University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

# Historic Landscape Preservation Master Plan

# Existing Planting Soils Evaluation

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## Introduction:

The University of North Carolina at Chapel Hill is undertaking an Historic Landscape Master Plan for the central portion of the campus. The following soils evaluation was undertaken to determine the limitation that soil may have on planting proposals and to help understand how soil quality has impacted previous plantings.

The Study area is divided into four parts. McCorkle Place at the north end of the original campus, Polk Place, south of Cameron Ave, the Bell Tower formal garden. Kenan Stadium Woods, and the Forest Theater, which is east of the main portion of the campus. Each of the areas will be discussed separately.

The evaluation was undertaken by observing ground conditions and the appearance of existing plantings, limited field probing using a soil auger and bulk density core tool, and interviews with campus grounds managers who are familiar with past soil disturbances and soil management. The observations and soil probing was undertaken on April 7th and 8th, 2008. Representative samples were taken and analyzed at A&L Soil Labs, Richmond, VA. Bulk density samples were processed and calculated at the office of Urban Trees + Soils, Annapolis, Maryland. Soil testing data from several sites in the study area prepared by the Bartlett Tree Expert Co in 2006 and 2007 was also utilized.

## Summary of findings:

The base mineral soil thruought the study area is suitable for long term tree growth with the exception of localized compaction, soil profile discontinuity, the result of previous construction damage and low organic levels. Each of these deficiencies can be resolve as part of the ongoing work and maintenance at the campus. The fine grained nature of many of the soils will require special construction techniques to reduce construction impacts. The critical recommendations are:

1. McCorkle Place and other areas retain significant areas of undisturbed soil, which should be treated as an historic artifact of equal importance to other elements of the original landscape fabric of the campus.

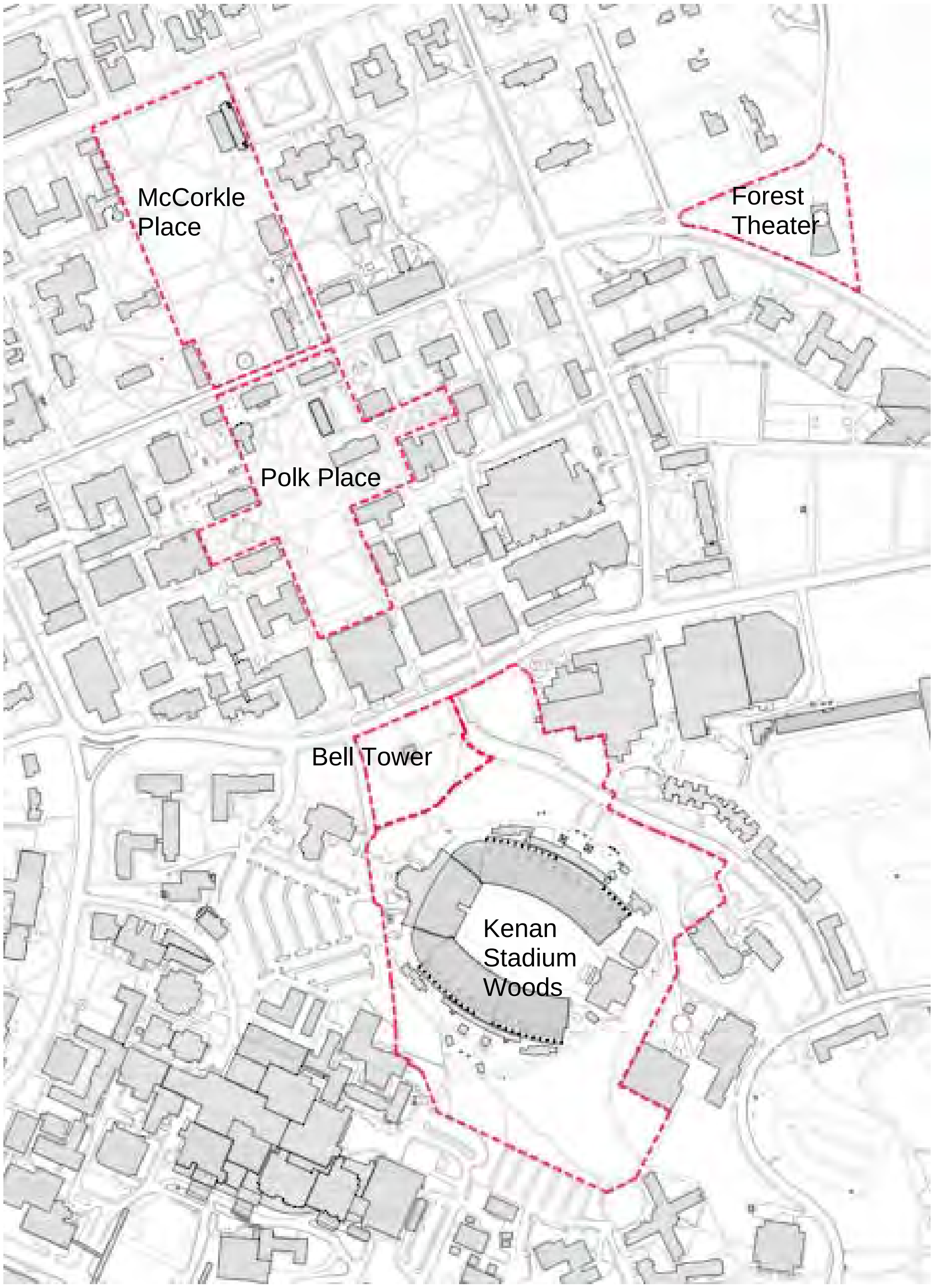
2. Soil preservation and protection is crucial for future tree and plant growth even in areas where there are no existing trees at present. Soil protection and management should be considered separately from other parts of the design and construction process. It should not be linked to tree preservation recommendations, which only look at the existing root system of the trees.

3. All design projects should include a project specific soils analysis prior to the start of detailed design. The design process should respect the findings of this analysis.

4. The stopping of forest succession by the removal or loss of seedling succession trees contributes to the ultimate decline of the forest and may be a significant factor in the decline of Kenan Stadium Woods.

**Limits of the study area:**

The following drawing outlines the limits of the master plan study area.




**Limits of the master plan study area.**

**Soil Overview:**
The current USDA soil designation of McCorkle place, Polk place and the Bell Tower is urban land or soil that is so disturbed that it was not mapped. Kenan Stadium Woods and the Forest Theater are mapped as Appling Series. The original soils of the disturbed soil portions of campus were most likely extensions of the Appling Series that surround the campus. While McCorkle place is not mapped, the soil profile under the Davey Poplar is similar to the Appling series. The Davey poplar is the oldest tree in this space and predates the founding of the University. For this reason is reasonable to assume that the majority of soils in the disturbed portions of the campus originated from various layers of the Appling profile. This profile is described as follows.

Soil profile to 36 inches similar to the Appling Series near the Davy Poplar

***Appling Series profile:***
Ap--0 to 6 inches; brown (10YR 5/3) sandy loam; weak medium granular structure; very friable; common medium pores: common fine roots; about 10 percent angular quartz gravel; slightly acid; clear smooth boundary. (5 to 12 inches thick)

| pH- | O.M. | Permeability | Shrink-Swell |
|---|---|---|---|
| 4.5-6.5 | .5-2. | 2.0- 6.0 in/hr | LOW |

E--6 to 9 inches: light yellowish brown (10YR 6/4) sandy loam; weak medium granular structure; very friable; common medium pores; common fine roots; about 5 percent angular quartz gravel; slightly acid; clear smooth boundary. (0 to 5 inches thick)

| pH- | O.M. | Permeability | Shrink-Swell |
|---|---|---|---|
| 4.5-6.5 | .5-2. | 0.6- 2.0 in/hr | LOW |

BE--9 to 12 inches; yellowish brown (10YR 5/6) sandy clay loam; weak medium subangular blocky structure; friable; few fine roots; few fine flakes of mica; strongly acid; gradual smooth boundary. (0 to 7 inches thick)

| pH- | O.M. | Permeability | Shrink-Swell |
|---|---|---|---|
| 4.5-6.5 | .5-2. | 0.6- 2.0 in/hr | LOW |

Bt--12 to 48 inches; strong brown (7.5YR 5/6) clay; common medium distinct yellowish brown (10YR 5/6) and prominent red (2.5YR 4/8) mottles; moderate medium subangular blocky structure; firm; sticky and plastic; few fine and medium roots; few distinct clay films on faces of peds; few fine flakes of mica; strongly acid; gradual wavy boundary. (Combined thickness of the Bt horizon is 24 to 50 inches)

| pH- | O.M. | Permeability | Shrink-Swell |
|---|---|---|---|
| 4.5-5.5 | .5-2. | 0.6- 2.0 in/hr | LOW |

BC--48 to 53 inches; mottled red (2.5YR 4/8) and brownish yellow (10YR 6/8) sandy clay loam; weak medium subangular blocky structure; friable; slightly sticky and slightly plastic; few fine and medium roots; few bodies of saprolite; common fine flakes of mica; strongly acid; gradual wavy boundary. (0 to 30 inches)

| pH- | O.M. | Permeability | Shrink-Swell |
|---|---|---|---|
| 4.5-5.5 | .5-2. | 0.6- 2.0 in/hr | LOW |

C--53 to 80 inches; reddish yellow (7.5YR 7/6), red (2.5YR 4/8), and yellow (10YR 8/6) sandy clay loam that weathered from saprolite; massive; friable; common fine flakes of mica; very strongly acid.

The colors of the various horizons in this profile can be used as a guide to determine the depth of cut or type of fill that is encountered. During the soil probing exercise, sub soils of either yellow brown or reddish yellow to orange soils were encountered.

These soils become more acidic, clayey and slower draining with depth, while organic matter decreases with depth. Remnant undisturbed soil horizons when encountered, even red and orange subsoils should still drain sufficiently for adequate plant growth if not compacted. All of the soils in this profile can be improved to support plants by increasing organic matter and reducing compaction, however, the higher the level in the profile any soil originates, the better the expectations for plant growth.

Small areas of soils from other locations or from very deep in the Appling soil profile should be expected to be encountered due to the significant amounts of construction in the study area over the history of the campus. The most disturbed soils are likely in Polk Place due to the newer buildings and the extensive utility work in this zone.

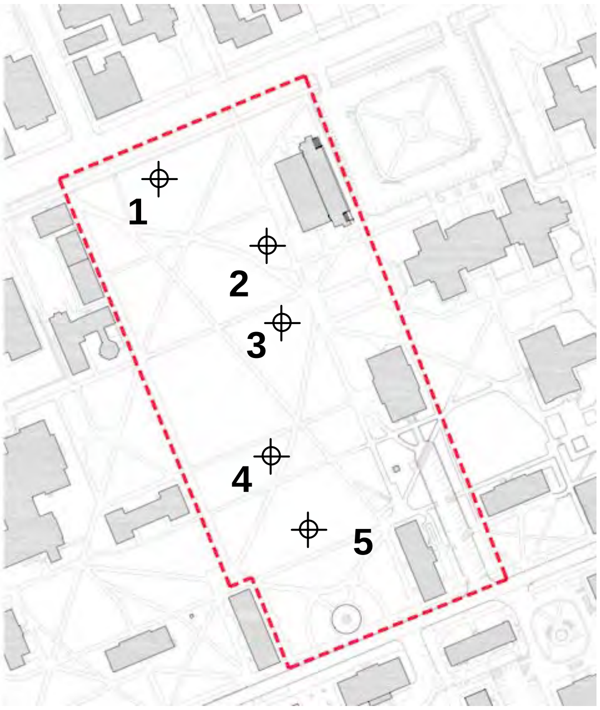
**McCorkle Place**

***Description:*** This site has significant areas of original and remnant soil. The soils in the larges areas of this quad are only slightly impacted by grading. The topography is undulating and the many large and historic trees have protected the ground from utility intrusion and other development work. The buildings that edge this space are smaller and older structures that likely had limited impact on soil during their construction. Limited areas of disturbed and compacted soils were observed related to previous construction. Plants are uniformly growing well with many large mature trees.

Compaction does not appear to be a serious problem. Even the south end of the space where there is frequent picks up games and student gatherings was still just under root limiting in the upper soil profile with less compaction below that elevation.

***Soil observations and testing***: Five test holes were dug in the area of McCorkle Place. 5 soil samples were kept from three of the test pits and two bulk density cores were extracted. Several other test holes were dug but not recorded as they were similar to nearby recorded holes and served to verify that the recorded information was taken at a typical site.

The test holes were made at the sites indicated on the following map.




McCorkle Place test hole locations

Test hole #1
Profile:

Lawn
A horizon 1-5-inch. Sandy loam topsoil, well drained

B horizon 5-12 inches. Sandy Loam, soft, wet with perched water on top of hard C 1 layer

C 1 horizon 12-22 inches. Sandy clay loam, hard, stiff layer that is drier. light color

C 2 horizon 22-27 inches. Sandy clay loam, Firmer and lighter

Soil likely to be an original soil profile

Testing data:
Bulk density B horizon 1.44 gr/cm3 (1.6 gr/cm3 beginning of root limiting bulk density in this soil texture).

B and C horizons tested separately for chemical and physical properties. See attached A&L report.

<u>Test Hole #2</u>
Profile

Lawn
A horizon 1-2 inch loam topsoil/sod

C1 horizon 12-9 inch clay, firm

C2 horizon 9-24 inch clay, dryer, hard

Compaction at or near root limiting levels, few roots in the C horizons. Soil horizon disturbed by previous construction.

Testing data:
C horizons tested for chemical and physical properties. See attached A&L report.

<u>Test Hole #3</u>

Profile similar to hole #2 with the exception of a deeper (9 inch) A horizon topsoil. This is a disturbed soil profile from construction of the nearby memorial.

<u>Test Hole #4</u>
Profile

Lawn
A horizon 1-6 inch Sandy Loam topsoil

B horizon 7-14 inch Sandy loam, wet soils on top of C 1 horizon

C1 horizon 15-26 inch Sandy clay loam moist but less wet that the lower portion of B above.

C2 horizon 27-36 inch Sandy clay loam, less wet than C 1

This soil profile was taken within the drip line of the Davy poplar, and is likely an undisturbed soil profile similar to the description of the Appling series soil description.  Living root tissue encountered at all levels of the profile.

Testing data:
B and C horizons tested for chemical  and physical properties.  See attached A&L report.

Test hole # 5
Profile similar to test hole #4

This location is a favorite student gathering place and used for frequent informal games. Compaction management of lawn has been a problem for grounds management team. A bulk density sample taken in H horizon soil. Test indicated a bulk density of 1.59 gr/cm3, which is just at the beginning of root limiting compaction for this soil type.

***Recommendations:*** The soil in the majority of this space is native relatively undisturbed profiles. This condition is relatively unique in a modern large university and **this resource should be protected and treated with the same care that is given to other historic artifacts on the campus**. All new work in this space should be undertaken with preservation of the soil resource as a high priority. This is not just a tree preservation issue, but an attempt to save the existing soil profile simply to preserve this resource.

Some areas of compaction can be identified but none seem to be significantly impacting long term tree performance due to the ability of the tree roots to access deep usable remnant soils. Areas of soils damaged by construction are limited and likely identifiable by observing lawn conditions during summer drought periods where areas of disturbed and compacted soils will brown out earlier than undisturbed soils. These areas should be recorded and monitored.

Existing conditions remediation: No changes to the soil are recommended. Surface core aeration to alleviate surface compaction as a part of the normal lawn maintenance should be sufficient. Compaction levels in areas of heavy use should be monitored and air spade root invigoration (see appendix) should be considered if compaction increases above root limiting levels.

The University should consider adopting organic soil maintenance practices in this area. A significant part of any soil is its soil food web (see appendix). This collection of microbes and insects are significantly damaged by fertilizers and other lawn treatments. Techniques that incorporate testing of soil biology levels, using compost teas (see appendix) and organic, low impact fertilizers, and management techniques that restrict use or rotates use around the area to allow the resting of soil should be developed for this space.

Any time fertilizer is added to this soil, it should be "organic" fertilizer and applied only after the results of soil testing indicate the nature and types of deficiencies and only after other less damaging techniques have been tried to correct the plant quality. Dosages should be the minimum anticipated to achieve the expected results of plant quality. Lawn fertilizer rates should accept some minimum amount of turf dieback as a trade off for preserving or protecting the soil's food web. An organic IPM program should be developed to reduce the application of fungicides, and other chemical controls of lawn pest. A person skilled in the development of organic plant management should be consulted to develop this plan.

New construction: Any new construction in this area should be preceded by a detailed soil evaluation and the development of a soil preservation and management plan. New projects should avoid undisturbed soil profiles. Where soil must be disturbed, each horizon should be removed, stored separately and reinstalled in the proper order. Installation techniques that avoid over compaction and damage to the soil food web should be employed.

In locations where the soil does not have to be graded but may be subjected to compaction during construction activity, it should be protected for compacting forces by the use of geogrid matting under a minimum of 6 inches of mulch. When larger equipment is needed, an additional protective matting of Alturnamats (see appendix) or heavier wooden matting depending on the type of equipment used, should be added over the geogrid/mulch mat. Note that these are soil protection requirements and not tree protection. They apply to all areas where undisturbed soil profiles exist.

Following construction, compost teas should be utilized in conjunction with biological soil testing to reinvigorated the soil food web in all soils within the construction zones.

New planting: In areas where the soil profile is not disturbed or compacted new plantings should be installed in a hole slightly larger than the root package of the plant. Over digging the hole is not required.

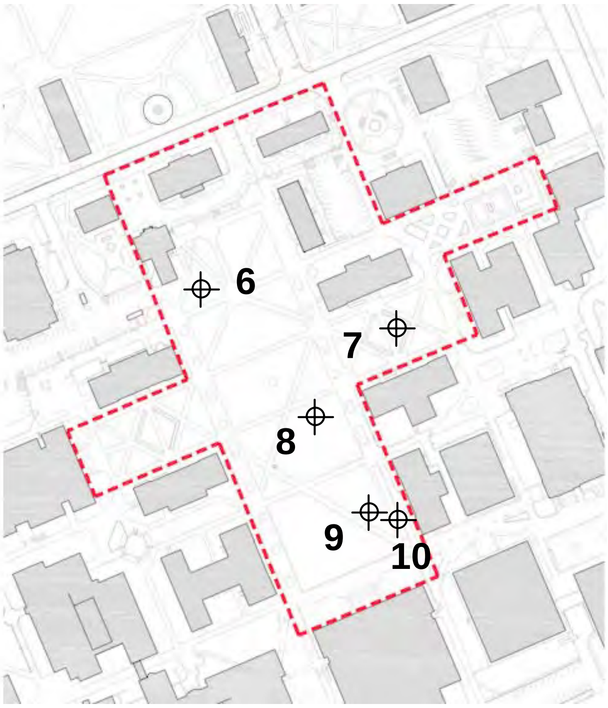
In areas where the soil retains its original profile but has been compacted, surface tilling of the entire planting bed may be warranted. For plantings outside the critical root zone of any existing tree, add 3 inch of compost and lightly surface till the compacted top 6 inches over the entire compacted zone. For plantings within the critical root zone of an existing tree, use of an airspade to loosen the soil and incorporate the compost is recommended.

In areas of new planting within disturbed and compacted B horizon soils outside the critical root zone of a tree, deep tilling of up to 6 inches of compost into the top 18-24 inches of the soil profile is recommended. Deep tilling may be undertaken with a backhoe subsoiling (see appendix).

**Polk Place**

***Description:*** The soils in the Polk Place Quadrangle are highly disturbed. Many of the buildings, site work projects and utility development of this space occurred after the time when large construction equipment was available and there has been significant soil disturbance. Mass grading, utiliies and building work has graded and compacted the soil. Multiple human constructed soil horizons and sharp, distinct soil horizon were observed. Remnant soil horizons including buried topsoil layers are found thruought the space. The soil quality appears to get worse the further south and west in the space. This is reflected in the tree growth and decline.

Soil compaction of differing amounts and different from horizon to horizon was encountered indicating fill and disturbed conditions. Compact was noted in many locations in the Bartlett compaction study as a significant impact on tree health.



Polk Place Test Hole locations

There is a strong relationship between the ages of the various buildings that front onto the quad and the health of the trees near these buildings. The older the building, the healthier the trees. This is particularly evident in the south west portion of the quad where buildings were constructed after 1940. Trees near recent utility work are also in decline

***Soil observations and testing***: Five test holes were dug and observed. Polk Place was the subject of extensive soil testing in May 2006 by the Bartlett Tree Expert Co. Chemical and bulk density testing was undertaken at that time. For this reason only one subsoil soil sample was collected from this part of the study area. A summary of the Bartlett soil testing is included.

Test Hole #6
Profile

Mulch
1-5 inches A1 horizon Sandy Loam

6-15 inches B1 horizon Sandy loam

Brick fragment encountered at about 12 inches

16 26 inches A2 horizon Sandy loam, buried remnant organic layer

27-34 inches B2 horizon Sandy loam

34 inches and deeper C1 horizon Sandy clay loam

This profile is a disturbed soil profile with fill placed over the remnant original soil. The sample was taken under the canopy of a large existing tree. The soil bulk density did not appear to be root limiting.

<u>Test hole # 7</u>
Profile

Lawn
1-5 inches A horizon loamy soil

6-10 inches B/C horizon Clay loam soil

11 inches down C horizon Clay soil

Oak root encountered

This soil is likely a disturbed soil with the A and A/B horizon added on top of the clay subsoil. The C horizon subsoil was not root limiting and likely was undisturbed.

<u>Test hole 8</u>
Profile

Lawn
1-6 inches A1 horizon brown loamy topsoil likely imported fill
7-24 inches C1 horizon yellow red clay loam
24-30 inches A2 horizon brown loamy topsoil possibly remnant original topsoil

Soil not photographed

This soil appears to be a disturbed fill soil over a remnant undisturbed A2 soil.

Test hole # 9
Profile

Soil profile similar to test hole # 8 except soil horizons are thinner and more compacted

Soil not photographed

Test hole # 10
Profile

Soil profile similar to the A2 and B2 layers of test hole # 7

Soil may be an undisturbed soil with moderate compaction.

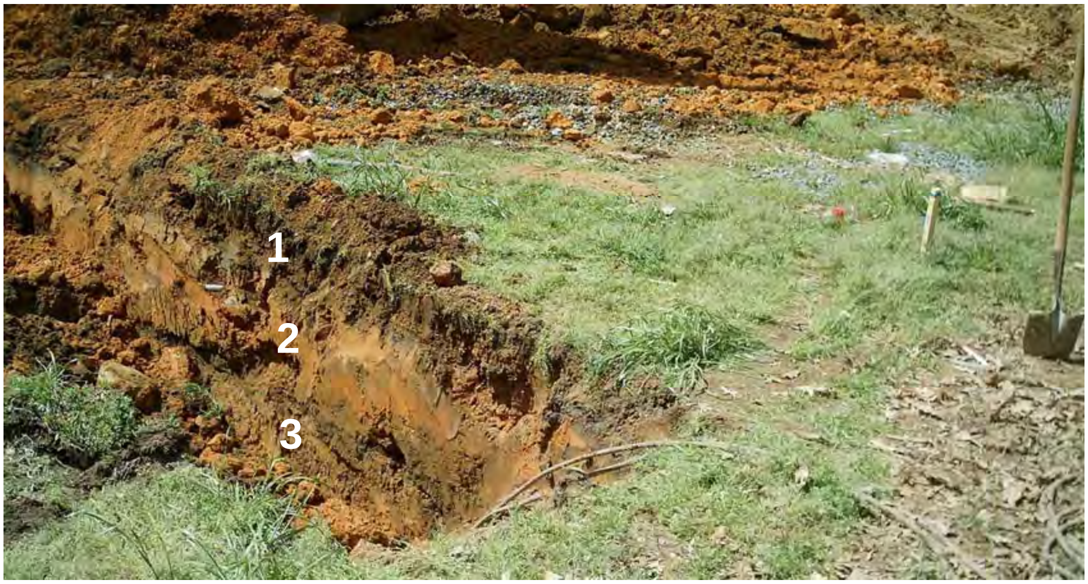
Soil not photographed

Bartlett Tree Expert Report Summary:

The May 2006 Bartlett Tree Expert Co report, "Polk Place Tree Preservation: Soil Density Assessment"  examines soil compaction at Polk Place and included significant numbers of bulk density samples,  The report was able to reference a significant number of chemical properties soil test made during the companies previous work at the campus.  This report is included in the appendix of this document.  The basic finding of the report is that soil outside the drip lines of large trees is compacted above root limiting levels, soil near or just inside the drip lines of trees is moderately compacted while soil within the areas of mulch immediately around the base of the trees was acceptably low.

Ongoing Soil Disturbance:
The landscape and soils of Polk Place is being further disturbed as this study is being prepared.  The work underscores the need for reform of soil practices and offers a glimpse of the existing soils and how the soils might respond to future construction.

The current soil protection is based solely on existing tree preservation.  Any soil outside the area of existing trees appears to be fair game for disturbance and no protection of existing soil is being provided.  A trench (see photograph) that was observed being dug showed that a large amount of remnant soil underlies the top surface of fill soils.  Even the top surface soils are reasonably useful with good ped structure and drainage.  Once this soil is disturbed, drainage is greatly reduced and ped structure is lost.  Soils are also contaminated with building material.  Repair of these degraded conditions is difficult and expensive.




**Trench at west side of Polk Place: 1. imported topsoil layer; 2. imported subsoil layer; 3. remnant original topsoil and subsoil layer.**


**Active soil disturbance**

1. **Damaged soil ped structure leads to....**
2. **Compacted soil with all structure lost resulting in ......**
3. **Poor drainage.**
4. **Soils contaminated with stone and rubble.**

***Recommendations:***

Existing conditions remediation: The Bartlett Report found significant compaction in the areas outside the drip lines of the large trees and moderate amounts of compaction in the turf areas at or within the drip lines of trees. The soil in mulched areas at the base of the trees was acceptable. The report recommended root invigoration within the limited areas around the tree, typically a radius of five times the trunk diameter. Root invigoration uses an air spade to incorporate organic matter and fertilizer into this zone while reducing compaction. Additional fertilizer treatments were also recommended based on soil testing results. These recommendations are appropriate and the campus has begun to implement these recommendations.

Given the extreme soil difference from place to place within the Polk Place quadrangle, it is difficult to make any specific recommendations for changes to the existing conditions beyond continuing the management strategies already in place. Several alternative strategies, however deserve further discussion.

There are many events scheduled for this quadrangle particularly associated with football games. The university has a planning strategy to limit impacts from these events by limiting the places where events can be staged and fencing off the areas where no event facilities any be placed. This strategy is aimed at preserving existing trees but fails to address larger soil compaction issues in the entire space. The current plan is partially responsible for the severe compaction on the turf areas outside the protected zones. Assuming that the final master plan incorporate large trees back into the southern end of the quad, a broader soil remediation and protection plan is needed.

An alternative to zoning the quad would be to treat the entire quad as a soil protection zone and develop strategies that can be implemented in a cost effective way to protect the soil of the entire quad from compaction. This would include the use of geogrid and geotextile mats that could be purchased once and reused for each event. This material is relatively easy to install on a temporary basis and could cover the entire area of the quad. This matting would then be reinforced with alturnamats in the areas of the most

**Alturnamats protecting soil**

intense use such as tents and main walking spaces. The alturnamats are light enough and easy enough to install to be practical for repeated use.

Once a workable plan is developed, further soil remediation can be considered to improve the soil across the entire quadrangle. A minimum of three different strategies must be developed. The area within the critical root zone of the existing trees, areas beyond the existing tree critical root zones, where soil is clearly disturbed by compaction of past construction, and areas where the soil may not require remediation. The development of this plan would need significant additional soil investigation and discussion with the University, but it should be possible to develop soil strategies that allow for most of the quadrangle to be used for events while supporting long lived trees and turf in the same space.

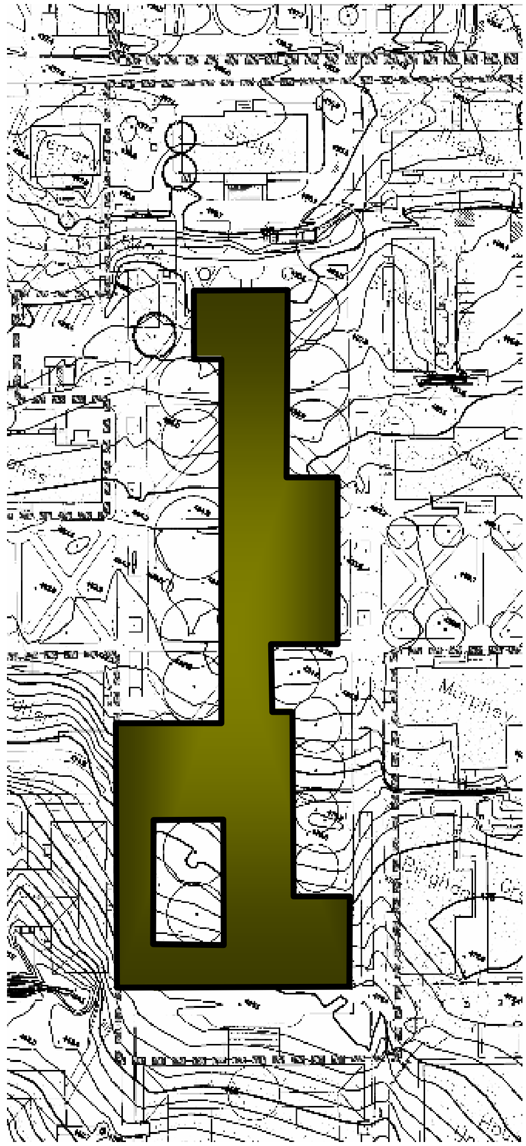
New construction: All new construction should start with a detailed soil report and soil plan. It should not be assumed that all the soil is bad nor is good. Soil in this area are quite varied and the fact that very large trees have been grown in most of the quad supports the notion that the underlying subsoils are supporting tree rooting. New construction must recognize that many areas of the Quad, the trees have out performed trees in seemingly better situation. Future soil management and design decisions need to assure that the soil resources that contributed to that performance are not damaged. To be successful careful soil analysis must be undertaken and the design must account for the information gained from that analysis.

Where usable soil and subsoils are encountered, they should be preserved in place using soil preservation techniques discussed for McCorkle Place. Where soils are not usable in place or must be disturbed, the underlying clay and sandy clay loam soil should be considered for reuse with added organic matter. Reuse of these soils most likely offers the most environmentally sustainable option and likely the best option for plant growth medium. The one exception to this is the soil medium for lawns where the clay soils will not provide satisfactory compaction resistance in heavily used areas. Here the addition of expanded shale may offer a good option for healthy, compaction resistant lawns.

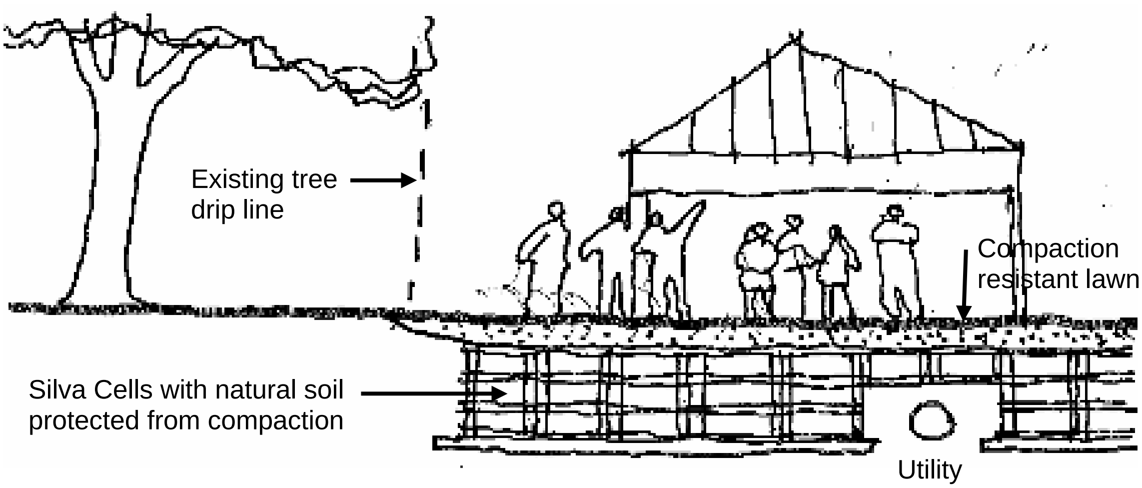
New planting: When new plantings are proposed for areas that are in compacted subsoils, absent the opportunity for large scale soil remediation, the planting holes should be dug as large as possible with the existing soil removed from the planting hole, mixed with composted pine fines and used as backfill around the tree. Plant root balls should generally be set high in these soils to improve drainage immediately around the root ball during establishment.

Silva Cells can be incorporated to expand soil volumes under paved areas and to bridge between usable soil volumes separated by walks and other structures.

<u>Tree / event conflict:</u> The quad may benefit from developing a new soils direction that permits the quad to be used for intensive activities while maintaining good lawn quality and develop long term healthy trees. It is possible through the use of a newly developed structural support system called Silva Cells to have a very compaction resistant lawn soil over the top of a natural profile of native soil that supports large tree growth. The natural soil within the Silva Cells would have low levels of compaction and be protected from further compaction by the Silva Cell. The details of such an approach need to respect the existing utility network. The Silva Cell system could also be extended under walks and in areas where the subsoils are compacted above root limiting levels. In areas where the trees are growing well, making changes to the soil is not recommended.



**Area to consider creation of impact resistant lawn soil over Silva Cell tree**

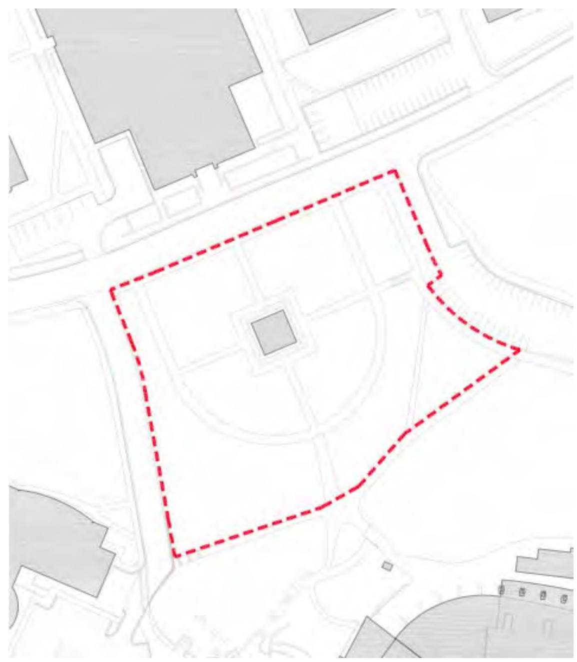



**Silva Cell under lawn soil**

**Bell Tower Formal Garden**

***Description:*** The soils around the Bell Tower within the formal garden are disturbed soils, which are supporting the boxwood and lawn planting in reasonable condition. The few places where the boxwood are not growing well in the interior of the space are likely due to damage during events and other activities. One section of box along the southern portion of the outer edge of the planting seems to be declining due to differences in soil. Should this row of box be retained, soil improvement for these plants would be recommended to make the soil in this area similar to the adjacent soils.

***Soil observations and testing*****:** Several test pits were dug to confirm drainage. Given the past good plant performance and limited changes being considered for this area, testing of the soil was not undertaken. The soil associated with the boxwood has been tested as part of the ongoing management of this space and nutrient management has been satisfactory.



**Bell Tower Formal garden**

***Recommendations:***

<u>Existing conditions remediation</u>: Should the outer row of box be retained, minor changes to soil should be made in the south edge of this planting. Box should be removed and the soil changed to match the texture of the adjacent soils. This area is quite limited in area. No other changes are recommended

New construction: Preserve and protect the existing soil profile from disturbance and compaction during any construction in this area.

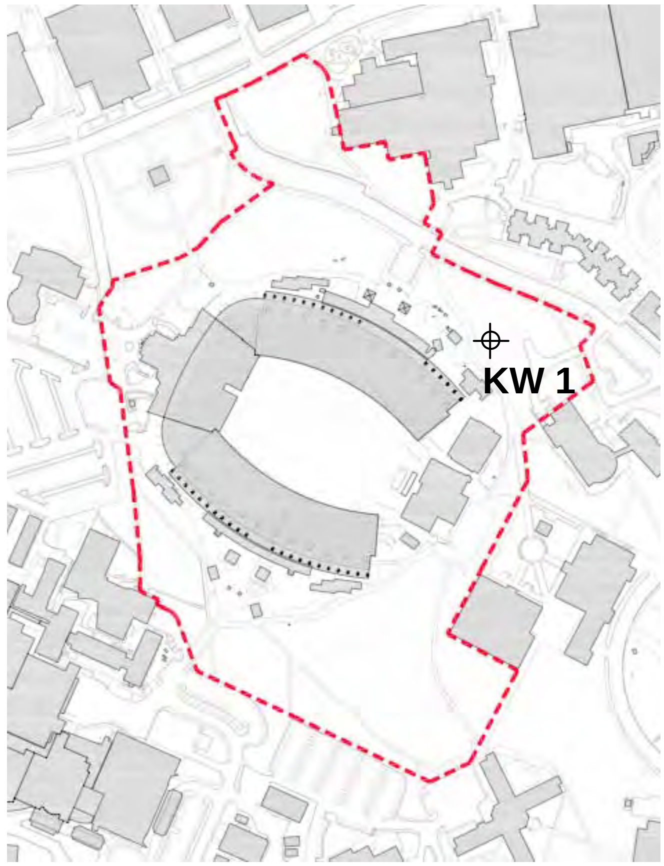
New planting: Dig oversized plantings hole 2-3 times the width of the root ball or make linear bed modifications for any replanting of boxwood. In areas immediately around the Bell Tower formal garden that is proposed for reforestation, break up soil compaction with backhoe subsoiling (see appendix) to depths of at least 24 inches and add at least 6 inches of organic matter tilled into the top 6 inches of the existing A horizon, over the entire reforestation area before planting. Install reforestation plantings in minimum sized plantings holes after the bed treatments.

## Kenan Stadium Woods

***Description:***
Kenan Stadium Woods is a large forested area surrounding the stadium. The grades within the forest are generally original topography particularly on the north side of the stadium but there has been considerable soil disturbance thruought the area. These disturbances include compaction, grading and utility cuts.

On the North side of the stadium there are two sections of woods bisected with a diagonal walk. On the south side of this walk there has been minimum amounts of disturbance. While the north side has been impacted by utility work, grading and compaction from event use associated with football games.

On the south side of the stadium the soil disturbance has been much greater with considerable grading and associated with walks and roads. Surface compaction is pervasive. Once past the southeast corner of the stadium the soil conditions to the south improve dramatically. On the east and west ends of the stadium, all soil is disturbed with considerable grading, steep slopes, erosion, paving and compaction.




**Kenan Stadium Woods**

**Declining forest with crusted soil and no seedling trees.**

**Healthy forest with leaf duff and seedling trees.**

This amount of surface compaction is not great enough in this soil texture to be the sole reason for tree decline. While compaction may be a part of the problem with the declining forest, other issues such as erosion, surface crusting which slows infiltration, loss of leaf duff, other soil disturbances, and other tree stress vectors also are likely contributing to the decline of the trees.

In the declining forested areas young under story trees particularly seedling succession trees are not present. It is likely that in these declining forest areas, the large trees are not so much in decline as the natural succession of the forest has been stopped. Older trees, in competition for canopy and light continue to go through natural decline processes but are not being replaced. This is evident in the two images above. This decline is then accelerated by other factors of soil and abusive use of the space. Restarting the succession process is critical to the future success of these forested areas.

***Soil observations and testing:***
The soil situation within Kenan Woods is extremely complex. Detailed analysis will be needed specific to each project and is beyond the scope of this overview. A number of unrecorded soil probes were made to gauge the general state of the soil, which provided information for the previous description. One compaction test sample was taken in a location where the soil appeared to be heavily compacted. This will serve as reference sample for future investigations.

Compaction sample KW 1 - Area of previous intense use and surface compaction. Upper soil profile retained its original B and C horizons. The A horizon was eroded. Forest in a declining state

Bulk density 1.56 gr/cm3, This is only slightly below the beginning of root limiting density for loam soil.

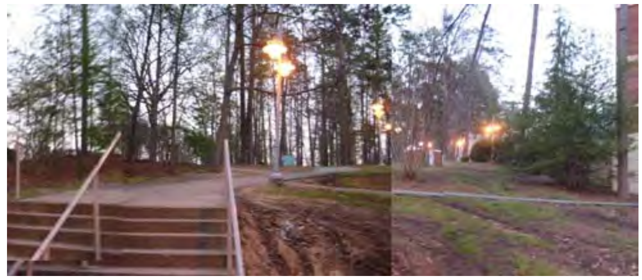
***Recommendations:***

<u>Existing conditions remediation</u>: It is important to stabilize the soils that have lost leaf duff and have active surface soil crusting, and erosion. Applications of 4 inches of mulch combined with surface scarification or light tilling (top 1-2 inches) to reduce surface crusting is critical in areas of bare earth. Restricting access to the forested areas by fencing and improved walk configurations is needed. Changing lawn areas on the south side of the stadium to mulch should be considered.


**Surface erosion, crusting and compaction**

In the areas where the greatest amount of compaction and surface crusting accompanies significant tree decline large scale soil invigoration combined with fences to restrict pedestrian and vehicular traffic must be considered.

In areas of steep slopes and severe erosion use of stabilizing jute blankets in conjunction with the surface scarification, adding new topsoil and mulching may be required.



**Erosion on steep bank**

At the south edge of the woods, an area of soil has been impacted by adjacent construction. Sediment and gravel has filled over the existing soil. This must be removed, the soil scarified and mulched. Airspade soil invigoration and sediment removal techniques may be appropriate to improve this area.

**Construction damage**

New construction: All new construction design efforts must be preceded by a detailed soil analysis to determine the appropriate approach to preserving and restoring soil. Designs and construction details must be developed with the least horizontal and vertical foot print possible while accomplishing the use goals. Walks must be made wide enough to handle peak loads with limited amounts of pedestrian overflow onto soil areas. Fencing, walls, curbs and other barriers need to be considered to guide pedestrians to avoid short cutting into wooded areas. Facilities related to game events should be in designated contained areas.

Any proposed walls or structures with in the forest should be designed with low impact profiles that have small or no footings to reduce both soil disruption and tree root damage. All grading and work should include protection of adjacent undisturbed soils using mulch and alturnamats.

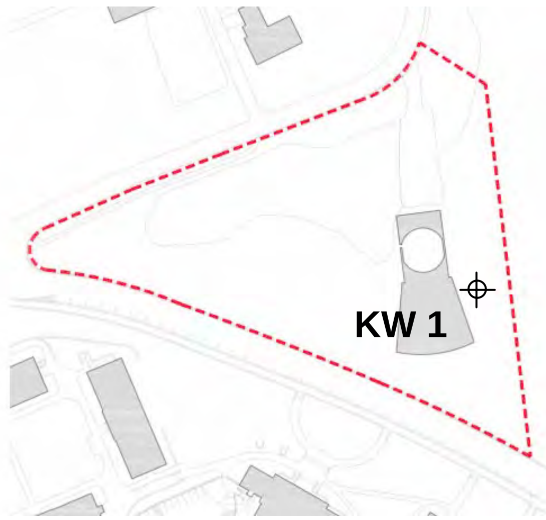
New planting: any planting within the forest area should be specified with the smallest size planting hole to reduce root damage to the existing tree roots. Ground cover plantings should be installed into soils that have been subjected to airspade soil invigoration to a depth of 6-9 inches immediately prior to the planting. Plants must be places between roots.

Forest succession: Restart forest success in areas of declining forest, and develop management plans to foster sound succession processes in the entire area of the Kenan Stadium Woods.

**Forest Theater**

***Description:***

The majority of the soils in the area around the Forest Theater are undisturbed. The theater was built into the existing topography and little grading was required. It is likely that the soil between the back side of the stone edging of the seats and the front side of the next row of seats would support good tree growth once the tree reached the remnant soil layers below. Considerable surface rooting, from tree around the theater, was observed in this soil.




**Forest Theater site**

The stage surface has supported large trees indicating reasonable remnant soil below the crusted surface. Even the parking lot behind the theater would likely support large trees at its perimeter.

Several areas of erosion and bare soil was observe that need restoration. The lowest level of the theater seating below the stage apparently does not drain sufficiently and floods in wet weather.

The forest west of the theater has been cleared of most of the forest succession seedlings. This suggests that long term forest health will decline as the larger trees die.

***Soil observations and testing:***

Several un-recorded soil probes were made confirming that the soil around the theater is basically undisturbed. The soil profile was similar to the Appling soil series. One undisturbed bulk density sample was taken in the area of undisturbed woods to provide a reference bulk density for this soil type.

Compaction sample FT 1 - Area of undisturbed forest soil. The upper soil profile retained its original A, B and C horizons. Forest in a healthy state

Bulk density 1.46 gr/cm3, which is below the root limiting density for loam soil.

***Recommendations:***

<u>Existing conditions remediation</u>: Places where there is no leaf duff, compaction, soil crusting and/or erosion should be restored by airspade soil invigoration and mulching. In eroded areas topsoil may need to be added to cover exposed roots.

**Path with leaf duff worn away, erosion, surface crusting and lack of seedling trees.**

<u>Forest succession:</u> Develop forest succession management to avoid the long term decline observed in the Kenan Stadium Woods.

<u>New construction</u>: All new construction design efforts must be preceded by a detailed soil analysis to determine the appropriate approach to preserving and restoring soil. Designs and construction details must be developed with the least horizontal and vertical foot print possible while accomplishing the use goals. Walks must be made wide enough to handle peak loads with limited amounts of pedestrian overflow onto soil areas. Fencing, walls, curbs and other barriers need to be considered to guide pedestrians to avoid short cutting into wooded areas.

Any proposed walls or structures within the forest should be designed with low impact profiles that have small or no footings to reduce both soil disruption and tree root damage. All grading and work should include protection of adjacent undisturbed soils using mulch and alturnamats.

<u>New planting</u>: Any planting within the forest area should be specified with the smallest size planting hole to reduce root damage to the existing tree roots. Plants must be places between roots.

<u>Forest succession:</u> Develop forest succession management to avoid the long term decline observed in the Kenan Stadium Woods.

**Appendix A - terminology**

The following are definitions of terms in the report that may not be generally understood.

*Air spade*: A tool that uses compressed air to blow soil apart and reduce compaction with little impact on tree roots growing in that soil.

*Air spade soil invigoration*: Loosening the soil and incorporating compost into the top 6 to 9 inches of the surface using an air spade. The process allows the soil to be improved with little damage to the tree. Prescription fertilizer can also be incorporated into the soil at the time of soil invigoration.

*Alturnamats*: Plastic matting designed to spread loads of vehicles when they must pass over good soil that needs to be preserved. When placed over a thick mulch blanket and a geogrid blanket, very large vehicle loads can pass over the soil with little increase in soil compaction. (www.alturnamats.com)

*Backhoe subsoiling*: Using a backhoe to dig through layers of compost and compacted soil to loosen the soil and relieve compaction. Approximately 4-6" of compost is placed over the compacted soil. The backhoe digs through the compost into the soil to a depth of 24 inches below the original soil depth. The soil and the compost are lifted and then dropped back into place. As the soil is dropped, much of the compost falls into the spaces between the soil peds.

*Compost tea*: A mixture of specialty compost and sugars soaked in water that is agitated with air for approximately 24 hours. During this period microbes in the compost multiply and remain in the liquid to be able to be applied on soil to stimulate biological activity in the soil. Can be very effective to improving soil when combined with compost applications.

*Silva Cells*: Structural frame and deck system designed to be filled with soil to support tree roots under paved areas. The system can be adapted to support lawn soils. (www.Deeproot.com)

*Soil food web*: The groups of microbes and insects that live in the soil contributing to the chemical and physical health of the soil. These life forms can process all the chemicals needed by a plant and can reduce or even eliminate the need for fertilizer.

**Appendix B - A & L Soil Test**
Attached PDF file

**Appendix C - Polk Place Tree Preservation Soil Density Assessment**
Attached PDF file

**Report Number:**
R08106-0058
**Account Number:**
25256


# A&L Eastern Laboratories, Inc.

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**Send To:** URBAN & ASSOCIATES
915 CREEK DR
ANNAPOLIS, MD 21401

**Grower:** UNC

**Submitted By:** URBAN & ASSOCIATES

**Farm I.D.:** **Field I.D.:**

## SOIL ANALYSIS REPORT

**Page:** 1 **Date Received:** 4/15/2008 **Date of Analysis:** 4/16/2008 **Date of Report:** 4/18/2008 **Analytical Method(s):** Mehlich III MD

| Sample Number | Lab Number | Organic Matter | | | Phosphorus | | | | Potassium | | Magnesium | | Calcium | | Sodium | | pH | | Acidity | C.E.C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | ENR lbs/A | Rate | Available ppm | Rate | Reserve ppm | Rate | K ppm | Rate | MG ppm | Rate | CA ppm | Rate | NA ppm | Rate | Soil pH | Buffer Index | H meq/100g | meq/100g |
| 1B | 4616 | 1.6 | 75 | L | 146 | VH MD=161 | | | 109 | H MD=69 | 105 | H MD=83 | 490 | M MD=35 | 15 | VL | 5.7 | 6.8 | 1.0 | 4.6 |
| 1C | 4617 | 0.7 | 56 | VL | 22 | L MD=26 | | | 105 | H MD=66 | 170 | VH MD=132 | 390 | L MD=23 | 17 | VL | 5.3 | 6.8 | 1.7 | 5.4 |
| 2C | 4618 | 0.5 | 45 | VL | 4 | VL MD=7 | | | 72 | L MD=45 | 190 | M MD=147 | 410 | VL MD=25 | 35 | VL | 4.4 | 6.3 | 6.6 | 10.5 |
| 4B | 4619 | 0.7 | 57 | VL | 105 | VH MD=117 | | | 88 | M MD=55 | 120 | H MD=94 | 420 | L MD=26 | 19 | VL | 5.5 | 6.8 | 1.2 | 4.6 |
| 4C | 4620 | 0.6 | 54 | VL | 29 | L MD=34 | | | 104 | H MD=66 | 120 | H MD=94 | 320 | VL MD=14 | 21 | VL | 4.7 | 6.6 | 3.0 | 5.9 |

| Sample Number | Percent Base Saturation | | | | | Nitrate | | Sulfur | | Zinc | | Manganese | | Iron | | Copper | | Boron | | Soluble Salts | | Chloride | | Aluminum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K % | Mg % | Ca % | Na % | H % | NO3-N ppm | Rate | SO4-S ppm | Rate | ZN ppm | Rate | MN ppm | Rate | FE ppm | Rate | CU ppm | Rate | B ppm | Rate | ms/cm | Rate | CL ppm | Rate | AL ppm | Rate |
| 1B | 6.0 | 18.8 | 52.7 | 1.4 | 21.1 | | | 15 | L | 6.5 | H | 115 | VH | 163 | VH | 2.5 | H | 0.3 | VL | 0.08 | VL | | | | |
| 1C | 5.0 | 26.3 | 36.3 | 1.4 | 31.0 | | | 81 | VH | 3.8 | H | 60 | VH | 82 | VH | 1.2 | M | 0.2 | VL | 0.08 | VL | | | | |
| 2C | 1.8 | 15.0 | 19.4 | 1.4 | 62.3 | | | 257 | VH | 1.4 | L | 5 | L | 44 | H | 0.7 | L | 0.2 | VL | 0.13 | VL | | | | |
| 4B | 4.9 | 21.8 | 45.7 | 1.8 | 25.8 | | | 33 | H | 4.2 | H | 60 | VH | 98 | VH | 0.8 | L | 0.2 | VL | 0.11 | VL | | | | |
| 4C | 4.5 | 16.9 | 27.0 | 1.5 | 50.0 | | | 133 | VH | 1.8 | L | 21 | H | 52 | VH | 0.4 | L | 0.2 | VL | 0.10 | VL | | | | |

MD-FIV

Values on this report represent the plant available nutrients in the soil.
Rating after each value: VL (Very Low), L (Low), M (Medium), H (High), VH (Very High).
ENR - Estimated Nitrogen Release. C.E.C. - Cation Exchange Capacity.

Explanation of symbols: % (percent), ppm (parts per million), lbs/A (pounds per acre), ms/cm (milli-mhos per centimeter), meq/100g (milli-equivalent per 100 grams).
Conversions: ppm x 2 = lbs/A, Soluble Salts ms/cm x 640 = ppm.

This report applies to the sample(s) tested. Samples are retained a maximum of thirty days after testing. Soil Analysis prepared by:
A & L EASTERN LABORATORIES, INC.

by: Paul Chu
Paul Chu, Ph.D.

**Report Number:**
R08106-0058

**Account Number:**
25256

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## SOIL ANALYSIS REPORT

**Page:** 2 **Date Received:** 4/15/2008 **Date of Analysis:** 4/16/2008 **Date of Report:** 4/18/2008 **Analytical Method(s):** Mehlich III MD

| Sample Number | Lab Number | Organic Matter | | | Phosphorus | | | | Potassium | | Magnesium | | Calcium | | Sodium | | pH | | Acidity | C.E.C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % | ENR | | Available | | Reserve | | K | | MG | | CA | | NA | | Soil | Buffer | H | |
| | | | lbs/A | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | pH | Index | meq/100g | meq/100g |
| 7C | 4621 | 0.6 | 44 | VL | 12 | VL<br>MD=16 | | | 169 | H<br>MD=108 | 195 | M<br>MD=151 | 430 | VL<br>MD=28 | 31 | VL | 4.3 | 6.1 | 8.5 | 12.8 |
| | | | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |

| Sample Number | Percent Base Saturation | | | | | Nitrate | | Sulfur | | Zinc | | Manganese | | Iron | | Copper | | Boron | | Soluble Salts | | Chloride | | Aluminum | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | K | Mg | Ca | Na | H | NO3-N | | SO4-S | | ZN | | MN | | FE | | CU | | B | | | | CL | | AL | |
| | % | % | % | % | % | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ppm | Rate | ms/cm | Rate | ppm | Rate | ppm | Rate |
| 7C | 3.4 | 12.7 | 16.8 | 1.1 | 66.1 | | | 407 | VH | 1.5 | L | 10 | M | 48 | H | 0.5 | L | 0.1 | VL | 0.21 | VL | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
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MD-FIV

Values on this report represent the plant available nutrients in the soil.
Rating after each value: VL (Very Low), L (Low), M (Medium), H (High), VH (Very High).
ENR - Estimated Nitrogen Release. C.E.C. - Cation Exchange Capacity.

Explanation of symbols: % (percent), ppm (parts per million), lbs/A (pounds per acre), ms/cm (milli-mhos per centimeter), meq/100g (milli-equivalent per 100 grams).
Conversions: ppm x 2 = lbs/A, Soluble Salts ms/cm x 640 = ppm.

This report applies to the sample(s) tested. Samples are retained a maximum of thirty days after testing. Soil Analysis prepared by:
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by: Paul Chu
Paul Chu, Ph.D.

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ANNAPOLIS, MD 21401

**Grower:** UNC

**Submitted By:** URBAN & ASSOCIATES

**ATTN:** JAMES URBAN

**Date Received:** 4/15/08 **Date Reported:** 04/18/2008

## REPORT OF ANALYSIS



| LAB NO. | SAMPLE ID | ANALYSIS | RESULT | UNIT | METHOD |
|---|---|---|---|---|---|
| 4616 | 1B | Sand | 57 | % | Bouyoucos 1962 |
| | | Silt | 26 | % | Bouyoucos 1962 |
| | | Clay | 17 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Sandy Loam | | Bouyoucus 1962 |
| 4617 | 1C | Sand | 51 | % | Bouyoucos 1962 |
| | | Silt | 20 | % | Bouyoucos 1962 |
| | | Clay | 29 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Sandy Clay Loam | | Bouyoucus 1962 |
| 4618 | 2C | Sand | 43 | % | Bouyoucos 1962 |
| | | Silt | 10 | % | Bouyoucos 1962 |
| | | Clay | 47 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Clay | | Bouyoucus 1962 |
| 4619 | 4B | Sand | 57 | % | Bouyoucos 1962 |
| | | Silt | 24 | % | Bouyoucos 1962 |
| | | Clay | 19 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Sandy Loam | | Bouyoucus 1962 |
| 4620 | 4C | Sand | 51 | % | Bouyoucos 1962 |
| | | Silt | 16 | % | Bouyoucos 1962 |
| | | Clay | 33 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Sandy Clay Loam | | Bouyoucus 1962 |

ALE-MISC



Paul Chu, Ph.D.

**Report Number:**
R08106-0058
**Acount Number:**
25256

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ANNAPOLIS, MD 21401

**Grower:** UNC

**Submitted By:** URBAN & ASSOCIATES

**ATTN:** JAMES URBAN

**Date Received:** 4/15/08 **Date Reported:** 04/18/2008

## REPORT OF ANALYSIS



| LAB NO. | SAMPLE ID | ANALYSIS | RESULT | UNIT | METHOD |
|---|---|---|---|---|---|
| 4621 | 7C | Sand | 25 | % | Bouyoucos 1962 |
| | | Silt | 20 | % | Bouyoucos 1962 |
| | | Clay | 55 | % | Bouyoucos 1962 |
| | | Soil Textural Class | Clay | | Bouyoucus 1962 |

ALE-MISC



Paul Chu, Ph.D.

# Polk Place Tree Preservation: Soil Density Assessment

Prepared for:
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Chapel Hill NC

May 30, 2006

# Soil Density Assessment at Polk Place

## Introduction / Statement of Problem

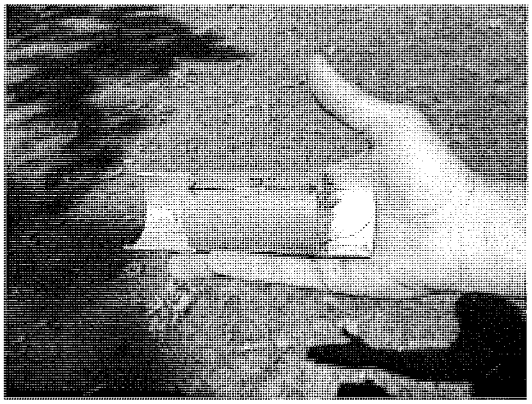
The University contacted the Bartlett Tree Research Laboratory to assess whether there were steps that should be taken to enhance the health of the trees on Polk Place.

From initial discussions with campus administrators and University arborists, we learned that the trees on Polk Place have been declining and dying at an increasing rate over the past few years. This is a key location on campus both from a student use perspective and an aesthetic perspective. The trees that line the area are an integral part of Polk Place. Their loss would profoundly alter the experience of the area.

One hypothesis for the decline of the trees is that the high use of the area is causing soil compaction that limits the root growth of the trees. If this is indeed the case, examining the bulk density of the soil and the pattern of bulk density differences could confirm this diagnosis. To achieve that end, soil samples were collected to determine the bulk density of the soil in and around this area.

Polk Place.

# Materials and Methods



Undisturbed soil core cut to length for soil density analysis.

Samples were collected using a slide hammer and a two inch diameter by six inch long undisturbed core sample tube. Three-inch long sub-samples were cut from each core for analysis. The samples were shipped to the Bartlett Tree Research Laboratory in Charlotte where they were dried and weighed. Results of these tests are reported in Tables 1 through 4. Soil nutrient samples were also collected in March 2006.

Samples were collected from four locations on campus. The first location was areas outside the driplines of the trees along Polk Place (Table 1). These samples were collected to determine if a soil density problem generally existed in Polk Place. The second set of samples were~~as~~ taken in the area to the east and adjacent to South Building. These 'control' samples were taken to determine if the soil in the areas of high use on Polk Place was materially different in density from neighboring areas receiving lesser use (Table 2). The third set of samples were~~as~~ collected from areas at or inside the tree driplines on Polk Place but outside the mulch rings (Table 3). These samples were taken to determine if the University's policy of fencing off areas under the driplines during large organized events (such as "Tar Heel Town") has been able to limit soil compaction. The fourth set of samples were~~as~~ collected in areas within the mulch surrounding the trees (Table 4).

These samples were collected to determine if the mulch treatment that is in place on some trees has been able to reduce the level of compaction.

Table 1. Soil Densities found on Polk Place outside the driplines of trees.

| Sample location | Bulk Density (g/cc) | Comments |
|---|---|---|
| Area ~~left~~ east of Wilson Library outside dripline | 1.7 | Compacted |
| Area ~~left~~ east of Wilson Library outside dripline | 1.8 | Compacted |
| Area center of Polk Place outside dripline | 1.6 | Compacted |
| Area center of Polk Place outside dripline | 1.7 | Compacted |
| Area ~~Left~~ east of flag pole outside dripline | 1.6 | Compacted |
| Area east~~Left~~ of flag pole outside dripline | 1.8 | Compacted |
| Average | 1.7 | Compacted |

Table 2. Soil Densities found at 'Control' Locations east of South Building.

| Sample location | Bulk Density (g/cc) | Comments |
|---|---|---|
| Control sample east of South Building outside dripline | 1.4 | Acceptable |
| Control sample east of South Building outside dripline | 1.6 | Compacted |
| Control sample east of South Building outside dripline | 1.4 | Acceptable |
| Average | 1.46 | Moderately Compacted |

Table 3. Soil Densities found on Polk Place at or inside the dripline of trees.

| Sample location | Bulk Density (g/cc) | Comments |
|---|---|---|
| 21" white oak ~~facing~~ east of Wilson Library ~~on Left~~ at dripline | 1.43 | Acceptable |
| 22" white oak on ~~left~~ east side at dripline | 1.60 | Compacted |
| 36" white oak ~~south~~ north of | 1.54 | Moderately |

| | | |
|---|---|---|
| persimmon dripline | | Compacted |
| Average | 1.52 | Moderately Compacted |

Table 4. Soil Densities found on Polk Place in Mulch surrounding Trees.

| Sample location | Bulk Density (g/cc) | Comments |
|---|---|---|
| 21" white oak ~~facing~~ east of Wilson Library ~~on Left~~ in mulch | 1.51 | Moderately Compacted |
| 22" white oak on ~~left~~ east side in mulch | 0.99 | Acceptable |
| 36" white oak ~~south~~ north of persimmon in mulch | 0.91 | Acceptable |
| 41" white oak furthest north on east side of S~~s~~outh Building in mulch | 0.94 | Acceptable |
| Average | 1.09 | Acceptable |

Critical bulk densities (g/cc) for willow oak in Sandy Clay loam soils are:
< 1.45 Acceptable density
1.46-1.55 Moderately compacted
>1.55 Seriously compacted

Density references: Water 1.0, Brick 1.9, Asphalt 2.2, Concrete 2.4 g/cc

# Results

In the soil density samples collected from outside the driplines of Polk Place, the average soil density was 1.7 g/cc. This is considered seriously compacted and would most likely inhibit tree root growth. Soil compacted at this level is not a sustainable environment for trees.

The 'control' areas around the South building had an average density of approximately 1.46 g/cc which is on the line between acceptable and moderately compacted. The difference in soil densities between these first two sets of samples indicates that a greater level of soil compaction exists in the areas of high use on Polk Place relative to the areas of lawn receiving lesser use.

With the exception of samples collected from the 21 inch diameter white oak ~~facing~~ east of Wilson Library, it was found that soil densities were significantly lower in the mulched areas than at the dripline of the trees. The average density in the mulch area of these samples was 1.09 g/cc and the average density at the dripline was 1.52 g/cc.

The lower average density of 1.52 g/cc at the driplines on Polk Place, compared to the average density of 1.7 g/cc outside the driplines, indicates that past efforts during large organized University events to fence-off areas under the driplines may indeed be limiting soil compaction.

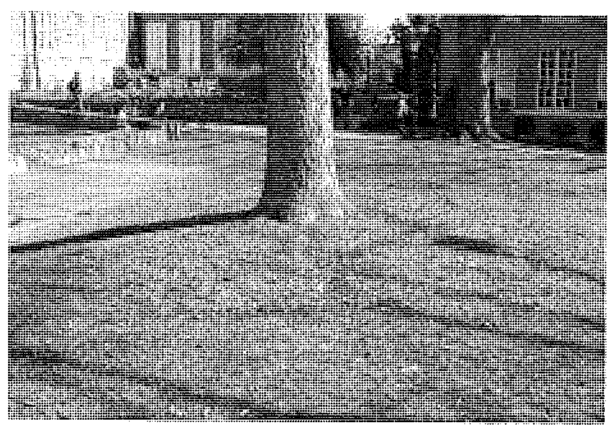
The results of the soil nutrient analysis are attached. It was found that nitrogen and potassium levels were both low and that calcium levels were medium. Organic matter levels were very low. Low levels of soil organic matter is one of the reason that the soil is susceptable to compaction.

The majority of the trees on Polk Place are oaks that are approximately 80 years old. While these oaks are mature trees, they are not at the end of their natural expected lifespan. Healthy oak trees can live 150 to 200 years or more, with proper maintenance.

# Recommendations

1) To reduce the levels of soil compaction, the trees on P~~l~~olk Place should receive a Root Invigoration treatment. This is a process that tills the soil using ~~high pressure~~high-pressure air and incorporates organic matter and nutrients. The standard radius of treatment is five times the diameter of the tree trunk. Therefore, a 24 inch diameter tree should have a treatment radius of 10 feet from the trunk. For optimum soil conditions for this treatment, it should be done in the late November/December time frame. This treatment, in conjunction with mulching, will increase the soil organic matter level, which will make the soil more resistant to compaction in the future. Root Invigoration should include the removal of soil from the lower trunk (root collar) of the tree, if excess soil is present.

2) Mulch should be applied to all of the trees to conserve soil moisture and reduce future compaction. This treatment should be applied as soon as practical (summer 2006). The mulch area should correspond to the area that will receive Root Invigoration next winter (radius = trunk diameter X 5). Mulch is best applied as a two inches thick layer of compost covered with a two



Current mulching practices have succeeded in reducing soil compaction, but mulch ring inch layer of wood chip mulch. Mulch thickness should be monitored regularly and additional mulch should be added when thickness of the mulch layer becomes less than two inches.

3) The use of the area within the dripline (or calculated equivelant area) of these trees should be restricted during all organized events that take place off of the paved areas in Polk Place. This restriction should consist of fencing off the area so as to keep people, furniture, supplies vehicles, etc. off of the area. Wet soil is more susceptable to compaction than dry soil, so if heavy rainfall has occurred prior to an event that has saturated the soil, or if rainfall of one inch or more is anticipated immediately prior to or during an event, the distance from the tree trunks to the fence should be increased by a factor of 1.3.

   For trees with an unusually small crown, the equivelant dripline area should be calculated as follows: Trunk diameter measured in inches times 1.25 = restricted area measured in feet. So a 30 inch diameter tree would have a calculated equivalent area diameter of 37.5 feet. This figure should be increased as described above for wet soil.

4) In the turf area outside the expanded mulch rings, turf based soil decompation (core aeration or water jet aeration) should be conducted on an annual basis in the winter. This should be part of a routine turf management program that includes fertilization, pH adjustment, thatch management, irrigation and overseeding, as needed.

5) The trees on Polk Place should be fertilized with nitrogen, potassium and calcium (gypsum) as soon as practical to overcome the nutrient deficiencies that are currently present. As part of a continuing tree health care program, the soil should be sampled on an annual basis in the fall and fertilizer should be applied on an 'as needed' or prescription fertilization basis.

6) Insect borers and ambrosia beetles are attracted to trees that are experienceing stress from root restriction and root damage. To reduce the risk of bark beetles and borers attacking the trees on Polk Place, the trees should be treated from the root flare to the lowest branch with the appropriate insecticide (*Onyx*) two times per year, once in February/March and a second time in June. The first application should be applied as soon as practical even if it is not one of the prefered dates. If stress related borers (two lined chestnut borer or others) are found in the crowns of the trees, a *Merit* or other appropriate treatment should be provided. Treatments should only be applied under the supervision of a NC Certified Applicator.

7) If sap oozing (bleading) occurs on the trunks of any of these trees, a sample of the trunk should be collected and analysed for the fungal pathogen *Phytophthora*. Infected trees should receive up to four treatments per year starting as soon as possbile. *Agrifos* and *Subdue* are the prefered materials. Treatments should only be applied under the supervision of a NC Certified Applicator.

8) The health of the trees, soil nutrient status and soil density should be monitored on a regular basis. The trees should be visually inspected at least monthly for health and pest problems. The soil density should be sampled annually in late fall so that soil remediation can be conducted during winter break, if needed. The soil within the dripline of the trees should be sampled for nutrient content on an annual basis and presciption fertilization should be applied when needed. If decline symptoms persist or become worse, a complete diagnosis should be conducted to determine the cause. If soil samples continue to show high levels of compaction in future years, greater restrictions should be placed on the area around the trees.