FINAL REPORT

SHIP – Soil Health Improvement Project

Ocean County Soil Conservation District

with funding from

Barnegat Bay Partnership

Prime Award # CE98212311

Project Period: June 30, 2011 – October 31, 2014

Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement CE-98212311 to Ocean County College, it has not undergone the Agency's publications review process and, therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

Soil Health Improvement Project (SHIP) – Final Report

<u>Table of Contents</u>

SHIP – Soil Health Improvement Project

The Ocean County Soil Conservation District, Jacques Cousteau National Estuarine Research Reserve, Rutgers Agricultural Experiment Station, the American Littoral Society, Ocean County Parks and Recreation and Montclair State University teamed up to implement the Soil Health Improvement Project at Jakes Branch County Park, 1100 Double Trouble Road, in Beachwood. The project was funded by the Barnegat Bay Partnership, Science and Technical Advisory Committee.

Looking at existing communities within the Barnegat Bay watershed, nearly 88% of the soils may be characterized as sands and loamy sands. These sandy soils have nearly 50% pore space with rapid water infiltration rates ranging 6-20 inches per hour, equating to relatively efficient drainage.

However, with land development comes soil compaction, which reduces the water infiltration rate to near zero - making these soils almost as dense as concrete. When the soil becomes this dense, our lawns and athletic fields are forced to have shallow root systems. This is problematic because these landscapes are then unable to absorb and utilize water properly, making their growth unsustainable and ultimately preventing absorption of pollutants before they enter stormwater runoff.

Goals of SHIP:
1. *Identify optimal physical, chemical and biological properties of Ocean County's sandy soils to improve infiltration and reduce runoff and nutrient loss*
2. *Develop simple, low cost and practical soil restoration techniques that are transferable to homeowners*

Demonstration Gardens were created to showcase landscaping options for various site conditions:

1. Wetland Garden
2. Butterfly Garden
3. Woodland (Shade) Garden
4. Sun Garden
5. Rain Garden

The culminating workshop of SHIP: *Digging Deeper – Practical Demonstrations to Improve Soil Health* was held at Jakes Branch County Park *on October 31, 2014*. This workshop highlighted the research results from Dr. James Murphy, Rutgers University and Dr. Jennifer Krumins, Montclair University, and included a series of equipment and soil assessment demonstrations. The majority of the participants indicated that Education, Outreach and Training were required to implement soil health practices. Ocean County Soil Conservation District intends to continue to provide outreach and educational opportunities through continuing partnering with Jakes Branch and other partners.

The plots with greatest improvement in soil physical properties and turf cover were those that were both tilled and amended with the greatest amount of OM (245 ft^3 of leaf compost per 1,000-ft^2). Thus, the more extensive the improvements in soil health, the better the persistence and quality of the turf cover.

Tillage improved the physical properties (decreased bulk density and increase water retention) of the severely compacted soil, which limited drought stress on the turf during summer months. Amending the soil with leaf compost further decreased bulk density and increased water holding capacity. The greatest improvement in soil physical properties was observed at a SOM of 5.5%.

In situations where a complete renovation (soil amendment and re-establishment of grass) is not possible, multiple applications of leaf compost will probably be required to have a significant impact on soil properties.

Conclusions:

- Deep tillage reduced compaction and improved physical properties (soil bulk density and water retention)
- Amending soil with leaf compost further improved soil properties
- Improved soil properties enhanced turf persistence and quality
- Amending to 5.0 % SOM produced the greatest improvements in the soil and turf
- Non-amended plots had unacceptable turf quality (poor ground cover and weed invasion) throughout 2014

Recommendations:

- When severe compaction is a problem, deep tillage (12 inches) with a subsoiler is beneficial.
- Soils low in OM (Organic Matter) should be amended with OM source such as leaf compost (especially sandy soils)
- Select OM amendment that is uniform and mature (C:N ratio < 30:1)

For more information, including the research reports, presentations, garden designs and details, and all other information related to this project, please visit the dedicated webpage at http://www.soildistrict.org/healthy-yards/jakes-branch-ship-project/ or contact the Ocean County Soil Conservation District at 609-971-7002.

SOIL HEALTH IMPROVEMENT PROJECT

Final Report on

Soil Health Effects on Turf Cover

November 26, 2014

Dr. James A. Murphy
Mr. Charles J. Schmid

Department of Plant Biology & Pathology
New Jersey Agricultural Experiment Station
Rutgers, The State University of New Jersey
New Brunswick, NJ 08901

Report contents

EXECUTIVE SUMMARY

In coastal regions of New Jersey, most landscapes have highly weathered, sandy soils that are low in soil organic matter (SOM) making it difficult to establish and maintain many plants including turfgrasses. Sandy soils have poor water- and nutrient-holding capacity (cation exchange capacity; CEC), which require relatively frequent irrigation and fertilizer applications to maintain turfgrass cover. Severe compaction of soil with heavy construction equipment is also a common problem of developed land, making it difficult to establish and sustain soil cover with turfgrass and other plantings.

Trial I. A study was initiated to determine the effects of several levels of soil health improvement on a severely compacted soil. Specifically, the trial determined the effects of tillage to reduce soil compaction and the combination of tillage and amending to increase the SOM on the establishment and survival of a low maintenance turfgrass cover. Four soil treatments consisting of two levels of tillage (none or subsoiler and Rotadairon®) and three levels of organic matter amending (0, 61, and 245 ft^3 $1000\text{-}ft^{-2}$) were applied prior to establishing the turf cover. All levels of soil health improvement eventually resulted in greater establishment and persistence of turf cover. Initial establishment of plots amended with leaf compost was delayed due to a C:N imbalance in compost. Once the effect of the C:N imbalance had diminished, leaf compost amended plots consistently sustained the highest quality turf cover. Both of the soil improvement actions, soil tillage and amendment with leaf compost, improved soil physical properties; soil bulk density was greatly decreased and soil water retention was increased. The plots with greatest improvement in soil physical properties and turf cover were those that were both tilled and amended with the greatest amount of OM (245 ft^3 of leaf compost per $1{,}000\text{-}ft^2$). Thus, the more extensive the improvements in soil health, the better the persistence and quality of the turf cover.

Trial II. A second field study was established on a non-compacted loamy sand to determine the effects of several levels of soil health improvement. Specifically, the trial examined the effects of i) soil fertility improvement, ii) soil fertility improvement combined with tillage, and iii) soil fertility improvement combined combined with organic matter amendment and tillage on the establishment and survival of a low maintenance turfgrass cover. Three organic matter amendments (leaf compost, sphagnum moss, and Scott's topsoil) were evaluated as organic matter amendments. Amending the loamy sand with all organic matter amendments improved soil physical properties (decreased bulk density and increase water retention) beyond what was achieved with soil fertility improvement and tillage treatment. Among the SOM amendments, the Scott's topsoil had the best overall effects on turf performance (color and quality) and soil properties. The greater nutrient content of the Scott's topsoil compared with the other amendments was attributed as the reason for the better turf performance. Unfortunately, none of the treatments were capable of sustaining turf cover (non-irrigated) through the summer of 2013. Thus, the inherent droughtiness of this loamy sand was not fully offset by increasing the SOM to as much as 7% (by weight). The trial area was re-established to tall fescue in 2014; it is plausible that a more deep-rooted turf cover could withstand drought on improved plots of this loamy sand. The scope of this grant does not allow testing of this hypothesis.

Trial III. A third field study was initiated to determine the effects of cultivation and leaf compost topdressing on soil physical properties and turfgrass quality of athletic field turf cover. Cultivation and

leaf compost topdressing treatments were arranged in a 5 x 2 factorial with five cultivation treatments (non-cultivated control, a Toro Greens Aerator equipped with hollow tines, a Verti-Drain, a Verti-Quake, and a combination of the Verti-Quake plus the Verti-Drain) and two leaft compost topdressing rates (0 and 16.7 ft^3 $1000\text{-}ft^{-2}$). Compared to Trials I and II, cultivation and leaf compost topdressing had little effect on soil physical properties and turfgrass quality in Trial III. These limited effects were probably due to several factors: the soil of the athletic field was not severely compacted; the cultivation treatments caused limited soil disruption and incorporation of leaf compared compared to the tillage used in Trials I and II; and the quantity of leaf compost applied was very small (0.2 inch) compared to the quanitities applied in Trials I (0.7 to 2.9 inches) and II (2.7 to 3.8 inches).

These trials confirm that improved soil health does positively impact the persistence and quality of turf cover. It is also clear from these trials that extent of the improvement in soil health is important. Turf cover responded positively to large quantites of OM added to the soil in addition to tillage of severely compacted soil. Large increases in SOM would be more readily accomplished during site development and establishment before the turf cover is present. However, once turf cover is established, large changes in SOM are not easily accomplished if the turf cover cannot be substantially disturbed. Therefore, substantial increases in SOM of established turf will require repeated applications of smaller quanitities of OM added via topdressing and incorporation with core aeration over many years. Topdressing of turf with approximately 0.2 inches of leaf compost per year was found to be feasible (Trial III). It would require several years or more of core aeration and topdressing with compost at 0.2-inch per year to observe effects similar those in Trials I and II.

I. IMPROVEMENT OF COMPACTED SOIL WITH TILLAGE AND LEAF COMPOST

INTRODUCTION

Severe compaction of soil with heavy construction equipment is a common problem of developed land, making it difficult to establish and sustain soil cover with turfgrass and other plantings. Soil compaction is the destruction of soil particles that results in a more dense soil mass with less pore space (Carrow and Petrovic, 1992). Compacted soils have increase soil strength which impedes root growth, decreases soil aeration (limited O_2), decreased infiltration and percolation rates, and excessive moisture retention (Carrow and Petrovic, 1992). Soil tillage is typically used to decrease compaction prior to the establishment of turfgrass.

The availability and application of compost products to turfgrass systems has dramatically increased over the past two decades (Bigelow and Soldat, 2013). Incorporation of organic amendments into a soil can improve both physical (soil structure, soil porosity, and density) and chemical (CEC) properties (McCoy, 1998). Previous studies have reported that compost incorporation into the soil can reduce turfgrass establishment time (Loschinkohl and Boehm, 2001; Gentilucci et al., 2001; Schnell et al., 2009). However, composts with high C:N ratio can result in poor turfgrass establishment due to nutrient imbalance (Gentilucci et al., 2001) The objective of this field study was to determine the effects of tillage to reduce soil compaction and amending to increase the soil organic matter (SOM) on the establishment and survival of a low maintenance turfgrass cover.

MATERIALS AND METHODS

Site Preparation and Establishment

Soil testing assessments identified a sandy loam at Jakes Branch County Park in Beachwood NJ that was severely compacted, acidic and low in P, K, Ca and Mg (Table 1). The soil organic matter content was 1.53%, by weight, which is considered a medium level for sandy loam.

Four soil treatments consisting of two levels of tillage and three levels of organic matter amending were applied to the sandy loam in a randomized complete block design with 4 replications. Due to space limitations it was not feasible to evaluate all combinations of these factors. Treatments included no soil improvements (control), tillage, tillage with leaf compost to increase SOM to 2.5 %, and tillage with leaf compost to increase SOM to 5.0 % (Table 2).

The trial site area was prepared by removing and stockpiling the topsoil-like layer (about 1 inch depth). The subsoil was graded to produce a smooth slope and rolled to firm after which the topsoil was replaced over the trial area and loosened with a Harley rake. These actions represent typical soil preparation methods for landscaping and represent the physical preparation of soil for the control treatment (#1).

Sixteen 8- x 20-feet plots were marked to serve as guides for tillage equipment. All treatments that received tillage were ripped three times with a subsoiler (1.5 to 2 feet apart) to the 12 inch depth, which broke up the soil surface into large clods. A Rotadairon® (5 feet swath) was used to till the large soil clods at the surface 6 inch depth into finer clods. The tiller approximately treated the center 6 feet of each 8-feet wide plot.

After this initial tillage, dolomitic lime, phosphate (0-46-0), and potash (0-0-50) were applied, based on soil test results, at 42, 4.7 and 6.1 lbs 1000-ft^{-2}, respectively, over the trial site.

After fertilization, the two treatment levels of leaf compost were incorporated into the sandy loam. The chemical properties of the leaf compost utilized in this study are listed in Table 1. Leaf compost was spread at 61 and 245 ft^3 1000-ft^{-2} over the center 6-feet swath of respective plots after which all tillage plots were tilled with 2 passes of a Rotadairon® tiller to approximately the 6-inch depth. The plots receiving the greatest organic matter amendment rate, 245 ft^3 1000-ft^{-2}, required a split-application of leaf compost and another 2 passes of the tiller to incorporate. Visual observations during soil sampling confirmed that leaf compost amendment was distributed uniformly throughout the 0 to 5 inch depth of the soil profile.

The trial site was fertilized and seeded with three varieties of turfgrass on 25 September 2012. OceanGro (5-5-0) fertilizer was applied to the entire trial area at 1 lb of N and available phosphate per 1,000-ft^2. 'Bullseye' tall fescue, 'Spyder LS' tall fescue, and 'Heron' hard fescue were seeded at 3.1, 3.3, and 2.5 lbs 1000-ft^{-2}, respectively. Following establishment, plots were maintain to simulate low to moderate maintenance conditions (i.e < 3 lbs N 1000-ft^{-2} yr^{-1}, low mowing input, no herbicide or fungicide applications, and irrigation only to prevent severe drought stress).

Data Collection and Analysis

After seeding, turfgrass establishment (% cover) was rated periodically from Oct. 2012 through Sept. 2013. Turf quality (1-9 scale; 9 = highest rating) and turf color (1-9 scale; 9 = highest rating) were rated periodically during fall 2012 and throughout 2013. Soil volumetric water content (VWC) and bulk density were measured with a Troxler (Model 3411-B; Troxler Electronic Labs, Inc., Research Triangle Park, NC) surface moisture-density gage operated in the backscatter mode.

Soil samples were collected on 22 Oct. 2013 to assess SOM, pH, and nutrient availability. Four samples per plot were collected with a 1.25" sample tube to a depth of 6.7". Organic matter content was determined by the loss on ignition (LOI) method (Nelson and Sommers, 1996). Nutrient availablility (P, K, Ca, and Mg) were extracted by the Mehlich 3 method (Mehlich, 1984).

Analysis of variance was performed on data using a randomized complete block design. Means were separated using Fisher's protected least significant difference (LSD) test at $p < 0.05$. Orthogonal contrasts were used to compare no tillage vs. tillage, not amended vs. amended, and amend to 2.5 % OM vs. amended to 5.0 % OM.

RESULTS AND DISCUSSION

Establishment and Turf Cover

Tillage and amendment of soil with leaf compost influenced the establishment of the turf. Initially, tillage and amending with leaf compost had a limited or negative effect on establishment (Table 3). This was likely due to the greater concentration of nutrients at the soil surface nearest seedling plants in the non-tilled, non-amended plots compared to other treatments. Additionally, the high C:N ratio (41) of the leaf compost caused symptoms of nitrogen deficiency in the turf plants (see color data in Table 4) and delayed establishment compared to non amended plots. Gentilucci et al. (2001) observed that incorporation of municipal solid waste co-compost with a C:N ratio of 42 caused poor germination of Kentucky bluegrass (*Poa pratensis* L.) in a highly eroded sandy loam. Generally, C:N ratios

< 30:1 are recommended for organic amendments, especially on sites where rapid establishment of turf cover is required (i.e sloped sites).

Improved turf cover with tillage and amending were apparent by May 2013. Turf cover of the plots receiving tillage only and amending with 61 ft^3 $1000\text{-}ft^{-2}$ leaf compost averaged about 90% by June 2013, which represented an increase in turf cover of 16% on average compared to the non-tilled treatment. The negative effect of the C:N ratio was still evident in June 2013 on the plots amended with 245 ft^3 $1000\text{-}ft^{-2}$ of leaf compost; turf cover was about 10% lower in this treatment compared to the plots treated with tillage only and leaf compost at 61 ft^3 $1000\text{-}ft^{-2}$. Turf cover in the non-tilled, non-amended plots was significantly decreased by August 2013 due to drought stress during July 2013. Drought stress had less of an effect on tillage only and amended plots, having only slightly decreased turf cover by Aug. 2013. By May 2014, all plots that received tillage had greater than 90% turf cover, while the non-tilled, non-amended plots had much less turf cover (< 60%). The negative effect of the C:N imbalance diminished over a 20 month period in plots amended with 245 ft^3 $1000\text{-}ft^{-2}$ of leaf compost during which 5 lbs N $1000\text{-}ft^{-2}$ was applied. The effect was not apparent after 9 monts in plots amended with 61 ft^3 $1000\text{-}ft^{-2}$ leaf compost and 2 lbs N $1000\text{-}ft^{-2}$ had been applied. Moderate fertilizer rates were used during establishment to simulate low maintenance conditions and not over fertilize non-amended plots. However, greater N fertilization rates probably could have been used over a shorter period to diminish the effects of the C:N imbalance more quickly.

Turf Color and Turf Quality

Turf color of plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ was lower than all other treatments throughout 2012 and 2013. This was likely due to reduced nitrogen availability in the soil caused by the high C:N ratio in the leaf compost and increased microbial activity. The effects of the C:N imbalance on turf color diminished by 2014 and plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ had the highest color ratings throughout the season. Turf color of non-amended treatments, both tilled and non-tilled, were below an acceptable level throughout 2014 and decreased as the season progressed suggesting that a reduced level of soil nitrogen.

Turf quality was generally better on plots receiving soil improvement treatments; however, the quality of plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ lagged behind the tillage only and 61 ft^3 $1000\text{-}ft^{-2}$ leaf compost treatments (Table 5). This was attributed to the leaf compost having a C:N ratio that was greater than recommended. By August 2013, turf quality of the non-tilled, non-amended plots was significantly decreased compared to the tillage only and amended plots. Similar to turf color, turf quality during 2014 was significantly better on plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$. These plots had the greatest turf quality on all dates in 2014. Turf quality of the tilled, non-amended plots decreased in 2014 and by the end of the season they were only slightly better than the non-tilled, non-amended plots (data not shown).

Soil Volumetric Water Content and Bulk Density

Drought stress was evident during the June 2013 evaluation of the trial and visual observations of wilt clearly indicated that the non-tilled treatment was experiencing greater drought stress than the soil improvement treatments (Table 6). Measurements of soil VWC in 2013 indicated that soil improvement treatments increased water holding capacity of the soil (Table 6). Amending the sandy loam with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ increased soil VWC by 11 and 8% in May and June 2013, respectively, compared to the non-tilled treatment. By 20 May 2014, plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ had increased VWC by 15% compared to control; whereas, plots amended with leaf compost at 61 ft^3 $1000\text{-}ft^{-2}$ did not increase soil VWC. No differences in volumetric water content were observed between treatments on 26 Aug 2014. Low soil VWC (< 15%) on this date suggests that the field was under drought conditions and extra water stored by compost amended plots had been exhausted by this time.

Tillage and amending soil with leaf compost reduced the bulk density of the sandy loam (Table 7). The greatest reduction in compaction of the sandy loam during 2013 was observed in the plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$, which decreased bulk density by 23 to 26 lbs ft^{-3} compared to the non-tilled, non-amended plots. The soil bulk density of all treatments was lower during 2014 than 2013. This result suggests that the perennial growth of the turf and resulting accumulation of thatch (layer of organic matter) at the soil surface lowered the bulk density of the overall surface profile of all plots. Similar to the results in 2013, plots amended with leaf compost at 245 ft^3 $1000\text{-}ft^{-2}$ had the lowest soil bulk density compared to all other treatments throughout 2014.

Soil Fertility

Soil nutrients (except K) were greater in all leaf compost amended plots compared to non-tilled, non-amended and tillage only, and increased as the rate of amendment increased (Table 8). Amending soil with leaf compost at 61 and 245 ft^3 $1000\text{-}ft^{-2}$ resulted in SOM contents of 3.0 and 5.5 %, respectively. As expected, the higher rate of leaf compost amending had a greater increase in SOM. By the end of 2013, SOM was values were slightly greater than the targeted amount suggesting that the moderate N fertilization rates used to establish the turfgrass did not have a significant impact (reduction) on SOM content. Soil pH was also influenced by compost; plots that received leaf compost had a higher soil pH than non-amended plots. At the time of this report, soil samples for fertility analysis have not been collected. Soil sampling is scheduled for early November. Data will be reported in a peer reviewed manuscript.

CONCLUSIONS

Tillage improved the physical properties (decreased bulk density and increase water retention) of the severely compacted soil, which limited drought stress on the turf during summer months. Amending the soil with leaf compost further decreased bulk density and increased water holding capacity. The greatest improvement in soil physical properties was observed at a SOM of 5.5%. Soil fertility was also improved by amending the soil with leaf compost; however, an imbalance in the carbon and nitrogen content of the leaf compost initially limited turf establishment when the leaf compost was applied at the highest rate. The decrease in overall performance caused by the high C:N ratio in the leaf compost slowly diminished over time and eventually the plots amended with the greatest amount of leaf compost produced the highest quality turf in this study. Thus, deep tillage to reduce compaction of the soil and amending with compost to increase SOM to 3.0 to 5.5% were highly effective methods for the proper establishment and maintanence of landscape turf. By the end of the study, the best performaning plots had a SOM content of 5.5%. Care should be taken in selecting uniform and mature compost.

II. IMPROVEMENT OF LOAMY SAND WITH ORGANIC MATTER AMENDMENTS

INTRODUCTION

In coastal regions of New Jersey, most soils are highly weathered, sandy soils that are low in soil organic matter (SOM) making it difficult to establish and maintain turfgrasses. Sandy soils have poor water- and nutrient-holding capacity (cation exchange capacity; CEC), which require frequent irrigation and fertilizer applications to maintain turfgrass (Craul, 1985). Amendment of sandy soils with organic matter (OM) can improve water- and nutrient- holding capacity of soil. Several studies have shown that incorporation of organic amendments such as composted sewage-sludge and animal manures, can improve the physical and chemical properties of sandy soils (Tester, 1990; Warren and Fonteno, 1993). However, little data is available on the effectiveness of locally available organic amendments at improving physical and chemical properties of coastal New Jersey soils.

The objectives of this field study was to determine the effect of increasing the OM content with several locally available amendment sources on the establishment and survival of a low maintenance turfgrass cover on a loamy sand.

MATERIALS AND METHODS

Site Preparation and Establishment

The experimental site was located in open field at Jakes Branch County Park in Beachwood NJ, which was vegetated with weeds (largely annual grasses and sedges and some broadleaves) growing on a 6-inch deep layer of loamy sand containing 3.5% soil organic matter (SOM), by weight. The topsoil layer was readily penetrated with a soil probe and displayed no characteristics of severe compaction. Weeds were eliminated with glyphosate.

The treatment structure in this experiment included several controls to determine the effects, if any, caused by changes in soil potassium, pH and bulk density separate from effects caused by organic matter addition. One control received no improvement practices except for a typical N and phosphate fertilizer application at seeding. A second control received a surface application of potassium fertilization and liming based on soil test results. The third control treatment incorporated the application of potassium fertilization and limestone with the tillage method used to incorporate the organic matter amendments. The three organic matter amendment treatments were 223 ft^3 $1000ft^{-2}$ of leaf compost, 313 ft^3 1000-ft^{-2} of Scotts Premium Topsoil, and 167 ft^3 1000-ft^{-2} of Premier sphagnum peat. These rates were selected based on the goal of increasing organic matter content of the loamy sand to 7% by weight. Chemical properties of these amendments are listed in table 9.

Soil treatments were initiated 24 September 2012 and are listed in table 10. A Harley rake was used to loosen and stir the surface inch of topsoil over the entire trial area, simulating conventional soil tillage to prepare landscapes for seeding with turfgrass. This was the extent of the physical preparation of the soil for the N-P and N-P-K-lime treatments. Based on soil test results, potash (0-0-50) was applied at 6.1 pounds per 1,000 square feet to all treatments except the non-amended (OceanGro only) treatment. Similarly, calcitic lime was applied at 32.0 pounds per 1,000 square feet to all treatments except the non-amended and Scotts Topsoil treatments. The Scotts Topsoil treatment was not limed because of the relatively high pH of this amendment.

Each 9- x 9-feet plot was marked to guide the incorporate of amendments in four treatments with tillage. All organic matter amendments were applied in two split applications on 25 September 2012. After the first split rate was applied and raked evenly over the center 6- x 6-ft of each plot, one pass of a Rotadairon® tiller was used to incorporate the amendment to an approximate depth of 6 inches. Two passes (in opposite directions) of the tiller were used to incorporate amendments after the second split rate was applied. After tillage, soil was hand raked to evenly spread and smooth the soil within each 9- x 9-feet plot.

OceanGro (5-5-0) fertilizer and turfgrass seed were applied to all plots on 25 September 2012. The entire trial received 1 pound of N and available phosphate per 1,000 square feet. The trial at was seeded at 3.1, 3.3, and 2.5 pounds per 1,000 square feet with 'Bullseye' tall fescue, 'Spyder LS' tall fescue, and 'Heron' hard fescue, respectively.

During late summer 2013, the study area experienced extensive turf loss due to drought stress and summer patch disease (*Magnaporthe poae*) on fine fescue. Because of this, the study was re-seeded in the fall of 2013. Non-selective herbicide (glyphosate) was applied at 2 fl oz per 1,000 square on 23 August and 4 September 2013 to clean up weeds from the study area prior to seeding. The study was seed to 'Bull's-eye' tall fescue at a rate of 9.6 pounds per 1,000 square feet on 20 September 2013 using a Mataway® overseeder. Plots were fertilized on 22 October 2013 using Lebanon 16-0-8 and Andersons 43-0-0 at rates of 0.4 and 0.6 lbs pound N per 1,000 square feet. An additional fertilizer application was made on 20 May 2014, using Lebanon 26-0-5 at a rate of 1.1 pound N per 1,000 square feet.

Data Collection and Analysis

After seeding, turfgrass establishment (% cover) was rated periodically from Oct. 2012 through Sept. 2014. Turf quality (1-9 scale; 9 = highest rating) and turf color (1-9 scale; 9 = highest rating) were rated periodically during fall 2012 and throughout 2014. Soil volumetric water content (VWC) and bulk density were measured with a Troxler (Model 3411-B; Troxler Electronic Labs, Inc., Research Triangle Park, NC) surface moisture-density gage operated in the backscatter mode.

Soil samples were collected on 22 Oct. 2013 to assess SOM, pH, and nutrient availability. Four samples per plot were collected with a 1.25" sample tube to a depth of 6.7". Organic matter content was determined by the loss on ignition (LOI) method (Nelson and Sommers, 1996). Nutrient availability (P, K, Ca, and Mg) were extracted by the Mehlich 3 method (Mehlich, 1984).

Analysis of variance was performed on data using a randomized complete block design. Means were separated using Fisher's protected least significant difference (LSD) test at $p < 0.05$. Orthogonal contrasts were used to make comparisons between specific treatments / treatment combinations.

RESULTS AND DISCUSSION

Establishment and Turf Cover

Scott's premium topsoil amended plots were the quickest to establish in the fall of 2012, having almost 98% cover by 19 November (< 2 months after seeding; Table 11). Plots amended with sphagnum peat were also quick to establish, having greater than 80% cover by late fall 2012. Non-OM amended plots (treatments 1, 2, 3) had fair establishment resulting in greater than 70% cover by November 2012. However, establishment of turf in the leaf compost amended plots was much slower, having only 50% cover by Nov 2012. This result in leaf compost plots was likely due to a high C: N ratio (29) of the leaf compost, causing symptoms of nitrogen deficiency in the turf plants (see color data in Table 13) and delayed establishment. By December 2012, all treatments had greater than 87% turfgrass cover, except the leaf compost amended plots which only had 66% cover.

During the re-establishment of the trial, both Scotts topsoil and sphagnum amended plots established rapidly, having 89 and 81% cover, respectively, by 20 Jun 2014 (Table 11). Leaf compost amended plots were not delayed in re-establishment in 2013-2014 and achieved 71% cover by June 2014, which was significantly greater than control plots. This result suggests that nitrogen availability in the soil was not affected by leaf compost amendment. All plots had greater than 80% cover by 26 Aug 2014.

Turf Quality

All OM amendment treatments had better turf quality than the control and fertilizer-amended plots by May 2013 (Table 12). By June 2013, when drought stress started to become evident on the trial, both tillage and OM amendment improved color ratings compared to non-tillage and control treatments. Severe drought during the summer of 2013 caused the quality of all treatments to be reduced to below an acceptable level. As noted previously, significant turf loss during this period required re-establishment of turf in the trial. During re-establishment of turf in fall of 2013, there were few differences between treatments for turf quality. During 2014, the Scotts topsoil and sphagnum amended plots had better turf quality than non-amended plots.

Turf Color

During establishment (fall 2012), turf color was affected by OM amendment (Table 13). Plots amended with Scotts topsoil and sphagnum peat had significantly higher color rating compare with the control and fertilizer-amended plots; however, leaf compost amended plots had the poorest color rating of all treatments on 19 November. This effect of leaf compost was likely due to reduced nitrogen availability in the soil caused by the high C: N ratio of the leaf compost and increased microbial activity. The effect of the C: N imbalance on turf color diminished by spring 2013 (March-May). Plots amended with leaf compost had the highest color ratings during re-establishment (22 Oct. 2013). No differences were seen in turf color between treatments in 2014 (data not shown). Fertilizer applications on 22 October 2013 and 20 May 2014 most likely masked any color differences between treatments.

Soil Volumetric Water Content and Bulk Density

Addition of soil OM amendments (leaf compost, Scotts topsoil, sphagnum peat) to the loamy sand significantly increased soil VWC compared to the control and fertilizer-amended plots throughout 2013 except for the leaf compost amended plots on 14 Aug. 13 (Table 14). Both Scotts topsoil and sphagnum peat amendments increased soil VWC compared to leaf compost amendment on 14 Aug. 2013. This trend of Scotts topsoil and sphagnum peat amended plots having greatest soil VWC while the control and fertilizer-amended plots had the lowest soil VWC continued during 2014. Early in 2014

(20 May), leaf compost amended plots had greater soil VWC compared with the control and fertilizer-amended plots; however, there were no differences between these treatments by August 2014.

Organic matter amended plots had significantly lower soil bulk density than non-OM amended plots throughout 2013 (Table 15). By June 2013, Scotts topsoil and sphagnum amended plots had lower soil bulk density than leaf compost amended plots. This trend continued through 2014, with both Scotts topsoil and sphagnum amended plots having lower bulk density compared to all other treatments. By August 2014, soil bulk density of leaf compost amended plots was not different from the non-amended plots (treatments 1, 2, & 3). Reductions in bulk density have been associated with improved root-system performance (Thompson et al., 1987) and thus improve nutrient uptake, drought avoidance, and overall turfgrass performance.

Organic Matter and Soil Fertility

Amending the loamy sand with organic matter amendments increased soil organic matter content by 23 to 54% compared to the control on 20 September 2013 (Table 16). The greatest increase in soil organic matter was found in plots amended with sphagnum peat (7.2% by weight).

Soil chemical properties were also impacted by soil OM amendment treatments. The Scott's topsoil amendment increased soil pH of plots to 6.1, which was significantly greater than all other treatments. No other statistical significant differences in soil pH were found between treatments in 2013. Soil potassium was increased in all treatments compared to the control (no potassium applied). Of all the OM amendment treatments, the Scotts topsoil had the greatest impact on soil nutrients, increasing P, Ca, and Mg availability in the soil compared to all other treatments, except Mg in sphagnum peat amended plots. At the time of this report, soil samples for OM and fertility analysis have not been collected for 2014. Soil sampling and testing is scheduled for November 2014. Data will be reported in a peer reviewed manuscript.

CONCLUSIONS

Amending the loamy sand at Jakes Branch County Park with organic matter amendments improved soil physical properties (decreased bulk density and increase water retention). Among the OM amendments in this study, the Scott's topsoil had the best overall effects on turf performance (color and quality) and soil properties. This result was probably due to the Scotts topsoil amendment having greater nutrient content compared to the other organic matter amendments (Table 9). Soil amending with leaf compost initially inhibited establishment of turfgrass; however, this effect diminished over time and eventually plots performed well. Tillage had little effect on the physical properties of the loamy sand, which was probably a result of the high sand content of this soil and limited compaction. On very sandy soils where turfgrass will be established, amending the soil to 6 to 7% OM content will result in substantial improvement in the soil physical and fertility properties, which will improve turf establishment and overall performance. However, our results indicate that long term survival of turf on extremely sand soil may require some irrigation. None of the organic amendments were able to ensure survival of turf (primarily hard fescue) without irrigation during 2013. Re-establishment of turf to tall fescue in 2014 will allow determination of whether a major change in turfgrass species will have an impact on survival with limited irrigation.

III. CULTIVATION AND COMPOST TOPDRESSING EFFECTS ON SOIL PROPERTIES OF AN ESTABLISHED SPORTS TURF

The objectives of this trial were to determine the effects of cultivation and leaf compost topdressing on turf and soil properties.

MATERIALS AND METHODS

This field trial was initiated 13 December 2012 on a soccer field comprised of tall fescue, Kentucky bluegrass and white clover grown on loamy sand at Jakes Branch County Park in Beachwood NJ. The topsoil layer was approximately 6 inches deep and contained 2.5% soil organic matter (SOM).

Cultivation and leaf compost topdressing treatments were arranged in a 5 x 2 factorial using a split-plot design with 4 replications. Main plots (cultivation treatments) were 8- x 50-feet and subplots (leaf compost topdressing) were 8- x 25-feet. The five cultivation treatments included a non-cultivated control; a Toro Greens Aerator equipped with 5/8-inch diam. hollow tines a that penetrated to the 2.5-inch depth in 2.25-inch hole spacing; a Verti-Drain 7521 equipped with 1-inch diam. side-eject coring tines that penetrated to the 8-inch depth; a Verti-Quake 2521 equipped with 10-inch blades (10-inch blade spacing) that penetrated to the 6-inch deep; and a combination of the Verti-Quake plus the Verti-Drain treatments. After cultivation treatments were applied, 25-gallons (3.33 cubic feet or 0.2-inch) of leaf compost were spread over the surface of subplots (200 square feet). A garden rake and leaf rake were used to incorporate the leaf compost into the canopy of the turf. Summary of cultivation and leaf compost topdressing treatments listed in table 17.

Soil tests indicate that soluble potash should be applied at 1 to 2 pounds per 1000 square feet. Soil phosphorus and pH were within recommended ranges; no applications needed at this time.

RESULTS AND DISCUSSION

Turf Color

Cultivation treatments had little effect on the turf color of the soccer field during 2013 (Table 18). Only in early spring did the Verti-Drain + Verti-Quake treatment under the no topdressing level improved color compared to other cultivation treatments and the non-cultivated control. Since this was the most aggressive cultivation treatment, it is possible that warming of the soil and severing of plant crowns and rhizome stimulated early spring growth. However, the better green-up caused by leaf compost topdressing improved turf color of all cultivation treatments and a cultivation effect was not apparent under leaf compost topdressing (Tables 18). Early spring color responses eventually dissipated; no color response was seen in May and leaf compost topdressing reduced turf color by June 2013 (Table 18). By August 2013, there was no difference in color between compost topdressed and non-topdressed plots.

Turf Quality

Similar to turf color, turf quality in early spring was better on plots topdressed with leaf compost; however, turf quality was poorer on topdressed plots by May 2013 (Table 19). The dark color of the compost probably increased surface warming in early spring which accelerated early season growth but the high C: N ultimately curtailed turf growth due to low N availability to the plants. Throughout the rest of 2013 (June-August), cultivation and compost topdressing treatments had no effect on turfgrass quality (Table 19)

Soil Volumetric Water Content and Bulk Density

Cultivation treatments only affected soil bulk density in March 2013 (Table 20). All cultivation treatments reduce soil bulk density by approximately 5% compared to the non-cultivated control but only under the non-topdressed level; under topdressed conditions, no differences were observed (Table 21). Topdressing with leaf compost reduced soil bulk density of only the non-cultivated plots in March (Table 21) and all treatments in June 2013 (Table 20). The reduction in soil bulk density by topdressing was approximately 2% in June. Overall, the soil bulk density values observed in this trial were very low and probably did not restrict plant growth.

Similarly, soil volumetric water content had a limited response to cultivation and topdressing in 2013. The Verti-Drain + Verti-Quake treatment had lower soil volumetric water content under non-topdressed conditions compared to the non-cultivated control and other cultivation treatments except the Verti-Drain treatment in June 2013. No cultivation effect was seen under topdressed conditions. Topdressing with leaf compost increased soil volumetric water content of the Verti-Drain + Verti-Quake treatment.

CONCLUSIONS

Cultivation and compost topdressing treatments had a limited effect on turfgrass cover and soil properties. This result is likely due to several factors. First, the athletic field soil was not limited by problems associated with compaction of the soil (e.g., surface bulk density of <1.0 g cm^{-3}, approximately 1.4 g cm^{-3} at the 0- to 6-inch soil depth). Second, the soil volume impacted by cultivation treatments was very limited and the quantity of leaf compost applied was small compared to the tillage and amendment quantities used in Trials I and II. Thus, any impact from treatments was not sufficient to produce substantial responses in the turf or soil. Compared to the quantity of leaf compost applied in Trials I and II (Table 22), plots in this trial received 1/3 to 1/10 the quantity of leaf compost. In situations where a complete renovation (soil amendment and re-establishment of grass) is not possible, multiple applications of leaf compost will probably be required to have a significant impact on soil properties.

References

Bigelow C.A., and D.J. Soldat. 2013. Turfgrass root zones: management, construction methods, amendment characterization, and use. In: J.C. Steir et al., editors. Turfgrass: biology, use, and management. Agron. Monogr. 56. ASA, CSSA, and SSSA, Madison, WI. p. 425-456.

Bremner, J.M. 1996. Nitrogen-Total. *In* Methods of soil analysis. Part 2. Chemical analysis. SSSA Book Ser. 5. SSSA, Madison, WI. p. 1085-1121.

Craul, P.J. 1985. A description of urban soils and their desired characteristics. J. Arborculture 11(11):330-339

Carrow, R.N., and M.A. Petrovic. 1992. Effects of traffic on turfgrasses. In: D.V. Waddington et al., editors, Turfgrasses. ASA, CSSA, and SSSA, Madison, WI. p. 285-330

Gentilucci, G., J.A. Murphy, and D.E. Zaurov. 2001. Nitrogen requirement for Kentucky bluegrass grown on compost amended soil. Int. Turfgrass Soc. Res. J. 9:506-517

Loschinkohl, C., and M.J. Boehm. 2001. Composted biosolids incorporation improves turfgrass establishment on disturbed urban soil and reduces leaf rust severity. HortScience 36:790-794.

McCoy, E.L. 1998. Sand and organic amendments influences on soil physical properties related to turf establishment. Agron. J. 90:411-419.

Mehlich, A. 1984. Mehlich 3 soil test extractant: A modification of the Mehlich 2 extractant. Commun. Soil Sci. Plant Anal. 15:1409-1416.

Nelson, D.S. and L.E. Sommers. 1996. Total carbon, organic carbon, and organic matter. *In* Methods of Soil Analysis, Part 3. SSSA Book Ser. 5. SSSA, Madison, WI. p. 961-1010.

Schnell, R.W., D.M. Vietor, R.H. White, and T.L. Provin. 2009. Effects of compost biosolids and nitrogen on turfgrass establishment, sod properties, and nutrient export at harvest. HortScience 44:1746-1750.

Tester, C.F. 1990. Organic amendments effects on physical and chemical properties of sandy soil. Soil Sci. Soc. Am. J. 54:827-831.

Thompson, P.J., I.J. Jansen, and C.L. Hooks. 1987. Penetrometer resistance and bulk density as parameters for predicting root system performance in mine soils. Soil Sci. Soc. Am. J. 51:1288-1293.

Warren, S.L. and W.C. Fonteno. 1993. Changes in physical and chemical properties of a loamy sand soil when amended with composted poultry litter. J. Environ. Hort. 11(4):186-190.

TABLES

Table 1. Chemical properties of sandy loam and leaf compost amendment utilized in the establishment of tall fescue and fine fescue turf at Jakes Branch County Park in Beachwood, NJ.

Material	pH	EC [a]	OM [b]	N [c]	P [d]	K	Ca	Mg	C:N ratio
		mmhos/cm	----- % -----		------------ lbs/A [e] -------------				
Sandy loam	5.27	n.d.[f]	1.5	n.d.	49	43	100	675	n.d.
Leaf compost	6.90	0.41	46.3	1.14	18	32	23	8	41

[a] Electrical conductivity

[b] Organic matter determine by loss on ignition (Nelson and Sommers, 1996)

[c] Total N determined by Kjeldahl method (Bremner, 1996)

[d] P, K, Ca, and Mg extracted by Mehlich 3method (Mehlich, 1984)

[e] 1 ppm = 2 lbs/A

[f] not determined

Table 2. Summary of the levels of tillage and organic matter amendment of four treatments evaluated on sandy loam at Jakes Branch County Park in Beachwood, NJ.

Treatment #	Tillage	Organic Matter Amendment
1	None	None
2	Subsoiler & Rotadairon®	None
3	Subsoiler & Rotadairon®	61 ft^3 of leaf compost / 1000 ft^2
4	Subsoiler & Rotadairon®	245 ft^3 of leaf compost / 1000 ft^2

Table 3. Tillage and leaf compost effects on the establishment of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2012, 2013 and 2014.

	Treatment Factors		------------- 2012 -------------			-------------------------- 2013 ----------------------------					- 2014 -
#	Tillage[a]	Leaf Compost[b]	18-Oct	19-Nov	19-Dec	4-Mar	9-May	23-Jun	4-Aug	3-Sep	20-May
		ft^3 $1000\text{-}ft^{-2}$	Visual Rating of Turf Cover (%)								
1	None	0	28	48	73	69	56	73	28	38	59
2	Yes	0	38	44	61	58	74	91	90	80	90
3	Yes	61	28	34	50	50	66	88	83	78	95
4	Yes	245	26	31	46	40	61	79	78	74	91
	Orthogonal Contrasts										
	Treatment 1 vs. 2, 3, 4		NS	**	***	***	*	**	***	***	***
	Treatment 2 vs. 3, 4		**	**	***	***	*	*	NS	NS	NS
	Treatment 3 vs. 4		NS	NS	NS	**	NS	*	NS	NS	NS
	CV (%)		13.2	13.9	5	6.6	9.9	6.1	11.8	11.2	6.7

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 $ft^3/1000\text{-}ft^2$ or as two split applications of 245 $ft^3/1000\text{-}ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

Table 4. Tillage and leaf compost effects on the turf color of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2012, 2013 and 2014.

	Treatment Factors		------------ 2012 ------------			--------------------- 2013 -------------------------					------------------------ 2014 ------------------------				
#	Tillage[a]	Leaf Compost[b]	18-Oct	19-Nov	19-Dec	4-Mar	9-May	23-Jun	14-Aug	3-Sep	20-May	20-Jun	11-Jul	6-Aug	26-Aug
		ft^3 1000-ft^{-2}	--- Turf Color (9 = dark green color, 5 = acceptable green color) ---												
1	None	0	6.8	5.3	6.8	4.8	3.5	6.5	7.0	6.0	4.5	3.5	3	2.3	2.8
2	Yes	0	7.8	5.8	6.3	5.5	5.5	7.5	4.5	4.8	5	4.8	3.8	3	3
3	Yes	61	6.3	5.3	5.8	5.0	5.3	6.5	6.3	5.5	6.5	6.5	7	6.5	6
4	Yes	245	6.0	4.5	4.5	4.0	3.8	5.0	4.3	4.0	7.5	7.8	7.8	7.8	7.5
	Orthogonal Contrasts														
	Treatment 1 vs. 2, 3, 4		NS	NS	**	NS	**	NS	***	**	***	***	***	***	***
	Treatment 2 vs. 3, 4		***	**	**	*	*	***	NS	NS	***	**	***	***	***
	Treatment 3 vs. 4		NS	*	**	*	**	***	**	**	*	NS	NS	*	**
	CV (%)		5.1	8.1	9.2	12.1	12.8	6.9	11.3	10.5	7.5	14.8	14.2	15.7	13.1

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 ft^3/1000-ft^2 or as two split applications of 245 ft^3/1000-ft^2. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

Table 5. Tillage and leaf compost effects on the turf quality of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013 and 2014.

	Treatment Factors		---------------------- 2013			---------------------	------------------------------ 2014				-------------------------------
#	Tillage[a]	Leaf Compost[b]	9-May	23-Jun	14-Aug	3-Sep	20-May	20-Jun	11-Jul	6-Aug	26-Aug
		ft^3 1000-ft^{-2}	----------------------------- Turf Quality (9 = best, 5 = acceptable) -----------------------------------								
1	None	0	2.8	5.0	2.0	2.0	3.5	3.5	2.5	2.0	2.0
2	Yes	0	4.3	6.8	5.8	5.0	6.0	5.3	4.0	2.8	2.5
3	Yes	61	4.0	6.5	5.8	5.5	7.0	7.0	7.0	5.8	5.0
4	Yes	245	3.0	4.8	5.0	4.3	8.0	8.0	7.5	6.8	6.8
	Orthogonal Contrasts										
	Treatment 1 vs. 2, 3, 4		*	*	***	***	***	***	***	***	***
	Treatment 2 vs. 3, 4		NS	*	NS	NS	***	***	***	***	***
	Treatment 3 vs. 4		*	**	NS	*	***	*	NS	*	**
	CV (%)		16.5	12.3	20.7	17.9	4.7	8.1	12.7	14.6	18.5

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 ft^3/1000-ft^2 or as two split applications of 245 ft^3/1000-ft^2. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

Table 6. Tillage and leaf compost effects on the soil volumetric water content of a turfgrass mixture (tall fescue and hard fescue) grown on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013 and 2014.

	Treatment Factors		Volumetric Water Content[c]				
#	Tillage[a]	Leaf Compost[b]	9-May-13	23-Jun-13	13-Aug-13	20-May-14	26-Aug-14
		ft^3 $1000\text{-}ft^{-2}$	---------------------------------- % ------------------------------------				
1	None	0	21	13	23	20	14
2	Yes	0	20	13	20	18	13
3	Yes	61	23	15	21	17	13
4	Yes	245	32	21	23	23	15
	Orthogonal Contrasts						
	Treatment 1 vs. 2, 3, 4		*	*	NS	NS	NS
	Treatment 2 vs. 3, 4		***	**	NS	NS	NS
	Treatment 3 vs. 4		***	**	NS	*	NS
	CV (%)		9.4	15.6	15.3	13.9	17.5

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 ft^3/1000-ft^2 or as two split applications of 245 ft^3/1000-ft^2. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

[c] Volumetric water content measured with a Troxler (Model 3411-B) surface moisture-density gage in the backscatter mode.

Table 7. Tillage and leaf compost effects on the bulk density of a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013 and 2014.

	Treatment Factors		Bulk Density				
#	Tillage[a]	Leaf Compost[b]	9-May-12	23-Jun-12	13-Aug-12	20-May-14	26-Aug-14
		ft^3 $1000\text{-}ft^{-2}$	--------------------------------- lbs ft^{-3} ---------------------------------				
1	None	0	86	80	82	66	64
2	Yes	0	84	74	72	56	61
3	Yes	61	76	70	68	53	55
4	Yes	245	60	57	58	46	47
	Orthogonal Contrasts						
	Treatment 1 vs. 2, 3, 4		***	***	***	***	***
	Treatment 2 vs. 3, 4		***	***	***	*	**
	Treatment 3 vs. 4		***	***	***	*	**
	CV (%)		3.3	3.8	3.3	6.6	6.3

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 ft^3/1000-ft^2 or as two split applications of 245 ft^3/1000-ft^2. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

[c] Bulk density measured with a Troxler (Model 3411-B) surface moisture-density gage in the backscatter mode.

Table 8. Soil tillage and amendment effects on soil organic matter, pH, and nutrient availability of tall fescue/fine fescue turf in Beachwood, NJ

#	Treatment Factors		22-Oct-13					
	Tillage[a]	Leaf Compost[b]	OM	pH	P	K	Ca	Mg
		ft^3 $1000\text{-}ft^{-2}$	%		---------------------- lb/A ----------------------			
1	None	0	2.0	5.2	83	105	833	126
2	Yes	0	1.6	5.6	74	102	775	176
3	Yes	61	3.0	5.8	98	117	1646	284
4	Yes	245	5.5	5.9	121	137	2615	428
	Orthogonal Contrasts							
	Treatment 1 vs. 2, 3, 4		**	***	NS	NS	***	***
	Treatment 2 vs. 3, 4		***	*	*	NS	***	***
	Treatment 3 vs. 4		***	NS	NS	NS	***	***
	CV (%)		21.2	2.7	20.3	18.7	16.4	10.4

[a] Tillage included three passes (1.5 to 2 feet apart) of a subsoiler to the 12 inch depth after which a Rotadairon rototiller (5 feet swath) was operated twice over each plot treating approximately the center 6 feet of each plot.

[b] Leaf compost applied as one application at 61 $ft^3/1000\text{-}ft^2$ or as two split applications of 245 $ft^3/1000\text{-}ft^2$. All tillage plots received 2 passes of a Rotadairon® tiller after each application of leaf compost.

[c] Organic matter determine by loss on ignition (Nelson and Sommers, 1996)

[d] P, K, Ca, and Mg extracted by Mehlich 3method (Mehlich, 1984)

[e] 1 ppm = 2 lbs/A

Table 9. Chemical properties of loamy sand soil and amendments utilized in the establishment of tall fescue and fine fescue turf at Jakes Branch County Park in Beachwood, NJ.

Material	pH	EC [a]	OM [b]	N [c]	P [d]	K	Ca	Mg	C:N ratio
		mmhos/cm	------ % ------		---------------- lbs/A [e] -----------------				
Loamy sand	5.50	n.d.[f]	3.5	n.d.	435	36	2230	193	n.d.
Leaf compost	7.01	0.37	43.4	1.50	9	32	12	4	29
Sphagnum moss	5.10	0.46	93.0	1.65	0	2	2	4	56
Scott's topsoil	7.21	8.47	34.3	1.71	1	925	290	132	20

[a] Electrical conductivity

[b] Organic matter determine by loss on ignition (Nelson and Sommers, 1996)

[c] Total N determined by Kjeldahl method (Bremner, 1996)

[d] P, K, Ca, and Mg extracted by Mehlich 3 method (Mehlich, 1984)

[e] 1 ppm = 2 lbs/A

[f] not determined

Table 10. Summary of the fertility and organic matter amendment levels of the six treatments applied to the loamy sand site at Jakes Branch County Park in Beachwood, NJ on 24 and 25 September 2012.

#	Soil Fertility			OM [a]	OM Amendment	Tillage[f]
	5-5-0 [b]	0-0-50[c]	Lime[d]	Source	Rate[e]	
					ft^3 / 1,000-ft^2	
1	yes	no	no	none	0	none
2	yes	yes	yes	none	0	none
3	yes	yes	yes	none	0	Rotadairon®
4	yes	yes	yes	Leaf compost	223	Rotadairon®
5	yes	yes	yes	Sphagnum peat	313	Rotadairon®
6	yes	yes	no	Scotts Topsoil	167[g]	Rotadairon®

[a] Organic matter

[b] OceanGro (5-5-0) fertilizer applied at 1 pound of N and available phosphate per 1,000 square feet on 25 September 2012.

[c] Soluble potash (0-0-50) applied at 6.1 pounds per 1,000 square feet on 24 September 2012.

[d] Calcitic lime applied at 32.0 pounds per 1,000 square feet on 24 September 2012.

[e] Amendment rates of each organic matter source were based on increasing organic matter content of the loamy sand to 7% by weight.

[f] Tillage plots received 1 pass of a Rotadairon® tiller after the first split application of organic amendments and 2 passes of the tiller after the second split application of organic amendments.

[g] Compressed volume (bale = 3 cubic feet).

Table 11. Fertility and organic matter amendment effects on the establishment of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 and 20 September 2013 on loamy sand at Jakes Branch County Park in Beachwood, NJ.

#	Treatment Factors[a]	Turfgrass establishment								
		-------------- 2012 --------------			------ 2013 -------		------------------ 2014 --------------------			
		18-Oct	19-Nov	20-Dec	5-Mar	20-Nov	20-Jun	11-Jul	6-Aug	26-Aug
		-------------------------------Visual rating of turfgrass cover (%) ------------------------------								
1	N	31	70	90	85	6	39	65	71	80
2	N,K, Lime	36	71	91	89	5	51	79	90	92
3	N,K, Lime, Tillage	28	73	91	90	5	59	66	79	81
4	N,K, Lime, LC, Tillage	36	50	66	74	6	71	76	86	92
5	N,K, Lime, ST, Tillage	46	98	96	98	4	89	92	97	99
6	N,K, Lime, SPH, Tillage	45	81	87	89	6	81	89	95	97
	$LSD_{(p < 0.05)}$	8	7	9	9	1	21	20	15	12
	CV%	14	6	7	7	13	21	17	12	9

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft^3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft^3/1000-ft^2. All treatments applied 24 September 2012.

Table 12. Fertility and organic matter amendment effects on turf quality of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 and 20 September 2013 on loamy sand at Jakes Branch County Park in Beachwood, NJ.

#	Treatment Factors[a]	------------------------ 2013		-------------------------			------------ 2014	-------------	
		10-May	24-Jun	10-Oct	22-Oct	20-Nov	11-Jul	6-Aug	26-Aug
		---------------------- Turf Quality (9 = best, 5 = acceptable) ----------------------							
1	N	4.5	2.5	3.0	5.8	7.3	4.3	4.8	6.0
2	N,K, Lime	3.3	2.0	2.0	6.3	7.3	6.0	6.8	7.5
3	N,K, Lime, Tillage	4.0	4.0	2.0	6.0	7.5	4.3	5.3	6.3
4	N,K, Lime, LC, Tillage	5.3	6.5	1.0	5.3	8.0	5.3	6.5	7.3
5	N,K, Lime, ST, Tillage	6.5	7.8	3.5	6.5	7.3	8.3	8.8	8.8
6	N,K, Lime, SPH, Tillage	6.3	6.0	2.8	6.0	7.0	7.3	8.3	7.8
	$LSD_{(p < 0.05)}$	1.1	1.1	0.4	1.0	0.8	2.2	2.5	1.5
	CV%	14.2	14.9	12.4	11.6	7.1	25.4	24.4	13.9

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft^3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft3/1000-ft^2. All treatments applied 24 September 2012.

Table 13. Fertility and organic matter amendment effects on turf color of a turfgrass mixture (tall fescue and hard fescue) seeded on 25 September 2012 and 20 September 2013 on loamy sand at Jakes Branch County Park in Beachwood, NJ.

#	Treatment Factors[a]	------ 2012 ------		------------------------- 2013 -------------------------				
		18-Oct	19-Nov	5-Mar	10-May	24-Jun	22-Oct	20-Nov
		------------- Turf Color (9 = dark green color, 5 = acceptable green color) -------------						
1	N	5.8	6.0	3.8	3.8	3.0	4.8	5.8
2	N,K, Lime	5.0	5.8	3.8	3.8	3.5	5.0	5.8
3	N,K, Lime, Tillage	6.5	6.8	5.0	5.0	4.5	5.0	5.5
4	N,K, Lime, LC, Tillage	6.8	4.0	5.0	6.3	6.3	6.5	6.0
5	N,K, Lime, ST, Tillage	7.5	8.8	6.3	7.8	8.0	4.8	5.0
6	N,K, Lime, SPH, Tillage	9.0	8.0	5.5	6.8	6.0	4.5	5.0
	$LSD_{(p < 0.05)}$	0.8	0.5	0.8	0.9	1.6	0.9	0.5
	CV%	8.3	5.3	10.8	10.7	20.2	11.4	5.7

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft^3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft^3/1000-ft^2. All treatments applied 24 September 2012.

Table 14. Effect fertility and organic matter amendment treatments on the soil volumetric water content of a turfgrass mixture (tall fescue and hard fescue) grown on a loamy sand at Jakes Branch County Park in Beachwood, NJ during 2013 and 2014.

#	Treatment Factors[a]	Volumetric water content[b]					
		------------------ 2013 ------------------				------ 2014 ------	
		5-Mar	13-Jun	14-Aug	20-Nov	20-May	26-Aug
		------------------------------- % ---------------------------------					
1	N	22.9	12.8	19.8	21.9	24.0	9.9
2	N,K, Lime	22.7	13.3	17.3	21.8	24.2	10.4
3	N,K, Lime, Tillage	21.1	11.2	18.4	21.0	23.2	8.8
4	N,K, Lime, LC, Tillage	27.4	14.9	15.8	24.0	27.0	7.7
5	N,K, Lime, ST, Tillage	31.5	19.0	28.6	30.1	32.8	16.8
6	N,K, Lime, SPH, Tillage	28.6	18.6	24.8	30.2	32.6	15.7
	$LSD_{(p < 0.05)}$	2.4	2.4	2.6	1.3	2.1	2.4
	CV%	6.2	10.9	8.4	3.4	5.2	13.4

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft^3/1000-ft^2. All treatments applied 24 September 2012.

[b] Volumetric water content measured with a Troxler (Model 3411-B) surface moisture-density gage in the backscatter mode.

Table 15. Effect fertility and organic matter amendment treatments on the bulk density of a turfgrass mixture (tall fescue and hard fescue) grown on a sandy loam at Jakes Branch County Park in Beachwood, NJ during 2013 and 2014.

#	Treatment Factors[a]	Bulk density[b]					
		------------------ 2013 ------------------				------ 2014 ------	
		5-Mar	13-Jun	14-Aug	20-Nov	20-May	26-Aug
		---------------------------------- lbs ft^{-3} -------------------------------------					
1	N	63.7	66.8	65.1	64.7	61.1	52.6
2	N,K, Lime	63.4	65.5	65.1	64.7	60.7	51.7
3	N,K, Lime, Tillage	65.9	67.4	67.5	65.3	62.3	51.5
4	N,K, Lime, LC, Tillage	55.6	55.2	61.6	56.8	53.4	49.5
5	N,K, Lime, ST, Tillage	51.9	52.7	54.4	51.4	48.6	43.5
6	N,K, Lime, SPH, Tillage	52.7	52.0	54.0	49.7	47.9	43.8
	$LSD_{(p < 0.05)}$	3.2	3.0	3.7	2.8	3.6	3.3
	CV%	3.6	3.4	4.0	3.0	4.2	4.5

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft^3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft^3/1000-ft^2. All treatments applied 24 September 2012.

[b] Bulk density measured with a Troxler (Model 3411-B) surface moisture-density gage in the backscatter mode.

Table 16. Fertility and organic matter amendment effects on soil organic matter, pH, and nutrient availability of tall fescue/fine fescue turf in Beachwood, NJ.

#	Treatments[a]	20-Sep-13										
		OM[b]	pH	P[c]	K	Ca	Mg	B	Zn	Mn	Cu	Fe
		%		--------------- lb A^{-1}	------------------			----------------------- ppm	--------------------			
1	N	4.68	5.02	494	59	2304	207	0.87	22.7	20.9	5.93	472
2	N,K, Lime	4.88	5.23	533	126	2640	213	0.71	24.0	17.2	6.04	522
3	N,K, Lime, Tillage	4.39	5.12	484	98	2497	193	0.94	22.1	16.4	5.59	446
4	N,K, Lime, LC, Tillage	5.74	5.25	460	133	2998	342	1.14	19.9	15.6	5.44	406
5	N,K, Lime, ST, Tillage	6.13	6.09	637	148	4499	480	1.31	19.6	17.7	4.96	412
6	N,K, Lime, SPH, Tillage	7.21	5.16	389	118	2536	505	1.10	18.2	20.6	4.66	436
	$LSD_{0.05}$	0.68	0.24	88	35	525	53	0.24	3.8	ns	ns	51
	C.V.	8.2	3.0	11.6	20.4	12.0	10.9	16.0	11.8	15.9	12.0	7.6

[a] Potassium (K; 0-0-50) applied at 6.1 lbs / 1,000-ft^2; Calcitic lime applied at 32.0 lbs / 1,000-ft^2; Leaf compost (LC) applied at 223 ft^3/1000-ft^2; Scott's topsoil (ST) applied at 313 ft^3/1000-ft^2; sphagnum peat (SPH) applied at 167 ft^3/1000-ft^2. All treatments applied 24 September 2012.

[b] Organic matter determine by loss on ignition (Nelson and Sommers, 1996)

[c] P, K, Ca, Mg, B, Zn, Mn, Cu, and Fe extracted by Mehlich 3 method (Mehlich, 1984)

[d] 1 ppm = 2 lbs/A

Table 17. Summary of cultivation and leaf compost topdressing treatments applied on 13 December 2012 to a soccer field grown on loamy sand at Jakes Branch County Park in Beachwood NJ.

Treatment #	Tillage	Topdressing
1	None	None
2	None	0.2-inch Leaf Compost
3	Toro Greens Aerator	None
4	Toro Greens Aerator	0.2-inch Leaf Compost
5	Verti-Drain 7521	None
6	Verti-Drain 7521	0.2-inch Leaf Compost
7	Verti-Quake 2521	None
8	Verti-Quake 2521	0.2-inch Leaf Compost
9	Verti-Quake + Verti-Drain	None
10	Verti-Quake + Verti-Drain	0.2-inch Leaf Compost

Table 18. Cultivation and leaf compost effects on the turf color of a soccer field applied on 13 December 2012 on a sandy loam at Jakes Branch County Park in Beachwood NJ.

ANOVA Source	2013			
	5 Mar.	10-May	24 Jun.	14-Aug
Cultivation	ns	ns	ns	ns
Compost	**	ns	*	ns
Cultivation x Compost	*	ns	ns	*
CV (%)	4.7	12.8	16.6	10.6
Cultivation Main Effect				
	Turf Color (9 = dark green color, 5 = acceptable green color)			
Non-cultivated Control	3.5	4.6	4.6	6.9
Toro Aerator[a]	4	5.1	4.9	6.9
Verti-Drain[b]	4	5.6	4.3	6.9
Verti-Quake[c]	3.5	4.3	4.9	7.0
Verti-Drain + Verti-Quake	4.5	5.1	4.5	9.6
$LSD_{0.05}$	0.8	1	ns	ns
Topdressing Main Effect				
None	3.5	5.1	5.2	7.0
Yes[d]	4.4	4.8	4.5	6.9

[a] Toro Greens Aerator quipped with 5/8-inch diam. hollow tines a that penetrated to the 2.5-inch depth in 2.25-inch hole spacing.

[b] Verti-Drain 7521 equipped with 1-inch diam. side-eject coring tines that penetrated to the 8-inch depth.

[c] Verti-Quake 2521 equipped with 10-inch blades that penetrated to the 6-inch deep.

[d] Leaf compost (3.33 cubic feet or 0.2-inch) applied to 200 square feet subplots.

Table 19. Cultivation and leaf compost effects on the turf quality of a soccer field applied on 13 December 2012 on a sandy loam at Jakes Branch County Park in Beachwood NJ.

ANOVA Source	2013			
	5 Mar.	10-May	24 Jun.	14-Aug
Cultivation	ns	ns	ns	ns
Compost	***	*	ns	ns
Cultivation x Compost	ns	ns	ns	ns
CV (%)	7.4	15.1	19.2	21.7
Cultivation Main Effect				
	---------- Turf Quality (9 =best, 5 = acceptable) ----------			
Non-cultivated Control	3.8	4.4	4.4	6.8
Toro Aerator[a]	4.1	5.1	4.5	6.9
Verti-Drain[b]	4.1	5.1	4.9	7.4
Verti-Quake[c]	3.5	4.6	4.5	7.4
Verti-Drain + Verti-Quake	4	5	4.1	7
$LSD_{0.05}$	ns	ns	ns	ns
Topdressing Main Effect				
None	3.6	5.1	4.7	7.3
Yes[d]	4.3	4.6	4.3	6.9

[a] Toro Greens Aerator quipped with 5/8-inch diam. hollow tines a that penetrated to the 2.5-inch depth in 2.25-inch hole spacing.

[b] Verti-Drain 7521 equipped with 1-inch diam. side-eject coring tines that penetrated to the 8-inch depth.

[c] Verti-Quake 2521 equipped with 10-inch blades that penetrated to the 6-inch deep.

[d] Leaf compost (3.33 cubic feet or 0.2-inch) applied to 200 square feet subplots.

Table 20. Cultivation and leaf compost effects on turf color of a soccer field applied on 13 December 2012 on a sandy loam at Jakes Branch County Park in Beachwood NJ.

	Volumetric Water Content		Bulk Density	
	2013		2013	
ANOVA Source	5 Mar.	24 Jun.	5 Mar.	24 Jun.
Cultivation	NS	NS	NS	NS
Compost	NS	NS	*	*
Cultivation x Compost	NS	*	*	NS
CV (%)	10.9	6.4	2	2.9
Cultivation Main Effect				
	---------- $m^3\ m^{-3}$ ----------		---------- $g\ cm^{-3}$ ----------	
Non-cultivated Control	0.253	0.280	0.92	0.97
Toro Aerator[a]	0.272	0.290	0.90	0.95
Verti-Drain[b]	0.250	0.276	0.89	0.97
Verti-Quake[c]	0.255	0.285	0.89	0.95
Verti-Drain + Verti-Quake	0.255	0.269	0.91	0.96
$LSD_{0.05}$	NS	NS	NS	NS
Topdressing Main Effect				
None	0.255	0.277	0.91	0.97
Yes[d]	0.258	0.282	0.90	0.95

[a] Toro Greens Aerator quipped with 5/8-inch diam. hollow tines a that penetrated to the 2.5-inch depth in 2.25-inch hole spacing.

[b] Verti-Drain 7521 equipped with 1-inch diam. side-eject coring tines that penetrated to the 8-inch depth.

[c] Verti-Quake 2521 equipped with 10-inch blades that penetrated to the 6-inch deep.

[d] Leaf compost (3.33 cubic feet or 0.2-inch) applied to 200 square feet subplots.

Table 21. Interaction effect of cultivation and leaf compost effects on the soil volumetric water content and bulk density of a soccer field (tall fescue, Kentucky bluegrass and white clover) applied on 13 December 2012 on a sandy loam at Jakes Branch County Park in Beachwood NJ.

Cultivation Treatment	Volumetric Water Content		Bulk Density	
	24 Jun. 2013		5 Mar. 2013	
	No Compost	Leaf Compost	No Compost	Leaf Compost
	---------- $m^3\ m^{-3}$ ----------		---------- $g\ cm^{-3}$ ----------	
Non-cultivated Control	0.282	0.279	0.95	0.90
Toro Aerator[a]	0.295	0.284	0.90	0.91
Verti-Drain[b]	0.271	0.280	0.91	0.88
Verti-Quake[c]	0.292	0.277	0.90	0.89
Verti-Drain + Verti-Quake	0.247	0.290	0.91	0.91
$LSD_{0.05}$ within column & date	0.026		0.03	
$LSD_{0.05}$ within row & date	0.027		0.03	

[a] Toro Greens Aerator quipped with 5/8-inch diam. hollow tines a that penetrated to the 2.5-inch depth in 2.25-inch hole spacing.

[b] Verti-Drain 7521 equipped with 1-inch diam. side-eject coring tines that penetrated to the 8-inch depth.

[c] Verti-Quake 2521 equipped with 10-inch blades that penetrated to the 6-inch deep.

[d] Leaf compost (3.33 cubic feet or 0.2-inch) applied to 200 square feet subplots.

Table 22. Comparison of leaf compost quantity applied to three soil health improvement trials in Jakes Branch County Park in Beachwood NJ.

Treatment	Volume of compost per plot	Compressed bales per plot	Plot Size	Compost rate	Compost depth
	- ft^3 -		- ft^2 -	- ft^3 / 1000-ft^2 -	- inch -
Trial I					
Leaf compost amended to 2.5 %	7.4	n.a.‡	120	61	0.7
Leaf compost amended to 5.0 %	29.4	n.a.	120	245	2.9
Trial II					
Leaf compost	8.0	n.a.	36	223	2.7
Scott's topsoil	11.3	n.a.	36	313	3.8
Sphagnum (compressed bale)	6.0†	2	36	167†	2.0†
Trial III					
Leaf compost	3.3	n.a.	200	16.7	0.2

† Compressed volume

‡ n.a. = not applicable

To: Christine Raabe

From: James Murphy

Re: Responses to Comments on the Soil Amendment and Compaction Research

General

There does not appear to be any groundbreaking revelations in either of these reports, rather the findings reaffirm the significance of amending soils with organic materials (OM) through improved physical, chemical and biological conditions. These studies further confirm how OM helps to support soil structure through building soil aggregates, sustaining the diversity and arrangement of soil pores.

Response – Groundbreaking revelations were not expected from this research. Ocean County Soil Conservation District requested that replicated plot work be done to document the extent of enhanced persistence and quality of turf cover with improved soil health under conditions of Ocean County. It was expected that improving health of soil would positively impact the persistence and quality of turf cover. What wasn't known was the level of soil health needed to maximize persistence and quality of turf cover. This work indicates that each incremental improvement in soil health resulted in increasingly better persistence and quality of turf cover. Thus, the more costly efforts that dramatically improved soil health resulted in the most persistence and highest quality turf cover. Over time, repeated use of lower cost efforts to improve soil could be expected to enhance turf cover. For example, topdressing turf with approximately 0.2 inch of a quality organic matter source and core aerating to mix and incoroprate the amendment into the turf-soil surface once a year would have positive benefits after several years. Long term (3 or more years) research of topdressing turf-soil with ogranic matter was not within the scope of this grant.

Specific

1. The study utilized several cool season grasses and compared these to the existing (untreated turf). Why didn't the study attempt to apply amendments, tillage and other practices on the existing vegetation?

   Response – Reviewers misunderstood the objectives and antecedent soil conditions in Trials I and II, which studied the establishment and maintenance of turf cover on ALL plots. There was not an existing turf cover in the areas of the park were the soil health was poor and available to conduct Trials I and II. A third trial was initiated on existing turf (one of the athletic fields) at Jakes Branch County Park; this trial has been added to the final report. As it turned out, soil health was already very good in that athletic field (see data Trial III in the report), so there was very little to learn from soil health treatments on that field and the trial was abandoned after the first year of data collection.

2. The studies concluded that greatest improvements were observed when OM reached 5.5%. Given the characteristics of these soils, is this recommended level of OM easily sustainable for homeowners and other property owners (community groups, parks departments, etc.)?

   Response – Authors are not certain of what is meant by "…easily sustainable for homeowners… ", perhaps the question is whether it is easy to attain such a high level of soil organic matter (SOM). A SOM content of 5.5% would be very challenging to achieve in soils that are already low in organic matter. This quantity of SOM was targeted in the research to determine whether SOM content that is much greater than typical for undisturbed soils in the county would be beneficial. The results indicate that it would be beneficial although probably only useful for new development or re-construction. A soil organic matter content of 2.5% in the 0- to 6-inch is a much more realistic goal for property owners and managers. Based on the changes of SOM observed in these trials, it probably would require about 1.0-inch of leaf compost (~0.2 inch added per year over 5 years) to increase the SOM of a turf-soil by approximately 1.0%. Core aeration would also need to be practiced in conjunction with the topdressing to mix and incorporate the organic matter into the turf-soil surface.

3. The researchers discussed turf density and color as indicators. However, there does not appear to be an evaluation of root density or rooting depths and how this may be used as indicator of improved soil health. Was this information collected? If so, it should be included in the report.

   Response – Assessments of root density or rooting depths are very laborious and expensive data and were not within the scope of this grant. Thus, rooting data were not collected. It is logical that rooting was much greater in plots with the greatest turf cover; that is, more plants per area translate to more roots in the soil.

4. The reports did not indicate if there was a layer or thickness of OM; how was it distributed through 0-6”, and does that influence the findings?

   Response – Table 22 was added to the report to clarify how much (thickness) compost was added in each of the trials. Edits were also made in the report to clearly indicate that the organic matter amendments were tilled to uniformily incorporate the organic matter into the 0- to 6-inch soil depth in Trials I and II or topdressed and brushed into the turf of Trial III. The findings were different depending how the compost (quantity and incorporation) was applied. See the report for details.

5. Is there an optimum or recommended C:N ratio that can be gleaned from this research? And, what are the nitrogen recommendations associated with OM recommendations in the reports to avoid “burning through” the OM?

   Response – These trials corroborate previous research and recommendations that organic matter amendments with a C:N ratio <30:1 are best suited for applications involving the establishment and maintenance of landscape turf. This has been further emphasized and clarified in the report. Production agriculture often recommends a lower C:N ratio of soil organic amendments, <20:1.

6. It is unclear if the plots were subject to foot/athletic traffic or if they were mowed. If not, would the researchers expect to see similar results in turf subject to normal maintenance and wear-and-tear?

   Response – The plots in Trials I and II only received traffic from mowing and the occassional foot traffic from park visitors, animals, and researchers visiting to collect data. Traffic in Trial III included play from youth soccer; damage from play was low to moderate. Mowing was very infrequent due to budgetary restrictions at Jakes Branch County Park. The response would be similar although greater damage from traffic would limit the extent of improved turf performance. Extensive traffic would cause compaction of the soil and, if severe, would reduce the health of the soil. It would be expected that turf plots with better soil health would be less effected but not immune to the problems of traffic. Studying traffic effects on soil health was not within the scope of this grant.

General comments/suggestions for the overall final report.

1. Make sure that the final report addresses the goals and objectives set forth in the proposal, *i.e.* has the research conducted provided enough information to "develop simple, low cost, and practical soil restoration techniques and procedures that are transferrable at the homeowner scale."

   Response – The report was edited to address the concepts important to the development of "simple, low cost, and practical soil restoration techniques and procedures that are transferrable at the homeowner scale."

2. What recommendations can be made from the research and outreach components of the project (tied to #1 above)?

   Response – An Executive Summary was added to the final report that addressed recommendations generated from this research.

3. Given the legislation that has passed since this project was started, we are interested in understanding if this information can be useful in effectively implementing both the Soil Restoration Act and Fertilizer Bill? If it is, please be sure to include that in the final report.

   Response – An Executive Summary was added to the final report that addressed recommendations generated from this research.

4. Is there additional future research that would be useful to answer questions generated during the course of this project? Any future lines of research should be mentioned in the final report. The reviewers had the following suggestions, but there are surely others:

   a. How would amending existing turf (without seeding) compare to the results found here with new cool season grasses?
   b. What would be required to maintain soil OM at the recommended 5.5% over a longer period?

   Response – Added to the final report are comments regarding the scope of the grant limiting the ability to evaluate issues related to soil health and turf cover. Accordingly, these are plausible research studies. Items a. above is addressed in the final report. Monitoring of the existing plots at Jakes Branch County Park over a longer period of time either with or without supplemental additions of OM would provide data on item b. above.

5. One of the reviewers asked if these amendments and practices can be used to reduce water infrastructure costs and reduce irrigation needs for homeowners? Could these ideas help the State of NJ in developing and implementing the Water Supply Plan?

   Response – These amendments and practices do impact water holding capacity of the soil, which should impact stormwater management. How much of an impact is a question that is difficult to answer with a high degree of confidence without further study. The current research clearly indicates that these practices substantially reduce the need to irrigate turf. In the case of the loamy sand study (Trial II), however, irrigation could not be completely eliminated; turf failure occurred without any irrigation. While significant savings in irrigation are feasible, property owners would need to understand that periodic re-establishment of turf cover would be necessary in some circumstances (loamy sands and sands) if a complete elimation of irrigation was desired.

Effects of Tillage and Organic Amendment on Soil Micro-Community of a Suburban Park

Jennifer Adams Krumins, Elijah Bohoroquez and Lina Halawani

Department of Microbiology and Molecular Biology, at Montclair State University, Montclair, NJ

Introduction

Soil compaction caused by development and recreational use can have negative effects on nutrient retention within a watershed. This may be increased in the future when the frequency of heavy rainfall associated with climate change combines with poor soil health and compaction to cause shallow root systems and limit retention of water and nutrients in soil communities. The native soils in healthy natural forested conditions have little to no runoff and limited nutrient contribution to the nearby watersheds (Forman 1998). By tilling soil and increasing organic content, the retention of water, and thus nutrients, can be increased (Guzha 2004).

The soil micro-food web plays an essential role in cycling organic matter and thus making mineral nutrients available to plants (Coleman et al. 2004). Bacteria, fungi and nematodes are important and representative members of the micro-food web. Indeed soil nematode counts have long been used as measures of soil health and maturity (Bongers 1990). Together with the soil food web, plant and animal interactions all contribute organic components to soil aggregates which stabilize water and nutrient retention (Tisdall and Oades 1982).

The project described here was carried out in conjunction with a major restoration effort in a typical suburban park that has poorly functioning and compacted soil associated with development and recreational use. The goal of this project was to evaluate the merits of different soil restoration techniques. We focused specifically on characterizing and quantifying the micro-food web of soils that has undergone a restoration treatment and those that had not. Treatments were chosen by Dr. James Murphy of Rutgers University in an effort to increase soil organic matter content, which has been linked with increased water holding capacity. Deep tillage (90cm) has been associated with greater root penetration, and thus increased water uptake by vegetation, but no tillage situations can also increase water retention when combined with organic matter additions (Varsa et al 1997).

Methods

We carried out soil micro food web analysis on compacted soils of Jakes Branch Park in Ocean County, NJ as part of the experimental design established by Dr. James Murphy of Rutgers University. We studied the soils of two plots. The first, described by Dr. Murphy and team as the sandy loam plot, was adjacent the butterfly garden that was established as part of this funded work. Therefore, I define those data as the butterfly garden plot data. The second, described by Dr. Murphy as a loamy sand with 3.5% soil organic matter was described as an open field. I also describe it as the open field plot data. Please see photos in figure 1. Plot characteristics and treatment applications are as described completely by Murphy and Schmid in their reports. In the butterfly garden plots we measured the soil micro food web of the control plots with no treatment and the plots that were tilled with highest compost amendment. In the open field plots we made the same measurements of the control plots (in this case they were only treated with minimal fertilizer) and the most treated plots that were tilled and treated with leaf compost. To maximize replication and resolution of treatment differences we sampled control subplots and compared them to Dr. Murphy's highest level treatment subplots.


Figure 1. Photos taken of the butterfly garden plot (left) recently after treatment application, and the open field plot (right) in December of 2013, one year after treatment application.

To measure microbial community abundance and composition as well as nematode abundance, soil cores were taken after 0 month, 1 month, 3 month, and 12 month periods from subplots of four control and four of the highest treatment at the butterfly garden plots. Following the same sampling schedule of the butterfly garden plots, soil cores were taken repeatedly from the open field plots of four of the control and four of the highest treatment.

Soil Bacterial Density

Bacterial density was quantified using acridine orange direct counts (AODC) (Hobbie et al. 1977). Phosphate buffer solution (PBS) had 0.1 gram of soil from one plot suspended in it, and 2 ml of 1.5% formalin added to fix the microorganisms. 100 uL of this solution was mixed with 900 uL of PBS and 200 uL of acridine orange. Samples were vortexed to break up the soil pellet between steps, and to integrate the solution. Samples were vacuum captured on a 25mm 0.2 µm black polycarbonate filter (Millipore, Billerica, MA). Cells were then enumerated using a Nikon *Ti* epifluorescent microscope. Total cell number is presented as cells per gram dry weight of soil.

Soil Community Profiling

Following collection, samples for molecular analysis were stored at -20°C. Later, we extracted whole community DNA from 0.25 g sub-samples using the Ultra Clean Soil DNA Isolation Kit according to their guidelines for maximum yield (MoBio Laboratories, Solana Beach, CA). We analyzed both fungal and bacterial communities for composition differences by amplifying extracted DNA using PCR followed by terminal restriction fragment length polymorphism (TPFLP) (Liu et al. 1997). Targeting the fungal community, we used a 6FAM (fluorescently labeled) forward primer, ITS1-F (CTTGGTCATTTAGAGGAAGTAA), and an unlabeled reverse primer, ITS4 (TCCTCCGCTTATTGATATGC). These primers amplify the intergenic transcribed spacer region (ITS) of ribosomal DNA and have been used successfully to amplify ascomycete and basidiomycete fungi (Klamer et al. 2002, Allison et al. 2007, Krumins et al 2009). Therefore, we assume our molecular profiling captured mycorrhizal as well as saprotrophic fungi. Targeting the bacterial community, we used a 6FAM (fluorescently labeled) forward primer, SSU 27F (AGAGTTTGATCCTGGCTCAG), and an unlabeled reverse primer SSU 1492R (GGTTACCTTGTTACGACTT). These primers amplify the small subunit 16s of ribosomal DNA, and are used extensively to characterize bacterial community structure (*e.g.,* Blum et al. 2004).

We carried out the bacterial community PCR in 50 µl reactions that included: 1X PCR buffer, 2.0mM $MgCl_2$, 200 µM dNTP (each), 1.0 µM primer (forward and reverse), 0.4 µg $µl^{-1}$ BSA (bovine serum albumin) (Roche Diagnostics, Indianapolis, IN), and 1.25 U DNA polymerase per 50 µl reaction. Unless stated, all PCR reagents were obtained from Applied Biosystems (Foster City, CA). We performed amplification reactions then validated all PCR reactions on a 1.5% agarose gel.

We digested amplified fungal and bacterial DNA using the restriction enzyme *Hha1* (New England Biolabs, Beverly, MA). We separated denatured restriction fragments using capillary electrophoresis with an ABI3010 Genetic Analyzer (Applied Biosystems, Foster City, CA). Capillary electrophoresis produces an array of multiple terminal fragments of varying length that are detected by their fluorescent marker. Each fragment theoretically represents a unique fungal or bacterial taxa or operational taxonomic unit (OTU). We used Applied Biosystems' GeneScan software to analyze the fragment patterns of each sample and produced a binary array of presence or absence of each OTU in each of our treatment combinations. We established a minimum response threshold of 50 relative fluorescence units for a fragment to be considered an OTU.

Soil Nematode Density

Soil was gathered using using a 5cm soil corer according to the treatment map of Murphy and Schmid. All soil was sieved through a >2.0mm sieve to remove large inorganic particles. 50 grams of soil was weighed, and placed on top of a coffee filter over a plastic strainer in 100 mL of tap water then transferred to an incubator. After three days the water was transferred to a 6x6 gridded petri dish and observed under a microscope (Nikon SMZ-1000 Optical Zoom). Nematodes were differentiated into two groups, bactivores and herbivores or omnivores. All nematodes were counted, and these numbers were divided over the mass of soil used in order to calculate soil nematode density.

Data Analysis

We used a two way analysis of variance (ANOVA) to test for effects of plot site and soil restoration treatment: on bacterial abundance, bacterial and fungal OTU richness as well as nematode density. When appropriate we separated means between nitrogen treatments with a Bonferroni test. We were able to separate differences in microbial community structure for bacteria and fungi using principle components analysis (PCA). The presence or absence of OTU served as variables for the PCA that separated bacterial and fungal communities based on molecular profile. We followed all PCA with a multivariate analysis of variance (MANOVA) of the first three component scores to determine significant effects of plot site and restoration treatment. All statistical analyses were conducted in SAS Version 9.1 (SAS Institute, Inc. Cary, NC), and all significance values are set at $P=0.05$.

Results

Total bacterial counts (Fig. 2) were consistently higher per gram dry weight of soil in the field plots as opposed to the butterfly garden plots. Within each plot, treated subplots held more bacteria than non-treated subplots, though non-significant at $p=0.05$.

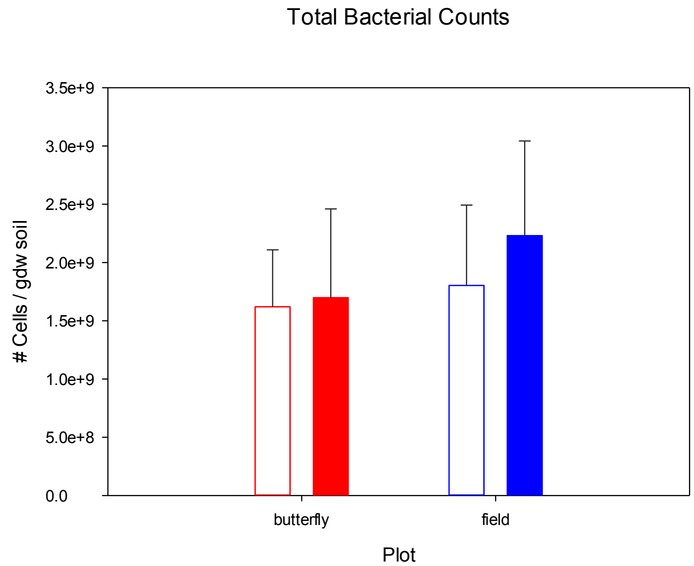


Figure 2. AODC of soils from two plots, treated and untreated. N=4, and open bars are from control plots and filled bars are from treated plots. ANOVA plot effect F=2.46, P= 0.1243 treat effect F= 1.13, P= 0.2949.

The diversity of bacterial taxa (Fig. 3) as determined by molecular profiling was higher in the field plot than the butterfly garden plot, but a difference in treated subplots was only found in the butterfly garden plot, though non-significant.

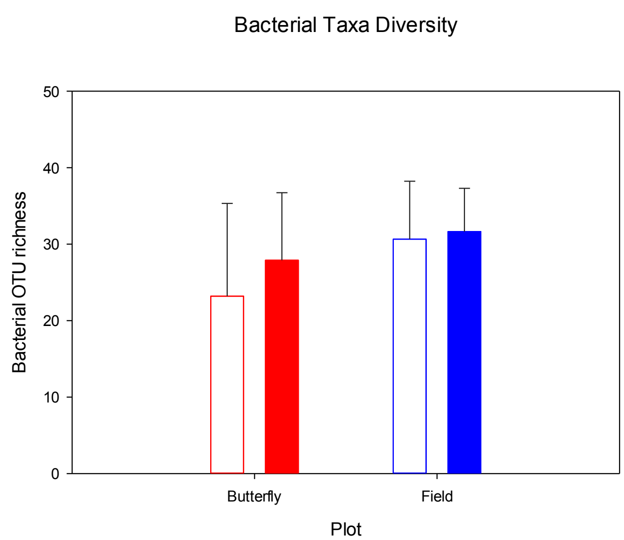


Figure 3. Bacterial diversity as measured by TRFLP OTU. N=4 and open bars indicate control plots and filled bars indicate treated plots. ANOVA plot F=3.94 P=0.051 treat F= 0.96 P=0.3315 Plot X treat F = 1.63 P=0.2055.

The bacterial community composition (Fig. 4) was significantly different between the two plots, but it did not differ depending on treatments of the subplots as determined by molecular community profiling.

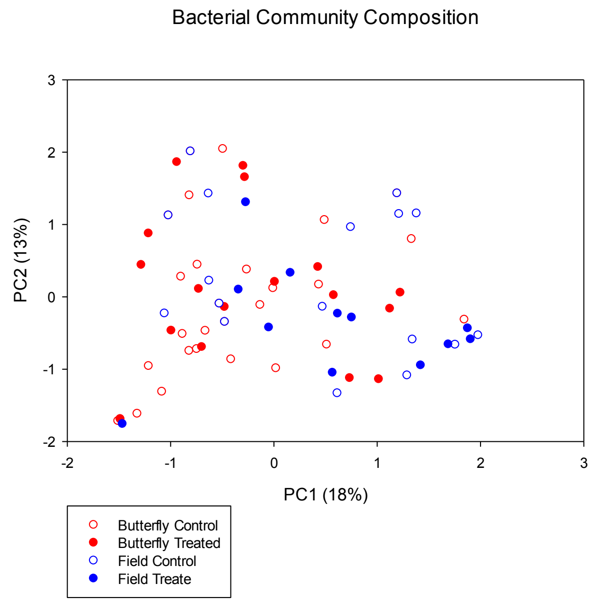


Figure 4. Differences in bacterial community composition as determined by TRFLP,n=4. Manova Wilk's Lambda Plot => F=4.03 and P<0.05 Treatment => F=0.65 and P=0.5886.

The diversity of fungal taxa as determined by molecular profiling was different depending on the plot (Fig. 5), and there was a non-significant interaction between the treatments and the plots. That is, the open field plot had higher fungal diversity than the butterfly plots, especially in the treated subplots. However, the treated subplots of the butterfly garden plot had lower diversity than the controls. Again, this was a non-significant trend.

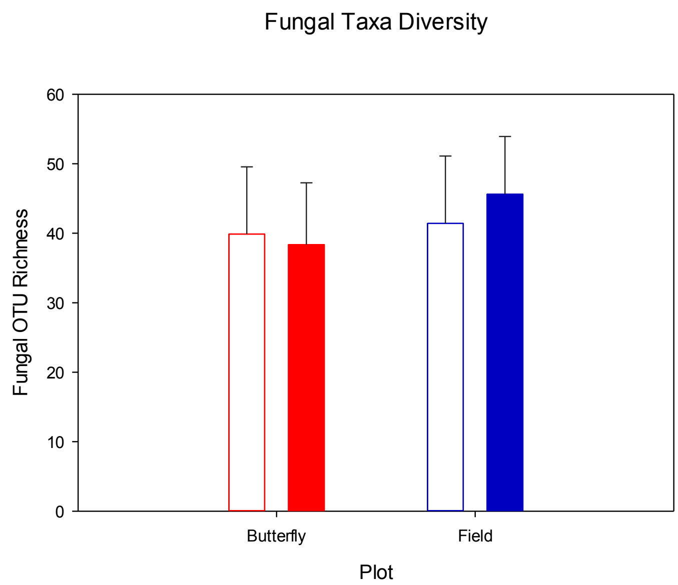


Figure 5. Fungal diversity as measured by TRFLP OTU. N=4 and open bars indicate control plots and filled bars indicate treated plots. ANOVA plot F= 4.63 and P<0.05 treat F=0.20 P=0.6594 Plot X treat F=1.72 P=0.1934.

Although the absolute number of fungal taxa did not vary significantly between the subplot treatments, the composition of the communities varied extensively. There were highly significant differences in the fungal community composition between the plots and within the plots between the treated subplots (Fig. 6).

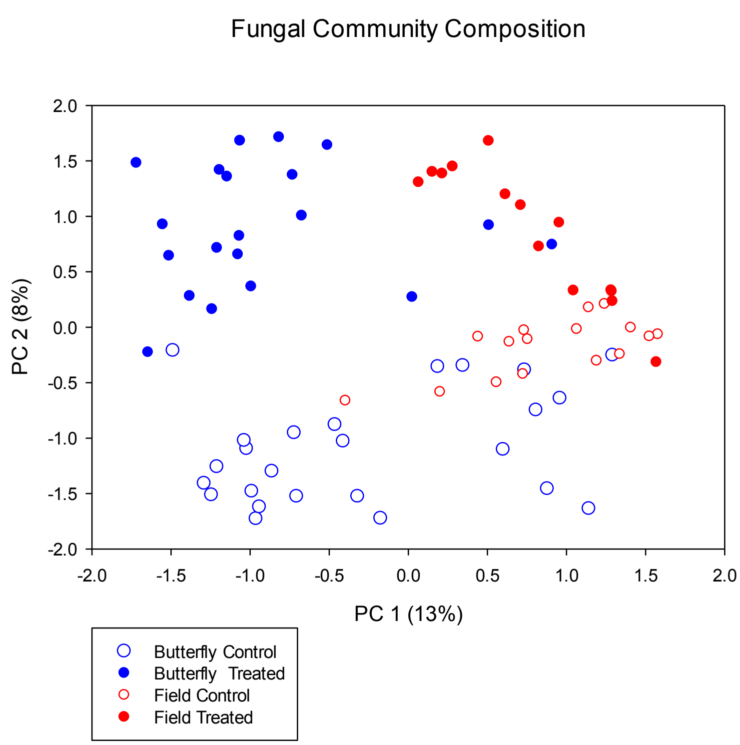


Figure 6. Differences in bacterial community composition as determined by TRFLP,n=4. MANOVA Wilk's Lambda plot => F=73.83 and P<0.0001 treat => F=63.96 and P<0.0001.

The density of bactivorous nematodes was significantly higher in the field than butterfly garden plots (Fig. 7A). Further, in both across both plots, the treated soil supported greater density of bacterial feeding nematodes than the untreated controls, though non significant. The density of herbivorous nematodes was not significantly different between either plot or within the plots at the sub plot treatment levels (Fig. 7B). Though non significant, the density of herbivores in the treated subplots of the open field were far greater than nematode densities elsewhere.

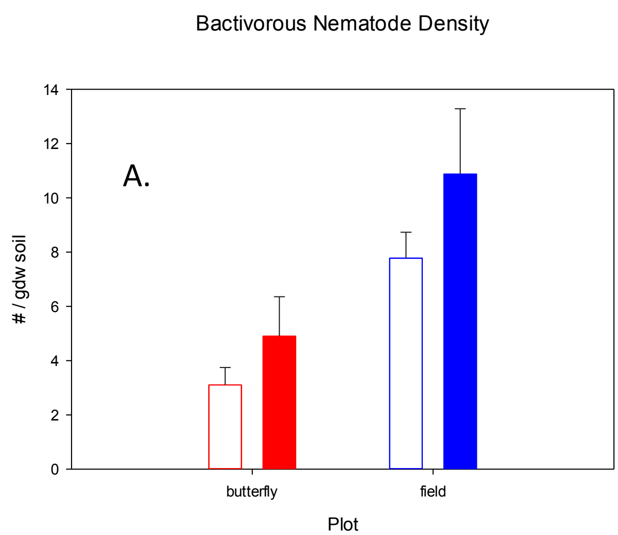


Figure 7A. Soil bactivorous nematode counts. N=4. ANOVA plot F=14.70 P<0.001 treat F= 3.26 P=0.08. N=4 and open bars indicate control plots and filled bars indicate treated plots.

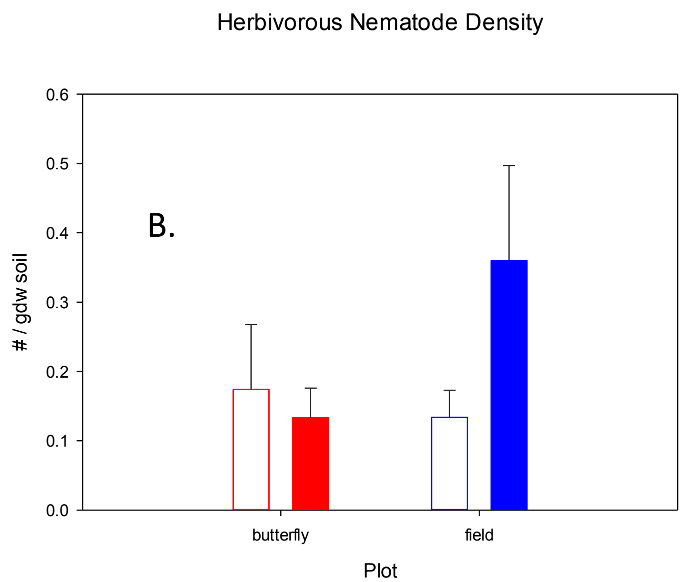


Figure 7B. Soil herbivorous nematode counts, n=4. ANOVA plot F=0.71, P=0.4036 treat F= 0.97, P=0.3274. N=4 and open bars indicate control plots and filled bars indicate treated plots.

Discussion

Bacterial counts varied between the plots; this is not surprising. However, it is important to note that bacterial counts were relatively much higher in the treated subplots of the open field than that of the butterfly garden (Fig. 2). The open field was most compacted, and vegetation was allowed to die during the experiment. This result suggests that the treatments were most important when conditions were least favorable. Bacterial diversity and community composition varied greatly between the plots, but not between the subplot treatments (Figs. 3 and 4). Our results agree with the notion that the parent material matters more to determine composition of the organisms present (Coleman et al. 2004), but the conditions imposed by the treatment allowed the community to be more productive (Fig. 2).

The fungal community responded quite nicely to the treatments, and this varied between the two plots. Again, the parent material will ultimately determine the composition of the community (Fig. 5 and 6), but within the plots, the composition of the treated subplots varied greatly from that of the controls. Fungi do not grow as individual cells, they are hyphal in their morphology and saprotrophic. The increased aeration and organic matter contributions to the treated subplots had a significant effect on the kinds of fungi living in the soil.

Bactivorous nematode abundance was determined to have been positively but non-significantly affected by tillage and nutrient amendment. However, the response of bacteria feeding and plant feeding nematodes was not the same. The non significant, but sharp increase in plant feeding nematode density within the treated subplots compared to controls of the open field may have interacted with the drought to affect grass growth. These plots died back for a period of time due to lack of water and possibly high plant feeding nematode density.

Clearly the aeration and organic matter amendments played an important role in shaping the kind of microorganisms and flora living in the soils. Results and trends were not always statistically significant. This may be due to greater stress imposed on the plots like drought. However, the results presented here represent an average through time as the plots responded to the treatments over a course of one year. From these results we can infer that the treated subplot soils supported a more robust and diverse micro food web. However, differences between subplots were always secondary to differences between the plots meaning that the parent material matters. All treatments imposed to increase soil health should consider the quality and state of the parent material as baseline conditions.

Conclusions and Recommendations for Management

This study compares soil restoration treatments on two very different plots with highly variable starting soil conditions. For this reason, the primary differences in the data are found between the two study plots. However, though not always statistically significant, biologically significant differences can be found between the treated and untreated subplots. For instance, in almost all response variables measured, soil tillage and organic amendment across the both of the study plots resulted in an increase in organism biomass. This was not the case for plant parasitic nematodes (Fig. 7B) where we found an interaction in the plot and treatment factors. This may be due to the drought experienced by the open field plots. However, it is important to note that the fungal community of the soil was most greatly affected by the soil treatments across both sites (Fig. 6).

Soil compaction is an unfortunate reality of suburban development. However, our results and those of Dr. Murphy show that soil health and the negative affects of compaction can be reversed. Developers and land managers should consider soil health remediation as part of their management practice. This might include soil aeration and organic matter amendments to the soil. Once these treatments are in place, regular watering will result in the most robust grass or plant community production. Vegetation will then naturally remediate the soil through rooting, leading to further aeration and organic matter contributions to the soil.

Low Cost Recommendations

The results of this work demonstrate the value of adding complex organic matter to soils rather than industrial fertilizer. Dr. Murphy applied fertilizer to all subplots of the open field, but he only applied leaf compost to the butterfly garden plots. The open field plots had the highest numbers of plant feeding nematodes, and also in combination with drought conditions, were least successful in establishing grass. The benefits of complex organic additions like compost may be realized over a period of time. Though the tillage treatments imposed on these plots were fairly costly, reasonably priced alternatives may exist to aerate small private properties. The results of this project demonstrate the value of soil aeration and addition of complex organic matter like leaf compost to improve soil diversity and establish a robust rooted plant system.

Acknowledgements

We are very grateful to the Barnegat Bay Partnership for funding this work. This work was conducted in collaboration with James Murphy and the students of Rutgers University and the Ocean County Soil Conservation District. We thank Idali Rios and Adam Parker for making valuable contributions to this research.

References

Allison, S. D., C. A. Hanson, and K. K. Treseder. 2007. Nitrogen fertilization reduces diversity and alters community structure of active fungi in boreal ecosystems. Soil Biology & Biochemistry 39:1878-1887.

Bongers, T. 1990. The maturity index: an ecological measure of environmental disturbance based on nematode species composition Oecologia 83:14-19.

Coleman, D. C., D. A. J. Crossley, and P. F. Hendrix, editors. 2004. Fundamentals of Soil Ecology. 2nd Edition edition. Elsevier, Amsterdam.

Forman, Richard T. T. "Hydrology of the New Jersey Pine Barrens." *Pine Barrens: Ecosystem and Landscape*. New Brunswick, NJ: Rutgers UP, 1998.

Guzha, A.c. "Effects of Tillage on Soil Microrelief, Surface Depression Storage and Soil Water Storage." *Soil and Tillage Research* 76.2 (2004): 105-14.

Hobbie, J. E., R. J. Daley, and S. Jasper. 1977. Use of nucleopore filters for counting bacteria by fluorescence microscopy. Applied and Environmental Microbiology 33:1225-1228.

Klamer, M., M. S. Roberts, L. H. Levine, B. G. Drake, and J. L. Garland. 2002. Influence of elevated CO2 on the fungal community in a coastal scrub oak forest soil investigated with terminal restriction fragment length polymorphism. Applied and Environmental Microbiology 68:4370-4376.

Krumins, J. A., J. Dighton, D. M. Gray, R. B. Franklin, and M. S. Roberts. 2009. Soil microbial community response to nitrogen enrichment in two scrub oak forests. Forest Ecology and Management 258 1383–1390.

Liu, W.-T., T. L. Marsh, H. Cheng, and L. J. Forney. 1997. Characterization of microbial diversity by determining terminal restriction fragment length polymorphisms of genes encoding 16S rRNA. Applied and Environmental Microbiology 63:4516-4522.

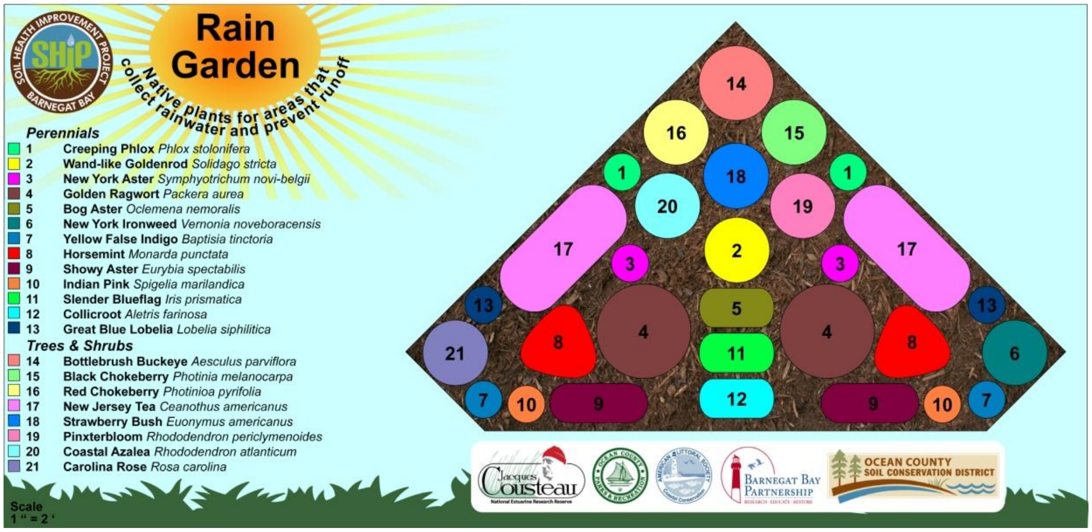
Tisdall, J. M., and J. M. Oades. "Organic Matter and Water-stable Aggregates in Soils." *Journal of Soil Science* 33.2 (1982): 141-63.

Varsa, E.c., S.k. Chong, J.o. Abolaji, D.a. Farquhar, and F.j. Olsen. "Effect of Deep Tillage on Soil Physical Characteristics and Corn (Zea Mays L.) Root Growth and Production." *Soil and Tillage Research* 43.3-4 (1997): 219-28.

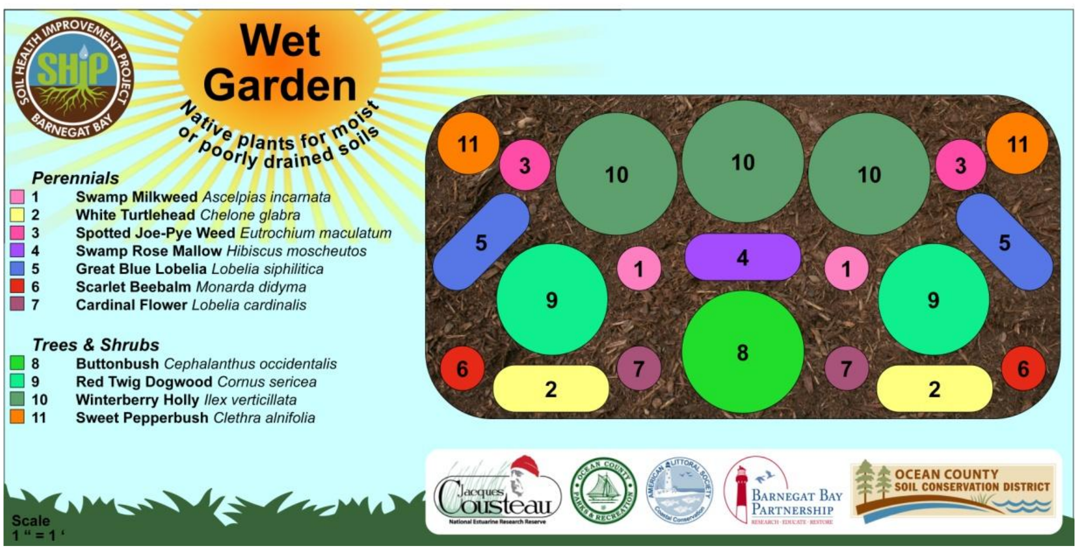
3. **Soil Amendment and Native Plantings – Demonstration and Site Improvement**
   Each Garden Sign is depicted below and the Garden-Specific QR Code for further information. Each Garden also has a dedicated page on the District's SHIP WebPage: http://www.soildistrict.org/healthy-yards/jakes-branch-ship-project/

- *Butterfly Garden*

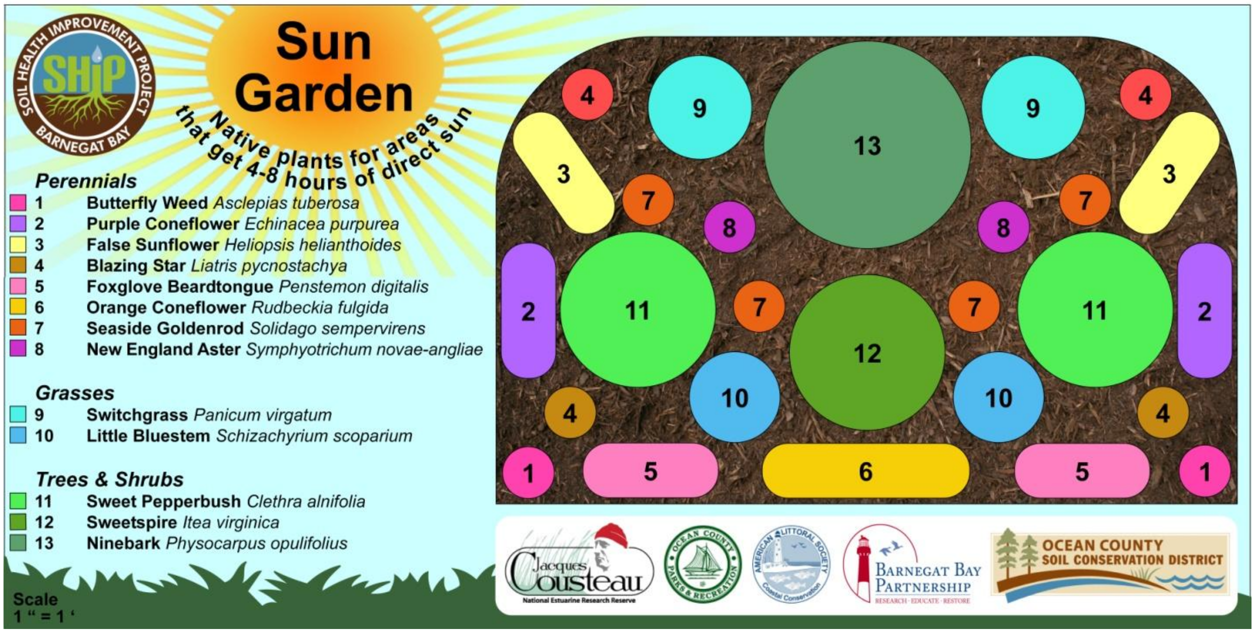
- *Rain Garden*



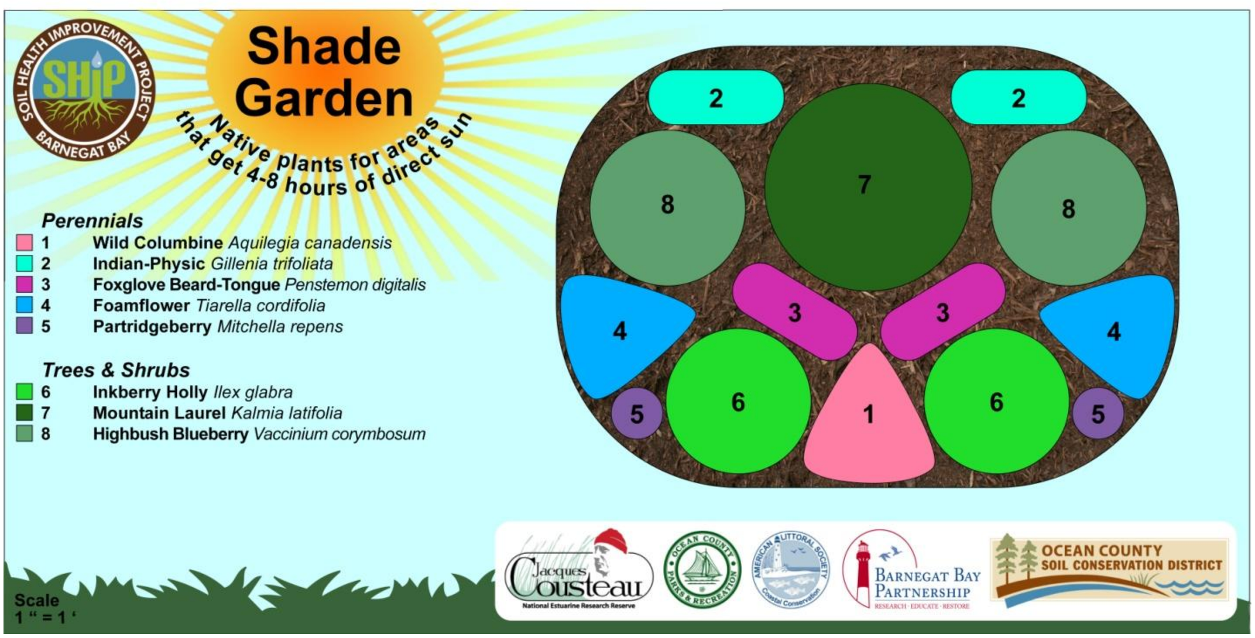
- *Wet Garden*



- *Sun Garden*



- *Shade Garden*



Educational Activities

A significant component of the SHIP project was an over-arching plan to incorporate educational activities throughout the duration of the research. This was accomplished through a cadre of partner organizations including:

1. Jacques Cousteau National Estuarine Research Reserve – Lisa Auermuller
2. American Littoral Society – Helen Henderson/Judy DiFiglio
3. Rutgers Cooperative Extension - * Modified to Cara Muscio as consultant
4. Staff at Jakes Branch County Park

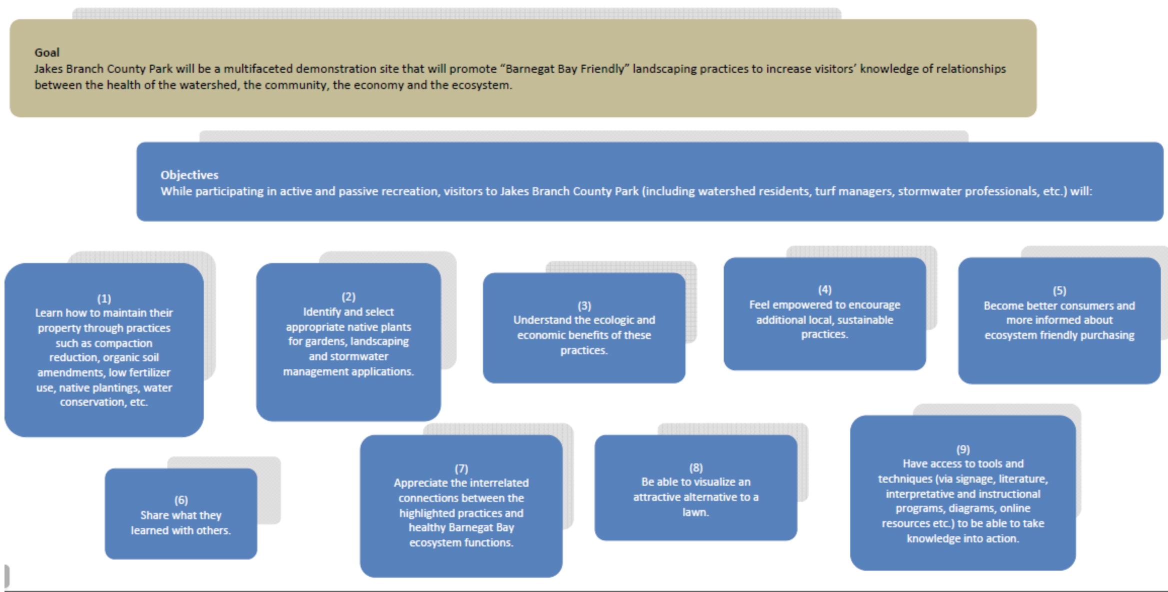
Jakes Branch Demonstration Project
Education and Outreach Goal and Objectives

Goal:
Jakes Branch County Park will be a multifaceted demonstration site that will promote "Barnegat Bay Friendly" landscaping practices to increase visitors' knowledge of relationships between the health of the watershed, the community, the economy and the ecosystem.

Objectives:
While participating in active and passive recreation, visitors to Jakes Branch County Park (including watershed residents, turf managers, stormwater professionals, etc.) will:

- Learn how to maintain their property through practices such as compaction reduction, organic soil amendments, low fertilizer use, native plantings, water conservation, etc.;
- Identify and select appropriate native plants for gardens, landscaping and stormwater management applications;
- Have access to tools and techniques (via signage, literature, interpretative and instructional programs, diagrams, online resources etc.) to be able to take knowledge into action;
- Understand the ecologic and economic benefits of these practices;
- Appreciate the interrelated connections between the highlighted practices and healthy Barnegat Bay ecosystem functions;
- Be able to visualize an attractive alternative to a lawn;
- Become better consumers and more informed about ecosystem friendly purchasing;
- Share what they learned with others;
- Feel empowered to encourage additional local, sustainable practices.

Jakes Branch Demonstration Project
Education and Outreach Goal, Objectives, Tasks and Responsible Parties



Task	*Responsible Party*	*Objective(s)*
Advertising, registration and marketing outreach support	JC NERR	Project Administration
Assembly of supplemental handout materials	JC NERR	1, 2, 3, 4, 5, 6, 7, 8, 9
Evaluation on the effectiveness of programs	JC NERR	1, 2, 3, 4, 5, 6, 7, 8, 9
Design and oversee native plantings	ALS – via Judy DeFiglio	1, 2, 3, 5, 7, 8
Communicate about the project through multimedia and social networking (i.e. weekly blog writing, posting on Facebook page, special e-announcements through email lists)	ALS – via Judy DeFiglio	1, 3, 5, 7, 9
Update web pages with pertinent information, fact sheets, links, photos	ALS	1, 2, 3, 5, 7, 8, 9
Write articles for the ALS newsletter (6000 members and state and federal delegations)	ALS	1, 2, 3, 5, 7, 9
Incorporation of project information into Barnegat Bay presentations	ALS	1, 3, 5, 7, 8, 9,
Lead a local field trip to the completed project site	ALS	1, 2, 3, 4, 5, 7, 8, 9
Develop a Homeowners Factsheet on amending soil with organic materials	ALS	1, 3, 5, 7, 9
Create a site profile of the Jakes Branch Soil Health Improvement Project (SHIP) on a variety of websites	RCE	8, 9
Collaborate and assist in developing and implementing education and workshops	RCE	1, 2, 3, 4, 5, 6, 7, 8, 9
Create and conduct a "Train the trainer" workshop for Master Gardeners, park volunteers and staff and other partners to prepare individuals for giving presentation at and/or about Jakes Branch	RCE	1, 2, 3, 4, 5, 6, 7, 8, 9,
Provide Jakes Branch staff with a curriculum of relevant reference materials relating to sustainable landscape and the BMPs in use at the site	RCE	1, 2, 3, 4, 6, 7, 8, 9
Coordinate with Jakes Branch staff to create educational opportunities for the site	RCE	1, 2, 3, 4, 6, 7, 8, 9

A collaborative effort was launched to design a branding for the SHIP project. JCNERRS initiated a subcontract with a graphic artist to design a logo that captured the soil health/watershed health essence of the Soil Health Improvement Project. The logo shown here was chosen and has been utilized on all workshop, promotional materials, website pages, display theme, etc.

SHIP Display – A tabletop display was created and produced that highlights:

- The Functions of a Healthy Soil
- Simple Ways to Assess a Healthy Soil
- Steps to Improve Soil Health
- SHIP Partners

** This display proved so popular that the Barnegat Bay Partnership purchased a second one for use at festivals, events, conferences, etc. by any/all partners. JCNERRS had funding for an additional display which is housed at the OC Soil District office and on display in the lobby. The third display is kept on exhibit at Jakes Branch County Park. In the future, the plan is to have the SHIP display rotate around the County at the libraries for sharing publications, etc. related to soil health and watershed health.

American Littoral Society Created this tri-fold brochure to highlight native gardens at the SHIP project

www.soildistrict.org

Program:

Rain Barrel Demonstration and Building Workshop

Date:

Sunday, March 30, 2014
Demonstration 10:00am
Building Workshop
11:15am – 12:45pm.

Location:

Jakes Branch Park,
1100 Double Trouble Rd., Beachwood, NJ

Register At:

Jakes Branch
732-281-2750

RSVP By:

March 24, 2014

Healthy Soil Is At The Root Of Everything!

Bring-Your-Own-Barrel Workshops Return to Jakes Branch

Come out and learn about Rain Barrels at Jakes Branch County Park on March 30, 2014. There will be an indoor information session and demonstration at 10:00am, and an optional Build your Own Barrel workshop beginning at 11:15 am. You will learn about the practical issues associated with rainwater capture, barrel installation and maintenance, and how capturing rain can help conserve water and reduce stormwater.

The barrel building portion of this workshop is limited to 12 people, and registration is first come, first served. Bring a 35-50 gallon trash bin or food grade plastic container, and we will help you turn it into a rain barrel! Both portions of the workshop are free, but please pre-register by Monday, March 24, 2014. To pre-register, or for more information, please contact Jakes Branch County Park at 732-281-2750.

Save H20 *and* help your garden grow!

Coordination for this project provided by:

Our Partners:

Funding for this project provided by:

SOIL HEALTH IMPROVEMENT PROJECT
SHiP
BARNEGAT BAY

www.soildistrict.org

Program:

GO NATIVE! Plant Walk and Talk

Date:

Saturday April 26, 2014

and

Wednesday May 14, 2014

Time: 1:00 – 2:00 pm

Location:

Jakes Branch County Park Nature Center, Beachwood

Register at:

Visit the Jakes Branch Nature Center or call 732-281-2750 to register

Cost:

FREE

Healthy Soil Is At The Root Of Everything!

Sick of your boring garden? Tired of buying plants from the local "big box" store only to have them die? Discover why gardening with native plants is the answer, and find out how native wildflowers can become the star of your garden!

Beyond beauty, these plants will attract more wildlife while standing up to drought, bugs and bad soil! The program includes a short walk on our handicap-accessible Plant Discovery Trail which includes 6 demonstration gardens for all types of growing conditions!

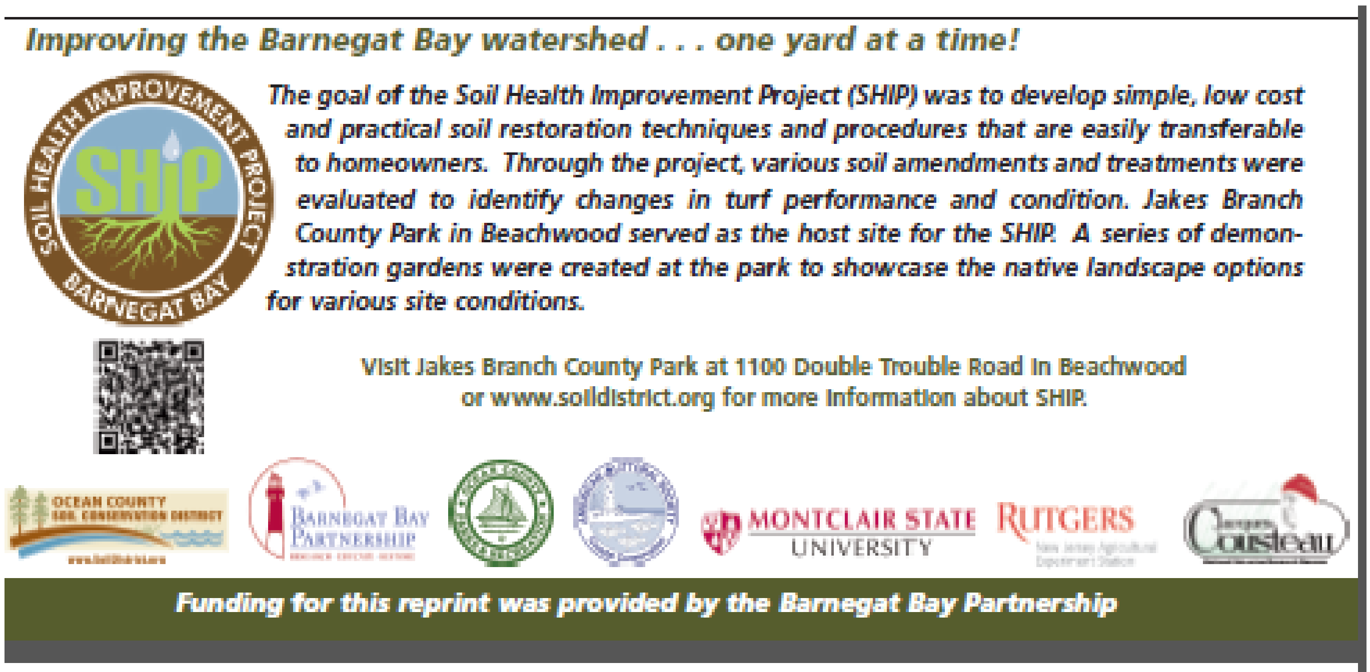
Coordination for this project provided by: Ocean County Soil Conservation District

Our Partners: Rutgers New Jersey Agricultural Experiment Station; Montclair State University

Funding for this project provided by: Barnegat Bay Partnership

An additional 7500 copies of *The Low Maintenance Landscaping Guide for Barnegat Bay Watershed* was reprinted using SHIP funds.

7500 copies of this popular guidebook were printed and distributed since 2013 through various partners and venues. Municipalities and numerous partners, agencies and organizations regularly obtain quantities for educational and outreach use. The publication was updated to include SHIP details and information on the inside cover as shown below:



This publication will be available for use with the SHIP display and is being distributed to municipalities and partners utilizing the FREE order form as shown.

OCEAN COUNTY
SOIL CONSERVATION DISTRICT

714 Lacey Road, Forked River, NJ 08731 Tel (609) 971-7002 Fax (609) 971-3391
www.SoilDistrict.org

The Ocean County Soil Conservation District is pleased to announce the release of the newly updated and revised *"Low Maintenance Landscaping for the Barnegat Bay Watershed"* booklets. We have quantities available for FREE for all interested parties. Our goal is to get it in the hands of as many residents of our watershed as possible so that they may consider the best management practices described when landscaping their yards, and help improve water quality at the same time. This unique guide provides Ocean County homeowners background information on the importance of soil health, eco-friendly pest control techniques, native plant suggestions, important fertilizing information and much more. **This publication is also available (along with numerous other resources related to Soil Health and our watershed) are all available and downloadable on our website www.soildistrict.org, (under Top Soil Health Resources) Please access them there and share our link with your residents/constituents.**

Below is a request form that can be filled out to place an order for FREE ***"Low Maintenance Landscaping for Barnegat Bay Watershed" (60 per box)***
Please PRINT & Fax to: 609-971-3391 or mail to above address.

Number of Copies Requested: ______________________________

Organization Name: ______________________________

*Contact Person: ______________________________
* *It is very important to give a specific contact person to whom these can be delivered.*

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

Email: ______________________________

Phone: ______________ Fax: ______________

Since District staff regularly visit each municipality throughout the county, these can be delivered to your office. They can also be picked up at our Forked River office. (Hours: Mon. –Thurs.7:15 - 4:15)
Please check preference: ____________ Please Deliver ____________ Will Pick-up

Please be advised this order form is also available on the Ocean County Soil Conservation District's website: www.soildistrict.org along with additional information about our programs and projects.

The Ocean County Soil Conservation District Staff

Funding for the printing of the 2015 version of the guidebook was provided by the Barnegat Bay Partnership through the SHIP (Soil Health Improvement Project) Prime Award # CE98212311.

Please visit our SHIP webpage for further details regarding this project
http://www.soildistrict.org/healthy-yards/jakes-branch-ship-project/

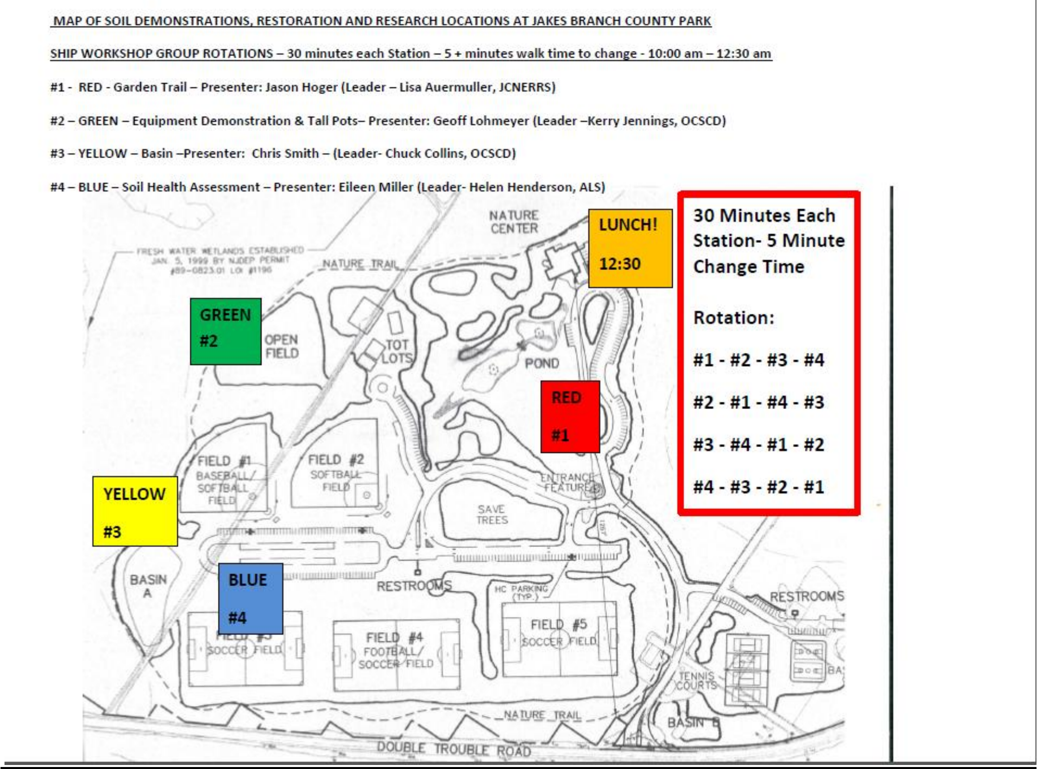
Healthy Soil is at the Root of Everything!

October 31, 2014

Digging Deeper – Practical Demonstrations to Improve Soil Health

The SHIP Project: Jakes Branch County Park has been developed into a multifaceted demonstration site that promotes "Barnegat Bay Friendly" landscaping practices.

8:30 – 9:00	Registration & Morning Refreshments
9:00 – 9:20	Welcome to Jakes Branch – Michael Mangum, Director, Ocean County Parks & Recreation Barnegat Bay Partnership – Dr. Stan Hales, Director District 9 State Assembly Members (Invited)
9:25 – 9:30	SHIP – Partner Introductions & Agenda Review – Christine Raabe, Director, Ocean County Soil Conservation District
9:30 – 10:00	**Presentations by the Researchers–** Dr. James Murphy, Rutgers University: "*Improvement of Soil Function through De- Compaction and Organic Matter Addition"* Dr. Jennifer Krumins, Montclair University: *"Soil Food Web"*
10:00 – 12:30	Soil Health Assessment Tools – Demonstration & Site Tour – Outside in Groups #1 - #4 - Follow the Leader
12:30 – 1:00	LUNCH!
1:00 – 1:20	GO Native! - Helen Henderson, American Littoral Society
1:20 – 1:30	Resources, Resources, Resources – Packets and SHIP Website- Christine Raabe
1:30 – 1:45	Group Discussion - Opportunities for Projects , Engaging Participants & Practical Considerations – Lisa Auermuller, Jacques Cousteau National Estuarine Research Reserve
1:45 – 2:00	Wrap –Up, Evaluations & Professional Develop Certificates – Christine Raabe



<u>SHIP Workshop Registrants –</u> There were 68 registrants for the SHIP workshop that represented municipal, county and state government agencies, as well as students from OCVTS & non-profits.

Name-Last	**Name-First**	**Email**	**Organization or Affiliation**
Ackerman	Ben	BAckerman@co.ocean.nj.us	Jakes Branch County park
Ambrosio	Richard	richard.ambrosio@dep.nj.gov	NJDEP/Water Compliance & Enforcement
Auermuller	Lisa	auermull@marine.rutgers.edu	Jacques Cousteau Reserve
Bolger	Erin	ebolger@twp.brick.nj.us	Brick Township
Brooks	Marjorie	ocbeachbaby2@verizon.net	Ocean City Environmental Commission
Cats	Taylor	tcats204@gmail.com	OCVTS
Cisk	Matt	mcsisk@ochd.org	Ocean County Health Department
Collins	Chuck	ccollins@soildistrict.org	Ocean County Soil Conservation District
Costaris	Charlene	cmcostaris-mail@yahoo.com	OCSCD
Cruz	Yari	YARIBEBE97@aol.com	OCTVS
Curtis	Nicole	angelcole98@yahoo.co.uk	OCVTS
Davidson	Steven	steve@earthgroomers.com	Earth Groomers Landscaping
Davis	Lana	lana.davis_66@yahoo.com	NJDOT
Delgado	Matthew	mateodel13@gmail.com	OCVTS
Devine	Christina	devinechristina@laceyschools.org	OCVTS
DiMatteo	Joseph	jdimatteo@brickmua.com	Brick Utilities
Earl	David	david.earl@dot.nj.gov	New Jersey Department of Transportation Office of Landscape
Espinos	John	Johnespinosiii@gmail.com	OCVTS
Fix	Lauren	lfix13@gmail.com	OCVTS
Graff	Jeff	Jgraff@co.ocean.nj.us	Ocean County Parks and Recreation
Gross	Michael	mgross@georgian.edu	Georgian Court University
Hales	Stan	shales@ocean.edu	Ocean County College, Barnegat Bay Partnership

Harris	Russell	rharris@twp.brick.nj.us	Brick Township Engineering Department
Henderson	Helen	helen@littoralsociety.org	American Littoral Society
Hewitt	Tim	THewitt@co.ocean.nj.us	Ocean County Parks & Recreation
Hoger	Jason	jhoger@co.ocean.nj.us	OCPR
Hopkinson	Cyndie	EVENTS@SOILDISTRICT.ORG	OCSCD
Householder	Victoria	xohottieox09@yahoo.com	OCVTS
Jennings	Kerry	kjennings@soildistrict.org	OCSCD
Johnson	Justin	Justinjohnson123466@gmail.com	OCVTS
Judge	Mary	mjudge@ocean.edu	Ocean County College, Barnegat Bay Partnership
Knezick	Tom	tom@pinelandsnursery.com	Pinelands Nursery
Kondrup	Shari	skondrup@brickmua.com	Brick Township Municipal Utilities Authority
Krumins	Jennifer	kruminsj@mail.montclair.edu	Montclair State University, Dept of Biology and Molec Biology
Lockward	Daniel	daniel.lockward@dep.nj.gov	NJDEP
Lohmeyer	Geoffrey	glohmeyer@co.ocean.nj.us	Ocean County Parks & Recreation
Lurig	Lynette	lynette.lurig@dep.nj.gov	NJDEP
Mangum	Mike	mmangum@co.ocean.nj.us	Ocean County Parks & Recreation
Maxwell-Doyle	Martha	mmdoyle@ocean.edu	Barnegat Bay Partnership
Miller	Eileen	eileen.miller@nj.usda.gov	USDA NRCS
Murphy	Jim	murphy@aesop.rutgers.edu	Rutgers University, Department of Plant Biology and Pathology
Muscio	Cara	cara.m.muscio@gmail.com	
Phillips	James	jphillips76@hotmail.com	Atlantic Highlands
Pirozek	Joseph	jpirozek@co.ocean.nj.us	Ocean County Department of Parks and Recreation
Pollock	William	w.pollock@verizon.net	Ocean County Soil Conservation District
Pullen	Kenneth	kpullen@co.ocean.nj.us	Ocean County Parks & Recreation
Raabe	Christine	craabe@soildistrict.org	Ocean County Soil
Santiago	Nelson	NSantiago@ochd.org	Ocean County Health Department
Schroeder	George	georgewschroeder@gmail.com	Irving Design Group, LLC
Shepperd	Nori	nori.shepperd@dot.state.nj.us	NJDOT Landscape Architecture
Smildzins	Imants	imants@wsbeng.net	WSB engineering group
Smith	Chris	runsunsoil@comcast.net	OCSCD
Sponaugle	Jessica	jessica.sponaugle@dep.nj.gov	NJDEP
Springer	Jay	Jay.Springer@dep.nj.gov	DEP: Bureau of Environmental Analysis, Restoration and Standa
Stiers	Robert	RSTIERS@CO.OCEAN.NJ.US	OCEAN COUNTY ROADS
Sullivan	Dan	DSullivan@co.ocean.nj.us	Ocean County Parks & Recreation
Szulecki	Kim Ann	kszuleck@mail.ocvts.org	Ocean County Vocational Technical School
Taylor	GraceAnne	ambassadorwma13@gmail.com	AmeriCorps Member, NJ Watershed Ambassador Program, Bar
Todd	Erica	critterrun@aol.com	OCVTS
Tomko	Peter	ptomko@ocean.edu	Ocean County College Building & Grounds
Truppa	Julianna	juliannatruppa@yahoo.com	OCVTS
Urban	Michelle	MUrban@co.ocean.nj.us	Jakes Branch County Park
Walzer	Karen	kwalzer@ocean.edu	Barnegat Bay Partnership
Washington	Anthony	anthony.washington@dep.nj.gov	NJDEP Division of Water Quality, Bureau of Nonpoint Pollution
Wengrowski	Ed	ed.wengrowski@njpines.state.nj.us	NJ Pinelands Commission
Wenzel	Britta	bwenzel@savebarengatbay.org	Save Barnegat Bay
Zingis Jr.	Z. John	jzingishome3@verizon.net	Air, Land & Sea Environmental Management Services, Inc.

SHIP – Digging Deeper – Practical Demonstrations to Improve Soil Health

EVALUATION

Name (optional) ____ Date: 10/31/14

Please rate the following aspects of the workshop by checking your response.

	Excellent	Very Good	Good	Fair	Poor
Overall Rating:	☐	☐	☐	☐	☐
Location:	☐	☐	☐	☐	☐
Facility and Comfort:	☐	☐	☐	☐	☐

Part 1: Presentations by the Researchers (Overall Rating)	☐	☐	☐	☐	☐
Dr. James Murphy, Rutgers University "Improvement of Soil Function through De-Compaction and Organic Matter Addition"	☐	☐	☐	☐	☐

Comments:

____

Dr. Jennifer Krumins, Montclair Univ. "Soil Food Web"	☐	☐	☐	☐	☐

Comments:

____

Part 2: Tour of Gardens,

Equipment Demonstration,

Soil Health Assessment (Overall Rating) ☐ ☐ ☐ ☐ ☐

Jason Hoger, OCP&R

Tour of Demonstration Gardens ☐ ☐ ☐ ☐ ☐

Comments:

____

Jeff Lohmeyer, OCP&R

Equipment Demonstration and Tall Pots ☐ ☐ ☐ ☐ ☐

Comments:

____

Chris Smith, Soil Scientist

Basin ☐ ☐ ☐ ☐ ☐

Comments:

____

Eileen Miller, Natural Resources

Conservation Service (NRCS) ☐ ☐ ☐ ☐ ☐

Soil Health Assessment

Comments:

____

Which of the presentations did you find most valuable and why?

How did the workshop provide you with information that will assist you in your job duties and responsibilities?

Did the workshop change the way you think about soil health? Please explain.

What group of people/profession do you think needs to know more about soil health?

What do you think will be the impediments to implementing soil health?

What action items are needed to overcome these?

What additional topics/presentations would you like to be addressed in future workshops? Please list.

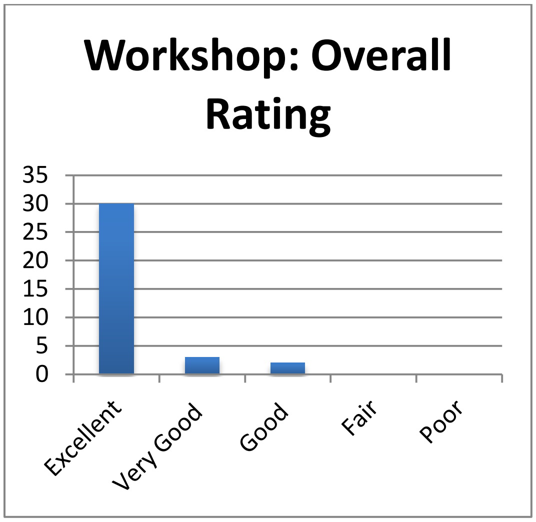
Please provide any additional comments, accolades, questions, etc.

Thank you for your participation in the

SHIP – Digging Deeper: Practical Demonstrations to Improve Soil Health Workshop

Evaluation Summary: SHIP: Digging Deeper – Practical Demonstrations to Improve Soil Health, Workshop, October 31, 2014

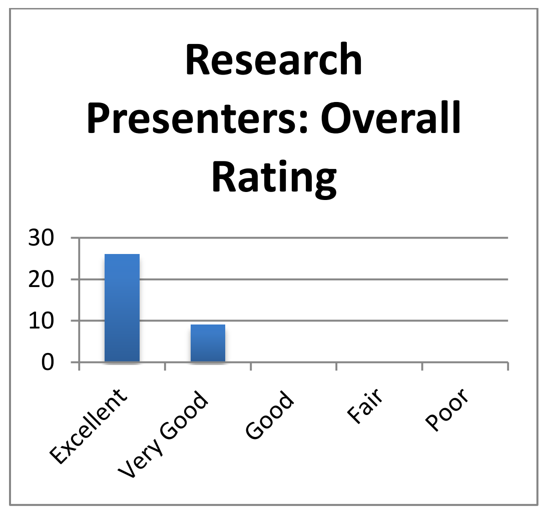
The Ocean County Soil Conservation District collaborated with partners on the delivery of a culminating workshop to share research findings and best practices with constituents. The workshop was attended by 55 participants, of which, 36 submitted an evaluation. Following is a summary of the feedback received.



- 86% of the respondents gave the *Workshop* an overall rating of "Excellent"
- 9% "Very Good"
- 6% "Good"
- No respondents rated the workshop as "Fair" or "Poor"

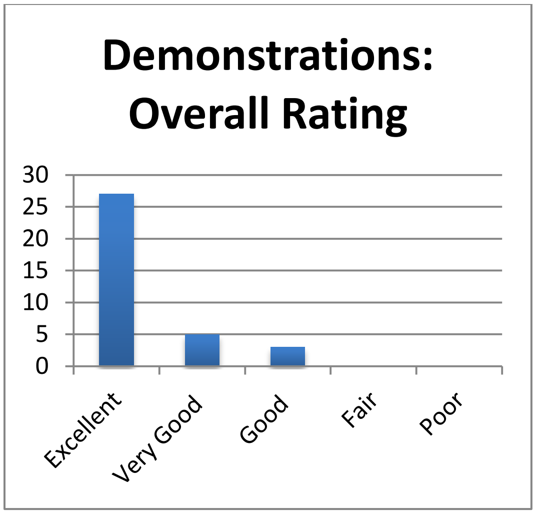
Comments included: *"The entire seminar was extremely informative and well presented"*, *"Great example of interagency collaboration"*.

Dr. James Murphy and Dr. Jennifer Krumins presented their findings on *"Improvement of Soil Function through De-Compaction and Organic Matter Addition"* and *"Soil Food Web"*, respectively.



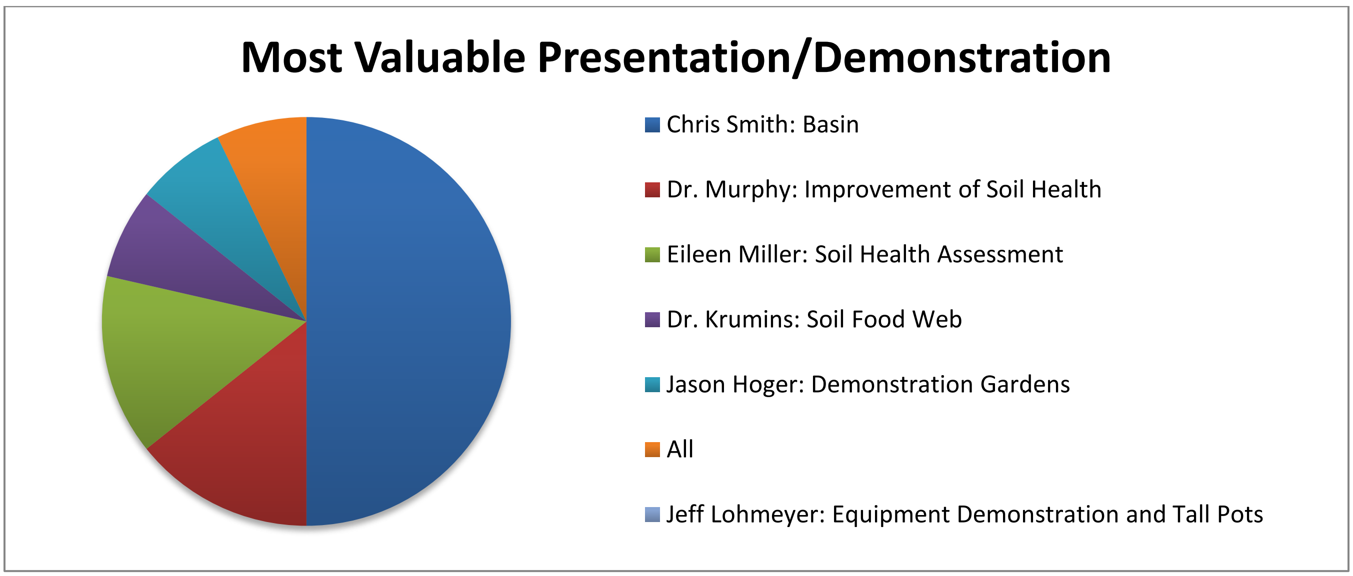
- 74% of the respondents rated the *Research Presentations* as "Excellent"
- 26% "Very Good"
- No respondents rated their presentations as "Good", "Fair" or "Poor"

Comments received included: *"very informative"*, *"great*



Partners presented information on their respective roles within the project: *Jason Hoger: Tour of Demonstration Gardens*, *Jeff Lohmeyer: Equipment Demonstration and Tall Pots*, *Chris Smith: Basins*, *Eileen Miller: Soil Health Assessment*.

- 77% of the respondents rated the *Demonstrations* as "Excellent"
- 14% "Very Good"
- 9% "Good"
- No respondents rated the Demonstrations as "Fair" or "Poor"

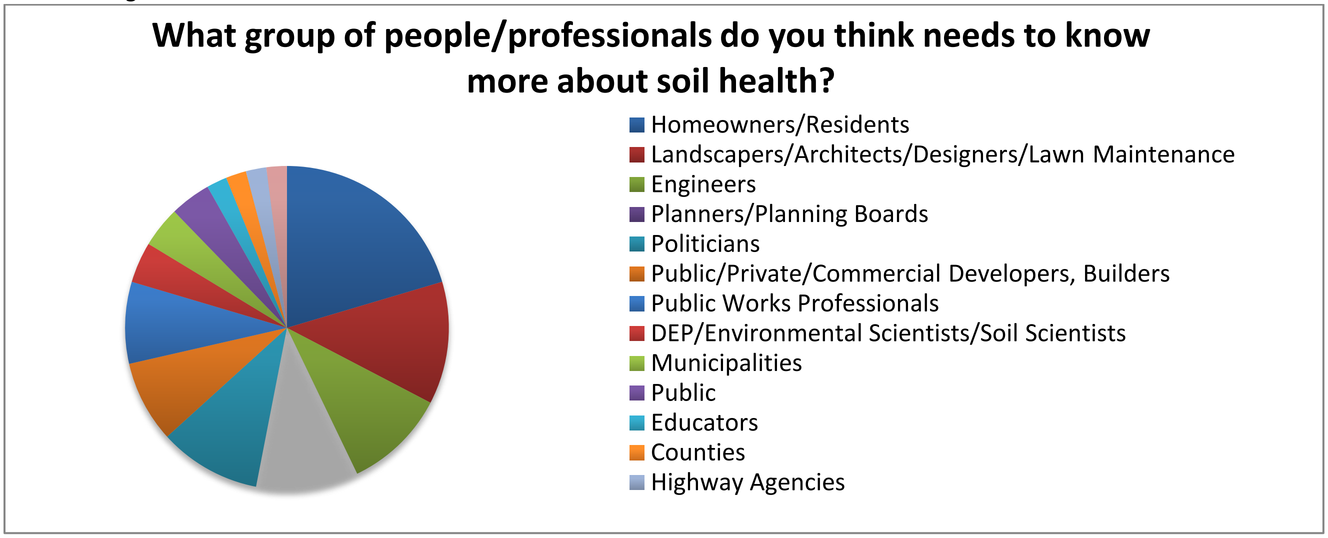


Of the six presentations/demonstrations shared:

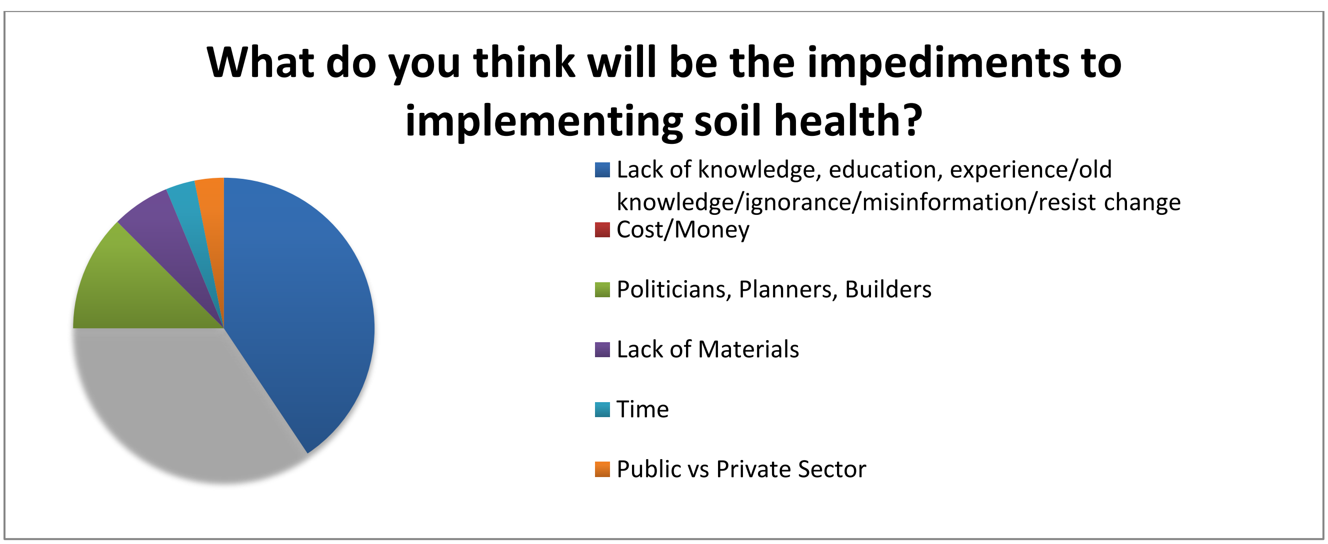
- 50% of respondents rated "Chris Smith: Basin" as the most valuable, with comments including: "excellent and inspiring", "offered cheap options for homeowners", "real world practice", "learned the most".
- 14% of the respondents rated each Dr. James Murphy and Eileen Miller as most valuable. Comments about Dr. Murphy's presentation included: *"well done explaining the results"*, "*achieved maximum benefit for compost/carbon mixtures for soil"*. Comments about Eileen Miller's demonstration included: *"very knowledgeable"*, *"very good demonstration on soil structure and health"*.
- 7% of the respondents rated the presentation/demonstration by each Dr. Jennifer Krumins and Jason Hoger as most valuable. Comments for Dr. Krumins included: *"the right amount of complexity for the topic and audience"*, *"good information on soil ecosystem, good graphics"*,

"you don't really think of soil web information in regards to soil health, provided whole picture". Comments for Jason Hoger included: *"good knowledge"*, *"very helpful with plant materials"*.

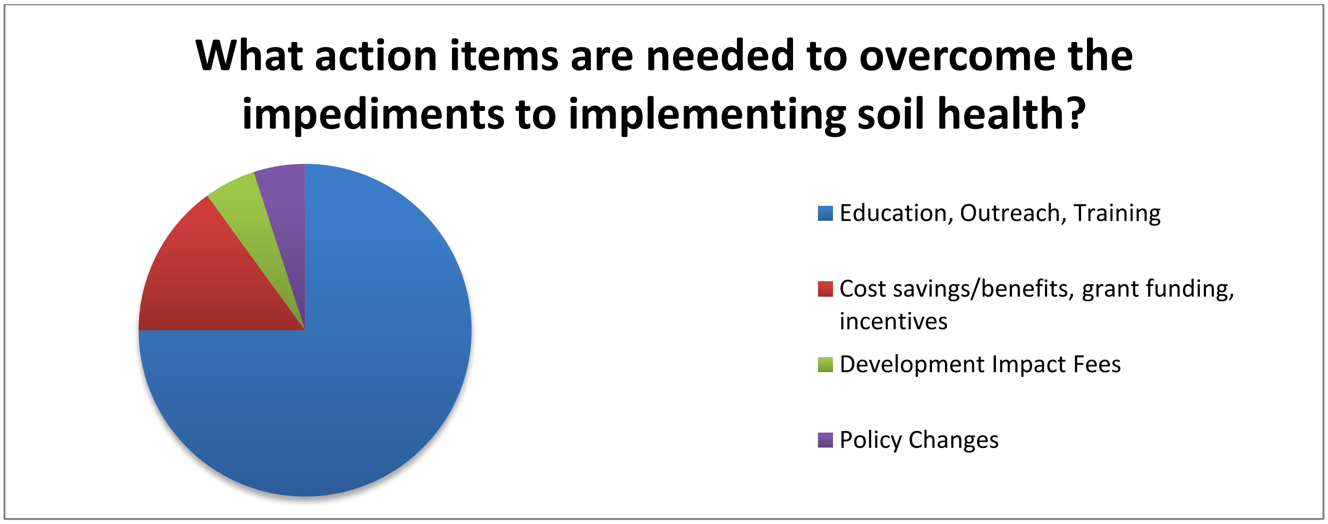
- 7% of the respondents rated ALL of the presentations and demonstrations as most valuable. Comments included: *"They were all interesting and useful. They were interrelated, so all good together."*



- 22% of the respondents think Homeowners/Residents need to know more about soil health.
- 13% think Landscapers/Architects/Designers/Lawn Maintenance workers
- 11% think each Engineers, Planners/Planning Boards, and Politicians
- 9% think each Public/Private Commercial Developers, Builders and Public Works Professionals
- 4% think each DEP/Environmental Scientists/Soil Scientists, Municipalities, and the Public
- 2% think each Educators, Counties, Highway Agencies, and Farmers



- 40% of respondents think Lack of Knowledge, education, experience/ignorance/misinformation/resistance to change will be an impediment to implementing soil health
- 34% think Cost/Money
- 13% think Politicians/Planners/Builders
- 6% think Lack of Materials
- 3% think each Time and Public vs Private Sector



- 75% of respondents think Education/Outreach/Training are needed to overcome impediments to implementing soil health
- 15% think Cost savings/benefits, grant funding, incentives
- 5% think each Development Impact Fees and Policy Changes

Participants were asked: ***"How did the workshop provide you with information that will assist you in your job duties and responsibilities?"*** **Comments included:**

- *"I will be able to educate my facilities about stormwater management on a new level."*
- *"Provide information to education of public"*
- *"Help with retrofitting basins in a watershed"*
- *"Helped with giving examples and outreach"*
- *'Expanded the topic beyond what I was teaching"*
- *"Remediation techniques"*
- *"Can't wait to use the new SHIP webpage as a resource"*
- *"I can now better educate the public on issues and green infrastructure"*
- *"As a regulator, it is important to explain to the community a cause and effect for actions that are harmful to the bay and how they can be fixed."*
- *"Broader/better insights into all aspects of soil health and water quality"*
- *"Connected the dots between soil, water, landscape"*

Participants were asked: ***"Did the workshop change the way you think about soil?"*** **Comments included:**

- *“Yes, and it solidified my views on no-till soil management”*
- *“Yes, there are more components to soil health than just chemistry”*
- *“Yes, I looked at it just as soil”*
- *“Emphasized the importance of getting the message out”*
- *“Yes, it increased my knowledge to take to municipalities I work with individually for soil infrastructure”*
- *“More aware of impacts and remediation”*
- *“Expanded my understanding of it”*

Participants were asked: *“What additional topics would you like to be addressed in future workshops/presentations?”* Comments included:

- *“Intense Basin workshop”*
- *“Retention Basins”*
- *“More concerning the urban and suburban property owners and what they can do”*
- *“Basin workshop”*
- *“How To: Plant, Maintain, Train”*
- *“Funding”*
- *“The engineering of a garden is intimidating, such as a rain garden. A workshop of a more detailed How-To”*
- *“Selection of Native Plants”*
- *“Soil testing - to help grow and maintain native plants!”*

Independent Education/Multimedia consultant Cara Muscio was contracted to perform several tasks in conjunction with the Soil Health Improvement Project at Jakes Branch County Park, funded by the Barnegat Bay Partnership Science and Technical Committee.

The Grant Contract tasks outlined in the revised February 2013 contract were:

1. Collaborate and Assist the **Project Team** in developing and implementing education and workshops to train staff and volunteer educators and community property managers from all BBP partners (including Master Gardeners, Master Composters).

▪ **Project Team** includes: ALS –Judy DiFiglio & Helen Henderson; OCSCD –Christine Raabe & Chuck Collins; Jakes Branch –Jason Hoger; JCNERRS –Lisa Auermuller –leader

2. Coordinate volunteers to assist in plantings and events related to SHIP at Jakes Branch.

3. Document grant activities and create a video/PowerPoint/multimedia presentation focused on ALL of the features related to Soil Health, native landscaping, stormwater management on park property/home landscapes, rain barrels, etc.

4. Conduct 2 Rain Barrel Workshops (for general public to "Make and Take") (Spring & Fall). Create an instructional video to assist in future trainings.

5. Participate in the Native Plant Fair at Jakes Branch with a Rain Barrel demonstration on May 19, 2013.

6. Create and conduct a "**Train the Trainer"** workshop for park staff, volunteers, and other partners to prepare individuals for giving on-site interpretive presentations and educational/programs opportunities about the Jakes Branch Soil Health Improvement Project.

7. Provide Jakes Branch staff with a compendium/resource kit of relevant reference materials for use by staff at the site.

1.Collaborate on Educational Program Development

Contractor attended all meetings and collaborated via email on educational program, materials development, and event planning, including the SHIP panel display and program branding.

2.Coordinate Volunteers

Contractor attempted to coordinate volunteer involvement in the planting of the gardens at the park, however, the timing of activities (mid-summer, mid-day) was not ideal for the senior populations that would be volunteering (primarily Master Gardeners and Barnegat Bay Volunteer Master Naturalists). Later maintenance was coordinated by Parks Staff, and the part-time OCSCD education coordinator.

3. Document Activities/ Educational Video Creation

Rather than simply relying on posting static Power Point presentations, video footage was captured for the various aspects of this project. Primarily footage was captured from the summary events: Native Plant Fair/Jakes Branch Demonstration Day event, as well as the "SHIP –Digging Deeper" workshop for professionals. This footage was edited into a series of short videos to help explain elements of the research, demonstration, and education components of the project. A YouTube page was then created for the Ocean County Soil Conservation District (https://www.youtube.com/channel/UCL7v8bGRyek4_CY354gyISg), including the SHIP logo, and the videos were uploaded in HD widescreen, with all identifying information and tags completed.

<u>A list of the videos generated is as follows: (all are linked on the Soil District's SHIP website)</u>

1. Soil Health Improvement Project Introduction
2. Soil Health Introduction
3. Soil Health Improvement Research
4. Turfgrass Experiment
5. Butterfly/Pollinator Garden
6. Shade Pocket Garden
7. Wet Garden
8. Rain Garden
9. Sun Garden
10. Rain Barrel Demonstration

In addition, the PowerPoint presentations for the Digging Deeper Professional workshop were edited into videos with voice-over from the presenters.
Pending final review, the web pages and videos will all be set from 'private/unlisted' to live, and be available to the public.

4. Rain Barrel Workshops

Two "Bring Your Own Barrel" rain barrel building workshops were held at Jakes Branch County Park in conjunction with the SHIP project. A third was scheduled for Spring of 2014, however was cancelled due to severe weather and low attendance. The first, in April 2013 had 7 attendants, while the second in August had 4. The two-hour workshop presented information on why rain barrels were effective for water conservation and preventing stormwater pollution, and then led each participant through the process of building a rain barrel out of a container they brought to the workshop.
The 10 of 11 anonymous evaluations returned rated the workshop 5 out of 5, where 1 is poor and 5 is excellent. They also unanimously "strongly agreed" (Likert Scale, 1-5, 5 = strongly agree) with statements indicating they would use their rain barrel, and either build more barrels, or teach someone else to build barrels.
Though the groups were small, the personal attention given to each attendant in understanding the process, proficiency with power tools, and care and maintenance concerns left participants feeling confident about their future rain barrel building abilities.
Comments on the workshops:

April 2013

- Great Class!!
- Great informative presentation. Looking forward to more classes.
- Great course –instructors were terrific! Looking forward to future classes.

August 2013

- After years of wanting to make a rain barrel –and attending how-to workshops, this class finally offered both the "how-to" as well as the equipment and tools so that I left with a ready-made product! Thank you! I plan on making more!
- Very well done!

 Excellent Instructor. Hands on Lesson. Very Professionally Presented. Thank you!!

In addition, two demonstration rain barrel building sessions were performed in conjunction with other SHIP events happening at Jakes Branch County Park (2013 Native Plant Fair and 2014 Native Fair/SHIP Demonstration Day). It is estimated that over 40 people attended the two demonstrations, and learned how to build a rain barrel, as well as how rain barrels and rain gardens control stormwater, conserve water, and promote infiltration to benefit their landscapes.

5. Participate in Native Plant Fair, 2013
As stated above, the consultant provided Rain Barrel Demonstrations at both Native Plant Fair events (2013 and 2014), as well as recording summary video of the activities at the 2014 Native Fair/Demo Day and the Digging Deeper workshop.

6. Train the Trainer Workshop
Although the consultant participated in meetings about the event, she did not perform this task. By the time this event had arisen, OCSCD had hired a part-time education coordinator who organized the workshop along with the project lead.

7. Project Compilation/Website
The initial grant proposal included compiling information from the project into a format that was usable by Jakes Branch Staff at the site. This goal was amended to populating the SHIP webpage with all resources about the project to be used by park staff and the public.

The Soil Health Information Project website was initially created (http://www.soildistrict.org/healthy-yards/jakes-branch-ship-project/) and populated by OCSCD staff. A wealth of excellent information was added to this page; however, it was incredibly densely packed and not necessarily targeted to the homeowner audience. A QR code was generated for the SHIP page, for inclusion into the Low Maintenance Guide and the Bayscaping Brochure. Information on the main page was streamlined and broken out into several separate pages for the project, including, the demonstration elements at Jakes Branch, a page on soil health, and a page with technical resources for the project. QR codes were also generated for the garden display signs and each linked to an individual demonstration garden page on the website, featuring photos, presentation, and video links.

A further goal was to amend the demonstration garden maps so that a homeowner could click on the hyperlinked plant name, and be taken to a page with more information about the plant, and photographs. However, the NJ Yards Native Plant database was not yet ready for launch at the completion of the project. At this time, the demonstration garden pages have a link to the Barnegat Bay Partnership Native Plant Brochure, which can be downloaded to view more information about the plants utilized.
All media materials generated by the project (photo, Video, PowerPoint, and Documents) are housed in an online dropbox, and will be provided to OCSCD on DVD as archival materials. SHIP Final Report,

Financial Reporting

The amount of the subcontract was $5000. Project work was billed at $40/hr. Expenses for the rain barrel workshops came out of the grant supply fund, rather than the subcontract. Travel and other miscellaneous expenses were tallied as in-kind donations. Quarterly time sheets were submitted to SHIP grant coordinator, Christine Raabe of Ocean County Soil Conservation District. A summary of quarterly invoices, supply costs, and in-kind donations appears below.

Project Invoices

These totals represent the billed hours for the project.	**Amount**
Quarter	
q1, 2013	360
q2,2013	480
q3, 2013	860
q4, 2013	640
q1, 2014	580
q2, 2014	360
q3 through 10/31, 2014	1720
Total	5000

Write-up on Volunteer Services Offered to Jakes Branch Gardens for SHIP Workshop – Becky Laboy

Jakes Branch County Park is host to 5 Demonstration Gardens, funded by the Soil Health Improvement Project (SHIP). These gardens are designed to showcase healthy soil techniques and best land-use practices for homeowners to observe and replicate in their own yards and gardens. The Sun, Shade, Rain, Wet and Butterfly gardens were implemented in 2012 and were to be a showpiece for the culminating SHIP – Digging Deeper Workshop held on October 31, 2014. In preparation for the workshop, the gardens needed to be weeded and replanted with native plants that did not survive their initial installation, 2 years prior. A call for volunteers was answered by 11 energetic plant enthusiasts from various affiliations, including the Jersey Shore Chapter of the Native Plant Society of New Jersey, Cattus Island County Park, and Americorp Watershed Ambassadors. On Monday, October 18 and Saturday October 20, these 11 volunteers, equipped with gloves, trowels and shovels, began the labor-intensive task of pulling invasive weeds and rouge plants from the beds, as well as replanting 25 native flowering perennials and shrubs. Enormous “thanks” to Ruby Corman, Jordan Foreman, Margery King, Sherri Lareau, Barbara Leaman, Phyllis Long, GraceAnne Taylor, Rich Tomasik, Rita Verneke, and Betty and George Wood. Together, they donated 46 hours of weeding and planting labor, resulting in 5 spectacular, workshop-ready, demonstration gardens to share with the public. When asked about the task, Watershed Ambassador, Ruby Corman, replied, “It was super fun, I love getting out and working in the dirt!” The Ocean County Soil Conservation District loves working in the dirt, too!

VOLUNTEER SERVICE HOURS

Date		Hours	Facility	Task
Ruby Corman - Watershed Ambassador 2014-2015				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Jordan Foreman - Watershed Ambassador 2014-2015				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Margery King - Cattus Island				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Sherri Lareau - JSC-NPSNJ				
	10/18/2014	2	Jakes Branch	SHIP Weeding/Planting
Total:		2		
Barbara Leaman - Cattus Island				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Phyllis Long - Cattus Island				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
GraceAnne Taylor - Watershed Ambassador				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Rich Tomasik - Cattus Island				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		

Rita Verneke - JSC-NPSNJ				
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		4		
Betty Wood - JSC-NPSNJ				
	10/18/2014	2	Jakes Branch	SHIP Weeding/Planting
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		6		
George Wood - JSC-NPSNJ				
	10/18/2014	2	Jakes Branch	SHIP Weeding/Planting
	10/20/2014	4	Jakes Branch	SHIP Weeding/Planting
Total:		6		
Total Service Hours		46	VALUE – $920.00	@$20/hr

Volunteers weeding the Gardens at Jakes Branch in Preparation for Workshop