. How did Irma and Maria effect your home garden?

.How did you get rid of the debris that it caused?

6. What is your knowledge of fertilization?

. Do you know about its benefits?

a. What methods of fertilization do you use?

b. Do you know about composting as a fertilization technique?

.Are you using it and how?

1. Do you know any benefits of gardening?
2. How much time are you willing to spend on your garden?
3. How much money are you willing to spend on your garden?
4. Do you have enough space to grow?
5. Do you experience any difficulties with your garden?
    1. Do you experience any growing difficulties?
    2. Do you have a tough time obtaining gardening resources?
        1. I.e. Fertilizers, Gardening Tools/Equipment, Insecticides, Pesticides, Saplings, Seeds and Seedlings

1. There are classes at the La Plata Wildlife Refuge for the community to participate in covering “fishing and YZ”.
    1. Have you participated in any classes at the La Plata Wildlife Refuge?
    2. Are you interested in taking any classes at the La Plata Wildlife Refuge?
2. Our team is going to be creating an educational program to teach the community about composting and home gardening.
    1. Would you prefer to learn about home gardening through a class at the La Plata Wildlife Refuge or reading a brochure? Would you like a combination of both? Are there any other methods that you would recommend?
        1. In a class, would you like to see examples or take a hands-on approach?
        2. Would you be able to understand a class in English?

Introduction

?Hablas ingles?

¡Hola! Me llamo (State Names)

Somos estudiantes de WPI, una Universidad en los Estados Unidos, Estamos aquí para realizar investigaciones sobre jardinería doméstica en Puerto Rico. Estamos interesados en aprender sobre cómo las comunidades utilizan huertos caseros, sus estrategias de jardinería, y las dificultades que muchos tienen con la jardinería. Si usted está dispuesto, ¿podemos hacerle unas preguntas?

Questions (In Spanish)

1. ¿De donde eres?
2. ¿Qué te trae a la plata?
3. ¿de dónde sacas la comida?
4. ¿Tienes experiencia en jardinería?
5. ¿Tienes un jardín en casa?

a. ¿Cultiva alimentos u otro tipo de planta en el jardín de su casa?

i.¿Qué es lo que cultiva?

b. ¿Cómo mantienes tu jardín durante toda la temporada?

.¿Cuánto tiempo pasas manteniendo tu jardín?

c. ¿Cómo efecto Irma y María su jardín casero?

.¿Cómo deshacerse de los escombros que causó?

6. ¿Cuál es su conocimiento del compost?

. ¿Conoce sus beneficios?

a. ¿Qué métodos de fertilización utiliza?

b. ¿Conoces el compostaje como técnica de fertilización?

.¿Lo estás llevando a cabo y cómo?

1. ¿Conoces algún beneficio de la jardinería?
2. ¿Cuánto tiempo estás dispuesto a gastar en tu jardín?
3. ¿Cuánto dinero estás dispuesto a gastar en tu jardín?
4. ¿Tienes suficiente espacio para cultivar plantas?
5. ¿Experimenta alguna dificultad con su jardín?

a. ¿Experimenta alguna dificultad creciente?

b. ¿Le resulta difícil obtener recursos de jardinería?

i.I.e. fertilizantes, equipos de jardinería, herramientas de jardinería, insecticidas, pesticidas, árboles, semillas y plántulas

1. Hay clases en el refugio de vida silvestre de la plata para que la comunidad participe en la cobertura de "pesca y YZ".

a. ¿Ha participado en alguna clase en el refugio de vida silvestre de la plata?

b. ¿Está interesado en tomar clases en el refugio de vida silvestre de la plata?

2. Nuestro equipo va a crear un programa educativo para enseñar a la comunidad sobre el compostaje y la jardinería doméstica.

. ¿Preferirías aprender sobre jardinería doméstica a través de una clase en el refugio de vida silvestre de la plata o leyendo un folleto? ¿Quiere una combinación de ambos? ¿Hay algún otro método que recomiende?

i.En una clase, ¿le gustaría ver ejemplos o adoptar un enfoque de práctica?

ii.¿Serías capaz de entender una clase en inglés?

Appendix B - Expert Interview Questions

Introduction

- WPI Students
- Goal is to promote food self-sufficiency in the area using home gardens
- Conducting a growing experiment in the La Plata Wildlife Refuge
- Interested in local gardening techniques, strategies, and implementation

Topics to Touch On

1. Composting/Fertilization
2. Crop/Plant Selection
3. Gardening Materials
4. Maintenance

a. Weeding
b. Pests/Animals

5. Plant Placement
6. Watering

. Drainage

Questions

1. How big is your garden?
2. What plants do you grow? - Scientific name?

a. Do you grow them as seeds or buy seedlings?
b. Is there an advantage to growing these types of plants?

3. Plant Placement

. What is the typical spacing between plants on your farm?

i.Why do you space in this way?

4. How much time do you spend in your garden each day?
5. What gardening materials do you use for gardening?

. Where do you buy these materials?
a. What gardening materials are difficult or easy to obtain?
b. I.e. Fertilizers, Gardening Tools/Equipment, Insecticides, Pesticides, Saplings, Seeds and Seedlings

6. What type of composting do you use?

. How do you get the compost? I.e. do you make it or buy it?
a. What is in the compost?
b. How do you apply the compost?
c. How do you dispose of your debris? Leaves, sticks, tree trunks, etc.

7. What maintenance of the garden, beds, gardening tools, etc. do you perform?

. What tools are used for this maintenance
a. What pests, either insects or animals do you have to protect against?

.How do you protect against these pests?

b. How do you ensure that weeds don't take over?

.How do you prevent weeds?

i.How do you remove weeds?

8. How do you water on a day to day basis?

. Do you have an irrigation system in place?
a. Do you have a drainage system in place?
b. Do you have measures to protect against overwatering and underwatering?

c. How do you retain moisture in the soil? Especially during the dry season.

9. Do you have any specialized gardening techniques that are specific to the Caribbean, Puerto Rico, your agri-center or your land/soil?

. Do you take precautions when a hurricane is going to hit Puerto Rico?

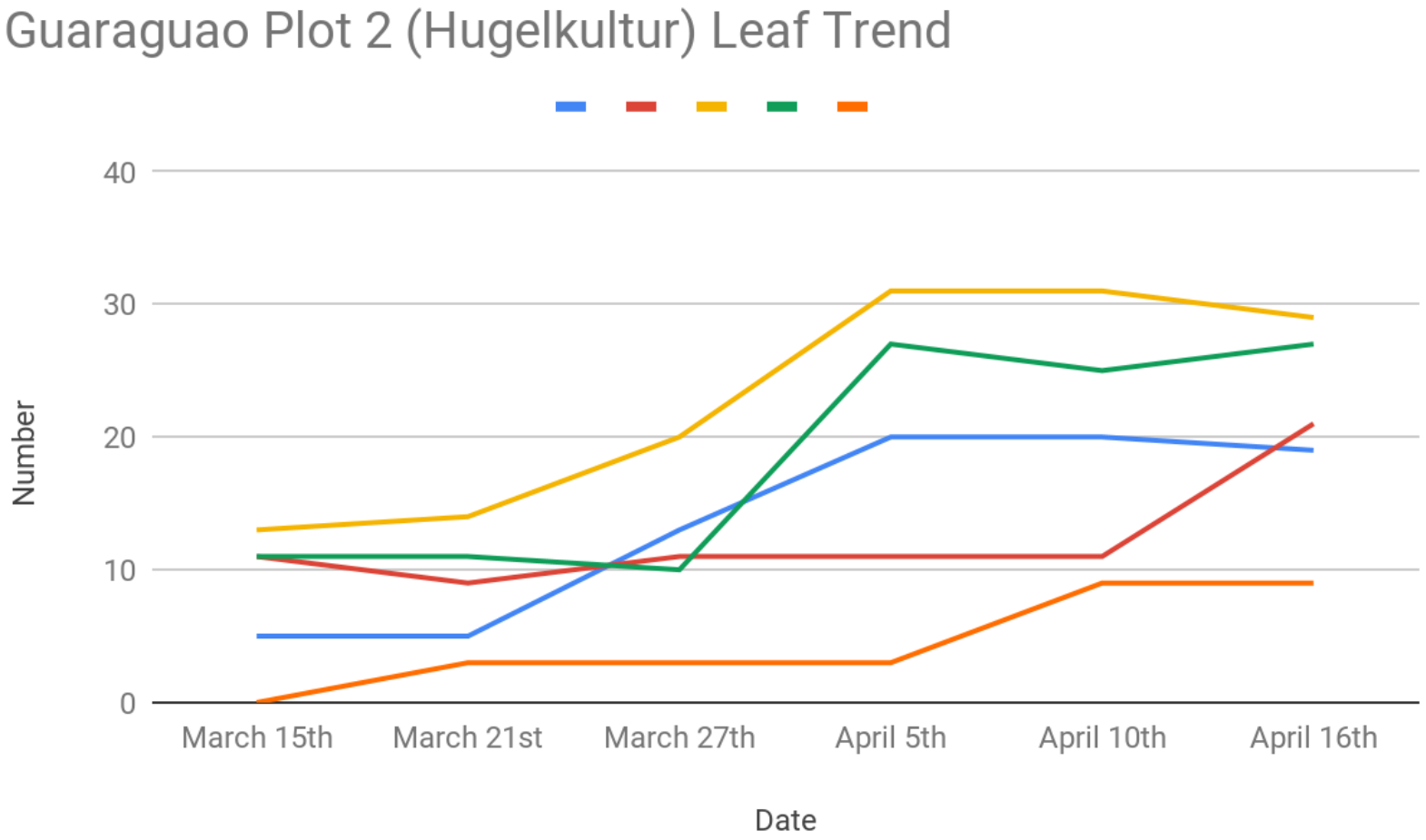
.Fortification, moving vulnerable/valuable plants, ordering extra seeds, etc.

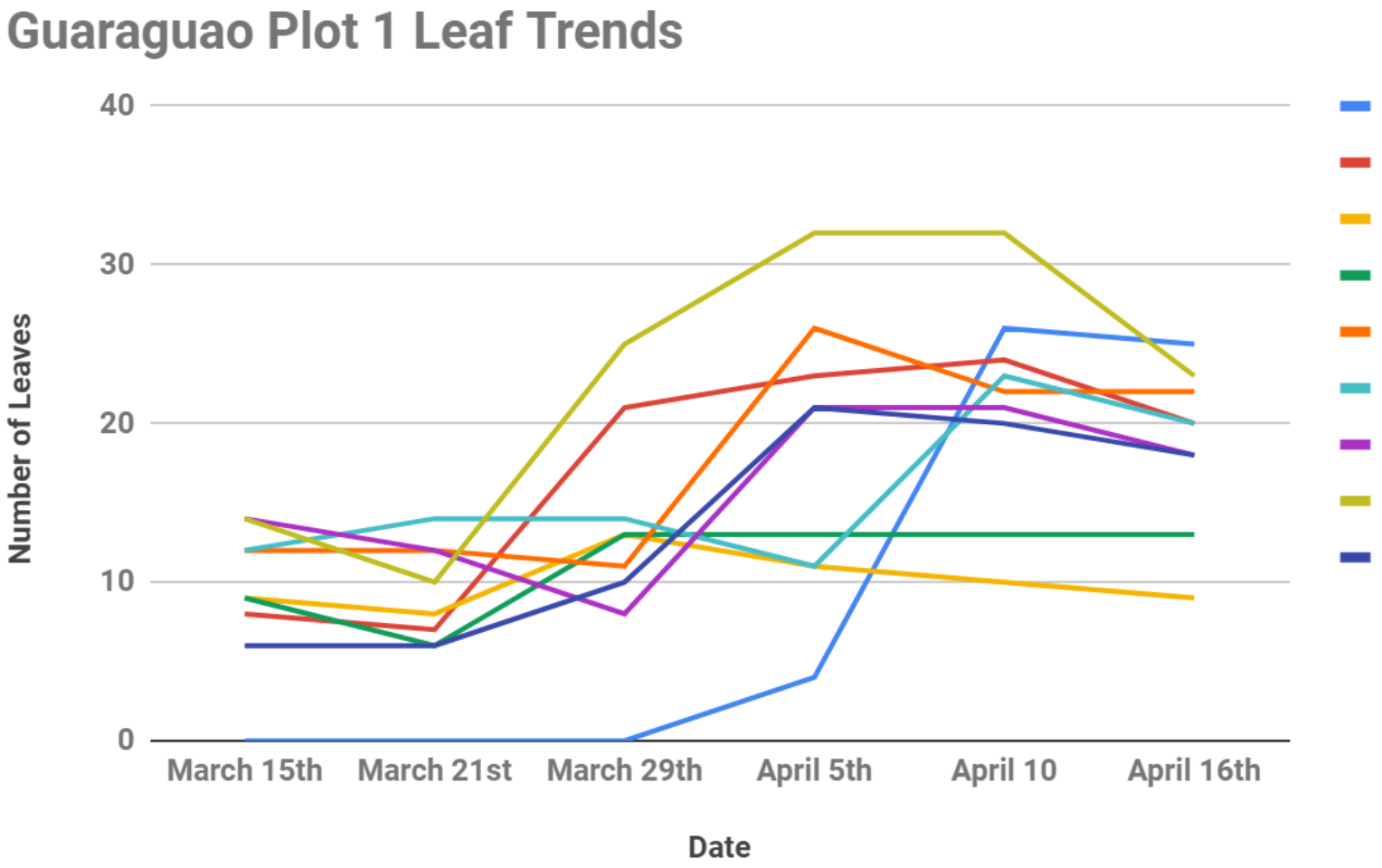
a. How did you deal with the effects of Hurricanes Irma and Maria?

Appendix C - Tree Data

Guaraguao Plot 1

	Dates	March 15th	March 21st	March 29th	April 5th	April 10	April 16th
1	Leaves	0	0	0	0	2	15
	Buds	0	0	6	4	10	5
	Sprouts	0	0	1	10	4	4
	Other comments	Short, all leaves spotted/eaten	none	Small webbing (spider/caterpillar)	spider web	1 leaf eaten; overgrown with weeds	1 egg sack pulling 2 leaves together
2	Leaves	0	0	0	4	26	25
	Buds	4	6	20	14	14	8
	Sprouts	0	2	8	6	8	12
	Other comments	Short	none	1 spider	4 eaten/spotted; web	4 eaten	8 spotted/eaten
3	Leaves	8	7	21	23	24	20
	Buds	3	0	2	4	3	3
	Sprouts	0	3	2	3	3	2
	Other comments	2 leaves eaten; mosquito	2 empty branches	9 leaves eaten	16 leaves spotted/eaten	15 spotted/eaten	fly/18 eaten
4	Leaves	9	8	13	11	10	9
	Buds	0	1	0	3	1	2
	Sprouts	2	1	1	3	2	3
	Other comments	No bugs	3 spotted	No Comment	6 spotted/eaten	2 spotted/eaten	6 spotted/eaten
5	Leaves	9	6	13	13	13	13
	Buds	1	10	0	3	1	3
	Sprouts	2	4	2	1	2	3
	Other comments	5 leaves eaten	5 leaves eaten	2 leaves eaten	5 spotted/eaten; spider web	6 spotted/eaten	9 eaten/ spotted
6	Leaves	12	12	11	26	22	22
	Buds	2	1	1	3	2	2
	Sprouts	1	1	2	2	1	1
	Other comments	9 leaves eaten/spotted	all eaten/spotted	9 leaves eaten/spotted	16 spotted/eaten	2 eaten/ spotted; 1 spider	13 spotted/eaten
7	Leaves	12	14	14	11	23	20
	Buds	2	1	2	3	3	4
	Sprouts	1	1	1	3	1	4
	Other comments	7 spotted	6 spotted/eaten	8 leaves eaten/spotted	8 eaten/spotted	2 eaten	7 spotted/eaten
8	Leaves	14	12	8	21	21	18
	Buds	2	2	18	4	3	4
	Sprouts	0	1	3	4	1	3
	Other comments	5 L eaten; 11L w/ spots	11 eaten/spotted	1 spider, buds almost leaves	7 eaten/spotted	4 eaten	3 eaten/ 1 web
9	Leaves	14	10	25	32	32	23
	Buds	1	4	2	3	3	1
	Sprouts	0	15	3	3	3	2
	Other comments	1 spider web; 1 spider, 10 eaten	severe damage to six leaves (eaten)	4 leaves eaten	7 eaten/spotted	5 spotted	2 spotted/ eaten
10	Leaves	6	6	10	21	20	18
	Buds	1	1	2	2	3	3
	Sprouts	1	2	1	2	2	0
	Other comments	all spotted or eaten	all spotted/eaten	6 new leaves, caterpiller web	10 spotted/eaten	4 spotted/eaten	2 spotted/eaten

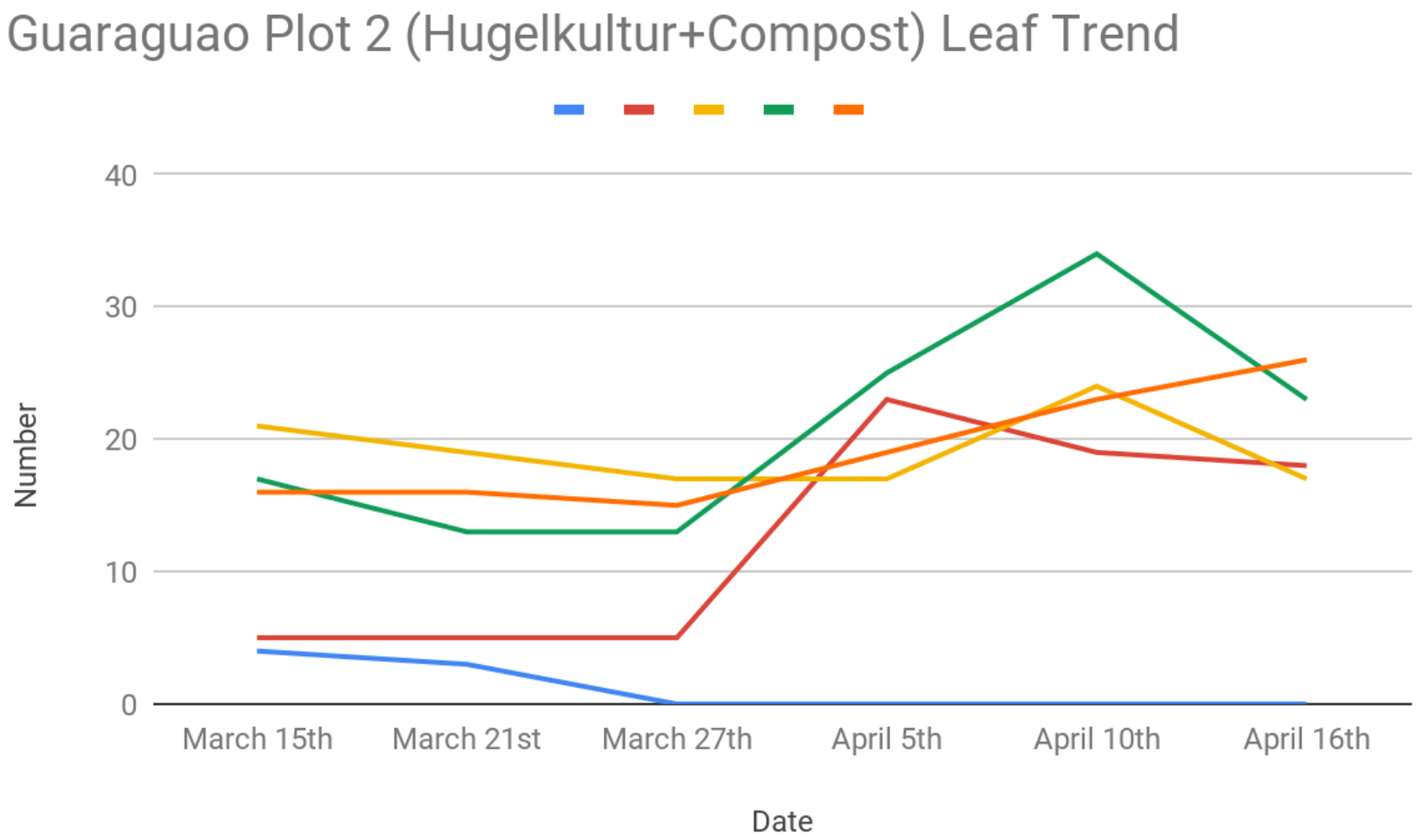

Guaraguao Plot 2 (Hugelkultur) Leaf Trend
40
30
20
10
0
Number
March 15th
March 21st
March 27th
April 5th
April 10th
April 16th
Date


Guaraguao Plot 1 Leaf Trends
40
30
20
10
0
Number of Leaves
March 15th
March 21st
March 29th
April 5th
April 10
April 16th
Date

Guaraguao Plot 2

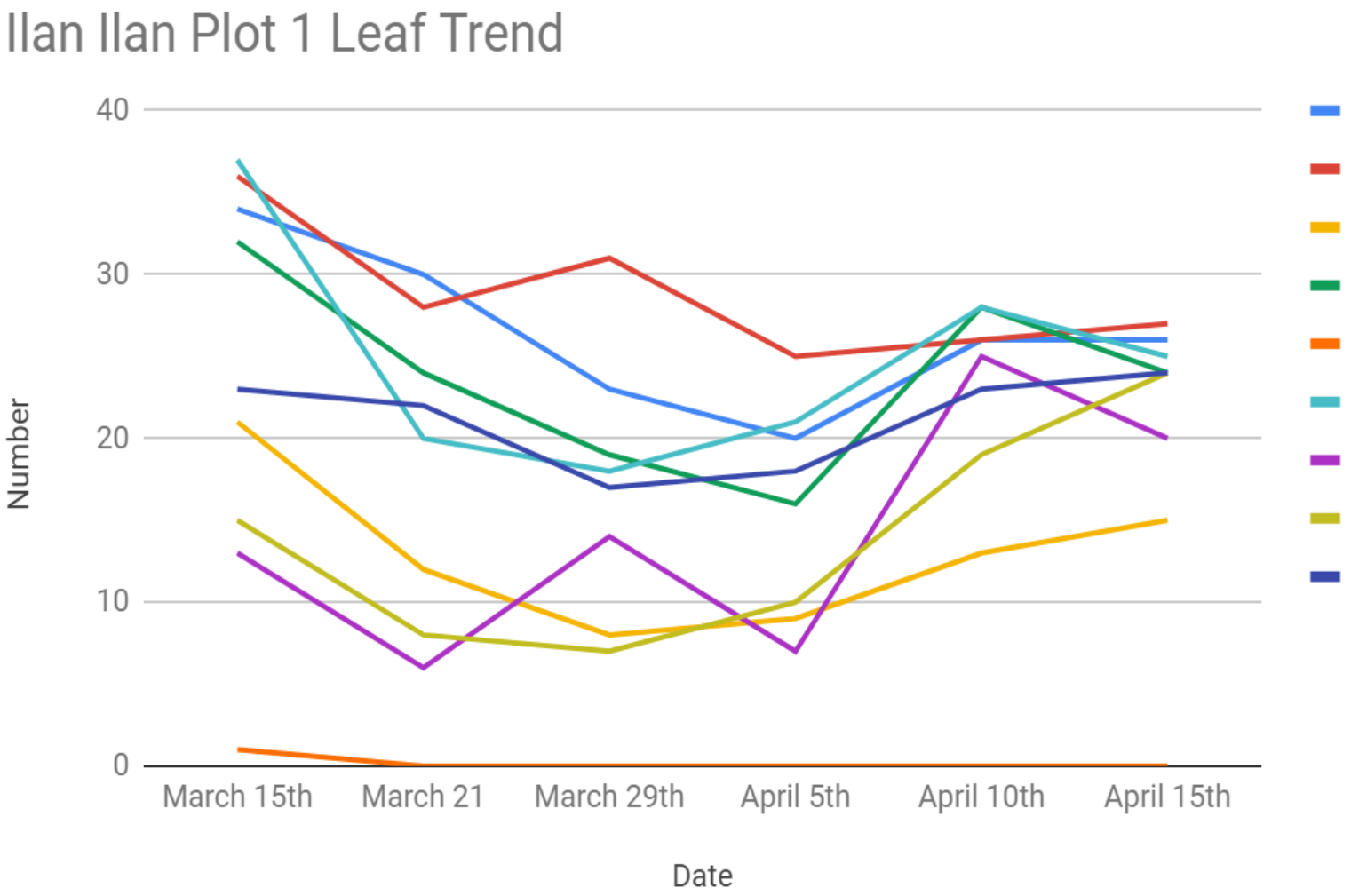
	Dates	March 15th	March 21st	March 27th	April 5th	April 10th	April 16th
1	Leaves	5	5	13	20	20	19
	Buds	0	0	1	2	2	2
	Sprouts	0	2	1	1	0	0
	Other comments	all leaves spotted or eaten	2 leaves eaten, 5 spotted	5 leaves spotted	4 spotted	7 spotted	6 spotted
2	Leaves	4	3	0	0	0	0
	Buds	0	1	Tree ripped up	Tree ripped up	Tree ripped up	Tree ripped up
	Sprouts	1	2	by iguanas	by iguanas	By iguana	By iguana
	Other comments	all leaves eaten or spotted	3 leaves eaten				
3	Leaves	11	9	11	11	11	21
	Buds	1	1	0	2	10	4
	Sprouts	1	2	0	2	2	3
	Other comments	3 leaves spotted or eaten	1 leaf with spots	11 leaves spotted	2 spotted	2 spotted	2 spotted
4	Leaves	13	14	20	31	31	29
	Buds	1	2	10	4	4	4
	Sprouts	2	2	3	0	0	0
	Other comments	6 leaves spotted/eaten	5 leaves eaten	4 leaves eaten	5 eaten	4 eaten/spotted	2 spotted, 4 eaten
5	Leaves	5	5	5	23	19	18
	Buds	1	0	1	2	2	2
	Sprouts	0	1	2	2	1	0
	Other comments	2 spotted/eaten	3 leaves spotted	4 leaves spotted	6 spotted	1 spotted, almost empty branch	1 spotted
6	Leaves	11	11	10	27	25	27
	Buds	1	0	0	3	3	3
	Sprouts	0	2	3	1	1	1
	Other comments	7 leaves spotted/eaten	7 leaves spotted	7 leaves spotted	6 spotted	6 spotted, leaves are growing	Fungus growing on 23 leaves
7	Leaves	0	3	3	3	9	9
	Buds	1	0	1	8	3	2
	Sprouts	1	1	0	2	1	1
	Other comments	no bugs	"healthish" - moderately healthy?	1 leaf eaten	1 eaten	1 eaten	Healthy
8	Leaves	21	19	17	17	24	17
	Buds	1	0	1	10	2	2
	Sprouts	1	2	2	2	1	1
	Other comments	7 spotted/eaten	6 leaves spotted	8 leaves eaten/spotted	8 spotted	9 spotted	10 spotted
9	Leaves	17	13	13	25	34	23
	Buds	2	2	1	9	3	3
	Sprouts	0	0	2	4	1	1
	Other comments	5 leaves spotted/eaten	3 leaves spotted, 1 eaten	4 leaves spotted	5 spotted, 1 empty, 1 web	9 spotted	1 web, 3 spotted
10	Leaves	16	16	15	19	23	26
	Buds	2	1	0	4	6	2
	Sprouts	0	0	1	2	2	1
	Other comments	11 spotted/eaten	6 leaves spotted, 6 eaten	11 leaves eaten/spotted, 1 bug	14 spotted/eaten	6 spotted, 4 eaten	10 spotted, 4 eaten

- Hugelkultur


Guaraguao Plot 2 (Hugelkultur+Compost) Leaf Trend
40
30
20
10
0
Number
March 15th
March 21st
March 27th
April 5th
April 10th
April 16th
Date

Ilan Ilan Plot 1

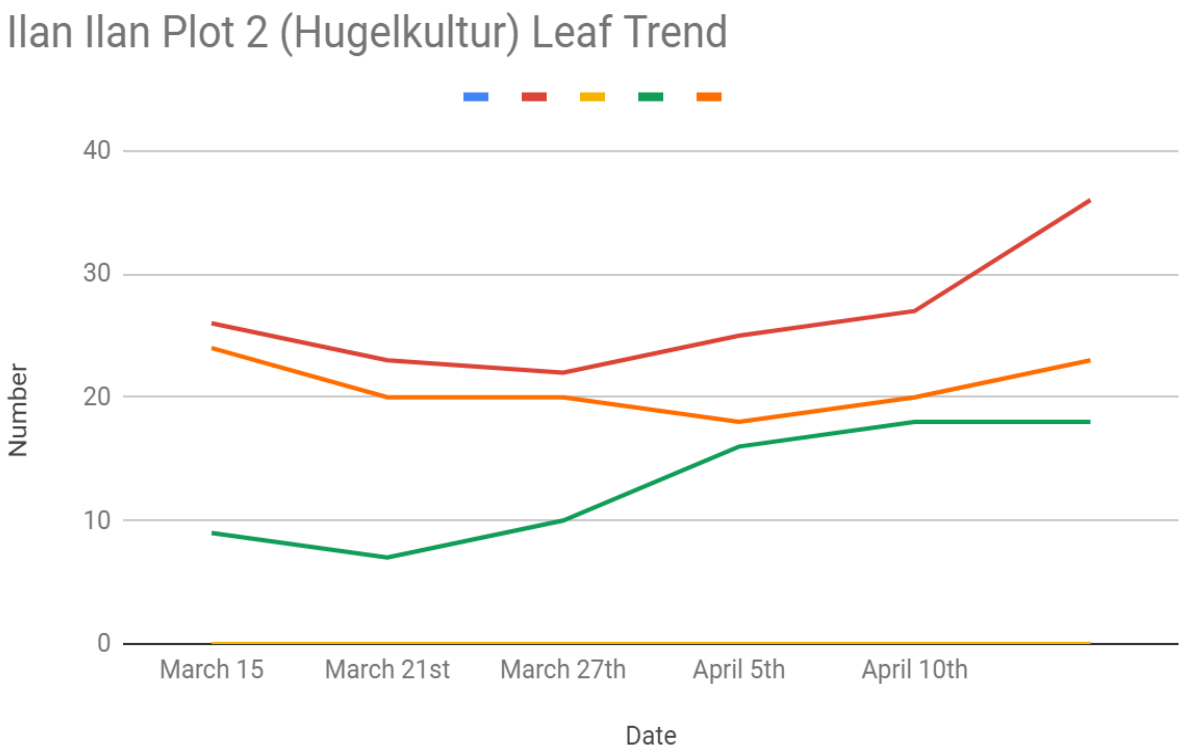
	Dates	March 15th	March 21	March 29th	April 5th	April 10th	April 15th
1	Leaves	34	30	23	20	26	26
	Buds	4	4	7	5	6	10
	Sprouts	0	3	3	3	3	3
	Other comments	lady bug	5 yellow; 11 spotted	3 leaves eaten	3 eaten; 3 empty	2 empties; 3 eaten	2 empties
2	Leaves	36	28	31	25	26	27
	Buds	5	2	5	9	9	10
	Sprouts	0	2	4	4	4	3
	Other comments	6 eaten	16 eaten	4 leaves eaten, 2 branches empty	2 empty branches/ 10 eaten/spotted	2 empties; 5 eaten	2 empties
3	Leaves	21	12	8	9	13	15
	Buds	2	5	13	17	4	12
	Sprouts	0	1	2	8	4	5
	Other comments	18 L black or eaten	4 empty branches; eall leaves eaten/spotted	5 branches empty, 2 leaves eaten	4 empty branches;	3 empties; 1 web	looks sick/3 empties/ 8 eaten
4	Leaves	32	24	19	16	28	24
	Buds	2	6	16	13	11	19
	Sprouts	0	4	4	6	7	6
	Other comments	9L eaten; 5 branches empty	all spotted/ eaten	5 empty branches, 7 leaves eaten	2 empty branches	1empt; 4 eaten	8 eaten
5	Leaves	1	0	0	0	0	0
	Buds	1	0	0	0	0	2
	Sprouts	0	0	0	0	0	2
	Other comments	leaves look dead; several branches empty	dead?	Looks dead, 1 spider web	dead	dead	dead last week
6	Leaves	37	20	18	21	28	25
	Buds	7	5	9	16	8	19
	Sprouts	3	6	5	5	6	9
	Other comments	6 leaves eaten	10 spotted/eaten	5 branches empty, 3 leaves eaten	5 empty branches; 11 eaten	6 empty; 9 eaten	4 empties/ 11 eaten
7	Leaves	9	7	6	7	18	16
	Buds	2	2	4	17	7	8
	Sprouts	1	2	3	5	4	5
	Other comments	6 leaves eaten; several branches empty	7 branches empty; all leaves eaten/spotted	6 branches empty	not in good shape; 11 empty branches	5 empty; 4 eaten	4 eaten/ 9 empty
8	Leaves	13	6	14	7	25	20
	Buds	1	5	1	10	15	8
	Sprouts	0	1	0	4	5	6
	Other comments	2 leaves eaten, 4 empty, dead?	all leaves spotted; 6 empty brancehes	3 leaves eaten	6 empty; NEW TRUNK	2 empty	3 empties/ 3 shrunken leaves
9	Leaves	15	8	7	10	19	24
	Buds	2	5	7	15	9	10
	Sprouts	1	2	2	6	3	4
	Other comments	3 empty branches	3 empty branches; spider; 4 spotted/eaten leaves	4 branches empty	4 empty branches	4 empty, 3 spotted	3 empties/ 4 spotted
10	Leaves	23	22	17	18	23	24
	Buds	3	1	0	14	7	19
	Sprouts	1	1	1	6	2	5
	Other comments	16 spotted or eaten; 9 empty	all leaves spotted/eaten	7 branches empty, 9 leaves eaten	16 leaves eaten	5 empty, 12 spotted, 4 eaten	8 spotted/ 8 eaten

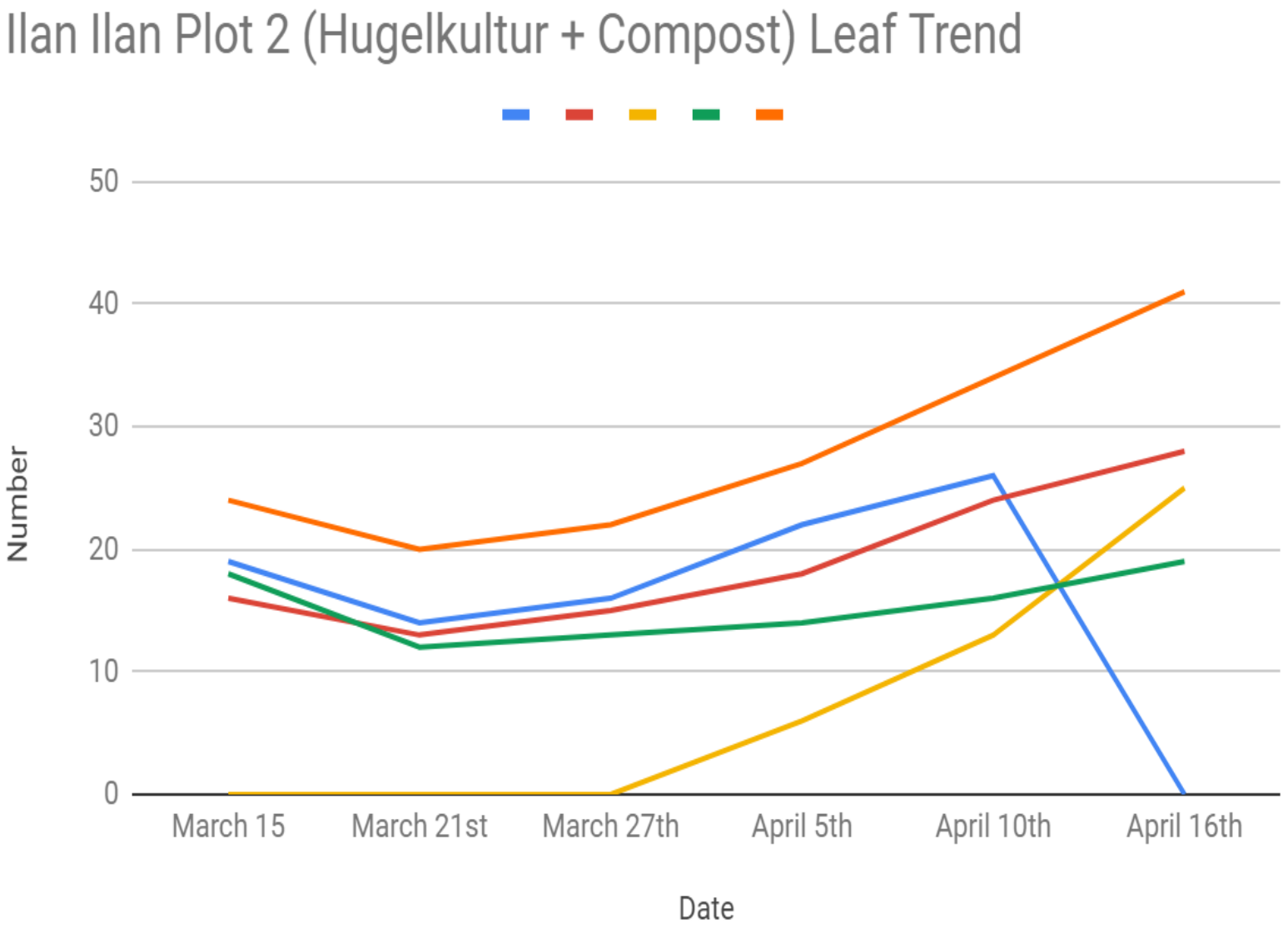

Ilan Ilan Plot 1 Leaf Trend
40
30
20
10
0
Number
March 15th
March 21
March 29th
April 5th
April 10th
April 15th
Date

Ilan Ilan Plot 2

	Dates	March 15	March 21st	March 27th	April 5th	April 10th	April 16th
1	Leaves	0	0	0	0	0	0
	Buds	0	0	0	0	0	0
	Sprouts	0	0	0	0	0	0
	Other comments	spider web; dead?; all branches empty	Looks dead	Dead	Spider webs, Dead	Dead, 10 spiders	Dead
2	Leaves	19	14	16	22	26	0
	Buds	3	1	5	9	4	Dead, run over
	Sprouts	1	2	4	3	3	By mower
	Other comments	splint; 3 L eaten	6 leaves spotted, 2 eaten	8 leaves spotted	5 spotted, 2 empty	6 spotted, 2 empty	
3	Leaves	26	23	22	25	27	36
	Buds	5	4	13	8	10	7
	Sprouts	0	2	5	3	5	5
	Other comments	5 leaves eaten	12 leaves spotted, 1 eaten, 1 spider	11 leaves spotted	8 spotted, 1 eaten	7 spotted, 1 eaten	6 spotted
4	Leaves	0	0	0	0	0	0
	Buds	0	0	0	0	0	10
	Sprouts	0	0	0	0	0	0
	Other comments	Dead?/ all branches empty	Looks dead	Dead	Dead	dead	8 empty, top half looks dead
5	Leaves	16	13	15	18	24	28
	Buds	2	0	6	8	4	8
	Sprouts	2	2	2	4	2	3
	Other comments	1 empty branch; 3 spotted/ eaten	8 leaves spotted, 2 eaten	8 leaves spotted	5 spotted, 5 empty	5 spotted	1 spotted, 3 empty
6	Leaves	9	7	10	16	18	18
	Buds	0	0	0	10	11	9
	Sprouts	2	2	2	3	4	3
	Other comments	7 spotted/eaten; 1 jumping spider	6 leaves spotted	6 leaves spotted, 1 spider	2 empty, 6 spotted, Spider web	5 spotted, 1 empty	2 empty, 1 spotted
7	Leaves	0	0	0	6	13	25
	Buds	2	1	5	18	13	10
	Sprouts	0	0	1	3	3	5
	Other comments	Dead?; all branches empty	Trunk looks green, brown branches	7 empty branches	6 empty	5 empty	6 empty
8	Leaves	18	12	13	14	16	19
	Buds	0	0	2	6	9	6
	Sprouts	1	1	1	2	2	4
	Other comments	10 spotted/eaten	10 leaves spotted	8 leaves eaten/spotted	9 spotted, 5 empty	1 empty, 9 spotted, 1 eaten, 1 s	9 spotted
9	Leaves	24	20	20	18	20	23
	Buds	4	2	0	8	6	8
	Sprouts	2	1	2	4	3	3
	Other comments	8 eaten/ spotted	7 leaves spotted, 1 eaten, spider	8 leaves spotted	9 spotted/eaten	1 empty, 9 spotted	1 empty, 8 spotted
10	Leaves	24	20	22	27	34	41
	Buds	3	2	5	12	7	17
	Sprouts	3	2	4	4	4	4
	Other comments	11 spotted/eaten	14 leaves spotted	12 leaves spotted	3 empty, 12 spotted	9 spotted, 3 empty	3 empty, 17 spotted

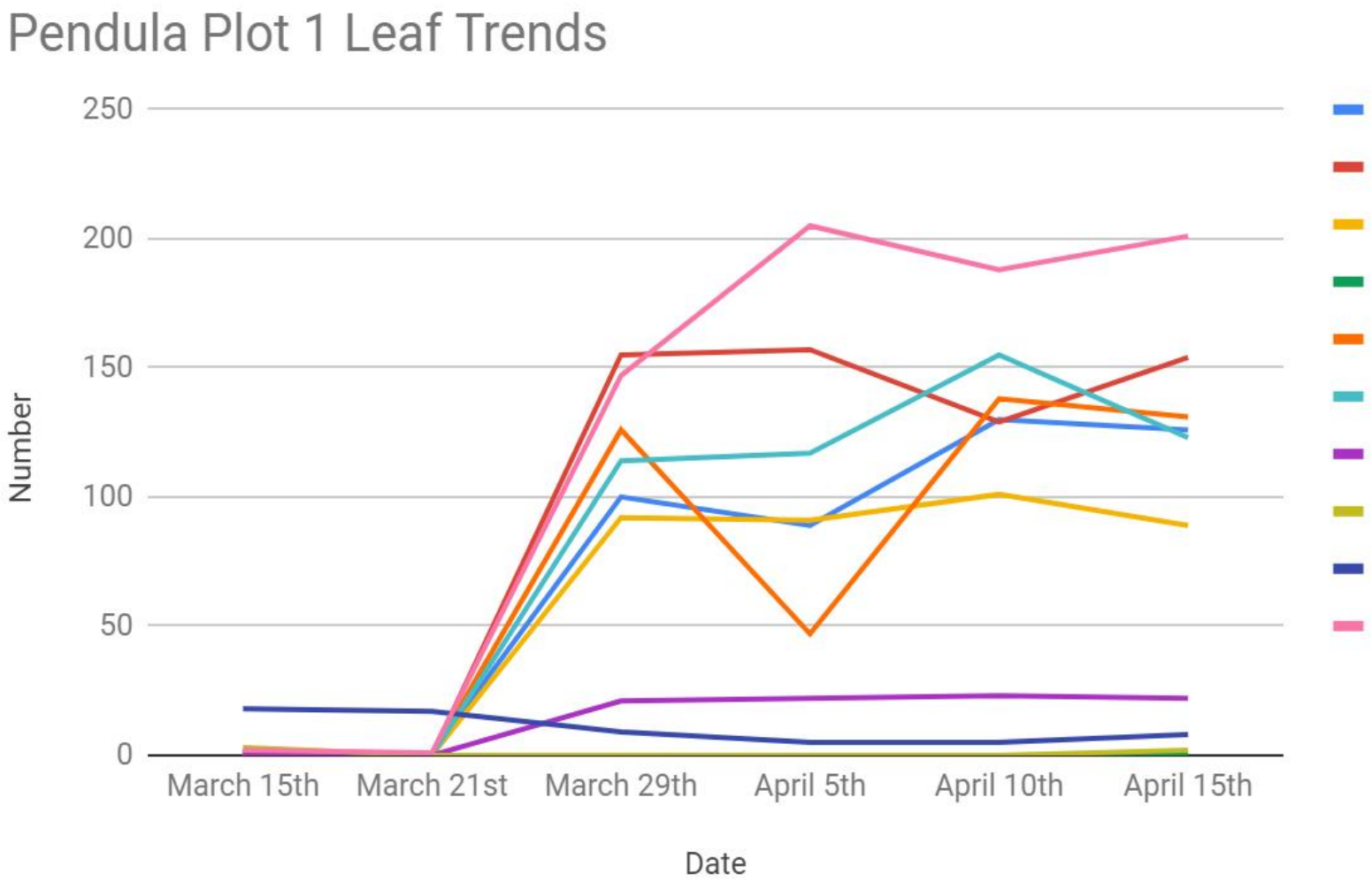
-Hugelkultur


Ilan Ilan Plot 2 (Hugelkultur) Leaf Trend
40
30
20
10
0
Number
March 15
March 21st
March 27th
April 5th
April 10th
Date


Ilan Ilan Plot 2 (Hugelkultur + Compost) Leaf Trend
50
40
30
20
10
0
Number
March 15
March 21st
March 27th
April 5th
April 10th
April 16th
Date

Pendula Plot 1

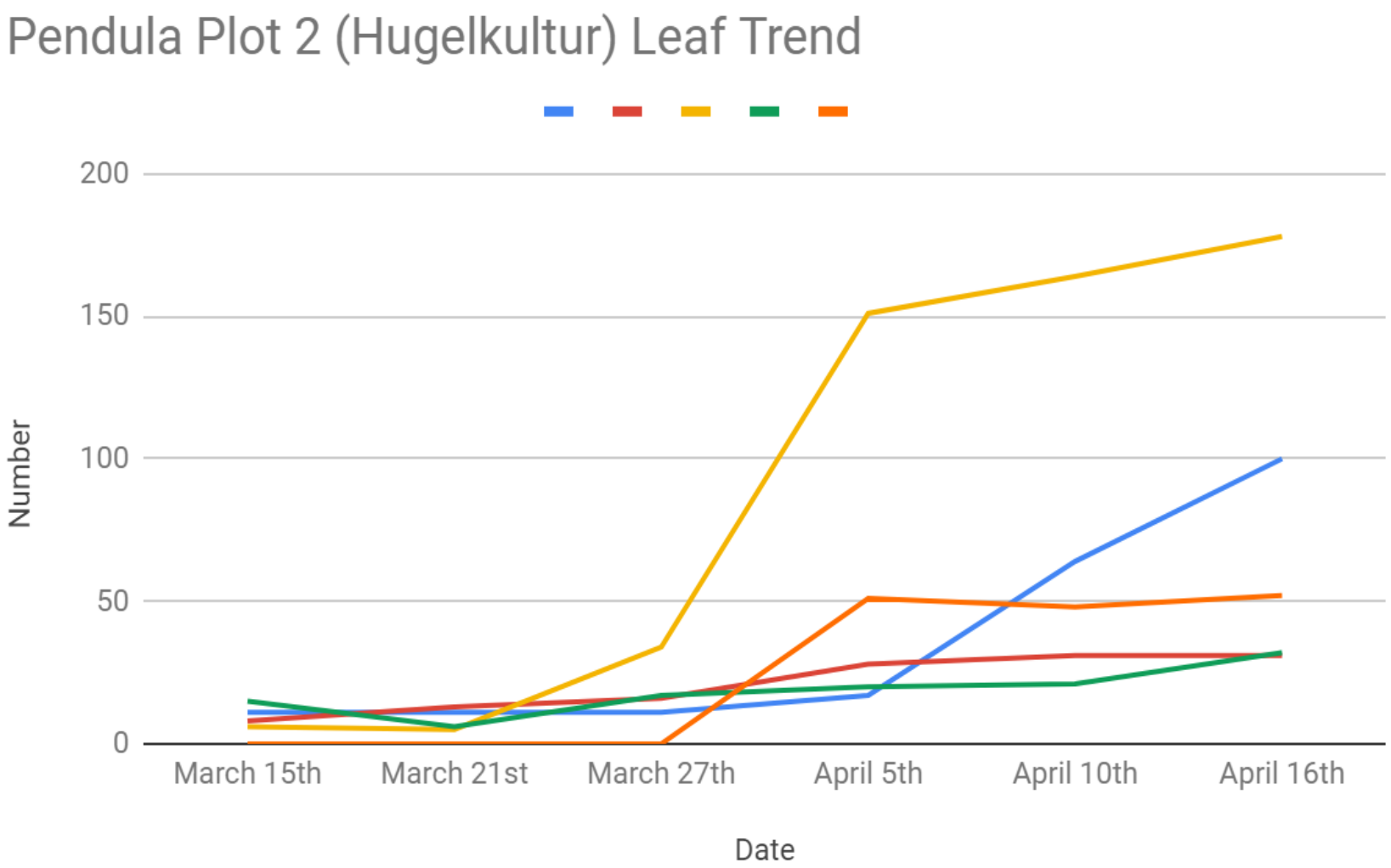
	Dates	March 15th	March 21st	March 29th	April 5th	April 10th	April 15th
1	Leaves	1	1	100	89	130	126
	Buds	32	1	16	17	1	29
	Sprouts	0	40	1	11	19	9
	Other comments	1 small bug	1 brown leaf	1 web	no comment	spiderweb	2 egg sacks/ants/ 5 eaten
2	Leaves	0	0	155	157	129	154
	Buds	38	6	33	27	32	48
	Sprouts	0	66	34	7	18	8
	Other comments	no bugs	ants	1 branch empty	1 empty branch	1 empty branch	1 empty branch
3	Leaves	0	0	92	91	101	89
	Buds	8	0	27	24	12	26
	Sprouts	0	39	23	8	7	7
	Other comments	no bugs	ants/ mosquitoes/6 empty branches	4 branches empty	5 empty branches	5 empties	6 empties/ 2 webs
4	Leaves	0	0	0	0	0	0
	Buds	0	0	0	0	0	0
	Sprouts	0	0	0	0	0	0
	Other comments	dead?	some brown/dead leaves; dead?	Dead?	dead; spider web	dead; 11 empty; spiderweb	dead
5	Leaves	1	0	126	47	138	131
	Buds	19	38	35	31	25	27
	Sprouts	1	38	25	10	6	5
	Other comments	spider web; 1 spider	1 dead leaf; 1 empty branch	9 leaves eaten	ants	1 empty; 45 eaten	1 spider w web/ several eaten
6	Leaves	1	0	114	117	155	123
	Buds	11	12	6	50	24	24
	Sprouts	0	27	13	13	6	8
	Other comments	no bugs	1 empty branch	5 leaves eaten	2 empty branches	2 empty; 16 eaten	spider
7	Leaves	0	0	21	22	23	22
	Buds	0	2	10	10	6	7
	Sprouts	0	9	0	5	0	2
	Other comments	dead?; no bugs	ant	No bugs	ants; very small	sticky substance; 1 leaf	2 leaves eaten
8	Leaves	3	0	0	0	0	2
	Buds	0	0	0	0	0	21
	Sprouts	0	0	0	0	0	0
	Other comments	no bugs	dead?	1 spider web	dead; fly; spiderweb	dead, possible bug burrowing in wood	majority of the tree dead
9	Leaves	18	17	9	5	5	8
	Buds	0	0	0	0	4	3
	Sprouts	0	0	0	0	0	2
	Other comments	all leaves spotted or eaten	8 empty branches dying?	3 leaves eaten, 2 spiders	man many ants; spots; dying?	1 spider, 5 empty	half of tree dead
10	Leaves	2	1	147	205	188	201
	Buds	3	15	1	45	24	22
	Sprouts	0	40	2	14	27	11
	Other comments	all but 2 branches empty	fly/ 4 empty branches		5 empty branches; short but leafy	healthy	4 empty branches

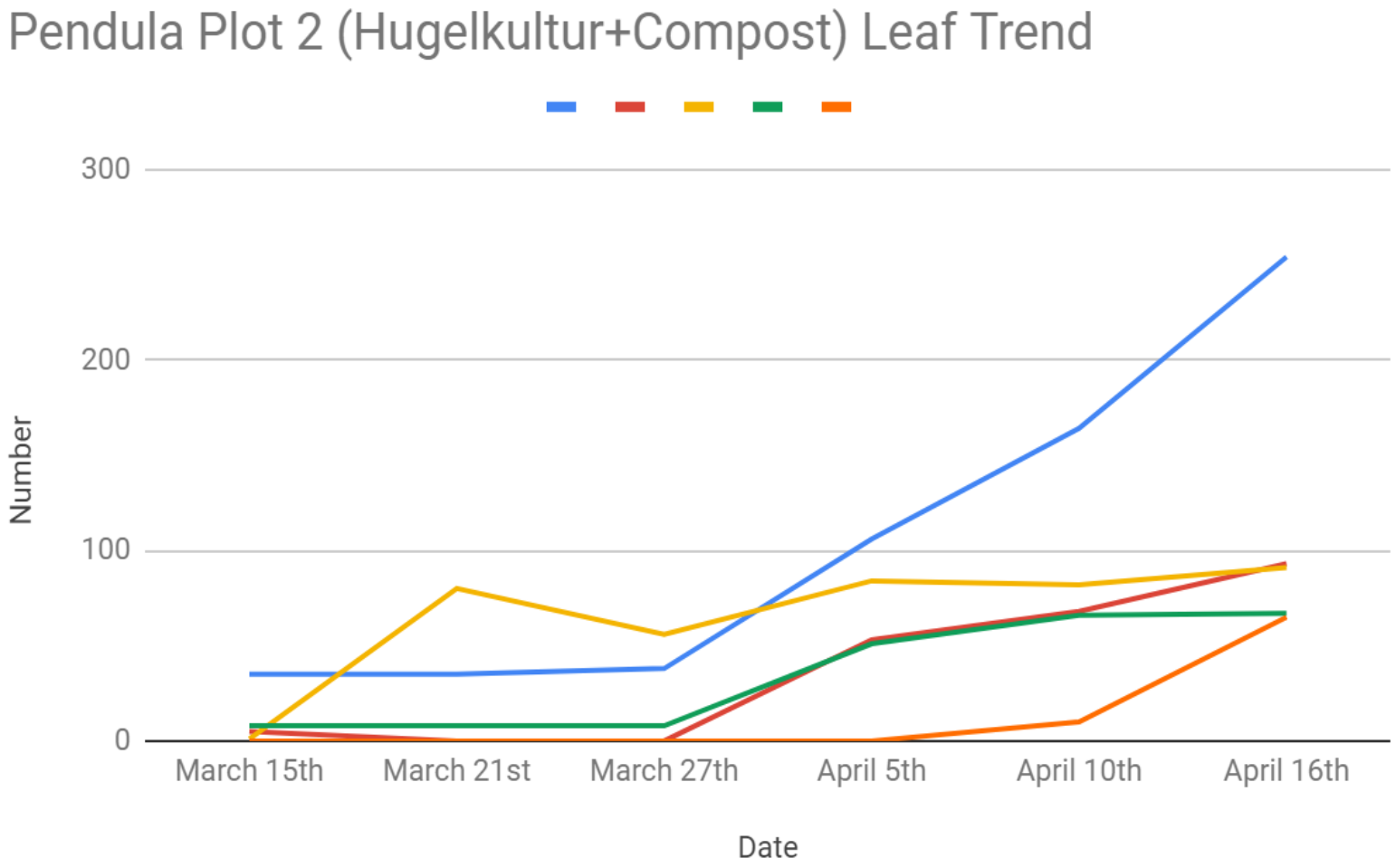

Pendula Plot 1 Leaf Trends
250
200
150
100
50
0
Number
March 15th
March 21st
March 29th
April 5th
April 10th
April 15th
Date

Pendula Plot 2

	Dates	March 15th	March 21st	March 27th	April 5th	April 10th	April 16th
1	Leaves	35	35	38	106	164	254
	Buds	0	2	9	121	71	36
	Sprouts	0	0	7	34	40	40
	Other comments	16 eaten/spotted	14 leaves spotted, 6 eaten	15 leaves spotted, 7 eaten, 1 dead	16 spotted/eaten	13 spotted, 5 eaten	16 spotted, 6 eaten
2	Leaves	11	11	11	17	64	100
	Buds	0	0	0	32	36	26
	Sprouts	1	0	0	3	15	23
	Other comments	8 leaves spotted/eaten	6 leaves eaten, 2 spotted	10 leaves spotted, 2 eaten	9 spotted	8 spotted, 3 eaten	10 spotted, 3 eaten
3	Leaves	5	0	0	53	68	93
	Buds	0	1	5	21	19	20
	Sprouts	0	0	6	16	15	13
	Other comments	2 spotted/ eaten	Slightly dead	1 spider	Tops of branches dead	Tops of branches dead	Tops of branches dead
4	Leaves	8	13	16	28	31	31
	Buds	7	7	6	9	5	6
	Sprouts	4	1	0	7	6	6
	Other comments	2 spotted	1 leaf spotted	Healthy	healthy	Healthy	Healthy
5	Leaves	6	5	34	151	164	178
	Buds	1	41	25	36	30	15
	Sprouts	1	0	2	20	18	23
	Other comments	6 spotted/eaten	5 leaves spotted	Healthy	Tops of branches dead	Tops of branches dead	Tops of branches dead
6	Leaves	1	80	56	84	82	91
	Buds	24	0	9	15	10	3
	Sprouts	1	9	14	7	6	7
	Other comments	all but 1 empty	Healthy	Healthy	Healthy	Healthy	Healthy
7	Leaves	8	8	8	51	66	67
	Buds	0	0	7	18	4	3
	Sprouts	0	0	0	9	11	12
	Other comments	no bugs	3 leaves spotted	5 leaves spotted	Healthy	Healthy	healthy
8	Leaves	15	6	17	20	21	32
	Buds	3	0	1	3	9	6
	Sprouts	2	0	0	1	1	3
	Other comments	3 spotted/eaten; 1 broken branch with 5 leaves	4 leaves dying, 2 spotted	2 leaves spotted	4 spotted	2 spotted	3 spotted
9	Leaves	0	0	0	0	10	65
	Buds	0	0	0	5	43	16
	Sprouts	0	0	0	0	3	7
	Other comments	dead?	Looks dead	Dead	Improving	continues to improve	Healthy
10	Leaves	0	0	0	51	48	52
	Buds	0	4	10	16	12	9
	Sprouts	0	0	10	8	5	10
	Other comments	dead?	Signs of life	improving	Top of main stalk dead	Top of main stalk dead	Branch pointing away from pile is damaged

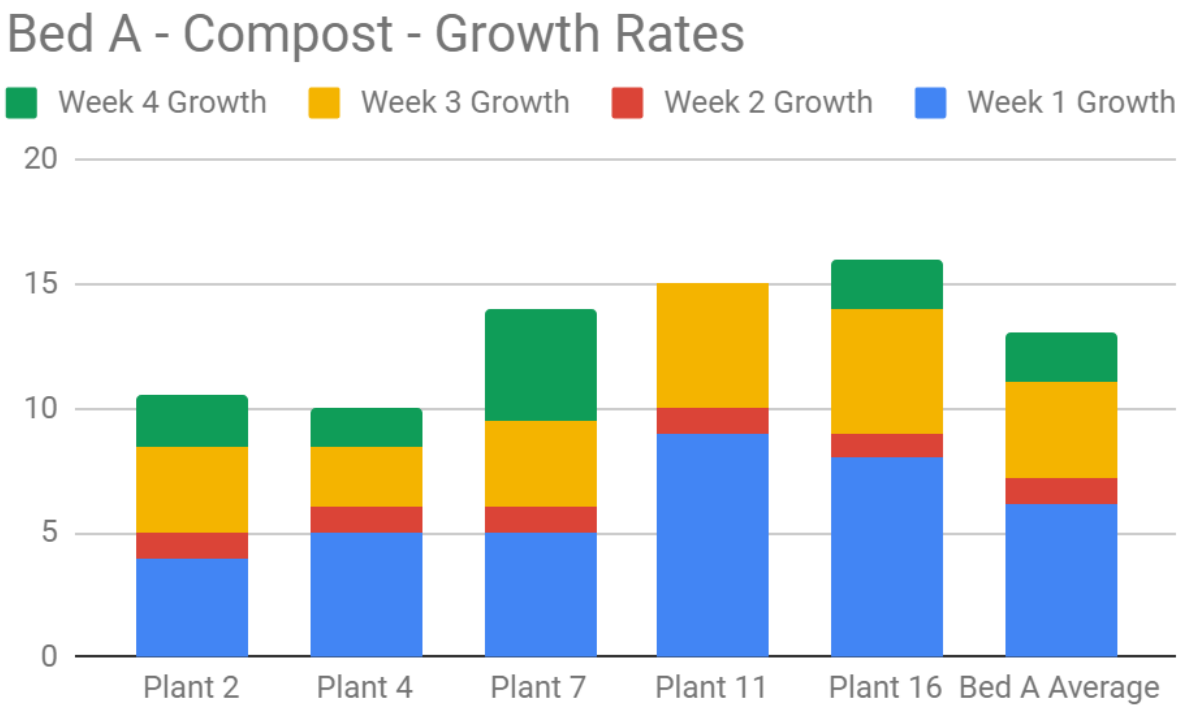
- Hugelkultur


Pendula Plot 2 (Hugelkultur) Leaf Trend
200
150
100
50
0
Number
March 15th
March 21st
March 27th
April 5th
April 10th
April 16th
Date


Pendula Plot 2 (Hugelkultur+Compost) Leaf Trend
300
200
100
0
Number
March 15th
March 21st
March 27th
April 5th
April 10th
April 16th
Date

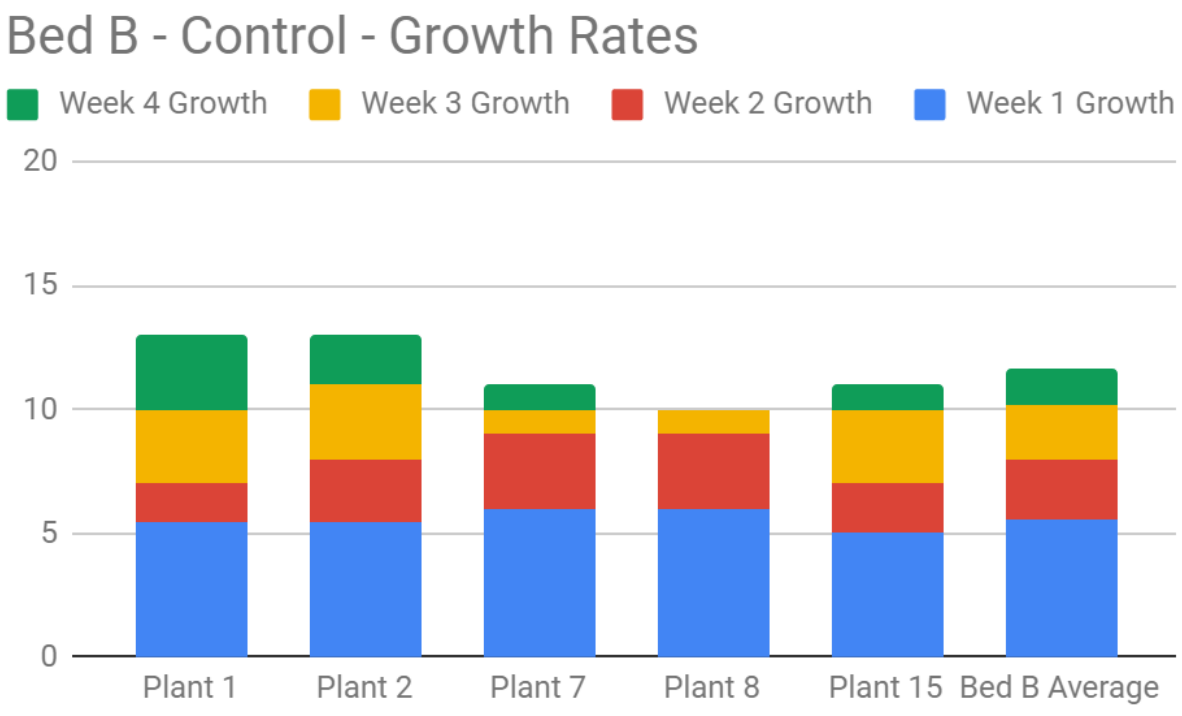
Appendix D - Tomato Data
Plot A

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
2	Leaves	11	16	42	102
	Height	4	5	8.5	10.5
	Yellow leaves	4	2	0	0
	Overall Health	okay	good	Healthy	healthy
4	Leaves	10	18	43	87
	Height	5	6	8.5	10
	Yellow leaves	1	0	0	0
	Overall Health	healthy	healthy	Healthy	healthy
7	Leaves	25	20	61	97
	Height	5	6	9.5	14
	Yellow leaves	5	3	0	0
	Overall Health	good	good	Healthy	healthy
11	Leaves	45	50	85	117
	Height	9	10	15	15
	Yellow leaves	1	0	0	0
	Overall Health	healthy	healthy	Healthy	healthy
16	Leaves	20	27	53	82
	Height	8	9	14	16
	Yellow leaves	4	3	0	0
	Overall Health	healthy	healthy	healthy	healthy
Overall Bed Health		T3 - very dead T5 - eaten healthy	good - best bed	T5 - gone	very healthy bed 100% healthy



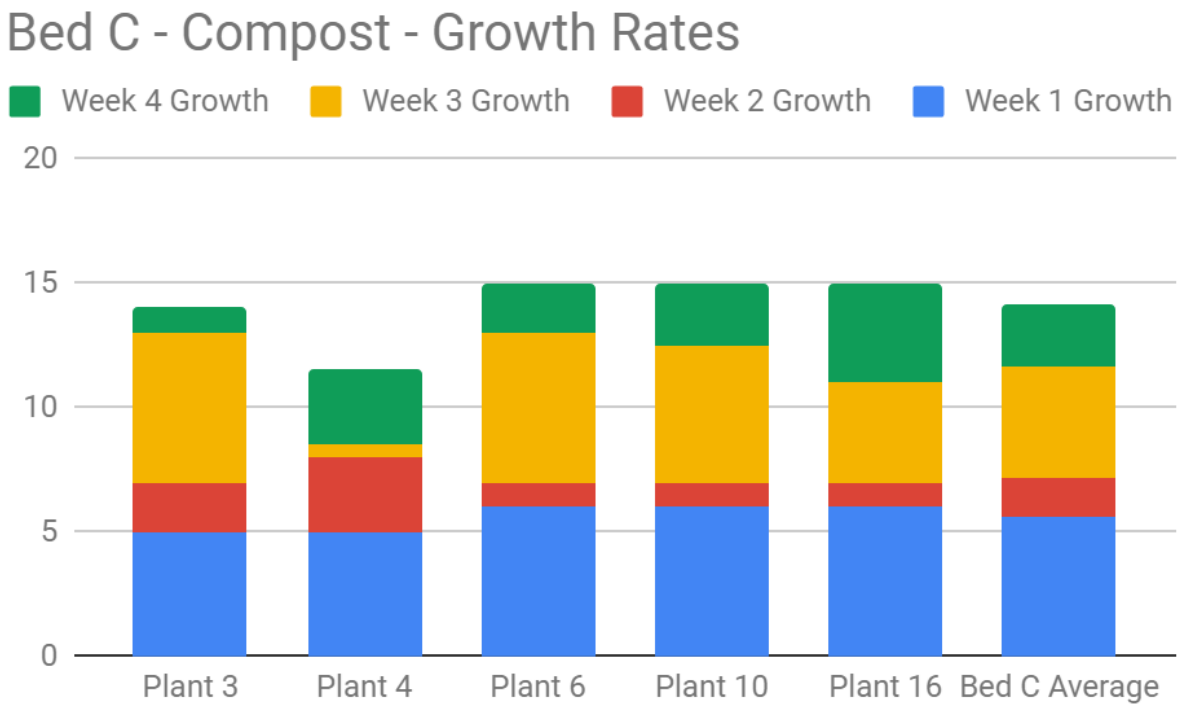
Plot B

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
1	Leaves	17	22	46	97
	Height	5.5	7	10	13
	Yellow leaves	3	0	0	0
	Overall Health	healthy	healthy	healthy	healthy
2	Leaves	18	25	43	99
	Height	5.5	8	11	13
	Yellow leaves	3	1	0	0
	Overall Health	healthy	healthy	Healthy	healthy
7	Leaves	18	28	40	78
	Height	6	9	10	11
	Yellow leaves	4	2	0	0
	Overall Health	good	good	Healthy	healthy
8	Leaves	18	27	46	67
	Height	6	9	10	10
	Yellow leaves	8	4	2	0
	Overall Health	fine	good	healthy	healthy
15	Leaves	18	23	37	58
	Height	5	7	10	11
	Yellow leaves	6	2	3	0
	Overall Health	good	good	good	healthy
Overall Bed Health		Good	good	Not as good as a but overall healthy	healthy - overall shorter than bed A



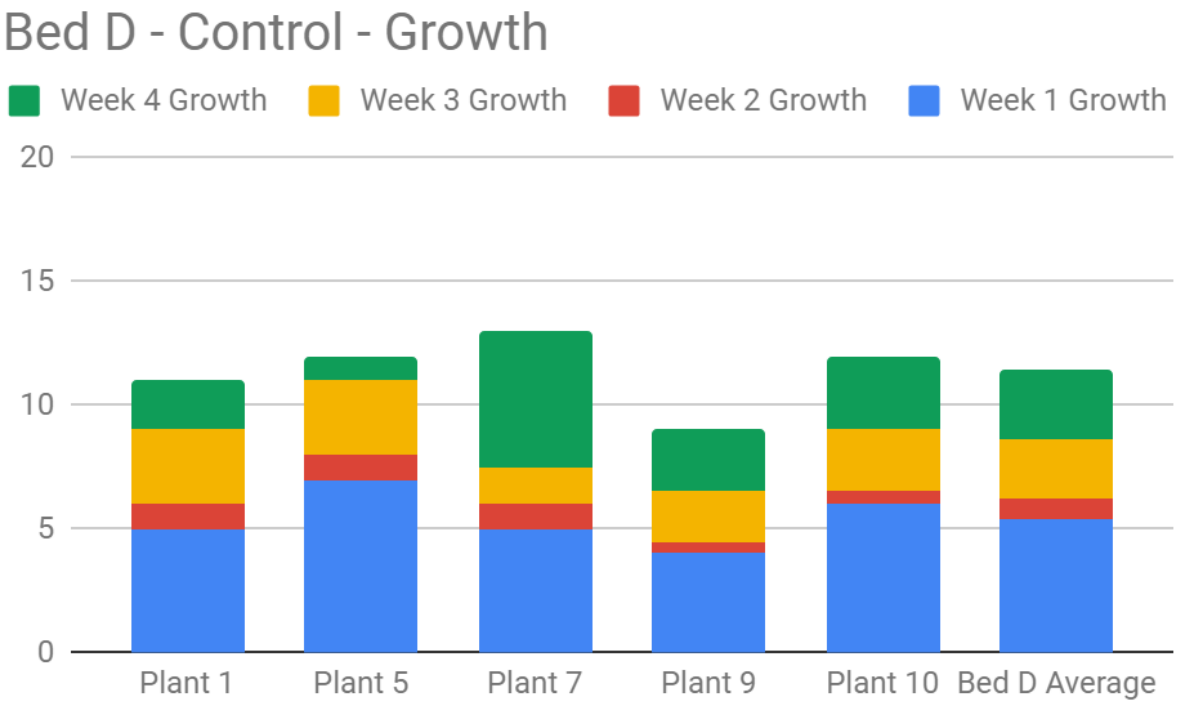
Plot C

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
3	Leaves	17	20	66	84
	Height	5	7	13	14
	Yellow leaves	3	2	0	0
	Overall Health	healthy	healthy	Healthy	healthy
4	Leaves	14	20	57	72
	Height	5	8	8.5	11.5
	Yellow leaves	14	5	0	0
	Overall Health	bad	fine	Healthy	healthy
6	Leaves	19	22	65	93
	Height	6	7	13	15
	Yellow leaves	2	0	0	0
	Overall Health	good	healthy	healthy	healthy
10	Leaves	30	40	92	91
	Height	6	7	12.5	15
	Yellow leaves	8	3	0	0
	Overall Health	good	good	Healthy	healthy
16	Leaves	15	18	57	68
	Height	6	7	11	15
	Yellow leaves	5	2	0	0
	Overall Health	good	good	healthy	healthy
Overall Bed Health		T1 - very dead. T4 - not quite dead. T7 also bad. T15 best plant Wide variety of healthy and not healthy	good	Healthy, great bed	healthy, best bed



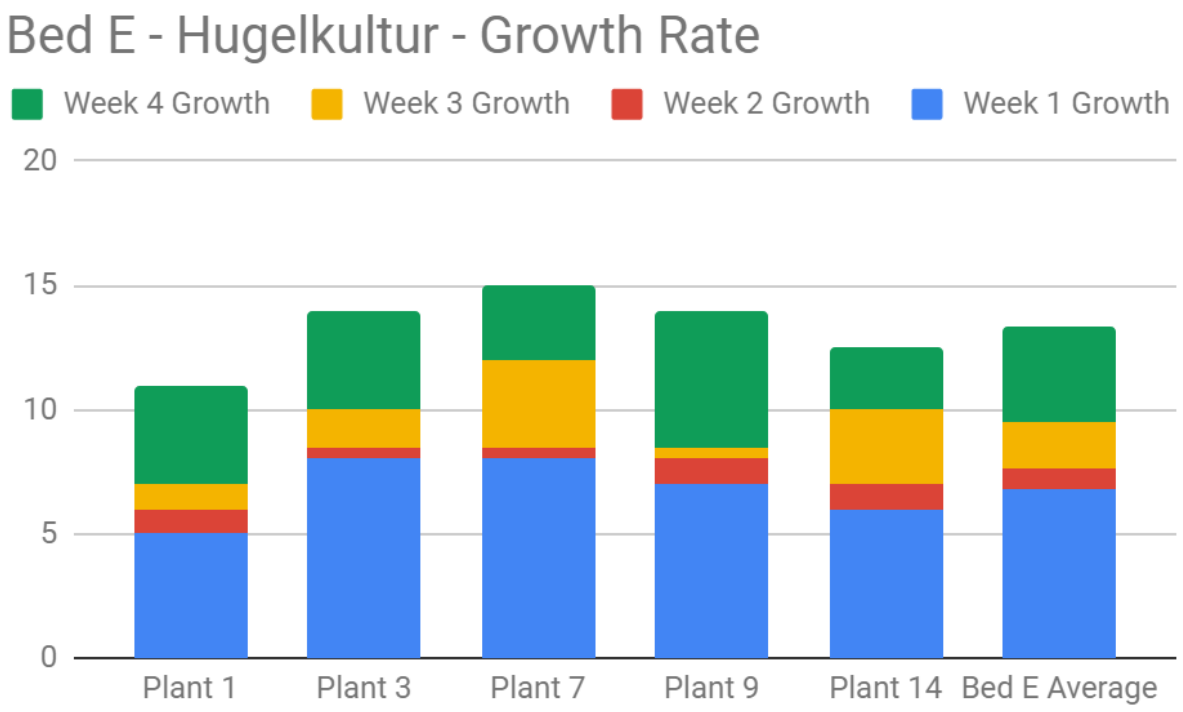
Plot D

Plant #	Dates	March 26th	April 5th	April 10	April 16th
1	Leaves	16	20	55	62
	Height	5	6	9	11
	Yellow leaves	3	1	0	0
	Overall Health	good	good	healthy	healthy
5	Leaves	18	22	41	69
	Height	7	8	11	12
	Yellow leaves	1	0	0	0
	Overall Health	good	good	Healthy	healthy
7	Leaves	11	27	61	74
	Height	5	6	7.5	13
	Yellow leaves	0	0	3	0
	Overall Health	bad	okay	Good	healthy
9	Leaves	13	20	35	38
	Height	4	4.5	6.5	9
	Yellow leaves	5	2	2	0
	Overall Health	fine	fine	good	healthy
10	Leaves	15	19?	40	57
	Height	6	6.5	9	12
	Yellow leaves	6	3	2	0
	Overall Health	good	good	Good	healthy
Overall Bed Health		T7 & T14 are wilting T13 - very green T15 - best plant	good	Good, several plants wilted	good



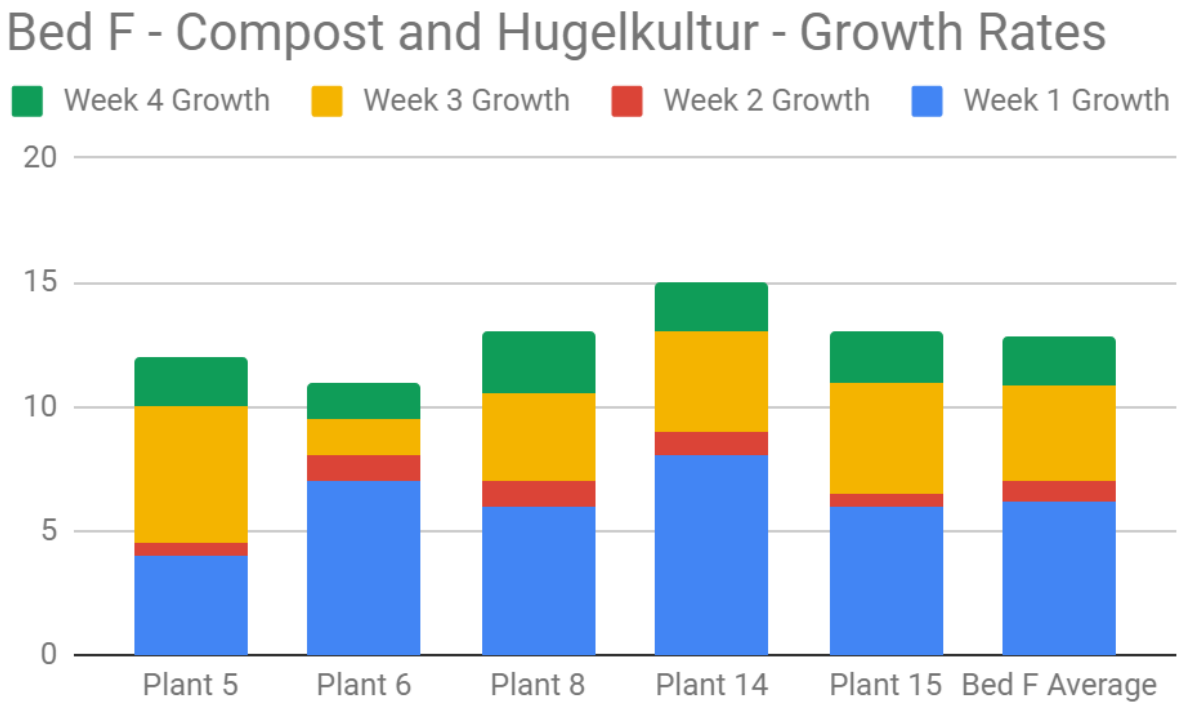
Plot E

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
1	Leaves	21	28	65	101
	Height	5	6	7	11
	Yellow leaves	5	3	0	0
	Overall Health	good	good	healthy	healthy
3	Leaves	18	22	58	92
	Height	8	8.5	10	14
	Yellow leaves	6	3	6	0
	Overall Health	fine	good	Good	healthy
7	Leaves	28	32	92	104
	Height	8	8.5	12	15
	Yellow leaves	6	3	2	0
	Overall Health	good	good	Healthy	healthy
9	Leaves	13	10	51	98
	Height	7	8	8.5	14
	Yellow leaves	3	1	1	0
	Overall Health	fine	fine	Healthy	healthy
14	Leaves	16	18	53	52
	Height	6	7	10	12.5
	Yellow leaves	4	2	1	0
	Overall Health	healthy	healthy	good	healthy
Overall Bed Health		T3 & T4 - showing weakness Very healthy bed, possibly best	Very Healthy bed still	Healthy	very healthy



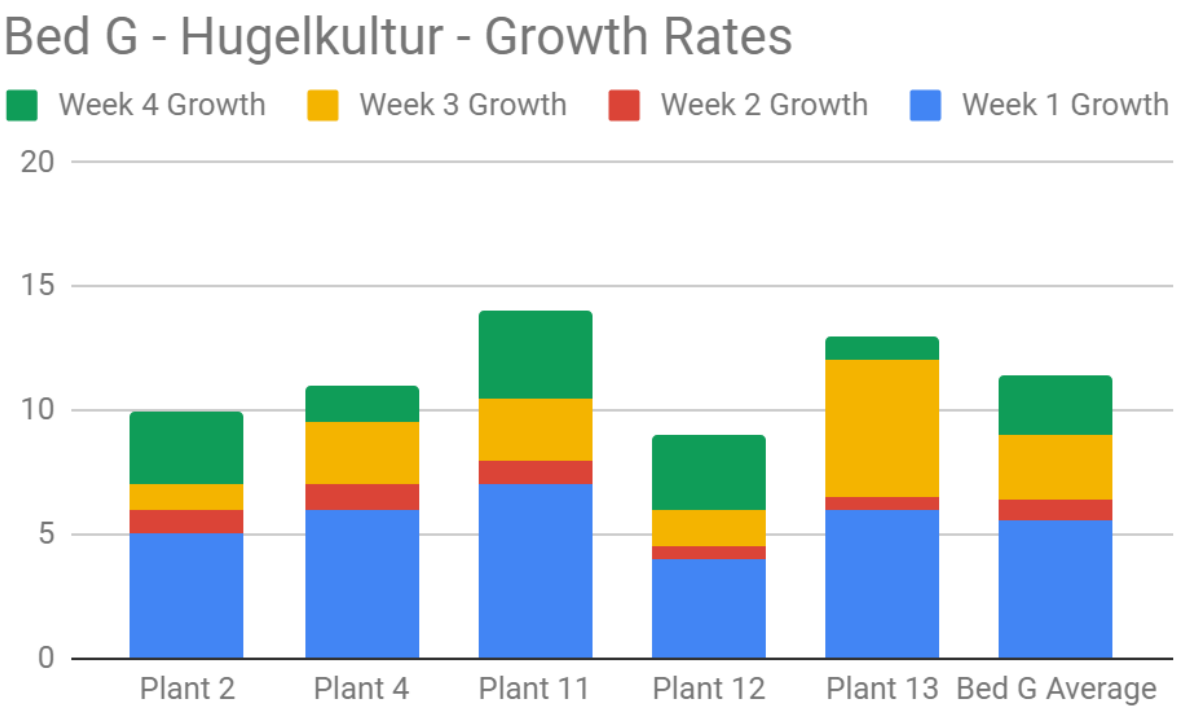
Plot F

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
5	Leaves	10	12	37	48
	Height	4	4.5	10	12
	Yellow leaves	10	5	1	0
	Overall Health	bad	fine	Good	healthy
6	Leaves	20	23	19	42
	Height	7	8	9.5	11
	Yellow leaves	3	2	0	0
	Overall Health	good	good	Partial eaten	healthy
8	Leaves	16	18	73	75
	Height	6	7	10.5	13
	Yellow leaves	16	5	8	0
	Overall Health	bad	fine/okay	good	healthy
14	Leaves	18	19	88	85
	Height	8	9	13	15
	Yellow leaves	2	1	0	0
	Overall Health	healthy	healthy	healthy	healthy
15	Leaves	24	25	107	97
	Height	6	6.5	11	13
	Yellow leaves	7	5	0	0
	Overall Health	good	good	Healthy	healthy
Overall Bed Health		T17 - best plant T3 & T5 & T8 - droopy and worst	still best no droopiness	Healthy, some evidence of being eaten	healthy



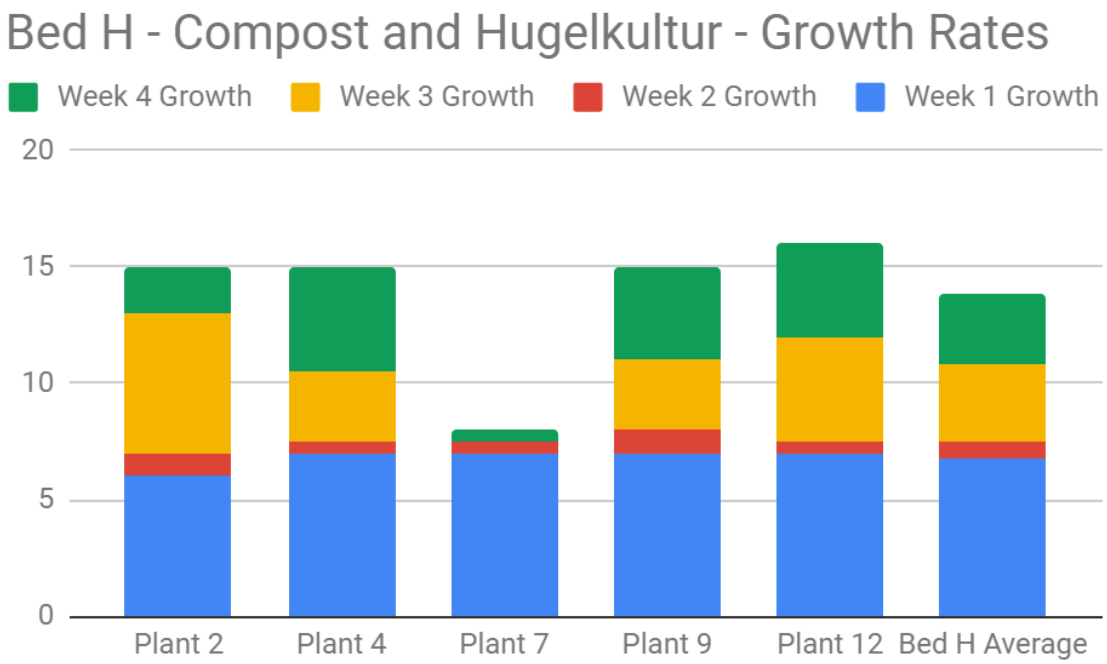
Plot G

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
2	Leaves	10	12	19	28
	Height	5	6	7	10
	Yellow leaves	0	0	2	0
	Overall Health	healthy	healthy	fine	healthy
4	Leaves	18	19	39	52
	Height	6	7	9.5	11
	Yellow leaves	5	4	2	0
	Overall Health	good	good	good	healthy
11	Leaves	18	19	48	78
	Height	7	8	10.5	14
	Yellow leaves	8	6	0	0
	Overall Health	fine	good	Healthy	healthy
12	Leaves	13	17	52	76
	Height	4	4.5	6	9
	Yellow leaves	4	4	2	0
	Overall Health	fine	good	Fine	healthy
13	Leaves	18	19	42	97
	Height	6	6.5	12	13
	Yellow leaves	5	4	1	0
	Overall Health	good	good	healthy	healthy
Overall Bed Health		Very Similar plants T1 - droopy T12 - weird stalk (curvy) T14 - best plant	#14 still best plant	Healthy but short	healthy but short



Plot H

Plant #	Dates	March 26th	April 5th	April 10th	April 16th
2	Leaves	15	10	74	86
	Height	6	7	13	15
	Yellow leaves	2	0	0	0
	Overall Health	healthy	healthy	healthy	healthy
4	Leaves	18	10	70	78
	Height	7	7.5	10.5	15
	Yellow leaves	4	3	0	0
	Overall Health	healthy	healthy	healthy	healthy
7	Leaves	14	14	52	86
	Height	7	7.5	4	8
	Yellow leaves	1	1	1	0
	Overall Health	good	healthy	Fine	healthy
9	Leaves	15	17	61	89
	Height	7	8	11	15
	Yellow leaves	7	5	0	0
	Overall Health	good	healthy	Healthy	healthy
12	Leaves	17	20	50	102
	Height	7	7.5	12	16
	Yellow leaves	1	0	0	0
	Overall Health	good	good	Healthy	healthy
Overall Bed Health		T3 & T6 & T7 - worst T11 - best Very green bed Good bed health	all pretty good	healthy, t3 gone	healthy



Appendix E - Lettuce Data

March 26th			April 5th			April 10th			April 16th		
Plot A		Plot E	Plot A		Plot E	Plot A		Plot E	Plot A		Plot E
L1	Bad	L1	Bad	L1	Dead	L1	Dead	L1	Dead	L1	Dead
L2	Bad	L2	Good	L2	Healthy	L2	Healthy	L2	Dead	L2	Dead
L3	Bad	L3	Bad	L3	Dead	L3	Dead	L3	Dead	L3	Dead
L4	Average	L4	Average	L4	Dead	L4	Dead	L4	Dead	L4	Average
L5	Average	L5	Bad	L5	Good	L5	Dead	L5	Healthy	L5	Dead
L6	Bad	L6	Bad	L6	Dead	L6	Dead	L6	Dead	L6	Dead
Plot B		Plot F	Plot B		Plot F	Plot B		Plot F	Plot B		Plot F
L1	Good	L1	Average	L1	Dead	L1	Average	L1	Dead	L1	Good
L2	Average	L2	Average	L2	Good	L2	Good	L2	Healthy	L2	Healthy
L3	Bad	L3	Average	L3	Dead	L3	Dead	L3	Dead	L3	Dead
L4	Bad	L4	Average	L4	Dead	L4	Healthy	L4	Dead	L4	Healthy
L5	Bad	L5	Bad	L5	Dead	L5	Dead	L5	Dead	L5	Dead
L6	Bad	L6	Bad	L6	Dead	L6	Dead	L6	Dead	L6	Dead
Plot C		Plot G	Plot C		Plot G	Plot C		Plot G	Plot C		Plot G
L1	Bad	L1	Bad	L1	Good	L1	Dead	L1	Healthy	L1	Dead
L2	Bad	L2	Bad	L2	Dead	L2	Dead	L2	Dead	L2	Good
L3	Average	L3	Average	L3	Dead	L3	Average	L3	Dead	L3	Good
L4	Bad	L4	Bad	L4	Dead	L4	Dead	L4	Dead	L4	Dead
L5	Bad	L5	Bad	L5	Dead	L5	Dead	L5	Dead	L5	Dead
L6	Bad	L6	Bad	L6	Dead	L6	Dead	L6	Dead	L6	Dead
Plot D		Plot H	Plot D		Plot H	Plot D		Plot H	Plot D		Plot H
L1	Good	L1	Average	L1	Good	L1	Healthy	L1	Average	L1	Healthy
L2	Good	L2	Bad	L2	Average	L2	Good	L2	Bad	L2	Good
L3	Bad	L3	Bad	L3	Average	L3	Dead	L3	Bad	L3	Dead
L4	Average	L4	Bad	L4	Healthy	L4	Dead	L4	Bad	L4	Dead
L5	Average	L5	Bad	L5	Good	L5	Dead	L5	Average	L5	Dead
L6	Average	L6	Bad	L6	Good	L6	Dead	L6	Average	L6	Dead

Leaf Count

March 26th				April 5th				April 10th				April 16th			
Plot A		Plot E		Plot A		Plot E		Plot A		Plot E		Plot A		Plot E	
L1	2	L1	3	L1	0	L1	0	L1	0	L1	0	L1	0	L1	0
L2	2	L2	1	L2	3	L2	0	L2	3	L2	0	L2	3	L2	0
L3	1	L3	2	L3	0	L3	0	L3	0	L3	0	L3	0	L3	0
L4	2	L4	4	L4	0	L4	4	L4	0	L4	4	L4	0	L4	4
L5	3	L5	3	L5	4	L5	0	L5	4	L5	0	L5	2	L5	0
L6	4	L6	1	L6	0	L6	0	L6	0	L6	0	L6	0	L6	0
Plot B		Plot F		Plot B		Plot F		Plot B		Plot F		Plot B		Plot F	
L1	2	L1	1	L1	0	L1	2	L1	0	L1	3	L1	0	L1	3
L2	3	L2	1	L2	3	L2	4	L2	3	L2	4	L2	3	L2	4
L3	3	L3	1	L3	0	L3	0	L3	0	L3	0	L3	0	L3	0
L4	4	L4	3	L4	0	L4	4	L4	0	L4	4	L4	0	L4	5
L5	2	L5	2	L5	0	L5	0	L5	0	L5	0	L5	0	L5	0
L6	3	L6	3	L6	0	L6	0	L6	0	L6	0	L6	0	L6	0
Plot C		Plot G		Plot C		Plot G		Plot C		Plot G		Plot C		Plot G	
L1	2	L1	3	L1	4	L1	0	L1	4	L1	0	L1	4	L1	0
L2	1	L2	2	L2	0	L2	0	L2	0	L2	0	L2	0	L2	4
L3	3	L3	2	L3	0	L3	3	L3	0	L3	3	L3	0	L3	4
L4	2	L4	3	L4	0	L4	0	L4	0	L4	0	L4	0	L4	0
L5	3	L5	1	L5	0	L5	0	L5	0	L5	0	L5	0	L5	0
L6	4	L6	2	L6	0	L6	0	L6	0	L6	0	L6	0	L6	0
Plot D		Plot H		Plot D		Plot H		Plot D		Plot H		Plot D		Plot H	
L1	2	L1	4	L1	4	L1	8	L1	4	L1	12	L1	4	L1	15
L2	3	L2	3	L2	3	L2	3	L2	3	L2	3	L2	3	L2	3
L3	3	L3	2	L3	3	L3	0	L3	3	L3	0	L3	4	L3	0
L4	3	L4	4	L4	5	L4	0	L4	5	L4	0	L4	5	L4	0
L5	4	L5	4	L5	4	L5	0	L5	3	L5	0	L5	3	L5	0
L6	2	L6	4	L6	4	L6	0	L6	4	L6	0	L6	4	L6	0

Appendix F - La Plata Interview Data

Interview (date)	1	2	3	4	5	5a	5ai	5b	5bi	5c	5ci	6	6a	6b	6c	6d
Person 1 (3/27)	Fishing	Buys food	Very little	Used to have one	Food	Plantanos, tried to plant Roccao	Only waters				No knowledge of fertilization	No	None	No	No	
Person 2 (3/27)	Fishing	Buys and grows food	Yes	Yes	Food	Plantano, Yautia, Malanga, Pana, raised rabbits	Watering, fertilization, weeding/cleming area, adds fresh soil	1-2 hours a day	Not asked, did not know		Knows its to improve soil quality	Yes, it helps plants grow	Yes	Yes they use rabbit manuer	Yes	
	Fishing and enjoying nature													Yes he leaves plantano leave around the trees so nutrients can return to tree		
Person 3 (3/27)	Fishing and enjoying nature	Buys and grows food	Yes	Yes they have a small farm	Food	Plantano, pumpkin, tomato, Yautia. Raise cows and bulls	Watering and removes dead material from trees	Check plants every day	Maria destroyed a lot of the plants		Yes, their soil is not nutrient rich	Yes, it helps plants grow	Yes		Yes	
Person 4 (3/27)	Fishing and enjoying nature	Buys food	Very little, but her husband has more	Yes	Food	Plantanos, Yautia	She does not know	She does not take care of garden			No knowledge of fertilization	No	None	No	No	
Person 5 (4/3)	Fishing	Buys and grows food	Yes	Yes	Food	Plantano, banana, eggplant, chives	Watering keeps the area clean	Daily care, watering in the mornign and afternoon	Destroyed the whole garden	Church collected debris, then the government disposed of it	Has knowledge of fertilization	Yes	None	Yes	No	
Person 6 (4/3)	Fishing	Buys food	Yes	Yes	Flowers	Not applicable	Watering and fertilizing	Could not give estimate, but it was very little	Had a lot of debris after Maria	He burned the majority of the wood and also used it as fire wood	Yes, it is good for helping soil	Yes	Places fish within gardens	Yes	No	
Person 7 (4/5)	Fishing Kayaking	Buys and Grows food	Yes	Yes	Food	Plantanos, Banana, Mango, and citrus	Waters plants daily, keeps area clean	Spends 1 full day every 1-2 weeks maintaining garden	Yes, Maria destroyed everything	Municipality disposed of the debris	Knows its to improve soil quality	Yes, it helps plants grow	Buys morganic fertilizer from homedepot	No	No	
Person 8 (4/5)	Fishing	Buys food	Basic understanding	Yes	Flowers	Does not grow food	Waters, use fertilizer (20/20), weeds by hand	1-2 hours during weekends	Yes there was a lot of debris	Chopped it up and put it into a pile	Knows its to improve soil quality	Yes	Buys morganic fertilizer	Yes	places coffee grinds, eggshells, and bananas into a pile to decompose	
						Peppers, Tomatoes, Pumpkins, peas, avacados, Pana, Breadfruit			It destroyed the garden and caused other damage	Piled up debris and manicipality disposed of it	Knows its to improve soil quality					
Person 9 (4/5)	Fishing	Buys and grows food	Yes	Yes a small garden	Food	Yams, breadfruit, Malanga, Yautia, has medicinal plants and orcids at La Plata	Waters and keeps area clean	1-2 hours a week				Yes	None	Yes	No	
Person 10 (4/5)	Gardening and teaching her children	Buys and grows food	Yes	Yes, grows within forest, not structured	Food		Waters, transplants and trims	1 hour a day	Yes there was significant damage which cleared an area to allow for garden beds to be created	Piled up debris and let it decompose	Knows its to improve soil quality	Yes	Composting??	Yes	Place coffee grounds around plants	
Person 11 (4/5)	Ian's Class	Buys food working towards	Yes	Yes 1 acre farm	Food	Plantain, Papaya, mandonian, limes, Yautia	Water and weed beds	2 half days a week		Chopped it up and put it into a pile	Knows its to improve soil quality	Yes	Inorganic fertilizer	Yes	Does not use it, but looking into it	
						Coffee, Yautia, Banana, Orange, basil, Fennel, Passion fruit, Tomatoes, Papaya,		1 hour 3 days a week and 3 hours on Saturday	Coffee farm destroyed	Mowed debris to one pile and let it decompose	Knows its to improve soil quality				Piles up leftovers, such egg shells, grass, and leaves then lets it decompose	
Person 12 (4/5)	Ian's Class	Buys and grows food	Yes	Yes has a farm	Food		Watering and weeding					Yes	Compost	Yes		

Person 13 (4/5)	Morovis	Ian's Class	Buys and grows food	Yes	Yes has a farm	Food	Plantians, banana, Yuca, Sweet Potato, Name	Watering, cuts weeds no pesticides	7 hours a day, 7 days a week	His farm was destroyed	Pushed debris into a pile	Knows its to improve soil quality	Yes	inorganic fertilizer, but wants to stop	Yes	uses horse manuer and peels of plantians
Person 14 (4/5)	Morovis	Ian's Class	Local famer's markets and grows	Yes	Yes	Food	Roots, Greens, and fruits	Watering, climate	1-2 hours a day	Destroyed his garden	Pushed it aside and used it for compost	Its very good for the soil	Yes	Compost	Yes	Yes
Person 15 (4/5)	Guaynabo	Ian's Class	Famers market and grows food	A little bit	Potted Plants and small garden	Food	Breadfruit, banana, avacado, Pana	Watering, changing soil, transplanting into bigger pots, prunning	4 hours	not many plants, but destroyed Pana	Placed debris in the woods	Knows its to improve soil quality	Yes	Compost	Yes	Uses scraps from kitchen. Places it in a trash can with holes to let material decompose
Person 16 (4/5)	San Juan	Ian's Class	Buys most food from Famer's market and grows some food	A little bit	Potted plants due to living on 15th floor	Food	Tomatoes, Spices	Watering, transplanting, removes flowers	0.5 hours a day	Not applicable. Was not living in PR at the time		Yes	Yes	Compost	Yes	Uses a little basket to decompose egg shells and other scraps
Person 17 (4/5)	Manati	Ian's Class	Buys food from Famer's market and grows food	Yes, worked on a farm	Yes about a quarter acre farm	Food	Beans, raddish, lettuce, corn, plantains, tomatoes, horses, goats, sheep, and rabbits.	Water, weed, fertilize, rotate crops	7 hours per day	Destroyed everything	Piled up debris and let it decompose	Knows its to improve soil quality	Yes	Compost	Yes	Uses animal manuer, dead iguanas, grass, and other natural materials
Person 18 (4/10)	Dorado	Fishing	Supermarket, doesnt grow food	Yes, works for agricultural dept. of PR	No	No	Does not have garden	No garden	0	Created a lot of debris	Piled up debris and let it decompose	A little know-ledge	Yes	None	Yes	Does not use it
Person 19 (4/10)	Dorado	Fishing/family time	Supermarket, Grows some food	Yes	Yes	Food	Avocado, Gandules, Tomatoes, Peppers, Squash, Pomergranates, Plantians, Bananas, Peas,	Fertilizes, waters	1-2 hours a day	Pushed over many trees, lots of debris	Piled it up in front yard and town took it	The basics, improve soil health	Yes	Adds horse manure	Yes	Just uses horse manure
Person 20 (4/12)	Toa Alta	Fishing/Nature	Supermarket, Grows some food	Yes	Yes	Food	Plantians, Yuca, Nane, pumpkin, Ajies, eggplant, Lemon, Orange	Cleans and maintains the area, Fertilizes	1-2 hours a day	Destroyed all of his plants	Government took debris	Knows its to improve soil quality	Yes	Compost	Yes	Uses grass and leftovers
Person 21 (4/12)	Veja Alta	Fishing	Supermarket and grows food	Yes	Yes	Food	Plantians, Bananas, Ajies	Plants low maintenance plants, fertilizes every couple of months	1 hour every few couple months	Destroyed every-thing, cut down an avacado tree	Government took debris	Basic knowledge of compost and its basics benefits	Yes	An organic fertilizer bougth from store, ever 6 months	Yes	Doesnt compost

Interview date	1	2	3	4	5	5.1	5.2
Person 1 (3/27)	Economic/save money	Is willing to put in a lot of time	$20-25	Has a good amount of space to grow	Yes, many difficulties	Has a hard time keeping plants alive	Yes, hard to obtain tools, soil, compost, plants
Person 2 (3/27)	Yes, economic	Yes see 1.5.B	How ever much they need for compost and plants (Plantanos $2)	Yes they have plenty of space	Yes	Soil isnt nutrient rich, so they buy compost. They have a parasite that effect citrus and they use a liquid chemical to kill it. Iguanas are very bad. They eat tomatoes, so he uses air rifle to kill them	No
Person 3 (3/27)	Yes its very important for the family economic wise satisfying to see plants grow Can grow medicines	Yes, checks plants every day		Yes they have plenty of space	Yes	Tried to grow melons but parasites killed them. Iguanas have are a major problem, so they dug a trench and placed chicken wire around plants. Another parasite effects citrus called "Huevo Negro" (not sure if this is correct)	Not too much difficulty. They go to San Sebastian to buy plants and use seeds of plants to grow new fruits/veg.
Person 4 (3/27)	Yes to save money growing medicinal herbs	Willing to spend an hour a day	Not much, will use materials available for free such as seeds	Yes she has a decent amount of space to grow	Yes	Majority of problems are do to iguana, but they also have problems with chickens	No problems
Person 5 (4/3)	Yes to save money	Willing to spend a whole day planting and maintaining garden	$100-80	Yes	Yes	The major probelm is with pests. Iguanas cause a lot of problems and he uses dogs to protect plants	No is able to buy everything within supermarket
Person 6 (4/3)	Yes its more convenient than going to store	None	None	Not applicable. Does not want garden	Does not have garden		
Person 7 (4/5)	Yes to grow food and save money	Yes see 1.5.B	About $40 a month	No, wants more space	Yes	He does not have enough space for growing because he lives in a urban area	No problems obtaining materials
Person 8 (4/5)	Yes, grow food	Willing to spend more time could not estimate amount	Very little	Yes she has plenty of space to grow	No	Has dogs to deter iguanas	No problems obtaining materials
Person 9 (4/5)	Yes to grow food and save money	Yes see 1.5.B	Very little, buys seeds which are inexpensive	Yes a decent size home garden	Some	Caterpillars eat the leaves of tomato plants, Iguanas eat tomatoes, birds eat the fruits doesnt stop the plants from growing	No
Person 10 (4/5)	Yes to save money	Yes see 1.5.B	None	Yes they have plenty of space	Yes	Iguanas will eat the fruits and vegetables, but they use dogs to deter iguanas. Citrus fungus that causes trees to die or not produce fruit after 3-4 years, produces poor quality fruit Theres nothing they can do about the fungus	Can be difficult obtainign seeds or saplings of various trees
Person 11 (4/5)	Yes to grow food and save money	yes see 1.5.B	$400 a week	Yes he has plenty of space, but working on expanding	Yes	Insects, uses natural pestisides. Weather not much to do about it. Its an Urban farm so no major problems with iguana	No problems obtaining materials
Person 12 (4/5)	Yes to grow food and save money	4-5 hours a day	$150 a month Depending on season	Yes but would prefer to have more space	Yes	Fungus- does not do anything to prevent it Bacteria infections Insects eat leaves and fruits Weather No iguanas due to mountains Difficulties finding ways to clear land	Problems with obtaining seeds from US
Person 13 (4/5)	Yes to grow food and save money	yes see 1.5.B	$7000 for farm, $50 for 100lbs of seeds	Yes 13 acre farm	Yes	Mice, No iguana, rats- leaves the alone but has dogs and traps Many problem is with money	No problems obtaining materials
Person 14 (4/5)	Food self sustainability,	3-4 hours a day	However much is needed	Yes	Yes	Pests, weather (hurricanes), drought	No problems obtaining materials
Person 15 (4/5)	To grow medicine and food	As much as possible	Not sure	Yes but small	Yes	Iguanas eat sweet peppers- doesn't do anythign to stop them	Difficulty with exchnging or collecting seeds Difficulty finding the right tools (pickax or hoe)
Person 16 (4/5)	To grow medicine and food	3 full days a week	$50,000	No, the space is too small	Yes	Worms/catipillars/white flies eat the tomato leaves - uses Neem to deter them	Difficulty with obtaining gardening tools, most tools are made for construction
Person 17 (4/5)	Its very benfitial and cost effective to grow their own food	wants to be a full-time farmer	$5,000 a year	Yes	Yes	Iguanas eat plants- Kills them, eats them or uses them in compost Catipillar- squishes them and leaves them in the plants Money- trying to get funding	No problems obtaining materials
Person 18 (4/10)	Understands it saves money	5 hours a day	$600 month	16x20m	Not many	Only snails	No problems obtaining materials
Person 19 (4/10)	Yes can save a lot of money	1-2 hour a day	$100 a month	Plenty of space	Yes	Insects that kill bananas- Does nothing about them Iguanas- Uses dogs to deter them	No problems obtaining materials
Person 20 (4/12)	Yes can save a lot of money	1-2 hours a day	$12	Plenty of space	Yes	Iguana- dogs to deter them Parasite- Didn't do anything Rats/mice-Poison Caterpillar-Didn't do anything about it	No problems obtaining materials
Person 21 (4/12)	Yes can save a lot of money	1 day week	$30-40 a month	Not enough	Yes	Caterpillars- uses Malathion pesticide Parasites	No problems obtaining materials

Interview date	1.1	1.2	2.1	2.1.1	2.1.2
Person 1 (3/27)	No	No	None	neither	No
Person 2 (3/27)	No	No	A brouchure or other reading material	No class	No
Person 3 (3/27)	No	No	A combination of class and brouchure	Hands-on	No
Person 4 (3/27)	No	Yes	Combination, prefer brouchure but would take class if she had time	Hands-on	No
Person 5 (4/3)	No	Yes	Combination	Hands-on	No
Person 6 (4/3)	No	Yes	Combination	Hands-on	No
Person 7 (4/5)	No	Yes	Combination of a class and brouchure	Hands-on	A little bit
Person 8 (4/5)	No	Yes	Combination	Hands-on	Yes
Person 9 (4/5)	No	Yes	Combination	Hands-on	Yes
Person 10 (4/5)	Yes	Yes	Class	Outside and hands-on	Yes
Person 11 (4/5)	Yes	Yes	Combination	More visual leanring	Yes
Person 12 (4/5)	No	Yes	Combination	No preference	Yes
Person 13 (4/5)	No	Yes	Combination	Mainly brouchure and lecture	Yes
Person 14 (4/5)	No	Yes	Hands-on	Hands-on	Yes
Person 15 (4/5)	No	Yes	Combination	Mostly hands-on	Yes
Person 16 (4/5)	No	Yes	Combination	Hands-on	Yes
Person 17 (4/5)	No	Yes	Combination	Lecture with visuals and brouchure	Yes
Person 18 (4/10)	No	No	Combination	Hands-on	No
Person 19 (4/10)	No	No	Combination	Hands-on	Yes
Person 20 (4/12)	No	Yes	Combination	Hands-on	Yes
Person 21 (4/12)	No	Yes	Hands-on	Hands-on	No

Appendix G - PowerPoint

Home Gardening

Benefits

01	Increased Food sustainability	Improves a family's access to fruits, vegetables, and other produce Lessens the effects of food shortages Less dependent on supermarkets
02	Economic Gain	Save money through buying less groceries Gain income through selling surplus crops This money can be used for other important expenses
03	Improved Health	Gardens can supply families with essential nutrients Families can grow medicinal herbs to cure sickness or illness
04	Environmental Improvement	Gardens are homes for many animals and organisms Increases land conversation

6 Practices of Home Gardening

Bed Creation

Germination

Transplanting

Fertilization

Maintenance

Pest Control

Bed Creation-In ground beds

1. Find a plot of land big enough for all your plants, receives sun, and is easy enough to access
2. Dig up the plot of land with a shovel, rototiller, or any other equipment available
3. Remove old vegetation and large objects such as rocks and roots
4. Mix in some sand and fertilizer into the soil

Bed Creation-Raised Beds

1. Find space for garden
2. Create an enclosed container of any material and shape
3. Remove vegetation from plotted area in shape of container
4. Place the container in the plot and fill it with nutrient rich soil
5. Other materials can be used to create raised garden beds

Germination

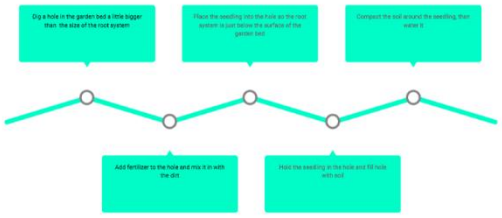
An inexpensive method of growing seedlings from seeds. Germination should happen during off season, so seedlings will be ready for growing season

Obtain Containers → Plant Seed → Water and Sunlight → Acclimation → Transplanting

Hands-on Activity

OR

Transplanting

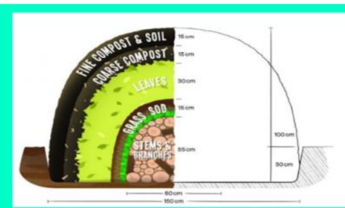


Fertilization

Inorganic Fertilizer
Bought in most hardware or large retail stores. They can be mixed into the soil or with water, then applied to the soil surrounding plants.

Compost
Involves decomposing organic materials, such as food scraps or wood debris, to create a nutrient rich soil. These materials are left to decompose, but the process is quickened through turning the compost pile with a pitchfork to mix air into it.

Hugelkultur



Maintenance

Pest Control

Iguana

Iguanas are one of the major pest in Puerto Rico and cause extensive damage to gardens. They will burrow into gardens and eat the crops. Methods to deter them are listed below.

- Hang cans and CDs around beds
- Plant Oregano
- Dogs scare the iguanas away
- Hunt them
- Wrap chicken wire around beds

Insects

Common insects in Puerto Rico include whiteflies, caterpillars, croton scales, aphids, mealybugs, and more. These insects wreak havoc of gardens by eating leaves and produce, spread disease, and stunting plant growth. Methods to deter them are listed below.

- Neem oil
- Malathion
- Aramite
- Bacillus thuringiensis (BT)
- Natural Repellents: Neem, Cilantro, Lemongrass, Oregano, & basil

Fungus

Citrus Greening is a major problem in Puerto Rico that affects all citrus trees. The fungus deforms the leaves and fruit of the trees. After about 4 years the tree will die. The best way to stop Citrus Greening and other fungi from spreading involves cutting the infected parts.

- Cut off the affected leaves
- Place the leaves in a bag to prevent the spores from spreading
- Clean off all tools used

Questions?

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In Spanish

JARDINERÍA CASERA

BENEFICIOS

01	Mayor sostenibilidad alimentaria	• Mejora el acceso de una familia a frutas, verduras y otros productos • Disminuye los efectos de la escasez de alimentos • Menos dependiente de los supermercados
02	Ganancia económica	• Ahorre dinero comprando menos comestibles • Obtenga ingresos mediante la venta de cosechas excedentes • Este dinero se puede utilizar para otros gastos importantes
03	Mejora de la salud	• Los jardines pueden suministrar a las familias nutrientes esenciales • Las familias pueden cultivar hierbas medicinales para curar enfermedades
04	Mejoramiento ambiental	• Los jardines son hogares para muchos animales y organismos • Aumenta la conservación de la tierra

6 PRÁCTICAS DE JARDINERÍA CASERA

Creación de lecho de jardín

Germinación

Trasplante

Fertilización

Mantenimiento

Control de plagas

CREACIÓN DE JARDINERÍA CAMA - EN SUELO

1. Encuentra una parcela de tierra lo suficientemente grande para todas tus plantas, donde recibe dol sol, y fácil acceso
2. Desenterrar la parcela de tierra con una pala, rototiller, o cualquier otro equipo disponible
3. Eliminar la vegetación y objetos grandes como rocas y raíces
4. Mezclar un poco de arena y fertilizante en el suelo

CREACIÓN DE JARDINERÍA CAMA -CAMAS DE JARDÍN ELEVADO

1. Encuentra espacio para el jardín
2. Cree un contenedor cerrado de cualquier material y forma
3. Elimine la vegetación del área trazada en forma de contenedo
4. Coloque el recipiente en la parcela y llénelo con suelo rico en nutrientes
5. Otros materiales se pueden utilizar para crear camas de jardín elevadas

GERMINACIÓN

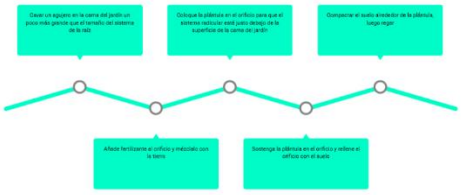
La germinación es un método económico de cultivo de plántulas a partir de semillas. Debería suceder durante la temporada baja, por lo que las plántulas estarán listas para la temporada de crecimiento

Obtener contenedores → Semillas de plantas → Agua y luz solar → Aclimatación → Trasplante

ACTIVIDAD PRÁCTICA

OR

TRASPLANTE

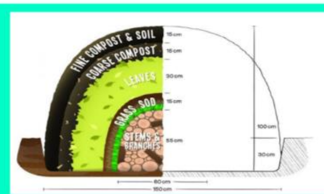


Fertilización

Fertilizante inorgánico
Comprado en la mayoría de hardware o grandes tiendas minoristas. Se pueden mezclar en el suelo o con agua, luego se aplican a las plantas circundantes del suelo.

Compost
Consiste en descomponer los materiales orgánicos, como restos de alimentos o desechos de madera, para crear un suelo rico en nutrientes. Estos materiales se han dejado para descomponer, pero el proceso se ha acelerado a través de girar la pila de compost con un tridente para mezclar el aire en él.

Hugelkultur



Mantenimiento

Control de plagas

Iguana

Las iguanas son una de las principales plagas de Puerto Rico y causan grandes daños a los jardines. Se enterrarán en los jardines y comerán los cultivos. Métodos para disuadirlos se enumeran a continuación.

- Colgar latas y CDs alrededor de las camas
- Planta de orégano
- Los perros asustan a las iguanas
- Cazar y comerlos
- Envolver alambre de pollo alrededor de las camas

Insectos

Los insectos comunes en Puerto Rico incluyen moscas blancas, orugas, escamas de crotones, pulgones, cochinillas y más. Estos insectos causan estragos en los jardines comiendo hojas y produciendo, propagando enfermedades y haciendo crecer el crecimiento de las plantas. Los métodos para disuadirlos se enumeran a continuación.

- Neem oil
- Melacion
- Aramite
- Bacillus thuringiensis (BT)
- Repelentes naturales: Neem, cilantro, limoncillo, orégano, y albohaca

Hongo

Citrus greening es un problema importante en Puerto Rico que afecta a todos los árboles de cítricos. El hongo deforma las hojas y el fruto de los árboles. Después de aproximadamente 4 años el árbol morirá. La mejor manera de evitar que Citrus greening y otros hongos se propaguen consiste en cortar las partes infectadas.

- Cortar las hojas afectados
- Coloque las hojas en una bolsa para evitar que las esporas se propaguen
- Limpie todas las herramientas utilizadas

Preguntas?

Citations:

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Appendix H - Brochure

Maintenance

Watering

Watering is an important aspect of home gardening that supports healthy plants and large crop yields. Excessive watering can cause the plant to rot. While underwatering leads to plants dying. The amount of water required depends on the weather, plant and its stage of life. Since Puerto Rico experiences a wet and dry season it is important to vary the amount of water throughout the year. During the dry season it is recommended to place leaves on the soil to retain moisture and protect the dirt against the sun. Also, plants require more water when seedlings and when im bloom or budding. Plants need less water when matured or bearing fruits or flowers.

Weeding and Cleaning

Another important part of maintaining a garden is weeding. Weeds compete with desirable plants for nutrients, sunlight and water. It is important to remove weeds to maintain healthy and unobstructed plants. To prevent weeds mulch or another barrier can be placed on top of soil. It is also important to remove sticks, stones and other debris from the garden to maintain a clean garden. Keeping a garden clear reduces the amount of habitats for pests

Crop Rotation

Crop rotation is a crucial part of long term garden maintenance that is often overlooked. Different plants require slightly different nutrients. By rotating where plants are located in your garden it gives the ground a break and allows for healthier plants and garden soil.

Pest Control

Types of Pest

- Iguana
- Insects
- Fungus

Deterrents

Iguana

Iguana deterrents can consist of hanging CD's or cans around beds. Chicken wire around beds is also very effective and perhaps the best method. Additionally, dogs and hunting can be useful if gardners have dogs and prefer to hunt.

Insects

For insects, the best methods of dettereants consist of Neem oil, BT, Aramite, lemon grass, and oregano. These methods are used by both locals and experts.

Fungus

For Fungus, when fungus infects plants, The best thing to do is cut the fungus off because the plants could still yield offspring. Then put the infected plants in a plastic bag and throw them out. Heavily sterilize equipment used.

The La Plata Wildlife Refuge
Departamento de Recurso Naturales y Ambientales

Home Gardening

Improving Local Food self-sustainability

Brian Liwo; Brandon Malarney; Jordan Pickunka; Greg Roe

Benefits

1. Provide families with a sources of fruits and vegetables
2. Families save money on groceries
3. Families can sell extra produce
4. Supply medicinal herbs to aid sicknesses and illnesses
5. Improve Access to nutrients

Bed Creation

Start by find a plot of land big enough to fit all the plants you want in your garden. Make sure the plot receives plenty of sunlight and has access to water.

Raised Garden Beds

Raised garden beds can be created by placing wood or another barrier in a rectangle and then filling the middle with topsoil. Also, you can re-use materials such as fridges or tires. These types of beds allow for good drainage during the rainy season and typically have less weeds. It is important to water these beds consistently and often during the dry season.

In Ground Garden Beds

They are created by digging into the ground about 9 inches. Remove all vegetation, rocks, and other objects that are within the garden plot. Sand and fertilizer can be mixed into the soil to improve the nutrient content, and porosity. Addition, trenches can be added to around the garden beds to hold water.

Germination

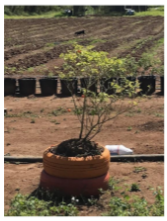
If money is an issue we recommend that seeds are grown indoors instead of purchasing seedlings to save money. Seeds should be placed in small growing containers with holes at the bottom to allow for drainage. Place enriched soil in the containers and gently press the seeds into the soil. Cover the seeds and water to moisten the dirt. The seeds should be placed in a window for direct sunlight. When the seeds sprout they should be gradually acclimated to the outdoors for 7-10 days by placing them outside for increased increments of time. After acclimation, the seedlings are ready for transplanting. Germination should take place during the gardening off-season so seedlings can be transplanted at the beginning of the garden season.

Transplanting

Transplanting involves planting seedlings into garden beds. This process should take place during the early morning or later in the evening when the sun is less harsh. First, dig a hole in the garden bed about the same size of the root system. Mix fertilizer into the hole, then place the seedling in the hole. The root system should be just below the surface of the garden bed. Fill in the hole with soil. Lastly, water the seedling.

Before transplanting the next seedling, it must be properly spaced from the previous seedling. Here is a list of spacing between plants:

- Tomatoes - 24"
- Sweet Pepper - 24"
- Plantains - 36"



Fertilization

Fertilization is an important aspect of home gardening that improves the nutrient content within soil. Plants need various nutrients in order to produce fruits or vegetables, therefore it is important to add fertilizer when the soil lacks the necessary nutrients.Two main fertilizers include inorganic and compost

Inorganic Fertilizer

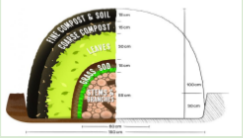
These can be purchased in the gardening section of most hardware or large retail stores. There are different types of inorganic fertilizers that can be mixed together to meet the nutrient requirements of various plants. Inorganic fertilizers can be mixed into the soil or with water, then applied to the soil surrounding plants. This method is particularly to fertilize long term plants, such such as fruit trees, to help boost crop production.

Composting

Composting involves the decomposing of organic materials to create a nutrient rich soil. Some common materials used in compost include kitchen scraps, manure, and wood chips, grass clippings. These materials can be piled and left to decompose, but compost production can be quickened through aeration. Aeration involves turning the compost pile with a pitchfork to mix air into it. The air helps increase decomposition

Another method of composting is Hugelkultur. Creating a Hugelkultur bed involves removing sod from a patch of ground, placing woody debris into the hole, covering the wood with the sod, then covering the sod with foliage, course and fine compost in that order. The large surface area of the mound can be used to grow plants and is very low maintenance.

After a severe storm or hurricane, the debris can be used to create compost. Small sticks and branches can be placed in compost piles or Hugelkultur mounds. Larger logs or debris can be piled, then left to sit. These piles can provide nutrient runoff if placed up slope of gardens. After a few years, the mounds with decompose into nutrient rich material that can be used in gardens, too.



In Spanish

El Mantenimiento

Riego

El riego es un aspecto importante de la jardinería doméstica que apoya plantas sanas y grandes cosechas. El riego excesivo puede hacer que la planta se pudra. Mientras que el bajo riego conduce a las plantas muriendo. La cantidad de agua requerida depende del clima, la planta y su etapa de la vida. Desde Puerto Rico experimenta una estación húmeda y seca es importante variar la cantidad de agua durante todo el año. Durante la estación seca se recomienda colocar las hojas en el suelo para retener la humedad y proteger la suciedad contra el sol. Además, las plantas requieren más agua cuando las plántulas y cuando están en floración o en ciernes. Las plantas necesitan menos agua cuando maduran o llevan frutas o flores.

Deshierbe y Limpieza

Otra parte importante de mantener un jardín es el deshierbe. Las malas hierbas compiten con plantas deseables para nutrientes, luz solar y agua. Es importante eliminar las malas hierbas para mantener las plantas sanas y sin obstrucciones. Para evitar el mantillo de malezas u otra barrera se puede colocar en la parte superior del suelo. También es importante eliminar palos, piedras y otros desechos del jardín para mantener un jardín limpio. Mantener un jardín despejado reduce la cantidad de hábitats para las plagas

Rotación de Cultivos

La rotación de cultivos es una parte crucial del mantenimiento de jardines a largo plazo que a menudo se pasa por alto. Las diferentes plantas requieren nutrientes ligeramente diferentes. Girando donde las plantas se encuentran en su jardín da el suelo una rotura y permite plantas más sanas y suelo de jardín.

Control de Plagas

Tipos de Plagas

Iguana
Insectos
Hongo

Los Elementos de Disuasión

Iguana

Los disuentes de Iguana pueden consistir en colgar CDs o latas alrededor de las camas. Alambre de pollo alrededor de las camas es también muy eficaz y tal vez el mejor método. Además, los perros y la caza pueden ser útiles si los jardineros tienen perros y prefieren cazar.

Insectos

Para los insectos, los mejores métodos de dettereants consisten en aceite de Neem, BT, Aramita, hierba de limón y orégano. Estos métodos son utilizados por locales y expertos.

Hongo

Para hongos, cuando los hongos infectan las plantas, lo mejor que puede hacer es cortar el hongo porque las plantas todavía podrían producir descendencia. Luego coloca las plantas infectadas en una bolsa de plástico y tíralo. Equipo fuertemente esterilizar utilizado.

Refugio de Vida Silvestre del Embalse La Plata

Departamento de Recurso Naturales y Ambientales

Jardinería Doméstica

Mejora de la Sostenibilidad Alimentaria Local

Brian Liwo; Brandon Malarney; Jordan Pickunka; Greg Roe

Los Beneficios

1. Proporciona a las familias una fuente de frutas y verduras
2. Las familias ahorran dinero en comestibles
3. Las familias pueden vender productos adicionales
4. Suministra hierbas medicinales para ayudar con enfermedades y dolencias
5. Mejorar el acceso a los nutrientes

La Creación de Camas

Comience por encontrar una parcela de tierra lo suficientemente grande como para caber todas las plantas que desee en su jardín. Asegúrese de que la parcela recibe mucha luz solar y tiene acceso al agua.

Camas de Jardín Elevado

Las camas de jardín elevadas se pueden crear colocando madera u otra barrera en un rectángulo y luego llenando el medio con tierra vegetal. Además, puede reutilizar materiales como frigoríficos o neumáticos. Estos tipos de camas permiten un buen drenaje durante la temporada de lluvias y típicamente tienen menos malas hierbas. Es importante regar estas camas de forma consistente y a menudo durante la estación seca.

Las Camas de Jardín en El Suelo

Se crean cavando en el suelo alrededor de 9 pulgadas. Retire toda la vegetación, rocas y otros objetos que se encuentran dentro de la parcela de jardín. La arena y el fertilizante se pueden mezclar en el suelo para mejorar el contenido de nutrientes y la porosidad.

Germinación

Si el dinero es un problema, recomendamos que las semillas se cultivan en interiores en lugar de comprar plántulas para ahorrar dinero, las semillas deben colocarse en pequeños recipientes de cultivo con agujeros en la parte inferior para permitir el drenaje. Coloque el suelo enriquecido en los recipientes y presione suavemente las semillas en el suelo. Cubra las semillas y el agua para humedecer la suciedad. Las semillas deben colocarse en una ventana para la luz solar directa. Cuando las semillas germinan se deben aclimatarse gradualmente al aire libre durante 7-10 días colocándolas

Trasplantado

El trasplante consiste en plantar plántulas en camas de jardín. Este proceso debe tener lugar durante la mañana temprano o más tarde en la noche cuando el sol es menos áspero. En primer lugar, cavar un agujero en la cama del jardín sobre el mismo tamaño del sistema de la raíz. Mezclar el fertilizante en el orificio y luego colocar la plántula en el orificio. El sistema radicular debe estar justo debajo de la superficie de la cama del jardín. Rellene el orificio con tierra. Por último, regar la plántula.

Antes de trasplantar la siguiente plántula, debe estar adecuadamente espaciada de la plántula anterior. Aquí hay una lista de espaciado entre plantas:

- Tomate - 24"
- Ají dulce - 24"
- Platano - 36"

La Fertilización

La fertilización es un aspecto importante de la jardinería doméstica que mejora el contenido de nutrientes dentro del suelo. Las plantas necesitan varios nutrientes con el fin de producir frutas o verduras, por lo tanto, es importante añadir fertiliizante cuando el suelo carece de los nutrientes necesarios. Dos fertilizantes principales incluyen inorgánicos y compost

Fertilizante Inorgánico

Estos se pueden comprar en la sección de jardinería de la mayoría de hardware o grandes tiendas minoristas. Existen diferentes tipos de fertilizantes inorgánicos que se pueden mezclar para satisfacer las necesidades nutricionales de varias plantas. Los fertilizantes inorgánicos se pueden mezclar en el suelo o con agua, luego se aplican a las plantas circundantes del suelo. Este método es particularmente para fertilizar plantas de largo plazo, tales como árboles frutales, para ayudar a aumentar la producción de cultivos.

Compostaje

El compostaje involucra la descomposición de materiales orgánicos para crear un suelo rico en nutrientes. Algunos materiales comunes utilizados en el compost incluyen trozos de cocina, estiércol, y astillas de madera, recortes de hierba. Estos materiales pueden apilarse y dejarse para descomponerse, pero la producción de compost puede ser vivificada a través de la aireación. La aireación implica girar la pila de compost con un tridente para mezclar aire en ella. El aire ayuda a aumentar la descomposición.

Otro método de compostaje es Hugelkultur. La creación de una cama Hugelkultur consiste en eliminar el césped de un pedazo de tierra, colocando desechos leñosos en el agujero, cubriendo la madera con el césped, luego cubriendo el césped con follaje, curso y compost fino en ese orden. El gran área superficial del montículo se puede utilizar para cultivar plantas y es de muy bajo mantenimiento.

Después de una fuerte tormenta o huracán, los desechos se pueden usar para crear compost. Pequeños palos y ramas se pueden colocar en pilas de compost o montículos de Hugelkultur. Se pueden amontonan troncos o escombros más grandes, y luego se dejan para sentarse. Estas pilas pueden proporcionar escora de nutrientes si se colocan hasta la pendiente de los jardines. Después de unos años, los montículos con se descomponen en material rico en nutrientes que se puede utilizar en los jardines, también.

Appendix I - Bean in a Bag

The bean in a bag activity was designed to help students observe plant growth starting from a seed. The students will be able to observe the plant growth over two weeks, gaining knowledge about how a seed turns into a seedling. Additionally, depending on how many seeds germinate, the activity will provide the students with seedlings for them to plant in a pot or garden at home. Furthering their education of plant growth, and providing the family and home with bean plants that have the capability of maturing fully and producing food.

The activity requires one ziplock bag, one sheet of paper towel (cut in two), at least two seeds per student, and a stapler shared amongst the class. Additionally, the group will need access to water mixed with fertilizer to moisten the paper towels and provide nutrients to the seeds.

1. Hand out a ziplock and two pieces of paper towels, cut small enough to fit inside the ziplock baggie.
2. Hand out at least two seeds to each student, it is recommended that up to four seeds are given to each student to ensure that at least one sprouts, but the number of seeds should be determined based on cost and availability.
3. The paper towels should be stapled together ⅓ of the way above the bottom, these staples will support the seeds in the bag, allowing them to rest around the middle of the bag, giving space for roots to grow down and the sprout to grow up
    1. Ideally, the students will use one more staple than seed, with the staples evenly distributed in a line ⅓ of the way up the paper towels. For example, if there are two seeds there should be three staples applied in a line, the first seed will later be placed midway between staple one and two and the second seed will later be placed midway between staple two and three. The stapling process is shown in Figure 12 with seven staples, enough for six seeds, more than recommended for the experiment. The seed placement is described in step 6.

Figure 12. Paper Towel Stapled for Seeds to Rest (L., 2013)

4. The students should moisten, but not soak, the paper towels by dipping it in the solution or applying the solution using a spray bottle.

5. The wet, stapled paper towels should be placed within the ziplock baggie so that the line of staples is ⅓ of the way towards the bottom of the bag
6. The seeds should be placed in between the two paper towels inside the bag, resting around the midway line of the bag above the staples. The seeds should also be placed in between staples. Ideally, the roots will grow down between the staples and the sprout will grow up, unobstructed.
7. The baggie should not be sealed, to lower the chance of seeds rotting.
8. The students will bring home the ziplock bag containing two to four seeds. Additionally, they should be instructed to tape or fasten the baggie to the inside of a window so that the seeds receive sunlight and are encouraged to grow.
9. Over the course of the next two weeks, students can observe the growth of the bean plant from seed to seedling. It is important to rewet the paper towel if the bag becomes dry, but it is not necessary to add additional fertilizer. Also, emphasize that the baggie should never be closed all the way.
10. Once the seed becomes a seedling after two to three weeks, the seedlings can be carefully removed from the baggie and planted with care in a pot or garden. The seed should be one to two inches below the soil when it is planted with the top of the sprout taller than the soil. This is another way to determine when the seedling is ready to plant because the sprout needs to be larger than one to two inches to ensure that it will reach above the soil with correct seed placement. We recommend to add fertilizer to the hole and then plant to ensure maximum growth
    1. It is possible the roots will become attached to the paper towel, in this case, it is okay to plant the seedling with the paper towel surrounding the root system.
    2. However, the student should remove the staples by cutting the paper towel around the roots or by ripping the staple out.

Appendix J - Seed in a Cup

The seed in a cup activity was designed as a simple planting example to introduce students to common methods of planting. Our interviews showed us that there was a gap in the knowledge and practice of composting. This activity was designed to show the necessity and helpfulness of compost. Additionally, this activity also focuses on planting seeds, a common and self-sustaining practice that locals used. This activity also provides students with young bean plants for them to plant in their home garden for future food sustainability.

This activity requires one cup and two seeds per student. There also should be one safety pin for approximately every five students to share. The class also will share topsoil and compost that will be placed in the cup using a small spade. Ideally, biodegradable cups will be used so that when the seed matures into a seedling the cup can be placed directly into a garden or larger pot. However, if biodegradable cups are not available, this activity can be done using a normal paper or plastic cup. Directions for this activity are as follows:

1. Prior to this activity buckets of soil should be obtained for the students to use. We recommend that a small spade is placed inside the bucket of soil to help the students move the dirt from the bucket to their cup.
2. Also prior to this activity, compost should be obtained. We recommend placing a metal spoon in the compost to help students move the compost.
3. Hand out one cup and two seeds to every student.
4. Using a safety pin, poke 5-10 holes in the bottom of the cup to allow for water to drain when watering.
5. Fill ⅔ of the cup with topsoil.
6. Next, make two small holes in the dirt with a thumb or finger. The holes should be about one and a half inches deep. Additionally, the holes should be at least an inch apart.
7. Add compost to the bottom of each hole, filling the hole until it is one inch deep.
8. Place a seed at the bottom of each hole and brush dirt on top of the seed until the hole is filled.
9. Add water to the soil until moist. Adding water should be done slowly to lower the chances of overwatering. It is common that water will drip from the holes at the bottom of the cup, this indicates that the soil is saturated and to stop watering.
10. The students should bring the cup home and in two to three weeks the biodegradable cup can be placed directly in soil. If using non-biodegradable cups, it is necessary to transplant the bean seedlings into a pot or into a garden.

Additionally, to improve on the activity by incorporating a self-watering planter, replace the cup with a plastic water bottle and a strip of fabric three to four inches long (Pinola, 2013) Poke a hole in the cap and thread the piece of fabric halfway through the bottle top. Cut the bottle in half and place the top upside down inside the bottom half. The bottle should be cut so that when the top is sitting inside the bottom, the cap rests about an inch to two inches from the bottom with the fabric dangling above the base of the water bottle. Add soil to the top half of the water bottle, making sure that the fabric extends from the cap, up into the added soil. Steps 6-8 remain the same. Finally, instead of step 9, fill the bottom half of the water bottle with water so that the fabric draws water from the bottom half of the bottle into the soil (Pinola, 2013).

Appendix K - Planting Within a Garden Bed at La Plata

For this activity, we recommend recycling materials to use as garden beds so that the beds do not have to be prepared from scratch by the students or prepared before the students arrive. Similar to how La Plata already uses old tires and plastic drums as makeshift garden beds, we recommend filling tires, plastic drums, old refrigerators, and other large recycled containers with soil for students to plant in. Using recycled materials for garden beds is a beneficial practice in Puerto Rico that students can utilize in their own home gardens. We recommend having students transplant seedlings into the beds using compost within the planting process. A teaching point for the instructor to highlight during this activity is that plants go into shock after transplanting. To a beginning gardener, this could be worrisome but is a common occurrence in one to two days after transplanting. This time can be lessened by adding compost, another teaching point, but not avoided altogether. To guide the plant out of shock, it should be watered often but not overwatered. This transplanting process is important to teach about because a bad transplant could stunt the plant's development and not produce a high yield harvest.

This activity gives students a chance to practice transplanting seedlings, a valuable skill that is necessary for the development and maintenance of a home garden. This skill complements the "Seed in a Cup" and "Bean in a Bag" activities by teaching transplanting skills that will be used once the seeds grow in the home for both of these previously described activities. Also, to improve on this activity, we recommend incorporating the creation of compost, a common home gardening technique. This compost creation will also mitigate the costs that La Plata needs to conduct this activity. We recommend that compost creation be an activity during the same lesson as planting in a garden bed, but it is also possible to be an independent activity. We have adapted Jacqueline Siejo's compost creation activity that she uses as a lesson in one of her classes for use in La Plata. This activity requires a plastic trash can, a drill and drill bit capable of making 5 cm holes, as well as organic scraps. To make a compost rich in nutrients we recommend using a combination of dark and light organic scraps. Dark scraps include leaves and small pieces of wood. Light scraps include garden waste, fruits, vegetables, egg shells and meat scraps. To ensure healthy compost without testing the nutrient levels, we recommend using a variety of organic material and not using a large amount of a single waste. Steps for compost creation are as follows:

1. Drill 6-9 rows of 5 cm holes along the sides of the barrel to allow air circulation. Additionally, drill holes on the bottom of the barrel for more air circulation but primarily for water drainage.
2. Place the barrel on blocks to allow better air circulation and draining.
3. Fill the barrel ¾ of the way by alternating levels of dirt, dark scraps, and light scraps. The dirt levels do not have to be as thick as the scraps.
4. Add water until moist but not soaked. If there is water exiting the bottom of the barrel it is overwatered.