Research Proposal

The Effect of Soil Conditions on Plant Health at the University of Central Florida

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1. Introduction

When choosing a university, prospective students hope to be surrounded by a flourishing and healthy environment. Boyer (1987) of The Carnegie Foundation suggests, “The appearance of campus is, by far, the most influential characteristic during campus visits.” Studies have even suggested that regular exposure to natural environments could aid in the prevention of certain public health issues, such as mental ill health (Maller et al. 2005). As of 2010, the University of Central Florida was the second largest university with more than 56,000 enrolled students, and has still grown in recent years (UCF Today 2010). With this growth, the development of new buildings, parking garages, and housing has called for better landscaping on-campus, as well as increased consideration of how the campus affects surrounding natural lands and on-campus natural resources.

Urban environments have drastically changed the composition of natural ecosystems, particularly in recent years. Living soils are vulnerable to rapid changes but serve as good indicators of ecological health (Xiao-Lin Sun 2012). Soils within urban environments are susceptible to abnormal compaction. By reducing the ability of water infiltration within soils, severe compaction can increase the amount of run-off of pollutants and synthetic fertilizers. Local ecosystems are directly affected by this development. Sandy soils have a higher infiltration rate and are more susceptible to nutrient leaching (Nguyen and Marschner, 2013).

1.1. Soil conditions

Soil compaction is compression of particles leading to the reduction in the amount of pore space. Infiltration is the process by which water is absorbed into soil. Soil moisture is the amount of water saturation used for uptake by plants. The measure of a soil's acidity or alkalinity indicates pH value. Soil types are determined by composition and grain size of dried soil (sandy, organic, mixed, etc.)

Soil compaction is common in urban environments due to heavy pedestrian and motor vehicle traffic. Compaction may promote or harm plant health, the latter occurring more frequently (Kozlowski 1999). High compaction increases the degree of overflow and runoff of pesticides, herbicides, heavy metals, and excess nutrients (Olson et al. 2012). Subsoil is more vulnerable to compaction in areas of construction where topsoil was removed. Roots struggle to penetrate compacted soil, which limits their range. Infiltration of soil is important for plant roots to receive proper water uptake. Soils that are aerated and comprised of compost have higher rates of water infiltration (Olson et al. 2012). Organic soils are more likely to display these attributes and are more conducive to plant growth. Sandy soils, on the other hand, drain quickly and have difficulty retaining nutrients. Central Florida's native soil type is Myakka, which is comprised of a sandy topsoil and partially organic subsoil (USDA 2011).

Urban landscapes generally lead to increasingly acidic topsoil. Xiao-Lin Sun (2012) states that on average pH decreases by 0.9-1.02 over the span of many decades in unintentionally pH manipulated urban environments. While a decreasing pH can favor plants adapted to acidic conditions, such changes could lead to an increase of invasive species. The coevolution of plants and their specific environment suggests a need to understand the pH parameters in which they may survive.

1.2. Plant health

For this study, plant health is defined as the ability to perform normal biological functions, such as the ability to maintain healthy leaf color and structure with minimal signs of stress or disease. Döring (2012) suggests, “A plant can be regarded as healthy as long as its physiological performance, determined by its genetic potential and environmental conditions, is maintained.” Essential nutrients, such as nitrogen, phosphorous, and potassium (N-P-K) are derived from abiotic conditions, such as water and air. Nitrogen is important for all plant functions due to the major role it plays in building amino acids and chlorophyll production. Phosphorous is an energy source (ATP) during photosynthesis and important for DNA and RNA production. Potassium controls water uptake (stomata) and deficiencies are indicated by abnormal plant shape and color (Markham, 2010).

The effective ecological management of plants and their optimal soil conditions could help to maintain an aesthetically pleasing urban setting. In order to understand these biological conditions and how urbanization is affecting urban soil, fieldwork is needed to test specific soil types, compaction, and infiltration. This data can be used to make recommendations to maximize plant health in a variety of soil conditions.

1.3. Objectives and Hypothesis

This project evaluated plant beds for conditions that influence plant health and made recommendations to improve plant fitness and overall appearance at the University of Central Florida. We anticipated that soil compaction and infiltration would affect plant health. We also predicted that soil type would influence the content of macronutrients (N-P-K) and plant health.

2. Materials and Methods

There are four irrigation computer control units (CCU) on campus. Forty-four random sample sites, 11 in each unit, were selected for the study. Random sampling let us make conclusions for the entire campus. Using ArcGIS, a program for managing geographic data, points were plotted and arranged for collection. Locations were observed and classified as predominantly organic, sandy, a mix of organic and sandy, or construction rubble as a soil type. Soil types were distinguished by grain size. Large grains were classified as sandy and small were considered organic. Any signs of disease or abnormalities on the plants, including rigidity, were recorded for each planting bed. We observed plant health and took photographs that were evaluated by a local plant expert on a scale of 1 to 5. Clear signs of disease, parasitism, discoloration, structural weakness and little growth were given a plant health of 1. Plant beds with the absence of disease and all other factors were given a health of 5. The study was focused predominantly on ornamental plants and subcanopy. Randomly occurring invasive plants and mature canopies were not included in the plant health scale. A golf cart was used to find each planting bed.

The infiltrometer was inserted in an open location within a plant bed two feet from all plant bases. Mulch and debris were removed from the infiltration site to not skew results by blocking water flow. The device was filled with de-ionized water to avoid ion contaminants. We conducted a test to moisten the soil and then re-filled the device for data collection. The infiltrometer was set at fifteen minutes for each plot and was stopped when water reached three inches. Simultaneously, soil moisture and pH were tested away from the infiltrometer to avoid added water. The pH was measured from 3.5 to 8. A soil compaction test was used at depths of 3 and 6 inches into the ground. The compaction tester had a scale of 0 to 300+ (units not specified). One researcher would conduct the compaction experiment while the other would spot the device's depth. A core-sampling device was used to take samples for each soil type. Samples were taken from each bed and distributed over a plastic wrap to dry. Any debris, such as sticks and rocks were removed from the sample. The soil samples were tested for levels of nitrogen, phosphorus and potassium (macronutrients).

3. Results

Of the 44 campus plots there were seven that were organic soil, twenty-one that were sandy and sixteen of a mixed soil type. The sandy soil had more nutrients on average than the mixed or organic soil as shown in **Figure 1**. The mixed soil had the second most nutrients overall and the organic had the least on average.

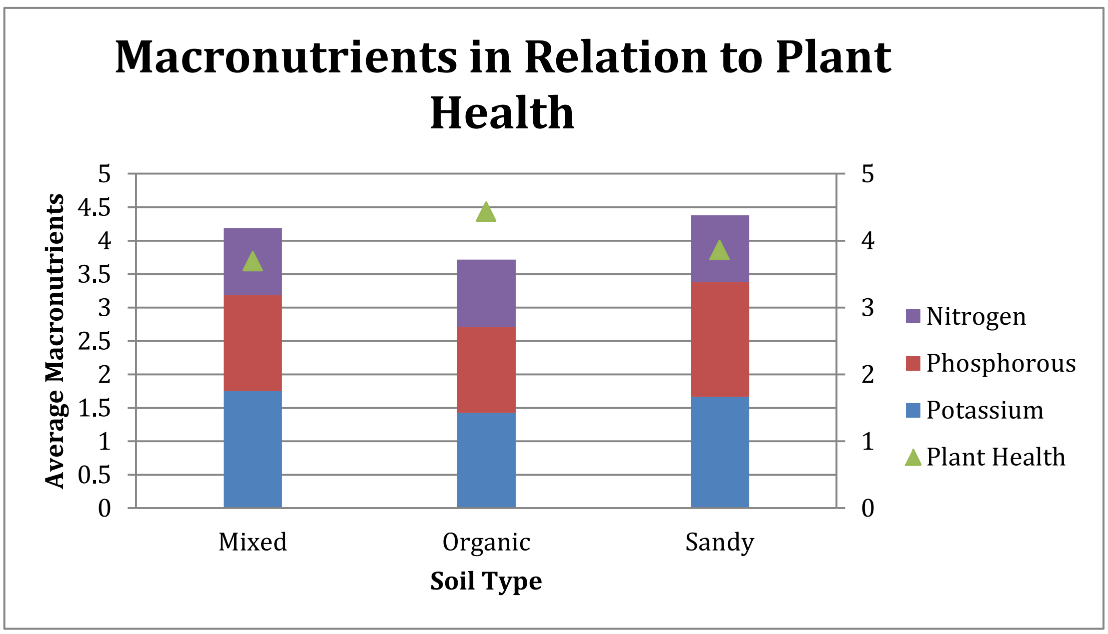

Figure 1. Macronutrients in relation to plant health.

Data for the pH readings and moisture were questionable. We did not find results for moisture and pH because we believe the meter to be inaccurate. The expert we consulted used a scale of 1-5 to evaluate plant health with 5 being healthier than 1. The organic soil had the highest plant health of the three soil types. There were two plots that had a plant health rating of 1. Three plots had a plant health of 2 and nine were rated 3. The majority were rated 4 and 5 with 14 and 16 respectively (see **Table 1**).

Table 1. The number of plots per each plant health rating, 1-5.

Plant Health Scale	The number of plots
1	2
2	3
3	9
4	14
5	16

The average infiltration was 53.83 inches per hour, with sandy soil having the highest infiltration rate. The average infiltration for mixed soil was 42.34 in/hr, organic soil was 48.48 in/hr, and sandy soil was 64.31 in/hr as per **Figure 3**.

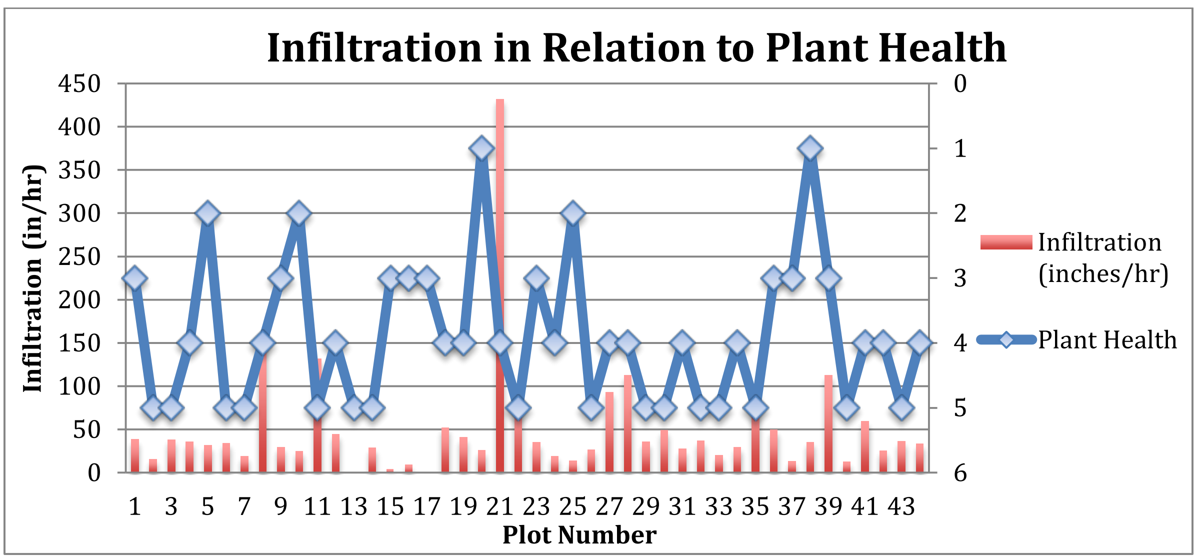

Figure 2. Infiltration in relation to Plant Health

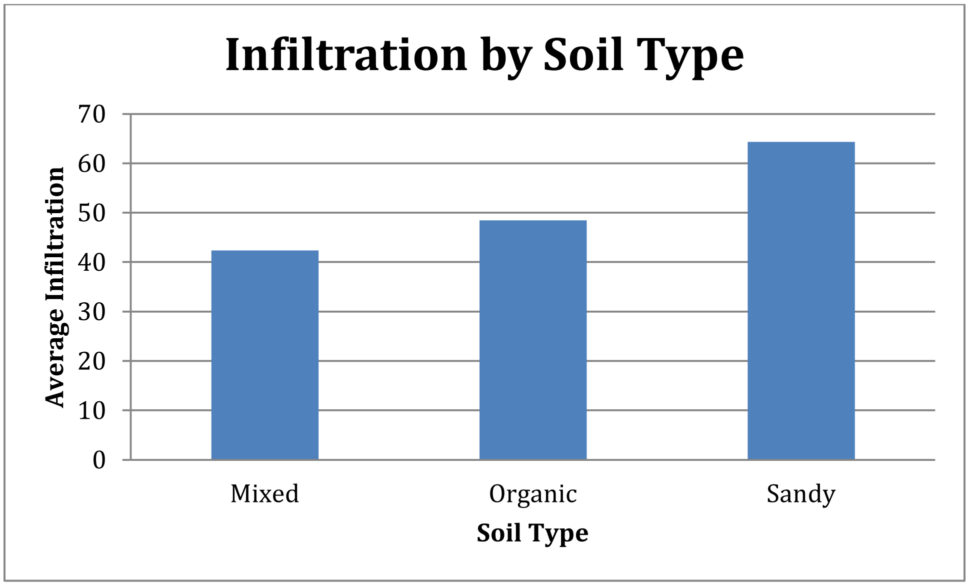

Figure 3. Average Infiltration by Soil Type.

The average compaction for a depth of 3 inches was 86.36 ± 30.85. The average compaction for a depth of 6 inches was 158.86 ± 67.57. The compaction meter did not have a unit specified but a scale from 0-300+ with three levels. From 0-199 is considered a green compaction zone that is good for most plant growth. 200-299 is considered a yellow compaction zone and decent for most plants growth. 300+ is considered a red compaction zone that is poor for plant growth. In **Table 2**, the greatest percentage of plots, 31%, had compaction zones of less than 200 and plant health ratings of 5. Plots rated with a health of 4 had the second highest green compaction zone (20%). Only 4% of the plots were considered in the red zone with 300+ compaction.

Table 2. Comparing the number of plots in each compaction zone to their health level.

	Compaction zone		
Plant health	Green	Yellow	Red
5	0.32	0.02	0.02
4	0.20	0.09	0.02
3	0.07	0.14	0
2	0.05	0.02	0
1	0.05	0	0

The F-test for the infiltration was significant with a p-value of $1.80213e^{-65}$. A one tailed T-test with two sample unequal variances was also significant with a p-value of $1.54693e^{-05}$.

The p-values that were closer to zero and did not correlated above 0.1 or higher are significant. The compaction at 3 inches F-test p-value was significant as shown in **Table 3.**

Table 3. The F-tests and T-test results regarding infiltration and compaction for all plots

	F-test	T-test one tail, two sample unequal variances
Infiltration	1.80213E-65	1.54693E-05
Compaction at 3 in	1.47192E-50	1.02576E-21
Compaction at 6 in	3.49157E-65	3.21102E-19

4. Discussion

This study demonstrated that soil conditions such as soil type and compaction were indicators of plant health in an urban environment. The majority of plots were shown healthy with only a few affected by these conditions **Table 1**. Organic soil had higher plant health but lower overall macronutrients than sandy and mixed soil types **Figure 1**. This may be due to the higher abundance of sandy soil types found on campus or fertilization by faculty prior to the study. Sandy soil types had the most macronutrients (**Figure 1**), which was an unexpected result. We predict this may be because of the higher abundance of planting beds with sandy soil types found on campus.

All of the plots were in the green compaction zone (0-200) at 3 inches. This meant that the immediate topsoil was not highly compressed. Plots 3, 11, and 22 had a higher compaction at 3 inches than at 6 inches, indicating a dense and healthy root structure. A plant health of 5 was determined for all 3 beds. Plots with a maximum plant health of 5 had the most plant beds in the green compaction zone (32%), with only one highly compacted plot at 6 inches. Plants with a health of 4 had the second most in the green compaction zone (20%) **Table 2**.

There were no observable correlations between infiltration and plant health, although our p-value was significant (1.80213E-65) **Figure 2**. Infiltration was most common for sandy soil types (64.31 in/hr) and decreased from organic to mixed soils **Figure 3**. This followed our prediction of sandy soil types and their ability to rapidly infiltrate.

A total of thirty-nine ornamental plants were analyzed in the study. Five of these plants occurred more than twice. Indian Hawthorn (*Rhaphiolepsis indica*) appeared in ten plant beds. Only one plot 15 (construction rubble) had the slowest rate of infiltration (4 inches/hour) and a high compaction (100/375 inches). Unhealthy plants suffered from sun damage, fungus, herbivory, and excessive moisture. Layers of mulch were common above sandy soil medium, which retained moisture and decreased plant matter decomposition. Dollarweed (*Hydrocotyle spp.*) and Balsampear (*Momordica charantia*) were two common invasive plants found in plant beds.

Soil amendments may be performed to increase aeration, decomposition of mulch, and reduce compaction to improve plant bed conditions. A core aerator can be used to manually amend compaction in plant beds. The addition of native sandy soil may increase infiltration in severely compacted beds. We faced a few problems during the time of our research. The infiltrometer does not accurately mimic the variations of natural rainfall. Filling a cup with water does not measure the velocity of rain occurring from clouds. Distilled water was used instead of de-ionized for the first three weeks of research. We adjusted to the nearest possible plant bed when plots were unavailable to locate. We did not take pictures of the gradient of soil types for core samples. This may have been beneficial to note in our analysis. The moisture readings were inconsistent with observable soil conditions. A different device would be encouraged if replicated. Future studies can be conducted to focus on specific plant species that do well in a wide range of conditions.

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